



## Using DEMATEL method to explore the core competences and causal effect of the IC design service company: An empirical case study

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### ABSTRACT

The booming of Integrated Circuit (IC) design service has become a critical sub-industry to the evolution of semiconductor industry. In this paper, we took the case of a tier one IC design service company to explore the core competences of this emerging industry. Seven core competences are defined throughout the research. More specifically, this paper analyzes the in-depth of the interrelation among the core competences by utilizing the DEMATEL method. They are divided into causal and effect groups, enabling readers to gain a better understanding of the interactive relationship between them, as well as making suggestions for improvement to enhance their overall performance. The result has shown that the Intellectual Property (IP) design capability is the most important core competence. Enhancing five of the core competences in the causal group will improve the overall performance. Further, DEMATEL method is demonstrated as a useful approach in exploring the interrelationship.

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### 1. Introduction

The rapid evolution of System On a Chip (SOC) design has changed the collaboration structures of the semiconductor industry and its value chain. Conventional semiconductor value chain includes fabless Integrated Circuit (IC) design, wafer fabrication, wafer testing, IC packaging and final tests, has been extremely fragmented and specialized (Frederix, 1996; OhJallachain, 1997). Moreover, silicon Intellectual Property (IP) providers, design service providers, design foundries and system design integrators are thriving in the new era of semiconductor industry (Chang & Tsai, 2002). In SOC era, IP solution, IC design and Application Specific Integrated Circuit (ASIC) services have become the essential roles in the newly semiconductor value network. This is due to the rising complexity of IC design, SOC implementation, IP integration and customization, and vast numbers of Research and Development (R&D) and Non-Recurring Engineering (NRE) cost, particularly in the advanced sub-wavelength nanometer technology nodes, such as 90 nm, 65 nm, 45/40 nm, 32 nm and beyond.

Today, more IC design or system companies are leaning toward the use of IC design service firms in making their chips to market

on time and within budget (Clendenin, 2006). The major function of IC design service is to act as a mediator between IC design and manufacturing, providing IC designers with an IP library, IP integration and customized modification, and IC manufacturing process technique to reduce not only the development cost but also design time. Furthermore, the IC design service companies provide turnkey solutions to produce ASICs and/or handle the manufacturing process in the comprehensive supply chain. The solutions provided include wafer foundry, IC packaging, IC testing, reliability qualification, failure analysis and logistic service. In return, the traditional IC design companies can focus on their core competence of product design, as well as becoming the marketing and sales channels which define the product specifications (Shih, Shih, Chien, & Chang, 2008). Currently, there are over 30 fabless IC design service companies in the market worldwide, including Global Unichip Corporation (GUC), Alchip, eASIC, eSilicon, Faraday, Open-Silicon and others (LaPedus, 2009).

This paper is written with three purposes. First, we use GUC as the case to explore the core competences of the IC design service company. The core competences are defined by combining and comparing literature review and interviews with the focus group, thus enable practitioners and scholars to have a better understanding of them. Second, abundant papers have contributed to identify core competences of various industries or firms by conducting case studies. However, the further discussions of the interaction of the core competences in the specific case are deficient (Onyeiwu, 2003). Therefore, in this paper, we utilize the Decision Making Trial and Evaluation Laboratory (DEMATEL) method to determine

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and distinguish the cause and effect relationship amongst these core competences inside GUC, and in turn, provide understandings on how these core competences affect each other and result in its final success. Third, GUC's core competences are analyzed and several enhancement strategies are proposed based on the causal relationship analysis that would enable GUC to maintain its competitive advantage and achieve an aspire level. A case with sufficient representativeness is suggested to be used for this kind of empirical research (Banerjee, 2003; Roux-Dufort & Metais, 1999). Based on this guideline, the reasons made us decide to use GUC as the case are: (1) GUC is accredited as the leading company in this field in terms of capital investment and annual sales revenue. It has 9 years of consecutive revenue growth and reported revenue of \$278.8 million in 2008, a 33% increase from 2007, which has proven its superior performance in this niche market and business; (2) GUC is the largest public traded company in this field in terms of annual revenue which provides a better representation and more public information.

This paper is organized as follow: In Section 2, a literature review is performed on core competences of IC design service industry; introduction of new research methodology is proposed in Section 3; a case study of the core competences and its results are conducted in Section 4, and the conclusions are provided in the final section.

## 2. Defining core competences for a successful IC design service industry and company

The core competences have been studied and discussed extensively, and the definition of the core competences has been verified and evolved along with abundant researches. The notion from the researches in the early stage has deemed that a core competence is a set of problem-defining and problem-solving capabilities that enables a firm to generate idiosyncratic strategic growth energy, gain competitive advantage, and create significant market power (Hitt & Ireland, 1985, 1986; Lei, Hitt, & Bettis, 1996; Snow & Hrebiniak, 1980). Extensive discussions in 1990s have further defined distinct concepts of core competences, which entail to provide possible access to new markets, satisfy specific customer needs and difficulty of being imitated (Prahalad & Hamel, 1990). A core competence is a set of fundamental strengths that allows a firm to do better than others, and consequently, lead to new products or new markets (Grant, 1991; Javidan, 1998).

Subsequent researches have summarized that the contents of a core competence embrace technologies, knowledge, skills and systems that are possessed by a firm, which can act as catalysts in generating competitive assets and advantages (Hamel & Prahalad, 1994; Markides & Williamson, 1994; Petts, 1997). Attributes of the core competence include complexity, invisibility, durability, appropriative, non-substitutability and superiority (Aaker, 1989; Collis & Montgomery, 1995; Flood, Gannon, & Paauwe, 1996; Hall, 1992; Hamel & Prahalad, 1994; Petts, 1997). Hence, core competence is a fundamental success factor for various end products and services today along with the upcoming future.

What are the core competences of a successful IC design company? Chu, Shyu, and Khosla (2008) identified that the core competences include technical innovations, solid supply chains, total solutions, excellent technical specifications, flexibility in marketing, as well as pricing strategies, and stability of partner relationships between customers and vendors. The core competences of Taiwan's IC design companies specifically, attribute to the speed of design, speed of implementation, low cost but outstanding design capability pool, quality of design and outsourcing manufacturing, flexibility in response to rapid change and various applications of market demand, integrated and superior supply chain and a

competitive overall cost (Chang & Tsai, 2002). The core competences of a successful IC design service company would have been similar to that of an IC design company as abovementioned (Shih et al., 2008). However, due to their different functionalities, the core competence between an IC design company and an IC service company may vary, thus further identifications will be required. For this kind of emerging industry, academic studies suggest to conduct an in-depth case study to obtain the insight (Brockhoff, 2003; Walsh & Linton, 2001). Based on the analyses above, this paper further applies the focus group research method to define the specific core competences for IC design service industry.

Focus group research is based on facilitating an organized discussion with a selected group of individuals, for they were believed to be representatives of various classes. Discussions are used to reveal insights and provide understandings in ways that simple survey items may not be able to achieve. The focus group research has long been prominent in the marketing studies (Morgan, 1988), partially because the market researchers are seeking to achieve the emotional and unconscious motivations which are not amenable to the structured questions of conventional survey research. Additionally, interaction is also the key to successful focus groups because participants often bring different perspectives through the verbal communications. This brainstorm process brings extra information to the existing issues as well as inspirations for new ideas. The research host has raised a number of issues, including the possible core competences that are recognized by participants, industrial analysts, academic researchers, and so on. Through the discussions together with the aid of answers to open-ended questionnaires and recording equipment, opinions are integrated and summarized. Through the focus group research procedure based on the present studies of core competence, particularly in IC design field, seven core competences are defined and will be furthered analyzed and discussed in Section 4.

## 3. The DEMATEL method

The DEMATEL method has been developed initially to study the structural relations in a complex system (Liou, Yen, & Tzeng, 2007; Wu, 2008). The mathematical concepts are then evolved and adapted in many academic fields, such as industrial strategy analysis, competence evaluation, solution analysis, selection, and etc.; it has been proven as a useful method to solve complicated problems. Wu and Lee (2007) have combined DEMATEL and fuzzy theory to categorize the required competencies for better promoting the competency development of global managers. Tzeng, Chiang, and Li (2007) have brought together DEMATEL, Analytic Hierarchy Process (AHP) and fuzzy integral to build a selection model for evaluating intertwined effects in e-learning programs. Liou et al. (2007) have utilized the fuzzy logic and DEMATEL to create an effective safety management system for airlines. Huang, Shyu, and Tzeng (2007) have applied DEMATEL and gray relational analysis in reconfiguring the innovation policy portfolios as well as defining the policy of the Taiwanese Government.

Further researches have reaffirmed the benefits of using DEMATEL method. Lin and Wu (2008) have suggested that DEMATEL is a powerful technique in causal analysis that enables the researchers to separate the involving criteria of a system into the cause and effect groups. This technique will allow the decision-makers to acknowledge the criteria of greater influence. Tseng (2009) has also exploited this method in dealing with real estate agent service quality expectation ranking with uncertainty. Tsai and Chou (2009) have integrated DEMATEL and Multiple Criteria Decision Making (MCDM) techniques to establish a selection model for evaluating the management systems for sustainable development in small and medium enterprises. DEMATEL has been

successfully applied to many research fields with the purpose to render sophisticated problems and transform complex systems into structurally causal and effect relationships. Therefore, DEMATEL can be extended in solving causal relationship issues of core competences of an industry or company, which in turn, provide improvement options.

The DEMATEL model construction process is described below:

**Step 1: Generating the direct-relation matrix**

The measurement of the relationship between factors  $i$  and  $j$  requires that the comparison scale to be constructed according to the following four influential levels: No influence (0), Low influence (1), Medium influence (2), High influence (3), and Very high influence (4). The integer score  $x_{ij}^k$  is given by the  $k$ th expert and indicates the influential level that factor  $i$  has on factor  $j$ . The  $n \times n$  matrix  $A$  is calculated in Eq. (1) by averaging individual expert's scores,

$$a_{ij} = \frac{1}{H} \sum_{k=1}^H x_{ij}^k \quad (1)$$

where  $H$  is the total number of experts.

**Step 2: Normalizing the direct-relation matrix**

On the basis of the direct-relation matrix  $A$ , the normalized direct-relation matrix  $X$  can be obtained by the following: Let

$$s = \max \left( \max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}, \max_{1 \leq j \leq n} \sum_{i=1}^n a_{ij} \right) \quad (2)$$

then

$$X = \frac{A}{s} \quad (3)$$

The sum of each row  $j$  of matrix  $A$  represents the direct effects that factor  $i$  gives to the other factors;  $\max \left( \max_{1 \leq i \leq n} \sum_{j=1}^n a_{ij}, \max_{1 \leq j \leq n} \sum_{i=1}^n a_{ij} \right)$  represents the direct effects on others.

**Step 3: Attaining the total-relation matrix**

Once the normalized direct-relation  $X$  is obtained, the total-relation matrix  $T$  can be calculated by

$$T = X(I - X)^{-1} \quad (4)$$

where  $I$  is denoted as the identity matrix.

**Step 4: Producing a causal diagram**

The sum of rows and the sum of columns are separately denoted as vector  $D$  and vector  $R$ . The horizontal axis vector ( $D + R$ ), named "Prominence," is made by adding  $D$  to  $R$ , which represents the importance of the criterion. Similarly, the vertical axis ( $D - R$ ), named "Relation," is formed by subtracting  $D$  from  $R$ , which may divide criteria into a causal group and an effect group. Based on the above statements, the factor belongs to the causal group if ( $D - R$ ) is positive, and the factor belongs to the effect group when ( $D - R$ ) is negative. Therefore, the causal diagram can be acquired by mapping the dataset of ( $D + R$ ,  $D - R$ ).

$$T = [t_{ij}]_{n \times n} \quad i, j = 1, 2, \dots, n \quad (5)$$

$$D = \left[ \sum_{j=1}^n t_{ij} \right] = [t_{i \cdot g}]_{n \times 1} \quad (6)$$

$$R = \left[ \sum_{i=1}^n t_{ij} \right]_{1 \times n}^t = [t_{g \cdot j}]_{n \times 1} \quad (7)$$

**Step 5: Setting a threshold value and obtaining the inner dependence matrix**

In order to explain the structural relation amongst factors while keeping the complexity of the whole system at a manageable level, it is necessary to set a threshold value  $p$  to filter out negligible effects in matrix  $T$ . Only the factors whose effect in matrix  $T$  is greater than the threshold value will be shown in an inner dependence matrix. In this step, the threshold value  $p$  has been chosen by the experts and the results of the literature review.

## 4. Empirical study

This section will identify the core competences of GUC and measure the relationships among them, as well as identify potential tactics for GUC to reach the desired level of success. In order to do so, seven experts from different divisions of GUC were summoned and surveyed. These divisions include Design Service, Engineering, R&D, Business Operation and Marketing.

### 4.1. The case of Global Unichip Corporation (GUC)

GUC is a dedicated full IC design service foundry based in Taiwan, was founded in 1998. GUC is now available to public on the Taiwan Stock Exchange. GUC provides total solutions from silicon-proven IPs to complex time-to-market SOC turnkey services. These fully extended services include full steps SOC design, manufacturing, multi-project wafers (MPW), IP design and other customization solutions. Combining the successful business model and their core competences, GUC started to perform significant growth in revenue, increased of 108% YoY in 2006, up 36% YoY in 2007 and up 33% YoY in 2008 which the revenue was \$278.8 million. This has turned GUC into the tear one fabless IC design service company in worldwide semiconductor industry.

### 4.2. Procedure and results

First, the goal of this study is identified and a committee is formed. It is believed that a panel of experts can further enhance the quality of the study. More specifically, an expert validity survey has been designed for the gathered experts to confirm their expertise. Then, the qualified experts are formed as a focus group and conducts in-depth discussions to evaluate more specific ideas about the core competences by providing their suggestions and revisions based on their expertise and the past studies in the literatures that we have reviewed. The significant viewpoints received from the discussions provide confirmations to the results. Throughout the literature reviews and focus group processes, seven core competences of GUC are identified. They are: IP design capability, integrated IP turnkey solution, customized design capability, integrated supply chain services for turnkey IC production, comprehensive design capability for various applications, effective reduction of new product development cost for customers, and integrated streamline manufacturing technologies for IC production.

#### 4.2.1. IP design capability

IP is one of the key factors that enables the IC design implementation, particularly in the SOC era. The figure of merit of an IP includes electrical performance, capability of design for manufacturing, circuit size and re-usable flexibility that require sophisticated engineering techniques, as well as time and R&D investment. Therefore, development of success and widely adopted IPs is not only a core competence, but also a high entry barrier for competitors in the market.

#### 4.2.2. Integrated IP turnkey solution

IP reusability and integration of different IPs, such as processor, interface and coder/decoder for audio or video, are the core values in the SOC era. ICs' complemented function requires various contents and a combination of several IPs, which have become severe pressures to traditional IC designers because of the higher investments, longer time-to-market and lower successful rate. Therefore, the capability to provide integrated IP turnkey solution is crucial for the success.

#### 4.2.3. Customized design capability

The demands and specifications of ASIC or IC customers are comprehensive. Consequently, the existing designs or IPs may not perfectly fulfill the various demands of customers' designs. A successful IC design service company is required to provide various customization designs for the customer's specific demand in both the products and the associated software. If the IC design service company does not possess a powerful customized design capability, then the market share and growth will be limited.

#### 4.2.4. Integrated supply chain services for turnkey IC production

IC production contains complicated steps, which include photo-mask generation, wafer process, testing, package, reliability qualification and logistic. It is a crucial factor for most of the traditional IC design companies in defining ways to better integrate the sophisticated supply chain. Acting as a fabless turnkey, the IC service company needs to have the core competence to establish a complex but well managed semiconductor supply network for IC production and thus the end customers are able to relieve the pressure of production management and focus on their core business.

#### 4.2.5. Comprehensive design capability for various applications

There is a variety of IC applications in the industry, including processors, drivers, coders/decoders, multi-media, mobile solution, communication, controller, display, etc. An IC design service company needs to provide a comprehensive design capability for these applications, since it has no self-owned product and relies solely on the business from other IC design companies. The more extensive applications an IC design service company can provide, the more business the company will gain, with that more experiences will be accumulated. In addition, this positive growing cycle renders an IC design service company stronger competences and creates higher entry barrier to other competitors.

#### 4.2.6. Effective reduction of new product development cost for customers

A large IC design service company releases far more design cases to its supply network than its customers do. This is because the customers are usually the traditional or small-to-medium scale fabless IC design companies which will not have numerous cases. By consolidating more design cases, the company will have a massive purchasing power that effectively lowered its customers' total cost in IC manufacturing. Furthermore, customers can utilize the resource and facility of a service provider to eliminate the need for duplicated investment. This core competence helps customers to reduce their NRE cost and entry barrier for new IC design projects.

#### 4.2.7. Integrated streamline manufacturing technologies for IC production

As the IC manufacturing process has evolved into sub-wavelength technology nodes, such as 90 nm, 65 nm, 40 nm and beyond, the manufacturing technology has become very complicated and required detailed knowledge to integrate the complex process technologies in each IC production step along the entire supply chain. IC design companies in small or medium scales have

**Table 1**  
Direct-influence matrix.

|       | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ |
|-------|-------|-------|-------|-------|-------|-------|-------|
| $D_1$ | 0.00  | 3.67  | 3.83  | 1.33  | 1.67  | 3.00  | 1.67  |
| $D_2$ | 2.00  | 0.00  | 3.17  | 2.17  | 2.33  | 2.83  | 1.67  |
| $D_3$ | 2.67  | 3.17  | 0.00  | 2.33  | 2.00  | 2.83  | 2.00  |
| $D_4$ | 0.33  | 1.67  | 1.17  | 0.00  | 1.33  | 3.67  | 3.00  |
| $D_5$ | 2.17  | 2.50  | 2.83  | 2.00  | 0.00  | 2.00  | 1.83  |
| $D_6$ | 0.33  | 1.17  | 1.00  | 2.33  | 1.17  | 0.00  | 1.67  |
| $D_7$ | 1.17  | 2.50  | 2.50  | 3.17  | 1.17  | 2.83  | 0.00  |

**Table 2**  
Direct-relation matrix.

|       | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ |
|-------|-------|-------|-------|-------|-------|-------|-------|
| $D_1$ | 0.00  | 0.24  | 0.25  | 0.09  | 0.11  | 0.20  | 0.11  |
| $D_2$ | 0.13  | 0.00  | 0.21  | 0.14  | 0.15  | 0.19  | 0.11  |
| $D_3$ | 0.18  | 0.21  | 0.00  | 0.15  | 0.13  | 0.19  | 0.13  |
| $D_4$ | 0.02  | 0.11  | 0.08  | 0.00  | 0.09  | 0.24  | 0.20  |
| $D_5$ | 0.14  | 0.16  | 0.19  | 0.13  | 0.00  | 0.13  | 0.12  |
| $D_6$ | 0.02  | 0.08  | 0.07  | 0.15  | 0.08  | 0.00  | 0.11  |
| $D_7$ | 0.08  | 0.16  | 0.16  | 0.21  | 0.08  | 0.19  | 0.00  |

**Table 3**  
Total-influence matrix.

|       | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | $D_7$ |
|-------|-------|-------|-------|-------|-------|-------|-------|
| $D_1$ | 0.49  | 0.97  | 0.96  | 0.83  | 0.65  | 1.08  | 0.76  |
| $D_2$ | 0.56  | 0.71  | 0.87  | 0.82  | 0.64  | 1.01  | 0.71  |
| $D_3$ | 0.62  | 0.92  | 0.73  | 0.86  | 0.65  | 1.06  | 0.76  |
| $D_4$ | 0.35  | 0.62  | 0.58  | 0.53  | 0.46  | 0.84  | 0.63  |
| $D_5$ | 0.56  | 0.83  | 0.83  | 0.78  | 0.49  | 0.94  | 0.70  |
| $D_6$ | 0.27  | 0.46  | 0.44  | 0.52  | 0.35  | 0.48  | 0.45  |
| $D_7$ | 0.48  | 0.79  | 0.77  | 0.82  | 0.54  | 0.95  | 0.57  |

no sufficient knowledge and resource to collaborate closely with all suppliers in the supply chain. On the other hand, suppliers are, without a doubt, willing to spend resources for selective enormous customers only and thus an aggregator will obtain a better service level.

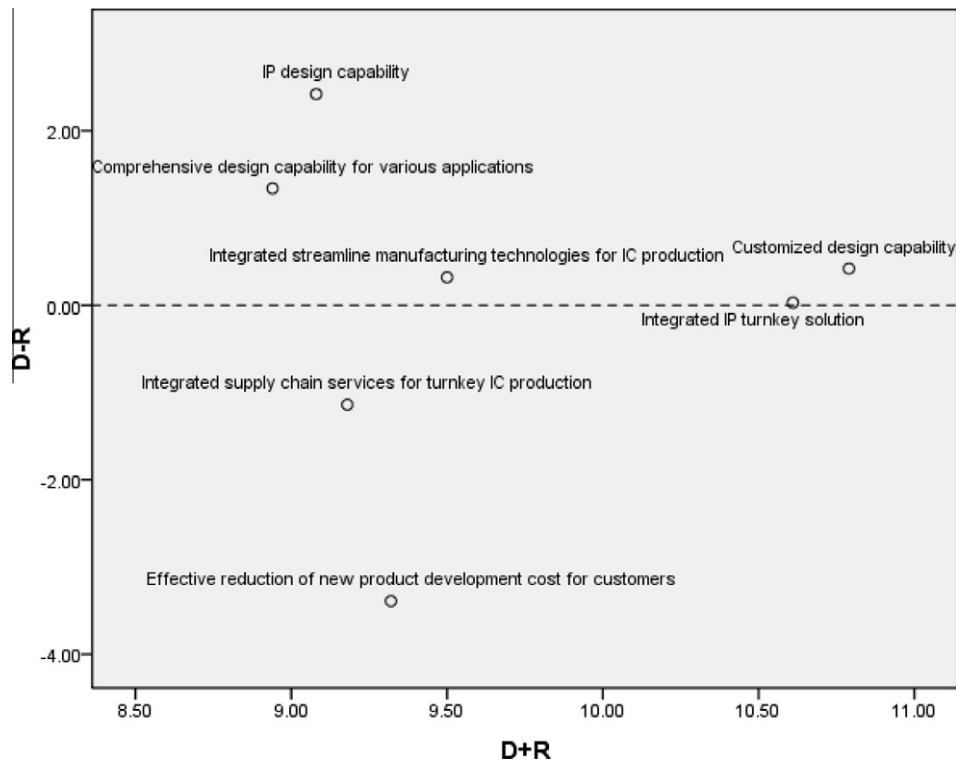
Based the seven core competences stated above, this research has further employed the DEMATEL method to capture the complex relationships among these competences. The collected pairwise comparison results have been obtained (the comparison mechanism has been described at step 1 of Section 3), and that the preliminary average direct-influence matrix is shown in Table 1. Based on the direct-influence matrix, these numbers are normalized continuously into the data shown in Table 2—the direct-relation matrix (calculated by formula (2) and (3)). Tables 3 and 4 present “total-influence matrix” and “total effects and net effects for each factor,” respectively. Finally, formula (5)–(7) have been used as the normalized matrix to produce the causal diagram by mapping a dataset of  $(D + R, D - R)$ , as displayed in Fig. 1.

#### 4.3. Discussions

The results shown in the causal diagram have clearly and intuitively discovered the importance of the order of these core competences in driving GUC to success. It is clear that, by looking at this causal diagram, the seven core competences can be divided into a causal and an effect group. The causal group contains IP design capability ( $D_1$ ), integrated IP turnkey solution ( $D_2$ ), customized design capability ( $D_3$ ), comprehensive design capability for various applications ( $D_5$ ) and integrated streamline manufacturing technologies for IC production ( $D_7$ ). The effect group includes

**Table 4**  
Total effects and net effects for each core competence.

| Core competence  |       | <i>D</i> | <i>R</i> | <i>D + R</i> | <i>D - R</i> |
|--|-------|----------|----------|--------------|--------------|
| IP design capability   | $D_1$ | 5.75     | 3.33     | 9.08         | 2.42         |
| Integrated IP turnkey solution                                     | $D_2$ | 5.32     | 5.29     | 10.61        | 0.03         |
| Customized design capability                                       | $D_3$ | 5.61     | 5.18     | 10.79        | 0.42         |
| Integrated supply chain services for turnkey IC production         | $D_4$ | 4.02     | 5.16     | 9.18         | -1.14        |
| Comprehensive design capability for various applications           | $D_5$ | 5.14     | 3.80     | 8.94         | 1.34         |
| Effective reduction of new product development cost for customers  | $D_6$ | 2.96     | 6.35     | 9.32         | -3.39        |
| Integrated streamline manufacturing technologies for IC production | $D_7$ | 4.91     | 4.59     | 9.50         | 0.32         |



**Fig. 1.** Impact-relationship map.

integrated supply chain services for turnkey IC production ( $D_4$ ) and effective reduction of new product development cost for customers ( $D_6$ ). The causal and effect structure implies that  $D_1$ ,  $D_2$ ,  $D_3$ ,  $D_5$  and  $D_7$  are the main core competences in supporting GUC to move toward the success. Subsequently,  $D_4$  and  $D_6$  are not possessed by GUC radically, instead, they are generated and affected by the other five core competences mentioned above. It also reveals that the IP design capability ( $D_1$ ) is the most important causal factor among the core competences and generates the competitive advantages, thus making it the most significant core competence to the capability of the IC design service company. These two guidelines of improvement direction will lead GUC toward a more successful level. The detailed discussion of GUC's core competences which affect the effect group are listed below:

#### 4.3.1. IP design capability ( $D_1$ )

GUC has designed abundant IPs; the categories contain mixed signal (e.g. analog to digital controller, power management), bus interface (e.g. Receiver/Transmitter, USB controller), multimedia (e.g. JPEG/audio/video coder/decoder), peripheral core and processor (ARM based). The company's strong capability in IP designs prompts the customers to reconsider the idea of contributing their own investments in developing or purchasing the IPs. Instead,

customers are now more inclined to exploit GUC's existing IPs, thus allowing GUC to gain more business from the market. Additionally, this capability creates a high entry barrier to other competitors.

#### 4.3.2. Integrated IP turnkey solution ( $D_2$ )

Many of SOC designs demand integrations of different IPs, such as processors, bus interface, mixed signal and multimedia functions. Besides the profound investment required for purchasing or licensing the IPs, the process of integrating them into a SOC IC is another crucial subject, for it requires professional knowledge, techniques, tools and experts. GUC is the leading company in providing integrated IP turnkey solution to their customers, enabling the minimization of their R&D costs and shorten their time-to-market schedule.

#### 4.3.3. Customized design capability ( $D_3$ )

Despite the fact that there is a tendency in which IPs are now reusable, most of the chip designs still require a certain level modification for those IPs. This is due to various concerns involving die size, performance, layout, power or package. Not only GUC has a relatively strong capability in making IP customization to fulfill different requirements of customers, but it also reduces customers' efforts.



#### 4.3.4. Comprehensive design capability for various applications ( $D_5$ )

In order to have a continuous growth in the design service market, GUC has made every effort to provide a wide range of IPs and design techniques for more customers' applications. The comprehensive design for various applications has expanded GUC's customer base and revenues through the years. In addition, accumulation of design cases of various applications have also enriched and strengthened GUC's design capability. This positive growing cycle has fostered a core competence and competitive advantages for GUC.

#### 4.3.5. Integrated streamline manufacturing technologies for IC production ( $D_7$ )

The small or medium size IC design companies have difficulties in obtaining sufficient amount of support from suppliers. Throughout the years of learning from the increasingly successful projects, GUC has become experienced in the whole advance IC manufacturing flow and technologies. By close collaborating with its suppliers, GUC has been a perfect intermediary between IC designers and supply chain by providing an integrated streamline manufacturing technologies for IC production. Therefore, GUC customers can focus on their core business.

## 5. Conclusions

Core competences are essential to the business success. Conventional researches have concentrated mainly on understanding the core competences of an industry or a firm, but did not provide sufficient analysis of the interaction relation between them. IC design service has newly emerged in the recent years and hence the core competences of its success remain unclear. Through the researches performed, this paper has made contributions in the following areas: (1) defining the core competences of this emerging business from the tier one company – GUC as a case; (2) further investigating the interrelationship of the core competences of GUC; (3) demonstrating DEMATEL method as a powerful group decision making tool in supporting the exploration of the cause and effect relationship in a complex system, as well as implementation for core competences analysis based on the generated casual diagram by the illustrated case study. Hence, researchers can make analysis and provide improvement strategies accordingly; (4) providing management implications and improvement suggestions to this case study.

The seven core competences of IC design service industry have been identified through literature reviews and focus group interviews. Subsequently, DEMATEL method is proposed and applied to the case study in exploring the causal and effect relationship amongst the core competences of GUC. Based on the casual diagram transformed by DEMATEL method, it has shown the seven core competences of GUC can be divided into a causal group and an effect group. The causal group includes the IP design capability, integrated IP turnkey solution, customized design capability, comprehensive design capability for various applications and integrated streamline manufacturing technologies for IC production, whereas the effect group contains the integrated supply chain services for turnkey IC production and effective reduction of new product development cost for customers. The diagram further indicates that the two core competences in the effect group are affected by the ones in the causal group. The management implications are that GUC needs to concentrate on improving the five core competences in the causal group, and in turn, enhance the effect group and ultimately strengthen its overall competitiveness. It has also revealed that the IP design capability is the most important cause factor of core competences for GUC. Consequently, GUC is recommended to input more resources for securing and

enhancing this core competence, which will have high influence to its overall competitive advantage.

In addition to the findings of the core competences of the IC design service company, this research also has established a solution to deal with the causal relationship analysis of core competences. The proposed of the DEMATEL method and procedure of this case study have shown that it is possible to solve the determination of a complex and interactive core competence issue of a firm. Therefore, it can be generalized or modified as required for similar analysis of other companies or industries. For future researches, surveys from customers may assist in confirming the main purposes and benefits of using IC design service, and that cross examination and analysis can be done afterward to render a more comprehensive, two-way perspective accordingly.

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