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A Configure-to-Order System Heuristic Model Production Scheduling for Textile Manufacturing: A Case Study of a Textile Company in the Philippines

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Abstract:*Due to the large variety of products made in textile fabric manufacturing, companies involved in this industry typically utilize a make-to-order production system, which causes potential operational inefficiencies due to suboptimal production scheduling in an industry where demand is generally unpredictable. As a result, these manufacturers experience difficulty in fulfilling customer orders especially during periods of peak demand. In order to mitigate the risk of delayed order fulfillment and lost customers, this paper explores and studies the option of utilizing a configure-to-order (CTO) production system, which introduces the concept of producing Work In Progress (WIP) greige fabrics in advance, in developing a heuristic model designed to indicate specific greige fabric Stock Keeping Units (SKUs) that should be designated for advance production, in addition to determining each of their production quantities, and the timing of their production. This case is applied to the situation of Oversea Warp Knitting incorporated, which currently experiences a similar problem.*

Key words: *production scheduling, configure to order system, textile manufacturing, heuristic models*

I. INTRODUCTION

Oversea Warp Knitting Incorporated (OWKI) is a Filipino-Chinese company involved in the Philippine textile industry, and is specifically engaged in the production of knitted fabrics made from yarn materials such as cotton and polyester. Some of the products in its current portfolio include Single and Polyester Jerseys, Rib, Dri Fit, and Cotton Spandex, among others, which are sold to locally-based garment manufacturers and retail wholesalers. Competing in a highly competitive environment, OWKI aims to take the initiative to further its position as an industry leader by helping customers succeed in their business through providing superior quality products and excellent services. The company plans to achieve this through a two-part business objective, namely to maximize the value proposition of its products and to improve its efficiencies by minimizing operational costs.

II. PROBLEM OVERVIEW

Generally, Oversea Warp Knitting Incorporation's does not fully utilize its production capacity during periods of normal demand. However, it faces significant difficulty in meeting the demands of its customers during peak seasons. This is because the company follows a make-to-order production system in manufacturing

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textile fabrics due to the complexity of carrying a high variety of products in its portfolio. This kind of system is more risk averse because the company does not have to produce SKUs without an order confirmation of a prospective buyer. With this system, it tries to avoid the risk of producing and holding SKUs in its inventory, as these generally have unpredictable demand. However, it frequently incurs significant opportunity costs. Specifically, it loses the opportunity of increasing its revenues by satisfying all of the orders of its customers, which the company cannot provide due to the temporary lack of available capacity in periods of high customer demand. It is important to find a solution to this problem as an interview with top management revealed that the company loses approximately 10% of its sales of two to three months in a year.

III. RELEVANT FACTORS AND PERFORMANCE METRICS

The operations research tool proposed to address the issue of the company having difficulty meeting demand is to develop a heuristic model through the use of Microsoft Excel that will utilize a configure to order system, which entails producing selected greige fabric SKUs in advance to be stored in inventor in order to potentially reduce the lead time required for customer order fulfillment.. This will be discussed in further detail in the Methodology section. The various inputs or relevant factors required by the model developed by the authors and its corresponding performance metric outputs are listed in the succeeding section.

Relevant Factors (Model Inputs)

List of SKUs with Historical Demand **-** This is a year's list of all the daily order of all the SKUs with their corresponding weights in kilograms and prices. A lot of data and information can be formulated from this list, which can be significant inputs to the model.

Total Production Capacity **-** This is the total machine hour capacity of all the different machines for all its SKUs. This wlll be needed in order to determine the maximum capacity of the machines, which will be the limit of the weekly ordered SKUs and the determinant of the excess available capacity for the production of the top selling greige fabrics in advance.

Sample Weekly Order **-** This is the list of actual weekly product orders that will serve as input data of the model. This is a crucial input in the analysis of the model because the current and target inventory level will be evaluated based on these sample orders.

Profit Margin Percentage **-** The percentage of the profit of each of the products of the company over their unit selling prices, which vary depending on the yarn material.

Average Daily Demand **-** Each of the top selling SKUs' daily average number of kilograms taken from a historical demand of one year.

Contribution Rating **-** This is the product of *Average Daily Demand* and *Profit Margin Percentage.* This rating is considered because it is important to both consider the volume and profitability of the SKUs.

Current Inventory **-** This is the week's current inventory level in each of the top selling SKU's in kilograms

Surplus Machine Hours **-** This is the total available machine hours of the company that is not being utilized by its weekly made-to-order productions. From this, the list of the top 11 SKUs will be allocated with proportional machine hours based on certain prioritizations.

IV. Performance Metrics (Model Outputs)

Primary Metrics

Days Level **-** This is the quotient of dividing the *Current Inventory* by the *Average Daily Demand.* This amount is the equivalent demand in the number of days of a particular SKU.

Target Days Level **-** This is the optimal stored days level of each of the top performing SKUs. This is derived from the historical performance of the company. Specifically, it takes into account the delays in its production and lost potential revenues. It is important to have the optimal target days level to always be able to meet to demands of its customers, while not having very significant amounts of inventory level.

Actual Machine Hours Utilized - This is the actual number of machine hours used for the production of a specific SKU fabric for the week. This number of hours utilized should be in support to reaching the identified target days level.

Equivalent Production For This Week - This is the total kilograms of production for each SKU.

Secondary Metrics

Average Number of Lead Time Days Taken per Kilo **-** Obtained from the company's past records, this is the average number of days it takes to produce a kilo of a particular SKU

Expected Number of Lead Time Days Taken per Kilo **-** Using the capacity of the machine, this is the expected number of days it takes to produce a kilo of a particular SKU

Lead Time Days Delayed per Kilo **-** This is the difference between *Average Number of Lead Time Days Taken per Kilo and Expected Number of Lead Time Days Taken per Kilo*

Zero Delay Days Level **-** This pertains to the amount of inventory that should be produced ahead to have no delays in days level. This is the product of the *Average Daily Demand* in Kilograms and the *Lead Time Days Delayed per Kilo.*

Lost Opportunity Days Level **-** This is the demand in days, worth ten percent of three months sales, that could not be met by the company in the past due to unavailable capacity. This is the product of *Expected Number of Lead Time Days Taken per Kilo* of a particular SKU and ten percent of the 3 month average demand.

Incompletion Rate **-** At the start of the week, this is the unachieved proportion of *Days Level* to the *Target Days Level*. In other words, it is the gap between the current level and the desired level of inventory for the SKU, which is expressed in terms of the percentage of the former.

Allocated Machine Hours - This is the machine hours allocation of each SKU based on its demand in volume, profitability, and percent of days level needed to reach its target level. The proportion between the percent of *Contribution Rating* and *Incompletion Rate* is 7:3, which is intuitively set by the group for its prioritization criteria for

Needed Machine Hours - This is the number of machine hours that an SKU needs to achieve its *Target Days Level*

Cumulative Excess Machine Hours - This is the excess available machine hours allocated to each SKU based on its prioritization

This Week's Fill Rate - This is the total additional percentage of days level of each SKU for the week.

V. METHODOLOGY

The methodology used to address the company's problem involves utilizing a configure-to-order production system, which can also be described as a hybrid of make-to-stock and make-to-order systems. The general objective is to move the customer order decoupling point (CODP) of the company's production to somewhere more downstream of the value chain. The CODP is the point in the production process where the inventory is last held in. In a make-to-stock production system, it is at the end of the process, which means that the ordered goods by the customer are already stored in finished goods inventory. This is shown in figure 1.

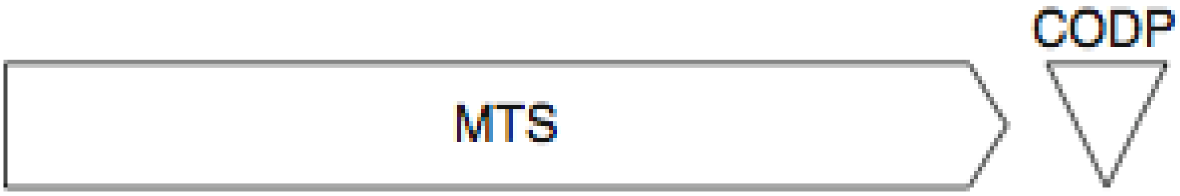

Figure 1: Make-to-stock production system

In contrast, a make-to-order system has the decoupling point at the other end of the value chain, which means that the entire production process only begins at the point of the customer's order. This is the current production method employed by the company, because of the high-variety-product nature of the textile industry. Again, this can be visualized through the following manner below:

Figure 2: Make-to-order production system

A configure to order system is basically a middle ground between the two aforementioned methods. As seen in the figure below, the CODP is placed between the middle of the upstream and downstream of the value chain process. In the context of OWKI, following a CTO system implies that the company should produce certain fabrics of the bottleneck stage in advance, such that when a customer orders that specific SKU, only the non- bottleneck stages are needed to complete the manufacturing process of the product, which significantly lessens the original order fulfillment lead time.

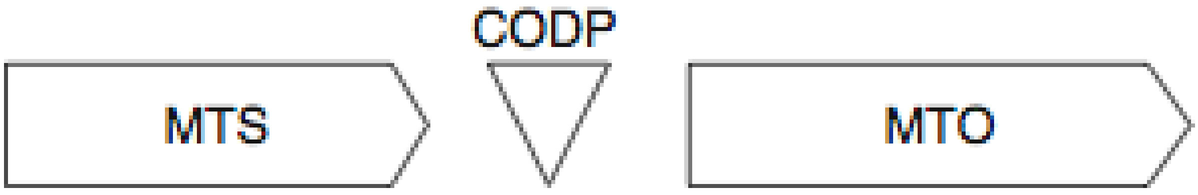

Figure 3: Make-to-stock production system and make-to-order production system

This concept is integrated into the OR tool developed by the group through the formulation of a heuristics model in Microsoft Excel. The model will determine the weekly production plan of the company that involves fabrics produced in advance. Moreover, a **VBA automation** was incorporated in order to extend the range of the model to reflect the situation to the end of at most three weeks.

There are two important initial stages in the development of the model, and these are the (1) identification of the bottleneck stage in the company's manufacturing process, and (2) the selection of which products at the bottleneck stage to produce.

Identification of the bottleneck stage

There are only two possible choices for the bottleneck stage or for where the decoupling point can be placed. These are (1) the point after the knitting stage, and (2) the point after the dyeing and finishing stage, wherein the fabrics should have already gone through the complete textile fabric manufacturing process. Based on an interview with the Operations Manager of the company's plants, the bottleneck stage happens during the knitting portion of the production. This means that the company should produce to stock greige fabrics, which are fabrics that have gone through the knitting process but have not yet undergone any process of dyeing and/or finishing.

Selection of greige fabric SKUs

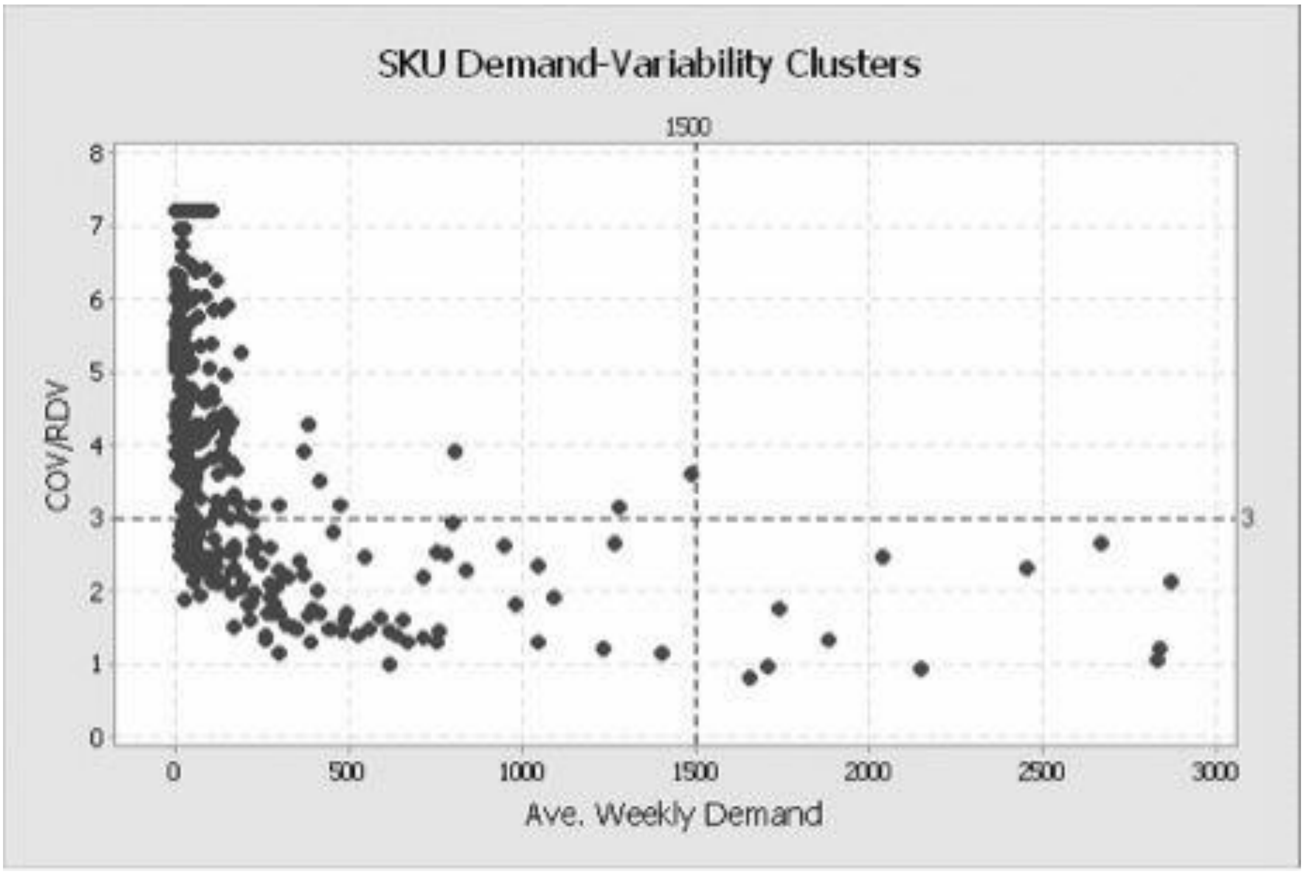

Figure 4: A scatter plot of OWKI's active SKUs and corresponding COV/RDV

In Kotayet et al. (2011), the authors used a Relative Demand Volatility (RDV) analysis, which created clusters for the different greige fabric SKUs based on their average volume demand and their Coefficient of Variation (CoV), a ratio which is arrived at by the division of the standard deviation of the specific product's demand and its average weekly demand. A scatter plot of the company's relatively active SKUs and their corresponding COV/RDVs yielded four clusters. For the purposes of this study, the cluster of significant interest is the one containing fabrics of high volume and low variability, which is located at the lower right area of the plot. There are 11 different SKUs located under this classification-- these are the SKUs that will be produced in advance for the model.

SKU Full Name	Average Weekly Demand (Kgs)	Coefficient of Variation (CoV)
LC2420TC15(1-1)34D	2871.55	2.12
LC2420TC14(1-1)34D	2666.49	2.66
SK2824CVC1832D	2834.97	1.19
SK2830CC2032D	2828.55	1.03
LC2420CVC14(1-1)34D	2457.01	2.32
SK2830CC2038D	2146.62	0.91
SK2830TC1830D	1739.66	1.75
SK2830CC-S1538D	2037.86	2.44
SK2824CVC1830D	1880.64	1.31
SK2830CVC1838D	1708.04	0.94
SK2830CVC1832D	1654.15	0.81

Table 1: Selected Top-Perfoming SKUs

The next stage after the determination of which SKUs to produce in advance is to list down the total weekly production capacity relevant to the abovementioned SKUs, which are expressed in the number of machine hours needed to produce one kilogram of every yarn count variant available for the machine, which is also somewhat dependent on the knitting type:

		Machine Hours Needed Per Kilogram of Each Yarn Count Variant					
# of Machines Available	Machine Hours Available	20	24	30	36	40	
89	14952	0.048	0.053	0.064	0.08	0.08	Single Jersey
		0.053	0.06	0.074	0.096	0.096	Lacoste
		0.053	0.06	0.074	0.096	0.096	Fleece
		0.053	0.06	0.074	0.096	0.096	Honeycomb

Figure 5: A Microsoft Excel screenshot of Machine Hours Needed Per Kilogram of Each Yarn Count Variant

After which a week's worth of sample orders was entered into a separate designated worksheet, a screenshot of which is shown directly below. Currently, the model can be extended to a maximum of three weeks. If the template of the names of these worksheets is followed to create further sheets (i.e. ORDERS WEEK #), it can be extended indefinitely. These are separate worksheets specifically intended for the input of the sample weekly orders, which should contain pertinent columns such as the full SKU name of the order, divided into their respective elements, along with the specified weight of the greige fabric. Moreover, orders of the chosen top 11 SKUs are subtracted from the total that will be calculated for the succeeding step. This is because these orders will be served through the advance fabric production. However, if the demand is greater than the current supply in inventory, the remaining amount is still retained in order to accurately reflect the necessary utilization for the week:

DATE	CUSTOMER	SKU	KNITTING	GAUGE	COUNT	MATERIAL	SPI	DIAMETER	WEIGHT	MODIFIED WT	
2/2	EVERGROWTH	SK2420CVC1532D	SK	24	20	CVC	15	32D	129.9	129.9	
2/2	YEWDEE	SK2420CVC1632D	SK	24	20	CVC	16	32D	390.7	390.7	
2/2	YEWDEE	SK2420CVC1632D	SK	24	20	CVC	16	32D	391.5	391.5	
2/2	BUM EQUIPMEN	SK2830CVC2038D	SK	28	30	CVC	20	38D	469.3	469.3	
2/2	STARWAVE	SK2830CVC1832D	SK	28	30	CVC	18	32D	211.2	211.2	
2/2	STARWAVE	SK2830TC1638D	SK	28	30	TC	16	38D	101.5	101.5	
2/2	CSJ	SK2424TC1518D	SK	24	24	TC	15	18D	255.2	255.2	LC2420TC15(1-1)34D
2/2	CSJ	SK2424TC1519D	SK	24	24	TC	15	19D	358.4	358.4	LC2420TC14(1-1)34D
2/2	CSJ	SK2424TC1520D	SK	24	24	TC	15	20D	127	127	SK2824CVC1832D
2/2	KERITH BROOK	SK2824CVC1632D	SK	28	24	CVC	16	32D	103.9	103.9	SK2830CC2032D
2/2	KERITH BROOK	SK2824CVC1632D	SK	28	24	CVC	16	32D	103.5	103.5	LC2420CVC14(1-1)34D
2/2	KERITH BROOK	SK2824CVC1632D	SK	28	24	CVC	16	32D	104	104	SK2830CC2038D
2/2	KERITH BROOK	SK2824CVC1632D	SK	28	24	CVC	16	32D	104	104	SK2830TC1830D
2/2	ROBERT BROWN	SK2420CVC1832D	SK	24	20	CVC	18	32D	527.2	527.2	SK2830CC-S1538D
2/2	ROBERT BROWN	SK2420CVC1632D	SK	24	20	CVC	16	32D	105.3	105.3	SK2824CVC1830D
2/2	ROBERT BROWN	SK2420CVC1632D	SK	24	20	CVC	16	32D	105.3	105.3	SK2830CVC1838D
2/2	ROBERT BROWN	SK2420CVC1632D	SK	24	20	CVC	16	32D	156.8	156.8	SK2830CVC1832D
2/2	UPSCALE	F2424CVC1534D	F	24	24	CVC	15	34D	542	542	
2/2	UPSCALE	F2430CVC1534D	F	24	30	CVC	15	34D	336.5	336.5	
2/2	CARNELIGH	F2430CVC1534D	F	24	30	CVC	15	34D	362.7	362.7	
2/2	CARNELIGH	F2430CVC1534D	F	24	30	CVC	15	34D	452.9	452.9	
2/2	WOODSGREEN	SK2830CVC1830D	SK	28	30	CVC	18	30D	104.4	104.4	
2/2	WOODSGREEN	SK2830CVC1830Dw/NL	SK	28	30	CVC	18	30D	131.2	131.2	
2/2	GRAVITEE	SK2420TC1934D	SK	24	20	TC	19	34D	512.8	512.8	
2/2	GRAVITEE	SK2420TC1934D	SK	24	20	TC	19	34D	255.3	255.3	
2/2	GRAVITEE	SK2420TC1634D	SK	24	20	TC	16	34D	308.1	308.1	
2/2	GOLDWING	SK2830CVC1832D	SK	28	30	CVC	18	32D	105.2	105.2	
2/2	GOLDWING	SK2830CVC1832D	SK	28	30	CVC	18	32D	158.3	158.3	
2/2	GOLDWING	SK2830CVC1832D	SK	28	30	CVC	18	32D	105.3	105.3	
2/2	GOLDWING	SK2830CVC1832D	SK	28	30	CVC	18	32D	105.6	105.6	
2/2	GOLDWING	SK2830CVC1832D	SK	28	30	CVC	18	32D	105.5	105.5	
2/2	TIONG HENG	SK2420CVC1634D	SK	24	20	CVC	16	34D	26.2	26.2	
2/2	TIONG HENG	SK2420CVC1634D	SK	24	20	CVC	16	34D	26.3	26.3	

Assumptions
Order of 2nd week onwards should not include chosen top performing SKUs

Figure 6: A Microsoft Excel screenshot of a sample of inventory

As mentioned previously, this will translate into the following weekly utilization table expressed in the number of machine hours used for the production of the week's sample orders—at least, for those fabrics that don't have inventory in store.

	Utilized Machine Hours	Machine Hours Utilized for Each Yarn Count Variant (for the Week)					
Backlog Hours		**20**	**24**	**30**	**36**	**40**	**Knitting Type**
	5597.56	2117.27	1600.62	1809.76	0.00	69.91	**Single Jersey**
	95.33	31.74	6.31	57.28	0.00	0.00	**Lacoste**
	184.67	0.00	99.59	85.08	0.00	0.00	**Fleece**
	0	0.00	0.00	0.00	0.00	0.00	**Honeycomb**

Figure 7: Weekly utilization table expressed in machine hours

Afterwards, the difference of the total production capacity and the total utilized machine hours for the week will be derived to get the total available surplus machine hours available for the advance production of the selected fabrics.

Surplus Machine Hours
9074.439863

Figure 8: The result of the simulation in Microsoft Excel

This total surplus machine hours is allocated to the production of the different SKUs through the employment of a prioritization scheme developed by the authors of this paper.

SKU Full Name	Product of Average Demand and Profit Margin Percentage	Production Priority	Profit Margin Percentage	Average Daily Demand (Kilos)	Current Inventory (Kilos)	Days Level	Target Days Level	Incompletion Rate	Allocated Machine Hours	Needed Machine Hours	Excess Allocated Machine Hours
LC2420TC15(1-1)34D	31.56	1	8%	410	0	0.00	77.89	100%	1071.71	1704.09	0.0
LC2420TC14(1-1)34D	29.30	2	8%	381	0	0.00	59.75	100%	1012.85	1213.85	0.0
SK2824CVC1832D	26.59	3	7%	405	0	0.00	29.29	100%	942.03	632.68	309.3
SK2830CC2032D	25.98	4	6%	404	0	0.00	49.03	100%	925.98	1267.86	0.0
LC2420CVC14(1-1)34D	23.05	5	7%	351	0	0.00	39.74	100%	849.43	743.94	105.4
SK2830CC2038D	19.71	6	6%	307	0	0.00	41.57	100%	762.41	815.86	52.0
SK2830TC1830D	19.12	7	8%	249	0	0.00	27.31	100%	746.82	434.44	364.4
SK2830CC-S1538D	18.72	8	6%	291	0	0.00	44.23	100%	736.32	824.10	276.6
SK2824CVC1830D	17.64	9	7%	269	0	0.00	29.62	100%	708.22	424.43	560.4
SK2830CVC1838D	16.02	10	7%	244	0	0.00	26.60	100%	665.94	415.43	810.9
SK2830CVC1832D	15.52	11	7%	236	0	0.00	28.84	100%	652.74	436.13	1027.5

Figure 9: The prioritization scheme developed by the authors

The prioritization scheme has its basis on two factors, with the first one having two sub-elements, namely: (1) the average daily volume demand, in kilograms, of each of the SKUs, and (2) their respective profit margin percentages, which are the quotient of their profit contributions to their unit selling prices. These two are multiplied to get a contribution rating value. The other factor to be considered is the rate of incompletion, which is the percentage gap between the current inventory, which is expressed in days level, and the respective target days levels for each SKU. These two factors are given intuitive weights of 70% and 30% respectively, because the authors argue that the ultimate emphasis of which greige fabrics to stock is dependent on its contribution ability in terms of demand volume and profit. Their weighted sums will then be taken, which will be used to determine how much of the total surplus machine hours will be allocated to each of their advance productions.

Days Level Calculations				
SKU	Average # of lead time days taken per kilo	Expected # of lead time days taken per kilo	Lead time days delay per kilo	Zero Delay Days Level
LC2420TC15(1-1)34D	0.171479773	0.002222222	0.169257551	69.43317017
LC2420TC14(1-1)34D	0.138459307	0.002222222	0.136237085	51.89649167
SK2824CVC1832D	0.053934272	0.002222222	0.051712049	20.94312198
SK2830CC2032D	0.099258849	0.002666667	0.096592183	39.0308183
LC2420CVC14(1-1)34D	0.094828002	0.002222222	0.09260578	32.50475858
SK2830CC2038D	0.113490543	0.002666667	0.110823876	33.98519007
SK2830TC1830D	0.087837803	0.002666667	0.085171136	21.16693963
SK2830CC-S1538D	0.129863738	0.002666667	0.127197072	37.02991331
SK2824CVC1830D	0.091864622	0.002222222	0.0896424	24.0835229
SK2830CVC1838D	0.086954579	0.002666667	0.084287912	20.56677307
SK2830CVC1832D	0.099967895	0.002666667	0.097301228	22.99291486

Figure 10: Days Level Calculations as it appeared in MS Excel

The production volume objectives of each of the chosen SKUs are expressed in terms of a target days level, which is based on an analysis on two levels of the company's historical production; first, the average lead time per kilo of each of the SKU fabrics according to historical rates is taken and compared to the expected lead time of the same measure. From here, the difference of the two is taken to reflect the amount of "delay" time that when multiplied to the average daily demand, shows the amount days level inventory that should have been produced in advance.

SKU Full Name	Zero Delay Days Level	Lost Opportunity Days Level	Target Days Level
LC2420TC15(1-1)34D	69.43	8.46	77.89
LC2420TC14(1-1)34D	51.90	7.85	59.75

SK2824CVC1832D	20.94	8.35	29.29
SK2830CC2032D	39.03	9.99	49.03
LC2420CVC14(1-1)34D	32.50	7.23	39.74
SK2830CC2038D	33.99	7.58	41.57
SK2830TC1830D	21.17	6.15	27.31
SK2830CC-S1538D	37.03	7.20	44.23
SK2824CVC1830D	24.08	5.54	29.62
SK2830CVC1838D	20.57	6.04	26.60
SK2830CVC1832D	22.99	5.84	28.84

Table 2: The Production Volume Objectives of the chosen SKUs

The previous level covered the demand of customers that experienced delays because of bottlenecks. For this second level, the Lost Opportunity Days Level worth of inventory is a measure of the amount of sales of customers that were turned away because of the unavailable capacity. Adding this to the formerly mentioned zero delays days level measure, the sum will reflect the total amount of potential demand that could be served by producing the equivalent amount of fabric in advance.

As mentioned earlier, the VBA aspect of the model (shown below) will be used to extend the range of the weekly production model to at most three weeks.

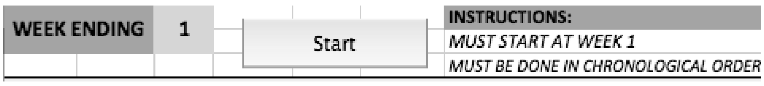

Figure 11: VBA programmed for simulation

VI. RESULTS

Week 1: Result of the First Random Sample Order

In the first week, there are no inventory levels and day's level for the SKUs. Machine hours are proportionally allocated to the different SKUs. Eight of the eleven SKU's Target Days Level were filled and achieved.

SKU Full Name	Days Level	Target Days Level	Incompletion Rate	Allocated Machine Hours	Needed Machine Hours	Cumulative Excess Allocated Machine Hours	Actual Machine Hours Utilized This Week	Equivalent Production For This Week (In Kilograms)	This Week's Fill Rate
LC2420TC15(1-1)34D	0.00	77.89	100%	1071.71	1704.09	0.00	1071.71	20094.54	63%
LC2420TC14(1-1)34D	0.00	59.75	100%	1012.85	1213.85	0.00	1012.85	18990.95	83%
SK2824CVC1832D	0.00	29.29	100%	942.03	632.68	309.35	632.68	11862.71	100%
SK2830CC2032D	0.00	49.03	100%	925.98	1267.86	0.00	1235.33	19302.07	97%
LC2420CVC14(1-1)34D	0.00	39.74	100%	849.43	743.94	105.49	743.94	13948.80	100%
SK2830CC2038D	0.00	41.57	100%	762.41	815.86	52.04	815.86	12747.83	100%
SK2830TC1830D	0.00	27.31	100%	746.82	434.44	364.42	434.44	6788.14	100%
SK2830CC-S1538D	0.00	44.23	100%	736.32	824.10	276.63	824.10	12876.63	100%
SK2824CVC1830D	0.00	29.62	100%	708.22	424.43	560.42	424.43	7958.04	100%
SK2830CVC1838D	0.00	26.60	100%	665.94	415.43	810.94	415.43	6491.05	100%
SK2830CVC1832D	0.00	28.84	100%	652.74	436.13	1027.54	436.13	6814.61	100%

Figure 12: Results of the first week simulation

Week 2: Result of the Second Random Sample Order

In the second week, the first SKU of the list, LC2420TC15(1-1)34D, had the highest Days Level with 46.11 days but was still 41% below from its Target Days Level of 77.89 days. With the proportions of allocated machine hours, its inventory level was refilled, utilizing 695.26 machine hours and producing 13,036.03 Kilograms. Moreover, all other SKUs also reached their Target Days Level, while leaving a Cumulative Excess Allocated Machine Hours of 6190.54.

SKU Full Name	Days Level	Target Days Level	Incompletion Rate	Allocated Machine Hours	Needed Machine Hours	Cumulative Excess Allocated Machine Hours	Actual Machine Hours Utilized This Week	Equivalent Production For This Week (In Kilograms)	This Week's Fill Rate
LC2420TC15(1-1)34D	46.11	77.89	41%	1255.64	695.26	560.38	695.26	13036.03	41%
LC2420TC14(1-1)34D	3.80	59.75	94%	1480.46	1136.59	904.25	1136.59	21311.01	94%
SK2824CVC1832D	23.06	29.29	21%	984.10	134.54	1753.80	134.54	2522.71	21%
SK2830CC2032D	18.28	49.03	63%	1197.97	795.17	2156.60	795.17	12424.60	63%
LC2420CVC14(1-1)34D	0.28	39.74	99%	1309.04	738.66	2726.98	738.66	13849.81	99%
SK2830CC2038D	31.98	41.57	23%	770.79	188.22	3309.56	188.22	2940.86	23%
SK2830TC1830D	21.11	27.31	23%	749.35	98.65	3960.27	98.65	1541.34	23%
SK2830CC-S1538D	10.35	44.23	77%	1040.32	631.28	4369.30	631.28	9863.81	77%
SK2824CVC1830D	0.12	29.62	100%	1135.09	422.72	5081.66	422.72	7926.07	100%
SK2830CVC1838D	18.51	26.60	30%	692.29	126.41	5647.54	126.41	1975.23	30%
SK2830CVC1832D	20.10	28.84	30%	675.21	132.21	6190.54	132.21	2065.79	30%

Figure 13: Results of the second week simulation

Week 3: Results of the Third Random Sample Order

In the third week, four of the inventory levels of the SKUs remained the same. This means that no customers ordered the following SKUs in the third week. Their Days Levels still remained equal with their corresponding Target Days Level, 59.75 days, 29.29 days, 27.31 days, and 44.23 days respectively. Also, all of the Days Level of the SKUs were either remained the same or replenished to reach their Target Days Level.

SKU Full Name	Days Level	Target Days Level	Incompletion Rate	Allocated Machine Hours	Needed Machine Hours	Cumulative Excess Allocated Machine Hours	Actual Machine Hours Utilized This Week	Equivalent Production For This Week (In Kilograms)	This Week's Fill Rate
LC2420TC15(1-1)34D	30.37	77.89	61%	1074.37	1039.73	34.63	1039.73	19494.98	61%
LC2420TC14(1-1)34D	59.75	59.75	0%	676.08	0.00	710.71	0.00	0.00	0%
SK2824CVC1832D	29.29	29.29	0%	613.52	0.00	1324.23	0.00	0.00	0%
SK2830CC2032D	28.22	49.03	42%	840.19	538.01	1626.41	538.01	8406.45	42%
LC2420CVC14(1-1)34D	0.00	39.74	100%	1099.29	743.94	1981.77	743.94	13948.80	100%
SK2830CC2038D	41.08	41.57	1%	461.49	9.54	2433.71	9.54	149.04	1%
SK2830TC1830D	27.31	27.31	0%	441.10	0.02	2874.80	0.02	0.25	0%
SK2830CC-S1538D	44.23	44.23	0%	431.79	-0.02	3306.61	-0.02	-0.29	0%
SK2824CVC1830D	1.59	29.62	95%	944.11	401.66	3849.07	401.66	7531.14	95%
SK2830CVC1838D	13.44	26.60	49%	650.50	205.57	4293.99	205.57	3212.10	49%
SK2830CVC1832D	7.22	28.84	75%	783.39	326.90	4750.48	326.90	5107.77	75%

Figure 14: Results of the third week simulation

The results of this model reveal the instructions needed for the advance production of key greige fabrics. After following this, it will yield the benefit of having inventory stored for the specified target days level, which is equivalent to the amount demand for the number of days value indicated. By having pre-processed fabrics stored in advance, the lead time of the usual customer order for these fabrics will be generally cut into half, since only the dyeing and finishing stages will be needed to complete them. In addition, the orders of the other SKUs will be less affected by bottlenecks that were brought as a result of a high volume of orders. This is because the total production capacity of the company available for the specified period will be less fully utilized and more "free" for the production of the latter.

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