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Digital Transformation on Business Operation and Internal Administration of Printing Houses Focusing on The Problem of Adjustable Work Processes of Employees

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Abstract

Nowadays, the print media business is in a recession due to an increased quantity of marketing competitors, an increase of specialized entrepreneurs, and a change in consumer behavior from paper-based publications to electronic format. These factors directly affect the business operation of entrepreneurs. We studied a working system of Chulalongkorn University Press relying on conventional and digital printing technologies. To minimize production costs in the printing house, the parameters derived from the constrained optimization problem need to be computed explicitly according to existing employees. The set of parameters corresponds to the number of jobs assigned to conventional and digital systems were observed, including the work efficiency in both systems. An average of the work efficiency levels was needed to define a constraint in an optimization modeling approach. In the experiments, the simulated annealing algorithm based on evolutionary computation was applied for identifying the parameters of the cost balance model.

Introduction

For years there has been much talk about the power and impact of digital transformation, the publishing industry is included. Book is not dead! But it does not mean that the publishing industry as we know it today will survive. If a printer invests in a new press, this automatically means that he must increase the job volume in order to operate the press economically. It is not only this case. Labor trends, along with the supply chain issue, will also affect the business greatly. Shortages on labor and raw materials will level out. Unfortunately, we think it is going to continue for several years. Publishing houses should rethink their inventory management. With the uncertainty in the markets, publishers are trying to cut back their initial printing quantities. They are going to reprint more frequently in smaller quantities, so instead of doing long run printing, they might do several short runs through the course of the year, moving to a stock replenishment mode.

Another issue to encounter the publishers today is that conventional process like offset printing may be not the proper process any more in book printing as the customers requires short run or on-demand printing, quick delivery, and environmentally friendly process. Of course, such process still needs long lead time and many labors to work. This is not the competitive price in the printing market. Digital production and automation is becoming a good choice. It is because of the stresses of finding labor and high cost of working process, automation is imperative. For those that can't invest in automation, it's going to be more and more difficult. Note that digital is not new to the publishing market, but inkjet advancements are shaking things up, allowing publishers to capitalize on evolving demand, boost productivity, and add value with additional services.

As Chulalongkorn University Press (CUpress) recently invested the web inkjet press in-line with sheet cutting and stacking machines for book printing service while the old offset machines are used for medium and long run printing and cover printing (Figure 1-2). It showed that the inkjet press system used the operators only 2 workers while the conventional system was still run by 12 workers. (pre-press + press + post-press). The question is that how to manage these workers in the conventional system that the CU press should not let them vacant from work. We therefore studied the digital transformation on business operation and internal administration of printing houses focusing on the problem of adjustable work processes of employees in the case of Chulalongkorn University Press. A working system relying on conventional and digital printing technologies were observed. A

model relating to the existing employees was proposed to minimize production costs in the printing house. A set of parameters corresponds to the number of tasks was assigned to both systems to estimate the work efficiency level of each position. An average of the work efficiency levels was needed to define a constraint in an optimization modeling approach. In the experiment, the simulated annealing algorithm based on evolutionary computation was applied for identifying the parameters of the cost balance model.

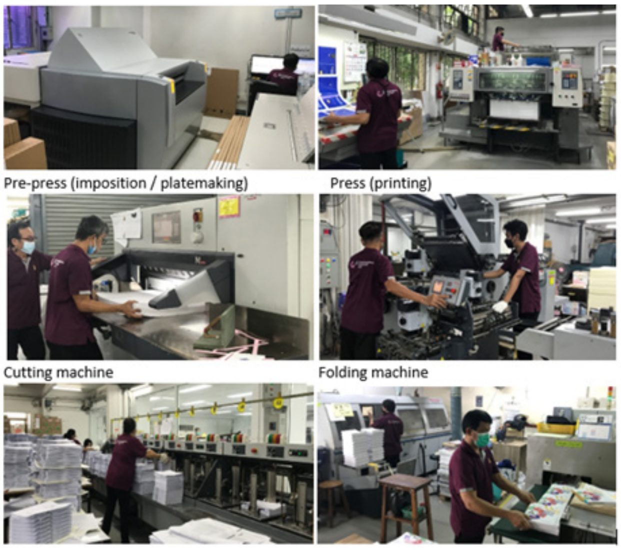

Figure 1: Workers involved in each step in conventional system (Offset printing).

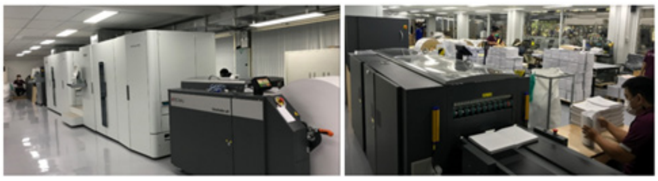

Figure 2: Workers involved in digital web inkjet press + inline sheet cutting and stacking.

Experiment

We collected the data of working environment from CU press as follows:

a. number of workers involved in production process (conventional and digital system)

b. salary of workers

c. machine payment (ex: inkjet press total click charge minimum 650,000 Baht/month)

d. fixed cost and variable cost for each system

Mathematical models were proposed to simulate the costing for each system and combined systems between conventional and digital systems. In real situation, the planning division of CU press must arrange the job orders day by day and to define which printing system should be used for each job order.

Heuristic approach was designated as it is a computational procedure that determines an optimal solution by iteratively trying to improve a candidate solution with regard to a given measure of quality. The main advantage of adopting a heuristic approach is that it offers a quick solution, which is easy to understand and implement [1-2]. Heuristic algorithms are practical, serving as fast and feasible short-term solutions to planning and scheduling problems. We proposed the Simulated Annealing (SA) technique to find the most reliable values. This technique is a popular algorithm used to optimize a multi-parameter model that can be implemented relatively quick -

Step 1: Initialize – Start with a random initial placement. Initialize a very high "temperature".

Step 2: Move – Perturb the placement through a defined move.

Step 3: Calculate score – calculate the change in the score due to the move made

To determine the cost when both systems were simultaneously used, we defined the parameters in the model based on staff working in the two processes as they have obligations with the CU press. The proposed costing models could be summarized in linear equation as followings [3]:

$$C^s_o = w_a a_s a_o + w_b b_s b_o + w_c c_{fp} c_o + w_d d_s d_o + w_e e_s e_o + w_f f_s f_o + w_g g_s g_o + w_h h_s h_o \ldots \quad (1)$$

$$C^s_n = w_a a_s a_n + w_b b_s b_n + w_c c_s c_n + w_d d_s d_n + w_e e_s e_n + w_f f_s f_n + w_g g_s g_n + w_h h_s h_n \ldots \quad (2)$$

where Cso : cost of staff in conventional system

C^s_n : cost of staff in digital system

a_o / a_n : number of editorial staff in conventional and digital systems

b_o / b_n : number of designer in conventional and digital systems

c_o / c_n : number of prepress staff in conventional and digital systems

d_o / d_n: number of printer in conventional and digital systems

e_o / e_n : number of folding machine staff in conventional system

f_o / f_n : number of cutting machine staff in conventional system

g_o /g_n : number of signature gathering machine staff in conventional system

h_o / h_n : number of binding machine staff in conventional and digital systems

$a_s/b_s/c_s/d_s/e_s/g_s/h_s$: salary for each staff

$w_a/w_b/w_c/w_d/w_e/w_f/w_g/w_h$: workload of each staff

Note that the w values fell in the range of $0 \le w_{a,}\ w_b, \ldots, w_h \le 1$. For example = 0.95, this means that the editorial staff has a workload in this job 95% compared to the maximum 100%. w values were co-variable in both equations as these staff can work in both systems. Accordingly, the cost based on working staff would be:

$$C^s = \alpha C^s_o + \beta C^s_n \quad \ldots\ldots\ldots\ldots \quad (3)$$

where α and β were the ratio of job allocation between two systems. Therefore

$$\alpha + \beta = 1.0 \quad \ldots\ldots\ldots\ldots \quad (4)$$

In case of variable cost, we could explain it in a linear equation as given in Equation 5.

$$Cp = \alpha C^p_o + \beta C^p_n \quad \ldots\ldots\ldots\ldots (5)$$

The total cost would be:

$$C^T = C^s + C^p \quad \ldots\ldots\ldots\ldots (6)$$

As CT was a function of α, β, w_a, w_b, … , w_h, we thus proposed P =[α, β, w_a, w_b, … , w_h] as a vector of parameters. This research was to find the optimal solution of these parameters to achieve the lowest total cost (C^T). MATLAB was used as a tool to calculate. In addition, the cost estimation should be determined under the condition that working efficiency of CUpress ( ) should not less than that of defined criteria ( ).

$$> \gamma \ldots\ldots\ldots\ldots (7)$$

Where = (w_a + w_b + + w_h)/8

Finally, constrained optimization was applied as follows:

$$\min^{P} T(P)$$

$$\text{s.t. } 0 < \alpha, \beta < 1$$

$$\alpha + \beta = 1$$

$$\geq \gamma$$

Results and discussion

The number of staff working in the conventional and web inkjet printing systems, including their salary are given in Table 1. The parameters obtained from the SA analysis under the present situation were as follows:

i. job allocation in conventional system (α) = 0.599984 (60%)

ii. job allocation in digital system (β) = 0.400016 (40%)

iii. average working efficiency ( ) 0.95015979

iv. Total cost (C^T) 2,072,845 THB/month (C^s = 452,845 THB, C^p = 1,620,000 THB)

v. C^s calculated from full workload of working staff

vi. C^p_o 975,000 THB / C^p_n 650,000 THB

It is shown that more job are allocated to the conventional system as most of the employees are still working with the CUpress. However, the CUpress has to accept the situation that the click charge payment for digital system must pay at the minimum amount. Some months will be loss, some months will be gain! Note that if we knew the sale volume of all jobs from the sale department, we could estimate the profit/loss based on the obtained total cost.

Digital transformation and costing in the next five years

It should be noted that 1-2 staff of the conventional production will be retired year by year. It is interesting to know how digital transformation can cope with this situation in the next five years, particularly costing. Our model can predict this phenomenon. The job allocation will be moved more to the web inkjet press to fulfill the minimum click charge per month. In addition, the inkjet press gives many advantages such as a few operators usage, reduced cost of paper roll, less waste and quick process.

Our survey showed the reduction of variable cost (C^p_n) of the digital system 15%, compared to the conventional system (C^p_o). While the cost of staff depended on the ratio of job allocation and work load of each staff. To find the optimal solution of parameters in the next five years from the model by SA, evolutional computing by random technique was applied step by step in order to observe the improvement of these parameters and total cost (C^T) [4-5]. Final result is given in Table 2. Job allocation for digital system will be up to 60%. This will help increasing the efficiency of the web inkjet press to reach the minimum click charge per month. Workload of staff in conventional system will decrease 50% as the CUpress will recruit the workers from other departments instead. The total cost (C^T) will reduce down to 20.78% per month. This help increasing the profit of the CUpress and the potential to get more jobs by price competition.

Table 1: Number of staff working in the conventional and digital printing systems

Staff (position)	Conventional Printing System	Digital Printing System	Salary (THB)
editorial	x	x	28,500/28,500
Designer1	x	x	30,500/27,650
Designer 2	x		26,000
Press operator 1	x	x	36,650/16,500
Press operator 2	x	x	20,000/21,500
Press operator 3	x		21,650
Pre-press 1	x		25,745
Pre-press 2	x		24,650
Cutting machine operator	x		19,500
Folding machine operator 1	x		19,500
Folding machine operator 2	x		21,000
Gathering machine operator 1	x		24,000
Gathering machine operator 2	x		18,500
Binding machine operator 1	x	x	24,000
Binding machine operator 2	x	x	18,500

In the case of full digital transformation, this means that we stop using conventional system. The cost of staff will be based on only six staff with full workload (136,650 THB/month). While the production cost depends on the number of jobs from the sale department which at least minimum click charge. By SA analysis, the total cost (C^T) will down to below one million THB/month including the materials cost (ink and paper). This represents the success of digital transformation at the CUpress in the future when the organization is leaned.

Table 2: Prediction of optimal solution of book production at the CUpress using the combination of conventional and digital systems

iteration = 89,104,677
total cost (CT) = 1,642,172.50 THB/Month (Cs : 273,497.50 THB, Cp : 1,430,000 THB)
α = 0.4000 (40%)
β = 0.5999 (60%)
working efficiency (v) = 95.030141 %

Conclusions

It was shown that digital transformation with the web inkjet press allowed publishing houses to repurpose their business by combining with conventional production, depending on the adjustable work processes of employees. Its benefit was to be able to reduce the total cost which is important to get more jobs. To approve the assumption, the simulated annealing algorithm based on evolutionary computation was applied for identifying the parameters of the cost balance model. Optimal solution showed that the total cost could decrease to the level of CUpress be able to compete in the book printing market. Interestingly, the success of digital transformation will be seen concretely when the CUpress stops using conventional production in the future after the retirement of employees.

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