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A DETAILED DATA FORECAST PLANNING METHOD FOR IMPROVING PROFITABILITY

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Abstract. *In Japan, PSI (Production, Sales and Inventory) management which manages the quantity plan data of sales, production and inventory is often performed in the SCM (Supply Chain Management) field. However, it is difficult to judge whether the result of PSI reached the medium- to long-term target at monetary level, so it is needed to find a way to realize profit purpose management besides the quantity control. Authors have proposed the advanced PSI management process using the concept of S&OP (Sales and Operations Planning). The finished goods PSI information including monetary data is interlocked in real time among logistics locations. The PSI process regarding how to increase the sales revenue and reduce the cost by avoiding key parts under stock or over stock is studied. Case studies show that detailed forecast planning method can determine necessary volume of key parts to support product demands optimally and achieve the purpose of improving profitability in manufacturing industry.*
Keywords: S&OP, PSI, SCM, Data model design, Multiple dimensional database, Demand planning, Statistic prediction, Data forecast

1. **Introduction.** Under current market environment with increasing uncertainty and risk, how to capture changes and respond quick in business activities is a big challenge. In the uncertain market environment of demand and the situation where supply cannot be fully grasped, the problem of inventory in the SCM business has become more apparent than before. Therefore, the efforts to rebuild the SCM system have been active [1]. During rebuilding the SCM system, S&OP [2], which has been actively introduced in Europe and the United States companies in recent years, is once again attracting worldwide attention.

S&OP is a concept proposed by Ling and Goddard in later 1980s [2]. The concept has evolved to sales companies, production centers, suppliers, distribution centers, etc. globally, and became a profitability-oriented demand and supply balance plan that integrates production, sales, inventory, and finance for the entire business [3]. S&OP is a superior way to balance supply-demand, and to integrate operational plans with financial plans quantitatively. Western and Korean companies were the first to implement S&OP and achieved expected results. As an example, Samsung has achieved planning integration based on the S&OP concept [4, 5].

PSI is the acronym for Production, Sales, and Inventory, and PSI management refers to coordinating these three parties [6]. Although it is similar to S&OP, there is a key difference that PSI manages quantity only. As the result of PSI management, sales performance is good at quantity level, and does not mean that is the best performance at

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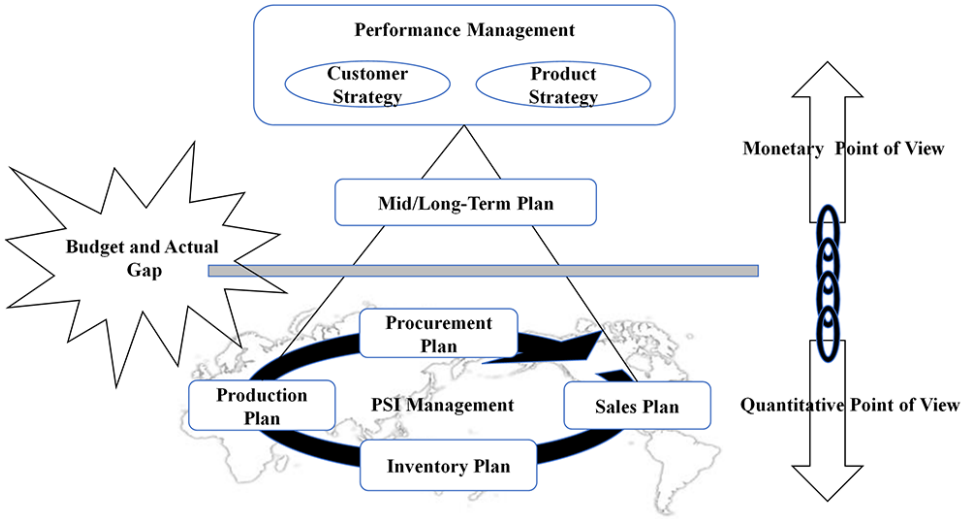


FIGURE 1. Difference between PSI and S&OP

monetary level to the financial target. Figure 1 shows Japanese PSI management how it differs from S&OP.

The nature of PSI management is a field-driven, bottom-up management method that takes the opposite approach to S&OP. Japanese companies have strengths in workplaces that emphasize flexibility and accuracy [7], and it is necessary to manage supply and demand in a way that respects both production and sales. Therefore, a realistic response to this issue would be to improve the PSI management and try to bring its performance closer to western-style S&OP, independently.

So far, an advanced business process has been proposed to enhance the current PSI management [8]. Three points are summarized as below:

1) Planning Data linkage between one location and related logistics location;
2) PSI Plan from both physical and monetary perspectives;
3) PSI Plan update based on the latest forecast information.

Figure 2 shows the real-time interlocking flow of PSI plan among locations. The PSI plan is divided into two parts on the time axis. Upper part means that the head office gathers the sales plan from individual sales company and assigns the production request to plants in order to ensure sufficient shipment to sales companies timely. Lower part means that the plant feeds back the accurate shipment quantity after adjusting the production capacity limits. If there are restrictions on the production site, the difference prompts the sales company and headquarter to make adjustment.

If any figure is corrected, the figure of the related locations can be updated or recalculated automatically. Thus, the process can improve the planning accuracy of each location, increase trust within departments or locations, and lead to actions to avoid overstocking or under stocking.

From the financial perspective, key parts under stock is a crucial factor resulting in the insufficient shipment of finished goods. According to its purposes, key parts is used for assembly finished goods, maintenance and independent sale, etc.; therefore, key parts is needed to forecast rationally during the business planning. Key parts plan in quantity is often performed in MRP (Material Requirements Planning) process of ERP (Enterprise Resource Planing). However, MRP only plans short recent period of parts or materials in quantity, such as one or two months; it cannot forecast the future demand. Until now, many papers address importance on integrating financial plan and SCM plan, few ones describe how to forecast the key parts with financial plan.

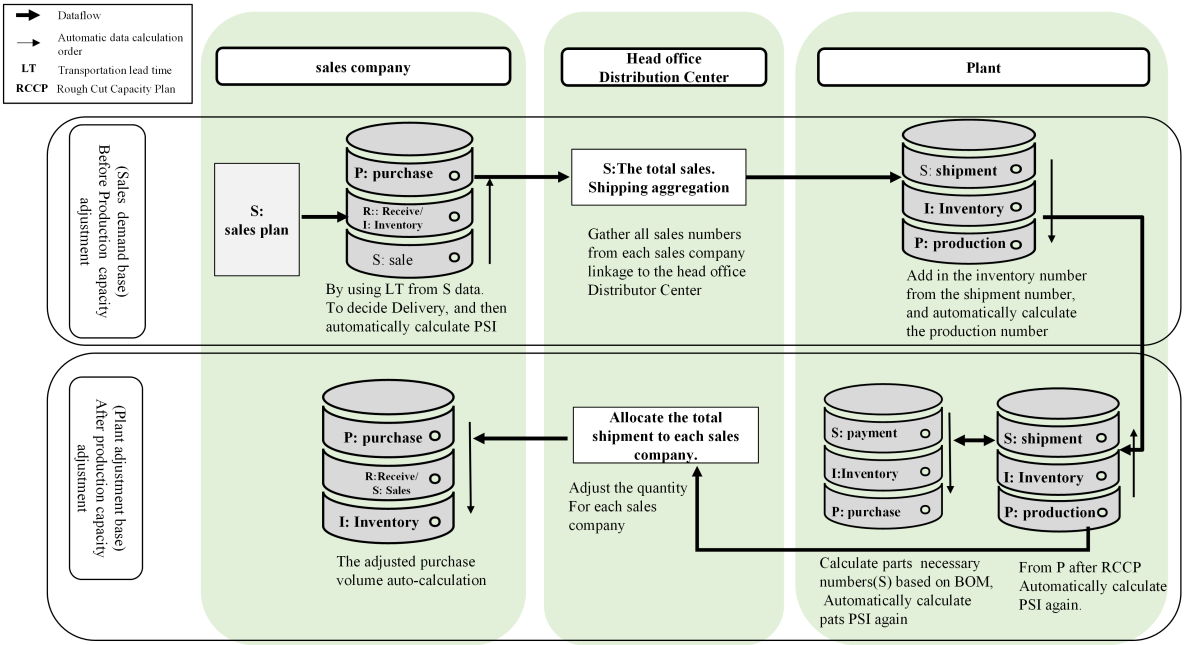


FIGURE 2. Linkage management among locations [8]

This study extends PSI management on how to perform detailed key parts forecast and PSI management, which enables product demand-supply plan more precise and visual.

2. **Demand Planning and Key Parts Planning.** Demand plan often starts from sales division. Sales team performs sales plan for products and customers; marketing team may create sales plan for brands based on marketing share information and sales promotion event plan; data scientists team creates sales prediction using statistic method as well. Finally, all plans reach the consensus of sales plan, and will be monitored constantly. A rough key parts plan/simulation is expected right now. Figure 3 shows the plan model structure among demand, supply and financial plan based on S&OP concepts [9]. Key parts plan is included in demand plan.

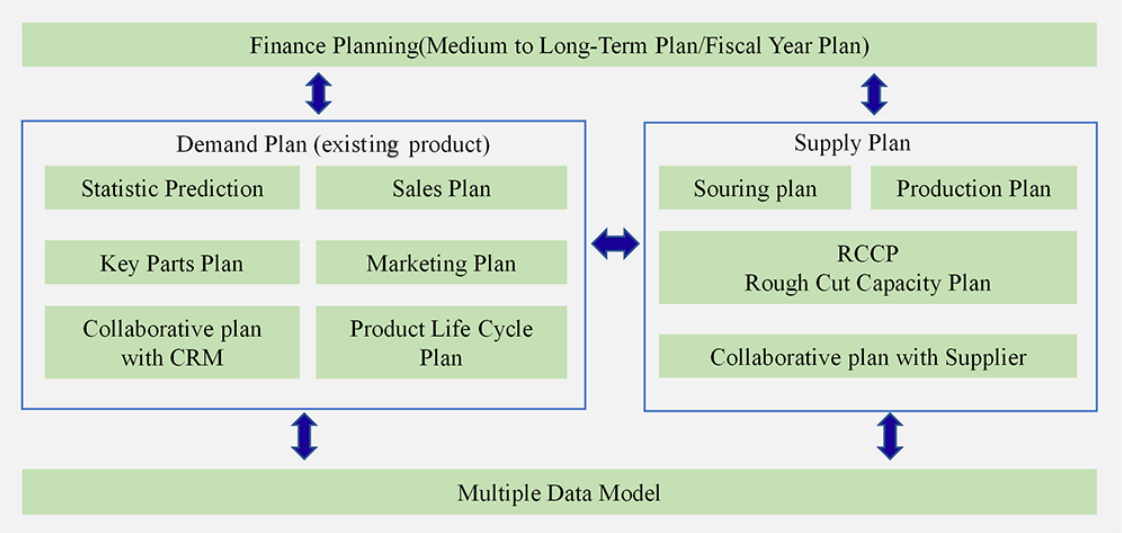


FIGURE 3. Plan model structure among demand, supply and financial plan

2.1. **Profitability-oriented demand planning.** A planning policy can be devised that considers how to absorb the changes when selecting demand planning items and method.

As shown in Figure 4, a policy is provided that helps to determine demand planning items and forecast method, taking inventory volatility by time and the financial impact into consideration.

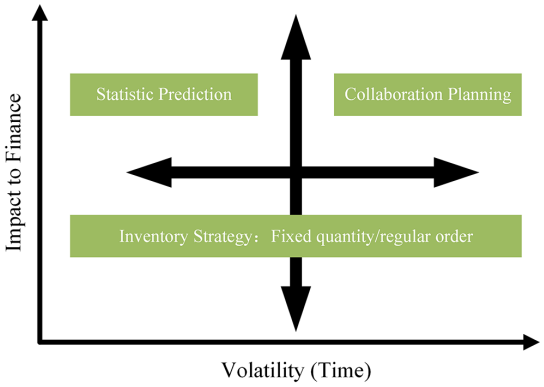


FIGURE 4. Demand planning policy

1) Statistic prediction

Since the inventory of products, semi-finished products and key parts has little fluctuation over time and big impact on revenue, statistical prediction can be used to forecast the near future trend based on past data. For example, forecast takes the moving average of the latest three months data. If there is a periodic fluctuation with seasonality, other predict models such as ARIMA and Holt-Winters [10], can be adopted to consider the effect of seasonality.

2) Inventory strategy: Fixed-quantity or regular order

When the inventory of products, semi-finished products and key parts has little impact on revenue over time, reordering point method that means to place a fixed quantity order every time if the inventory falls below a predetermined level, or regular order which replenishes the inventory on a regular basis, can be adopted.

3) Collaboration planning

If the inventory of products, semi-finished products and key parts has bigger impact on revenue and enough fluctuation over time, S&OP is the perfect method to adopt mainly. Advanced PSI planning process was proposed by authors to create the collaboration planning [8]. However, there is no detailed description to forecast key parts demand; from the following pages, case studies on key parts demand forecast are presented.

2.2. **Key parts planning method.** Regarding the relationship between key parts and parent products, there are two types.

a) The relationship between parts and products keeps nearly constant that does not fluctuate.

Assuming every car has 4 tires, there is a 1 : 4 relationship between the car and the tires. Using manufacturing BOM (Bill of Material), the required parts quantity is calculated according to the ratio of parent products and parts.

b) The relationship between parts and products fluctuates.

As an example, the number of DVD players for a car is not constant over time. For such case, past data is used to predict a rate between key parts and products, this rate is termed as statistic ratio, and the corresponding BOM is called as statistic BOM (S-BOM). In the next section, we show case studies regarding how to perform key parts planning.

3. **Case Studies for Key Parts Planning.** The solution including calculation and PSI management of key parts in operation planning is shown in Figure 5. Key parts are provided by external supplier partner.

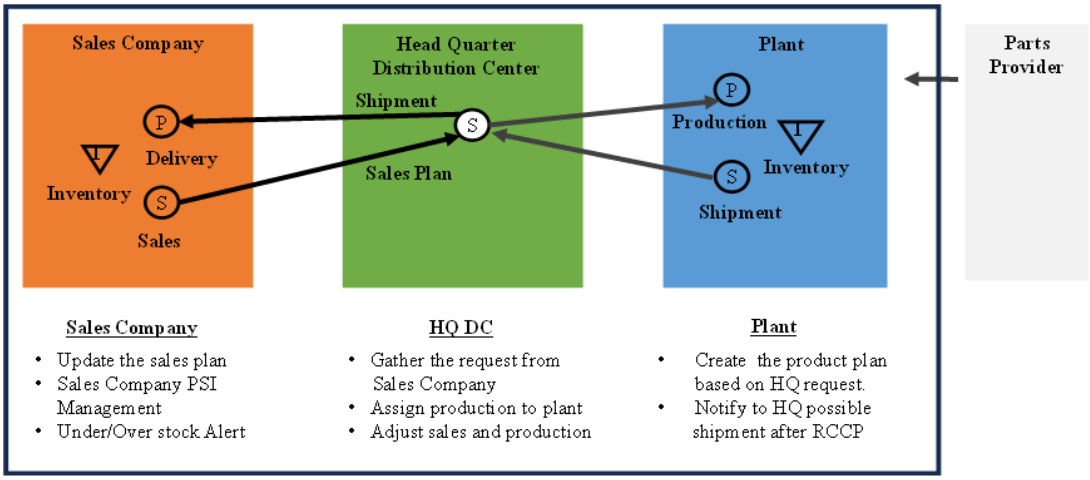


FIGURE 5. Logistics flow and PSI management

3.1. **Data model design.** Referring to the normalization model [11] which stores the data in Third Normal Form (3NF) and groups the data by the topic of the data (customers, sales, performance), data model is designed for case studies. The benefit of the proposed data model is that new topics can be added without affecting existing data. When using it for analysis, data is stored in cubes and used with dimensions dynamically. As an example, data of P, S, I also require three separate cubes, and individual number will be used in the analysis if necessary.

3.1.1. *Meta data model.* Firstly, considering how to represent the data that are related to inventory points for the logistics management, sales companies, plants, and HQ DC (Head-Quarter Distribution Center), they are all hierarchical data structures. As an example, in the case of a sales company tree, the branch of sales company consists of its country, region, and group. In the case of customer tree, the branch of customer is made up of its country, region, group, and so forth. As a solution, by adding the attributes (Attr_i, Attr_j) to the customer tree (customer dimension) shown in Figure 6, data can be aggregated and visualized from the necessary vision (e.g., by industry, location, as well as region).

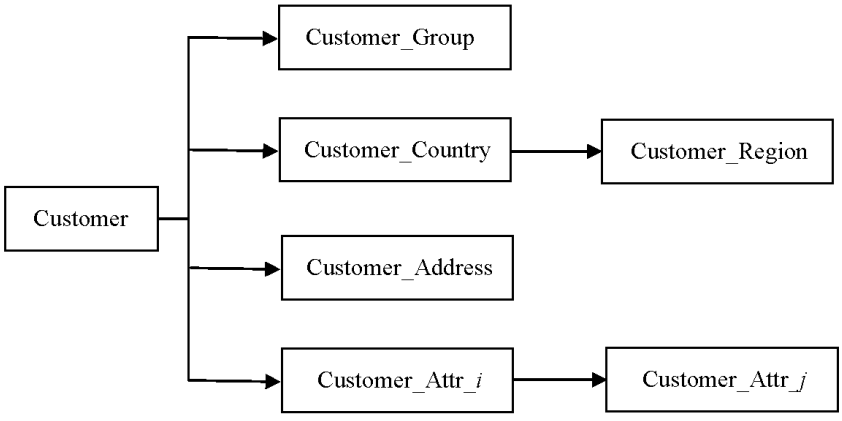


FIGURE 6. Customer dimension structure

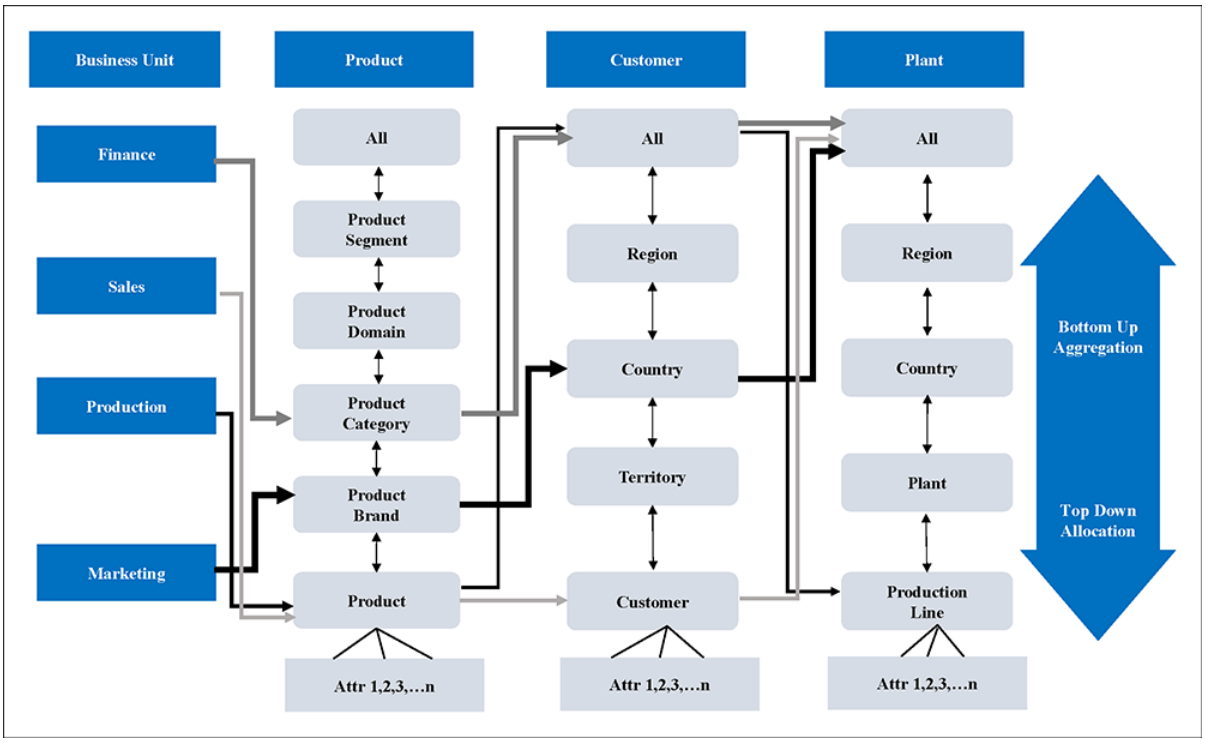


FIGURE 7. Plan model by linkage of multiple locations

3.1.2. *PSI planning data model.* Figure 7 shows the business division being mutually related to manage the data by their perspective.

Discussion or comparison among divisions needs to keep the same product dimension in the same level such as product category.

Individual division instantaneously slices and dices data to create data analysis. Marketing division manages and plans to promote products through events and campaigns at the brand level rather than the product level, no conscious of where the product was produced.

Also, the sales division plans on how much the product is sold, but no care of where the product was produced. Similarly, financial division manages product to product category concerning the monetary level, no matter who or where the products are sold, and where the products are produced.

In addition, even if each division has a different view, it is necessary to decide which granularity to stay and discuss. For example, when the above four divisions are trying to compare actual and plans, other divisions need to aggregate or allocate figures up or down to product category level in which financial division uses to manage.

3.1.3. *Product data model.* The product dimension manages the product tree and attributes. As shown in Figure 8, its structure is defined to analyze or aggregate with individual division. This means that the product is analyzed by product brand/product category/product domain/product segment in proper order. It is possible to check the forecast of each product by sales company or region, and to aggregate product characteristics such as color and pattern (Prod Attr_i and Attr_j) by adding attributes. Parts dimension can be designed by parts/parts category as well.

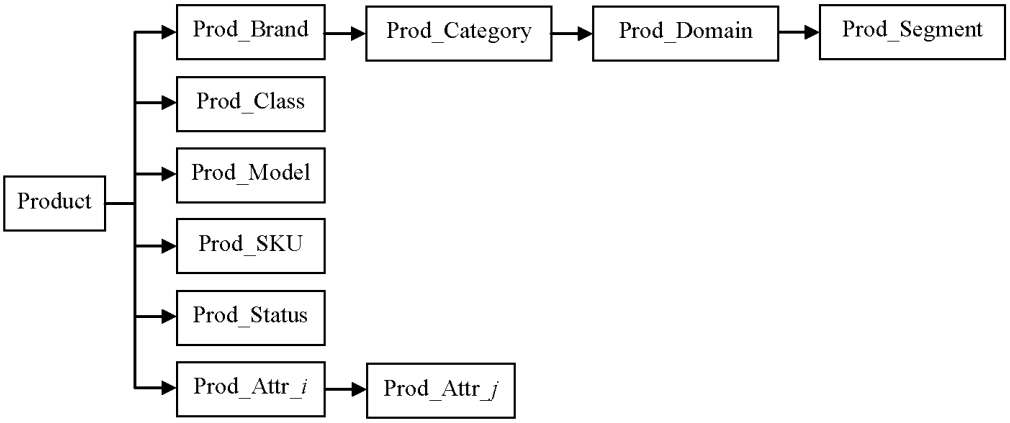


FIGURE 8. Product dimension structure

3.1.4. *P/L account data model.* Figures 9 and 10 show revenue and cost dimension for creating P/L statement report. The gross revenue account dimension controls sales revenue data, cost account dimension controls cost fees. They are also defined as hierarchy structure. Gross revenue or cost data can be drilled down to product category level.

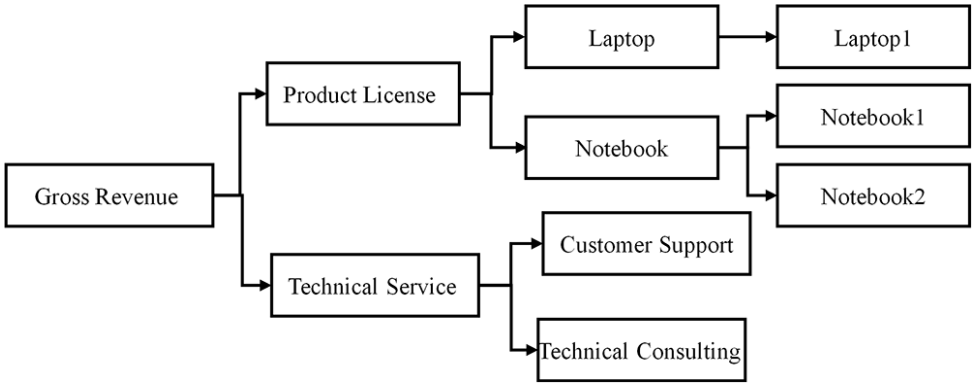


FIGURE 9. Revenue dimension structure

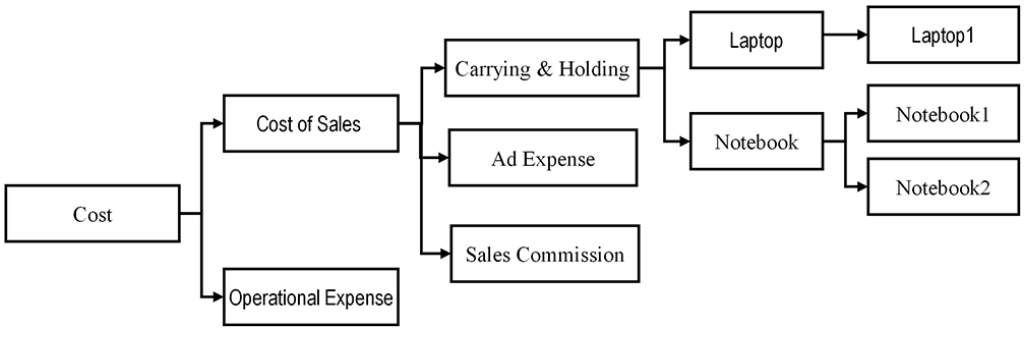
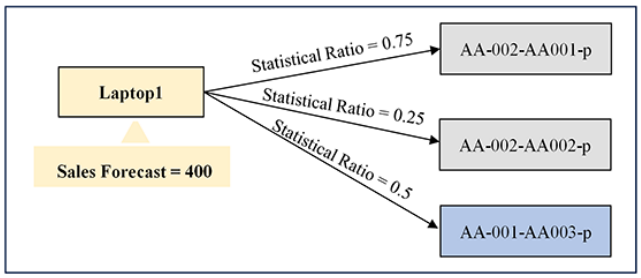


FIGURE 10. Cost dimension structure

3.2. **Key parts planning.**

3.2.1. *Key parts calculation.* Supposing in one plant, two cases of key parts necessary calculation are performed. Case 1 in Figure 11 shows that key parts is only used by one parent product.

Parent product sales forecast:
Sales forecast(quantity) = 40
ASP(average sale price) = $1,000
Sales forecast(amount) = $1,000 × 40 = $40,000
Parts AA-001-AA003-p necessary calculation;
Parts AA-001-AA003-p independent forecast as 100
Standard cost for AA-001-AA003-p = $100
Forecast AA-001-AA003-p = AA-001-AA003-p forecast(independent sale) + Laptop1 necessary
Forecast for AA-001-AA003-p in quantity = 100 + 40 × 0.5 = 120
Forecast for AA-001-AA003-p in amount = $100 × 120 = $12,000



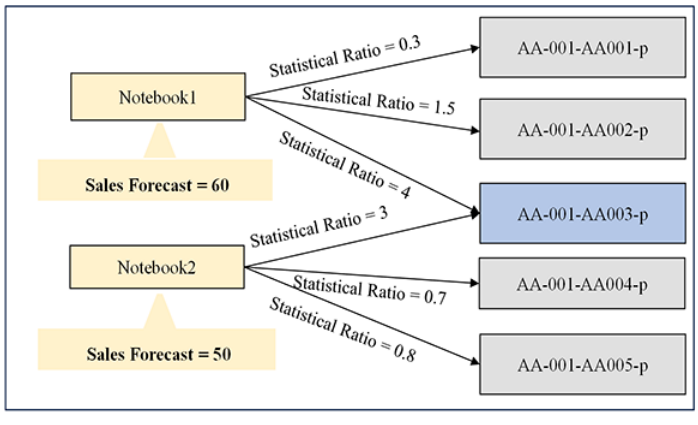
Statistic BOM structure

Parents	Parts	Time Period	Statistical Ratio
Laptop1	AA-002-AA001-p	Jan	0.75
Laptop1	AA-002-AA002-p	Jan	0.25
Laptop1	AA-001-AA003-p	Jan	0.5

Statistic BOM(S-BOM)

FIGURE 11. Pattern1: Key parts demand calculation by using S-BOM

Case 2 in Figure 12 shows that key parts is used to multiple parent products.
Parts: AA-001-AA003-p is used by NoteBook1, and NoteBook2 as well.
Parents sales forecast:
Sales forecast in quantity = 50 + 60 = 110
ASP for both = $1,000
Sales forecast in amount = $1,000 × 110 = $110,000
Parts AA-001-AA003-p necessary calculation;
Parts AA-001-AA003-p independent sale as 100
ASP for AA-001-AA003-p = $100
Forecast AA-001-AA003-p = AA-001-AA003-p forecast(independent sale) + Notebook1 necessary + Notebook2 necessary
Forecast for AA-001-AA003-p in quantity = 100 + 60 × 4 + 50 × 3 = 490
Forecast for AA-001-AA003-p in amount = $100 × 490 = $49,000



Statistic BOM structure

Parents	Parts	Time Period	Statistical Ratio
Notebook1	AA-001-AA001-p	Jan	0.3
Notebook 1	AA-001-AA002-p	Jan	1.5
Notebook1	AA-001-AA003-p	Jan	4
Notebook2	AA-001-AA003-p	Jan	3
Notebook2	AA-001-AA004-p	Jan	0.7
Notebook2	AA-001-AA005-p	Jan	0.8

Statistic BOM(S-BOM) Data

FIGURE 12. Pattern2: Key parts demand calculation by using S-BOM

3.2.2. *Key parts PSI management.* As key parts inventory issue has many impacts on revenue, cost and productivity, PSI management for key parts is valuable to perform.

Figure 13 shows key parts PSI plan in quantity. The upper part in Figure 13 shows dimension selection such as fiscal year, parts category and item.

(1) Demand(S)

Demand area controls numbers related to key parts demand which is calculated by BOM or SBOM as default.

Demand can be adjusted if needed.

Demand Sum(W_i) = Demand(W_i) + Demand Adjust(W_i).

(2) Purchase(P)

Purchase can be adjusted as well if there is the reason to modify.

Purchase Sum(W_i) = Purchase(W_i) + Purchase Adjust(W_i).

(3) Inventory(I)

Inventory(W_i) = Inventory(W_$i-1$) - Demand Sum(W_i) + Purchase Sum(W_i).

Calculated inventory should keep good balance and satisfy with the demand in the following week.

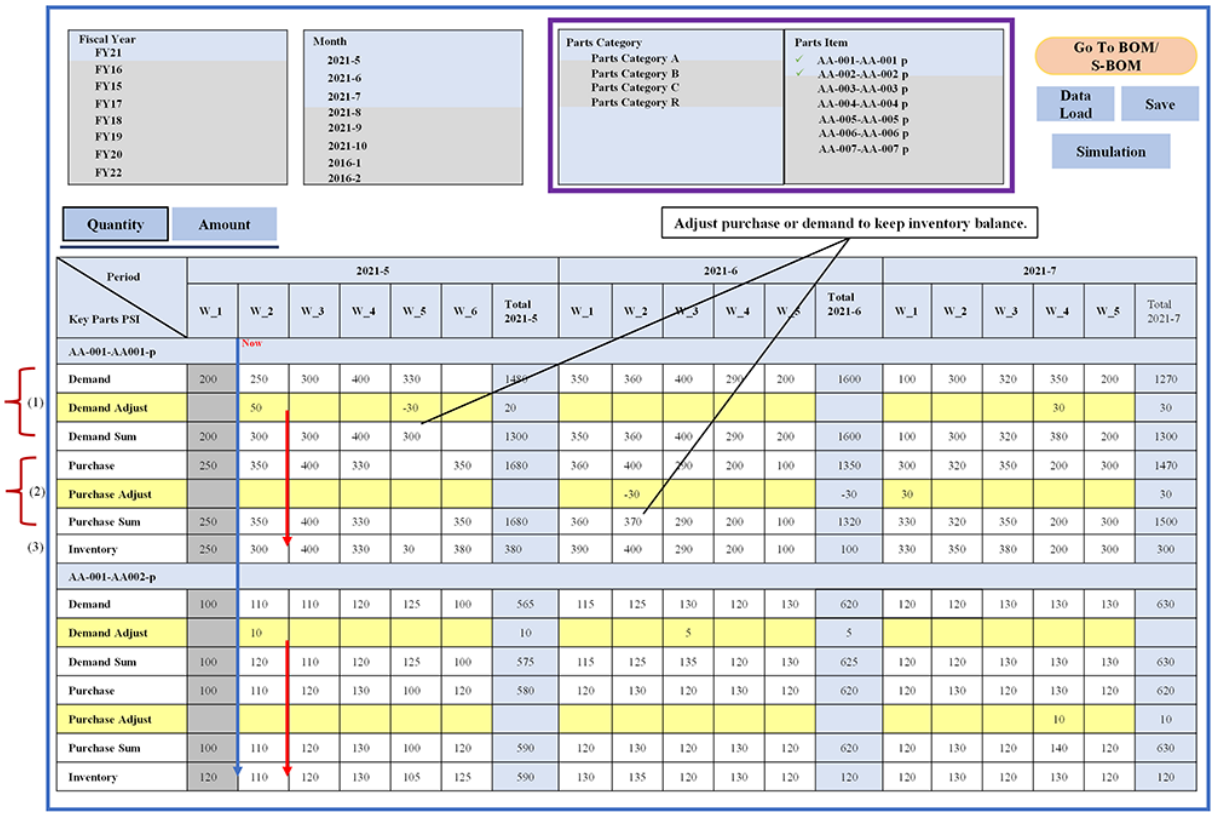


FIGURE 13. Key parts PSI plan in quantity

Figure 14 shows key parts PSI plan in amount.

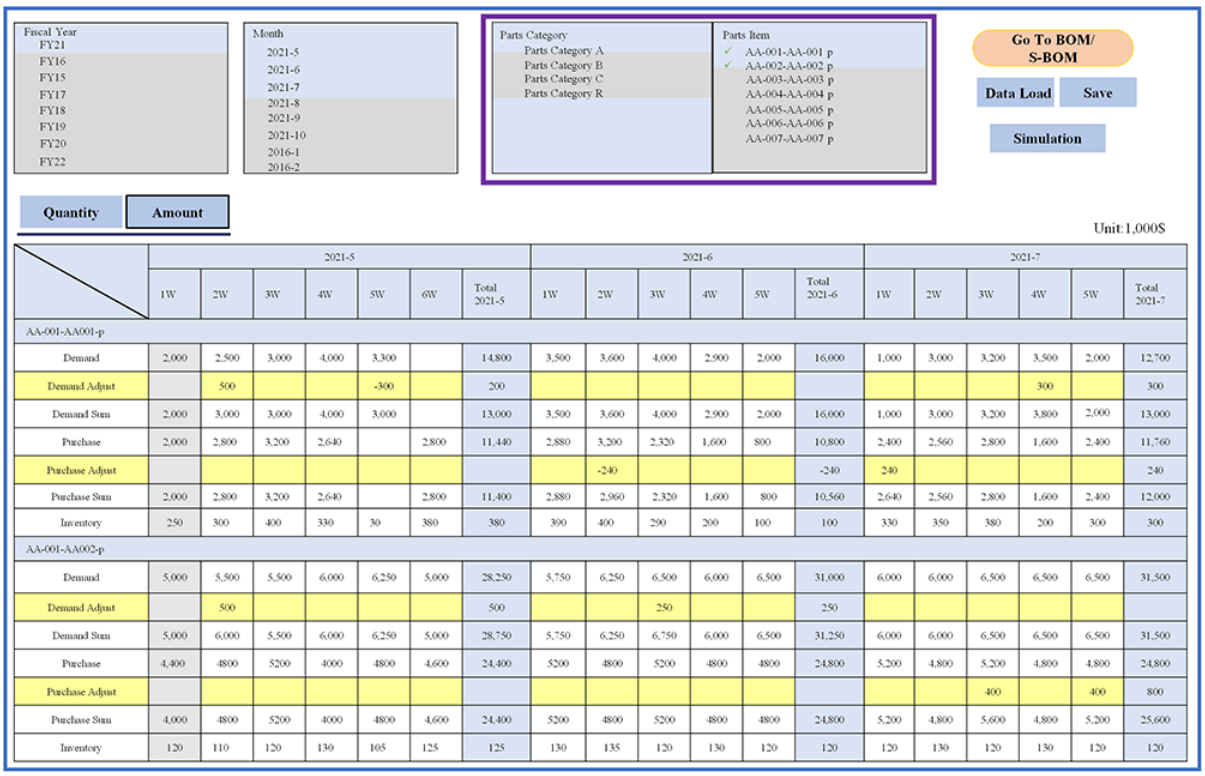
Amount(Demand(W_i)) = Internal Exchange Price(W_i) × Demand Sum(W_i)

Amount(Purchase(W_i)) = Standard Cost(W_i) × Purchase Sum(W_i)

Amount(Inventory(W_i)) = Average Inventory Cost(W_i) × Inventory(W_i).

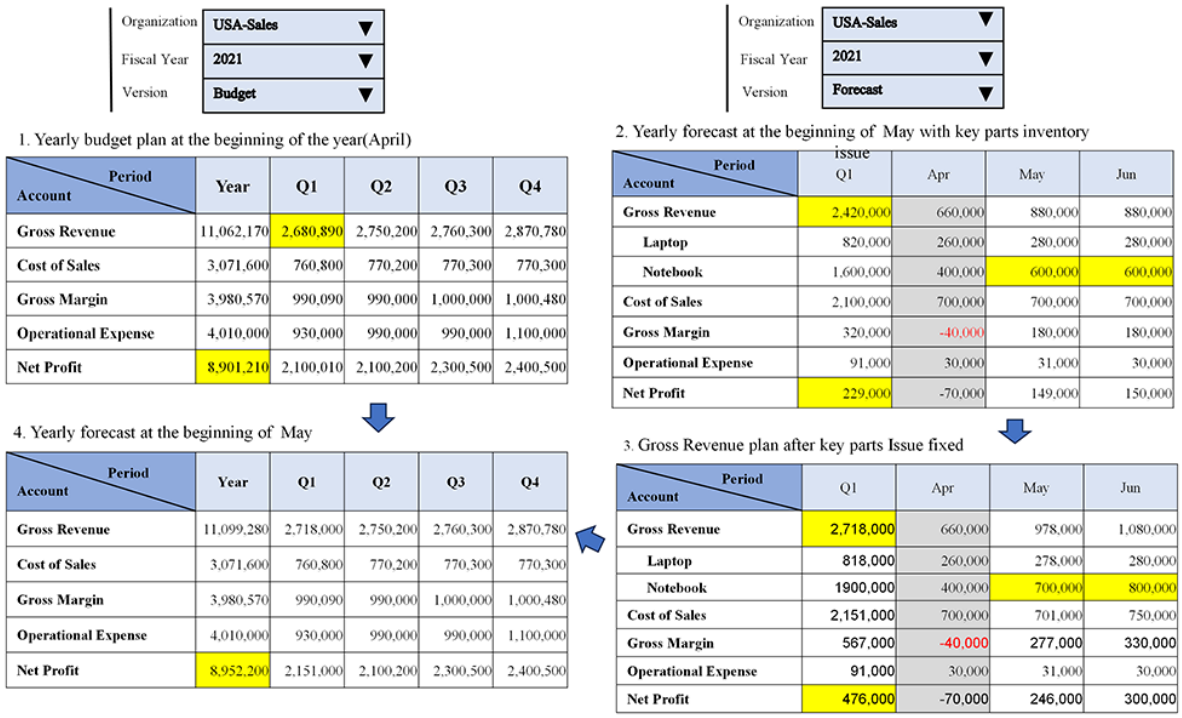
Assuming to add sales revenue to sales account, to add purchase cost, inventory carrying and holding cost so forth to cost account, we can catch how P/L changes according to PSI plan in Figure 15.

Figure 15 shows an example of how key parts planning affects P/L and Quarter level performance in the sales company (USA Sales). The sheet1 shows yearly sales budget.



	2021-5							2021-6						2021-7					
	1W	2W	3W	4W	5W	6W	Total 2021-5	1W	2W	3W	4W	5W	Total 2021-6	1W	2W	3W	4W	5W	Total 2021-7
AA-001-AA001-p																			
Demand	2,000	2,500	3,000	4,000	3,300		14,800	3,500	3,600	4,000	2,900	2,000	16,000	1,000	3,000	3,200	3,500	2,000	12,700
Demand Adjust		500			-300		200										300		300
Demand Sum	2,000	3,000	3,000	4,000	3,000		13,000	3,500	3,600	4,000	2,900	2,000	16,000	1,000	3,000	3,200	3,800	2,000	13,000
Purchase	2,000	2,800	3,200	2,640		2,800	11,440	2,880	3,200	2,320	1,600	800	10,800	2,400	2,560	2,800	1,600	2,400	11,760
Purchase Adjust									-240				-240	240					240
Purchase Sum	2,000	2,800	3,200	2,640		2,800	11,400	2,880	2,960	2,320	1,600	800	10,560	2,640	2,560	2,800	1,600	2,400	12,000
Inventory	250	300	400	330	30	380	380	390	400	290	200	100	100	330	350	380	200	300	300
AA-001-AA002-p																			
Demand	5,000	5,500	5,500	6,000	6,250	5,000	28,250	5,750	6,250	6,500	6,000	6,500	31,000	6,000	6,000	6,500	6,500	6,500	31,500
Demand Adjust		500					500			250			250						
Demand Sum	5,000	6,000	5,500	6,000	6,250	5,000	28,750	5,750	6,250	6,750	6,000	6,500	31,250	6,000	6,000	6,500	6,500	6,500	31,500
Purchase	4,400	4800	5200	4000	4800	4,600	24,400	5200	4800	5200	4800	4800	24,800	5,200	4,800	5,200	4,800	4,800	24,800
Purchase Adjust																400		400	800
Purchase Sum	4,000	4800	5200	4000	4800	4,600	24,400	5200	4800	5200	4800	4800	24,800	5,200	4,800	5,600	4,800	5,200	25,600
Inventory	120	110	120	130	105	125	125	130	135	120	130	120	120	120	130	120	130	120	120

FIGURE 14. Key parts PSI plan in amount



Account \ Period	Year	Q1	Q2	Q3	Q4
Gross Revenue	11,062,170	2,680,890	2,750,200	2,760,300	2,870,780
Cost of Sales	3,071,600	760,800	770,200	770,300	770,300
Gross Margin	3,980,570	990,090	990,000	1,000,000	1,000,480
Operational Expense	4,010,000	930,000	990,000	990,000	1,100,000
Net Profit	8,901,210	2,100,010	2,100,200	2,300,500	2,400,500

Account \ Period	Q1	Apr	May	Jun
Gross Revenue	2,420,000	660,000	880,000	880,000
Laptop	820,000	260,000	280,000	280,000
Notebook	1,600,000	400,000	600,000	600,000
Cost of Sales	2,100,000	700,000	700,000	700,000
Gross Margin	320,000	-40,000	180,000	180,000
Operational Expense	91,000	30,000	31,000	30,000
Net Profit	229,000	-70,000	149,000	150,000

Account \ Period	Q1	Apr	May	Jun
Gross Revenue	2,718,000	660,000	978,000	1,080,000
Laptop	818,000	260,000	278,000	280,000
Notebook	1900,000	400,000	700,000	800,000
Cost of Sales	2,151,000	700,000	701,000	750,000
Gross Margin	567,000	-40,000	277,000	330,000
Operational Expense	91,000	30,000	31,000	30,000
Net Profit	476,000	-70,000	246,000	300,000

Account \ Period	Year	Q1	Q2	Q3	Q4
Gross Revenue	11,099,280	2,718,000	2,750,200	2,760,300	2,870,780
Cost of Sales	3,071,600	760,800	770,200	770,300	770,300
Gross Margin	3,980,570	990,090	990,000	1,000,000	1,000,480
Operational Expense	4,010,000	930,000	990,000	990,000	1,100,000
Net Profit	8,952,200	2,151,000	2,100,200	2,300,500	2,400,500

FIGURE 15. Budget and financial plan forecast

The actual sales number is not good as plan at the end of last year (sheet2). Especially, Q1 gross revenue is sharply down. How to avoid continuously decrease and speed up the sales revenue needs to take smart actions.

It was found that notebook revenue decreased as the delivery of key parts "AA-001-AA003-p" was delayed. This results in the production being not completed timely. Due to the key parts being used in multiple notebook products, the inventory under stock issue in sales company occurred (sheet3). Thus, the key parts supply chain needs to be adjusted. The mentioned USA sales transferred the supplier to another company in order to ensure such key parts provided. As the result, sales revenue reaches the target and yearly budget plan (sheet4).

Taking key parts PSI management process into consideration, the total process and data model are shown in Figure 16. New addition for key parts detailed forecast and PSI management is marked in red frame from advanced PSI process [8], which refers to executive S&OP process [12, 13].

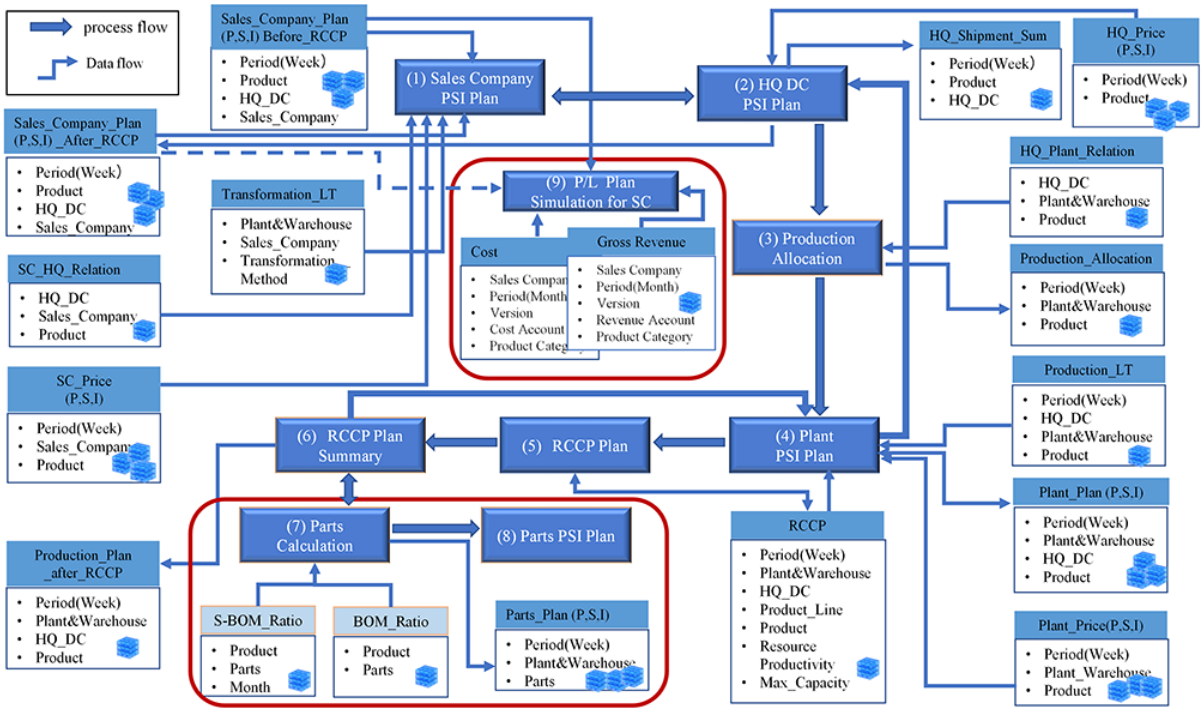


FIGURE 16. Collaboration planning process including key parts demand forecast

(1) Sales Company (SC) PSI Plan

As a result of formulating the sales plan for each sales company, PSI data is stored in sales Company Plan (P, S, I) by product, sales company and HQ_DC. Logistics flow between sales company and HQ_DC is controlled by the association cube (SC HQ Relation) which includes products, sales companies, and HQ DC items. The sales plan starts from inventory actual and delivery actual of the previous term, and then calculates delivery and inventory calendar for the next half year. In addition, since the finalized number of deliveries is returned after taking account of the production capacity, the data structure has two sets: a demand-based PSI number before RCCP (Rough Cut Capacity Planning) and a production limit-based number after RCCP. As a data model, there are two sets of cubes to present P (delivery), S (sales), and I (inventory).

(2) HQ DC PSI Plan

The shipping requests of each sales company are aggregated at the HQ DC S (sales) under their jurisdiction and performing the allocation plan to plants.

(3) Production Allocation

The current inventory status will be used as the primary response to the shipment requests of each sales company from the jurisdictional HQ DC, but HQ DC will allocate the production quantity based on the actual performance rate of the production destination in the previous term, and adjust the quantity in consideration of the seasonal situation, vacation schedule, etc. The relationship among HQ DC, plants and product is linked with the cube of HQ Plant relation.

(4) Plant PSI Plan

Considering various lead-time such as manufacturing and document creation based on production instructions that arrive at the plant, a chronological PSI (Production, Shipment and Inventory) plan is created. There are two numbers, before and after RCCP.

(5) RCCP Plan

Based on the productivity of employees, the operation rate of machines, and the operation schedule for each production line, the planned number of products that can be produced is determined.

(6) RCCP Plan Summary

Aggregate the production plan for each product after RCCP Plan Aggregating product plan number to upper layer plant from production line, the result is returned to the plant PSI plan (4). Deciding the number of shipments to the HQ DC in the process (4), and the number is returned to the HQ DC PSI planning process (2). After re-allocating or adjusting shipment number to the target sales companies in (2), then returning to the sales company PSI plan in (1), the final numbers of the plans can be delivered to each sales company. Due to missing parts discovered in the PSI control of parts in (8), the production plan for products is also adjusted in (4).

(7) Parts Calculation

Calculating the number of required parts by referring to manufacturing BOM or S-BOM, if both BOM and S-BOM are required, the results need to be summarized (e.g., car will have manufacturing tires and aftermarket tires). This process can be done before or after RCCP.

(8) Parts PSI Plan (Parts RCCP)

Time-series management of parts P (purchase), S (payment), and I (inventory) adjusts purchase or demand to keep inventory in good balance.

(9) P/L Plan Simulation for SC

Before or after RCCP, the simulation can be performed on how key parts plan changes the P/L status. Sales company takes Sales plan data into Gross Revenue cube, inventory cost data to Cost cube, and aggregates the data to the level of product category in which the financial team manages data. Therefore, key parts plan, revenue and loss data can be rationally integrated in one data model. Compared with previous period P/L data, profitability increase or decrease can be confirmed.

4. **Conclusions.** In a drastically changing business environment, companies in the manufacturing industry are facing a difficult task to realize their potential and maximum profits. The study focuses on the issues of demand planning and performance management that have been put into practice for a long time in Japan. A multi-dimensional database model is used to formulate a demand planning model for key parts and provide an improved PSI plan process. The contributions can be summarized as follows.

1) Demand planning policy provided shall become a guidance for choosing PSI management items and forecast method.

2) The detailed forecasting planning method may enhance the totally performance from the financial perspective.

3) A proposal of key parts PSI planning is suggested for Japanese manufacturing industry. It helps companies improve the total performance and profitability continuously, and generalizes the implementation of planning solution for IT vendors.

Case studies are summarized on how to perform detailed demand planning by using statistic BOM in this paper. To support key parts demand calculation, it is necessary to gather the past sales data. Much more data shall improve the result for statistic ratio in S-BOM. For processing manufacturing industry, another issue is on how to calculate the key parts payment/receive forecast during processing from phase to phase.

REFERENCES

[1] K. Ishikawa, Future inventory management-collaboration between SCM restructuring and management decisions by S&OP, *Factory Management*, vol.67, no.3, pp.36-41, 2021 (in Japanese).

[2] R. C. Ling and W. E. Goddard, *Orchestrating Success: Improve Control of the Business with Sales & Operations Planning*, Wiley, 1992.

[3] K. Matsubara, Understanding the S&OP process at Teishokuya, *IT Leaders*, 2013 (in Japanese).

[4] T. F. Wallace, *Sales & Operation Planning beyond the Basics*, Steelwedge Software, 2011.

[5] T. Akikawa, Factors behind the realization of S&OP: A case study of ribs, *Japan Society of Commerce, Circulation Studies*, vol.17, no.1, pp.1-21, 2014 (in Japanese).

[6] S. Urabe, S. Huang and S. Munakata, PSI-cockpit: A supply-demand planning system focusing on achieving goals through resolving KPI conflicts, *Proc. of the 2016 Int. Conf. on Industrial Engineering and Operations Management*, Kuala Lumpur, Malaysia, pp.662-670, 2016.

[7] K. Okazaki, Verifying suitability for Japanese manufacturing industry from advanced case studies in the US, *LOG-BIZ*, pp.28-31, 2014 (in Japanese).

[8] X. Qin, T. Akikawa and Z. Liu, A new proposal for advancement of PSI management introducing S&OP concepts, *Journal of Japan Logistics Society*, vol.31, 2023 (in Japanese).

[9] T. Wallace and B. Stahl, The demand planning process in executive S&OP, *The Journal of Business Forecasting*, pp.19-23, 2008.

[10] K. D. Makatjane and N. D. Moroke, Comparative study of holt-winters triple exponential smoothing and seasonal ARIMA: Forecasting short term seasonal car sales in South Africa, *Risk Governance & Control: Financial Markets & Institutions*, vol.6, no.1, 2016.

[11] J. Jones and E. Johnson, Data warehouse design using data model, *Journal of Data Warehousing*, vol.3, no.2, pp.55-62, 1998.

[12] E. John and J. R. Boyer, 10 proven steps to successful S&OP, *The Journal of Business Forecasting*, pp.4-10, 2009.

[13] P. Bower, How the S&OP process creates value in the supply chain, *The Journal of Business Forecasting*, pp.20-32, 2006.

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