ФИЗИКО-МАТЕМАТИЧЕСКИЕ И ТЕХНИЧЕСКИЕ НАУКИ

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MODELLING, RECOMMENDATION AND ANALISYS OF DEMAND PLANNING IN FMCG

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Abstract. *Most of the fast-moving consumer goods companies (FMCG) have two main targets in order to become successful on the market. First, it is profit maximization and the second one is cost optimization or minimization. If the company can hold those two key performance indicator (KPIs) in balance, it has all the odds to be competitive and successful in the field of operation. Supply Chain (SC) team and in particular Demand planning (DP) plays a crucial role in achieving those targets mentioned above with help of recommendation modelling systems. Demand planning team are those who can translate business needs into meaningful and measurable numbers for Supply Chain keeping healthy inventory level and delivering the goods that needed with the best freshness and availability possible. Further, we will describe and analyze how to achieve better results vs. current solutions on specific company called PepsiCo via modelling and analyzing Demand Planning in FMCG sector overall.*

Key words: *prediction, analyze, recommendation system, machine learning, big data, supervised training, dataset, Demand Planning, FMCG, Supply Chain.*

СЕКТОРДА ЖҰМЫС ЖАСАУ, ҰСЫНЫСТАР ЖӘНЕ ТАЛАПТЫ ТАЛДАУ

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Аңдатпа. *Жылдам өсіп келе жатқан тұтынушылық тауарлар (Fast-moving consumer goods – FMCG) компанияларының көпшілігі нарықта сәттілікке жету үшін екі негізгі мақсат қояды. Біріншіден, бұл пайданы максимизациялау, екіншіден, шығындарды оңтайландыру немесе азайту. Егер компания осы екі негізгі көрсеткішті (key performance indicator – KPI) теңгере алса, оның бәсекеге қабілетті және өз ісінде табысты болуға барлық мүмкіндігі бар. Ұсыныстарды модельдеу жүйелері арқылы жоғарыда аталған мақсаттарға жетуде жеткізілім тізбегі (Supply Chain – SC) тобы және әсіресе Сұранысты жоспарлау шешуші рөл атқарады. Жабдықтау тізбегі – бұл тауарлық-материалдық құндылықтарды сақтау және қажетті тауарларды максималды сергектікпен және қол жетімділікпен жеткізе отырып, бизнес қажеттіліктерін жеткізілім тізбегі үшін маңызды және өлшенетін сандарға айналдыра алатындар. Бұдан әрі біз жалпы FMCG секторына сұранысты жоспарлауды модельдеу және талдау арқылы нақты PepsiCo компаниясы үшін қазіргі шешімдерге қарағанда жақсы нәтижелерге қалай жетуге болатындығын сипаттаймыз және талдаймыз.*

Түйінді сөздер: *болжау, талдау, ұсыныстар жүйесі, машиналық оқыту, үлкен мәліметтер, бақыланатын оқыту, мәліметтер базасы, сұранысты жоспарлау, FMCG, жабдықтау тізбегі.*

МОДЕЛИРОВАНИЕ, РЕКОМЕНДАЦИИ И АНАЛИЗ СПРОСА ПЛАНИРОВАНИЯ В СЕКТОРЕ

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Аннотация. *Большинство быстроразвивающихся компаний по производству потребительских товаров (Fast-moving consumer goods – FMCG) преследуют две основные цели, чтобы добиться успеха на рынке. Во-первых, это максимизация прибыли, а во-вторых, оптимизация или минимизация затрат. Если компания сможет сбалансировать эти два ключевых показателя эффективности (key performance indicator – KPI), у нее есть все шансы на то, чтобы быть конкурентоспособной и успешной в своей области деятельности. Команда Supply Chain (SC), и в частности планирование спроса (Demand Planning – DP), играет решающую роль в достижении целей, упомянутых выше, с помощью систем моделирования рекомендаций. Команда по Supply chain – это те, кто может преобразовать потребности бизнеса в значимые и измеримые числа для supply chain, поддерживая здоровый уровень запасов и доставляя необходимые товары с максимальной свежестью и доступностью. Далее мы опишем и проанализируем, как добиться лучших результатов по сравнению с текущими решениями для конкретной компании PepsiCo, путем моделирования и анализа планирования спроса в секторе FMCG в целом.*

Ключевые слова: *прогнозирование, анализ, система рекомендаций, машинное обучение, большие данные, обучение с учителем, набор данных, планирование спроса, FMCG, цепочка поставок.*

Introduction

Majority of international companies in FMCG sector have complexities related to Supply Chain operations starting from Demand Planning and ending with Customer orders fulfillment.

There are many chains in between like procurement of raw materials, factory planning, supply planning, logistics, warehousing, distribution and customer service, but in this paper, we will be focusing only on Demand Planning and in particular Kazakhstan market, which makes this research unique and supposedly should solve profit maximization and cost optimization KPI issues, basically, meaning save some cash and time.

• DP function within Supply Chain is the starting point for a business that has production and appropriate scale. DP team works with Forecast Accuracy (FA) and bias, in other words DP planner predicts which product will be sold in particular city, channel (traditional or modern trade) with lag time of up to 16 weeks with best possible forecast accuracy (FA). So, providing high FA on Stock Keeping Unit (SKU) level with lag intervals two or four weeks lead to lower inventory levels, fresh products on shelves, product availability, less out of stocks of products and as a result, to higher cash flow, which makes the company agile and more competitive on the market.

• Lots of uncertainties should be taken into account in order to get high results. Such obstacles might be promotional activities, discounts, new product developments, equipment installations, ATL(Above The Line) and BTL(Below The Line) activities by Marketing team, competitor's activities, price increase, external factor (perhaps, COVID-19 or fasting periods) and many more...

• Modelling, recommendation and analysis is a big part of DP and to make predictions as accurate as possible, the company has to take the changing variables mentioned above and we will take into account only several of them, which are relevant to us and available on hand. As ethics suggest we cannot take insider's information to take advantage over the competitors. So, we will

be using in this research only historical data as well as the data available to us.

Healthy business supposed to have healthy inventory stocks in order to operate the business properly and have enough cash flow to pay the employees' salaries and dividends to shareholders and buy raw materials to keep business running. So, in this research we will try to answer how to predict the best possible FA and bias with the data on hand within scarcity of resources like manpower, time, efficiency & effectiveness resulting the highest possible productivity level.

• The dataset we need to analyze and observe mainly is historical data sales, which helps us to identify season spikes and the trend that will most probably will occur from period to period by categories.

• Legitimate external sources like Nielsen research reports, which can help us to get grasp of market share and analyze how the market is evolving, category growth and give an understanding where we are vs. our competitors and identify whether our actions in the past and current are well designed and executed by counterpart departments like Sales, Marketing, Trade Marketing, Finance and Supply Chain.

Answering and analyzing all the questions above with the help of new machine learning modelling in DP, we will be able to excel at predictions vs. current state resulting in higher profitability and cash flow optimization meaning that business unit can earn more profit, market share and other crucial performance indicators. Our model/recommendation system should help in sales prediction in right amount, in the right place and in a timely manner.

Methodology

Now the whole world faced pandemic virus called COVID-19, which dramatically changed the way people behaved before and after the virus entered our lives. One example with toilet papers that stocked out around the world during the first a couple of weeks since quarantines around the world were announced. There are researchers who proposed solution to manage demand uncertainty in Supply Chain Planning with manufacturing decisions modeled as "here-and-now", which are made before demand realization. Subsequently, the logistics decisions are postponed in a 'wait-and-see' mode to optimize in the face of uncertainty. But with such approach we can face out of stock on shelves plus increased prices for the goods in high demand, which will directly affect final customers who buy those products. [1]

Another research paper that proposes a new paradigm for tactical Demand Chain Planning (DCP), called robust planning, based on risk assessment of the supply and demand chain. It outlines that a significant number of information systems have emerged, but most of the adopt a myopic view of planning, based on pure deterministic planning methods. It demonstrates that such an approach fails to coop with the considerable uncertainty of the planning information. The proposed robust planning paradigm is introduced and it promise to reduce the number of re-planning cycles, through a better characterization of the expected service level performance over a medium planning horizon. [3]

Third paper shows large benefits which are achieved by Supply Chain Management that are accredited to the reduction of inventories, especially to decrease of safety stocks. While safety stocks are mainly influenced by uncertainty, it is appealing that most effort should be spent on the reduction of uncertainty. Two sources of uncertainty are known in supply chains: process uncertainty (ex. unreliable production processes, fluctuating lead times etc.) and demand uncertainty (difference in planned or estimated demand and actual sales). The purpose of Demand Planning is to improve decisions affecting demand accuracy and the calculation of safety stocks to reach a predefined service level. All decisions in the whole supply chain should be based on already fixed (accepted) customer orders and planned forecasts, the latter ones are determined in the Demand Planning process. Therefore, the performance of each supply chain entity depends on the quality 2 of the demand plan. This also implies that these figures need to be the result of a collaborative effort. [4]

The last paper talks about mainstream inventory management approaches typically assume a given theoretical demand distribution and estimate the required parameters from

historical data. A time series based framework uses a forecast (and a measure of forecast error) to characterize the demand model. However, demand might depend on many other factors rather than just time and demand history. Inspired by a retail inventory management application where customer demand, among other factors, highly depends on sales prices, price changes, weather conditions, paper presents two data-driven frameworks to set safety stock levels when demand depends on several exogenous variables. The first approach uses regression models to forecast demand and illustrates how estimation errors in this framework can be utilized to set required safety stocks. The second approach uses Linear Programming under different objectives and service level constraints to optimize a (linear) target inventory function of the exogenous variables. The researchers show that considerable improvements of the overly simplifying method of moments are possible and that the ordinary least squares approach yields a better performance than the LP-method, especially when the data sample for estimation is small and the objective is to satisfy a non-stock out probability constraint. However, if some of the standard assumptions of ordinary least squares regression are violated, the LP approach provides more robust inventory levels. [2] So, I have checked different approaches, which are discussed above and will try to find unique solution with insights from the researchers above. All the papers say that lower inventory level is good for the company, but it should not be at the cost of out of stock and the hardest part is that there are a lot of uncertainties and variables that fluctuate a lot.

First, we suggest dividing planning into two parts: short-term demand planning (up to 16 weeks) and long-term demand planning (16 weeks and up to 18 months). Where short-term planning looks for shorter periods on weekly basis by cities, channels (Traditional Trade – TT and Modern Trade – MT) and on SKU level and long-term planning analyzes broader period of time up to 18 months on monthly basis by regions, channels and pricing groups (group of the same SKUs or so-called sub-categories). The main difference is that the closer forecast appears the more focused analysis should be in place, since we have more data available to be analyzed, which directly affects inventory level and safety stocks.

Second, we propose to forecast sell out (sales from distributor to stores) and taking into account stock levels at the beginning of the month and respectively plan sell in volumes (sales from company to distributors). This approach results in win-win strategy and shows that we are caring about distributors as well as sales overall. This brings partnership to the next and loyalty toward us. In future, the best results might show sell out data (from stores to final consumers), but in real world of Kazakhstan it is hard to acquire such information. This approach is more suitable for developed countries, but we might come to the point when we will be able to analyze such data as well.

Third, data validity and history horizon. We decided that synchronization between distributor's ERP systems and our sales system should be on weekly basis and consolidated information for whole country will be as a baseline for DP. Three years should be more than enough to identify baseline for each SKU in portfolio (5 categories and around 350 SKUs).

Fourth, we mentioned above that there are a lot of uncertainties that should be taken into account like promotional activities and actions by competitors, price changes, weather conditions, any governmental restrictions, marketing advertisements, lottery and so on. But we should limit all the features that will be fed to modelling/recommendation system, otherwise it will consume a lot of manpower in collecting all those data and normalizing it on weekly basis for short-term planning. In addition, FMCG sector changes rapidly meaning that it might be a monkey work and increase FA slightly, when spending many resources.

Fifth, weekly meetings are deployed with Sales, Marketing, Trade Marketing and Supply Chain teams to get feedback in real time from the field of sales (stores, supermarkets and hypermarkets). Now, I explained the methodology how it supposed to work. Let's compare current state versus what will change with implementation of ML modelling/recommendation system in current processes.

Currently, there is a tool called Prolink that uses historical data for short-term planning and particularly excel spreadsheets, which uses statistical model Lewandowski, but is highly depended on DP planners that are feeding inputs manually from weekly short-term meetings and asymptotically produce FA. This approach is good, but human error-prone.

As a solution, we identified features that influence Demand forecast the most. Those are promo 3 activities, issues on factory, weather conditions that delay transportation, motivational programs for sales representatives and equipment installations in the stores. I gathered sell out historical data for the past three years, promo activities are partially in place, weather conditions can be acquired online, motivational programs and equipment installations are in process. Feeding the main features into ML modelling/ recommendation system should give better FA results and lessen human interaction thus giving better financial results to company and allot more time for planners to analyze forecast thoroughly.

Expected Results

Now, we got to the point where we will share our pathway to find a better solution. We did not implement the ML modelling/recommendation system yet. We will share our expectations and let us put our ideas below:

• We have specific company called PepsiCo Kazakhstan operating in Kazakhstan in two channels Traditional and Modern/Organized Trade within all the cities in the country.

• In our armory, we have the following parameters: historical baseline data by SKUs, channels, cities; historical promo activities by pricing groups/sub-categories and with exact discounting percentage; pricing history; weather conditions; equipment installations and motivational program for sales teams (bonuses for achieving sales target for defined period).

• We have to differentiate around 350 SKUs by categories, sub-categories, brands and pricing groups. The differentiation is needed to plan short-term and long-term on different levels.

• Analyze the current data on hand and create a model that will take as an input all the parameters above and give an output and we call it time-series Demand Planning model/ recommendation system. We plan to implement different models using the following approaches Moving Average, ARIMAX, SARIMAX, LSTM, linear regression, ordinary least squares regression and perhaps during the research we will encounter a few other models that might come in handy. After comparison, it will be seen, which works the best.

• We split the dataset as train and test and play around to get the best possible prediction outcomes with better FA and bias.

• Also, dataset will be cleaned of outliers (one-time promo activities or sales) to receive less noise from our model.

• After testing whole categories and getting the best possible outcomes, we will be able to define optimal inventory level to cover sell-out based on lead-time and sell-in plans, which supposedly should unfreeze cash in stock and decrease inventory level with no decrease in service level for final customers.

We believe that our research work should bring benefits to company we are focusing on and help keeping its leading positions in the categories they are presented and give a sense of how to execute sales in the most optimal and efficient way. If it works out, our proposal can be applied to other companies on the market. Since all the companies try to achieve the same goals and earn more money.

Conclusion

Summing up all the said above, every company wants to shift from good to best. In order to do so, it is not enough to rely only on manpower, which is error-prone as we did for decades during preceding manufacturing revolutions, the forth-manufacturing revolution is here. It is an era of new technologies, technologies like machine and deep learning, AI and other technologies can ease our daily, and work lives substantially with less errors and better results. Keeping that in mind, business owners/managers from small to big can gain a lot from those technologies and earn more cash with less efforts. We hope that our research will solve the current issues in the company and it can be applied to other companies on the market as well.

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