行政院國家科學委員會專題研究計畫 成果報告

台灣太陽能產業之產品策略
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 98-2221-E-216-004-
執 行 期 間 ：98 年 08 月 01 日至 99 年 07 月 31 日
執 行 單 位 ：中華大學工業管理學系

計 畫 主 持 人 ：李欣怡

計畫參與人員：博士班研究生-兼任助理人員：林俊宇

處 理 方 式 ：本計畫涉及專利或其他智慧財產權，2 年後可公開查詢

中 華 民 國 99 年 10 月 21 日

摘要

近年來，全球環保意識高漲與能源短缺，已喚起人類思考新的替代能源，而太陽能便成為能源產業中的新興產業，但太陽能電池的製造成本居高不下，且在功率轉換效率上卻偏低，因此技術的提升與產品策略的運用對於太陽能產業便是相形的急迫且重要。台灣在過去十幾年的努力下，已成功的發展半導體與 TFT-LCD 產業，而太陽能產業的製程與此兩大產業技術原理相似，且相較於其製程更為單純，故在此兩大產業製造程序與技術的穩固基礎上，台灣便可因全球化的再生能源之需求與本身技術之優勢，取得更有利的發展空間。目前對於台灣太陽能產業的研究多專注於整體產業策略與定性式的分析，但卻在太陽能產業的產品策略卻顯少著墨與探討。而產品策略所涵蓋範圍甚廣，且複雜性與不確定性極高，多種策略產品可增加計畫成功的機會。因此本計畫的研究成果，將有助於太陽能廠商以有效系統化的方法，提出最佳的產品策略方案。

本計畫利用詮釋結構模式分析(ISM)找出太陽能產品策略關鍵因子之關聯性與回饋關係。同時，考量專家對於評比時所產生語意之模糊性，加入模糊理論(Fuzzy Theory)之概念，整合出一套完整之模糊網路分析(FANP)評估模型，來構建產品策略問題的定性與定量的評估模式，並配合不同產品策略之利益、成本、機會和風險(BOCR)等重要構面，找出適合太陽能廠商之產品策略。本研究計畫之成果發展出完善的產品策略評估模式，有助於業者在太陽能產業供應鏈內之產品研發、製造及行銷更加深入之了解。運用本研究的具體成果，除了更貼近實務面外，更能確保台灣太陽能廠商在產品策略發展上的成功。

關鍵字: 太陽能電池；產品策略；模糊網路程序分析法；優勢、機會、成本、風險 (BOCR)

Abstract

With natural resource scarcity and environmental protection, the use of renewable energy has become a promise for offering clean and plentiful energy. Photovoltaic (PV) solar cell is one of the emerging renewable energy applications; however, it suffers a large difficulty in high production cost with low conversion efficiency currently. Hence, an urgent pressure to upgrade technology and to formulate product strategy is evident in the solar cell power industry. In order to prosper PV silicone solar cell power industry, this research develops a conceptual model to help analyze suitable strategic products. Interpretive structural modeling (ISM) is used to determine the interdependence among criteria first, and fuzzy analytic network process (FANP) with and benefits, opportunities, costs and risks is applied next to calculate the priorities of strategic products. The empirical study shows that the conceptual model can effectively and precisely handle such a complicated problem and can lead to an outstanding performance result.

Keywords: Photovoltaic (PV) Solar Cell Industry; Fuzzy Analytic Network Process, FANP; Interpretive Structural Modeling (ISM)

1. Introduction

Photovoltaic (PV) solar cells are semiconductor devices that transfer sunlight directly into electricity by converting the energy of the light to electrons in the atoms of the cell. The converting process is called the PV effect, and it is done without the use of either chemical reactions or moving parts (Milliken et al., 2007). With the policies of many countries in promoting the PV solar cell industry, the industry has grown tremendously, and the global production capacity of silicon solar cell increased from 52MWp in 2000 to 4.60GWp, 6.3GWp, 9.1GWp, and 12.0GWp in 2005, 2006, 2007 and 2008, respectively (Hirschman and Schmela, 2006; Wang, 2008). Even though PV systems can offer cleaner and plentiful energy, the major obstacle they face is that their energy cost is still too high (Hoffmann, 2006). The most commonly used solar cell today is made from crystalline silicon, but the main trend of solar cell industry is toward the PV silicon thin-film solar cell because of its potential reduction of production costs, low material consumption, lower energy consumption and a shorter energy payback time (Duke et al., 2005). The crystalline silicon material and energy consumption for making a PV silicon thin-film solar cell is only 1/10 of that for a traditional solar cell. However, solar radiation conversion efficiency (currently less than 12%), product stability (different absorption rates for lights with different wavelengths), and lifetime (deformation after extensive sun exposure) for PV silicon thin-film solar cells all need to be enhanced (Jager-Waldau, 2004; van Sark et al., 2007; Chen and Lin, 2008). In addition, thin-film technologies also face a wide range of problems from the lack of knowledge of basic material properties, the availability issues of production technologies to the legal concerns about patent infringements and the possible market perspectives. Compared with Japan, US or Europe, Taiwan government has an urgent pressure to formulate product strategies because its technologies are still behind those countries and its initial investment costs are very high. However, Taiwan has a great potential since its production capacity in semiconductor, flat panel display (FPD), and conventional PV solar cell industries, which are highly related to this emergent market, all have large shares in the world's markets. Accordingly, a plan to design product strategy for PV silicone thin-film solar cell power industry in Taiwan is necessary. In addition, firms within a manufacturing network are forced to integrate and collaborate with each other in order to develop new strategies, capacities and capabilities in a global competitive environment (Storey and Emberson, 2006). Thus, in this study, the product strategy will be considered from the perspective of a PV silicone thin-film solar cell power industry.

Product strategy involves decisions about target market, product mix, project prioritization, resource allocation and technology selection. With a tremendous degree of complexity and uncertainty, multiple strategic products are usually selected to increase the possibility of having a few successful projects (Balbontin et al., 2000). In essence, it is a set of strategic decisions to ensure that the right markets and products are pursued (Urban and Hauser, 1993). To facilitate the prosperousness of the PV silicone solar cell power industry, this research develops a conceptual model, using fuzzy analytic network process (FANP) with interpretive structural modeling (ISM) and benefits, opportunities, costs and risks (BOCR), to help analyze suitable strategic products for the thin-film solar cell power manufacturing network.

2. A conceptual model for selecting suitable strategic products

Because of fierce competition and limited resources, most companies today can only focus on a certain part of the production process, such as research and design, components production, assembly production, packing and testing, transportation and distribution, marketing and sales. With the industrial value chain being divided into tiny segments, each company can only concentrate on its specialized field and needs to share its capabilities to solve problems with partners or competitors to obtain the maximum benefits of the production network (Wiendahl and Lutz, 2002). In addition, a major process accompanying the inter-firm activities is the significant knowledge flow that takes place among the firms, and it is regarded as an important engine for innovation (Choi et al., 2008). Firms within the manufacturing network share a particular body of compound core capabilities, complementary assets and capability to learn (Kash and Rycoft, 2000). The core competitiveness of the firms is not just the advantages in capital, capacity and capability (Storey and Emberson, 2006; Heimeriks et al., 2009), but also in innovation and inspiration (Nonaka and Takeuchi, 1995). Accordingly, the product strategy for PV silicone thin-film solar cell power industry should be considered from the perspective of the manufacturing network.

Network resources contain both tangible properties such as financial capitals, core equipments, complementary technologies, and human resources, and intangible properties like patents, trademarks, and brand loyalty. Mutual trust, inter-organizational structure, working processes, and specific control systems are network capabilities. Distinctive competencies are the capabilities to integrate and coordinate network resources to produce superior performances (Barney, 1991; Mahoney and Pandian, 1992; Spear and Bowen, 1999). However, based on distinctive competencies and dynamic environments, a company in the manufacturing network needs to select a set of product strategies to achieve competitive advantages (Hawkins, 2004; Hill and Jones 2007). Distinctive competencies contain two constructs: network resources and network capabilities. Dynamic environments can be analyzed from four constructs: internal strengths and weaknesses, and external opportunities and threats. In order to help select a suitable product strategy, a conceptual model is built up and is as shown in Fig. 1.

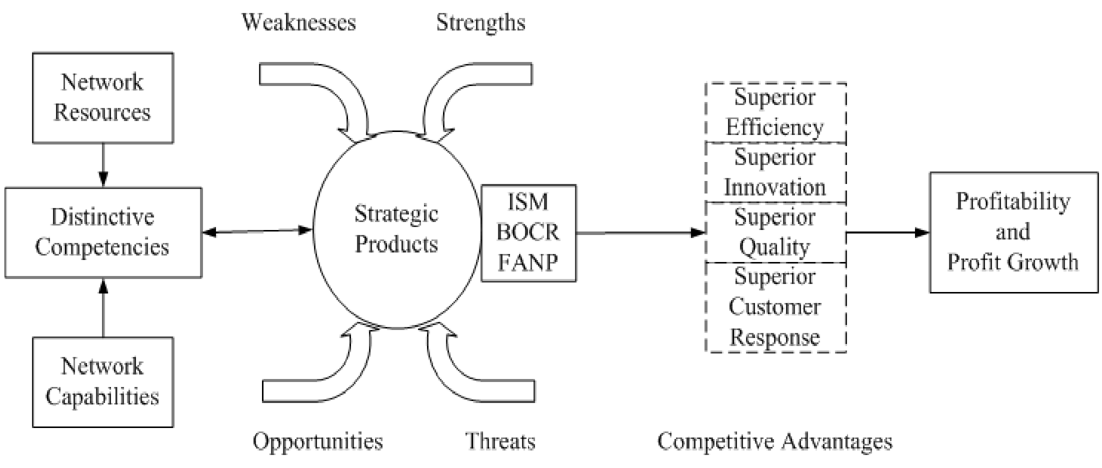

Fig. 1. Strategic products leading to competitive advantages.

3. A FANP model with ISM and BOCR for evaluating strategic products

A systematic FANP model incorporated with ISM and BOCR is proposed to help analyze the suitable strategic products from the perspectives of a large firm in a PV silicone solar cell power manufacturing network. The model is comprised of five phrases, as shown in Fig. 2, and the respective steps are described here.

Phase I: Construction of a PV silicone solar cell product strategy evaluation network.

Step 1. Form a committee of experts in the PV silicone solar cell industry and define the problem for selecting suitable strategic products.

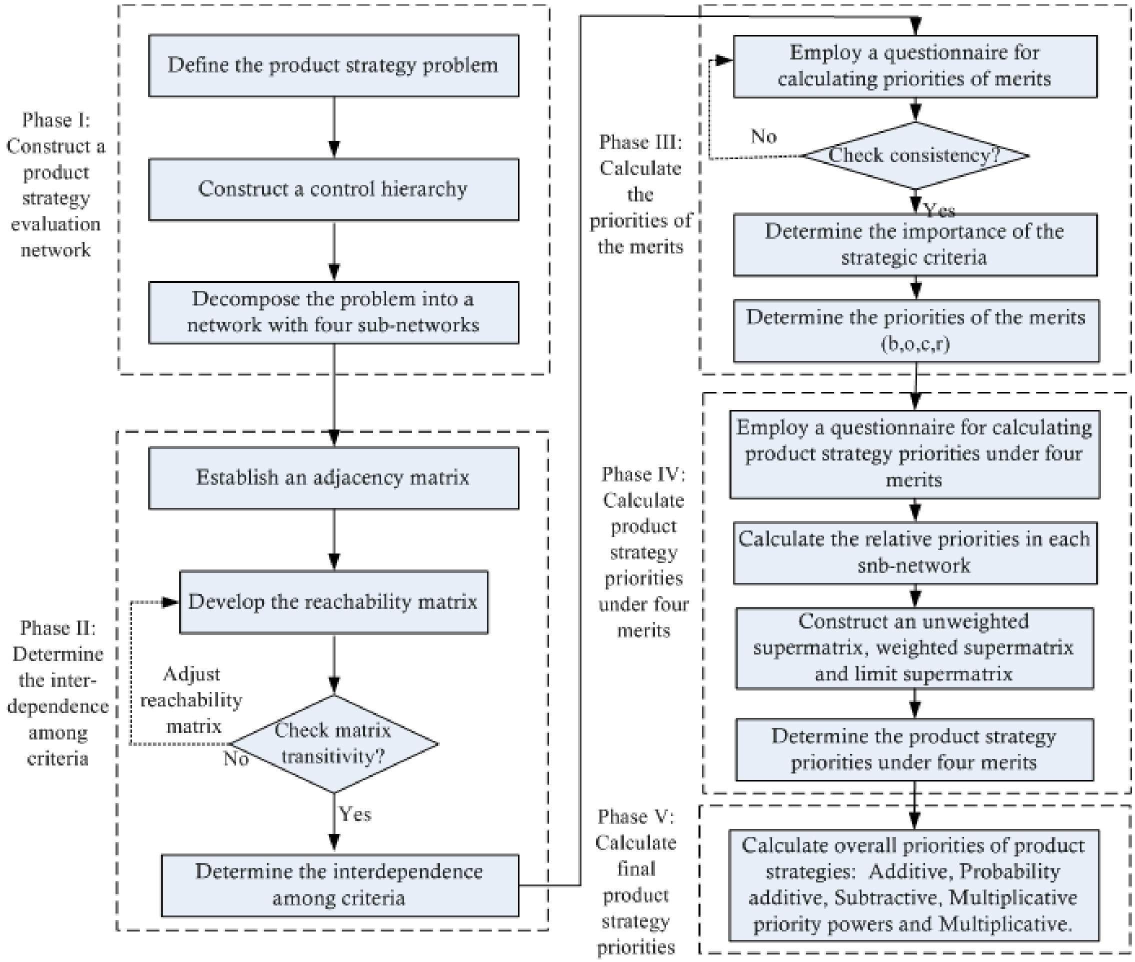

Fig. 2. Flowchart of the proposed model.

Step 2. Construct a control hierarchy for the strategic product evaluation problem.

Step 3. Decompose the strategic product evaluation problem into a network with four sub-networks.

Phase II: Determination of the interdependence among criteria.

Step 4. Establish an adjacency matrix which shows the contextual relationship among the criteria under each merit. In Phase II, ISM is adopted to determine the interdependence among the criteria. The adjacency matrix $\mathbf{D}_m$ is presented as follows:

$$
\mathbf{D}_m = \begin{array}{c} \\ x_1^m \\ x_2^m \\ \vdots \\ x_n^m \end{array} \begin{array}{c} \begin{array}{cccc} x_1^m & x_2^m & \cdots & x_n^m \end{array} \\ \begin{bmatrix} 0 & \pi_{12}^m & \cdots & \pi_{1n}^m \\ \pi_{21}^m & 0 & \cdots & \pi_{2n}^m \\ \vdots & \vdots & 0 & \vdots \\ \pi_{n1}^m & \pi_{n2}^m & \cdots & 0 \end{bmatrix} \end{array} \tag{1}
$$

Step 5. Develop the reachability matrix and check for transitivity. The initial reachability matrix $\mathbf{H}_m$ is calculated by adding $\mathbf{D}_m$ from step 4 with the unit matrix I:

$$
\mathbf{H}_m = \mathbf{D}_m + \mathrm{I} \tag{2}
$$

The final reachability matrix $\mathbf{H}_m^*$ is under the operators of the Boolean multiplication and addition (i.e., 1×0=0×1=0, 1+0=0+1=1), and a convergence can be met:

$$
\mathbf{H}_m^* = \mathbf{H}_m^b = \mathbf{H}_m^{b+1}, \quad \mathrm{b} > 1 \tag{3}
$$

Step 6. Determine the interdependence among criteria under each merit. Based on $\mathbf{H}_m^*$, the interdependence among criteria under merit *m* can be depicted.

Phase III: Calculation of priorities of the merits.

Step 7. Employ a questionnaire to collect experts' opinions on the importance of strategic criteria and the importance of merits to strategic criteria.

Step 8. Determine the priorities of the strategic criteria.

Step 9. Determine the importance of each merit to each strategic criterion.

Step 10. Determine the priorities of the merits.

Phase IV: Calculation of product strategy priorities under the four merits.

Step 11. Employ a questionnaire to collect experts' opinions on the importance of criteria, the interdependence among criteria and the expected performance of product strategies.

Step 12. Calculate the relative priorities in each sub-network.

Step 13. Form an unweighted supermatrix for each merit sub-network. Based on the procedure of ANP proposed by Saaty (1996), the priorities obtained from Step 12 are used to form an unweighted supermatrix for merit *m*:

$$
\mathbf{M}_m = \begin{array}{r} \\ \text{Merit } m \\ \text{Criteria} \\ \text{Product strategies} \end{array} \begin{array}{c} \begin{array}{ccc} \text{Merit } m & \text{Criteria} & \text{Product strategies} \end{array} \\ \begin{bmatrix} 0 & 0 & 0 \\ w_{CM} & \mathbf{W}_{\mathbf{CC}} & 0 \\ 0 & \mathbf{W}_{\mathbf{PC}} & \mathbf{I} \end{bmatrix} \end{array} \tag{4}
$$

Step 14. Calculate weighted supermatrix for each merit sub-network.

Step 15. Calculate the limit supermatrix and obtain the priorities of product strategies under each merit sub-network.

Phase V: Calculation of final priorities of the product strategies.

Step 16. Calculate overall priorities of the product strategies by synthesizing priorities of each product strategy under each merit from Step 15 with the corresponding normalized weights b, o, c and r from Step 10. There are five ways to combine the scores of each product strategy under B, O, C and R (Saaty, 2003).

Additive:

$$P_i = bB_i + oO_i + c(1/C_i)_{\text{Normalized}} + r(1/R_i)_{\text{Normalized}} \quad (5)$$

where B_i, O_i, C_i and R_i represent the synthesized results of product strategy *i* under merit *B*, *O*, *C* and *R*, respectively, and *b*, *o*, *c* and *r* are normalized weights of merit B, O, C and R, respectively.

Probabilistic additive

$$P_i = bB_i + oO_i + c(1 - C_i) + r(1 - R_i) \quad (6)$$

Subtractive

$$P_i = bB_i + oO_i - cC_i - rR_i \quad (7)$$

Multiplicative priority powers

$$P_i = B_i^b \, O_i^o \, [(1/C_i)_{\text{Normalized}}]^c \, [(1/R_i)_{\text{Normalized}}]^r \quad (8)$$

Multiplicative

$$P_i = B_i O_i / C_i R_i \quad (9)$$

4. A practical investigation for strategic products in industry

In order to examine the practicality of the proposed conceptual model, the PV silicon thin-film solar cell power industry in Taiwan is used as an example. The purpose of the control hierarchy in Fig. 3 is to calculate the priorities, b, o, c and r, of the four merits. The BOCR network has the same goal as the control hierarchy does, and the purpose of this network is to calculate the priorities of the product strategies. A set of questionnaire is completed by the experts to generate the priorities of the four merits and to collect experts' opinions on the importance of criteria, the interdependence among criteria and the expected performance of product strategies.

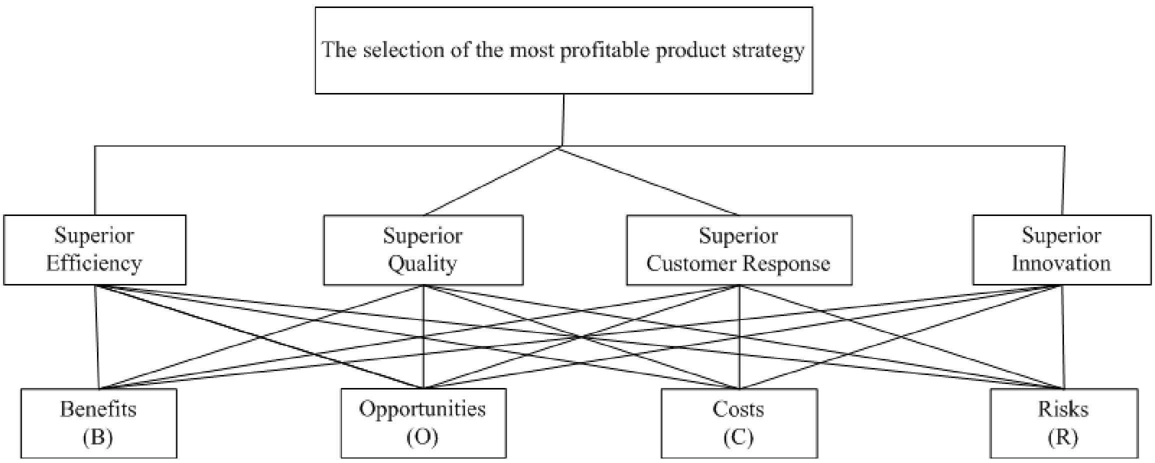

Fig. 3. Control hierarchy.

The BOCR network, as shown in Fig. 4, has the same goal as the control hierarchy does, and the purpose of this network is to calculate the priorities of the product strategies. A set of questionnaire is completed by the experts to generate the priorities of the four merits and to collect experts' opinions on the importance of criteria, the interdependence among criteria and the expected performance of product strategies.

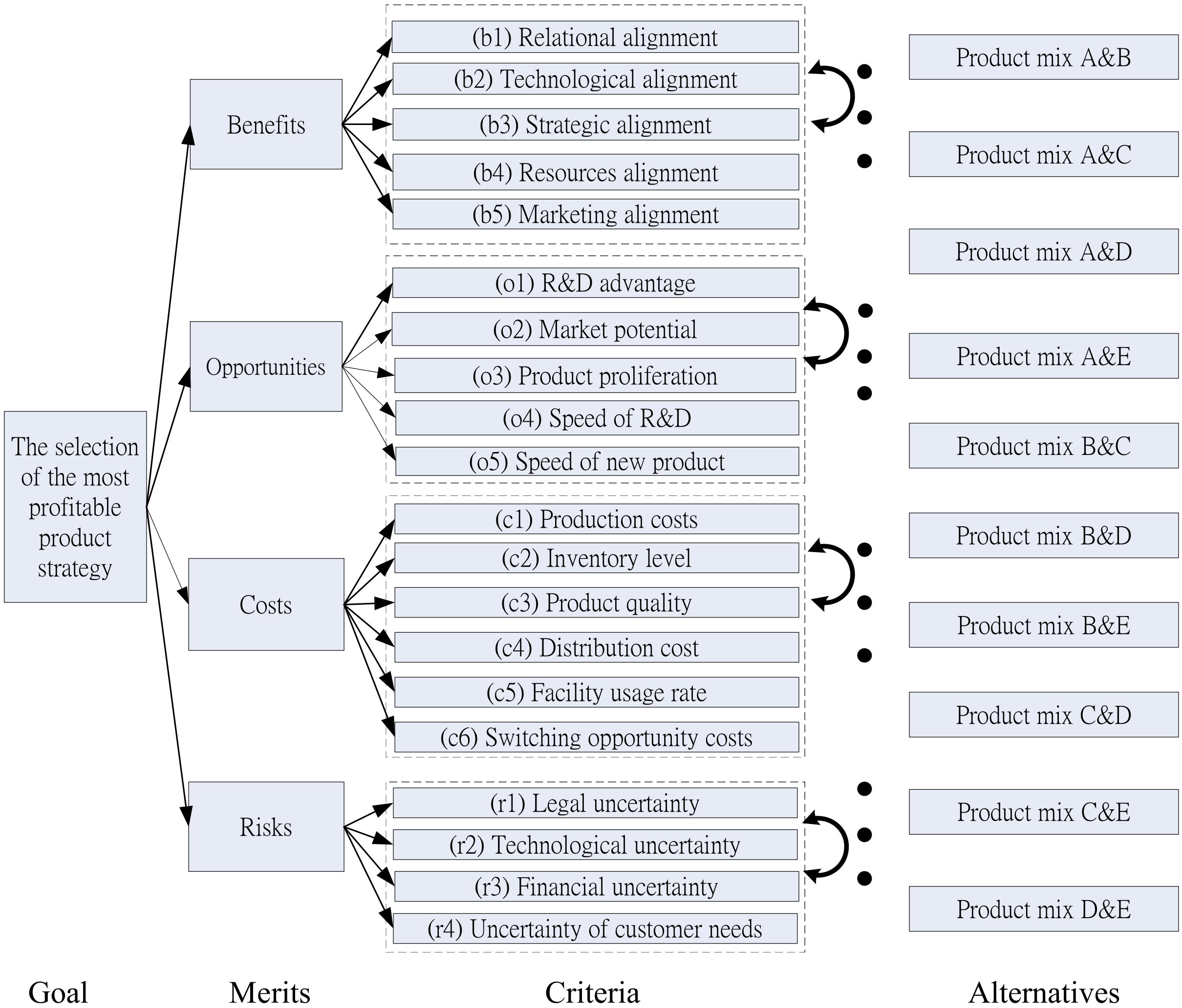

Fig. 4. The BOCR network.

The final ranking of the product mixes is calculated by the five methods, additive, probabilistic additive, subtractive, multiplicative priority powers and multiplicative, to aggregate the scores of each alternative under B, O, C and R. The results are as shown in Table 1.

5. Conclusion

From empirical demonstration, the conceptual model with a fuzzy analytic network process (FANP), interpretive structural modeling (ISM) and benefits, opportunities, costs and risks (BOCR) can effectively and precisely handle the complicated product strategy problem and lead to an outstanding result. From the practical view of the manufacturing industry, the outcome of strategic products analysis is the instrument for receiving supports from central authorities. In addition, official policy planners not only represent central authorities to show their points of views, but also utilize the model to design their development plan.

Table 1.
Final priorities of product mixes.

	Additive	Rank	Probabilistic additive	Rank	Subtractive	Rank	Multiplicative priority powers	Rank	Multiplicative	Rank
Product mix A&B	0.06790	10	0.40310	10	-0.02268	10	0.06088	10	0.19173	10
Product mix A&C	0.15243	1	0.47840	2	0.05262	2	0.14792	1	6.33361	2
Product mix A&D	0.08101	8	0.42753	8	0.00175	8	0.08034	8	0.55411	8
Product mix A&E	0.08547	7	0.43221	7	0.00643	7	0.08508	7	0.70843	7
Product mix B&C	0.11847	3	0.45934	3	0.03356	3	0.11505	3	2.67341	3
Product mix B&D	0.14899	2	0.47972	1	0.05395	1	0.14689	2	7.51181	1
Product mix B&E	0.07536	9	0.42028	9	-0.00549	9	0.07453	9	0.41997	9
Product mix C&D	0.09095	4	0.43749	4	0.01171	4	0.08992	4	0.83128	4
Product mix C&E	0.09123	5	0.43361	6	0.00784	6	0.08763	5	0.78551	5
Product mix D&E	0.08818	6	0.43454	5	0.00876	5	0.08744	6	0.72570	6

References

Alsema, E., 1998. Energy requirements of thin-film solar cell modules: a review. Renewable & Sustainable Energy Reviews 2, 387-415.

Applied Materials, (2008b). Thin films solar cells. http://www.appliedmaterials.com/products/thin_films_solar_cells_5.html

Balbontin, A., Yazdani, B.B., Cooper, R., Souder, W.E., 2000. New product development practices in American and British firms. Technovation 20, 257-274.

Barney, J.B., 1991. Company resources and sustainable competitive advantage. Journal of Management 17, 99-120.

Benner, M. J., Tushman, M. L., 2003. Exploitation, exploration, and process management: The productivity dilemma revisited. Academy Management Review 28, 238-256.

Cavallaro, F., 2010. A comparative assessment of thin-film photovoltaic production processes using the ELECTRE III method. Energy Policy 38, 463-474.

Chao, R.O., Kavadias, T.S., 2008. A theoretical framework for managing the new product development portfolio: when and how to use strategic buckets. Management Science 54(5), 907-921.

Chen, H.W., Lin, S.G., 2008. Contemporary development of renewable energy. Sci-Tech Policy Review 5(3), 1-28.

Chen, S.M., 1996. Evaluating weapon systems using fuzzy arithmetic operation. Fuzzy Sets and Systems 77, 265-276.

Chen, S.E., 2008. Strategic analysis of PV glass. A Special Report of Photonics Industry & Technology Development Association 75, 44-48.

Choi, B., Poon, S.K., Davis, J.G., 2008. Effects of knowledge management strategy on organizational performance. Omega 36, 235-251.

Compaan, A.D., 2006. Photocoltaics: clean power for the 21st century. Solar Energy Materials & Solar Cells 90, 2170-2180.

Dulmin, R., Mininno, V., 2003. Supplier selection using a multi-criteria decision aid method. Journal of Purchasing and Supply Management 9, 177-187.

Duke, R., Williams, R., Payne, A., 2005. Accelerating residential PV expansion: demand for competitive electricity markets, Energy Policy 33, 1912-1929.

ExternE, 2000. External costs of energy conversion-improvement of the ExternE methodology and assessment of energy-related transport externalities. Environmental External Costs of Transport, Springer, Heidelberg, 2001.

Fthenakis, V., Mason, J.E., Zweibel, K., 2009. The technical, geographical, and economic feasibility for solar energy to supply the energy of the US. Energy Policy 37, 387-399.

Gibson, C. B., Birkinshaw, J., 2004. The antecedents, consequences, and mediating role of organizational ambidexterity. Academy Management Journal 47, 209-226.

Hawkins, L., 2004. US auto makers get better grades for productivity. Wall Street Journal 11, 3-15.

Heimeriks, K.H., Klijn, E., Reuer, J.J., 2009. Building capabilities for alliance portfolio. Long Range Planning 42, 96-114.

Hill, C.W.L., Jones, G.R., 2007. Strategic management: an integrated approach, Houghton Mifflin, USA.

Hirschman, W.P., Schmela, M., 2006. Silicon shortage: market survey on cell and module production 2005. Photon International, March 100-125.

Hoffmann, W., 2006. PV solar electricity industry: market growth and perspective. Solar Energy Materials & Solar Cells 90, 3285-3311.

Hustad, T.P., 1996. Reviewing current practices in innovation management and a summary of selected best practices. In: The PDMA Handbook of New Product Development. Wiley and Sons, New York, pp. 489-511.

Jager-Waldau, A., 2004. Status of thin-film solar cell in research, production and the market. Solar Energy 77, 667-678.

Kash, D.E., Rycoft, R.W., 2000. Patterns of innovating complex technologies: A framework for adaptive network strategies. Research Policy 29, 819-831.

Krishnan, V., Gupta, S., 2001. Appropriateness and impact of platform-based product development. Management Science 47(1), 52-68.

Lee, L., Lee, H., 2003. Exploration and exploitation in the presence of network externalities. Management Science 49, 553-570.

Lee, J.H., Ryu Y.U., 2002. Exploration and adaptive rationality: the neo-Schumpeterian perspective. Simulation Model and Practical Theory 10, 297-320.

Loch, C.H., Kavadias, S., 2002. Dynamic portfolio selection of NPD programs using marginal returns. Management Science 48(10), 1227-1241.

Mahoney, J.T., Pandian, J.R., 1992. The resources-based view within the conversation of strategic management. Strategic Management Journal 13, 363-280.

Milliken, J., Joseck, F., Wang, M., Yuzugullu, E., 2007. The advanced Energy Initiative. Journal of Power Sources, 172, 121-131.

MOEA, 2008. The analysis and investment opportunities in photovoltaic industry. Department of Investment Services, Ministry of Economic Affaires (MOEA), www.dois.moea.gov.tw.

Muffatto, M., Roveda M., 2000. Developing product platform: analysis of the development process. Technovation 20(11), 617-630.

National Coordinating Committee on Climate Change, 2005. Measures for operation and management of clean development mechanism projects in China.

Repmann, T., Sehrbrock, B., Zahren, C., Seikmann, H., 2006. Microcrystalline silicone thin-film solar modules on glass. Solar Energy Materials & Solar Cells 90, 3047-3053.

Saaty, R.W., 2003. Decision Making in Complex Environments: The Analytic Hierarchy Process (AHP) for Decision Making and the Analytic Network Process (ANP) for Decision Making with Dependence and Feedback, Super Decisions, Pittsburgh.

Saaty, T.L., 1996. Decision Making with Dependence and Feedback: The Analytic Network Process, RWS Publications, Pittsburgh.

Shum, K.L., Watanabe, C., 2009. An innovation management approach for renewable energy deployment – the case of solar photovoltaic (PV) technology. Energy Policy 37, 3535-3544.

Spear, S., Bowen, H.K., 1999. Decoding the DNA of the Toyota production system. Harvard Business Review (September-October), 96-108.

Storey, J., Emberson, C., 2006. Supply chain management: theory, practice and future challenges, International Journal of Operation and Production Management 26(7), 754-774.

Talluri, S., Narasimhan, R., 2004. A methodology for strategic sourcing. European Journal of Operational Research 154, 236–250.

Urban, G., Hauser, J., 1993. Design and Marketing of New Products, Prentice Hall, Englewood Cliffs, NJ.

Van Sark, W.G.J.H., Brandsen, G.W., Fleuster, M., Hekkert, M.P., 2007. Analysis of the silicon market: will thin-film profit? Energy Policy 35, 3121-3125.

Wang, W.A., 2008. Analysis of production plan for silicone solar cell industry. A Special Report from Photonics Industry & Technology Development Association 75, 28-32.

Wiendahl, H.P., Lutz, S., 2002. Production networks. CIRP Annals –Manufacturing Technology 10, 1-14.

Yang, J.J., Chiu, H.N., Tzeng, G.-H., Yeh, R.H., 2008. Vendor selection by integrated fuzzy MCDM techniques with independent and interdependent relationships. Information Sciences 178(21), 4166–4183.

Zhang, P., Yang, Y., Shi, J., 2009. Opportunities and challenges for renewable energy policy in China. Renewable and Sustainable Energy Reviews 13, 439-449.

Zhang Z.X., 2007. China is moving away the pattern of "develop first and then treat the pollution". Energy Policy 35, 3547-3549.

成果報告自評

已完成論文 "A model to analyze strategic products for photovoltaic silicon thin-film solar cell power industry", 並被接受於: Renewable and Sustainable Energy Reviews (SCI期刊, IF 4.842)。

無研發成果推廣資料

98 年度專題研究計畫研究成果彙整表

計畫主持人：李欣怡			計畫編號：98-2221-E-216-004-				
計畫名稱：台灣太陽能產業之產品策略							
成果項目			量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）
			實際已達成數（被接受或已發表）	預期總達成數(含實際已達成數)	本計畫實際貢獻百分比		
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力（本國籍）	碩士生	0	0	100%	人次	
		博士生	1	1	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	1	1	100%	篇	已完成論文 A model to analyze strategic products for photovoltaic silicon thin-film solar cell power industry, 並被接受：Renewable and Sustainable Energy Reviews(SCI 期刊, IF 4.842)。
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力	碩士生	0	0	100%	人次	

	（外國籍）	博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)		無					

	成果項目	量化	名稱或內容性質簡述
科教處計畫加填項目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與（閱聽）人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

■達成目標

□未達成目標（請說明，以 100 字為限）

□實驗失敗

□因故實驗中斷

□其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文：■已發表 □未發表之文稿 □撰寫中 □無

專利：□已獲得 □申請中 ■無

技轉：□已技轉 □洽談中 ■無

其他：（以 100 字為限）

已完成論文,並被接受:Renewable and Sustainable Energy Reviews(SCI 期刊, IF 4.842)。

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

綠色環保意識日益高漲，太陽能產業成為台灣政府重點發展產業之一。本計畫以台灣太陽能電池為研究目標，且運用科學且客觀之方法來探討產品策略與管理面所發展之趨勢，以提供太陽能產業絕佳之競爭優勢。本計畫以模糊理論(Fuzzy Theory)、詮釋結構模式分析(ISM)與模糊網路分析(FANP)等方法來進行產品策略之評估，而為使產品更具競爭優勢，本計畫加入利益、成本、機會和風險(BOCR)等為重要考量構面，並整合出一套完整且創新之評估架構。在學術研究成果亦得到國際間之認同，已發表一篇 SCI 級期刊論文(篇名: A model to analyze strategic products for photovoltaic silicon thin-film solar cell power industry,期刊名: Renewable and Sustainable Energy Reviews)。在社會影響上，本研究計畫以具有實務經驗之專家來進行深入訪談與評估，除了學術理論基礎外，亦更貼近產業實務面，可適時提供台灣太陽能產業未來於國際間發展之重點策略為何，提供政府與企業相關之建議，使台灣太陽能於全球市場上大放異彩，同時於國際間更能顯示本國於全球產業之競爭地位。