Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 2 Pages: 195-205 ISSN 1339-5629

doi:10.22306/al.v9i2.294 *Received: 22 Jan. 2022; Revised: 05 Mar. 2022; Accepted: 18 Apr. 2022*

AN EMPIRICAL COMPARISON OF DRP AND DEMAND-DRIVEN DRP

Yassine Erraoui
The Laboratory of Engineering, Industrial Management and Innovation, Faculty of Science and Techniques, University Hassan 1st, Zip Code 577, 26000 Settat, Morocco, y.erraoui@uhp.ac.ma (corresponding author)
Abdelkabir Charkaoui
The Laboratory of Engineering, Industrial Management and Innovation, Faculty of Science and Techniques, University Hassan 1st, Zip Code 577, 26000 Settat, Morocco, abdelkabir.charkaoui@uhp.ac.ma

Keywords: supply chain, distribution networks, Distribution Resource Planning, Demand Driven Distribution Resource Planning, demand variability.

Abstract: Companies are nowadays challenged to offer high service levels while minimising inventory costs in an ever-increasing competitive market. One of the keys is to manage and improve the product flow in the distribution network continuously. In this paper, Demand Driven Distribution Resource Planning (DDDRP) is a proposed model for product flow management in distribution networks. It allows to optimise the flow by managing customer demand fluctuations. A literature review about flow management policies is presented, and then a case study is provided to make a comparison of the DDDRP concept with conventional management methods such as Distribution Resource Planning (DRP). To achieve this comparison, a discrete event simulation (DES) is adopted to measure the effectiveness of each model regarding the demand fluctuations, using key performance indicators. The simulation gives empirical results and illustrates the interests and benefits of the DDDRP approach in terms of inventory costs and service levels. The originality of this document concerns the assessment of Demand-Driven Distribution as a new approach of management and opens up new opportunities for optimising inventory and product flow in distribution networks.

1 Introduction

Companies are now required to appropriately manage products and information flows through supply chain distribution networks. As a definition, flow management entails coordinating all of the operations carried out during the product's distribution. It is critical since it directly influences inventory levels in each distribution unit and, consequently, the overall working capital and service levels. Bad flow management can result in a discrepancy between the quantity sold to the buyer and the amount produced by the manufacturer [1]. Many authors declare that optimising flow must take into account the important factor of demand variability management [2-4].

In this regard, Distribution Resource Planning (DRP) is a well-known push system that uses demand forecasting to determine when and how much the product should be replenished in downstream sites [5,6]. Moreover, pull systems have been developed as part of concepts such as LEAN, Theory of Constraints, and Just-In-Time. They offer real-time ways to deliver the product after the justification of the consumer demand [7,8].

On the other hand, Demand Driven Distribution Resource Planning (DDDRP) is a concept that combines the best of both systems by putting buffers in strategic points of the distribution network and pulling flow between them. Thus, it integrates the main axes, which are Lean distribution [7], Theory of constraints [9], and DRP logic [10].

The literature dedicated to evaluating the efficiency of flow is scarce. However, it has been proven that a good flow must contribute to a good service rate and an optimal inventory cost [11].

In this article, the efficiency of adopting a demand-driven strategy in distribution networks is evaluated by using an empirical analysis based on a real industrial situation. For this, we simulate the models through a multitude of demand variability scenarios and examine the effects on inventory and service levels.

The paper starts with a literature review on flow management models, describing the differences between the pull and push-flow approaches. Secondly, we give DDDRP model drivers, steps and formulas. The case study details and model implementation are then presented. Finally, we analyse the scenarios and the results of the simulation.

This paper is one of the first contributions to offer a new perspective on distribution management based on real consumer demands. We structured the work by proposing the axes, describing the model, and testing it empirically.

2 Flow management models: literature review

2.1 Push flow models in distribution

A push flow system is a strategy that involves pushing products through distribution networks in order to build up an inventory that can meet customer demand. Since 1970, Distribution Resources Planning (DRP) has been used to control inventory in a multiproduct, multi-echelon physical distribution environment. Since its appearance, the implementations of the DRP paradigm in distribution systems have reported several benefits. DRP is based on demand forecasting and replenishment generation, and it determines the time and quantities of all downstream

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 2 Pages: 195-205 ISSN 1339-5629

replenishments. It was first proposed as an extension to Material Requirement Planning (MRP), moving the same logic from production to distribution. To perform a DRP grid, inputs data include sales forecasts, customer orders, available inventory and stock security policy. Then, DRP method gives a calculation of resource requirements related to the quantity of needed products, time, transport and stock investment needs [6]. Many recent works studied the implementation of DRP model in various industrial sectors. In fact, some researchers focus on finding the best lotting techniques for the distributed items using the DRP method [12]. A study uses DRP technique to determine the appropriate quantity and replenishment time in inventory decisions in the food industry [13]. Otherwise, the autoregressive integrated moving average (ARIMA) model has been used since the DRP requires precise forecast data [14]. This study concerned a company of mining and trade of oil and gas. Some works try to find the best forecasting approach based on the time series of each Distribution Centre (DC) using the DRP method to avoid inventory shortage problems [15]. Moreover, based on the case of the oil fuels industry, some authors studied the need for diesel oil for companies using DRP approach [16].

2.2 Pull flow models in distribution

2.2.1 Lean distribution

To reduce waste and boost productivity, Lean principles can be applied to any distribution function [17]. Lean distribution is defined as a technique that replaces traditional ways focused on inventory and rescheduling to cope with the changing customer demand. It has recently gotten considerable attention from academics and industries. It focuses on avoiding waste in the downstream supply chain with the goal of putting the right product in the right place. In other words, it presents the ability to sustain a high level of customer service by reducing waste and movements in distribution centres [18].

Well-known companies such as Wall Mart, Tesco, and IKEA have all employed lean distribution. They adhere to a philosophy of adapting inventory movement to customer demand in order to improve operational product flows and respond quickly to demand changes from the supplier to the sales location [7].

There is much evidence in the literature about the economic benefits of implementing Lean distribution. In fact, they are related to the decrease of finished items stock, as well as shortening delivery lead times and change-over times [19]. Table 1 summarises the differences between traditional distribution management and lean distribution. Similarly, based on a case study in a Serbian company, table 2 shows some quantitative benefits of implementing lean concepts in distribution units.

Table 1 Comparison between Lean distribution and traditional management tools

Distribution elements	Traditional distribution management	Lean distribution
Systems variations	**Variations cause continuous resetting for plans**	**Isolation of variations and take them in consideration in all lean practices**
Forecasts	**The constraint of being more accurate in long-term and short-term planning**	**Used only for long-term and aggregate planning**
Inventory	**The inventory should not be close to customer orders**	**The inventory should be close to the source and redirected according to the replenishment needs**
Transportations	**It is forecast-driven**	**It is demand-driven and takes in consideration delivery conditions**

Table 2 Quantified improvements after LEAN distribution implementation [20]

Area of improvement	Improvement quantity	
	Before	After
Inventory accuracy	**9.29%**	**5.97%**
Reducing lost-time accidents	**15-20 days**	**7-10 days**
Reducing picking error	**0.17%**	**0.01%**
Inventory levels	**Decrease of 76%**	
Required storage space	**Decrease of 51%**	
Warehouse productivity	**Improvement of 9.43%**	
Warehouse productivity	**Improvement by 5%**	

Tables 1 and 2 demonstrate the relevance of implementing Lean techniques in distribution contexts. They show that the management does not rely on forecasts but actual customer demand, except for long-term and aggregate planning.

2.2.2 Theory of Constraints

The Theory of Constraints (TOC) offers a wide range of applications, including reducing material flow costs throughout the supply chain [21]. It provides a demand-pull approach, as opposed to typical replenishment models, which result in inventory accumulation and/or shortages, and eventually an inability to meet customer demand [22]. The core concept of TOC is that every firm can have a constraint that should be used to improve the system's performance [10]. Constraints are described as an element that prevents a system from fulfilling its intended objectives. The weakest link in an organisation appears to be the source of problems, which is physical in the form of bottleneck resource, with a capacity that is less than or equal to the demand imposed on it [23].

TOC is used in various industries, including production, finance, project management, marketing, supply chains, management, and commerce, with distribution being one of them. In reality, TOC allows for a shift in the distribution network from a push to a pull model, with goods being delivered according to market demand.

The use of TOC in distribution systems attempts to reduce inventory investment, lead time, and transportation costs while also improving customer service levels.

Multiple evidence are stated in the literature about implementing TOC in distribution, such as GM's Cadillac Division's aborted introduction of Custom Xpress delivery (CXD). P&G's reported an inventory reduction of US$600 million, and makers of Crayola crayons' reported improvements in customer service levels and inventory reduction [5]. Authors in recent works used processing tools of TOC to focus on transportation constraints in the supply chain [24], while others contributed to transforming management systems in warehouses using TOC [25]. The application of TOC tools in distribution elements such as inventory, supplier liability and planning of sales is also discussed and evaluated [10].

We conclude from the literature that DRP, Lean, and TOC are pure push and pull flow systems in distribution. However, demand-driven distribution resource planning (DDDRP) has recently emerged, using all these principles. It relies on real demand and implements buffer at strategic places in the network, drawing flow from market demand to feed those Buffers. In DDDRP concept, Buffers are sized in a way to protect the flow from the consequences of demand fluctuations.

3 Concept of demand-driven distribution

3.1 Model drivers

Demand Driven DRP is a multi-echelon inventory planning and execution system for effective distribution network flow management. The purpose of the concept is to reduce variability propagating in distribution networks – due to demand fluctuations - by strategically placing Buffers. These buffers are separated into three continuously sized zones (Figure 1): Red (300 units), which is responsible for the safety stock. Yellow (500 units), which is responsible for demand coverage, and Green (250 units), which is responsible for determining the frequency and number of orders.

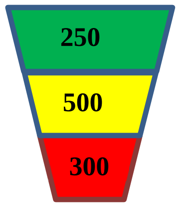

Figure 1 Sized Buffer

The Buffer zones are sized using a set of parameters and equations based on the DDMRP technique (equations 1 to 5) [26]. The concept of buffering, which is inspired by Lean distribution and TOC techniques, provides a solution to the amplification of variability in complex networks, which is often prone to cause inventory problems at network locations, either in the form of 'too little' causing miss sales and lack of components, or 'too much' resulting in excess cash and more needed space for stocking, known as the Bimodal effect (Figure 2).

To avoid the 'too much' or 'too little' issues, the target is to have the most of articles in an optimal range of inventory at all times (Figure 3) [26].

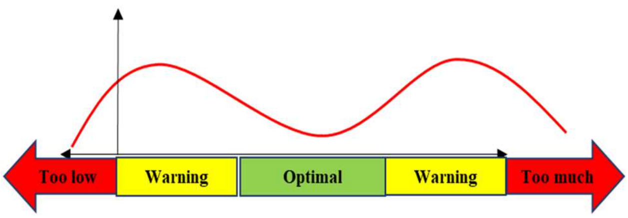

Figure 2 Bimodal effect

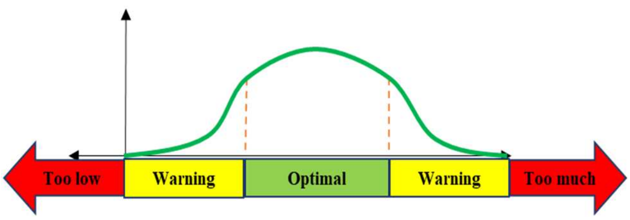

Figure 3 Optimal Situation of inventory

3.2 Parameters, steps and formulas

The Demand Driven DRP model is grouped into five parts, starting with buffer placement and ending with material replenishment execution. Figure 4 depicts a buffered random distribution network. Being physically in the form of decoupling 'hubs', Buffers are essential for reducing lead times and preventing amplified variability in the network. Due to the decoupling of 'Hubs,' the planning horizons will be shortened (Figure 4).

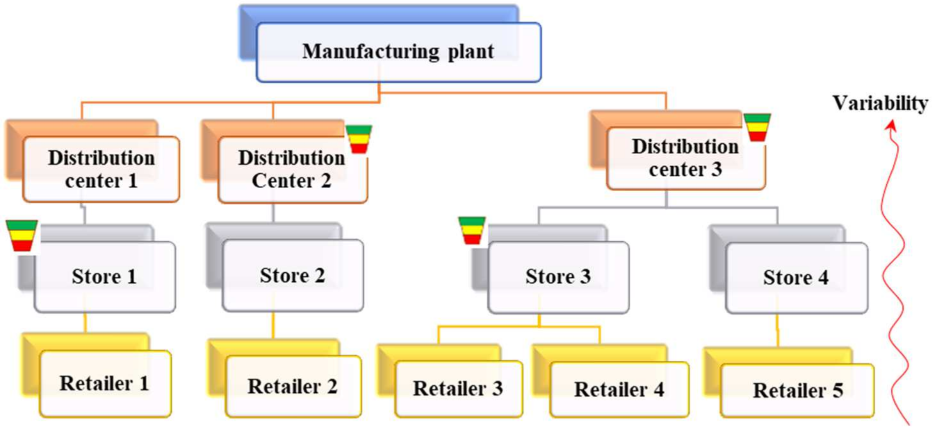

Figure 4 Distribution network with Buffers

After Buffer placement in the network, Profile and Sizes (step 2) refers to specific calculating methods; each buffer is colour-coded (figure 1). The buffer levels are determined using the distribution parameters, which include the lead time (LT) from a supplier centre to a receiver centre. In the context of distribution, LT refers to the time it takes to launch a product, prepare an order, load, transit, unload, and stock it. Otherwise, the longest cumulative non-buffered sequence in the distribution network is used to estimate decoupling lead time (DLT) for each reference. Buffer profile assignments are also included in the calculations (related to variability and lead time assignments). Furthermore, the calculation takes into account the average daily usage (ADU), product selling price, and demand adjustment parameters (DAF). The buffer profile and levels exploit the following DDMRP equations (1 to 5).

$$Red\ Base = ADU \times DLT \times lead\ time\ factor \quad (1)$$

$$Red\ Safety = Red\ base \times variability\ factor \quad (2)$$

$$Total\ red\ zone = Red\ Base + Red\ Safety \quad (3)$$

$$Yellow\ Zone = ADU \times DLT \quad (4)$$

$$Green\ Zone = ADU \times DLT \times Lead\ Time\ factor \quad (5)$$

The classic DRP incorporates the safety stock in a static way, allowing for the generation of a supply or replenishment order once the safety stock is surpassed. However, Demand Driven DRP, on the other hand, considers market changes as well as fluctuations in operating factors such as ADU to adjust Buffers continually. This variable character ensures a dynamic adjustment for the buffer (step 3), in which the level of protection flexes up and down depending on the condition of those parameters, implying that the buffer situation is constantly updated.

The level of adjustment prepares for the supply order generation phase (Step 4). The position of the net flow (NFP) in the buffer in relation to each article is crucial for generating those orders. The net flow equation is used to calculate this position, which takes into account Qualified sales (not forecasted sales), On-Hand Quantity, and Open Supply Quantity (equation 6). Based on the priority of every article, the last phase (step 5) is to execute or not the planned orders.

$$OH + OS - QS = net\ flow\ position \quad (6)$$

OH: On Hand Quantity, considering the available physical stock.
OS: Open Supply Quantity, considering the ordered but not received stock.
QS: Qualified Sales, considering Sales orders past due, sales orders due today, and qualified spikes.

3.3 Proposed Approach for DDDRP validation

For the study, a case of a three echelon network is proposed, with all relevant data valid, including distribution network, historical customer demand, lead times, initial inventory situations, and Holding/Manufacturing costs.

To perform this research, ARENA SIMULATION SOFTWARE was used to create a discrete event simulation (DES). With a replication length of one year, we can reproduce one year of distribution on a daily basis. The simulation will help to compare DRP and DDDRP models, by which we perform some relevant performance measures. They are working capital (WC) and on-time shipping (OTS) rates, which represent respectively inventory cost and service levels. Furthermore, simulation provides additional precise indicators for the models under consideration, such as the level of safety stock and Buffer sizes. Several different demand scenarios are studied in order to provide dependable and consistent results.

This approach was used on the DDDRP and DRP models in order to conduct an empirical comparison between forecasted and demand-driven concepts, as well as syntheses on each model's strengths and drawbacks.

4 Empirical study

4.1 *Case Study data*

A distribution network of a Moroccan structure specialising in the dairy products industry is the subject of the case study. Urban Distribution Centers (UDC), Regional Distribution Centers (RDC), and Factory are the three echelons of the distribution network (Figure 5).

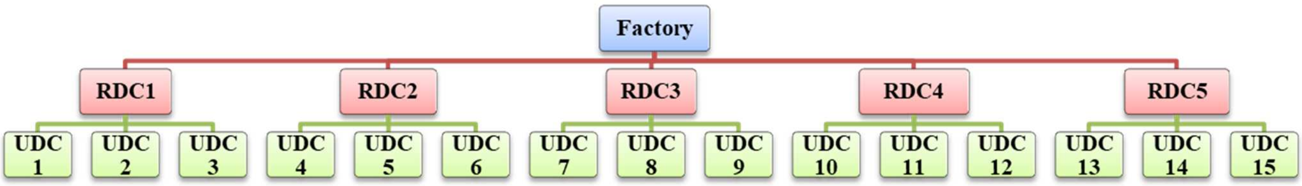

Figure 5 Distribution network of the case study

To conduct the study, the input parameters for all the UDCs and RDCs are initial On hand inventory, forecasted average daily usage (ADU) for every buffered location, and the Decoupling Lead time (DLT). Furthermore, the lead time (LT) (from RDCs to UDCs is 3 days, as is the Lead Time from Factory to RDCs), inventory holding costs, and selling prices are all provided.

Table 3 Some input data for three UDCs

Distribution Unit	Initial On Hand inventory	ADU	LT factor	Variability Factor
UDC1	**2000**	**400**	**50%**	**20%**
UDC2	**15000**	**3100**	**50%**	**20%**
UDC3	**15000**	**3500**	**50%**	**20%**

Table 3 shows an example of input data for the first three UDCs. ADU refers to the first month. Moreover, the duration of the LT and the amount of the demand variability are used to establish LT and variability factors.

4.2 *Models' implementation*

4.2.1 DRP implementation

Every UDC builds a DRP grid based on forecasted demand that is developed locally. Then it communicates the replenishment orders to the RDC supplier, which elaborates in the same way as its own DRP grid. In addition, every location takes into account its unique security requirements. Table 4 shows an elaborated DRP for UDC1 during the first 10 days of the year, with variable forecasted demand.

Table 4 Elaborated DRP for UDC1

Security stock	**550**		Week	1	2	3	4	5	6	7	8	9	10
			Demand	**550**	**550**	**550**	**550**	**550**	**2200**	**2200**	**550**	**550**	**550**
On Hand Start	**8000**		End Inventory	**8000**	**7450**	**6900**	**6350**	**5800**	**5250**	**3050**	**850**	**2300**	**1750**
Supply Quantity	**2000**		Projected On-Hand	**8000**	**7450**	**6900**	**6350**	**5800**	**5250**	**3050**	**2850**	**2300**	**1750**
Lead time (days)	**3**		Schedule Receipt	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2000**	**0**	**0**
			Schedule Start	**0**	**0**	**0**	**0**	**2000**	**0**	**0**	**2000**	**0**	**2000**

After the elaboration of DRP grids, the final push decision of the flow concerns the timing and quantity of all downstream locations' replenishments.

4.2.2 DDDRP implementation

The choice of strategic Buffer Positioning is referred in the Demand Driven DRP implementation to the 'Hub and Spoke' Configuration [26], which consists of installing an 'Inventory Hub' in the source unit and small stock locations on the warehouses (Figure 6). Consequently, all of our UDCs and RDCs are buffered in the case study. RDCs are thought to have sufficient capacity to meet the demands of UDCs. Table 5 depicts the second step of buffer sizing, showing a portion of the first month's findings for all UDCs units.

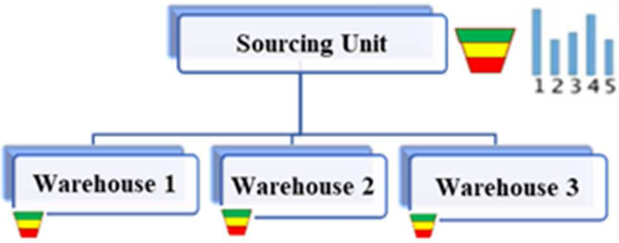

Figure 6 Hub and Spoke configuration

These calculated Buffer levels serve as the basis for the demand-driven planning process (Table 6). The real customer demand is represented in column 1, and future spikes are checked for a three-day horizon. Following that, the daily net flow position (NFP) in the buffer is stated in order to determine the order amount that has to be supplied.

The request day is the anticipated arrival date of the order amount. The NFP position in relation to the buffer sizes is shown in the planning priority. A supply is planned if the position is below the Top of Yellow (TOY), and the order amount is Top of Green (TOG) minus the NFP.

Table 5 Buffer sizing

		UDCs														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Parameters	ADU	400	3100	3500	600	1200	1000	1000	2300	3500	800	3200	2400	2100	1200	2400
	DLT	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
	Variability Factor	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
	LT Factor	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Buffer Levels	Red Safety	960	7440	8400	1440	2880	2400	2400	5520	8400	1920	7680	5760	5040	2880	5760
	Red Security	9	74	84	14	28	24	24	55	84	19	76	57	50	28	57
	Yellow zone	1200	9300	10500	1800	3600	3000	3000	6900	10500	2400	9600	7200	6300	3600	7200
	Green zone	960	7440	8400	1440	2880	2400	2400	5520	8400	1920	7680	5760	5040	2880	5760

Table 6 Demand Driven Planning

Day	Sales Order Due Today	Total Future Spike	On-Hand	On-Order	Showing-Up Order	Qualified Demand	NFP	Order amount	Request Date	Planning Priority
1	34604	16749	80000	0	0	51353	28647	23461	4	54.98%
2	0	16749	45396	23461	0	16749	52108	0	-	100.00%
3	16749	0	45396	23461	0	16749	52108	0	-	100.00%
4	13029	0	28647	23461	23461	13029	39079	13029	7	75.00%
5	0	0	39079	13029	0	0	52108	0	-	100.00%
6	0	0	39079	13029	0	0	52108	0	-	100.00%
7	913	21648	39079	13029	13029	22561	29547	22561	10	56.70%
8	0	21648	51195	22561	0	21648	52108	0	-	100.00%
9	0	21648	51195	22561	0	21648	52108	0	-	100.00%
10	21648	0	51195	22561	22561	21648	52108	0	-	100.00%
11	9535	0	52108	0	0	9535	42573	0	-	81.70%
12	764	0	42573	0	0	764	41809	0	-	80.24%
13	0	0	41809	0	0	0	41809	0	-	80.24%
14	5581	14838	41809	0	0	20419	21390	30718	17	41.05%
15	0	14838	36228	30718	0	14838	52108	0	-	100.00%
16	0	14838	36228	30718	0	14838	52108	0	-	100.00%
17	14838	0	36228	30718	30718	14838	52108	0	-	100.00%
18	10815	0	52108	0	0	10815	41293	0	-	79.25%
19	3666	0	41293	0	0	3666	37627	14481	22	72.21%
20	776	0	37627	14481	0	776	51332	0	-	98.51%
21	5566	0	36851	14481	0	5566	45766	0	-	87.83%
22	0	23301	31285	14481	14481	23301	22465	29643	25	43.11%
23	0	23301	45766	29643	0	23301	52108	0	-	100.00%
24	1133	23301	45766	29643	0	24434	50975	0	-	97.83%
25	23301	0	44633	29643	29643	23301	50975	0	-	97.83%
26	0	18096	50975	0	0	18096	32879	19229	29	63.10%
27	12189	18096	50975	19229	0	30285	39919	0	-	76.61%
28	0	41036	38786	19229	0	41036	16979	35129	31	32.58%

The final stage is to execute the planned orders. It is based on the Buffer status, which is calculated by dividing the On-Hand Status by the Top of the red zone (TOR). It allows making a decision about when to execute the detailed planning elaborated in the previous phase. The item with the smallest status creates an execution emergency. We didn't give much interest to this section because we were just interested in one product flow.

4.3 Models' comparison

4.3.1 Scenarios of Simulation

This study proceeds to challenge the Demand Driven DRP under several demand scenarios and compare it with a traditional DRP concept. The method entails employing three circumstances, which are listed in table 7.

Table 7 Scenarios of the simulation

Scenario	Particularity
1	**Stable demand along 12 months.**
2	**Variable demand characterised with 2 spikes every week. Each spike is 5 time the ordinary demand (Figure 7).**
3	**Monthly Seasonality, and the demand is fix along one month (Figure 8).**

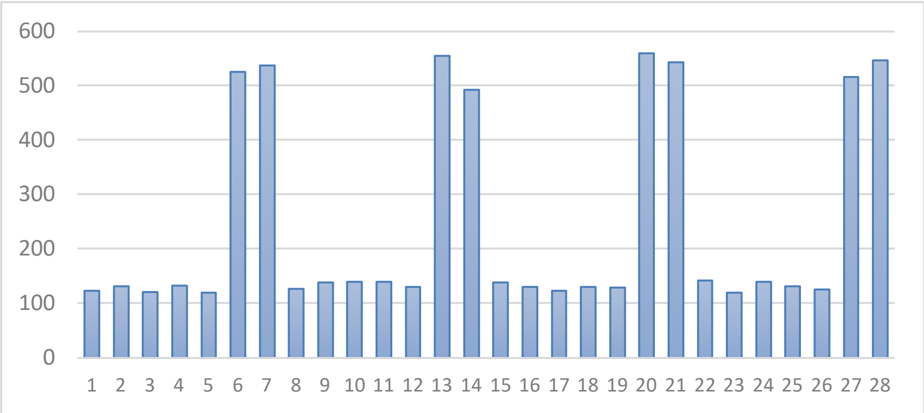

Figure 7 Demand with spikes

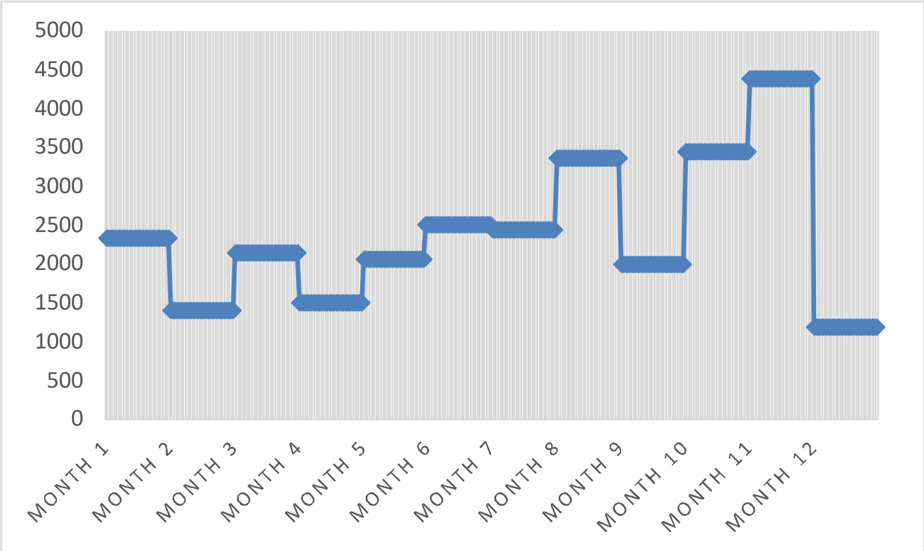

Figure 8 Seasonal demand

4.3.2 Results of simulation

Good flow management leads certainly to the minimum inventory cost and the best service level. That is why we generated key performance indicators (KPI) for service and inventory levels with ARENA SOFTWARE. We considered the same amount of annual demand in the three scenarios. The total amount of inventory cost represents working Capital during the simulated year, and the On-time Shipping rate is calculated by dividing the delivered on-time orders by the total number of orders. Table 8 summarises the findings for all the situations examined while using a deterministic lead time.

Table 8 ARENA Simulation Results

Scenario	Stable				Seasonal				Spikes			
Model	DRP		DDDRP		DRP		DDDRP		DRP		DDDRP	
KPI	WC (DH)	OTS	WC	OTS	WC	OTS	WC	OTS	WC	OTS	WC	OTS
RDC1	**5437.7**	**99.53%**	**1173**	**100%**	**7594**	**99.02%**	**1702**	**89.77%**	**5126**	**95.59%**	**2393**	**96.37%**
UDC1	**1637.54**		**1302**		**1483.46**		**1615**		**1895**		**3278**	
UDC2												
UDC3												
RDC2	**3324**	**98.25%**	**346**	**100%**	**3505**	**91.58%**	**1143**	**90.00%**	**3574**	**100.00%**	**1619**	**95.38%**
UDC4	**1389.72**		**551**		**1075.91**		**1125**		**954**		**1581**	
UDC5												
UDC6												
RDC3	**5375.2**	**100.00%**	**1064**	**100%**	**7897**	**92.28%**	**1612**	**97.69%**	**5276**	**99.30%**	**2919**	**97.03%**
UDC7	**2258.05**		**1319**		**808.18**		**1940**		**1556**		**2879**	
UDC8												
UDC9												
RDC4	**5329.2**	**100.00%**	**978**	**100%**	**5091**	**85.61%**	**2720**	**91.75%**	**5861**	**94.39%**	**3439**	**94.72%**
UDC10	**1963.59**		**1234**		**694.23**		**2486**		**1478.44**		**3323**	
UDC11												
UDC12												
RDC5	**4939.9**	**100.00%**	**882**	**100%**	**5416**	**99.30%**	**2006**	**97.36%**	**4321**	**100.00%**	**2296**	**99.01%**
UDC13	**2180.49**		**1153**		**1583.93**		**2015**		**1427.33**		**2681**	
UDC14												
UDC15												
Total KPI	**33835.39**	**99.56%**	**10002**	**100%**	**35148.71**	**93.56%**	**18364**	**93.31%**	**31468.77**	**97.86%**	**26408**	**96.50%**

The results in the table above are represented in the graphics in figure 9 and figure 10.

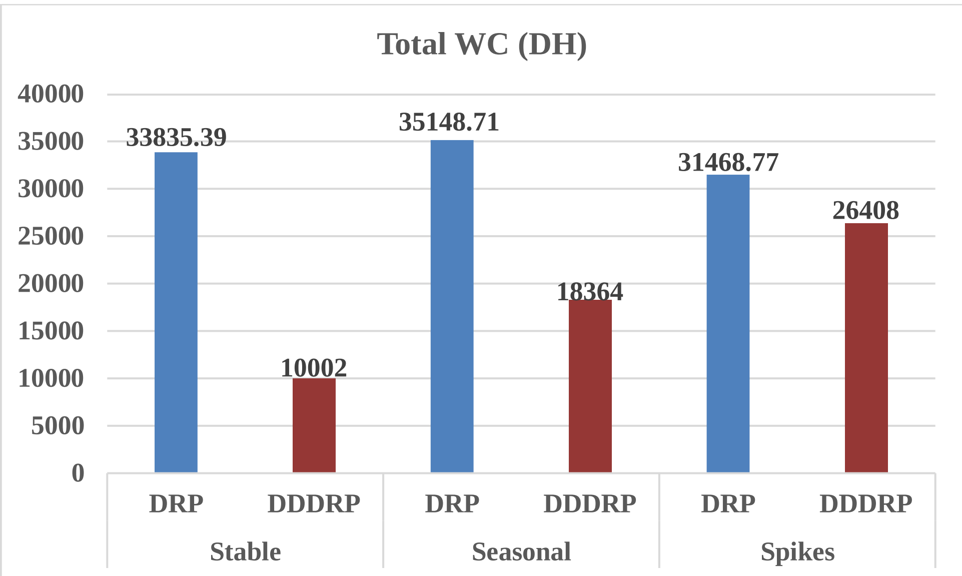

Figure 9 WC comparison between DRP and DDDRP models

Acta logistica - International Scientific Journal about Logistics
Volume: 9 2022 Issue: 2 Pages: 195-205 ISSN 1339-5629

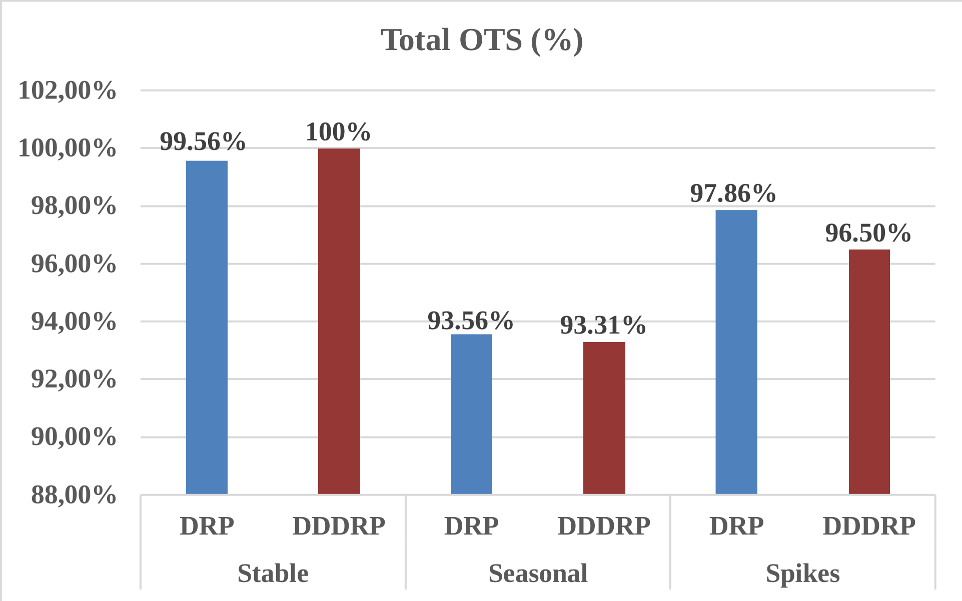

Figure 10 OTS comparison between DRP and DDDRP models

4.3.3 Interpretations and discussion

Table 8, figure 9, and figure 10 show the consumed inventory capital in each distribution unit and The OTS indicator that has been done for every three UDCs with their supplier RDC separately.

Both models present an ideal OTS for stable demand, but the significant difference is in the amount of stock required to ensure this rate. The DRP model's safety stock remains constant throughout the year. Aside from that, the DDDRP model's factors (LT factor = 0.5, variability factor = 0.2) represent the low degree of variability and the three-day of the LT. In terms of Working Capital, the end outcome demonstrates the advantage of demand-driven distribution.

On the other hand, the seasonal element has slightly altered the results. In fact, both models had a rise in inventory levels. It is valued at 4% for the DRP model and 83% for the DDDRP model. Concerning the DDDRP model, the LT factor remained unchanged, but the variability factor must be increased to accommodate demand fluctuations from month to month. As regards DRP, the safety stock policy remains unchanged, but the DDDRP buffer levels are adjusted monthly.

For the third scenario, inventory levels are reduced for DRP and augmented for DDDRP under the variable demand scenario (Spikes). These fluctuations are due to the imprecise estimation of LT and variability factors. The high level of precision used for forecasted demand also contributed to the stability of DRP inventory levels.

To summarise, the DDDRP model has the highest increasing amount of WC when demand shifts from stable to variable and seasonal. However, DDDRP outperforms DRP in terms of required WC to maintain an acceptable service rate in all circumstances.

5 Conclusion

The assessment of DDDRP model and the comparison of flow management policies in distribution networks are the main topics of this article. The purpose is to test how efficient these models are in terms of inventory and service levels under three different demand scenarios. A case study was used to compare the traditional DRP with the DDDRP technique. To accomplish so, a model based on real demand (Demand Driven DRP) was designed, with theoretical aspects described and procedures for implementation specified. Furthermore, for each model, a discrete event simulation revealed significant outcomes. In fact, demand driven DRP had high responsiveness to demand variability. Moreover, conventional DRP necessitates high forecasting accuracy. Finally, WC level in DDDRP is always higher than in DRP. The DDDRP model has demonstrated – at the first point – its benefits in this work. However, it can be challenging at certain levels of modelling.

In reality, the chosen LT and variability factors are critical, as they determine the Buffer levels and, consequently, the overall inventory level. So, works should be performed using heuristics to find the best factors choice in this situation. Otherwise, the study used a buffering approach which consists of putting a buffer in all the echelon's components (UDCs and RDCs). The optimal choice of strategic points for setting up buffers remains a challenge, especially for distribution networks with more than three levels.

As a perspective, the study of the process variability could consider a stochastic processing time in order to lead to more optimality in DDDRP policy.

References

[1] LEE, H.: Taming the Bullwhip, *Journal of Supply Chain Management*, Vol. 46, No. 1, pp. 7-7, 2010. https://doi.org/10.1111/j.1745-493x.2009.03180.x

[2] RAGHUNATHAN, S., TANG, C., YUE, X.: Analysis of the Bullwhip Effect in a Multiproduct Setting with Interdependent Demands, *Operations Research*, Vol. 65, No. 2, pp. 424-432, 2017. https://doi.org/10.1287/opre.2016.1571

[3] VICENTE, J., RELVAS, S., BARBOSA-PÓVOA, A.: Effective bullwhip metrics for multi-echelon distribution systems under order batching policies with cyclic demand, *International Journal of Production Research*, Vol. 56, No. 4, pp. 1593-1619, 2017. https://doi.org/10.1080/00207543.2017.1367105

[4] WANG, X., DISNEY, S.: The bullwhip effect: Progress, trends and directions, *European Journal of Operational Research*, Vol. 250, No. 3, pp. 691-701, 2016. https://doi.org/10.1016/j.ejor.2015.07.022

[5] WATSON, K., POLITO, T.: Comparison of DRP and TOC financial performance within a multi-product, multi-echelon physical distribution environment, *International Journal of Production Research*, Vol. 41, No. 4, pp. 741-765, 2003. https://doi.org/10.1080/0020754031000065511

[6] MARTIN, A.: *DRP*, New York: Wiley, 1995.

[7] JACA, C., SANTOS, J., ERRASTI, A., VILES, E.: Lean thinking with improvement teams in retail distribution: a case study, *Total Quality Management & Business Excellence*, Vol. 23, No. 3-4, pp. 449-465, 2012. https://doi.org/10.1080/14783363.2011.593907

[8] IKEZIRI, L., SOUZA, F., GUPTA, M., DE CAMARGO FIORINI, P.: Theory of constraints: review and bibliometric analysis, *International Journal of Production Research*, Vol. 57, No. 15-16, pp. 5068-5102, 2018. https://doi.org/10.1080/00207543.2018.1518602

[9] ŠUKALOVÁ, V., CENIGA, P.: Application of the Theory of Constraints Instrument in the Enterprise Distribution System, *Procedia Economics and Finance*, Vol. 23, pp. 134-139, 2015. https://doi.org/10.1016/s2212-5671(15)00445-1

[10] MICLO, R., FONTANILI, F., LAURAS, M., LAMOTHE, J., MILIAN, B.: An empirical comparison of MRPII and Demand-Driven MRP, *IFAC-PapersOnLine*, Vol. 49, No. 12, pp. 1725-1730, 2016. https://doi.org/10.1016/j.ifacol.2016.07.831

[11] MIRANDA, P., GARRIDO, R.: Inventory service-level optimisation within distribution network design problem, *International Journal of Production Economics*, Vol. 122, No. 1, pp. 276-285, 2009. https://doi.org/10.1016/j.ijpe.2009.06.010

[12] HANDAYANI, N., NADYA, Y., MAULANA, D.: Implementation of the Distribution Requirement Planning Method in Optimising the Distribution of Packaged Drinking Water Products, *PROZIMA (Productivity, Optimization and Manufacturing System Engineering)*, Vol. 5, No. 2, pp. 13-23, 2022.

[13] NGATILAH, Y., RAHMAWATI, N., PUJIASTUTI, C., PORWATI, I., HUTAGALUNG, A.: Inventory Control System Using Distribution Requirement Planning (DRP) (Case Study: Food Company), *Journal of Physics: Conference Series*, Vol. 1569, No. 3, pp. 1-5, 2020. https://doi.org/10.1088/1742-6596/1569/3/032005

[14] PRAMONO, S.N., ULKHAQ, M.M., NAUFAL, M.: An application of distribution requirements planning in inventory management: a case study, *Asian Journal of Advances in Research*, Vol. 11, No. 4, pp. 283-290, 2021.

[15] MAGDALENA, R., SULI, T.: Forecasting Methods and Implementation of DRP (Distribution Requirement Planning) Methods in Determining the Master Production Schedule, *IOP Conference Series: Materials Science and Engineering*, Vol. 528, No. 1, pp. 1-10, 2019. https://doi.org/10.1088/1757-899x/528/1/012049

[16] WAHYUNINGSIH, D., PRADANA, H.A., HAMIDAH: *Prediction of The Needs of Industrial Oil Fuels with The Implementation of Distribution Requirement Planning (DRP)*, 2018 3rd International Conference on Information Technology, Information System and Electrical Engineering (ICITISEE), 2018. https://doi.org/10.1109/icitisee.2018.8721002

[17] DANESE, P., MANFÈ, V., ROMANO, P.: A Systematic Literature Review on Recent Lean Research: State-of-the-art and Future Directions, *International Journal of Management Reviews*, Vol. 20, No. 2, pp. 579-605, 2017. https://doi.org/10.1111/ijmr.12156

[18] REICHHART, A., HOLWEG, M.: Lean distribution: concepts, contributions, conflicts, *International Journal of Production Research*, Vol. 45, No. 16, pp. 3699-3722, 2007. https://doi.org/10.1080/00207540701223576

[19] LUKIĆ, R.: The effects of application kaizen concept in food retail, *Ekonomski pogledi*, Vol. 15, No. 2, pp. 19-34, 2013. https://doi.org/10.5937/ekopog1302019l

[20] ANDELKOVIĆ, A., RADOSAVLJEVIĆ, M., STOŠIĆ, D.: Effects of Lean Tools in Achieving Lean Warehousing, *Economic Themes*, Vol. 54, No. 4, pp. 517-534, 2016. https://doi.org/10.1515/ethemes-2016-0026

[21] CYPLIK, P., DOMAŃSKI, R.: Implementation of the theory of constraints in the area of stock management within the supply chain-a case study, *LogForum*, Vol. 5, No. 3, pp. 1-12, 2009. http://www.logforum.net/vol5/issue3/no6

[22] ZHENG, K., TSAI, C, LI, R., CHEN, C., TSAI, S.: The Development of the Distribution/VMI Game Based on Theory of Constraints, *Asian Journal on

Quality, Vol. 10, No. 1, pp. 53-76, 2009. https://doi.org/10.1108/15982680980000627

[23] RADOVILSKY, Z.: A quantitative approach to estimate the size of the time buffer in the theory of constraints, *International Journal of Production Economics*, Vol. 55, No. 2, pp. 113-119, 1998. https://doi.org/10.1016/s0925-5273(97)00131-x

[24] AL AMIN, M., RAHMAN, A., SHAHRIA, A.: Application of Theory of Constraints in Supply Chain Management, *Journal of Engineering*, Vol. 10, No. 1, pp. 67-76, 2019.

[25] LEWANDOWSKA-CISZEK, A.: Theory of Constraints as a stimulus towards warehouse transformation process on the example of the Distribution Center, *Management and Production Engineering Review*, Vol. 9, No. 4, pp. 96-105, 2018. https://doi.org/10.24425/119550

[26] PTAK, C., SMITH, C., ORLICKY, J.: *Orlicky's material requirements planning*, New York, McGraw-Hill, 2013.

Review process

Single-blind peer review process.