行政院國家科學委員會補助專題研究計畫成果報告

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計畫編號：NSC90－2218－E－009－034
執行期間：　90 年　8 月　1 日至　91 年　7 月　31 日

計畫主持人：沙永傑
計畫參與人員：車振華

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執行單位：國立交通大學工業工程與管理研究所

中　華　民　國　91　年　10　月　15　日

行政院國家科學委員會專題研究計畫成果報告

半導體產業供應鏈配送網路之整體規劃及應用系統開發(I)

The Integration Planning of Supply Chain Network System for the Semiconductor Industry and an Application System Development (I)

計畫編號：NSC 90-2218-E-009-034

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主持人：沙永傑　國立交通大學工業工程與管理研究所

計畫參與人員：車振華　國立交通大學工業工程與管理研究所

1. Abstract

Supply chain management has offered a way to make industry more competitive. While widespread methodologies may only effectively solve the production-distribution problem from supplier- or customer-oriented consideration, those methods can't demonstrate actual situations. In the competitive semiconductor industry environment, simultaneously considering the perspectives of supplier and consumers is especially, because multiple manufacturing and demanding steps are performed for separate situations, concurrently. This work presents a novel interaction-oriented approach, based on the analytic hierarchy process (AHP) methodology, for solving the semiconductor distribution problem with multiple quantitative and qualitative criteria. This approach provides the expected optimal satisfaction for all the participators of the whole chain while the cooperative information is shared perfectly and effectively.

Keywords: interaction-oriented analytic hierarchy process, supply chain distribution networks

中文摘要

半導體產業為目前具成長性的產業，台灣半導體產業主要為國際廠代工，使得此產業從供應至消費形成一規模相當龐大的供應鏈網路系統。相對地，整個網路體系之控制變得非常複雜，因而在進行供應鏈網路系統規劃時，必須以宏觀的視野對整個產業的上、中、下游作整體規劃。另外一般供應鏈體系相關的研究仍僅考慮系統能達成單一目標，如成本最小化、銷售最大化…等，且亦缺少系統化的方法指示產業成員如何執行其任務，方可達成既定的目標。因此，本研究將提出交互導向之層級結構分析法，同時考量定性（彈性、滿意度…）及定量（成本、產能、交期…）多種評估指標，以期在多項資源限制條件下，建構出一適當的供應鏈配送網路系統，使產業能達到整體最適化的成果。

關鍵詞：交互導向層級結構分析、供應鏈配送網路、整體最適化

2. Introduction

Christopher (1992) stated that an adequate definition of supply chain from a logistical point of perspective is "a network of organizations that are involved, through upstream and downstream linkages, in different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer" point of perspective. Supply chain management, increases the competitiveness of the industrial environment, involves planning and managing the flow of information, material, and product through a multi-echelon of design, production/manufacturing, transportation and distribution until it reaches the customer.

In the semiconductor industry, modeling the supply chain is particularly critical. Semiconductor fabrication, assembly and testing facilities represent very substantial capital investments. The essence of supply chain management is considered to be the integration of business activities to serve end customers by establishing a strategic partner alliance. The relationships in a supply chain may adopt various legal forms (Ellram 1991). Figure 1 illustrates the relationship between the dependent natures of supplier-customer relations. For the semiconductor supply chain, the relationship between supplier and customer tends to create a decision problem involving multiple selections. That is, the relationship is in the quadrant I (strategically cooperative) of the figure 1.

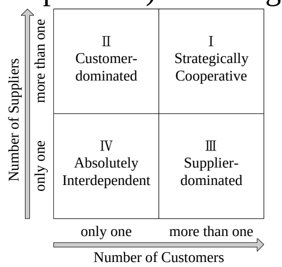

Figure1. Dependent natures of supplier-customer relations.

This study proposes an interaction-oriented based approach, based on AHP methodology, to solve the semiconductor supply chain distribution problem assuming a particular optimal satisfaction. This approach is preceded by an analysis to defining the best potential distribution points and release quantity for upstream companies, to determine feasible distribution downstream cooperators and volume and gather extensive information on them. The proposed approach thus aims to help determine which companies among the feasible cooperators will be included in the distribution network of a semiconductor supply chain and the size of the release quantity obtained from upstream suppliers. This work emphasized to present an efficient and systematic approach for modeling the distribution behavior of the semiconductor supply chain so as to maximize overall satisfaction with the chain.

3. Results and discussions

Semiconductor supply chain modeling is a team endeavor. The AHP is one available method for creating a systematic framework for group interaction and decision-making (Saaty 1980, 1982, 1983). Meanwhile, Dyer and Forman (1992) demonstrate the advantages of AHP in a group setting as follows: both tangibles and intangibles, individual values and shared values are included in an AHP-based group decision process, and group discussions are focused on objectives rather than on alternatives, being structured so that every factor relevant to the decision is considered in turn. Additionally, in structured analysis, the discussion continues until all relevant information from each individual member in the group has been considered and a consensus on decision alternatives has been reached.

In this study, the real-world application was applied to the {1-3-3-4-1} network topology. Herein, $\{E_0\text{-}E_1\text{-}E_2\text{-}E_3\text{-}E_4\}$ denotes the number of enterprises in the zero echelon (silicon material supply), first echelon (materials fabrication), second echelon (wafer fabrication), third echelon (assembly), and fourth echelon (Test). The network topology is modified according to actual conditions. To assess the importance of these critical success factors and analyze the performance of partnerships of the corporation A, the success factors and cooperators for alliances are structured in a hierarchy, as shown in Figure 2. For conciseness, data acquisition of other nodes is the same with the corporation A.

According to the viewpoints of suppliers and customers in each organization, prior weights are ready for linking enterprises. Combining these two viewpoints, the integrate viewpoint is formulated using multiplication methodology $SP^{e(x),e+1(y)} \times SP^{e+1(y),e(x)}$ ($SP^{e(x),e+1(y)}$ = the prior weight from node x in echelon e to node y in echelon $e+1$ and $SP^{e+1(y),e(x)}$ = the prior weight from node y in echelon $e+1$ to node x in echelon e). The integrated linkage weights (IW) are then calculated and also listed in Table 1. The integrated semiconductor supply chain network is established using $\underline{IW}$ or $\underline{\underline{IW}}$, which were included in the Table 1. Up to this point, the integrated network is ready for a supply chain distribution decision. Since the total quantity of the batch size of customer demand is 1000 unites, Fig. 3 briefly demonstrates the supply chain network with $\underline{IW}$ and $\underline{\underline{IW}}$, which are depicted by separately placing their values with 100% out of and in brackets attached to arcs, with two network situations presented herein. Tables 2(a) and (b) present the results of the two illustrative network situations. Table 2(a) presents the results of supply chain distribution problem in situation 1 were obtained, in which customer demand is satisfied and total supplier and customer preferences are optimized. Meanwhile, Table 2(b) displays the results of the same supply chain distribution problem, since the acceptable value of integrated linkage weight c exceeds 0.2. The results of distribution problem of situations 1 and 2 demonstrate that nodes $C_{1.1}$ and $C_{1.3}$ of echelon 1 and nodes $C_{3.1}$, $C_{3.2}$, and $C_{3.3}$ of echelon 3 exist in both situations, and that other nodes in echelon 2 are indwelled in both situations. In situation 2, the lower limit of acceptable value of integrated linkage weight c is given, and equals 0.2, that linkage weights $\underline{IW}^{0(1),1(2)}$, $\underline{IW}^{1(2),2(1)}$, $\underline{IW}^{2(1),3(3)}$, $\underline{IW}^{2(1),3(4)}$, $\underline{IW}^{2(2),3(1)}$, $\underline{IW}^{2(2),3(2)}$, $\underline{IW}^{2(2),3(4)}$, $\underline{IW}^{2(3),3(1)}$, $\underline{IW}^{2(3),3(3)}$, and $\underline{IW}^{2(3),3(4)}$ are incompetent and will be removed from the supply chain distribution network. Meanwhile, while $\sum_{x=1}\underline{IW}^{0(x),1(2)}$ and $\sum_{x=1\sim3}\underline{IW}^{2(x),3(4)}$ are both zero, the nodes $C_{1.2}$ and $C_{3.4}$ would be eliminated from this chain, which could lead to $\underline{IW}^{2(1),3(4)}$, $\underline{IW}^{2(2),3(1)}$, $\underline{IW}^{2(2),3(2)}$, and $\underline{IW}^{3(4),4(1)}$ losing their purpose. After limiting the lower limit of integrated linkage weight, the processing volume of nodes $C_{1.2}$ and $C_{3.4}$ would be shared individually by nodes $C_{1.1}$ and $C_{1.3}$ and nodes $C_{3.1}$, $C_{3.2}$, and $C_{3.3}$ in the distribution decision.

These results could be compared to conventional aftermaths, which only consider one preference, for research seeking cost minimization and profit maximization. According to these analytical outcomes, Tables 2(a) and (b) which display the above two situations, reveal that the quantities of each node for processing in the plant of itself and transporting to the downstream factory simultaneously match the supplier and customers' multi satisfactory preferences.

4. Self-evaluation for this project

This project was performed following the schedule and scope proposed in proposal. This project proposed a systematic and flexible approach to efficiently and effectively solving the complex distribution decision problem for the supply chain environment of the semiconductor industry. Relationships are acquired by using the AHP-based technique, which enables both quantitative and qualitative factors to be included in the decision process, and models the veritably behavior of semiconductor manufacturing process by employing the interaction-oriented technique, which simultaneously integrates suppliers and customers' multi-satisfactory preferences. In the future, new or potential companies could be readily included in the existing supply chain network. Accordingly, this approach can provide a feasible quality solution and can easily and expeditiously be applied to real world applications. The results of this project will be written as a technical paper and submitted for publication in the international journal.

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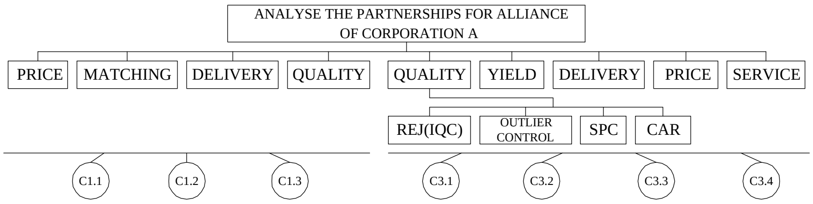

Figure 2. The AHP-hierarchy for analyzing the partnerships of the corporation A.

Table 1. Linkage weights of supplier and customer viewpoints.

For upstream supplier		For downstream		Integrate linkage weights (*IW*)
$C_{0.1} \leftarrow C_{1.1}$	1.000	$C_{0.1} \rightarrow C_{1.1}$	0.310	0.310
$C_{0.1} \leftarrow C_{1.2}$	1.000	$C_{0.1} \rightarrow C_{1.2}$	0.110	0.110
$C_{0.1} \leftarrow C_{1.3}$	1.000	$C_{0.1} \rightarrow C_{1.3}$	0.580	0.580
$C_{1.1} \leftarrow C_{2.1}$	0.410	$C_{1.1} \rightarrow C_{2.1}$	0.250	0.103
$C_{1.2} \leftarrow C_{2.1}$	0.205	$C_{1.2} \rightarrow C_{2.1}$	0.152	0.031
$C_{1.3} \leftarrow C_{2.1}$	0.384	$C_{1.3} \rightarrow C_{2.1}$	0.536	0.206
$C_{1.1} \leftarrow C_{2.2}$	0.235	$C_{1.1} \rightarrow C_{2.2}$	0.320	0.075
$C_{1.2} \leftarrow C_{2.2}$	0.422	$C_{1.2} \rightarrow C_{2.2}$	0.422	0.178
$C_{1.3} \leftarrow C_{2.2}$	0.343	$C_{1.3} \rightarrow C_{2.2}$	0.302	0.104
$C_{1.1} \leftarrow C_{2.3}$	0.127	$C_{1.1} \rightarrow C_{2.3}$	0.430	0.055
$C_{1.2} \leftarrow C_{2.3}$	0.221	$C_{1.2} \rightarrow C_{2.3}$	0.426	0.094
$C_{1.3} \leftarrow C_{2.3}$	0.652	$C_{1.3} \rightarrow C_{2.3}$	0.162	0.106
$C_{2.1} \leftarrow C_{3.1}$	0.751	$C_{2.1} \rightarrow C_{3.1}$	0.245	0.184
$C_{2.2} \leftarrow C_{3.1}$	0.111	$C_{2.2} \rightarrow C_{3.1}$	0.122	0.014
$C_{2.3} \leftarrow C_{3.1}$	0.138	$C_{2.3} \rightarrow C_{3.1}$	0.151	0.021
$C_{2.1} \leftarrow C_{3.2}$	0.315	$C_{2.1} \rightarrow C_{3.2}$	0.239	0.075
$C_{2.2} \leftarrow C_{3.2}$	0.132	$C_{2.2} \rightarrow C_{3.2}$	0.214	0.028
$C_{2.3} \leftarrow C_{3.2}$	0.553	$C_{2.3} \rightarrow C_{3.2}$	0.552	0.305
$C_{2.1} \leftarrow C_{3.3}$	0.250	$C_{2.1} \rightarrow C_{3.3}$	0.197	0.049
$C_{2.2} \leftarrow C_{3.3}$	0.643	$C_{2.2} \rightarrow C_{3.3}$	0.420	0.270
$C_{2.3} \leftarrow C_{3.3}$	0.107	$C_{2.3} \rightarrow C_{3.3}$	0.177	0.019
$C_{2.1} \leftarrow C_{3.4}$	0.121	$C_{2.1} \rightarrow C_{3.4}$	0.319	0.039
$C_{2.2} \leftarrow C_{3.4}$	0.276	$C_{2.2} \rightarrow C_{3.4}$	0.244	0.067
$C_{2.3} \leftarrow C_{3.4}$	0.603	$C_{2.3} \rightarrow C_{3.4}$	0.120	0.072

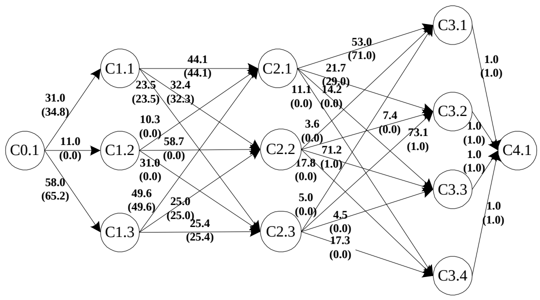

Figure 3. Complete network for situations 1 and 2.

Table 2. Results of physical distribution using the interaction-oriented approach. (a) Situation 1: subsistent relations must be maintained. (b) Situation 2: subsistent relations are not always maintained and 0.2 is set as an acceptable value.

(a) Supply \ Demand	$C_{1.1}$	$C_{1.2}$	$C_{1.3}$	$C_{2.1}$	$C_{2.2}$	$C_{2.3}$	$C_{3.1}$	$C_{3.2}$	$C_{3.3}$	$C_{3.4}$	$C_{4.1}$
$C_{0.1}$	310	110	580								
$C_{1.1}$				137	100	73					
$C_{1.2}$				11	65	34					
$C_{1.3}$				288	145	148					
$C_{2.1}$							231	94	62	48	
$C_{2.2}$							11	23	221	55	
$C_{2.3}$							13	186	12	44	
$C_{3.1}$											255
$C_{3.2}$											304
$C_{3.3}$											294
$C_{3.4}$											148
Total	310	110	580	436	310	255	255	304	294	148	1000

(b) Supply \ Demand	$C_{1.1}$	$C_{1.2}$	$C_{1.3}$	$C_{2.1}$	$C_{2.2}$	$C_{2.3}$	$C_{3.1}$	$C_{3.2}$	$C_{3.3}$	$C_{3.4}$	$C_{4.1}$
$C_{0.1}$	348	—	652								
$C_{1.1}$				154	113	82					
$C_{1.2}$				—	—	—					
$C_{1.3}$				323	163	166					
$C_{2.1}$							338	138	—	—	
$C_{2.2}$							—	—	275	—	
$C_{2.3}$							—	248	—	—	
$C_{3.1}$											338
$C_{3.2}$											386
$C_{3.3}$											275
$C_{3.4}$											—
Total	348	—	652	477	275	248	338	386	275	—	1000