

Operator Allocation in Procurement Process Using Computer Simulation and Data Envelopment Analysis

การจัดสรรพนักงานในกระบวนการจัดซื้อด้วยวิธีจำลองสถานการณ์และการวิเคราะห์การล้อมกรอบข้อมูล

Vason Techamaitrehit, Seerong Prichanont,
Department of Industrial Engineering,
Faculty of Engineering,
Chulalongkorn University, Pathumwan, Bangkok, 10330,
E-mail: Vason.Te@student.chula.ac.th, seerong.p@chula.ac.th

วสันต์ เตชะไมตรีจิตต์, สිරง ปรีชานนท์
ภาควิชาวิศวกรรมอุตสาหกรรม คณะวิศวกรรมศาสตร์
จุฬาลงกรณ์มหาวิทยาลัย เขตปทุมวัน กรุงเทพมหานคร 10330
E-mail: Vason.Te@student.chula.ac.th, seerong.p@chula.ac.th

Abstract

Thailand's commercial banks have been in fierce competition for quite some years. Procurement is an important department where strategic decisions are made. With various procurement types and demand fluctuation over the year, the bank could find it difficult to allocate operators to efficiently handle the tasks at hand. In this research, a procurement department of an existing Thai bank is used as a case study. In this particular bank, procurement department is divided into three teams which handle different types of procurement: Building, Outsourcing and General procurement. Currently, they are facing with a high rate of overall delayed work caused by a seasonal pattern of demand. Quarterly dynamic operator allocation alternatives are proposed in order to mitigate the effects of demand fluctuation and reduce the delayed work rate. The ARENA computer simulation is applied to assess alternatives. Parameters from the simulation model are collected and used for evaluating the alternative in Data Envelopment Analysis (DEA). Two DEA models which are BCC and MCDEA are used to determine the best allocation plan among alternatives. From simulation result, with proper operator allocation, the department can balance the operator utilization among teams which leads to lower cycle time and also the number of delayed work. Then these allocation plans are evaluated with DEA model. MCDEA shows superior discriminating power over BCC model by awarding only two scenarios while BCC award to 7 out of 9 scenarios to be an efficient alternative. Finally, with the best efficient allocation plan, the procurement department can reduce the number of delayed works by 2.6% without adding additional operator.

Keywords: operator allocation, computer simulation, data envelopment analysis, DEA

บทคัดย่อ

เนื่องด้วยธุรกิจธนาคารพาณิชย์ในประเทศไทย กำลังอยู่ในภาวะการแข่งขันที่สูงมาก หน่วยงานจัดซื้อซึ่งเป็นหน่วยงานสนับสนุนจึงมีบทบาทสำคัญในการจัดหาทรัพยากร เพื่อเพิ่มความสามารถในการแข่งขันและความพึงพอใจของลูกค้า โดยหน่วยงานจัดซื้อของธนาคารพาณิชย์แห่งหนึ่งในประเทศไทยที่กำลังประสบปัญหาในการจัดสรรพนักงาน เพื่อให้เกิดประสิทธิภาพสูงสุดขององค์กร ได้ถูกเลือกเพื่อนามาเป็นกรณีศึกษาในงานวิจัยนี้ ในธนาคารแห่งนี้ หน่วยงานจัดซื้อถูกแบ่งออกเป็นสามกลุ่มเพื่อทำการจัดซื้อสินค้าที่รูปแบบแตกต่างกันได้แก่ กลุ่มก่อสร้าง กลุ่มจัดจ้าง และกลุ่มทั่วไป ซึ่งขณะนี้หน่วยงานกำลังประสบปัญหาอัตรางานล่าช้าที่เพิ่มสูงขึ้น เนื่องจาก ความผันผวนของความต้องการจัดซื้อจัดจ้าง การจัดสรรพนักงานรายไตรมาสได้ถูกจัดทำให้ขึ้นเพื่อบรรเทาผลกระทบของความผันผวนและลดอัตรางานล่าช้าของหน่วยงานลง การสร้างแบบจำลองสถานการณ์ด้วยโปรแกรม ARENA ได้ถูกนำมาใช้เพื่อประเมินแผนการจัดสรรพนักงาน โดยผลลัพธ์จากแบบจำลองจะถูกเก็บและนำไปใช้ประเมินแผนการจัดสรรพนักงานด้วยการวิเคราะห์การล้อมกรอบข้อมูล โดยแบบจำลอง BCC และ MCDEA ได้ถูกนำมาใช้ เพื่อประเมินทางเลือกที่มีประสิทธิภาพสูงสุด โดยผลจากแบบจำลองพบว่าการจัดสรรพนักงานที่เหมาะสมสามารถช่วยปรับภาระงานของพนักงานให้มีความสมดุลกันระหว่างแผนก ซึ่งส่งผลให้ช่วยลดเวลาในการทำงาน และปริมาณงานล่าช้าลงได้ โคนแบบการจัดสรรพนักงานทั้งหมดถูกประเมินด้วยการวิเคราะห์การล้อมกรอบข้อมูล โดยแบบจำลอง BCC ที่มีความสามารถในการคัดแยกต่ำกว่าไม่สามารถจำแนกประสิทธิภาพของแผนการจัดสรรพนักงานได้ โดยประเมินว่า 7 จาก 9 แผนการจัดสรรพนักงานมีประสิทธิภาพ ในขณะที่แบบจำลอง MCDEA ที่มีความสามารถในการคัดแยกสูงกว่าประเมินให้เพียง 2 แผนการจัดสรรพนักงานเท่านั้นเป็นแผนการจัดสรรที่มีประสิทธิภาพ โดยท้ายที่สุดแล้ว แผนการจัดสรรพนักงานที่มีประสิทธิภาพนี้สามารถช่วยลดปริมาณงานล่าช้าในหน่วยงานจัดซื้อได้ถึง 2.6% โดยไม่ต้องเพิ่มพนักงาน

คำหลัก: การจัดสรรพนักงาน, แบบจำลองคอมพิวเตอร์, การวิเคราะห์การล้อมกรอบข้อมูล

1. Introduction

In Thailand, there are 14 commercial banks which compete intensely in the present. Procurement plays important role for supporting main operation by sourcing required resources strategically to improve competitiveness and ensure customer satisfaction. Hence, efficiency of procurement greatly affects responsiveness and cost of the business.

Bank A is one of the leading commercial banks in Thailand that aims to enhance their business competitiveness then the procurement department is demanded to improve its efficiency in order to align with a business goal. Procurement process can be considered as a labor-intensive manufacturing process with User Purchase Request (UPR) as an input and Purchase Order (PO) as an output. As a consequence, operator allocation is an important factor to the productivity and efficiency of

the process then the allocation decision should be well defined in order to ensure the improvement of the performance.

2. Procurement Process

The major procurement section for the bank, operators are called as "buyer" who responsible for execute procurement process according to the procurement policy. They are divided into 3 teams to handle different types of product which are Building team, General team and Outsource team.

Procurement process can be simply described as a conversion process of UPR into Purchase Approval (PA) and PO. The procurement process begins with creation of UPR from user then buyer will process the request according to sourcing policy. The difference types of sourcing process are applied for UPRs with various ranges of budget. The sourcing process can be separated by budget range

as shown in figure 1.

For PA budgeted below 1,000,000 Baht, sourcing process can be simply done with sending inquiry to at least 3 vendors for their quotation. Buyer will make negotiation once all quotations are received then issue PA to their manager for approval.

Secondly, PA with 1,000,000 to 5,000,000 Baht, the “Bidding” process will be applied for sourcing. Scope of Work (SOW) or Term of Reference (TOR) must be created according to the regulation then sent to at least 3 vendors along with the requisition. Once all quotations are submitted, each vendor will be evaluated based on designed criteria set by purchasing committee and then PA will be issued after negotiation is finished and vendor is selected.

Finally, PA with value more than 5,000,000 Baht, inquiry will be publicly announced and vendors have to make their bid on “Sealed Bidding” system then all bids will be opened on specific date and contract will be awarded. PA will be issued after criteria evaluation and negotiation.

In conclusion, the PA with higher required budget incurs more complex, higher approval authority and longer process time.

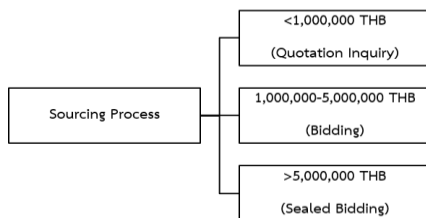


Figure 1 Diagram of Sourcing Process

3. Current Situation

Currently, management of the department has a direction to redefine manpower in order to get the

best outcome from their existing resources. This study is started with observation of demand which refers to number of incoming UPR in quarterly basis.

On average, demand for each team are not equal and distributed among 3 teams as 52% for building team, 35% general team and 13% for outsource team. Currently, the bank has total of 16 buyers in procurement department which 6 buyers are assigned to Building team, 6 buyers to General team and 4 buyers to Outsource team. From 2012 to 2015, demand of users which can be implied from number of PA are varied from month to month. PA quantity has been studied and grouped on quarterly basis in order align with regular milestone period and results are shown in figure 2.

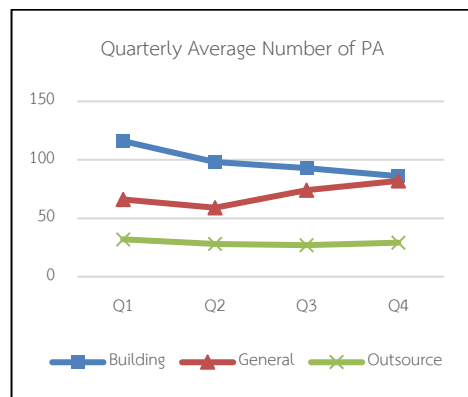


Figure 2 Quarterly trend of PA quantity by team from 2012-2015

The result shows pattern of transaction quantity which varies between teams. Quantity of work for Building team is high at the beginning of the year and decreases continuously through the end of the year. On the other hand, workload for General team gradually raises after second quarter meanwhile outsource requirement is quite constant. Major problem of the department is high delayed work rate which refers to procurement transactions those have

cycle time more than committed service level agreement (SLA). The trend of delay work is presented in figure 3 below. It shows the similar trend to the quantity of PA.

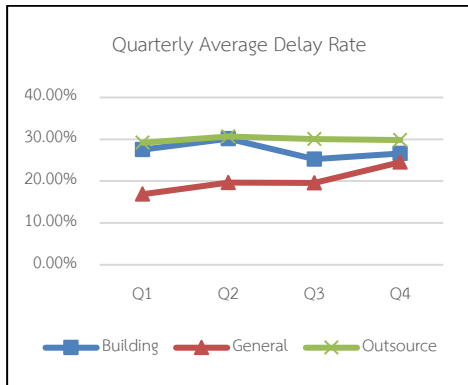


Figure 3 Quarterly Average Delay Rate by Team from 2012 to 2015

The number of delay work is increased during high demand period and lower in low-demanded period. For example, the delay rate of Building team is high in the first quarter while it is high in the fourth quarter for General team which is consistent with the PA trend.

In order to cope with this dynamic demand trend, dynamic operator allocation in each quarter will help department to balance utilization along the year. Assigning more operator in peak period can help to lower utilization of operators in a particular team and lead to lower cycle time along with delay rate of that team.

4. Literature Review

A study of operator allocation has been widely performed and developed in many perspectives and industries. Conventional approach that is still widely used is an optimization method. Optimization by math modeling is a method for solving operator

allocation problem in a deterministic way. Modern optimization tries to analyze problem in more stochastic manner. Two phased formulation [1] and four-phased hierarchical optimization model [2] were created to cope with practical problem with uncertainties.

Another technique that is compatible to more complex and stochastic problem is Simulation. Simulation technique has been widely applied. Computer Simulation is known as one of effective tool for solving problem in many business fields e.g. education [3], manufacturing [4], food industry [1], health care [5], etc. But simulation itself is only helps to visualize and simulate scenarios. The evaluation among scenarios to select the best option has to be done with Data Envelopment Analysis (DEA)

In general, simulation is considered as a tool to provide input/output for utilizing DEA. Model will be developed and run with several decided scenarios to test the process performance based on specific conditions.

Selected parameters from simulation result will be collected as input/output for further analysis with DEA. DEA as an assessing tool helps to evaluate options based on their relative efficiency. The optimal alternative will be selected based on their efficiency score which the maximum is 1. This integration of simulation technique and DEA is also known as “two-phase methodology” [1]. Variety of DEA models are selected to evaluate scenarios in different conditions. Apart of basic models like BCC or CCR, more complex models like Multiple Criteria DEA (MCDEA) [1], Principle Component Analysis (PCA) [6], Cross efficiency scoring based on BCC [7] were applied to have more discriminating power of scoring.

DEA is also used for additional feature of operator allocation e.g. including performance of operator [8], learning effect [9], fuzzified data [4]

which helps company to make better decision and get better performance.

In this study, the two-phase methodology is selected to evaluate scenarios. BCC and MCDEA are selected as an evaluation tool in this case since the discriminating power of these two models are able to cope with the evaluation of this study.

5. Objective of Research

Determine operator allocation in order to minimize number of delay and average delay time of procurement process by optimizing with average cycle time, average operator utilization and throughput of process

6. Scope of Study

This study focuses on following aspects

1. Focus only allocation of buyers which are operators who take major role in procurement process.
2. Focus only processes and activities those relate with buyers.
3. Performance of operators within team are assumed to be equal.
4. Learning effect is not considered.

7. Proposed Methodology

This study is conducted based on two-phased methodology as follow:

1) Develop simulation of procurement process using ARENA software and run model on whole year basis. The model will be input with variety of decided allocation alternatives which allocations are designed based on quantity of work of each team in each period according to table 1.

Table 1 Operator Allocation Scenario

	Quarter1			Quarter2			Quarter3			Quarter4		
	B	G	O	B	G	O	B	G	O	B	G	O
1	6	6	4	6	6	4	6	6	4	6	6	4
2	7	5	4	7	5	4	5	7	4	5	7	4
3	7	6	3	7	6	3	6	7	3	6	7	3
4	8	5	3	7	5	4	6	6	4	5	7	4
5	7	6	4	7	6	4	7	6	4	7	6	4
6	7	6	4	7	6	4	6	7	4	6	7	4
7	8	5	4	7	5	5	6	7	4	6	7	4
8	6	7	4	6	7	4	6	7	4	6	7	4
9	6	6	5	6	6	5	6	6	5	6	6	5

B, G, O stands for Building, General and Outsource team respectively

2) Collect concerned parameters from simulation and categorize them according to framework of DEA as shown in table 2. The input parameter refers to parameters those should be minimized and output parameter refers to parameters those should be maximized.

Table 2 Parameter from Simulation to be collected

Input	Output
- Number of delay work	- Average utilization of operator
- Average cycle time	- Throughput (number of finished job)
-Total number of operator	
- Number of required movement	

3) Utilize DEA model to determine the efficient operator allocation by using parameters from 2) as inputs and outputs for optimization. BCC and MCDEA are selected to be assessment tools in this study

3.1) BCC model

$$\max Z_0 = \sum_{r=1}^s u_r y_{rj_0} - u_0 \quad (1)$$

Subject to

$$\sum_{i=1}^m v_i x_{ij_0} = 1 \quad (2)$$

$$\sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} \leq 0, j = 1, \dots, n \quad (3)$$

$$u_r, v_i \geq 0 \text{ for all } r, i \text{ and } j$$

where z_0 is the relative efficiency of DMU₀, j is the DMU index, r is the output index, i is the input index, y_{rj} is the value of the r_{th} output for the j_{th} DMU, x_{ij} is the value of the i_{th} input of the j_{th} DMU, u_r is the weight given to the r_{th} output and v_i is the weight given to the i_{th} input. DMU₀ is the efficient alternative if $Z_0 = 1$

3.2) MCDEA model

$$\min d_0 \text{ or } \max h_0 = \sum_{r=1}^s u_r y_{rj_0} \quad (4)$$

$$\min M \quad (5)$$

$$\min \sum_{j=1}^n d_j \quad (6)$$

Subject to

$$\sum_{r=1}^s u_r y_{rj} - \sum_{i=1}^m v_i x_{ij} + d_j = 0, j = 1, \dots, n \quad (7)$$

$$\sum_{i=1}^m v_i x_{ij_0} = 1 \quad (8)$$

$$M - d_j \geq 0 \quad (9)$$

$$u_r, v_i, d_j \geq 0 \text{ for all } r, i \text{ and } j$$

where d_0 is the deviation variable for DMU₀ and d_j is the deviation variable for the j_{th} DMU, M is the maximum among all of d_j , DMU₀ is efficient if $h_0 = 1 - d_0$ equals to 1.

8. Results

Table 3 Simulation results

	Throughput	Avg. Utilization	No. of Delayed Work	Avg. Cycle Time	No. of Operator	No of Alloc.
1	2,143	0.38	1,090	4.82	16	0
2	2,144	0.38	1,082	4.85	16	2
3	2,143	0.38	1,080	4.81	16	1
4	2,143	0.38	1,062	4.85	16	3
5	2,149	0.36	1,072	4.79	17	0
6	2,150	0.36	1,081	4.83	17	1
7	2,149	0.36	1,056	4.76	17	3
8	2,145	0.36	1,076	4.83	17	0
9	2,146	0.36	1,082	4.86	17	0

Results of simulation are shown in table 3. The allocation does not have a strong effect to the process as expected due to the fact that the major processing time of the procurement is caused by external activities e.g. waiting for supplier to submit quotation or negotiation but the improvement of the process from the allocation can still be observed eventually.

By assigning more operators to support teams in more demand period, this results in lower of operator utilization of particular team which lead to lower number of delay work and can be obviously seen in scenario4. Then parameters in table 3 are evaluated with DEA model, BCC and MCDEA, which

assessment is shown in following table.

Table 4 DEA Results

Scenario	BCC	MCDEA		
		min d_0	minmax	minsum
1	1.000	1.000	0.999	0.998
2	1.000	1.000	0.988	0.994
3*	1.000	1.000	1.000	1.000
4*	1.000	1.000	1.000	1.000
5	1.000	1.000	0.9998	1.000
6	1.000	0.992	0.990	0.991
7	1.000	1.000	0.999	1.000
8	0.995	0.995	0.994	0.994
9	0.992	0.992	0.989	0.989

Results from DEA explicit a low discriminating power of BCC. With small different of result among options, BCC model was unable to distinguish relative efficiency of scenarios which can be seen from 7 out of 9 scenarios get efficiency score at 1. Meanwhile, MCDEA with stronger discriminating power shows more variety of score in each scenario. Finally, there are only two scenarios which are scenario 3 and 4 those got rewarded as efficiency alternatives by having efficiency score at 1 in all objective functions and help company to reduce delay work up to 2.6%.

9. Conclusion

This study determines manpower in procurement department by focusing on improve efficiency of labor-incentive procurement process and reducing delay work. The optimal operator allocation started with study on demand side and found pattern of fluctuated demand. Then dynamic operator allocation alternatives were created and studied by using of combination between simulation and DEA. Computer simulation is the input/output

generator of different operator allocation alternatives. Then DEA as an assessment tool for evaluating alternatives helps select the efficient alternative based on their relative score.

For further research, the improvement of external waiting time can be studied in order to evaluate each alternative considering efficiency and investment. Moreover, learning effect of operator should be taken into consideration for more precise decision of allocation.

Acknowledgment

I am using this opportunity to express my gratitude to everyone who supported me throughout this research. I am thankful for their aspiring guidance and cooperation during the period.

I express my warm thanks to my research advisor, Asst. Prof. Seerok Prichanont for his support and invaluable guidance along with management of Bank A for providing opportunity and resource of this research.

Reference

- [1] Ruzanita Mat Rani et al., Determining the Optimal Operator Allocation in SME's Food Manufacturing Company Using Computer Simulation and Data Envelopment Analysis, Statistic and Operational Research International Conference (SORIC), 1613,102-112 (2014)
- [2] Egilmez G. et al., Stochastic skill-based manpower allocation in a cellular manufacturing system, Journal of Manufacturing Systems, 41,193-198 (2014)
- [3] Watanabe S. P. et al., Internal Staff Allocation and the Changing Workload of Japanese Professoriate: A Multilevel Statistical Analysis with Simulations, University of California Berkeley,1.13, 1-10 (2013)
- [4] Azadeh A. et al., An integrated fuzzy DEA-Fuzzy simulation approach for optimization of

- operator allocation with learning effects in multi products CMS, Applied Mathematical Modelling, 37, 9922-9933 (2013)
- [5] Oh, C. et al., Use of a simulation-based decision support tool to improve emergency department throughput., Operations Research for Health Care, 9, 29-39, (2016)
- [6] Azadeh A. and M. Anvari, Implementation of multivariate methods as decision making models for optimization of operator allocation by computer simulation in CMS, SIMULATION SERIES, 26:4, 316-325 (2016)
- [7] Ertay T. and D. Ruan, Data envelopment analysis based decision model for optimal operator allocation in CMS, European journal of operational research, 164, 800-810 (2005)
- [8] Rani R. M. et al., Determining the optimal operator allocation using a three-phase methodology, Proceedings of the Universiti Kebangsaan Malaysia, 1614, 851-858 (2014)
- [9] Azadeh A., et al., An integrated fuzzy DEA–fuzzy C-means–simulation for optimization of operator allocation in cellular manufacturing systems, Applied Mathematical Modelling, 46, 361-375 (2013)