DEVELOPMENT OF OUTBOUND VOLUME FORECAST MODEL

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ABSTRACT

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The commissioner of this thesis is Metso Minerals Oy. One of company's biggest distribution centers is a 3PL warehouse located in the Netherlands. The objective of the research was to create a forecasting model for outbound volumes as currently warehouse strictly relies on data from corresponding period of previous year. Unexpected fluctuations of volumes cause challenges with distributing human resources. Better forecasting and resourcing could increase warehouse's reliability and performance which has also a positive impact on customer satisfaction.

Research methods were mostly quantitative as these were based on statistical data and numerical calculations. In addition to that, analysis was prepared by using judgmental techniques, knowledge of SAP software and business-related facts which had an influence on forecasting.

Forecasting was tested by using several techniques using commonly in business analytics. Moreover, an additional model was developed using available SAP transactions. Testing and statistical data analysis have resulted in creating forecasting dashboard including most suitable methods and elements vital for forecasting and strategy making.

The recommendations included factors which need to be considered for better forecasting and possible scenarios. Additionally, there is a list of practices on how to distribute the volumes more evenly. Improvement suggestions were presented to the management of Distribution Center Europe in Tampere, Finland.

Key words: forecast model, outbound volumes, forecasting

CONTENTS

ABBREVIATIONS

3PL	3rd Party Logistics
AR	Autoregressive Model
DC	Distribution Center
DCE	Distribution Center Europe
ERP	Enterprise Resource Planning
ICPO	Intercompany Purchase Order
ICSO	Intercompany Sales Order
MAD	Mean Absolute Deviation
RPA	Robotic Process Automation
SAP	Enterprise Resource Planning System
SC	Supply Chain
SCM	Supply Chain Management
SL	Service Level
SSO	Sales Support Organization
VL10H	SAP transaction
WMA	Weighted Moving Average and
YWM_OUTB_DEL _MONITOR	SAP transaction

1 INTRODUCTION

The commissioner of this thesis is Metso Minerals Oy, Distribution Center. Metso Minerals (furtherly called Metso) is a Finnish company with over hundred years of tradition in mining and aggregates business. Company Distribution Centers (DC) and Sales Support Organisations (SSO) are located all around the world creating a tight network of supply chains (SC), providing wear and spare parts for the stone crushers. The subject of this this research, Distribution Center Europe (DCE) is a 3PL warehouse, located in the Netherlands.

DCs are playing an important role in supply chain as goods are just one step ahead from the customer, therefore, good warehouse operation planning is vital to have an efficient work flow (Grosse, Glock, Neumann, 2017). Warehouses functions have evolved and are now facilitators of competitive tools like high-quality customer service. According to "Design and control of warehouse order picking: A literature review" by de Koster, Le-Duc and Roodbergen (2007, 481), order picking in outbound section has been identified "as the most labour-intensive and costly activity for almost every warehouse; the cost of order picking is estimated to be as much as 55% of the total warehouse operating expense". High percentage emphasizes the importance of picking as crucial warehouse operation.

Warehouse is dealing with picking in half-automatic way. ERP system is used to create the single workflows, however picking is performed manually by labour force. By forecasting upcoming workloads, the number of workers could be optimized and allocated to the correct department. Forecasting would allow to use the labour in correct time and place saving some costs.

In addition to financial impact, underperformance like delays or poor picking quality "lead to unsatisfactory service and high operational cost for the warehouse, and consequently for the whole supply chain" de Koster et. al say. Even though the DCE is an 3PL warehouse, Metso wants to contribute in outbound volume forecast planning to assure good partnership and high customer satisfaction as part of Metso values.

1.1 Thesis background

Forecasting is important for the companies as it determines many aspects of business activities. Company’s operations, starting from acquiring raw materials and ending on delivering goods to the end-customers, take a lot of time. Companies race for better lead times and loyal customers, therefore they cannot wait anymore for demand to occur, but they want to learn how to prevent future needs and be able to react to them quickly.

According to Defraeye and Van Nieuwenhuyse in their “Staffing and scheduling under nonstationary demand for service: A literature review"” (2016), forecasting workload and scheduling human resources are some of key actions assuring cost and service quality. Currently, the workload forecasting has been done by the warehouse itself based on the statistical data from the previous years. The forecasting has been prepared by reading the data from the previous year based on historical information from SAP. Forecasting did not take into consideration seasonal changes or external factors. The results on a monthly and weekly level were quite satisfying, however, the biggest challenge is to forecast the upcoming workload on a daily level.

1.2 Research objectives

The main objective of this research is to develop new model of outbound line forecast for 3PL partner working as Metso’s DC. Outsourced warehouse does not have access to Metso’s internal business and market related data which they could use for forecasting, therefore Metso’s input is significant to improve both parties’ profitability.

In order to build the forecasting model, it is necessary to find what elements should be taken into consideration which could support the forecasting process. Research has to define current trends and patterns of the volumes to be used in forecasting. Moreover, it also has to define what factors are affecting the volumes.

Currently, the warehouse is strictly relying on numbers corresponding to the same week and day of the previous year, despite the changing factors. By receiving forecast, the warehouse can exploit this data by arranging resources in more efficient way. This can lower the operating costs and improve on-time delivery.

1.3 Research methods

The research will have strongly quantitative nature as it will require big data retrieving and analysis. In addition to that, some qualitative methods will be used, mostly management judgment. In this type of method, company's own employees create the forecasting as they have experience in this field of expertise and know company's business, market and customers which may have an influence on volume changes.

The first phase of research will cover the analysis of statistical data and characteristics of volume from different angles. Data has been divided into two research periods of the same time frames of the following three years.

Secondly, there is a need of investigation what tools and data new model would need to increase forecasting's accuracy and reliability. Therefore, several forecasting methods will be selected and tested.

Management judgment methods will be used based on work experience and tacit knowledge from different teams within Metso. Moreover, exploratory experiment will be tried in order to develop new model based on utilization of available SAP reports.

2 THEORETICAL FRAMEWORK

2.1 Forecasting

According to Ghiani, Laporte and Musmanno, in their ”Introduction to logistics systems management.” (2013, 44), forecasting is “is an attempt to determine in advance the most likely outcome of an uncertain variable”. Because of the time lag in business activities of the supply chain, the predictions are needed to plan and control day to day logistics processes like picking, packing and shipping.

There is a variety of forecasting methods, but none of them can predict the future perfectly, therefore, forecasting is based on hypotheses. As Ghiani et al. says, to be able to use prediction methods, historical data must show some regularity.

Forecasting can be divided into long-term, medium-term and short-term. In this research medium- and short-term forecasting is going to be presented, as long-term predictions cover the period of one, up to five years.

2.2 Importance and challenges of forecasting

The marketplace of the global corporations like Metso, consists of many elements which have great susceptibility to change and evolve. There are dozens of Metso’s locations and warehouses which are simultaneously ordering the parts from DCE Europe as well as shipping the goods to it. It is challenging to maintain and synchronize the work load it is affecting, however, the existing software and historical data do give a possibility to have an overview on the entire process.

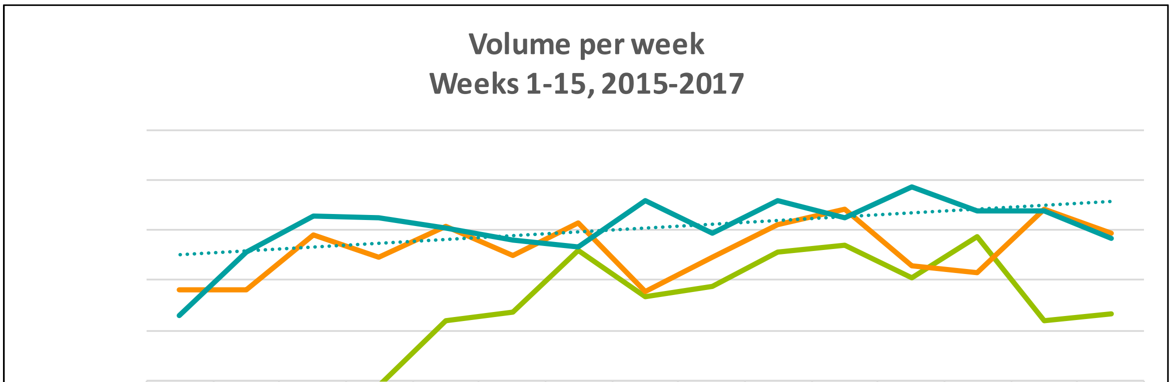
According to Chase (2013,3) “improvements in demand forecasting accuracy have been a key ingredient in allowing companies to gain exponential performance in supply chain efficiencies”. DCE is one of the biggest warehouses, therefore, its own efficiency and reliability has a vast impact on the rest of the supply chain, including its customers.

3 HISTORICAL DATA ANLYSIS

The historical data has been divided in two periods of 15 weeks. The analysis includes fluctuation analysis and daily distribution of volumes. Moreover, the research investigates the ordering pattern of three most ordering parties and potential influence of bank holidays considering working days and SAP limitations.

3.1 Volume of weeks 1-15

Metso has moved to the new warehouse at the beginning of the year 2015. Full dispatch capacity was reached on week 7, therefore weeks 1 to 6 of year 2015 should not be taken under consideration in this analysis. In comparison to volumes of next year 2016 in Figure 1, there has been a quite significant growth. In week 14, the volume doubled and in week 15 it was still high.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2015		116	400	1449	2092	2179	2804	2345	2445	2781	2849	2532	2932	2099	2162
2016	2411	2400	2948	2727	3036	2744	3064	2394	2730	3055	3208	2645	2573	3217	2969
2017	2148	2774	3139	3131	3025	2896	2832	3301	2978	3302	3116	3432	3198	3190	2918

FIGURE 1. Outbound volume per week. Weeks 1-15, 2015-2017

Volumes per week of years 2016 and 2017 shows that there has been an increase of 8%. There has been only two weeks when the volume was lower: week 1, generally considered as week lower in volume because of after-Christmas season. Second case happened in week 7, with a drop of 8% in volumes which was followed by dramatic increase of 38%.

Based on Table 1, a growth from one year to another is clearly noticeable. The economic situation on the market is improving and more sales is being generated. The trendline of year 2016 was continuously increasing.

TABLE 1. Volume change between years 2015-2016 and 2016-217. Weeks 1-15.

Week	2015	2016	Difference
1	-	2411	-
2	116	2400	-
3	400	2948	-
4	1449	2727	-
5	2092	3036	-
6	2179	2744	-
7	2804	3064	9 %
8	2345	2394	2 %
9	2445	2730	12 %
10	2781	3055	10 %
11	2849	3208	13 %
12	2532	2645	4 %
13	2932	2573	-12 %
14	2099	3217	53 %
15	2162	2969	37 %
SUM	22949	25855	13 %

Week	2016	2017	Difference
1	2411	2148	-11 %
2	2400	2774	16 %
3	2948	3139	6 %
4	2727	3131	15 %
5	3036	3025	0 %
6	2744	2896	6 %
7	3064	2833	-8 %
8	2394	3301	38 %
9	2730	2978	9 %
10	3055	3302	8 %
11	3208	3116	-3 %
12	2645	3432	30 %
13	2573	3198	24 %
14	3217	3190	-1 %
15	2969	2918	-2 %
SUM	42121	45381	8 %

The market changes should be taken into consideration in forecasting the next year's figures. In case of year 2017 compared to year 2016, the 8% volume increase meant on average 217 lines. The data from the previous years is providing good guidelines, nevertheless it is important to keep in mind market changes and respond to them.

3.2 Volume of weeks 16-30

When comparing weeks 16 to 30 in Figure 2, it is possible to notice that there is much more volume variety between the weeks, especially in year 2017. Some weeks are almost overlapping with data from 2016 and some differ by 20-30%. Similarly to weeks 1-15, there is 7-8% incline in trend.

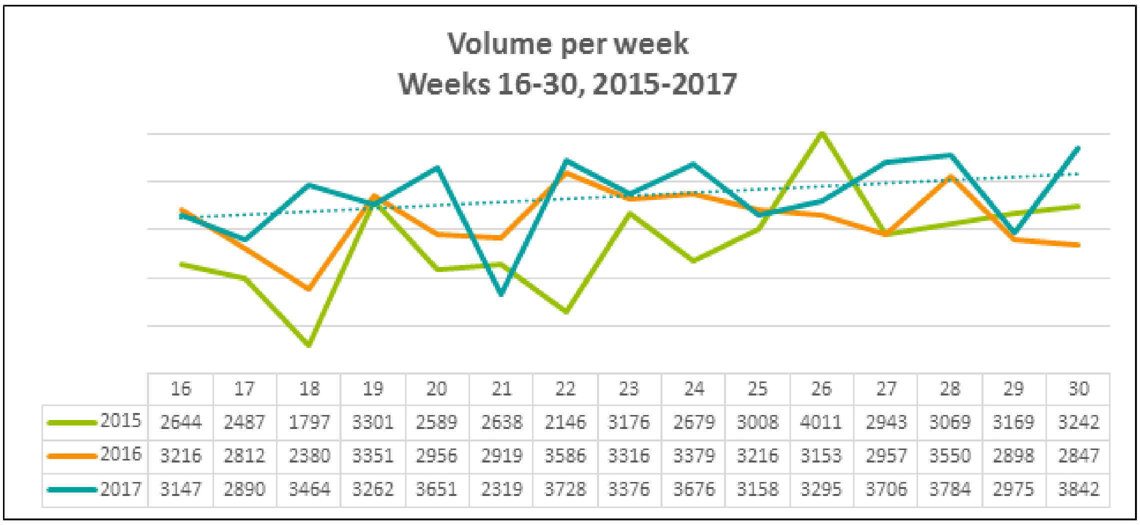


FIGURE 2. Outbound volume per week. Weeks 16-30, 2015-2017

July (weeks 27-30, Figure 2) is considered to be a peak of summer holidays in Europe and generally more quite time. In 2015 and 2016, the average amount of lines in weeks 27-30 was between 3063 and 3105 lines, while in 2017 it reached number of 3576.

The comparison of volumes of weeks 16-30 also indicates rather high increase.

TABLE 2. Volume change between years 2015 and 2016 and 2016 and 2017. Weeks 16-30.

Week	2015	2016	Difference
16	2644	3216	22 %
17	2487	2812	13 %
18	1798	2380	32 %
19	3301	3351	2 %
20	2589	2956	14 %
21	2638	2919	11 %
22	2146	3586	67 %
23	3176	3316	4 %
24	2679	3379	26 %
25	3008	3216	7 %
26	4011	3153	-21 %
27	2943	2957	0 %
28	3069	3550	16 %
29	3169	2898	-9 %
30	3242	2847	-12 %
SUM	**42900**	**46536**	**8 %**

Week	2016	2017	Difference
16	3216	3147	-2 %
17	2812	2890	3 %
18	2380	3465	31 %
19	3351	3262	-3 %
20	2956	3651	19 %
21	2919	2319	-26 %
22	3586	3728	4 %
23	3316	3376	2 %
24	3379	3676	8 %
25	3216	3158	-2 %
26	3153	3295	4 %
27	2957	3706	20 %
28	3550	3784	6 %
29	2898	2975	3 %
30	2847	3842	26 %
SUM	**46536**	**50274**	**7 %**

3.3 Volume on daily level

One of the main challenges in planning warehouse resources is uneven distribution of daily volumes. Figure 3 shows that in weeks 1-15, Mondays and Fridays have the lowest volumes of the week, while Tuesday and Thursday are busier. Wednesday's volumes reach volumes of around 20% of total.

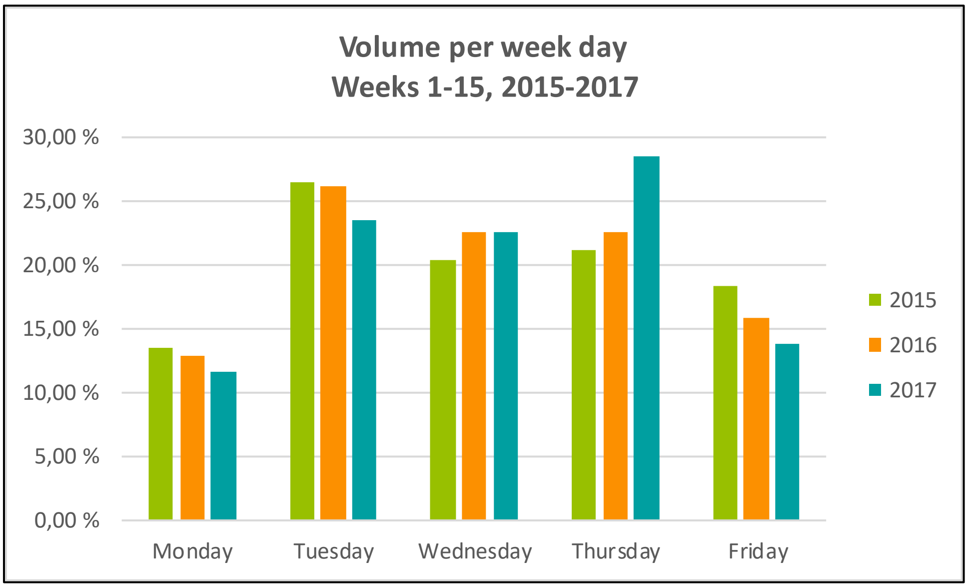


FIGURE 3. Outbound volume per week day. Weeks 1-15, 2015-2017

In weeks 16-30, Figure 4 shows quite even volumes between Tuesday and Wednesday. In 2017, Thursday volumes reached almost 30% of weekly volumes. Monday and Friday were again significantly calmer days.

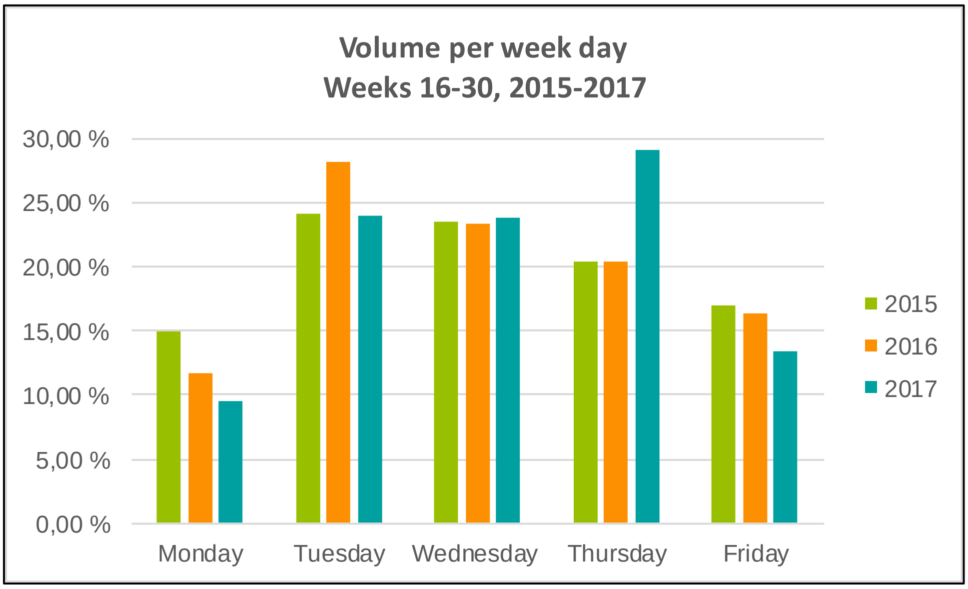
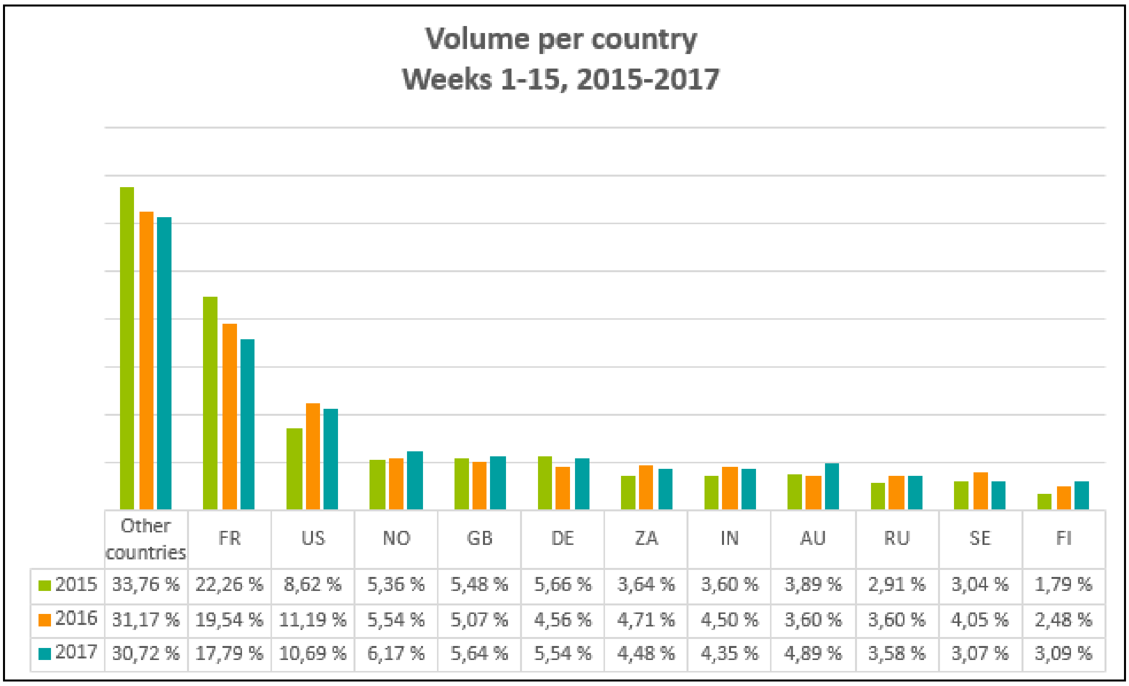


FIGURE 4. Outbound volume per week day. Weeks 16-30, 2015-2017

There are two reasons for imbalance in volume distribution on a daily level. The first one is the routes, which are schedule flows according to which warehouse picks, packs and ships the goods. Thursday is a closing day for packing ocean shipments, which are usually much larger, replenishment orders to other Metso locations. In addition to that, Tuesday and Thursday are also closing days for air consolidation shipments. Customers prefer shipping the orders outside Europe by air consolidation as it is less expensive then shipping it on daily basis. Adjusting routes for different days may help in better workload management.

3.4 Volume per country

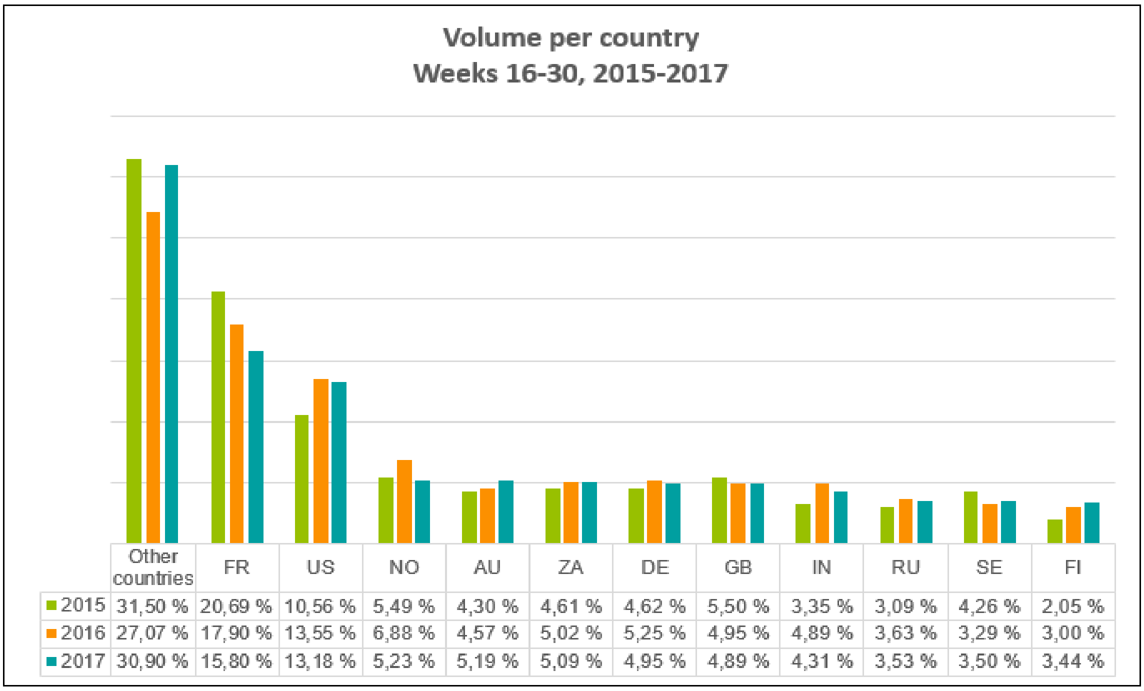
The following chapter focuses on analysing ordering countries which have the biggest share of volumes. Defying characteristics of ordering partners is essential in finding factors influencing volume fluctuations.



	Other countries	FR	US	NO	GB	DE	ZA	IN	AU	RU	SE	FI
2015	33,76 %	22,26 %	8,62 %	5,36 %	5,48 %	5,66 %	3,64 %	3,60 %	3,89 %	2,91 %	3,04 %	1,79 %
2016	31,17 %	19,54 %	11,19 %	5,54 %	5,07 %	4,56 %	4,71 %	4,50 %	3,60 %	3,60 %	4,05 %	2,48 %
2017	30,72 %	17,79 %	10,69 %	6,17 %	5,64 %	5,54 %	4,48 %	4,35 %	4,89 %	3,58 %	3,07 %	3,09 %

FIGURE 5. Outbound volume per country. Weeks 1-15, 2015-2017

Both, Figure 5 and 6 show that France and United States are the countries which place the biggest amounts of orders to DCE. Orders from France are divided between orders of Metso France and its production. Other orders from this area come from number of distributors which are mostly small enterprises.



	Other countries	FR	US	NO	AU	ZA	DE	GB	IN	RU	SE	FI
2015	31,50 %	20,69 %	10,56 %	5,49 %	4,30 %	4,61 %	4,62 %	5,50 %	3,35 %	3,09 %	4,26 %	2,05 %
2016	27,07 %	17,90 %	13,55 %	6,88 %	4,57 %	5,02 %	5,25 %	4,95 %	4,89 %	3,63 %	3,29 %	3,00 %
2017	30,90 %	15,80 %	13,18 %	5,23 %	5,19 %	5,09 %	4,95 %	4,89 %	4,31 %	3,53 %	3,50 %	3,44 %

FIGURE 6. Outbound volume per country. Weeks 16-30, 2015-2017

Another major customer is the United States. In 2017 its share has increased by 2,07% in comparison to year 2015 (Figure 5). Additional three countries, that is Norway, Great Britain and Germany have been also ordering more from DCE’s warehouse comparing to previous years and share of each one has exceeded 5% in 2017.

During the period of three years, France's volume in weeks 1-15 as well as in weeks 16-30 have been steadily decreasing by total 4,68%. On contrary, United States' volume has increased in the same period by 2,35%

The outbound volumes of other countries remained on relatively same level, except for Australia which volumes increased in weeks 1-15 by exactly one percent. Comparing weeks 16-30, Australia has been rated as fourth most order party with result of 5,19%.
In comparison of weeks 16-30, the division between France, United States and France is more even. Right after, Norway, Australia and South Africa have been the most active countries and each have exceeded 5% of volumes within this time frame.

3.5 Impact of national holidays on outbound volumes

Based on statistical data, it is necessary to analyse in detail most active ordering parties by country to find possible trends and patterns in volume changes. Further analysis takes into consideration volumes of top three countries ordering roughly over 5% to 22% of weekly outbound volumes.

The bank holiday calendar was compiled manually from multiple resources like www.timeanddate.com and they were validated with governmental sites as in many cases it has appeared that the holiday was a trading day. Similarly, to findings in work "Developing a Volume Forecasting Model" (Batrinca, Hesse and Treleaven, 2017, 11), the statistical data has shown that some countries tend to substitute the holidays that fall on a weekend with previous or following workday creating long weekends. Another example can be observed when a holiday falls on a Tuesday or Thursday, some countries or companies may give their employees an additional day off resulting in four-day weekend. Creating detailed holiday calendar will be vital for further forecasting.

Intercompany orders have a feature which prevents the order from being released in cases when either dispatch day or arrival day is a national holiday. This may cause a cumulation of backlog order lines and imbalance in their release time frame. Therefore, the analysis should also take into consideration public holidays in Netherlands, listed below in Table 3.

TABLE 3. Holidays in the Netherlands, years 2015-2017
*Warehouse is not closed but has very limited operations

Holiday in the Nethelands	2015 (week)	2016 (week)	2017 (week)
New Year's Day	1st January (1)	1st January (53)	1st January (52)
Good Friday*	3rd April (14)	25th March (12)	14th April (15)
Easter Monday	6th April (15)	28th March (13)	17th April (16)
King's Birthday	27th April (18)	27th April (17)	27th April (17)
Liberation Day	5th May (19)	Next in 2020	Next in 2020
Ascension Day	14th May (20)	5th May (18)	25th May (21)
Whit Monday	25th May (22)	16th May (20)	5th June (23)
Christmas Day	25th December (52)	25th December (51)	25th December (52)

Bank holidays affecting warehouse's operations are marked in Table 4 in blue.

TABLE 4. Amount of bank holidays per week among most ordering countries and warehouse. Weeks 1-15, 2015-207

Amount of bank holidays per week among most ordering countries and warehouse Weeks 1-15, 2015-2017																
		Week														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Year	2015	2	2	0	4	2	0	0	1	1	0	0	0	0	2	1
	2016	1	0	1	1	0	5	1	0	1	0	0	3	1	0	1
	2017	2	0	1	2	4	1	0	1	0	1	0	1	0	2	2

During analysis of weeks 1-15 (Table 3 and 4, Figure 1), it is possible to notice some dependence during Easter period held accordingly in weeks 14/15 (2015), 12/13 (2016) and 15/16 (2017). Easter is holiday held in many different countries including the Netherlands. In years 2015 and 2016 we see a peak in preceding weeks and drop in Easter week accordingly by 28% and by 18% as more than a few countries are keeping holidays, including the warehouse in Netherlands. However, in year 2017 the peak was not visible anymore. Instead, the volumes were steadily high through six weeks. It may be caused by the fact that also in week 14 there were another two free days.

Another assumption may be impact of the quarters. Plenty of companies want to finalize projects and sales by the certain quarters. The goods must arrive to the end-customer before they can be invoiced. Therefore, the orders are being placed several weeks in advance which inclines

Quarter in year 2015 ended in the middle of week 14, just couple of days before Easter. The volume peaked week before. In year 2016, quarter ended in week 13 and was preceded by two other bank holidays in week 12 (South Africa and Norway), therefore the volume raised already in week 10 and 11. In year 2017, quarter also ended in week 13 and the peak happened a week earlier.

TABLE 5. Amount of bank holidays per week among most ordering countries and warehouse. Weeks 16-30, 2015-207

Amount of bank holidays per week among most ordering countries and warehouse Weeks 16-30, 2015-2017																
		Week														
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Year	2015	0	0	2	3	1	0	1	1	0	1	0	1	0	1	0
	2016	0	2	3	0	2	0	1	1	1	0	0	1	1	0	0
	2017	1	2	1	0	1	1	2	3	1	0	0	1	1	0	0

Week 16-30 (Table 3 and 5, Figure 2), show much more variety in volumes than during first 15 weeks of the year. The reason is several bank holidays in the Netherlands happening merely week by week (marked in blue). These are mostly Christian holidays which influence many more countries. In numerous weeks there is more than one free day per week happening in few countries simultaneously. Another observing is the fact, that despite the volumes growing year by year, there are several weeks with almost overlapping numbers. These are weeks 19, 23, 25 and 29.

Volumes in week 18 in years 2015 and 2016 dropped after week 17 accordingly by 28% (2015) and 15% (2016) and increased drastically in week 19 by almost 84% and 41%. In year 2017, there were three following weeks with warehouse closed at least one day per week. These kept the volumes at about 3000 until the first full work weeks 18, 19 and 20 when volumes by 19%-26% comparing to week 17.

Considering quarters, in year 2015 the second quarter ended in middle of week 27 lifting the volumes to record high 4011 lines increasing it and then dropping by one thousand line which is even more than average per one day. In year 2016 and 2017 change of quarters, which happened in week 26 was rather stable, just minor increase of 6-12% in week before. End of quarter two happens during holiday season so the difference may not be that visible in this case. Therefore, it was considered necessary to analyse several countries which have been ordering the most during several years.

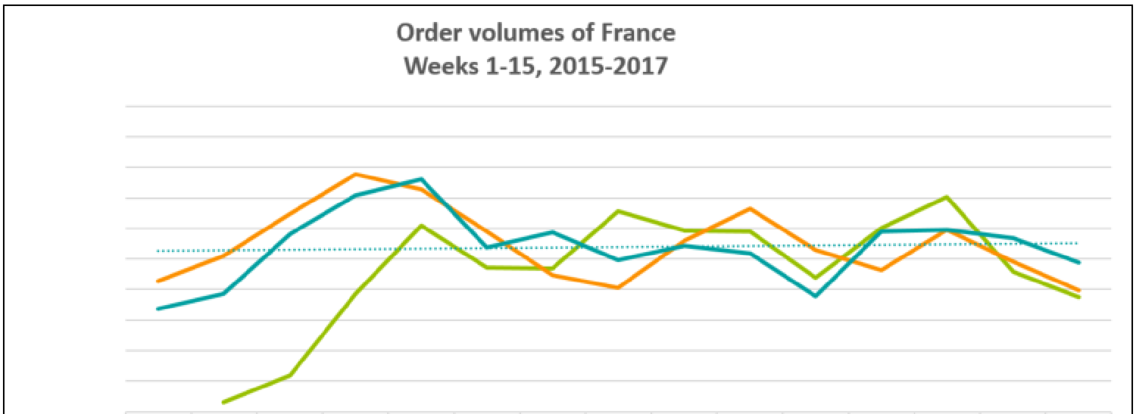
3.5.1 France

France is the most ordering country among Metso partners. The orders come from two different Metso locations positioned in France as well as some distributors. There are quite many holidays in France, listed below (Table 6).

TABLE 6. Holidays in France, years 2015-2017

Holiday in France	2015 (week)	2016 (week)	2017 (week)
New Year's Day	1st January (1)	1st January (53)	1st January (52)
Good Friday	3rd April (14)	25th March (12)	14th April (15)
Easter Monday	6th April (15)	28th March (13)	17th April (16)
May Day	1st May (18)	1st May (17)	1st May (18)
V-E Day	8th May (19)	8th May (18)	8th May (19)
Ascension Day	14th May (20)	5th May (18)	25th May (21)
Whit Monday	25th May (22)	16th May (20)	5th June (23)
Bastille Day	14th July (29)	14th July (28)	14th July (28)
Assumption Day	15th August (33)	15th August (33)	15th August (33)
All Saints Day	1st November (44)	1st November (44)	1st November (44)
Armistice Day	11th November (46)	11th November (45)	11th November (45)
Christmas Day	25th December (52)	25th December (51)	25th December (52)

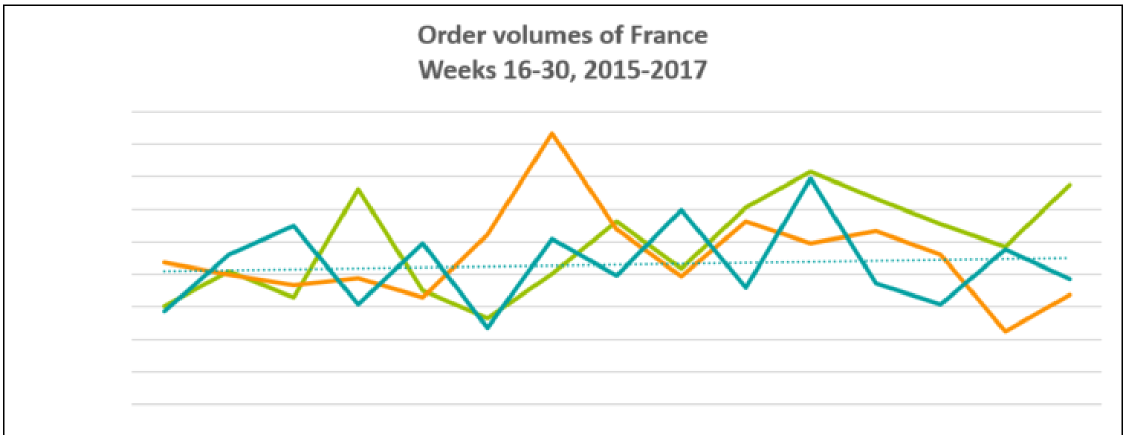
In Figure 7 there is a historical data on France's volumes. Ordering pattern in weeks 1-15 is very similar year by year.



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2015		31	118	386	610	471	470	655	592	590	438	600	704	458	374
2016	428	510	647	777	727	590	448	406	559	666	529	462	595	490	397
2017	336	385	582	709	762	537	587	496	543	519	377	590	595	567	488

FIGURE 7. Order volumes of France. Weeks 1-15, 2015-2017

The trendline for 2017 is going up steadily. Between year 2016 and 2017, the biggest deviation between order lines can be noticed around Easter time. Easter causes a peak and then a drop in volumes by 30-40%. There is also some incline just before quarter change in week 13.



	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2015	403	511	430	763	450	365	503	664	517	706	815	732	656	584	776
2016	537	500	468	489	429	624	935	639	493	664	596	633	561	326	437
2017	386	562	650	409	597	336	608	496	697	460	794	473	409	578	487

FIGURE 8. Order volumes of France. Weeks 16-30, 2015-2017

Figure 8 shows that the second period of research is less predictable. France does not have ICPO orders in use so they mostly use manual PO for order replenishments and ICSOs that are delivered directly to the end-customers. Orders are not disabled by SAP limitations, but are depended on manual process time and warehouse's holidays. Nevertheless, bank holiday, the Bastille Day seems to decrease the amount of order lines as are also holiday weeks starting usually in second half of July, from week 28.

3.5.2 The United States

The USA is second most ordering party. Most of their orders are ocean shipment and these are stock replenishment orders. DCE is one of the biggest suppliers for Metso USA. Bank holidays calendar of the USA (Table 7) differs a lot from holidays in Europe.

TABLE 7. Holidays in the United States, years 2015-2017

Holiday in USA	2015 (week)	2016 (week)	2017 (week)
New Year's Day	1st January (1)	1st January (53)	1st January (52)
President's Day	16th February (8)	15th February (7)	20th February (8)
Memorial Day	25th May (22)	30th May (22)	29th May (22)
Independence Day	3rd July (27)	4th July (27)	4th July (27)
Labor Day	7th September (37)	5th September (36)	4th September (36)
Columbus Day	12th October (42)	10th October (41)	9th October (41)
Veterans Day	11th November (46)	11th November (45)	11th November (45)
Thanksgiving	26th November (48)	24th November (47)	23th November (47)
Day after Thanksgiving	27th November (48)	25th November (47)	24th November (47)
Christmas Day	25th December (52)	26th December (52)	25th December (52)

This customer is also affected by holidays of the Netherlands as majority of their orders are ICPOs. In addition to that, this customer's ICPOs are fully automated and automatically shifted to the following week if packing deadline date is a bank holiday in either shipping or receiving location. However, the schedules have been changing several times during last three years and we do not have a historical data which days they were.

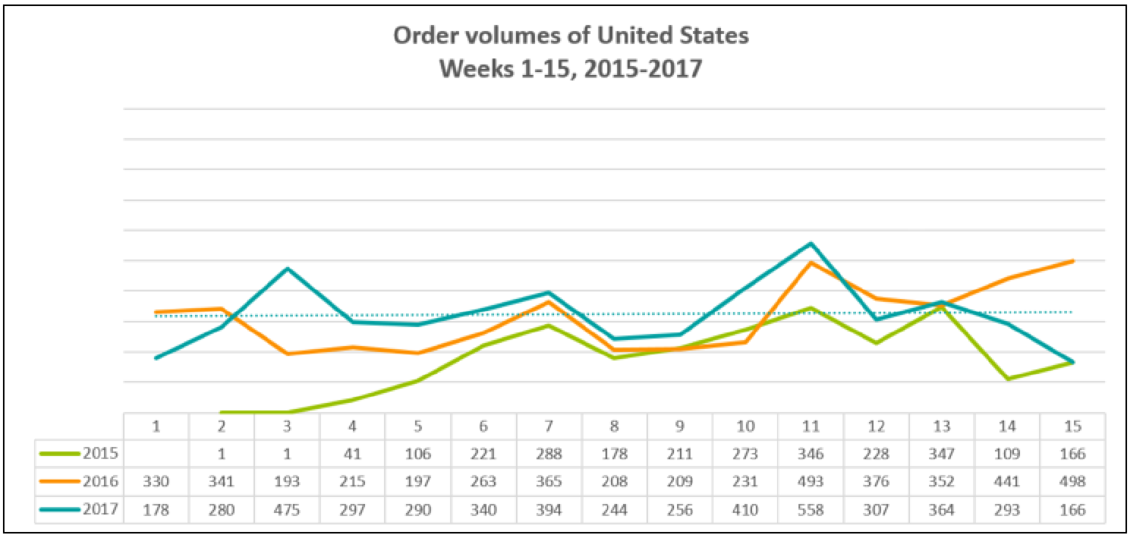
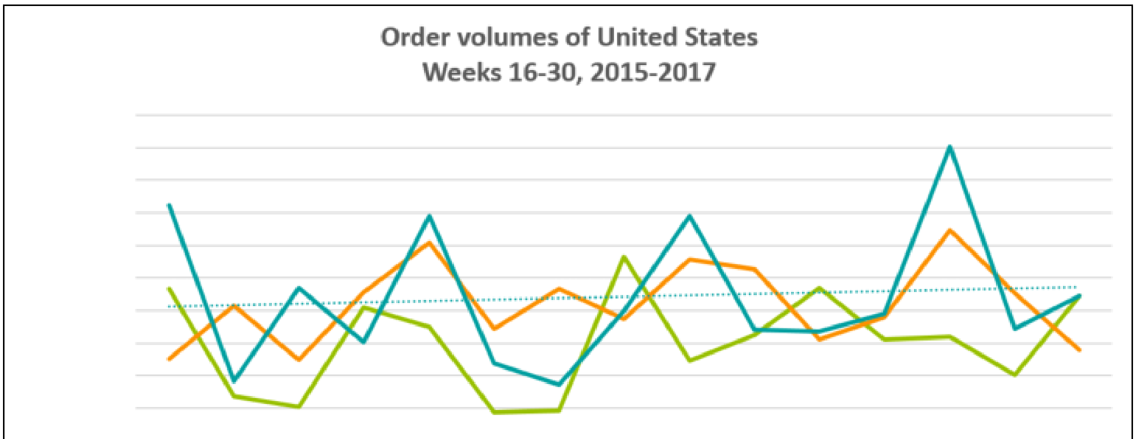


FIGURE 9. Order volumes of United States. Weeks 1-15, 2015-2017

Figure 9 shows that there is a repeating pattern in most of the weeks 1-15. In the edge of 2015 and 2016 holidays occurred on weekends which did not affect the shipping schedule. In year 2017, the SAP schedule limitations must have cumulated the order lines, inclining in week 3. Increase in week 11 is most likely caused by quarter change. Lead time to United States is much longer, so orders arrive much earlier.



	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2015	467	136	105	408	350	88	94	565	246	326	468	311	318	201	445
2016	250	414	248	455	608	343	466	373	557	526	310	379	646	454	277
2017	723	184	470	304	691	238	171	397	690	342	335	389	903	345	445

FIGURE 10. Order volumes of United States. Weeks 16-30, 2015-2017

In weeks 16-30 in Figure 10 it is possible to notice much firmer influence of Dutch holidays on the ordering volumes. Easter in United States is not celebrated as it is in Europe. In all three years, the volume increased rapidly in the following week even quadrupling the amount of lines from the previous week. Common trend for high increases are also vast declines balancing the average amount of orders.

Other fluctuations were caused by Memorial Day in United States and Ascension Day and Whit Monday in Europe. Huge celebrations of Independence Day in week 27 have kept volumes quite low.

3.5.3 Norway

Similarly to United States, Norway also has ICPOs in use, however, their calendar is in line with most of the other European countries which is not causing any additional challenges (Table 8).

TABLE 8. Holidays in Norway, years 2015-2017

Holiday in Norway	2015 (week)	2016 (week)	2017 (week)
New Year's Day	1st January (1)	1st January (53)	1st-2nd January (52/1)
Maundy Thursday	2nd April (14)	24th March (12)	13th April (15)
Good Friday	3rd April (14)	25th March (12)	14th April (15)
Easter Monday	6th April (15)	28th March (13)	17th April (16)
Labour Day	1st May (18)	1st May (17)	1st May (18)
Ascension Day	14th May (20)	5th May (18)	25th May (21)
Constitution Day	17th May (20)	17th May (20)	17th May (20)
Whit Monday	25th May (25)	16th May (20)	5th June (23)
Christmas Day	25th December (52)	25th December (51)	25th December (52)
St. Stephen's Day	26th December (52)	26th December (52)	26th December (52)

During the examined year presented in Figure 11, the volumes were very stable, drawing almost a straight pattern line. Norway celebrates Easter also on Thursday, which let Norwegians be on holidays five days in a row.

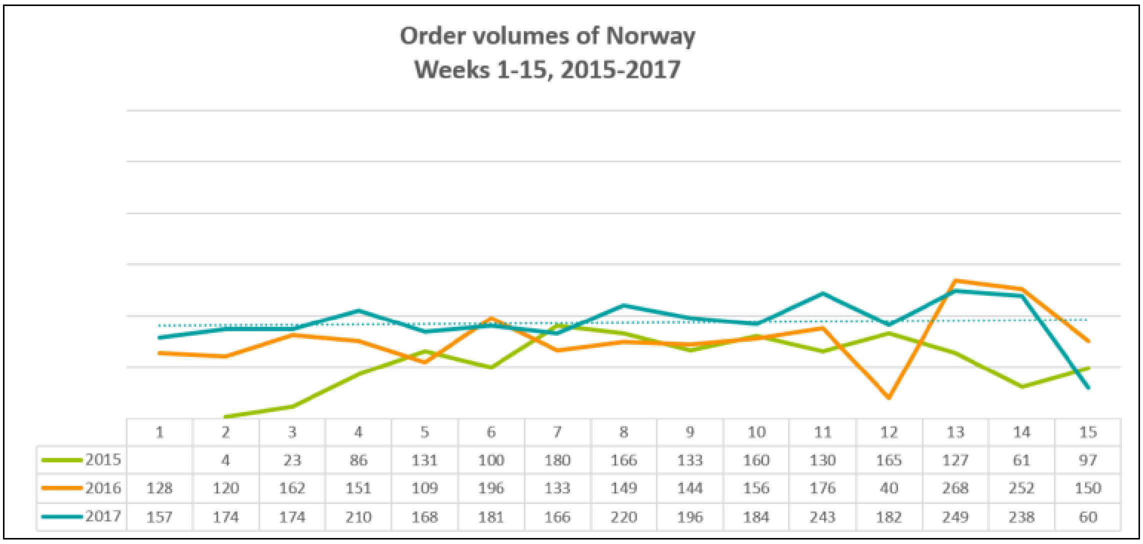
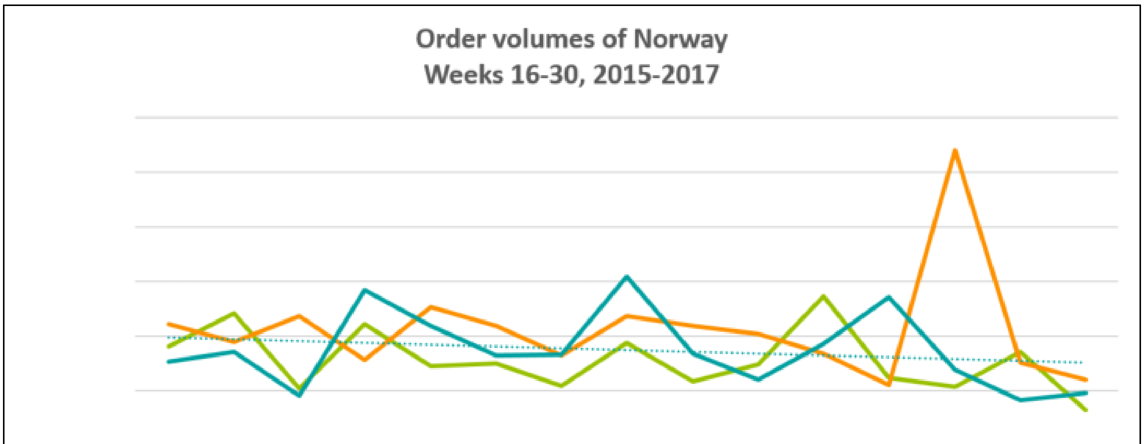


FIGURE 11. Order volumes of Norway. Weeks 1-15, 2015-2017

Significant drop can be noticed in week 14 of year 2015 (volume decreased by half), in week 12 of year 2016 (amount decreased by 77%) and in week 15 of year 2017 (decreased by almost 75%).



	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
2015	181	243	104	222	145	150	110	189	118	149	274	125	108	172	65
2016	222	190	237	158	254	219	166	238	220	204	168	111	540	152	121
2017	154	172	92	285	219	165	167	310	168	121	187	271	139	83	97

FIGURE 12. Order volumes of France. Weeks 16-30, 2015-2017

In second period of analysis showed in Figure 12, the most impacted time is end of April and beginning of May when Dutch King's Day and Labour Day happen in the same or following weeks (weeks 17/18). Despite of different weeks for Ascension Day and White Monday, there is similar pattern for weeks 22 and 23. In addition to that, there was a record high volume on week 28 in year 2016 caused by 344-line single order of end-customer. The reason is most likely a campaign or major service break.

3.6 High volume orders

Unexpected orders with high amount of order lines causes imbalance in warehouse outbound operations. Example of volume peak of Norway in week 28 in year 2016 led to further analysis of delivery size.

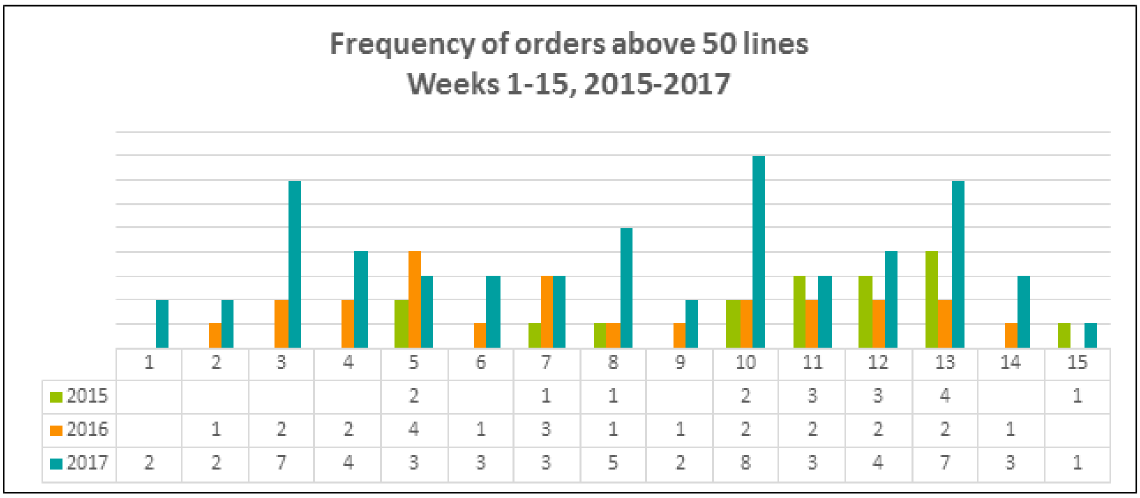


FIGURE 13. Frequency of orders above 50 lines. Weeks 1-15, 2015-2017

As showed on graph above, in Figure 13, the amount of single orders with larger amount of lines has been increasing year by year from 17 to 57 per first research period of 15 weeks. Altogether, out of 98 occurrences, 48 orders were ordered directly to the end-customer of distributor. 25 deliveries contained more than 100 lines, major reaching 284 lines.

In 2017, the amount of enormous-size orders increased significantly comparing to the previous years. Data shows three major peaks in week 3, 10 and 13, once again, including many orders to the distributors. There might have been some sales campaign directed to them which was not informed to DCE.

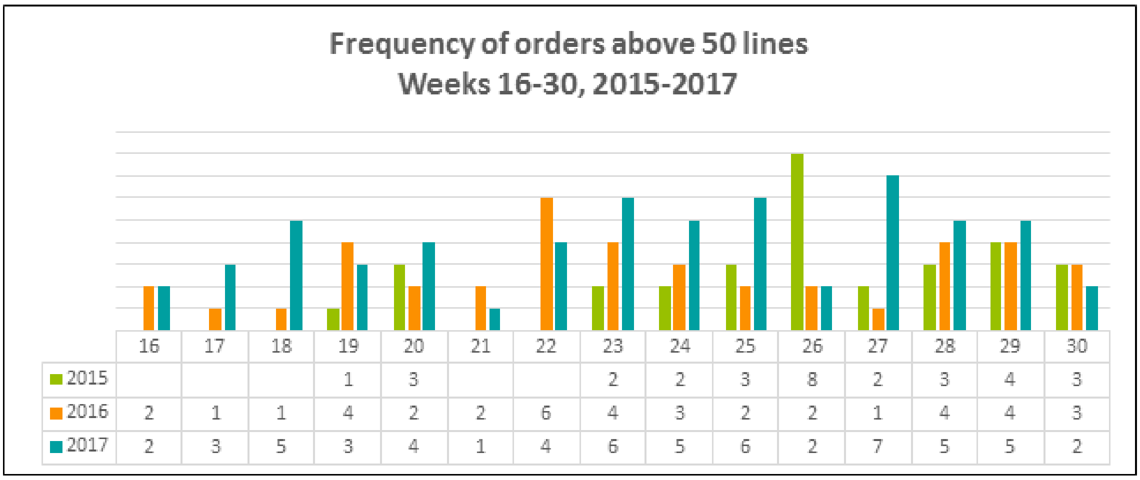


FIGURE 14. Frequency of orders above 50 lines. Weeks 16-30, 2015-2017

High volume deliveries have been even more common in period of 16-30 weeks (Figure 14). Also this time, almost half of orders were ordered directly to the customers or distributors. Among them, there were eight deliveries over 200, with higher score of 469 lines.

DCE is aware of impact of holidays on shipping schedule of intercompany orders, however fluctuations observed among orders of distributors and end-customer most likely can be explained partially by operations of sales department.

Sales department is a valuable source on sales and market situation. According to Uniform Code Council, Inc. And Voluntary Interindustry Commerce Standards (VICS) Association (2005, 17), "it is important to understand that's the sales forecast and order forecast are inextricably linked. Thus, when a change occurs in the sales forecast, there should be a dynamic synchronization process that automatically adjusts the order forecast. The two forecasting processes should not be approached independently". Therefore, in order to create an accurate forecasting of delivery volumes it is essential to start cooperation with sales department and improve communication.

3.7 Findings on influence of holidays on outbound volumes

The analysis of the holidays among most ordering parties has shown the following observations:

1. Volumes in weeks 1-15 are much more stable and predictable than weeks 16-30. There seems to be an impact of Christmas and New Years to ordering parties' winter holidays and forwarders' break in shipping schedules.
2. Easter is causing significant disruptions in delivery schedules. Easter holidays take place in different weeks every year causing forecasting challenges especially when there are several bank holidays occurring few weeks in a row.
3. End of quarter 1 is causing volume peaks one or two weeks before, depending whether quarter ends in the middle of week or at the end of the week.
4. The bigger the peak, the bigger the drop in the following week
5. Non-EU countries ordering by ICPOs are affected also by Dutch holidays. Holidays in either ordering or shipping countries disrupt automatically released orders and cause condensing of orders lines for the following week.

6. Weeks 28 and 29 are most common weeks for keeping summer holidays which is visible in the volume decline. All analysed countries have lower volumes by the end of July.
7. It would be valuable for DCE to receive information about major orders as results of campaigns or renovation service ordered to the customers to assure labour capacity in the warehouse (Norway, week 28 in year 2016).

4 FACTORS INFLUENCING VOLUME CHANGES

There are several factors causing fluctuation of volumes in outbound as well as in whole warehouse. According to Chase (2013, 32), “industry consolidation, globalization and emphasis on lean manufacturing have put much stress on the supply chain, making it difficult to responds to large swings in demand with an efficient supply response”. Companies focusing on seasonality and trends driven by the market, now need to take into consideration more factors to outperform the competition and keep the customers satisfied with products being delivered when promised. Most of them are listed below.

4.1 Service levels (SL)

Every Metso DC has a scope of materials which should be available to replenish to other units. The scopes are divided among the DCs to keep inventory healthy and warehouses profitable. Service levels (SL) define what should be desired performance percentage and describe the probability of parts being available when other Metso units or customer places the order. The levels are expressed in percentage. The higher the percentage, the more items must be kept in safety stock.

During last years, the service levels in DCE and other units have been risen several times as Metso wants to improve customer satisfaction which is related to better availability of parts and shorter lead-times. Higher SL means increased inventory value and also increased amount of inbound lines for several weeks or months, depending on the lead time. Due to SL increase in DCE and other DCs, also the outbound experiences short-term volume peaks followed by steady volume growth. It is essential to inform DCE about SL changes in other units so the warehouse can prepare for volume fluctuations.

4.2 Market situation

Product-related campaigns, fairs, bigger deals with new and current customers may have an influence on temporary volume increase in sales and warehouse. Also, economic growth has a positive impact on business to business sales and encourages customers to buy more products as, correspondingly, their own business is expanding as well.

4.3 Correlation between outbound and inbound

Performance of Metso's vendors is efficient to deliver the goods to the end-customers on time. There might be many disruptions impacting outbound in case the inbound orders did not arrive to the warehouse punctually. The example might be public holidays, like week-long Lunar New Year in case of China, make the factories freeze for at least one week before holidays as their workers are travelling to their hometowns to celebrate it with their families. All in all, Chinese holidays take about two weeks. Forecasting becomes even more challenging as every year; the holidays start in different week and different weekday.

Even though Chinese factories are working around the clock to fulfil the orders before holidays, logistic companies struggle with delivering goods on time because of lack of vessels to cover for increased capacity of orders fulfilled by Chinese wholesalers shipping their goods for export to Europe.

Relying on one source of vendor in the longer run, may have an impact on uneven volumes of orders piled up awaiting product availability. The challenge is to be up to date on inbound order status. This require good relations and communication with the supplier to get the signals regarding supply difficulties fast enough to be able to use back-up supplier when needed.

4.4 Packing and shipping schedules for forwarding agents in SAP (routes)

Data analysis has shown that the biggest volume peaks are on Tuesdays and Thursdays. Both days are scheduled for air shipments to countries outside European Union. Moreover, Thursday is the packing deadline for all ocean shipments. Ocean shipments require much more time as the goods have to be packed in more time-consuming way. Furtherly, these are usually much bigger shipments as the order lines have been consolidated from several different orders.

All the ocean shipments have same packing deadline date which, as mentioned previously, due to system constrains, may be postponed by week or even two, if either shipping date or arrival date is a holiday in either country. Deliveries can be created only a week ahead, so it is very probable to see several times a year double amount of ocean lines scheduled for one week on top of the regular volumes of order lines to other countries. A solution could be balancing the volumes lines by changing the deadline packing day of ocean shipment to other day.

Apart from ocean orders when DCE takes care of shipment booking, there are routes which indicate short packing time slots even though it is known that order will be picked by the customer in the upcoming weeks. The routes should be revised and adjusted to realistic customer’s needs. In this way, warehouse can focus on prioritizing the orders and allocating resources more efficiently.

4.5 Urgent orders

Urgent orders are caused mostly by unexpected situations where the customer’s machine needs maintenance and specific spare parts are needed for repair. The parts are ordered, packed and sent during the same day. Warehouse is instructed to prioritize urgent orders and should pack them before standard orders.

4.6 Relocation orders

Relocation orders are outcome of systematic inventory monitoring aiming to defy excess obsolete and ultra-slow moving items and transfer them to other Metso warehouses where the parts are sold faster or critical. The list of parts is prepared and validated quarterly by Global Inventory Planners.

According to the policy of relocation orders (Appendix 2) “relocation is also targeting bigger number of materials and larger lots at the time”. Moreover, “relocation POs must be made within a week”. Relocation orders follow standard order flow and affect warehouse volumes. The report run conditions of this type of orders may have some impact on outbound volumes.

4.7 Public holidays

Long public holidays have a big impact on the economy both in inbound and in outbound. According to Godfrey and Powell (2000, 452), there are several different challenges with public holidays. Some might be fixed to a date (Christmas), fixed to a day of the week (Labour Day), or some may vary from one year to another (Easter). It also may be problematic to define which weeks (before or after) or days will be influences.

Countries like China and France are Metso’s biggest suppliers for the spare and wear parts because of their factories. Backlog in inbound reflects to outbound as there are no parts in stock to fulfil customer’s order. Inbound deliveries in holiday season are usually combined in bigger shipments. As these arrive to the warehouse and become taken to stock, they trigger deliveries of the bigger orders placed in the past but not available until then. Automatic releases cause peaks in outbound volumes.

In case of France and Finland, the summer break in work of factories lasts two to four weeks. As manufacturer of many critical parts, a break in supply has a major impact on availability. Production breaks should always be taken into consideration when the volume is forecasted.

5 FORECASTING MODELS AND METHODS

This section outlines statistical forecasting models commonly used in business analytics as well as in supply chain management. The analyses were supported by Ravinder & Misra (2016, 184-186) who presented a commonly used approach called Multiplicative Decomposition Method (formula 1), where time-series can be expressed as mixture of different elements. The formula emphasize how many different factors should be considered in forecasting.

$$X_t = T_t \times S_t \times C_t \times R_t \qquad (1)$$

Where:
X_t = time-series value at time t
T_t = trend component at time t
S_t = seasonal component at time t
C_t = cyclic component at time t
R_t = random component at time t

Because of the characteristics of available data, gathered in same observation periods (weeks 1-15 and 16-30) from different years, there was a possibility to use forecasting methods focusing on time series. All the elements, except for cyclic component were recognized in the Figures 1 and 2 and other analyses in further chapters. The reason why cyclic component did not appear, is because it occurs on typically longer periods than seasons, that is about 5 to 8 years. In this research, the forecasting need is much shorter.

All of the methods required usage of Microsoft Excel. According to a survey conducted by Purdue University and the SAS Institute found out that over 85 percent of the respondents still use Excel even though they have also an access to ERP and other solutions due to lack of reporting capabilities. (Chase, 2013, 7.)

In addition to well-known forecasting models, one more method was investigated which could be furtherly developed for forecasting purposes. Data was extracted from two SAP transactions and combined to give an overview of released on unreleased orders.

5.1 Forecasting process and method selection

There is large variety of forecasting methods. Most of them focus on short-term forecasting and smoothening random peaks and falls. These models middle the historical data from the same period and do not take into consideration trend or seasonality, neither change over the years.

Ghiani (2013, 51), has described the forecasting process is three steps:

1. Data preprocessing.
2. Choice of forecasting method.
3. Evaluation of the forecasting accuracy.

First phase includes data cleaning, segregation and transformation. The second phase is mostly used based on methods suitable for particular time range and desired outcome. In this research, several methods were selected as there were no previous forecasting models. The third step evaluates the forecasting methods. Mean absolute deviation (MAD) method and, in some cases, early data of year 2018 was used as common comparison to define forecast error and to define how successful the methods were.

5.2 Medium-term forecasting methods

Medium-term forecasts are defined for period reaching from few a few months up to one year. The forecasting is used "for tactical logistical decisions, such as setting annual production and distribution plans, inventory management and slot allocation in warehouses" (Ghiani, 2013, 43).

5.2.1 Simple average method

In the first method, I have use very simple method of averaging. I have averaged the data of previous years to conclude a volume for the upcoming one. In case of first four weeks I took an average of year 2016 and 2017 as beginning of 2015 was a transfer period from one warehouse to another and the values do not have any essential information.

Furtherly, having already the actual volumes for the beginning of year 2018, I had a possibility to check the primary results. I have created two scenarios to test in which one I tried to reach smallest forecast error possible. Firstly, I raised the volumes by 8% as previous analysis has shown that volumes have been raising by this amount from year to year. Secondly, I raised up the volumes by 20%.

MAD value was calculated to test which forecast was closer to the actual result. In this case, MAD has become much closer to 0, giving a result of 177 for the average forecast with scenario of 20% increase, which is very good comparing to overall volumes (Table 9).

TABLE 9. Results of simple average method forecasting

Week	2015	2016	2017	Forecast 2018 (average)	Forecast 2018 (average) +8%	Forecast 2018 (average) +20%	Actual volumes	Forecast error	Forecast error (+8% vs actual)	Forecast error (+20% vs actual)
1	0	2411	2148	2280	2462	2736	2943	663	481	207
2	116	2400	2774	2587	2794	3104	2969	382	175	-135
3	400	2948	3139	3044	3287	3652	3254	211	-33	-398
4	1449	2727	3131	2929	3163	3515	3502	573	339	-13
5	2092	3036	3025	3031	3273	3637	3239	209	-34	-398
6	2179	2744	2896	2820	3046	3384	3336	516	290	-48
7	2804	3064	2832	2900	3132	3480	3763	863	631	283
8	2345	2394	3301	2680	2894	3216	3292	612	398	76
9	2445	2730	2978	2718	2935	3261	3200	482	265	-61
10	2781	3055	3302	3046	3290	3655	3678	632	388	23
11	2849	3208	3116	3058	3302	3669	3655	597	353	-14
12	2532	2645	3432	2870	3099	3444	3462	592	363	18
13	2932	2573	3198	2901	3133	3481	3190	289	57	-291
14	2099	3217	3190	2835	3062	3402	3011	176	-51	-391
15	2162	2969	2918	2683	2898	3220	3112	429	214	-108
16	2644	3216	3147	3002	3243	3603	3890	888	647	287
17	2487	2812	2890	2500	2700	3000	2650	150	-50	-350
18	1797	2380	3464	2547	2751	3056	3136	589	385	80
19	3301	3351	3262	3305	3569	3966		MAD	MAD	MAD
20	2589	2956	3651	3065	3311	3678		492	286	177
21	2638	2919	2319	2625	2835	3150		MIN	MIN	MIN
22	2146	3586	3728	3153	3406	3784		150	-51	-398
23	3176	3316	3376	3289	3552	3947		MAX	MAX	MAX
24	2679	3379	3676	3245	3504	3894		888	647	287
25	3008	3216	3158	3127	3378	3753				
26	4011	3153	3295	3486	3765	4184				
27	2943	2957	3706	3202	3458	3842				
28	3069	3550	3784	3468	3745	4161				
29	3169	2898	2975	3014	3255	3617				
30	3242	2847	3842	3310	3575	3972				

In the next comparison (Table 10), bank holidays were considered. For the days when warehouse is not operating numbers were adjusted manually. The same practice was applied to numbers, in cases when bigger cross-country holidays that may have affected ordering volumes.

TABLE 10. Results of simple average method forecasting with holiday-related adjustments

Week	2015	2016	2017	Forecast 2018 (average)	Forecast 2018 (average) +holidays	Forecast (average) 2018 + 8%	Forecast (average) 2018 +20%	Actual volumes	Forecast error +holidays vs actual	Forecast error (+8% vs actual)	Forecast error (+20% vs actual)
1	0	2411	2148	2280	2280	2462	2736	2943	663	481	207
2	116	2400	2774	2587	2587	2794	3104	2969	382	175	-135
3	400	2948	3139	3044	3044	3287	3652	3254	211	-33	-398
4	1449	2727	3131	2929	2929	3163	3515	3502	573	339	-13
5	2092	3036	3025	3031	3031	3273	3637	3239	209	-34	-398
6	2179	2744	2896	2820	2820	3046	3384	3336	516	290	-48
7	2804	3064	2832	2900	2900	3132	3480	3763	863	631	283
8	2345	2394	3301	2680	2680	2894	3216	3292	612	398	76
9	2445	2730	2978	2718	2718	2935	3261	3200	482	265	-61
10	2781	3055	3302	3046	3046	3290	3655	3678	632	388	23
11	2849	3208	3116	3058	3058	3303	3670	3655	597	352	-15
12	2532	2645	3432	2870	3110	3359	3732	3462	352	103	-270
13	2932	2573	3198	2901	2554	2758	3065	3190	636	432	125
14	2099	3217	3190	2835	2627	2838	3153	3011	384	173	-142
15	2162	2969	2918	2683	2683	2898	3220	3112	429	214	-108
16	2644	3216	3147	3002	3002	3242	3602	3890	888	648	288
17	2487	2812	2890	2730	2500	2700	3000	2650	150	-50	-350
18	1797	2380	3464	2547	2547	2751	3056	3136	589	385	80
19	3301	3351	3262	3305	2429	2624			MAD	MAD	MAD
20	2589	2956	3651	3065	3065	3310			509	300	168
21	2638	2919	2319	2625	2826	3052			MIN	MIN	MIN
22	2146	3586	3728	3153	3153	3405			150	-50	-398
23	3176	3316	3376	3289	3327	3593			MAX	MAX	MAX
24	2679	3379	3676	3245	3433	3708			888	648	288
25	3008	3216	3158	3127	3167	3420			Easter		
26	4011	3153	3295	3486	3311	3576			King's Day		
27	2943	2957	3706	3202	3288	3551			Ascension Day		
28	3069	3550	3784	3468	3601	3889			Whit Monday		
29	3169	2898	2975	3014	2962	3199			1st May		
30	3242	2847	3842	3310	3333	3600					

In this forecast, MAD value has decreased by 9, so the results have improved a little bit. Holidays do have clear impact on volumes, however, the impact of cumulation of several incomplete weeks in a row is not that easy to define as we have only the date from three full periods. So far, very few holidays have taken place in the same week as in the previous years, so it is hard to find a clear answer. However, what is common for all the values is the effect of the end of the quarter. These have been always higher on the previous week.

5.2.2 Weighted average method

Weighted average is commonly known to be more accurate measurement of statistical data which does have some relations to each other. This method was used for forecasting outbound volumes on a daily level. The formula for this method is:

$$Weighted\ Avg_x = w_1 x_1 + w_2 x_2 \ldots w_n x_n \tag{2}$$

$w = relative\ weight(\%)$
$x = value$

This method required some testing on how much weight should be assigned to which year. After several trials, year 2015 was given weight 0,1, year 2016 weight 0,2 and the latest year the biggest weight of 0,7.

The results of the final values presented in Table 11 are not as satisfying as expected. MAD value has remained still quite high. The method has not recognized a dramatical increase of volumes from one year to another. Some adjustments on holidays could improve accuracy even more after detailed research taking into considerations SAP routes and packing schedules.

TABLE 11. Results of weighted average method forecasting. Weeks 1-18.

Week	2015	2016	2017	Forecast 2018	Actual volumes	Forecast error
1		2411	2148	1986	2943	957
2	116	2400	2774	2433	2969	536
3	400	2948	3139	2827	3254	427
4	1449	2727	3131	2882	3502	620
5	2092	3036	3025	2934	3239	305
6	2179	2744	2896	2794	3336	542
7	2804	3064	2832	2876	3763	887
8	2345	2394	3301	3024	3292	268
9	2445	2730	2978	2875	3200	325
10	2781	3055	3302	3201	3678	478
11	2849	3208	3116	3108	3655	547
12	2532	2645	3432	3185	3462	277
13	2932	2573	3198	3046	3190	144
14	2099	3217	3190	3086	3011	-75
15	2162	2969	2918	2853	3112	259
16	2644	3216	3147	3111	3890	780
17	2487	2812	2890	2834	2650	-184
18	1797	2380	3464	3081	3136	56
19	3301	3351	3262	3284		MAD
20	2589	2956	3651	3406		426
21	2638	2919	2319	2471		MIN
22	2146	3586	3728	3541		-184
23	3176	3316	3376	3344		MAX
24	2679	3379	3676	3517		957
25	3008	3216	3158	3155		
26	4011	3153	3295	3338		
27	2943	2957	3706	3480		
28	3069	3550	3784	3666		
29	3169	2898	2975	2979		
30	3242	2847	3842	3583		
Weights: 0,1; 0,2; 0,7						

5.3 Short-term forecasting

Short-term forecasting is ranging from few days to several weeks ahead. Its role is to help scheduling human resources for better productivity and performance. Forecasts for shorter intervals like upcoming day, or for next few hours is rather uncommon in logistics. (Ghiani, 2013, 45.)

5.3.1 Autoregressive model

I chose commonly known autoregressive model AR(1) because it is suitable for handling wide ranges of different series patters. Autoregressive Model uses the past values of the variable in linear combination. The formula 2 of order *p* is presented below:

$$y_t = c + \phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_p y_{t-p} + e_t, \qquad (3)$$

where *cc* is a constant and e_t is white noise. Lagged values y_t are predictors against themselves.

In data analysis of autoregressive model, there is a need to run first, second and third order models. The first and second order trials were the best one as they were closest to 0, but different from it, therefore they appeared to be statistically significant.

Because beginning of year 2015 was still a transfer period to a new warehouse, different time periods were tried to achieve the best result. In addition to separate trials for weeks 1-15 and weeks 16-30, I have tried creating one forecast for all 30 weeks a time. Trials included two most recent years and all three of them. Below, in Figure 15 and Table 12, I present results of first and second order results of the autoregressive model.

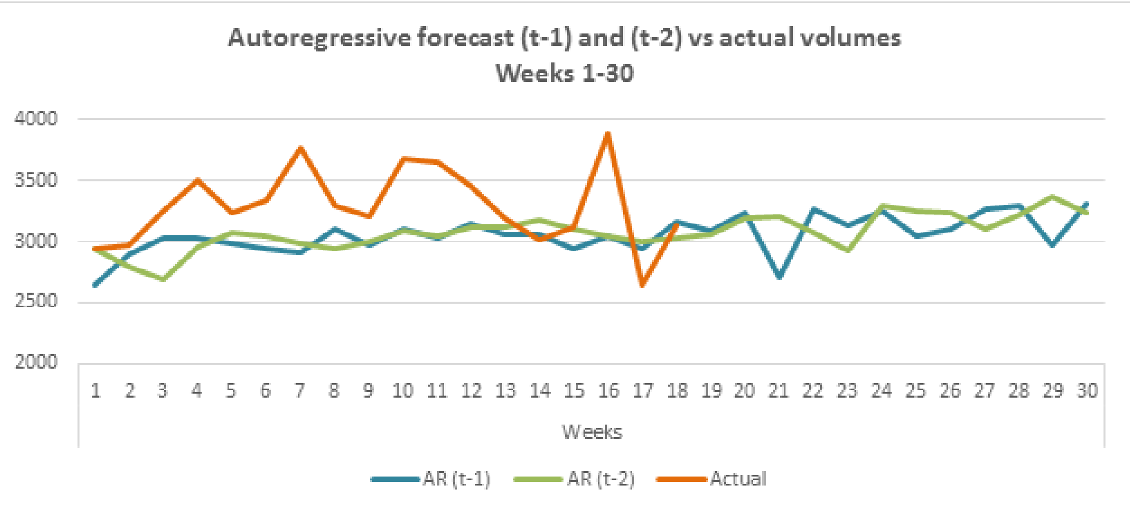


FIGURE 15. Comparison of autoregressive forecast vs actual volumes

Figure 15 displays the peaks and valleys from data of 2015-2017 have been smoothened. The line shows some trends, whoever, seasonality is not clearly visible. MAD is in both cases is around 340, which rather satisfactory result.

Autoregressive models are widely used in forecasting, however according to Pesaran and Timmermann, they are “unstable and subject to structural breaks” (Journal of Econometrics 129, 2005, 183-217). Volumes in outbound are often changing from one week to another, therefore, autoregressive model in this simplest version is not enough to forecast exact numbers for the upcoming weeks but, nevertheless, is often showing good direction.

TABLE 12. Results of autoregressive method of forecasting

Week	Forecast (t-1)	Actual volumes	Forecast error (t-1)	Forecast (t-2)	Actual volumes	Forecast error (t-2)
1	2641	2943	-302	2940	2943	-3
2	2890	2969	-79	2793	2969	-176
3	3036	3254	-218	2693	3254	-561
4	3032	3502	-470	2956	3502	-546
5	2990	3239	-249	3068	3239	-171
6	2939	3336	-397	3046	3336	-290
7	2913	3763	-850	2989	3763	-774
8	3100	3292	-192	2937	3292	-355
9	2972	3200	-228	3005	3200	-195
10	3101	3678	-577	3090	3678	-588
11	3026	3655	-629	3050	3655	-605
12	3152	3462	-310	3116	3462	-346
13	3059	3190	-131	3118	3190	-72
14	3056	3011	45	3172	3011	161
15	2948	3112	-164	3098	3112	-14
16	3039	3890	-851	3044	3890	-846
17	2937	2650	287	3003	2650	353
18	3165	3136	29	3026	3136	-110
19	3085			3053		
20	3239		MAD	3194		MAD
21	2709		334	3204		343
22	3270		MIN	3075		MIN
23	3130		-851	2925		-846
24	3249		MAX	3297		MAX
25	3043		287	3244		353
26	3098			3240		
27	3261			3105		
28	3292			3225		
29	2970			3367		
30	3315			3240		

5.3.2 Weighted moving average

Weighted moving average is a forecasting method which uses historical data, however, prioritizes newest values with given weights. The older the value, the smaller the weight. I have selected this method as the volumes show inclining trend toward the year.
The formula for this model is:

$$\text{WMA}_M = \frac{np_M + (n-1)p_{M-1} + \cdots + 2p_{(M-n+2)} + p_{(M-n+1)}}{n + (n-1) + \cdots + 2 + 1} \qquad (4)$$

Where *p* is volume and *M* a numerator.

This method is used for short and medium-term forecasting. Below, in Table 13. I used as example data from previous years. In first trial, I have given weight for 4th oldest value 0,1; for 3rd oldest value 0,2 for 2nd 0,3 and for the first one 0,4.

TABLE 13. Results of weighted moving average method of forecasting. Weights 0,1; 0,2; 0,3; 0,4.

Week	2015	WMA 2015	Forecast error	2016	WMA 2016	Forecast error	2017	WMA 2017	Forecast error
1	0			2411			2148		
2	116			2400			2774		
3	400			2948			3139		
4	1449			2727			3131		
5	2092	723	1369	3036	2696	340	3025	2964	61
6	2179	1363	816	2744	2862	-118	2896	3055	-159
7	2804	1829	975	3064	2849	215	2832	3006	-174
8	2345	2339	6	2394	2929	-535	3301	2920	381
9	2445	2424	21	2730	2729	1	2978	3052	-74
10	2781	2460	321	3055	2697	358	3302	3038	265
11	2849	2595	254	3208	2826	382	3116	3158	-42
12	2532	2697	-165	2645	2985	-340	3432	3163	269
13	2932	2668	264	2573	2904	-331	3198	3266	-68
14	2099	2780	-681	3217	2770	447	3190	3262	-72
15	2162	2511	-349	2969	2909	61	2918	3233	-315
16	2644	2334	310	3216	2932	284	3147	3107	40
17	2487	2419	68	2812	3078	-266	2890	3092	-202
18	1797	2430	-633	2380	3005	-625	3464	3003	461
19	3301	2210	1091	3351	2736	615	3262	3174	88
20	2589	2621	-32	2956	2938	18	3651	3237	414
21	2638	2634	4	2919	2945	-26	2319	3421	-1102
22	2146	2672	-526	3586	2963	623	3728	3022	706
23	3176	2498	678	3316	3236	80	3376	3243	133
24	2679	2701	-22	3379	3282	97	3676	3298	378
25	3008	2717	291	3216	3356	-140	3158	3461	-303
26	4011	2857	1154	3153	3322	-169	3295	3414	-119
27	2943	3360	-417	2957	3233	-276	3706	3338	368
28	3069	3250	-181	3550	3110	440	3784	3470	314
29	3169	3214	-45	2898	3259	-361	2975	3600	-625
30	3242	3178	64	2847	3131	-284	3842	3396	446
			MAD=413			MAD=286			MAD=292
Weights 0,1; 0,2; 0,3; 0,4									

In the second trial, presented in Table 14, I have considered only two older values and gave them values 2 for second oldest and 3 for the newer one.

TABLE 14. Results of weighted moving average method of forecasting . Weights 2 and 3.

Week	2015	WMA 2015	Forecast error	2016	WMA 2016	Forecast error	2017	WMA 2017	Forecast error
1	0			2411			2148		
2	116			2400			2774		
3	400	70	330	2948	2404	544	3139	2524	615
4	1449	286	1163	2727	2729	-2	3131	2993	138
5	2092	1029	1063	3036	2815	221	3025	3134	-109
6	2179	1835	344	2744	2912	-168	2896	3067	-171
7	2804	2144	660	3064	2861	203	2832	2948	-116
8	2345	2554	-209	2394	2936	-542	3301	2858	443
9	2445	2529	-84	2730	2662	68	2978	3113	-135
10	2781	2405	376	3055	2596	459	3302	3107	195
11	2849	2647	202	3208	2925	283	3116	3172	-56
12	2532	2822	-290	2645	3147	-502	3432	3190	242
13	2932	2659	273	2573	2870	-297	3198	3306	-108
14	2099	2772	-673	3217	2602	615	3190	3292	-102
15	2162	2432	-270	2969	2959	10	2918	3193	-275
16	2644	2137	507	3216	3068	148	3147	3027	120
17	2487	2451	36	2812	3117	-305	2890	3055	-165
18	1797	2550	-753	2380	2974	-594	3464	2993	471
19	3301	2073	1228	3351	2553	798	3262	3234	28
20	2589	2699	-110	2956	2963	-7	3651	3343	308
21	2638	2874	-236	2919	3114	-195	2319	3495	-1176
22	2146	2618	-472	3586	2934	652	3728	2852	876
23	3176	2343	833	3316	3319	-3	3376	3164	212
24	2679	2764	-85	3379	3424	-45	3676	3517	159
25	3008	2878	130	3216	3354	-138	3158	3556	-398
26	4011	2876	1135	3153	3281	-128	3295	3365	-70
27	2943	3610	-667	2957	3178	-221	3706	3240	466
28	3069	3370	-301	3550	3035	515	3784	3542	242
29	3169	3019	150	2898	3313	-415	2975	3753	-778
30	3242	3129	113	2847	3159	-312	3842	3299	543
			MAD=453			MAD=300			MAD=311
Weights: 2; 3									

MAD shows better result when considering more previous values and smaller weight. Choosing correct weights needs some trials and testing in order to achieve satisfying results.

5.4 Utilization of SAP reports

SAP offers wide range of transactions which could be used in forecasting if further developed and linked. Nowadays, Metso has in use Robotic Process Automation called Robin Robot which can run a series of actions in SAP or other system in no time. Every Metso employee can propose a solution that could be automated. I believe that Robin Robot could be exploit in the manual forecasting trial below.

The following data visibility trial has been conducted accordingly. Firstly, it was defined what DC's actual outbound volumes forecasting should take into consideration. These are:

- Regular orders ordered several days or weeks in advance with no delivery number yet.
- Backlog orders. Orders ordered several days or weeks in advance however unavailability does not yet allow to create delivery.
- Orders which shipping day is approaching soon and availability allows to create delivery. These orders are already visible for warehouse and queuing to be picked up.
- Orders created and shipped the same day. There is no record of them in SAP system until the order has been processed.
- Vendor returns. This type of shipments also generates a delivery. Vendor returns are rather rare, however sometimes they may cause an increase in volume.

Two transactions were run, VL10H and YWM_OUTB_DEL_MONITOR. First transaction contains all the order lines that do not have a delivery number yet (order not released/parts not yet available). List contained information on 7 days of backlog and orders to be shipped up to 14 days ahead. The other transaction contains all the deliveries, released to be shipped up to 7 days ahead which is maximum for this transaction.

The list was run every day at 9 am for three weeks. Because of the fact that it was run manually, and it was time consuming process, there might be some overlapping or missed data. The visibility percentage is presented in Table 15.

TABLE 15. Data on 15 test days

	Mo	Tue	Wed	Thu	Fri	
Workdays ahead / Test day	**1**	**2**	**3**	**4**	**5**	**Average**
+1d	76 %	82 %	62 %	16 %	31 %	**53 %**
+2d	76 %	49 %	10 %	24 %	45 %	**41 %**
+3d	45 %	9 %	14 %	37 %	38 %	**28 %**
+4d	10 %	14 %	31 %	38 %	41 %	**27 %**
+5d	19 %	23 %	36 %	33 %	7 %	**24 %**
+6d	22 %	25 %	32 %	12 %	28 %	**24 %**
+7d	24 %	28 %	13 %	25 %	17 %	**21 %**
+8d	25 %	12 %	25 %	18 %	2 %	**16 %**
+9d	12 %	24 %	16 %	16 %	19 %	**18 %**
+10d	24 %	16 %	16 %	19 %	15 %	**18 %**
Test day backlog (VL10H)	36	43	28	57	72	

	Mo	Tue	Wed	Thu	Fri	
Workdays ahead / Test day	**6**	**7**	**8**	**9**	**10**	**Average**
+1d	77 %	58 %	67 %	31 %	28 %	**52 %**
+2d	48 %	51 %	19 %	27 %	57 %	**40 %**
+3d	45 %	14 %	27 %	40 %	28 %	**31 %**
+4d	14 %	29 %	36 %	25 %	35 %	**28 %**
+5d	30 %	17 %	22 %	22 %	17 %	**22 %**
+6d	16 %	17 %	21 %	16 %	5 %	**15 %**
+7d	18 %	21 %	15 %	3 %	22 %	**16 %**
+8d	19 %	15 %	4 %	17 %	22 %	**16 %**
+9d	15 %	4 %	17 %	22 %	14 %	**14 %**
+10d	4 %	17 %	23 %	14 %	12 %	**14 %**
Test day backlog (VL10H)	46	57	38	62	30	

	Mo	Tue	Wed	Thu	Fri	
Workdays ahead / Test day	**11**	**12**	**13**	**14**	**15**	**Average**
+1d	72 %	44 %	76 %	33 %	36 %	**52 %**
+2d	31 %	49 %	20 %	10 %	38 %	**30 %**
+3d	40 %	16 %	10 %	26 %	58 %	**30 %**
+4d	17 %	7 %	21 %	46 %	36 %	**26 %**
+5d	6 %	27 %	43 %	35 %	26 %	**27 %**
+6d	25 %	23 %	34 %	25 %	10 %	**23 %**
+7d	22 %	34 %	18 %	10 %	32 %	**23 %**
+8d	14 %	13 %	11 %	34 %	29 %	**20 %**
+9d	12 %	10 %	32 %	34 %	11 %	**20 %**
+10d	10 %	32 %	34 %	10 %	15 %	**20 %**
Test day backlog (VL10H)	30	25	25	73	66	

The backlog listed in the table above is coming from transaction VL10H and its average is 46 lines per day. Warehouse’s reliability is merely 99% so backlog for open delivery from YWM_OUTB_DEL_MONITOR is rather rare. The backlog might be taken into consideration in future calculation if there is some exact data on when parts for these orders may become available.

The results in Table 16 have shown that on day 0, 9 am the average visibility for the next day reaches 53%. The average visibility for the first five days is 34% for the following days (five to ten) is only 19%.

TABLE 16. Result of volume visibility

Workdays ahead	Volume visibility
+1d	53 %
+2d	37 %
+3d	30 %
+4d	27 %
+5d	24 %
+6d	21 %
+7d	20 %
+8d	17 %
+9d	17 %
+10d	17 %

If added more features like detecting backlog orders availability and vendor returns, this method can be furtherly developed for forecasting purposes. Currently, the percentage of visibility for the following days are varying quite much. It is necessary to test this process on a longer run to be able to find certain patterns and behaviours.

5.5 Conclusions on forecasting methods

Table 17 shows the comparison of all forecasting methods analysed in this research. The main comparing factor is MAD value as well as minimum and maximum deviation calculated from the actual result.

TABLE 17. Comparison of forecasting methods

Forecasting method	Forecasting method	MAD	Minimum difference	Maximum difference
Simple Average Method	Simple Average Method	492	150	888
	+8% increase scenario	286	-51	647
	+20% increase scenario	177	-398	287
Simple Average Method with manual adjustments	Simple Average Method with manual adjustments (holidays)	509	150	888
	+8% increase scenario	300	-50	648
	+20% increase scenario	168	-398	288
Weighted Average Method	Weighted Average Method	426	-184	957
Autoregressive Model	(t-1)	334	-851	-864
	(t-2)	343	287	353
Weighted Moving Average	Weights 0,1; 0,2; 0,3; 0,4			
	Sample 1: 2015	413	-681	1369
	Sample 2: 2016	286	-625	623
	Sample 3: 2017	292	-1102	706
	Weights 2, 3			
	Sample 1: 2015	453	-753	1228
	Sample 2: 2016	300	-594	798
	Sample 3: 2017	311	-1176	876

Simple average methods appeared to be most efficient, MAD value in 20% increase scenario was as low as 177. In scenario with manual adjustments regarding holidays it reached result of 168 difference, which is very satisfactory. Other forecasting methods were struggling with certain pattern in volume changes and rapid growth from one year to another. There are many forecasting models that could be still utilized, however, they require a lot of statistical and analytical expertise to be applied.

Judgmental assets and knowledge of business factors are also very essential in analysing historical records and creating forecasting. Manual adjustments brought better results based on a previous experience and observations. To be able to provide detailed forecast, data should be evaluated manually by a person or people who know company’s business, internal and external influences like software limitations and cross-country market acquaintance

6 FORECASTING MODEL

Availability of software makes many companies, including Metso, own a mass of internal and external data but they struggle in finding a way to combine it and synchronize it to make it beneficial. Like in the trials described in previous chapters, there is a lot of data available, but there is not much value in it separately as it is not combined. As Küsters, McCullough and Bell describe, heterogenous data must be first merged and collected from different sources (2006, 606). Manual compilation takes time and therefore there is a risk of data overlapping which makes the forecasting less accurate. Küsters et al. says that forecasting systems should be including diverse data sources like data from SAP and holiday calendar and must be allocated in facility that allows connection to online facilities. This way data importing and exporting can be run in real-time.

The challenge of new forecasting software is consideration of regressors which characterize dynamic effects. Similarly to Küsters' and this research, Easter has showed to have an effect on volumes by causing lag effects and peaks. According to Küsters, software should have "rule-based system to create sensible combinations of regressors". Moreover, more than one forecasting model should be used to be able to validate the results. It is recommended to be able to add comments about calendar data, promotions, SL increases. In this way, the software could record the data with markings, analyze it and utilize it for future. Küsters says that forecasting software should support the analyst by creating reports, mixing tables from different sources and generate scenarios. These could be presented in a form of dashboard.

According to Person (2013, 103-104), dashboards have several tasks before these can improve the performance. Firstly, they should be based on causal links which drives the organizational objectives. They should cause a discussion on what is triggering the results. Moreover, they should make relevant people to take actions. Person also mentions that data should be up to date in order to keep objectives focus on right time.

The dashboard below, presented in Figure 17 includes all of the features listed in Küsters' and Person's papers. It contains few forecasting methods, it has place for notes and observations. Moreover, it presents data from different sources (outbound monitor for deliveries, open order database, calendar).

Person (2013, 108) mentions that dashboard are not a one-time project and should be developed and become part of company's culture and routine. After some period of time, layout can be changed to give a better overview tailored to DC's needs.

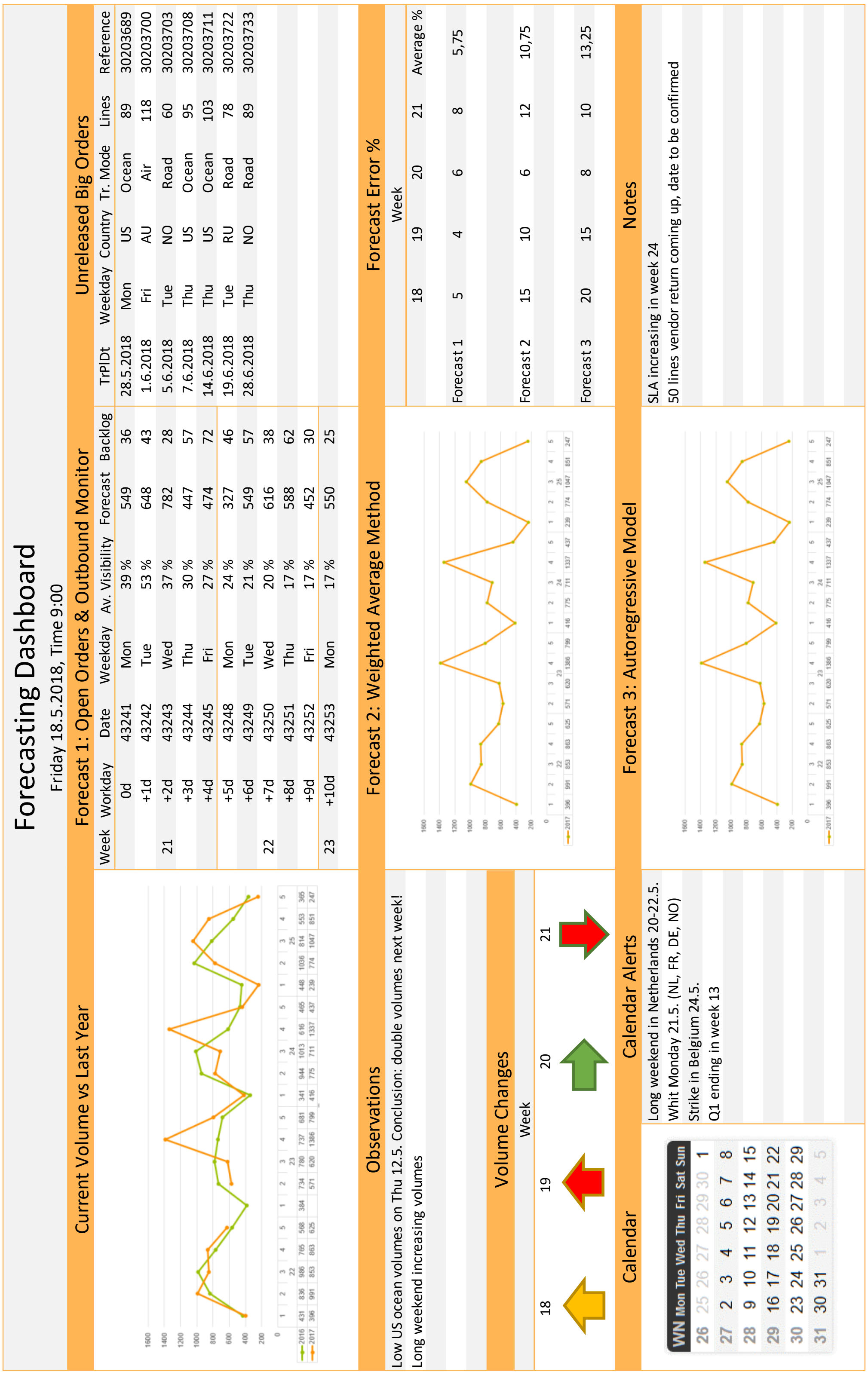


Figure 16. Forecasting dashboard

7 RECOMMENDATIONS

In addition to the implementation of the forecasting dashboard, three recommendations were listed to improve forecasting as well as support actions which aim on distributing outbound volumes more evenly. The recommendations mostly focus on system-related improvements but also emphasize the importance of communication within organization.

7.1 Adjusting routes and shipping schedules

Shipping schedules and routes should be analysed according to the volume per transportation mode. The data has shown that moving either road or ocean shipments to the other day may have a positive impact on the outbound volumes and could decrease Thursday volume peak.

Readjusting routes and shipping schedules can be fixed in SAP after primary communication with the forwarding agents. The solution is to either increase the amount of shipping days or to shift them to the other, less busy day. Balancing volumes thorough the days would increase shipping reliability as well as allow better resource planning.

7.2 Utilizing existing software

Metso has licenses for several software that are used in different departments and teams which could be used for forecasting purposes. All the software is adjustable to some extend and are able to be modified according to the needs of the users. If some features could be developed and added to the existing software or combined with other, the forecasting would be available in a matter of seconds.

The first software is Every Angle (EA), a software which is configurated with SAP system. EA is able to analyze itself data related to, for example, the outbound orders. It synchronizes metadata of the supply chain and shows whether open order lines are going to be released as scheduled. It also warns about possible delays, which is very essential in resource planning.

The drawbacks of current version of EA is the fact that currently, the report has to be run separately for intercompany and non-intercompany orders. Another aspect is that the software works on a data uploaded from the previous night, so the available data is not a real-time data.

Another existing software is PRIME. The software is used in procurement for defining demands and creating purchase requisitions for almost all Metso locations. PRIME could be linking the information on order demand right at the beginning of the supply chain. Currently the software shows DCE the demand only one step back, for example for PRIME gives an impulse when SSO needs to order some part. If DCE knew already that this part is going to be order from them, the information could have been exploited in the forecast. Unfortunately, at this stage, overseeing the demands of whole internal SCM of Metso is not available.

Metso has already in use Robotic Process Automation (RPA) tool in use. RPA could be used for downloading statistical data from the ERP systems and other sources like EA and PRIME, to create forecasting models and presenting the results on a dashboard. Once designed, the algorithms can run in no time large volumes of statistical data and compile them. Thanks to RPA, the user does not have to spend his or her time on collecting, sorting and synchronizing the data. The user can now focus on drawing conclusions and planning actions to respond to the current volumes.

7.3 Internal communication

Metso has to emphasize good communication with both, the supplier and customers regarding periodical production breaks, commonly kept in the summer time. The information about gaps in supply has to reach DCE at least several weeks in advance so Procurement Team has time to react and informs Order Desk Team who updates the orders and informs customer in time. Efficient communication maintain high customer satisfaction as well gives insight on order volumes for upcoming weeks.

Business activity breaks do have an impact on volumes and therefore should be considered in forecasting. DC should also send inquiry to the most ordering and supplying parties asking in advance about holiday schedules which may cause order imbalances. In Appendix 1 there is a list of holidays of most ordering countries for year 2018. Dutch calendar is also included as research has shown that DCE's activity breaks have a vast impact on volume cumulations other days.

According to Uniform Code Council, Inc. and VICS Association (2005, 11) "buyers and suppliers must share a variety of data to collaborate at the DC level. Sales history, sales forecasts and order plans, performance metrics and the details of promotional events all need to be available to both trading partners." Therefore, sales department should also collaborate with DCE in much tight manner. Information about new, confirmed deals, fairs and campaign should be passed to DCE before the orders are placed. Sales department also already has in their use sales forecast which may be very valuable knowledge for warehouse resource planning.

Chase (2013, 75) emphasizes that "the importance of working together with sales and marketing and the supply chain to identify the appropriate sensing and shaping response to optimize business results.". To become more accurate in forecasting, the companies need to take a wider approach, be sensitive to the market signals, translate them correctly and react to them in an effective way.

8 CONCLUSIONS AND DISCUSSION

The objective of this thesis was to develop new model of outbound volume forecast to support processes of 3PL acting as Metso's main Distribution Centre operating in Europe. The forecast model was created in form of a dashboard presented in Figure 17. Carried study defined the elements dashboard should contain and what factors have an influence on the volumes.

Firstly, the research was focused on existing historical data and analysing time series of in order to find trends and seasonality. According to Chase (2013, 78-79), statistical data must be available to be able to apply forecasting methods. The statistical data was available, and the research was conducted on first 30 weeks of three following years. Analysis showed that trend was gradually growing, and seasonal component could be noticed around Easter holidays and quarter changes, also noticed in Küsters' article (2006, 606). Additionally, according to Chase (2013, 81) the random component could be related to other influence factors such as sales promotion, competitor activities or be simply random. These implications were confirmed in this research.

Secondly, thesis was focused on causal variables that may have an impact on fluctuations. The vast increase of volumes, even though rather steady, was caused by SL adjustments. Tables 1 and 2 showed the increase of volumes one year by another from 7% to 13%. SLs have been adjusted more frequently than before. According to Ngniatedema, et al. (2015, 80), adjusted SL can indeed cause sporadic peaks in demand when stock is centralized, it is the primary source of supply for the customers and has no substitutes. DCE is one of the main and central DCs of Metso, therefore Ngniatedema's suggestion validates the cause. Another factor causing volume fluctuations was impact of public holidays. The matter was described also by Godfrey and Powell (2000). Authors define common problem of holidays in forecasting and their features: different types of holidays (fixed to date, weekday, changing yearly) as well as influence if holiday falls on other day probably exploited by causing long weekends. The implications have been presented below in Table 18.

TABLE 18. Implications of factors influencing order volumes

Factors influencing volumes	Influence	Effect
Urgent orders	Minor	Usually created and released on the same day. Hard to predict.
Relocation orders	Minor	May cause random, small increases in volumes.
Vendor returns	Minor	Usually small volumes, however, if bigger batches have to be shipped back to the vendor, may cause fluctuations.
Bank holidays of suppliers	Minor	Critical inbound backlog may cause compilation of outgoing orders.
Quarter changes	Medium	Increase in volumes on precending week.
Sales campaign and projects	Medium	May cause random, high increases in volumes.
Bank holidays of ordering parties	Major	Volumes decrease before holidays due to SAP limitations. Rapid increase of volumes in week after.
Bank holidays of DCE warehouse	Major	Weekly volume has to be processed during four days causing major fluctuations.
SL	Major	Rapid increase in volumes several weeks after the implementation of new level. Steady volume increase for the next months.
Market situation	Major	Long-term, steady increase in volumes.

The following chapter of this thesis has described several commonly known forecasting methods, simpler (ex. simple average) and more complex (ex. AR model). MAD value was chosen as the error measure to ensure consistency in method comparison. According to Green and Armstrong (2015), there is relatively few simple forecasting methods. Green and Armstrong (2015, 1679) state that analyses do require knowledge of experts in selecting variables and determining directions. In their research (2015, 1683), 84% of comparisons showed that simple forecasting methods were more accurate than complex methods. The research supports this thesis' result, as the simplest methods brought the best results.

All the analysis and results were used to build a forecasting dashboard presented in Figure 17. Dashboard was created according to Küsters' et al., (2006) and Person's (2013) advises to include real-time data, several forecasting methods with their performance. Currently the process is manual, so the actual dashboard creation will require support of RPA and IT.

Ability to maintain and analyze big data by manual means is currently becoming too challenging. Further studies are strongly recommended to determine in details possibility of utilizing existing software to support and develop the forecasting dashboard. There is many software in use like Every Angle and PRIME without having a link among each other to help data analysis. There is a potential in them as well as exploiting information from SAP transactions VL10H and YWM_OUTB_DEL_MONITOR. If the data compilation can be automatized, the information retrieved from these transactions can be very valuable. In addition, more detailed studies are needed on possible predictive scenarios which could be applied in the dashboard. The scenario should be adaptable to every route and shipping schedule change in SAP system as these are changed on regular basis.

Limitations on the research should be also noted. Because of narrow topic, there was relatively little literature on forecasting of 3PL. Most of the researches and papers focused either on inventory forecasting or making the picking process efficient by staffing and warehouse adjustments. Many statements regarding influential factors were recognized by similar results of other researches which confirms the validity of the research. Reliability was assured by running and calculating the statistics based on the same database and tools.

In conclusion, the thesis has succeeded in proving that there is a possibility to estimate the upcoming volumes to some extent by using several forecasting methods and data available in SAP. Nevertheless, it is very significant to consider other information and variables in channels and software to accomplish a forecast. The best solution to control the data from different sources was creating a forecasting dashboard. Dashboard is combing all the data influencing warehouse volumes which is needed for decision makers. By using this tool, the user is not only able to track the operations, but also to create a strategy. As a result, the warehouse is capable to react to volume fluctuations in time and keep the performance on a high level.

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APPENDICES

Appendix 1. Bank holidays in 2018. Days when warehouse is not operating or has limited operations are marked in red.

Bank holidays in 2018			
Week	**Country**	**Week**	**Country**
1	**Monday 1.1. NL, USA, FR, UK, DE, ZA, NO, AU**	**27**	Wednesday 4.7. USA
2		**28**	
3	Monday 15.1. USA	**29**	
4	Friday 26.1. AU	**30**	
5		**31**	
6		**32**	Monday 6.8. UK Thursday 9.8. ZA
7		**33**	Wednesday 15.8. FR
8	Monday 19.2. USA	**34**	
9		**35**	
10	Monday 5.3. AU	**36**	Monday 3.9. USA
11		**37**	
12	Wednesday 21.3. ZA	**38**	
13	Friday 30.3. NL, FR, UK, DE, ZA, NO, AU	**39**	Monday 24.9. ZA, AU
14	Monday 2.4. NL, FR, UK, DE, ZA, NO, AU	**40**	Wednesday 3.10. DE
15		**41**	Monday 8.10. USA
16		**42**	
17	Wednesday 25.4. AU **Friday 27.4. NL, ZA**	**43**	
18	Tuesday 1.5. FR, DE, ZA, NO	**44**	Thursday 1.11. FR, DE
19	Monday 7.5. UK Tuesday 8.5. FR **Thursday 10.5. NL, FR, DE, NO**	**45**	
20	Thursday 17.5. NO	**46**	Monday 12.11. USA
21	**Monday 21.5. NL, FR, DE, NO**	**47**	Thursday 23.11. USA Friday 24.11. USA
22	Monday 28.5. USA, UK	**48**	
23		**49**	
24		**50**	
25		**51**	Monday 17.12. ZA
26		**52**	**Tuesday 25.12. USA, NL, FR, UK, DE, ZA, NO, AU** **Wednesday 26.12. NL, UK, DE, ZA, NO, AU**

Appendix 2. PRIME policy

Relocation process

1. Relocations are done quarterly
2. Relocation report is validated by Global Inventory Planners– Global Inventory Planning will review the list of parts with relocation potential and make the decision whether or not to relocate. Locations no longer need to do this evaluation.
3. Relocation requests are sent to DSC locations by Global Inventory
4. Location makes relocation purchase orders manually

Scope of excess relocation list

- PRIME scope
- DC and satellite locations
- Obsolete and ultra-slow parts
- Excess critical parts

General information regarding relocations

- Up to 8 months of excess can be sent to the location
- All materials that are relocated must be of good quality and in saleable condition.
- Relocation PO's must be made within a week.
- Replaced materials are excluded from the scope of relocation

Balancing refers to the relocation of excess finished goods within the scope of the Distribution and Logistics network to a location needing the goods instead of procuring more goods from external suppliers. Typically balancing contains only one or few materials at the time based on open sales order demand. The Global Inventory Planning team is responsible for balancing inventory and communication towards the sites regarding necessary actions.