行政院國家科學委員會專題研究計畫 成果報告

生產管理的新思維-功能單元生產系統
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附件一

行政院國家科學委員會補助專題研究計畫

■ 成 果 報 告
□期中進度報告

生產管理的新思維-功能單元生產系統

計畫類別：■ 個別型計畫　　□ 整合型計畫
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執行期間：　　95　年　8　月　1　日至　　96　年　9　月　30　日

計畫主持人：
共同主持人：
計畫參與人員：

成果報告類型(依經費核定清單規定繳交)：■精簡報告　□完整報告

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中　華　民　國　96　年　10　月　1　日

A STUDY OF LABOR ASSIGNMENTS IN CELLULAR MANUFACTURING SYSTEMS

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Abstract

This study examines labor flexibility, defined by three strategies: dedicated (i.e., one operator for a single job), shared (i.e., two or more operators for a single job), and mixed (i.e., operators with both dedicated and shared jobs), in cellular manufacturing systems. Labor flexibility is proxied by an index of work sharing to study its relationship with system performance. Several schemes are generated: one cell with two and three operators for intra-cell study, respectively, and two cells with four and six operators for inter-cell study, correspondingly. Specifically, this study explores whether work sharing affects system performance directly and/or indirectly via work balancing, using simulation and statistical analyses. Issues including learning effect, fatigue, operators' interaction, lot size, and machine time variation are modeled in this study. The findings and framework developed in this paper may serve as guidelines and decision-making tool for corporate management.

Keywords:

Cellular Manufacturing Systems, Labor Assignment, Workload Balancing, Work Sharing, Simulation.

1 INTRODUCTION

This study is motivated by the fact that a production system is able to transform from producing large quantity- low variety to small quantity-high variety products. The key factor of the change is the implementation of cellular manufacturing systems (CMS), which decomposes the machines into several cells containing one or more multifunctional operators sharing the work in order to satisfy the increased orders of customized products. The concept of using multifunctional operators is referred to as labor flexibility achieved by cross-training operators in different tasks. Two types of flexibilities are considered, intra-cell labor flexibility refers to operators sharing the work within the same cell, whereas inter-cell labor flexibility refers to operators sharing work between different cells. The primary objective of this research is to study the relationship between labor flexibility and system performance, and the impact of the system characteristics such as number of operators and cells on the relationship. Three labor assignments strategies, dedicated (i.e., only one operator is responsible for a single job), shared (i.e., two or more operators for a single job), and mixed (i.e., operators with both dedicated and shared jobs) are used to denote different managerial considerations. Dedicated (shared) strategy represents the lower (upper) bound of labor flexibility, whereas mixed strategy corresponds to the middle part. The flexibility of labor indicates how much work is shared and is proxied by an index of work sharing. Another objective of this research is to study the importance of work balancing and how it correlates with work sharing and system performance. Relationship between work sharing and performance, and between workload balancing and performance are common issues found in many research topics. However, three of them are rarely put together for a study. The following seven hypotheses are generated and will be tested in this research.

H_1: The systems with flexible labor assignment strategy intra-cells perform better than that without flexible labor assignment strategy.

H_2: The systems with flexible labor assignment strategy inter-cell perform better than that without flexible labor assignment strategy.

H_3: Workload balancing and system performance are positively correlated.

H_4: Workload balancing and work sharing intra-cells are positively correlated.

H_5: Work sharing intra-cells and system performance are positively correlated.

H_6: Workload balancing and work sharing inter-cell are positively correlated.

H_7: Work sharing and system performance inter-cell are positively correlated.

2 LITERATURE REVIEW

Labor flexibility has attracted great attentions in the study of production systems. Sennott et al. [1] formulated Markov decision process models of K-station production lines and their numerical study for lines with two and three station showed that performance improved through capacity balancing and variability buffering. Felan and Fry [2] studied Dual Resource Constrained (DRC) job shop and recommended that it is better to have a mix of operators with no flexibility and some workers with very high flexibility rather than all workers with equal flexibility. Bokhorst et al. [3] focused on which operator should do the task given options in DRC systems. Jensen [4] examined the performance advantages of machine and labor flexibility and his study demonstrated that under several sets of conditions, promoting labor flexibility to the exclusion of machine flexibility provides superior performance. Several literatures focused on cross training operators. Slomp et al. [5] developed an integer programming (IP) model to select workers cross trained for particular machines. Brusco and Johns [6] applied also IP for evaluating cross training configurations at the policy level to minimize workforce staffing costs. Askin and Chen [7] developed decision rules combined with simulations and cross training is shown to have significant impact on throughput. As for the research methods, simulation is most frequently used. For instance, Djassemi [8] studied the factors influencing the flexibility of CMS, and cross trained operators were the most important factor. Schultz et al. [9] identified performance feedback and work interruptions are factors that may explain some of the negative effects diminishing the advantages of flexible workers. Mathematical model, generally incorporated with heuristics is another popular method. Using mixed integer programming, Suer and Dagli [10] modeled the cell loading in CMS to minimize the total intra-cell workforce transfers while Norman et al. [11] considered technical and human skills to maximize profits represented by a function of productivity, quality costs, and training costs. Data envelopment analysis was used by Ertay and Ruan [12] to decide the most efficient number of operators and the efficient measurement of labor assignment in CMS. In addition to the quantitative research, survey and review was used for qualitative study. Bidanda et al. [13] identified eight human issues involved in CMS from literature and determined their important by survey to a sample of academics, managers, and workers involved in CMS design and implementation.

3 METHODOLOGY

Simulations and statistics are the primary tools in this study. The following sections introduce the measures and assumptions for the simulation models.

3.1 Measures

- Workload

Workload is measured by the time including setup time, machine time, and part handling time. When working between cells, moving time is needed if a new job is in a different cell.

$Workload_{intra} = SU + MAC + PH$

$Workload_{inter} = SU + MAC + PH + MV$

SU : setup time.

PH: part handling time.

MV: moving time between cells.

MAC: machine time, or the time an operator spent on a machine to complete the task.

- Workload balancing

Cesani and Steudel [14] used WB_1 to measure the workload balancing. This study develops a second index, WB_2 . (Preliminary studies showed that WB_2 generates more efficient results than WB_1 .) Therefore, WB_2 will be used throughout this study to measure the workload balancing.

$$WB_1 = \sqrt{\frac{\sum_{i=1}^{N}(OPR_i - \frac{1}{N})^2}{N}}$$

$$WB_2 = \frac{1}{N}\sum_{i=1}^{N}\left|OPR_i - \frac{1}{N}\right|$$

WB_1 and WB_2 : measures of workload balance.

N : number of operators

OPR_i : proportion of the overall manual workload assigned to operator *i*.

$$OPR_i = F_i + \sum_{j=1, j\neq i}^{N} S_{ij}W_{ij} + \sum_{j=1, j\neq i}^{N} \sum_{k=j+1, k\neq j}^{N} S_{ijk}W_{ijk}$$

F_i : proportion of the overall workload assigned exclusively to operator *i*.

$S_{i,j,..,N}$: proportion of the overall workload shared among *N* operators.

W_{ij} : Percentage of workload done by the *i*th operator shared with the *j*th operator, with the constraint that for $S_{i,j,...,N}$ $W_i + W_j + ... + W_N = 1,\ i \neq j \neq ... \neq N$, $S_{ij} = S_{ji}$, and $\sum F_i + S_{i,j,..N} = 1$.

- Workload Sharing

This study focuses on three labor assignment strategies: dedication, sharing, and mixed. Two indices, $WSIntra$ and $WSInter$, were developed to evaluate the work sharing intra-cell and inter-cell, respectively. Both of the indices are at the internal of [0,1] in which complete dedication is given a value of ‘0’, and complete sharing is set to ‘1’.

$$WSIntra = \frac{SIntra_T}{F_T + SIntra_T + SInter_T}$$

$$WSInter = \frac{SInter_T}{F_T + SIntra_T + SInter_T}$$

F_T : total dedicated workload.

$F_T = \sum_{j=1}^{J}\sum_{i=1}^{N} F_{ij}$, where F_{ij} is the proportion of the workload assigned exclusively to operator *i* on job *j*.

$SIntra_T$: total shared workload within the cell.

$$SIntra_T = \sum_{j=1}^{J}\sum_{i=1}^{N} SIntra_{ij} \cdot W_j$$

$SIntra_{ij}$: percentage of workload of job *j* shared by operator *i* in the cell. $SIntra_{ij}$ =[0,1] and $\sum_{i=1}^{N} SInter_{ij} \leq 1$

W_j : percentage of job *j* on the overall workload.

$SInter_T$: total shared workload in the system.

$$SInter_T = \sum_{j=1}^{J}\sum_{i=1}^{N} SInter_{ij} \cdot W_j$$

$SInter_{ij}$: percentage of workload of job *j* shared by operator *i* in the system.

$SInter_{ij}$ = [0,1] and $\sum_{i=1}^{N} SInter_{ij} \leq 1$

- Performance

Performance is measured by relative performance as shown below:

$Perf = \frac{P_S}{P_{ideal}}$, where P_S is the throughput for the case studied, and P_{ideal} is the ideal maximum throughput when the labors are unconstrained.

3.2 Assumptions

The assumptions of the analyses are presented in the following sections.

- The operators perform the work according to the priorities defined in advance. The most significant job has the highest priority, followed by the job with the shorter process time. The next one is the dedicated job, and then the shared job. The job at the other cells has the least priority.
- The fast-paced operators will be affected by the slow-paced operators. Schultz et al. [9] documented that the differences between two operators within the cell are over certain limit, the working speed of the fast-paced operator will be reduced by 10%. In addition, the operator with fast speed will slow down intentionally while moving among machines or jobs and hence moving time is added. The followings illustrate the calculations.

$$MAC_{\inf} = \begin{cases} MAC_{ij}; & \frac{\max OPR_i}{\min OPR_i} < 1.2 \\ MAC_{ij} \times 110\%; & \frac{\max OPR_i}{\min OPR_i} \geq 1.2 \end{cases}$$

$MAC_{\inf}$: influenced machine time.

MAC_{ij} : machine time of *i*th operator on *j*th job.

OPR_i : proportion of the overall manual workload assigned to operator *i*.

- The material supplies are assumed to be unlimited.
- Machine breakdowns and defective products are irrelevant in this study.
- McCreery and Krajewski [15] described forgetting and learning effects of multifunctional workforce. The operator will need additional time as starting a new task, and there is a negative exponential relationship between process time per unit and lot size. To simply the model, this study assumes that the operators do not forget the operating skills during interruptions, and warm-up time is needed to restart a certain job. The machine time is adjusted as follows:

$$MAC_{Learning} = \begin{cases} MAC_{ini} & k = 0 \\ MAC_{ini} - e^{\frac{k}{n}\ln(MAC_1 - MAC_{ST})} & 0 < k < n \\ MAC_{ST} & k \geq n \end{cases}$$

MAC_{ini} : initial machine time.

MAC_{ST} : standard machine time.

n : number of repetitive jobs needed to reach the effective learning effect.

- The operator won't change the job until all of the jobs in the same lot are completed, and the work efficiency is reduced due to the fatigues and repeating movement. The lot size is set to high at 50, moderate at 5 and low at 2. Fatigue or repetitive work will decrease the work efficiency.

$$MAC = \begin{cases} MAC & ,(N_{job} \times MAC) < P \\ MAC \times 1.2 & ,(N_{job} \times MAC) \geq P \end{cases}$$

N_{job} : number of jobs completed.

P : time required to reach the stage of fatigue. Since it varied substantially by persons, it is set to an average of 200 with standard deviation of 100.

- Machine time is assumed to be normally distributed with mean of 50 and two levels of variation: 5 for low variation and 15 for high variation.
- The ratio of setup time to machine time is set to 1 for high and 0.1 for low. When the ratio is high, the operator will setup the machine and stay until the job is finished. When the ratio is low, the operator will leave the machine after completing the setup.
- This study examines four combinations of the labor assignment strategies pertaining to intra- and inter-cells: low (dedication) for intra-cell and low (dedication) for inter-cell, low (dedication) for intra-cell and high (mixed) for inter-cell, high (mixed) for intra-cell and low (dedication) for inter-cell, and high (mixed) for intra-cell and high (mixed) for inter-cell.
- The research also generates four scenarios: one cell with two operators, one cell with three operators, two cells with four operators, and three cells with six operators. All of them have five jobs to be processed.

4 SIMULATION RESULTS AND ANALYSIS

4.1 One cell / Two operators / Dedication

Appling dedication labor assignment strategy for two operators with five jobs will produce 32 combinations. Each combination is simulated 30 times. Table 1 shows the partial results of two combinations.

Table 1: Sample results of two combinations for one cell / two operators / dedication

Combination	Job	Operator 1	Operator 2	Index
1	1	X		OPR_1 =0.493
	2		X	OPR_2 =0.507
	3		X	WB_1 =0.007
	4	X		WB_2 =0.007
	5		X	$Perf$ =0.476
2	1		X	OPR_1 =0.308
	2	X		OPR_2 =0.692
	3	X		WB_1 =0.192
	4		X	WB_2 =0.192
	5		X	$Perf$ =0.382

Table 2 presents the regression results indicating the relationship between system performance and workload balancing. The p-value of 0.000 indicates a significant relationship between system performance and workload balancing at 99% of confidence level. The results provide support for H_3.

Table 2: Regression results and ANOVA

	Coeff		Coeff (std.)		
	Est.	Std. error	Beta	T	P-value
Int.	0.548	0.005		113.06	0.00***
WB	-0.466	0.022	-0.969	-21.61	0.00***

Source	DF	SS	MS	F	P-value
Regression	1	0.108	0.108	467.05	0.000***
Residual	30	0.007	0.000		
Total	31	0.115			

R^2 = .941 Adj. R^2 = .938 *α=0.1 **α=0.05 ***α=0.01

Table 3: ANCOVA results

Source	DF	SS	MS	F	P-value
Reg.	59	3.636	0.062	144.223	0.000***
Comb.	29	0.051	0.002	4.149	0.000***
WB	1	3.520	3.520	8237.015	0.000***
Comb.*WB	29	0.008	0.000	0.655	0.920
Error	900	0.385	0.000		
Total	960	217.048			

R^2 = .904 Adj. R^2 = .898

In order to test the impact of machine time on the relationship between workload balancing and system performance, 30 pair-wise cases are generated in which each pair contains two cases: one with low variability of machine time (i.e., machine time of 50 and standard deviation of 5) and the other with high variability of machine time (i.e., machine time of 50 and standard deviation of 15). The results of ANCOVA are presented in Table 3, indicating that the relationship between workload balancing and system performance is independent of machine time variation.

4.2 One cell / Two operators / mixed

Every job will have three options when the labor assignment strategy is mixed, resulting a total of 243 combinations. Table 4 demonstrates an example and the corresponding simulation results.

Table 4: Sample results of one combination for one cell / two operators / mixed

Job	Operator 1	Operator 2	Index
1	X		OPR_1 = 0.4930
2	X		OPR_2 = 0.5070
3	X	X	WB_1 = 0.0070
4	X		WB_2 = 0.0070
5		X	WS = 0.27
			$Perf$ = 0.39041

The regression results indicate that work sharing is significantly and positively related to workload balancing for a cell with two operators.

The normality test shows that the residuals will decrease as the work sharing increases. In other words, it is easier to reach workload balancing when the work sharing increases. The plots of work sharing against performance are shown on Fig. 1 and the statistical results indicate that the model is significant at 99% of confidence level.

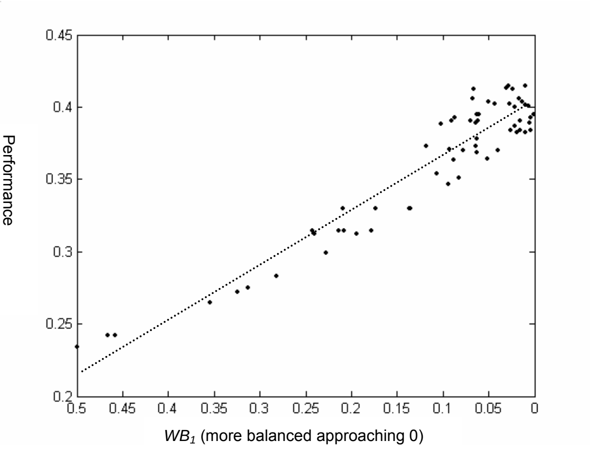

Figure 1: Workload balancing vs. performance

The results of path analysis reveal that the direct effect of work sharing on performance is 0.053 while the indirect effect on performance is 0.145. The work sharing affects system performance both directly and indirectly via work balancing. However, the magnitude of direct effect is much less than the indirect effect. That is, to have better performance in a cell with two operators, the supervisor should focus not only on the work sharing, but also on the workload balancing. Contrary to predictions, high level of work sharing with poor workload balancing has insignificant impact on system performance.

Similar to the previous process, the factor of machine time variation is tested for the case of one cell with two operators and mixed labor assignment strategy. When the variation is high (i.e., average machine time is 50 and standard deviation of machine is 15), the study found similar results to that with small machine time variation. Since the machine time variation is insignificant, it will be excluded for the rest of the research. While the factor of setup time ratio is also tested, the results are insignificant. Accordingly, low ratio of setup time to machine time is used for the rest of the study.

Next, this study examines the factor of lot size with three levels: 2 for small, 5 for moderate, and 50 for large, based on the three lot sizes on the four scenarios as indicated previously. The ANCOVA statistics show insignificant differences for the relationships between work sharing and workload balancing. However, the investigation of the relationships among work sharing, workload balancing, and performance, indicates that the impact of workload balancing on system performance are greater for small lot size than for the large one. When comparing direct effect with indirect effect of work sharing on system performance, all of the three lot sizes demonstrate higher direct effects than indirect effects. In addition, the direct and indirect effects differ substantially for small lot size. To simply the problems, moderate lot size of five will be used throughout the study.

4.3 One cell / Three operators / mixed

Allocating three operators to a cell with five jobs produces a total of 243 combinations of labor assignments. The statistical results indicate that the model is significant at 99% of confidence level. The findings indicate a positive relationship between workload balancing and system performance, and between work sharing and workload balancing. Both of the relationships are similar to those of one cell with two operators. However, the path analysis document different results. Work sharing has direct effect with coefficient of -0.189 and indirect effect with coefficient of 0.391 via workload balancing on system performance, respectively. The managerial implication is that increasing number of operator will improve the system performance when the workload is well balanced. Without good workload balancing, more operators will have negative impact on the system performance.

4.4 Comparisons for Intra-cell

Regression analysis is performed to compare four intra-cell scenarios: two operators with dedication strategy, two operators with mixed strategy, three operator with dedication strategy, and three operators with mixed strategy. The four regression models for the relationship between workload balancing and performance are as follows:

Performance (2 ops., dedication) = 0.482 - 0.457WB_2

Performance (2 ops, mixed) = 0.651 - 0.817WB_2

Performance (3 ops, dedication) = 0.602 - 0.753WB_2

Performance (3 operators, mixed) = 0.657 - 0.967WB_2

The results suggest that mixed labor assignments perform better than dedicated labor assignments. However, the relationship is weakened when the number of operators increases. In addition, mixed labor assignment with two operators performs better than dedicated labor assignment with three operators. The hypothesis test results are presented on Fig. 2 and 3, in which the arrows indicate significant correlations with '+' denoting a positive relationship and '-' representing a negative relationship.

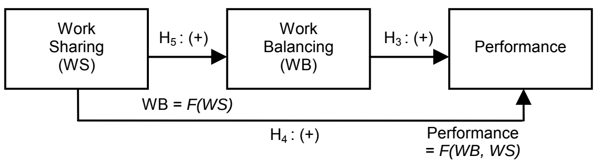

Figure 2: Relationship for intra-cell with two operators

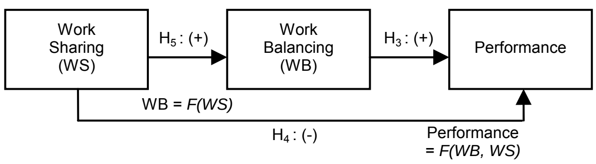

Figure 3: Relationship for intra-cell with three operators

4.5 Inter-cell (Two Cells / Four Operators / Mixed / Dedication)

Four operators working on two cells with mixed labor assignment for intra-cell and dedicated labor assignment for inter-cell generates a total of 59,049 combinations, in which 100 combinations are randomly selected for testing. Each combination is simulated 30 times to study the relationship among work sharing, workload balancing, and performance. The statistical results provide support for H_3 and H_4, but not for H_5, indicating a positive relationship between workload balancing and performance, and between work sharing and workload balancing. Work sharing is not positively correlated with system performance as expected. In fact, work sharing has significant negative effect on performance.

4.6 Inter-cell (Two Cells / Four Operators / Mixed / Mixed)

When two cells with four operators and mixed labor assignments are applied to both of intra- and inter- cells, 100 combinations out of approximately three billions are randomly selected to test H_6 and H_7. The results provide support for both hypothesizes at the 99% level. H_6 asserts that workload balancing and work sharing between cells are positively correlated. However, applying mixed labor assignment for inter-cell mitigates the association between work sharing and workload balancing for intra-cell. H_7 proposes a positive relationship between work sharing and system performance for inter-cell. The results of path analysis indicates that work sharing has direct effect of 0.045 and indirect effect (via workload balancing) of 0.141 on the system performance of intra-cell, and direct effect of 0.084 and indirect effect (via workload balancing) of 0.356 on the system performance of inter-cell. The direct effect of work sharing on system performance is significantly greater for inter-cell than for intra-cell. The management should focus on flexible labor assignments for inter-cell rather than that for intra-cell. An operator capable of performing multiple tasks between cells will improve the overall performance at a greater extent than conducting multiple tasks within a cell. Training an operator working between cells costs more than working within a cell, and the framework developed in this research provides a tool to study the relationship between cross training costs and performance improvement

4.7 Inter-cell (Three Cells / Six Operators / Mixed / Dedicated)

A similar process is conducted for the case of three cells with six operators. When mixed labor assignment is used for intra-cell and when dedicated labor assignment is used for inter-cell, the results are similar to that of mixed labor assignments for both of intra- and inter-cells.

When the labor assignments for intra- and inter-cells are both mixed, the results fail to support H_6. Specifically, workload balancing doesn't improve by higher work sharing either for intra- or inter-cells. However, the findings provide evidence to support H_7, indicating that workload balancing is positively correlated with system performance. The results also show that the direct effect of work sharing on system performance is higher for inter-cell than for intra-cell. When the number of cells increases, the situation is more complex and the impact of work sharing on workload balancing is reduced. As for practical application, an operator capable of performing multiple tasks might not improve the workload balancing, but will have positive impact on the overall performance.

4.8 Summary

Both of the studies for intra- and inter-cells indicate that better work sharing produces superior system performance, providing support for H_1 and H_2. For the analysis of intra-cell, a positive relationship between workload balancing and system performance is observed. For a low variation of machine time, the slope of regression model denotes a constant relationship. When the variation is high, the association between workload balancing and system performance still remains positive, but becomes less significant.

Moreover, the work sharing for intra-cell has direct effects on workload balancing and system performance. When studying the system with two operators, both the direct and indirect effects are positive. With three operators, work sharing is positively related to workload balancing and negatively associated with system performance. The results also indicate that the one cell with two operators and mixed labor assignment produces better system performance than that with three operators and dedicated labor assignment. Two operators capable of sharing the workload for each other outperform three operators working on their own within a cell.

Tuning to the inter-cell analysis, work sharing is linearly and positively correlated with workload balancing and with system performance when studying two cells. However, when three cells are considered, the work sharing has less significant or no effect on workload balancing. For both two and three cells, work sharing is positively related to system performance, and the work sharing for inter-cell have a greater impact on workload balancing than work sharing for intra-cell. The hypothesis test results are shown on Fig. 4 and 5 in which the arrows indicate significant correlations with '+' representing a positive relationship and '-' denoting a negative relationship.

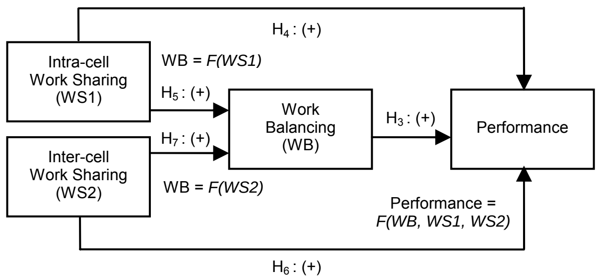

Figure 4: Relationship for inter-cell with two cells

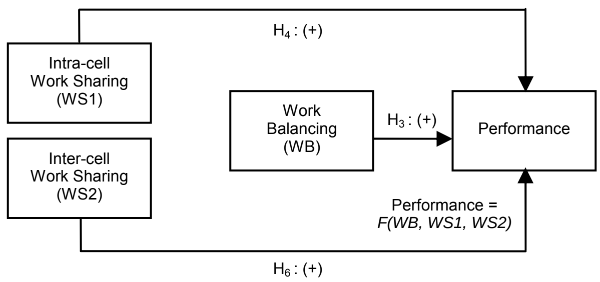

Figure 5: Relationship for intra-cell with three cells

5 CONCLUSIONS AND FUTURE WORK

This objective is this research is to study the impact of labor assignment strategies on system performance. The working environment is so called Dual Resources Constrained (DRC), defined previously with only one cell and extended to two, up to three cells in this study. Factors including lot size, machine time variation, ratio of setup time to machine time, forgetting and learning effects, and interaction effect between fast and slow operators are considered. Problems are modeled and simulated to obtain sufficient data for analysis. Statistical techniques including regression analysis, ANOVA, ANCOVA, and path analysis are used to explore the relationship among labor assignment strategy, workload balancing, and system performance. With limited labor resources, mixed labor assignment directly and indirectly improves the performance within a cell. When more operators work within the cell, only the indirect effect remains positive. It is noted that the mixed labor assignment for inter-cell shows different results than that for intra-cell. Under simple situations (fewer number of cells and operators), mixed labor assignment for inter-cell have direct and indirect effects on the system performance. As the situations become more complicated (more number of cells and operators), the study found significant direct effect but insignificant indirect effect. Taken together, in relatively simple working environment, managers should focus on mixed labor assignment for intra-cell. When the working environment becomes more complicated, mixed labor assignment for inter-cell is imperative to improve the overall system performance.

Multifunctional operators are the key element for mixed labor assignment strategy. This study indicates that when more than 70 % of the skills are shared by all of the operators requiring higher training costs, system performance does not improve significantly. The procedure developed in this paper provides a tool for the trade-off analysis between training cost and performance improvement.

Although many factors are tested simultaneously in this study, some issues remain untouched. For example, the psychological factors of the operators are critical to system performance, but they are very difficult to be modeled and studied. Prior studies present analysis qualitatively rather then quantitatively. Modeling the qualitative factors in a quantitative way may increase the validity of the model and serves as a better tool for system analysis and decision making. A second avenue of research is to use different performance index, such as inventory levels, makespan, cost, and multi-objective with more than one index, to study the cellular manufacturing systems.

6 ACKNOWLEDGMENTS

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7 REFERENCES

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出席國際學術會議心得報告

計畫編號	NSC　　95-2416-H-004-041
計畫名稱	生產管理的新思維-功能單元生產系統
出國人員姓名 服務機關及職稱	洪叔民 國立政治大學企管系助理教授
會議時間地點	Valparaiso, Chile, 29 July – 2 August, 2007
會議名稱	19^{th} International Conference on Production Research
發表論文題目	A STUDY OF LABOR ASSIGNMENTS IN CELLULAR MANUFACTURING SYSTEMS

一、參加會議經過

This is a conference focused on issues related to production research. About 80% of the participants are teaching in universities and the rest of them are practitioners working in private companies, research institutes, or governments. More than 100 papers were peer-reviewed and selected to be presented in the ocnference. I used the first 15 minutes to present the model I developed and the rest of the time, 15 minutes to answer the questions from the audience. It is clear that I received good feedback from the audience.

二、與會心得

This conference is sponsored by International Fundation on Production Reserch. This fundation also publishes a well-known journal, International Journal of Research. It is quite an opportunity to exchange the latest knowledge and development of production research and get to know the scholars in this field.