
Supply Planning Optimization Under Uncertainties in Vaccine Manufacturer

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ABSTRACT

Indonesian and global health issues that influence each other's welfare and standard of living create the need for constant availability of vaccines that can be relied upon by the public and also the current competition in the vaccine industry that requires precise and efficient sales and operational planning to be able to meet customer needs in the market. This needs to be supported by a supply planning process, where all parties in supply line can coordinate in achieving demand fulfillment. However, in its implementation, there are several obstacles, including uncertainties in demand planning, facility and equipment downtime, regulation changes, distortion of information between lines of production, engineering division, material resource planning, due to different targets, poor communication, processing speed, accuracy and synchronization of data to the system. In this Journal, a supply planning optimization framework concept will be proposed that makes the cross-functional alignment at a vaccine company in Indonesia more effective and efficient. In this journal, key aspects of supply planning will be discussed that can influence the direction of fulfillment planning in the company. A research approach through design thinking with related functions will be used to extract information in more depth. It is hoped that the resulting framework design can be a reference not only for practitioners but also for academics in understanding the importance of the role of supply planning which is able to integrate cross-functional interests in the supply chain.

Keyword: supply chain, supply planning, cross-functional alignment, design thinking, optimization, uncertainty

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INTRODUCTION

In recent years, especially since the Covid pandemic hit the world and Indonesia, the global community and healthcare industry players have increasingly shown concern and special attention regarding the availability of vaccines for the public. Competition in the national vaccine industry has also become increasingly intense for industry players. The growth of production capacity, which has not been able to keep up with the increase in national and global vaccine consumption, is the main obstacle in this highly competitive environment. To be able to compete in this industry, companies are striving to run their businesses more effectively and efficiently to respond to changing customer needs—demanding not only the required quantity according to demand and timeliness but also competitive prices. Good coordination between functions within the company in terms of the supply chain—starting from planning demand from customers, carrying out the production process while maintaining production capacity, and ensuring timely deliveries to customers—is essential to compete in the market.

To create and implement supply chain planning, good coordination in the exchange of information and data is required. Information distortion is one of the obstacles to supply chain coordination in companies. Information and data that are not transparent, accurate, or uniform can cause various parties to make mistakes in demand forecasting. Such forecasting errors should be reduced through better information exchange (Boonsthonsatit S., 2015; Choi, 2020;

Gurtu & Johny, 2021; Itang et al., 2022; Saini et al., 2023; Wen et al., 2019; Zimon et al., 2019). Parties involved in the company's supply chain should not make forecasts based solely on their own data but must also agree to use the same data source as other functions.

Sales and Operations Planning (S&OP) is a cross-functional coordination process designed to achieve consensus on tactical plans within an organization (Bagni et al., 2022; Bozutti & Espôsto, 2019; Hulthén et al., 2016; Kreuter et al., 2022; Papier & Thonemann, 2021). The S&OP process aims to balance supply and demand. In recent years, numerous industry players have learned about and paid more attention to S&OP, recognizing its usefulness in improving tactical and operational planning to anticipate customer demand while simultaneously reducing inventory value and minimizing operating costs (Almeida et al., 2022; Bhalla et al., 2023; Dittfeld et al., 2020; Kaipia et al., 2017; Roscoe et al., 2020; Rota & de Souza, 2021).

Supply planning, as part of S&OP, plays a highly significant role in determining whether the sales target will be achieved. To understand the complexities of supply planning, this study examines a vaccine company in Indonesia, hereinafter referred to as *Company X*. *Company X* operates in the vaccine manufacturing industry, has been established for over 130 years, and has contributed to supply not only in Indonesia but also globally. For 130 years, *Company X* was the only vaccine company in Indonesia. Since the pandemic, competition in the Indonesian vaccine industry began in 2021 with the establishment of new vaccine manufacturers. *Company X* has one production site in Bandung that produces oral polio vaccines, tetanus vaccines, diphtheria vaccines, pertussis vaccines, recombinant vaccines, hepatitis B vaccines, influenza vaccines, inactivated polio vaccines, and a Covid vaccine brand product widely known to the public during 2021–2022, as well as one site for animal breeding, model animals, and donor animals. The products marketed by the company include semi-finished goods and finished goods consisting of several types of vaccines and bulk products packaged in vials, ampoules, pouches, pre-filled syringes (*pfs*), or bottles.

This study addresses significant gaps in supply chain coordination and S&OP processes, particularly in the context of the vaccine industry. Previous studies, such as those by Pujawan & Mahendrawathi (2017), have emphasized the importance of S&OP in balancing supply and demand, as well as the role of information exchange in reducing forecasting errors. However, these studies did not focus specifically on the complexities of the vaccine industry, which faces unique challenges such as global competition, fluctuating demand, and the critical need for timely production and delivery. Lapede (2005) also discussed the broader implications of S&OP in improving operational efficiency but did not examine the specific impact of these practices in the context of vaccine supply chain management, which has been heavily influenced by the Covid-19 pandemic. This study fills that gap by investigating how *Company X*, a long-established vaccine manufacturer in Indonesia, implements S&OP and supply planning strategies to meet increasing demand while navigating competition and maintaining production efficiency.

The objective of this study is to assess the effectiveness of S&OP processes in vaccine manufacturing, with a particular focus on supply planning and demand forecasting. The

findings are expected to provide valuable insights into how vaccine companies can improve their coordination, reduce forecasting errors, and enhance operational efficiency. The study contributes to the understanding of supply chain optimization in the vaccine industry, particularly in response to global competition and the challenges brought about by the Covid-19 pandemic. It offers practical implications for policymakers, industry players, and supply chain managers seeking to improve vaccine supply chains, reduce inventory costs, and meet market demand more effectively.

METHOD

The objective of this research is to find satisfactory solutions for creating a supply planning approach under uncertainty that is applicable and accountable in meeting demand requirements, rather than aiming for an optimal solution that is often impossible to achieve.

Based on the above objective, *Design Thinking* by Herbert Simon (1969), outlined in his book *The Science of the Artificial*, was applied with a focus on qualitative data. However, when relevant quantitative data is available that can support the analysis, it will also be utilized.

Design Thinking

Design Thinking is a methodology that provides a solution-based approach to problem-solving. It is a non-linear, iterative process that may have anywhere from three to seven phases, depending on the source. In this study, five stages are used to address or approach problem-solving within the *Design Thinking* framework. These five stages are:

1. Empathize – Research the user’s needs. This stage is crucial since *Design Thinking* is a human-centered problem-solving approach.
2. Define – State the user’s needs and problems. This stage helps collect ideas to establish features, functions, and other elements to solve the problem at hand, or at least give users opportunities to resolve issues themselves.
3. Ideate – Challenge assumptions and generate ideas. This allows for producing as many ideas as possible at the start of the ideation stage.
4. Prototype – Begin creating solutions. This experimental phase aims to identify the best possible solution for each of the problems identified in the earlier stages.
5. Test – Try out the solutions.

Design Thinking in *Company X*

1. Empathize – In building empathy, there are three important aspects that must be fulfilled:
 - a. Stakeholder Identification – *Pemerintah Indonesia* (Indonesian Government), global institutions, bilateral countries, and the private sector.
 - b. Data Collection – Interviews and observation.
 - c. Understanding Needs:
 1. Demand fulfilment.
 2. Sales growth in value.
 3. Early warning regarding potential supply delays.
 4. Fluidity and agility in responding to demand changes.

2. Define –

a. Problem Identification:

1. Annual increase in demand for almost all products.
 2. Slower growth in production capacity.
 3. Tightening regulations adding to output limitations.
 4. Slow acknowledgement of potential supply delays.
3. Ideate – Six ideas were generated to address the identified problems using an empathy-based approach toward the user — in this case, the demand planning function/sales sector.
4. Prototype – Creation and proposal of six new supply planning frameworks and policies to the supply planning function and demand planning function.
5. Test – Implementation of the solution to be tested in both the short term and the long run to observe how company stakeholders and the market respond.

RESULTS AND DISCUSSION

John Douglas, (2021) states that planning is a continuous process, involving assessment, goal setting, as well as implementation and evaluation. This approach emphasizes the importance of adapting to changes that occur in the environment.

Although design thinking is a non-linear, after the author conducted research based on design thinking methodology and through interviews, discussions and observation, results were obtained that could be used as discussion space as mention in order above, namely:

1. Demand Planning Reconciliation: Since the stakeholders or customers is divided in 4 different sector, recognizing and consolidating the demand stakeholder’s nature in demand planning becoming crucial. Every sales sector need to configure best scenario in order to fulfill company’s target per month, per year and long term sales target. The output of shipment plan or demand planning would be better to be submitted or published by one structure in sales division or directorate to ensure the alignment of all sales sector with each one’s unique nature of sales demand.
2. Demand Planning Confidence Level: In demand reconciliation, it is suggested that every demand per quarter or even per month to be breakdown also based on confidence level sales team has. Since the preparation of operational manufacture require a long time 4 to 9 months in procurement lead time, production lead time, it would help the supply planning team to configure all material planning, production planning and distribution planning as effective, efficient and as accurate as possible.

Table 1. Demand Planning Confidence Level at the end of Demand Table

Vaccine A 10 doses (via ls)	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (JML)	Period	Type	Confidence Level

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De ma nd	Gover nment	–	744 ,35 0	170 ,93 0	349 ,59 0	720 ,67 0	334 ,47 6	41, 794	–	–	–	–	–	2,36 1,81 0	Jan – Jun	Mont hly	40%
	Privat e	2,4 10	2,6 30	2,1 20	4,4 70	2,1 50	1,5 00	5,1 70	4,7 00	3,9 00	4,3 70	3,8 60	94, 800	132, 080	Jan – Aug	Cum ulativ e	60%
	Expor t	268 ,81 0	221 ,65 0	28, 900	10, 100	69, 650	231 ,86 0	70, 550	30, 50	12, 50	23, 80	50, 70	70, 800	1,09 4,63 0	Jan – Jun	Mont hly	100%
Tot al De ma nd	Total	271 ,22 0	968 ,63 0	201 ,95 0	364 ,06 0	792 ,89 0	567 ,83 6	117 ,51 4	35, 20	16, 40	33, 17	54, 56	165 ,60 0	3,58 8,52 0	Jan – Dec	In Total	20%

3. Buffer / Spare Production Slot: There’s so many factors influence and impacting supply chain throughout the supply period such as unplanned downtime, quality pending issue with already allocated / dedicated batch, raw material stock out due to so many factors, and regulation change. To anticipate these uncertainty, supply planning would be best not to include all production slot available as initial supply planning. This would benefit in maintaining trust within customer and company’s credibility. Although it could also seems that the company cannot fulfill the require demand set by the market or sales division, but it would ensure if this policy monitored and executed carefully every month.
4. Coordinated Pull and Push Between Demand and Supply Planning: In high demand and competitiveness among vaccine manufacturer around the world, although it’s a healthy one, supply planning submitted to customer is the capability and resiliency statement of one’s company. Demand and Supply Planning need to establish a good collaboration in favor of both customer needs and sustainability of the vaccine supply. There are cases when production, raw material and other operational aspect should stretch their capability to meet the demand, there are also cases when sales sector negotiate with the customer to make supply planning to end customers more flexible but still fulfill the demand full year also for the sustainability of stock resiliency in long term. This coordination should be held at least once a month to get a closed up figure of supply and demand control balance.

Table 2. Buffered Supply Planning and Coordinated Pull & Push Supply Demand

Full Capacity (version 25 July 2024)

Vaccin e A 10 doses (vials)	Descrip tion	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (JML)
Dema nd	Gover nment	–	744, 350	170, 930	349, 590	720, 670	334, 476	41,7 94	–	–	–	–	–	2,361, 810
	Private	2,410	2,63 0	2,12 0	4,47 0	2,15 0	1,50 0	5,17 0	4,70 0	3,90 0	4,37 0	3,86 0	94,8 00	132,0 80
	Export	268,8 10	221, 650	28,9 00	10,0 00	69,6 50	231, 860	70,5 50	30,5 00	12,5 00	28,8 00	50,7 00	70,8 00	1,094, 630
Total Dema nd	Total	271,2 20	968, 630	201, 950	364, 060	792, 890	567, 836	117, 514	35,2 00	16,4 00	33,1 70	54,5 60	165, 600	3,588, 520

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Monthly Output	204,740	139,200	516,950	208,200	500,000	450,000	100,000	150,000	100,000	50,000	–	–	2,418,570
Estimated Balance	1,103,470	274,040	588,680	432,660	140,280	22,440	4,930	119,730	203,330	220,160	165,600	–	
Estimated Initial Stock	1,169,950												
Balance in Dec 2025	–												

Buffered Capacity (version 25 July 2024)

Vaccine A 10 doses (vials)	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (JML)
Demand	Government	–	744,350	170,930	349,590	720,670	334,476	41,794	–	–	–	–	–	2,361,810
	Private	2,410	2,630	2,120	4,470	2,150	1,500	5,170	4,700	3,900	4,370	3,860	94,800	132,080
	Export	268,810	221,650	28,900	10,000	69,650	231,860	70,550	30,500	12,500	28,800	50,700	70,800	1,094,630
Total Demand	Total	271,220	968,630	201,950	364,060	792,890	567,836	117,514	35,200	16,400	33,170	54,560	165,600	3,588,520
Monthly Output		100,000	139,200	450,000	100,000	450,000	450,000	50,000	150,000	150,000	100,000	50,000	–	2,189,200
Estimated Balance		998,730	169,300	417,350	153,290	189,090	306,926	374,440	259,640	126,040	59,210	63,770	–	229,370
Estimated Initial Stock		1,169,950												
Balance in Dec 2025		–	229,370											

Adjusted Demand (version 25 July 2024)

Vaccine A 10 doses (vials)	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total (JML)
Demand	Government	–	744,350	50,000	150,000	720,670	300,000	20,000	50,000	100,000	36,980	–	–	2,172,000
	Private	2,410	2,630	2,120	4,470	2,150	1,500	5,170	4,700	3,900	4,370	3,860	94,800	132,080
	Export	268,810	221,650	28,900	10,000	69,650	231,860	70,550	30,500	12,500	28,800	50,700	70,800	1,055,070
Total Demand	Total	271,220	968,630	164,470	473,810	792,470	533,360	95,720	85,200	116,400	70,150	54,560	165,600	3,359,150
Monthly Output		100,000	139,200	450,000	100,000	450,000	450,000	95,000	150,000	150,000	100,000	70,000	–	2,218,200
Estimated Balance		998,730	169,300	538,280	473,810	170,990	87,630	41,906	106,710	140,310	170,160	165,600	–	

Balanc e	
Estima ted Initial Stock	1,169, 950
Balanc e in Dec 2025	–

5. Dashboard and Monitoring for Everyone: Since Company X policy in manufacture in a make to order strategy, every batch produced will be based on demand, and every number batch is submitted to customer, it is crucial matter if the batch allocated not going as planned. While supply planning is a subject to change due to uncertainty in operational, it is unacceptable if the changes or deviation of supply planning is too late to be anticipated by the customers. A dashboard of supply planning and a detail monitoring system could help prevent this from happening. Dashboard and Monitoring system should be open to everyone in demand and supply planning function within the Company X. Everyone should be able to cross check, reminding and collaboration of strategy based on one dashboard and monitoring system.
6. All 5 suggest tools should be tested in order to challenge it's efficacy in solving problem in supply planning under uncertainty. Testing parameters should be obtained by the consensus from both demand and supply function within Company X to reach satisfactory in problem solving. Alteration and refinements are to be expected since design thinking methodology is not a concrete and inflexible approach to problem solving.

CONCLUSION

The research conclusion includes a summary of the findings from the current process, along with the implications and recommendations for future research. *Implications* refer to practical suggestions that can be drawn from the research results. *Research limitations* encompass various aspects that should be taken into consideration for improving future studies. Meanwhile, *recommendations* are provided for future research based on limitations that could not be overcome by the researchers in this study.

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