

Journal of
Economics and Political Economy

www.kspjournals.org

Volume 7

December 2020

Issue 4

**AHP analysis of classifying and positioning the
crucial influential factors of brand establishment in
the semiconductor industry**

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Abstract. This study categorizes the crucial influencing factors and positions them according to their importance in achieving the impact of semiconductor brand establishment on improving corporate performance and meeting customer needs. This study conducted an in-depth literature review that recognizes the crucial factors necessary for implementing influence in establishing a semiconductor brand. This study identifies five main variables and 17 subvariables, including "Customer value", "Brand equity", "Brand loyalty", "Brand orientation" and "Brand performance", and provides experts' suggestions. They performed the positioning of 17 subvariables and 5 main variables representing crucial influential factors using an analytical hierarchy process (AHP) technique per their relevance in crucial influential factor implementation. The results show that 5 main variables and 17 subvariables play a vital role in the successful implementation of the impact of establishing a semiconductor brand, and "Customer value" has gained more weight compared to the other main variables. 'Addressing problem', 'Superior value' and 'New product development' are more important than are other subvariables. The limitation of this study is that, first, although this study consults experts from the semiconductor industry and academia of various countries, their opinions are only relevant to their regions. Second, the development of this model only applies to the semiconductor industry. Third, only expert opinion variables were used for pairwise comparisons. This study compensates for the lack of key factors in establishing a semiconductor brand, using the literature and expert questionnaires to obtain the weight of each factor through the AHP method and ranking them in order of importance. It examines the overall situation of the practice of building brand comprehension, missing no factor, understanding where the key points are and using them effectively. This research advances the implementation focus of the key factors that affect the establishment of semiconductor brands. According to the results of the literature review, this study is the first on implementing key factors affecting the establishment of a semiconductor brand. This study attempts to fill this gap.

Keywords. Crucial influential factors, Establishing semiconductor brand, AHP.

JEL. C44, M21, M31, D81, L29.

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1. Introduction

There are many electronic products in our lives, especially personal electronic products, whose functions are becoming increasingly diverse and whose size and weight are steadily decreasing, which has changed all the lifestyles of our generation. As electronic products are being upgraded increasingly rapidly, companies are also using strong and attractive advertising to stimulate consumer demand, which has led fans to pursue new products (such as the Apple mobile phone replacement wave). Coupled with the continued growth of the Chinese mainland economy and the mentality of comparing or showing off wealth, even if electronic products are still serviceable, consumers are happy to buy new products to catch up with the latest fashion trends. This consumer attitude has led to the rise of mainland China as one of the world's major electronic consumer markets. This trend has driven the vigorous development of the overall electronic products industry and brought about the growth of the upstream semiconductor industry. SEMI (Semiconductor Equipment and Materials International) predicts that by 2025, connectivity, data centers, communications, automotive and advanced software will drive strong demand. Future IC manufacturing driven by edge intelligence and 5G includes artificial intelligence, big data, fog computing, deep learning, augmented reality, edge computing, Internet of Things, audiovisual, machine learning, and thinking internet. Based on the continuous advancement of technology in the semiconductor industry, the trend is to distribute all intelligence from the cloud to the edge at gigabit speed through wireless technology.

The semiconductor industry is one of the most globalized and strategically important industries (Grimes & Du, 2020). This research mainly discusses semiconductor manufacturers and their equipment suppliers in the semiconductor industry. They often affect the final application market and are highly cyclical. The semiconductor industry is a high-tech industry with clear specifications and strict standards for the selection of raw materials, manufacturing processes, and assembly procedures. Although this market is vast, only a few approved suppliers can enjoy the dividends from this market. Taiwan's main development industry is the semiconductor industry, but in the face of this vast market, they now find that most of the manufacturers in the supply chain are OEMs or outsourcers. There are relatively few manufacturers with their brands, even with certain technical capabilities; there is still room for growth in the establishment of product brands. From the perspective of the overall supply chain, even reducing the number of suppliers in the semiconductor industry has always been considering a strategy, but, this point is not strictly true for a company (Vayvay & Cruz-Cunha, 2016a). A manufacturer needs sustainable development. For suppliers that have not yet produced a brand effect, it is often difficult to maintain a place throughout the supply chain. In addition to commonly used price strategies, brand establishment

is often the most critical strategy. However, there is little relevant research on establishing industrial brands, especially in the semiconductor industry.

Therefore, interested potential suppliers and researchers want to identify the crucial factors for the establishment of a semiconductor brand. After careful analysis, this study found that the entire semiconductor supply chain is controlled by a few manufacturers, with already established brands and trust already won from end users. Therefore, most manufacturers want to identify these crucial factors to build their brands; this urgent need became the birth of this study. This study will establish the crucial influencing factors of semiconductor brands using the AHP method for classification and positioning to facilitate further research. To meet the above standards, this study mainly achieves the following two goals:

(1) Identify establishing semiconductor brands that have successfully implemented crucial influencing factors and classify them based on literature reviews and expert recommendations; and

(2) Determine the expected effect on the semiconductor industry of the positioning of the determined standards and substandards in implementing crucial influencing factors.

2. Literature review

The conclusion of the industrial brand B2B research shows that marketing capabilities and network capabilities directly or indirectly establish brand equity by creating value and customer value together (Zhang *et al.*, 2015a), but how can we build an understanding of brand equity in the industrial market? The research results show that in the current B2B market environment, customer value is regarded as the cornerstone of suppliers in the industry (Anderson & Narus, 1998; Keränen & Jalkala, 2013); in addition, the study pointed out that the cocreation of customer value can directly or indirectly affect brand performance. The model emphasizes the role of brand orientation in translating key management and organizational factors into corporate value and brand performance (Chang *et al.*, 2018a). Whether it is brand performance or industry brand image, brand orientation can build buyer trust, and brand performance will affect long-term commitment and brand loyalty (Syed Alwi *et al.*, 2016a). Brand orientation has become an attractive business concept, and it is believed that brands play an important role in providing customer value and improving company performance. (Zhang *et al.*, 2016a).

2.1. Semiconductor industry

The Semiconductor Industry Association announced, “*Semiconductors are the Brains of Modern Electronics - Semiconductors are an essential component of electronic devices, enabling advances in communications, computing, healthcare, military systems, transportation, clean energy, and countless other applications*”. The most popular new technologies include edge intelligence, 5G, artificial intelligence, big data, fog computing, deep learning, AR, edge computing, Internet of Things, audiovisual, machine learning, and Internet of Thought,

A. Kingson & W.-H. Lai, JEPE, 7(4), 2020, p.234-260.

all of which rely on breakthroughs in semiconductor chip technology. With continuous improvement to achieve the required functions, the highest technical content in particular is in the wafer front-end process, combining chemistry, physics, electronic materials science and other technologies in this study.

From the beginning, the semiconductor industry used physical dimensions (the minimum gate length of transistors) as a measure of continuous technological progress (Wong *et al.*, 2020). Following logic IC technology from 20nm in 2014 to the 16nm process in 2015, until the current 5 nm mass production, ASML announced, “High-NA: Continuation of shrink roadmap: In the same way that 0.33NA enables 7nm and 5nm Logic, 0.55NA EUV will be need to enable 3nm Logic.” The entire process continues to subvert the traditional Moore's Law (Moore, 1965). Although the gate length is decreasing from 20nm to 3nm, the whole semiconductor manufacturing process is increasing, which increases the demand for the entire semiconductor equipment output. The semiconductor supply chain is not a single enterprise or a single industry. It is the overall cooperation between the upstream and downstream of the entire global supply chain. Figure 1 shows the current status and trends of semiconductors. Customers' roadmaps show a continued plan to shrink (Young, 2019), which states logic, performance memory & storage memory present situation and future path.

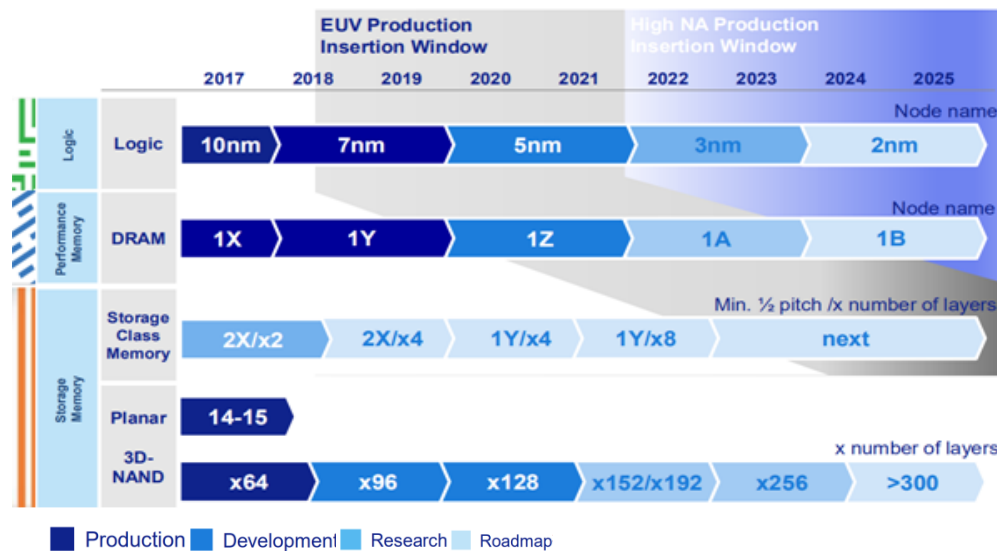


Figure 1. Customers' scaling roadmaps (Young, 2019).

Logic: TSMC's advanced process logic IC is 5 nm in 2020 and is expected to reach 2nm in 2024.

DRAM: Samsung plans to mass produce 16Gb LPDDR5 products based on third-generation 10nm-class (1z) process technology in the second half of 2020, consistent with the development of a 6,400Mb/s chipset (Maeil Business News Korea, 2020). The micro issue 1β process will use immersion quad patterning limit technology in 2024.

Storage Memory:

(1) Storage class memory: current is 1Y/x4, 1Y is ~15 nm, x4 means 4 layers; it is estimated that it will increase to over eight layers in 2024, and shorten by 1/2 pitch.

(2) Planar: This is old technology, no discussion.

(3) 3D-NAND: The figure shows that there are 128 layers in 2020; Samsung said the company is developing the industry's first NAND flash memory chip with 160 layers. Perhaps the number of layers will exceed 300 after 2024, but such an advance would seriously increase the difficulty of the process. However, this is only speculation. If there is a breakthrough in new technology, so many layers may not be needed.

The development of semiconductors is almost unlimited; each vendor in the entire supply chain is serving its customers, but how to become a member of the supply chain with products or services having established brands in the semiconductor industry that is, identifying the crucial influential factors in semiconductor brand establishment, is the focus of this study.

2.2. Influential factors in the semiconductor brand

The semiconductor industry uses various chemical materials to change semiconductors' conductivity, resistance, and capacitance. Some chemical raw materials have certain risks and safety. Suppliers provide chemical substances that meet the standards, which can create value in the entire chemical industry. The higher the purity of chemical substances used in the semiconductor industry, the higher the pass rate of the entire process, increasing customer value (Sheth, 2019). In the semiconductor industry, with the rapid development of applications, new processes are constantly being developed. In addition to efforts to achieve high process reliability, suppliers also affect industry brand equity through relationships between organizations (Dwivedi *et al.*, 2019) so that customers can develop brand loyalty toward their suppliers' products. This relationship exists because brand loyalty is a crucial indicator of building brand equity (Moslehpour *et al.*, 2018a). In addition, the semiconductor industry is a high-tech industry. Establishing corporate brand equity and positive brand associations in the minds of consumers requires higher brand positioning. This task can promote employee internal brand improvement, enhance employees' willingness and skills, and provide quality services (Zhang *et al.*, 2016b) to show better brand performance (Anees-ur-Rehman *et al.*, 2017) to satisfy customers' requirements.

In the entire semiconductor industry process, companies need many processes and various professional suppliers. With the boom in the semiconductor industry, many potential suppliers also hope to enter this industry. After obtaining qualified supplier qualifications, they not only hope that they will serve single or a few customers but also look forward to expanding their entire business by establishing a brand. Based on a literature investigation, this study identified 5 main brand influencing

factors: customer value, brand equity, brand loyalty, brand orientation, and brand performance, as described below.

2.2.1. Customer value

For the past 30 years, the Taiwanese government has regarded the semiconductor industry as a high-tech industry of strategic importance (Cho, 2019). Companies in the semiconductor industry can establish the structure and content of customer data through customer interaction and information, segmentation and differentiation of customer services, establishing correct customer value, creating customer value, establishing good customer relationship management (Tsou & Huang, 2018) and through direct or indirect value creation and customer value creation to establish brand equity (Zhang *et al.*, 2015b). In the semiconductor industry, process conditions and product portfolios are becoming more diverse. The management of the entire supply chain is not only limited to suppliers but also extends to the entire upstream and downstream relationship with customers. Its purpose is to provide superior customer value for the entire supply chain at lower costs (Sun *et al.*, 2016). The entire semiconductor supply chain has expanded into a complex network with decentralized and convergent flows. It not only is a chain but also attaches great importance to the management of upstream and downstream relationships to provide customers with superior value (Stadtler *et al.*, 2015). Every entrepreneur hopes that their company can operate and develop forever. The company's purpose is to create customer value, extract part of customer value in the form of profit, and create value for the enterprise (Kumar & Reinartz, 2016). In terms of long-term income generation and cost reduction, the enterprise as a supplier in the supply chain will look for opportunities to offer value to the buyer that is superior to that offered by its competitors (Vijayakumar *et al.*, 2019).

Semiconductor technology and new functions have continuously improved to implement new processes, and new product development (NPD) has become a very important task. Companies provide developed samples to customers for practical application and research and hope to introduce the samples into mass production later, bringing benefits to the enterprise (Vayvay & Cruz-Cunha, 2016b). Product modularity (PM) has a certain impact on cooperation in the semiconductor industry because the company has certain product architecture and technical interface standards (Ernst, 2005). PM is an effective new product development (NPD) strategy. It decomposes complex product design into independent modules adapted to the new configuration to respond to the frequent, rapid, and effective application of new products to meet market demand (Ye *et al.*, 2018). However, as products meeting future market requirements become more complex and diverse, there is inevitably a higher risk of failure in the new product development (NPD) phase (P.L. Pun *et al.*, 2019).

The expansion of semiconductor integrated circuits needs to rely on increasingly complex subtechnology, which also creates opportunities for coordination between the entire semiconductor industry and external

partners, and the partnership is based on supporting the addressing problems arising in the development of new products (Doering, 2020). These development process-related issues are risks in new product development, and these problems need to be addressed to reduce these risks (Echeveste *et al.*, 2017). To reduce risks, the entire supply chain takes part in value cocreation and encourages customers to give feedback to suppliers promptly so that suppliers can quickly solve potential problems and achieve better corporate performance and customer value (Groth, 2004).

2.2.2. Brand equity

There are many reasons for the high barrier to entry in the semiconductor industry, including first-mover advantage, economies of scale, brand recognition, stickiness and customer loyalty, intellectual property (IP), and high fixed capital expenditures (VerWey, 2019). Therefore, to continue to innovate and achieve profitability, companies need mechanisms to be reasonably priced and need to prevent them from being imitated by other companies. Approaches to achieving this goal include mechanisms, such as patents, copyrights, trade secrets, and powerful brand names (Shin *et al.*, 2017). A brand name can give a product increased utility and then define brand equity (Baalbaki & Guzmán, 2016). Companies define brand equity as the added value of the brand name and its attributes related to the product or service (Rahman *et al.*, 2019). Brand equity is formed through the thoughts, emotions, perceptions, images, and experiences associated with the brand (Keller, 1993); once the customer perceives that the supplier's brand quality is higher than their competitors, brand equity will gradually form (Zhang *et al.*, 2015c), and this brand quality perception will significantly affect perceived brand loyalty and have a certain impact on brand equity (Moslehpour *et al.*, 2018b). Koomey's Law states that the energy efficiency of computers in kilowatt-hours is increasing by over 50 percent per year, creating demand value. How many people will pay to increase speed is the key to the growth of the semiconductor industry (Hutcheson, 2018a). Different customers have different willingness to pay for a certain quality, especially in the semiconductor industry; customers will pay higher prices for computers with faster CPUs, more memory, and lower energy consumption (Inkaya *et al.*, 2018). If new raw materials or new processes in the chip manufacturing process can help improve performance, customers can pay more under specific conditions. In particular, due to the enormous investment in new products, suppliers charge high prices early in the product cycle, and customers will pay, which is the value of brand equity (Copeland & Shapiro, 2016).

2.2.3. Brand loyalty

Wang *et al.*, (2018) suggest using purchase loyalty, continuous purchase & commitment to brand to measure brand loyalty. Loyal customers are unlikely to change brands they trust; they will purchase products because of loyalty to the brand (Nguyen, N.T., 2020). Brand quality matters in

establishing customer loyalty and is a key factor in deciding whether to buy (Moslehpour *et al.*, 2018c). There is at least one perceived brand causality configuration requirement that will lead to higher brand loyalty and brand purchase intention (Foroudi *et al.*, 2018). Brand loyalty is traditionally considered a behavioral construct related to continuous purchase intention (Nam *et al.*, 2011). Users will continue to buy for some time, showing that brand loyalty has become a template for customer behavior (Padhi, P. K., 2018). A loyal customer will continuously purchase products with an excellent reputation, bringing more economic profits to the company (Helen & Ho, 2011). In principle, an organization is required to allocate its resources in a way that satisfies its employees and gives them the motivation and commitment to live up to brand values and achieve the brand goal (John, 2019), which should be the responsibility of the employees. However, when customers resonate with a brand and become attached to a brand and purchase it regularly, they become committed to the brand (Ramaseshan & Stein, 2014). Customers as stakeholders in the whole supply chain will commit to brand success (Merz *et al.*, 2018).

2.2.4. Brand orientation

Brand orientation should run through all our marketing activities and perform better than competitors (Y. Chang *et al.*, 2018b). The strategic focus of a company's leading brand and its subsequent development to protect and strengthen its brand's internal and external marketing activities, will make the brand recognizable, unique, and recognized (Anees-ur-Rehman *et al.*, 2018). Brands concentrate the activities leading companies in the highest value stage of the final product; these activities include marketing, branding, research, design, and product development (Frederick & Lee, 2019). In the semiconductor industry, companies can show long-term strategic behavior to stakeholders (Pellens & Della Malva, 2018). Long-term brand planning is crucial to the company's future success. The company is more likely to adopt a long-term strategic vision, recognize the value of brand orientation, and share the long-term planning of its products with customers (Y. Chang *et al.*, 2018c). To the extent that an enterprise is a concern, the key to long-term success is the success of patents, so the company must take acquiring patents as the long-term strategy of brand orientation (Distel, 2017). Chang *et al.* (2018) mentioned that brand is an important asset, so the company should be brand-oriented as a strategic direction, as Laukkanen *et al.* (2016) have the same opinion. Brands should take their image as an important asset and be loyal to their brand personality (Laub *et al.*, 2018). With the improvement of environmental protection awareness, semiconductor enterprises give increasing attention to environmentally sustainable consumption, and an eco-friendly brand is an important asset (Bekk *et al.*, 2016).

2.2.5. Brand performance

Based on (Syed Alwi *et al.*, 2016b), five factors are proposed to affect brand performance, namely product quality, service attributes, price position, supplier competence & distribution strategies. The higher the

product quality is, the more market share will improve brand performance (Olbrich *et al.*, 2017). Product quality directly affects the purchasing decision process, so it closely relates brand performance to product quality (Waluya *et al.*, 2019). The study found that product quality directly affects performance and is closely related to customer loyalty, customer satisfaction, and repurchase intention (Chang & Fong, 2010). In addition to providing quality products, product quality can also differentiate brand performance through employee factors and provide better overall services (Wang, 2017). Service quality evaluation is a cognitive process; service quality evaluation is the psychological result of service attributes: perception, learning, reasoning, and understanding. Experience is the key to forming perceived quality because customers often recall and compare similar service attributes obtained from different suppliers (Sultan & Wong, 2013). The virtual brand community implements open innovation by supporting point-to-point problem solutions, and the company can achieve in-depth development and reduce service costs in establishing contact with consumers (Elia *et al.*, 2020). For example, *The TSMC Open Innovation Platform® promotes the speedy implementation of innovation in the semiconductor design community, and its ecosystem partners use TSMC's IP, design implementation, and design for manufacturability (DFM) capabilities, process technology, and backend services* (TSMC, 2020).

The innovation engine of the semiconductor industry is Moore's Law; it has become an innovative brand. Metcalfe's Law mentions the need for lower prices to attract more users (Hutcheson, 2018b), but the price of EUV equipment produced by ASML in the Netherlands is increasing. The reason is that the company has the most advanced technology, and creating the best brand performance bests competitors. Measured by relative price, brand differentiation, and word of mouth, there is a positive correlation between brand loyalty and performance (Sta *et al.*, 2018). Effective brand price positioning is beneficial to enterprises, and reasonable prices can bring additional benefits, enhancing brand image and brand performance (Syed Alwi *et al.*, 2016c).

The semiconductor industry is a highly professional industry with a high threshold for entry, so there are certain requirements for suppliers' competence or professional skills (Taherdoost & Brard, 2019); therefore, to become a member of the qualified supply chain, suppliers must go through strict selection, audit and approval procedures. Suppliers' participation in new product development can bring new competence to buyers, quickly penetrate new markets, and save resources (Vayvay & Cruz-Cunha, 2016c). In terms of supplier competence, the industry also emphasizes reputation, historical records, and long-term sustainability in critical situations, especially environmental protection (Cheshmberah, 2020). Effective distribution strategies, product quality, and capabilities can explain how customers assess the reliability, experience, and management of the brand (Syed Alwi *et al.*, 2016d). Companies base many distribution strategies on a distributed hierarchical structure and usually adopt a deterministic

approach to address the complexity of the semiconductor supply chain (Mönch *et al.*, 2018). The ability to sell and distribute in the global market depends on the vision of senior management and satisfying the expectations of all supply and distribution channel partners. It is necessary to select distribution strategies so that products can reach customers quickly (Misra *et al.*, 2019).

3. Research methodology

3.1. AHP technique

Facing multicriteria decision-making (MCDM), the suitable mathematical method is AHP (Analytic Hierarchy Process); AHP relies on a series of pairwise comparisons, taking into account the perception and evaluation of decision makers. Saaty introduced AHP (1980). Complex issues or problems involving value or subjective judgment are suitable applications of the AHP method (Viswanadhan, 2005). AHP uses hierarchical structure and pairwise comparison to allow users to give different weights to each criterion (Ozdemir & Sahin, 2018). The AHP method assists users in obtaining weights instead of randomly assigning weights. However, the weight shows the relative importance of the indicators but does not mistake them for their decision importance (Harik *et al.*, 2015).

3.2. Procedure in the AHP technique

The following explains and defines the execution steps of the AHP method:

1st step: Through a literature review and expert interviews, this study selected five main influencing factors and used the AHP to identify the criterion.

2nd step: Establishing a research framework.

3rd step: Design the AHP questionnaire based on the main variables and subvariables.

4th step: Obtain 25 to 30 expert AHP questionnaires. Invite experts with over ten years of relevant industry experience to assign a weight to each influencing factor.

5th step: When the research framework is complete, the standard and substandard are compared in pairs. For pairwise comparisons, experts were asked to rate the relative importance of one factor according to Saaty's (1980) nine-point scale. The comparison time of the matrix was calculated using the formula $n(n-1)/2$, where n represents the number of entries of the matrix (Table 1); if they have four terms in any matrix, then the number of comparisons is four.

Table 1. *Saaty's discrete 9-value scale*

Scale	Judgment of preferences
1	Equally important
3	Weak importance of one over another
5	Essential or strong importance
7	Demonstrated importance
9	Absolute importance
2,4,6,8	Intermediate judgments between two adjacent judgments

6th Step: After pairwise comparison, the next step is to obtain the local weights of each item by calculating the eigenvalues and eigenvectors. The characteristic value calculation formula is as follows:

$$\lambda = \frac{\text{ith value of } \delta}{\text{ith entry in priority weights'}}$$

7thStep: Once the local weight of individual factors relative to other factors is calculated, the next step is to check whether the comparisons made are consistent. The following formula can also check the comparisons:

$$CR = \frac{CI}{RI} \text{ and } CI = \frac{\lambda_{\max} - n}{n - 1},$$

where CR is the consistency ratio, CI is the consistency index, calculated using the above formula, λ_{\max} is the highest eigenvalue, and n is the number of terms in the matrix. RI is a random index based on the size of matrix (n) as shown in Table 2. The values of CI and CR should always be less than 0.1 for the results to be consistent (Saaty, 1994).

Table 2. *Random consistency index*

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

8th Step: To calculate the local weight of a single item, one must also calculate the global weight. Use the following formula for the calculation:

$$\begin{aligned} \text{Global weights} &= \text{Local weights of criteria "m"} \\ &\times \text{Local weight of sub criteria "p" with respect to "m"}. \end{aligned}$$

9th Step: Calculate the global weights of all variables and subvariables and sort all global weights.

3.3. Research framework

Model development: The literature review confirms that the establishment of semiconductor brands classified under five main

variables. This study discussed the classification process with the expert group based on the results of the literature review and proposed a three-tier model to meet the research purpose. The first level of the model represents the goal of the research. Five main variables “Customer value”, “Brand equity”, “Brand loyalty”, “Brand orientation” and “Brand performance” are arranged in the second layer of the model which represents the individual main variables. The third level comes from the subvariables under each variable. The subvariables, such as superior value, addressing problems and new product development are placed under “Customer value”. The subvariables under “Brand equity” are willingness to pay, perceived brand, and brand name. The subvariables continuous purchase, purchase loyalty, and commitment to a brand are placed under “Brand loyalty”. The subvariables under “Brand orientation” are marketing activities, long-term strategy, and important assets. Similarly, the subvariables that come under “Brand performance” include product quality, service attributes, price position, supplier competence, and distribution strategies. This study develops the variables related to crucial influential factors assessments and the research framework of AHP in this study per Figure 2. Table 3 lists the background of the interviewed experts; Table 4 and Table 5 show the operational definitions of 5 main variables and 17 subvariables.

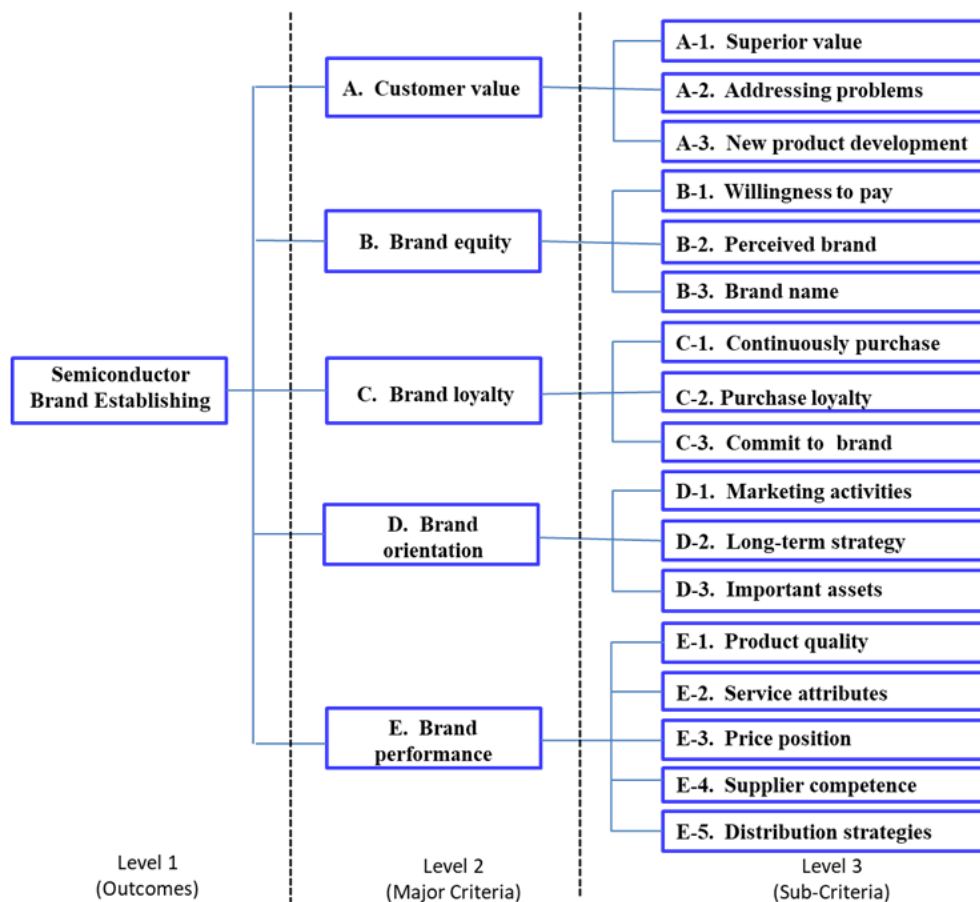


Figure 2. The research framework of AHP in this study

Table 3. *The interview experts' background*

No.	Expert's organization	Department/sector	Years of experience	Title
1	Industry	Supply Chain Management	10	Commodity Manager
2	Industry	SPC/GD&T/Black belt/PM	18	Vice President
3	Industry	Engineering Design, Management	24	General Manager
4	Industry	Product Quality Control	15	Quality Manager
5	Industry	Semiconductor equipment maintenance, process	15	Engineer
6	Industry	Gas Line Testing	10	Manager
7	Industry	Piping Engineering	22	General Manager
8	Industry	Piping Engineering	20	General Manager
9	Industry	Piping Engineering	12	CEO
10	Industry	Piping Engineering	17	CEO
11	Industry	Piping Engineering	11	Engineer Manager
12	Industry	Engineer	12	Senior Engineer
13	Industry	Engineer	11	Engineer

Table 4. *The operational definitions of the five main variables.*

Main variables	Operational Definition	Sources
Customer value	The customer perspective involves how customers perceive the value of the supplier's superiority to existing alternatives. The supplier's perspective recognizes the need to treat customers as the company's key assets and emphasizes the use of customer asset management to attract, develop, and keep customers. The customer supplier's point of view emphasizes that value is created through relationships, cooperation, and alliances.	Ulaga (2001)
Brand equity	Brand equity comes from the overall brand image created by the overall brand association perceived by consumers.	Michell <i>et al.</i> , (2001)
Brand loyalty	Brand loyalty is a deep-rooted commitment to consistently repurchasing or patronizing a preferred product/service, leading to repeated purchases of the same brand or the same set of brands, even though contextual influence and marketing efforts may lead to conversion behavior.	Oliver (1999)
Brand orientation	A specific marketing positioning is characterized by the high relevance of the top management to the brand. It also implies a strong and systematic approach to brand management.	(Hankinson, 2001a, b; Urde, 1994, 1999)
Brand performance	Market share and relative price	Chaudhuri & Holbrook (2001)

Table 5. *The operational definitions of 17 subvariables.*

Main variables	Subvariables	Operational definition	Reference
Customer value	Superior value	When sellers create more value for customers than competitors, they can obtain higher customer value.	Slater & Narver(2000)
	New product development	Problem-solving capability is crucial for new product development.	Chen <i>et al.</i> (2017)
	Addressing problems	Solving problems arising during transactions relationships.	Macaulay (1963)
Brand equity	Brand name	Buyers seem to make purchasing decisions based on brand rather than price.	Van Riel <i>et al.</i> (2005)
	Perceived brand	Consumer's judgment about a product's overall excellence or superiority. Perceived quality is (1) different from objective or actual quality, (2) a higher-level abstraction rather than a specific attribute of a product, (3) a global assessment that in some cases resembles attitude, and (4) a judgment usually made within a consumer's evoked set.	Zeithaml (1988)
	Willingness to pay	Customers expressed that they will spend more money to buy it or select service providers, with strong and positive brand images.	Davis <i>et al.</i> , (2008)
Brand loyalty	Purchase loyalty	The results indicate that when the product and brand level variables	Chaudhuri &

		are controlled for, brand trust and brand effect combine to determine purchase loyalty and attitudinal loyalty.	Holbrook(2001)
	Continuously purchase	Intend to keep buying the brand	Han & Sung (2008)
	Commit to brand	The brand commitment regarded as a behavioral phenomenon is usually defined as "the proportion of total purchases within a given product category devoted to the most frequently purchased brand".	Jacoby & Chestnut (1978)
Brand orientation	Marketing activities	Improving the brand orientation of marketing activities can improve overall marketing performance.	Wong, & Merrilees(2008)
	Long-term strategy	Long-term brand value comes from the company's success in maintaining and developing existing customer franchises.	Keller & Lehmann (2009)
	Important asset	The company's important asset is the brand.	Wong & Merrilees1 (2007)
Brand Performance	Product quality	Reliable brand	Van Riel <i>et al.</i> (2005)
	Service attributes	Satisfied with technical support	Cretu & Brodie (2007)
	Price position	Reasonable price	Hinterhuber (2004)
	Supplier competence	State exactly what products they will offer	Han & Sung (2008)
	Distribution strategies	Convenient for customers to order	Mudambi <i>et al.</i> (1997)

4. Data analysis and discussion

4.1. Comparison of variables and subvariables

After the model is established, the next step is to compare the main variables and subvariables in pairs. This study invited 27 experts to test relative preferences on individual factors. These experts come from academia, industry, and venture capital, and they are carefully selected because all have over ten years of experience in this industry and have a certain amount of practical experience and different perspectives to provide researchers with professional opinions. Table 6 is the background of the research subject experts. Through pairwise comparison, it examines the relative importance of each main variable. It compares the main variables with the outcomes. Similarly, the subvariables under all main variables were compared in pairs. Subvariables such as superior value, new product development, and addressing problems were compared to each other concerning "Customer value". The subvariables brand name, perceived brand and willingness to pay were compared to each other concerning "Brand equity". Subvariables such as purchase loyalty, continuous purchasing, and commitment to the brand were compared to each other concerning "Brand loyalty". The subvariables marketing activities, long-term strategy and important assets were compared to each other concerning "Brand orientation", and the subvariables product quality, service attributes, price position, supplier competence, and distribution strategies were compared to each other concerning "Brand performance".

Table 6. Background of the research subject experts

No.	Expert's organization	Department/sector	Experience	Title
1	Industry	Supply Chain Management	10	Commodity Manager
2	Industry	SPC/GD&T/Black belt/PM	18	Vice President
3	Industry	Engineering Design, Management	24	General Manager
4	Academic	Engineer	11	Senior Engineer
5	Consulting	Industry analysis	10	Analysts
6	Consulting	Industry analysis, Financial analysis, Value assessment	10	Analysts
7	Industry	Product Quality Control	15	Quality Manager
8	Industry	Sales	15	Sales Director
9	Consulting	Industry analysis	11	Analysts
10	Academic	Accounting and Management	14	Engineer
11	Industry	Semiconductor equipment maintenance, process	15	Engineer
12	Industry	Gas Line Testing	10	Manager
13	Industry	Piping Engineering	22	General Manager
14	Industry	Piping Engineering	20	General Manager
15	Industry	R & D	11	R & D
16	Industry	Piping Engineering	12	CEO
17	Industry	Piping Engineering	17	CEO
18	Industry	Piping Engineering	11	Engineer Manager
19	Consulting	Sales/Marketing Management	14	Engineer
20	Industry	Sales/Marketing Management	18	Manager
21	Industry	Procurement	13	Manager
22	Industry	Sales/Marketing Management	15	Director
23	Academic	Engineer	10	R & D
24	Academic	Engineer	13	Engineer
25	Industry	Engineer	12	Senior Engineer
26	Industry	Engineer	11	Engineer
27	Industry	Sales/Marketing Management	10	Director

Calculation of local weights: After comparing the mainvariables and subvariables, the next step is the calculation of local weightsCI and CR. The values of CI and CR should always be less than 0.1.Compare the main variables (influencing factors) in pairs to obtain the weight (E-vector), and check that the CI value is less than one, which causes CI to meet the consistency requirements per Table 7.

Table 7. Pairwise comparison of influencing factors (major variables)

Major variables	CV	BE	BL	BO	BP	E-vector
A. Customer Value (CV)	1.00	2.22	2.33	2.88	2.36	0.377
B. Brand Equity (BE)	0.45	1.00	1.01	1.52	1.13	0.176
C. Brand Loyalty (BL)	0.43	0.99	1.00	1.21	1.15	0.167
D. Brand Orientation (BO)	0.35	0.66	0.82	1.00	1.14	0.128
E. Brand Performance (BP)	0.42	0.88	0.87	0.88	1.00	0.152

Notes: λ max = 5.023108, CI = 0.005777, RI = 1.12, CR = 0.005158

Pairwise comparisons of the three subvariables (evaluation indicators) of customer value results are shown in Table 8.

Table 8. *Pairwise comparison of three evaluation indexes relative to customer value*

Subvariables	SV	AP	NPD	E-vector
A-1. Superior Value (SV)	1.00	0.67	1.29	0.309
A-2. Addressing Problems (AP)	1.50	1.00	1.75	0.444
A-3. New Product Development (NPD)	0.78	0.57	1.00	0.247

Notes: λ max = 3.001105, CI = 0.000552, RI = 0.58, CR = 0.000952

The three evaluation indicators of brand equity are compared in pairs, and the results are shown in Table 9.

Table 9. *Pairwise comparison of three evaluation indicators concerning brand equity*

Subvariables	WtP	PB	BN	E-vector
B-1. Willingness to Pay (WtP)	1.00	1.07	1.14	0.355
B-2. Perceived Brand (PB)	0.94	1.00	1.30	0.355
B-3. Brand Name (BN)	0.87	0.77	1.00	0.29

Notes: λ max = 3.004268, CI = 0.002134, RI = 0.58, CR = 0.003679

Pairwise comparisons of the three subvariables of brand loyalty results are shown in Table 10.

Table 10. *Pairwise comparison of three evaluation indicators concerning brand loyalty*

Subvariables	CP	PL	CB	E-vector
C-1. Continuously Purchase (CP)	1.00	1.23	1.22	0.379
C-2. Purchase Loyalty (PL)	0.82	1.00	1.11	0.321
C-3. Commit to Brand (CB)	0.82	0.90	1.00	0.3

Notes: λ max = 3.001317, CI = 0.000658, RI = 0.58, CR = 0.001135

The pairwise comparison results of the three evaluation indicators in the brand orientation are shown in Table 11.

Table 11. *Pairwise comparison of three evaluation indicators concerning brand orientation*

Subvariables	MA	LTS	IA	E-vector
D-1. Marketing Activities (MA)	1.00	0.67	1.06	0.294
D-2. Long-Term Strategy (LTS)	1.50	1.00	2.00	0.461
D-3. Important Asset (IA)	0.94	0.50	1.00	0.245

Notes: λ max = 3.006839, CI = 0.003419, RI = 0.58, CR = 0.005896

As with the previous method, Table 12 shows the results of the pairwise comparison of the five subvariables of brand performance results. Calculate global weight and sort: determine the local weight of each item relative to the upper layer, and then determine the correlation between individual items and the results of the hierarchical model.

Table 12. Pairwise comparison of five evaluation indicators concerning brand performance

Subvariables	PQ	SA	PP	SC	DS	E-vector
E-1. Product Quality (PQ)	1.00	2.89	2.18	3.25	3.33	0.411
E-2. Service Attributes (SA)	0.35	1.00	1.30	1.33	1.74	0.159
E-3. Price Position (PP)	0.46	0.77	1.00	1.41	2.23	0.199
E-4. Supplier Competence (SC)	0.31	0.75	0.71	1.00	1.71	0.137
E-5. Distribution Strategies (DS)	0.30	0.57	0.45	0.59	1.00	0.094

Notes: λ max = 5.077348, CI = 0.019337, RI = 1.12, CR = 0.017265

For research, the evaluation indicators were determined from the literature review, and the determined methods were determined in consultation with experts. After determining the three-level evaluation indicators, according to the design of the AHP hierarchy model, the first level is the focus target, the second level is the influence factor, and the third level is the evaluation indicator subvariables. After they completed the hierarchical model, all variables and subvariables were compared in pairs, and their local and global weights were calculated as shown in Table 13. The table mentions the global weight and ranking of all subvariables regarding the implementation priority of the semiconductor industry brand established in this study.

Table 13. AHP weight, main, and subvariable ranking levels

Main variables	Local/global weights (w)	Major factor Ranking	Subvariables	Local Weights (w)	Global Weights (w)	Sub variable Ranking
A. Customer Value	0.377	1	A-1. Superior Value	0.309	0.116493	2
			A-2. Addressing Problems	0.444	0.167388	1
			A-3. New Product Development	0.247	0.093119	3
B. Brand Equity	0.176	2	B-1. Willingness to Pay	0.355	0.062480	5
			B-2. Perceived Brand	0.355	0.062480	6
			B-3. Brand Name	0.29	0.051040	10
C. Brand Loyalty	0.167	3	C-1. Continuously Purchase	0.379	0.063293	4
			C-2. Purchase Loyalty	0.321	0.053607	9
			C-3. Commit to Brand	0.3	0.050100	11
D. Brand Orientation	0.128	5	D-1. Marketing Activities	0.294	0.037632	12
			D-2. Long-Term Strategy	0.461	0.059008	8
			D-3. Important Asset	0.245	0.031360	13
E. Brand Performance	0.152	4	E-1. Product Quality	0.411	0.062472	7
			E-2. Service Attributes	0.159	0.024168	15
			E-3. Price Position	0.199	0.030248	14
			E-4. Supplier Competence	0.137	0.020824	16
			E-5. Distribution Strategies	0.094	0.014288	17

4.2. Main variables

This study uses AHP research methods to ask experts to rank the importance of all variables and subvariables that affect the establishment of semiconductor brands. The ranking results show the relative importance of each success factor and provide a clear map for the company's senior management team and marketing director or manager. The above weights and rankings answer the basic questions of this research. The main

variables from the most important state to the least important state are "customer value" ($w = 0.377$), "brand equity" ($w = 0.176$), "brand loyalty" ($w = 0.167$), "brand performance" ($w = 0.152$) and "brand positioning" ($w = 0.128$). From the above analysis results, it can seem that the three main variables of "customer value", "brand equity" and "brand loyalty" are more important than the main variables such as "brand performance" and "brand positioning". Compared with other main variables, "customer value" is more weighted, and the gap with the second most important factor is more than twice the other gaps. As seen from Figure 3, experts agree that the importance of customer value is unquestionable, this point is also consistent with the statement that customers are gods in the semiconductor industry. Influencing factors and evaluation indicators were sorted by total weight. The result shows that for the company's senior management team and marketing executives or managers to succeed in brand building in the semiconductor industry, managers must attach importance to customer value, and customer value will ultimately lead to improved business performance. Although the aggregate weight of brand equity, brand loyalty, brand performance, and brand positioning is lower than customer value, their impact on semiconductor brand building cannot be ignored by managers.

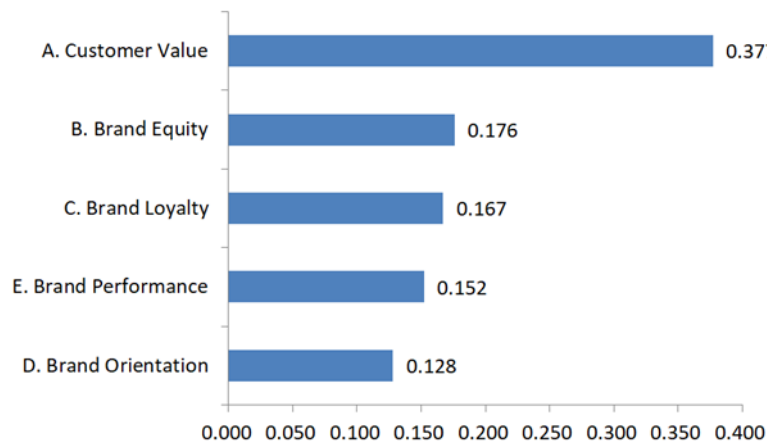


Figure 3. Sort of the influencing factors according to global weight

4.3. Subvariables

4.3.1. Customer value

The local weight of each evaluation index is shown in the fifth column of Table 13. When considering customer value in the establishment of semiconductor brands, this study suggests three subvariables: 'Superior value', 'Addressing problems', and 'New product development'. Based on AHP analysis, these subvariables rank from most important to least important as follows: 'Addressing problems' ($w = 0.444$), 'Superior value' ($w = 0.309$), and 'New product development' ($w = 0.247$). From the results, it can seem that among all the practices listed in "Customer value", 'Addressing problem' (0.444) has the highest local weight, reflecting that

the top management must focus on and take part in solving customer issues to reflect customer value.

4.3.2. Brand equity

Among the main variables for brand equity, this study recommends three subvariables: willingness to pay, perceived brand, and brand name. Based on AHP analysis, the ranking of each subvariables from most important to least important is "Willingness to pay" ($w = 0.355$), 'Perceived brand' ($w = 0.355$), and 'Brand name' ($w = 0.29$). The local weight results show that willingness to pay and brand perceptions are the same and are also the most important subvariables affecting brand equity.

4.3.3. Brand loyalty

In the main variables of "Brand loyalty", this study recommends the three subvariables 'Continuously purchase', 'Purchase loyalty' and 'Commit to brand'. According to AHP analysis, the subvariables from the most important to the least important are 'Continuously purchase' ($w = 0.377$), 'Purchase loyalty' ($w = 0.321$), and 'Commit to brand' ($w = 0.300$).

The results of local weight show that there is a compulsive desire from customers to continuously purchase a specific product as the most important subvariables in brand loyalty.

4.3.4. Brand orientation

Among the main variables of brand positioning, this study recommends three subvariables: 'Marketing activities', 'Long-term strategy', and 'Important assets'. Based on the AHP analysis, sort the subvariables from the most important to the least important as 'Long-term strategy' ($w = 0.461$), 'Marketing activities' ($w = 0.294$), and 'Important asset' ($w = 0.245$). The results show that building a long-term strategic approach to enable brand orientation in semiconductors is the most important subvariables.

4.3.5. Brand performance

Among the main variables of brand performance, this study proposes the five subvariables 'Product quality', 'Service attributes', 'Price position', 'Supplier competence', and 'Distribution strategies'. Based on AHP analysis, the subvariables from the most important to the least important are: 'Product quality' ($w = 0.411$), 'Price position' ($w = 0.199$), 'Service attributes' ($w = 0.159$), 'Supplier competence' ($w = 0.137$) and 'Distribution strategies' ($w = 0.094$). The results show that recognizing consumer demand for product quality is the most important subvariables affecting brand performance.

4.3.6. Managerial implications (Global Weights)

The above subvariables show each local weight in each main variable, and the 6 columns of Table 13 show the global weights of all subvariables sorted according to the global weight, as shown in the histogram in Figure 4. Therefore, the 'Problem solving' factor clearly has the greatest impact on the establishment of a brand in the semiconductor industry, followed by 'Superior value' as another key, but the last factor which has relatively little impact on the brand, is the 'Distribution strategy'. Understanding the applicability of evaluation indicators in the semiconductor industry is a

subjective issue. Using AHP MCDM (multicriteria decision-making) technology to enumerate subjective factors can help senior managers and marketing directors or managers prioritize major brand invitations. For managers and marketing experts, it is often difficult to determine which factors or practices require more attention to achieve the greatest effect. However, this problem can easily be solved by the sorting results obtained by the application of AHP technology.

The three evaluation indicators 'Addressing problems' (0.167388), 'Superior value' (0.116493), and 'New product development' (0.093119) ranked in the top three in the global weight, and all three concentrated on the "customer value" of the main variables, accounting for 0.377. They have a significant influence on the key factors for a brand established in the semiconductor industry. Therefore, the top-level management team must work to address problems within the organization and even customers. 'Addressing problems' in the transaction process will help to successfully build the brand. One can say that "Customer value" is the most critical factor in brand establishment, and an evaluation indicator exists to 'Addressing problems'. The second important evaluation indicator is the 'Superior value' (0.116493). Organizations need to create more value for customers than competitors do to obtain higher customer value. The third important evaluation indicator shown in the histogram is 'New product development' (0.093119). The company should try to acquire the ability to address problems and ensure the stability of the new product development process. This process will be an ongoing one, and the same evaluation should be customer-centric. The other evaluation clusters in the middle area of the bar graph are 'Continuously purchasing' (0.063293), 'Perceived brand' (0.06248), 'Willingness to pay' (0.06248), 'Product quality' (0.062472), 'Long-term strategy' (0.059008), 'Purchase loyalty' (0.053607), 'Brand name' (0.05104), 'Commit to brand' (0.0501) and 'Marketing activities' (0.037632). The middle part of this evaluation (approximately 50.21%) shows that, in addition to the success in the first three subvariables, the management team should also give due attention to these key factors that account for one-half of the weight. How to let the customers continuously purchase the company's product is important, as customers perceived the brand and are willing to pay for the merchandise because the product quality meets their requirements. Therefore, they must establish a long-term strategy to enable the company's customers to have purchase loyalty to its brand so that customers can be committed to the company's brand. All of these marketing activities revolve around the brand name.

The set of evaluation indicators in the bottom area of the diagram includes an 'Important asset' (0.03136), 'Price position' (0.030248), 'Service attributes' (0.024168), 'Supplier competence' (0.020824), and 'Distribution strategies' (0.014288). This stage is the third in brand establishment. The top-level management team needs to recognize that the brand is an important asset, set reasonable price positions for our products, understand

the service attributes of industrial products, develop a qualified supplier competence, and plan distribution strategies.

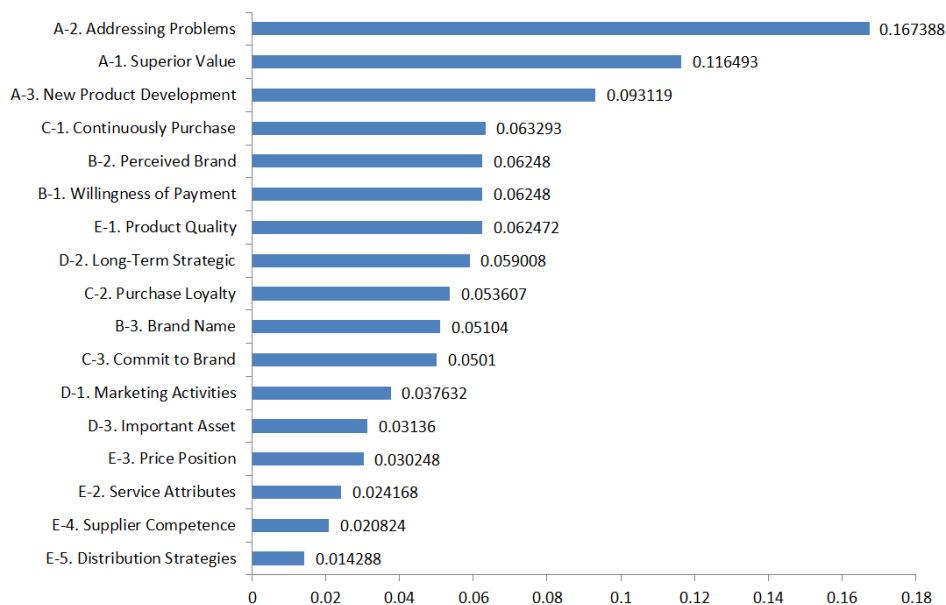


Figure 4. Sort of evaluation factors according to global weights

5. Conclusion and directions for future research

This study proposes a complete step-by-step model for top management teams and marketing experts in the semiconductor industry. Through this structure, the management team can have a good understanding of brand building and meet all prerequisites for brand building. This study found 17 evaluation indicators from the literature and ranked them according to their implementation priorities in the semiconductor industry. The analytic hierarchy process (AHP) concluded that when building a brand in the semiconductor industry, 'Solving problems' and its more important subvariables, creating 'Superior value' and being involved in 'New product development', are all under the main variable "Customer value". Since the histogram shows the importance of each evaluation indicator, the bias is to view a single indicator, so it is impossible to have a comprehensive overview. Therefore, this study adds the radar chart shown in Figure 5 so that the overall weight of all decisions can be visualized more clearly. In terms of managerial implications, the top management team viewing anglenot only compensates for the lack of key factors in establishing a semiconductor brand but also uses the literature and expert questionnaires to obtain the weight of each factor through the AHP method and rank them in order of importance. Looking at these weights from the manager’s standpoint, the overall strategy should focus on the main variable "Customer value"; and how to create customer value comes from solving the problems of customers and the company, creating overall excellence value and continuing to invest in the development of new products to match the development of technology. Customers will continue to buy the company's products, perceive the company's brand, and pay for its high-

quality products. The company should establish long-term strategic relationships with customers and suppliers under excellent product quality so that our customers are loyal to our company's brand, recognize our company's brand name and commit to our company's brand. Marketing activities turn the marketing orientation into an important asset of the company, with reasonable price positioning and wonderful service attributes, good supplier competence, and distribution strategies to lay the foundation for sustainable operation of the semiconductor brand. In this way, the overall situation in the brand-building process will become comprehensive, missing no factor, understanding the key points and using them effectively at the same time.

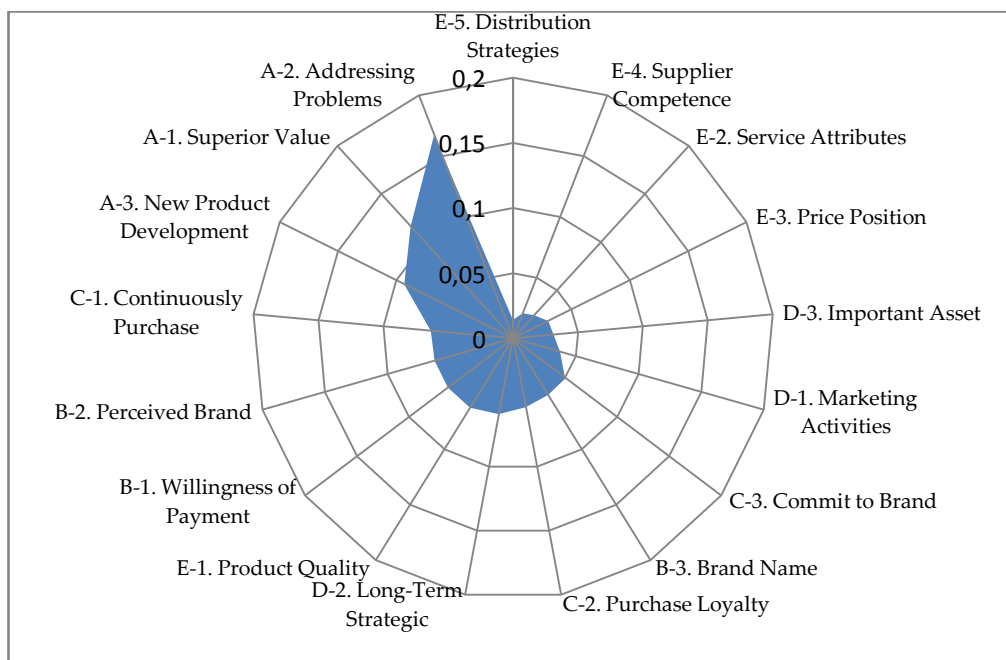


Figure 5. Radar chart of influencing factors based on global weights

Researchers choose AHP because this research method can handle both substantive projects and nonsubstantial projects. In the past, different researchers have successfully sorted different projects and dealt with subjective issues. This technique is very simple to use because it decomposes a multifaceted problem into a simple multilayer structure, which helps the senior management team understand the problem. As experts in this field take part in the decision-making process, the results of the analytic hierarchy process have received due attention.

The limitation of this study is that although the study first consulted industry and academic experts in Taiwan, China, Japan, South Korea, the United States, Singapore, Malaysia, and other regions, it is not limited to one region, but their opinions are only consistent with the relevant area. Second, the development of this model only applies to the semiconductor industry; whether it applies to other pansemiconductor industries requires more research.

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For future research, it is necessary to overcome the limitations of current research, and it is necessary to involve more experts from different countries and regions to have a global view of this issue. The practice of the research framework in this study may rank and verify the impact of influencing factors on other industries. For example, by applying this AHP method to the optoelectronic industry, researchers may use analytical tools to compare brand-building practices to test the importance of one of them. Since semiconductors have many products and supply chains from upstream, midstream, and downstream, future research can concentrate on a single product in the semiconductor supply system for more in-depth brand building research, and future research can explore how interrelational impact can add to fuzzy theory.

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