The Key Factors of New Car Models Development

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Abstract. Car industry is high technical, high connected, and high integrated. Meanwhile, developing new products has dominant competitive advantage. Therefore, the main purpose of the study is to explore the key factors of new car models development, and analyzed by DEMATEL and DANP. Results indicate that the key criteria are: customer needs, market analysis, marketing strategy, strategic planning of new product, technical capability of new product, new product design, and scheduling control. In addition, for the performance, customer needs, market analysis, and strategic planning of new product are the key factors which need to be improved immediately.

Introduction

Car industry is a locomotive industry with high technology, close connection and close integration. It can drive not only automotive and relevant parts industries’ annual production value (Fig. 1), but relevant raw material industries, such as steel, plastic, rubber, coating, glasses. Thus, car industry has been contributing a lot to Taiwan’s economy, tax income (high commodity tax) and job market.

![Figure 1. Value of Production and Proportion in Total Taiwan Manufacturing Industry - Taiwan Automotive. Manufacturers and Relevant Parts Industry from 2004 to 2012. (Excluding Production Value of Automotive Electronics). Source: [13]](image)

Yet, the number of sold cars in Taiwan’s automotive market has shrunk considerably due to slow growth of Taiwan’s economy and external influences, such as Asian financial crisis in 1998 and financial crisis of 2008 [7, 13]. Then, Taiwan joined World Trade Organization (WTO) in 2002 with the condition that the tariffs of import vehicles must be lowered yearly, which has worsened the condition for Taiwan’s automotive manufacturers. The effect of cutting vehicle tariffs yearly was that the domestic-made vehicle sale proportion dropped from 85% in 1998 to 73% in 2012. [13]. Under the circumstances of declined number of sale and increased import vehicle competitiveness, how to develop new car products with competitiveness and market popularity has become the most important task for product planning specialists in every Taiwan automotive manufacturer. When developing new car modes, Taiwan’s manufacturers generally adopt conservative measures such as their rules of thumb, follow the leading brands or mimic international successful cases, which often fails. Moreover, past relevant researches on key factors
of developing new products were mainly about electronics industry [2, 9], gas apparatus industry [1] and so on. There were little about new car product development, which is the main motive of this research to further explore the key factors that influences development of new car models.

In sum, the purposes of this research are: 1. To construct the evaluation framework for developing new car models by literature review and Delphi method; 2. To take DEMATEL as the based Analytic Network Process (DNAP) to discuss the key factors influencing development of new car models and to build their cause-effect interrelation; 3. The car industry can take the research results as reference when developing new car models.

**Literature Review**

**Definition of New Product**

This research has defined new products as: brand new car models, substantially or partly modified car models and products which can be strengthened as external and internal environment changed. The definition was provided based on past researches [6, 10, 14] and considering the features of car industry.

**Development Factor of New Product**

This research has organized relevant aspects and criteria in the past researches as shown in Table 1 and made it as the foundation to build evaluation framework.

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [18]     |        | 1. Market Demand; 2. Product Positioning; 3. Product Design; 4. Manufacturing; 5. Technical Support; 6. Financial Analysis; 7. Marketing |

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [5]      |        | 1. Process of High Quality New Product Development; 2. New Product Strategies; 3. Sufficient Human and Financial Resources; 4. R&D Fund for New Products; 5. Project Team for High Quality New Product; 6. Commitment from High-Rank Management; 7. Innovative Atmosphere and Culture; 8. Having a Cross-Functional Project Team; 9. High-Rank Management Responsible for The Result of New Product Development |

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [11]     | 1. Organization and Market | 1. Quality of Human Resources; 2. Market Potential of Product; 3. Capability for a New Product Introducing to the Market; 4. Return on Investment |
|          | 2. Manufacturing Capability | 5. Survival Chance of Products; 6. Integration Ability for Manufacturing Resources; 7. Competitors and Manufacturing Experience |
|          | 3. Technology | 8. Technology Uniqueness of Products; 9. Competitive Advantage of Products; 10. Accumulation of Technologies |

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [17]     | 1. Internal Factors of a Company | 1. In Accordance with Company’s Capability; 2. Patent Protection; 3. An Attitude with Proactive Approach and Reaction to New Product before Competition; 4. Supporting Growth and Innovation; 5. Organization; 6. Financial Demand (Earning Power) |
|          | 2. External Factors of a Company | 7. Market Scale; 8. Customer Needs; 9. Distribution and Sales Chain; 10. Competitors’ Movements; 11. Regulations |

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [4]      |        | 1. Product Strategies; 2. Sufficient Resources; 3. Capability for Developing Preliminary Actions; 4. Capability for Developing Actions; 5. Marketing Capability; 6. Development Procedures of New Products; 7. With Market Knowledge; 8. High Management’s Support; 9. Characteristics of Innovation Team; 10. Team |

| Research | Aspect | Criterion |
|----------|--------|-----------|
| [9]      | 1. Development Factors | 1. Technology Capability; 2. Development Risk; 3. Usability of Resources; 4. Development Scheduling |
|          | 2. Financial Factors | 5. Development Costs; 6. Manufacturing Costs; 7. Profit & Loss Balance; 8. Return on Investment |
|          | 3. Internal and External Factors | 9. Supports from High Management; 10. Manufacturing Capability; 11. Meeting Company’s Goals and Strategies; 12. Change of the Environment; 13. Contribution to Society Development |
Table 1. Aspects and Criteria Influencing New Product Development (Cont.).

| Researcher | Aspect | Criterion |
|------------|--------|-----------|
| [3]        | 1. Market and Finance | 1. Return on Investment; 2. Manufacturing Costs; 3. Procurement Costs; 4. Sales Growth; 5. Ratio of New Product Launch |
|            | 2. R&D Process and Design | 6. Duration of Project; 7. Mastering New Technologies and Specifications; 8. Strategy Positioning; 9. Complexity of Product Design; 10. Idea Sources from External; 11. DFM Information |
|            | 3. Internal Development of Company | 12. Abilities of R&D Department; 13. Comparing New Main Product with of the Industry; 14. Cooperation of Fundamental Research; 15. Training for Every Employee; 16. Integration of Cross-Department |
|            | 4. New Product Development | 17. Design Quality; 18. Launching New Product; 19. Improving & Refining Products; 20. Developing Unique Product |
|            | 5. Environment-Friendly Actions | 21. Using Low-Polluting and Green Material; 22. Reusable and Pollution-Free Recycled Material; 23. Whether the Use of Product Could Reduce Energy Consumption |
| [1]        | 1. Project Team for Developing New Product | 1. Coherent with Company’s Strategy; 2. Knowledge Sufficiency of New Product Field; 3. Sufficiency of Human Resource for New Product; 4. Ability of the Project Leader; 5. Support from High Management |
|            | 2. Marketing | 6. Market Acceptability; 7. Competitive Advantage in the Market; 8. Market Growability |
|            | 3. Technology of Development | 9. Mastering the Technology; 10. Risk Level of R&D; 11. Sufficiency of R&D Resources; 12. Reliability of Production System |
|            | 4. Commercialization of Product | 13. Level of Achievement of New Product Launch on Time; 14. Return on Investment in New Product; 15. Development Cost of New Product; 16. Commercializability of New Product; 17. Level of Mastering Patent of New Product; 18. Level of Product Differentiation; 19. Sufficiency of Product Support and Technical Support |

Framework, Methodology, and Research Design

Framework

This research developed a preliminary framework (Table 3) including 5 aspects and 19 criteria from the researches of [1, 2, 3, 4, 5, 8, 9, 11, 17, 18]. Then, Delphi method was employed and 6 experts (Table 4) were interviewed to get the first evaluation framework covering 5 aspects and 16 criteria (Table 5). During analyzing, the Consensus Deviation Index (CDI) was employed to test the experts’ consensus, and the threshold was set to 0.1. If any criterion’s CDI value was over 0.1, then another run of expert interview would be carried out for that criterion until all criteria’s CDIs were less than 0.1. In the 1st interview, there were 7 CDIs over 0.1 and, in the 2nd, there were 2. In the 3rd interview, all were under 0.1, which reached convergent expert validity. In order to have the criteria with certain importance, it was necessary to set a threshold to eliminate the less important criteria. After discussion with experts, it was decided that the average value 75 would be the threshold. 16 criteria therein were greater than 75, so all were kept, and the evaluation framework was the same as the one after first interview.
Table 2. Preliminary Framework.

| Aspect | Criteria |
|--------|----------|
| Market | Customer Needs, Market Analysis, Marketing Strategies |
| Product | New Product Strategies, New Product Design, New Product Planning, Level of Mastering Patent of New Product |
| Finance | Financial Analysis and Management, Return on Investment of New Product, Development Cost of New Product |
| Organization | Support from High Management, High-Quality Cross-Functional Project Team, Communication among Organizations, Influences from Society, Environment and Government Regulations |
| R&D | Technical Capability of New Product, Integration of Manufacturing Resources, Sufficiency of R&D Resources, Development Process of New Product, Scheduling Control |

Table 3. Introduction of Experts.

| Expert | Age | Education | Professional Experience |
|--------|-----|-----------|-------------------------|
| A      | 48  | Bachelor  | Working 22 years in car manufacturer, and including 10 years as CPPS. |
| B      | 45  | Bachelor  | Working 21 years in automotive manufacturer, and including 8 years as CPPS. |
| C      | 51  | Bachelor  | Working 22 years in automotive manufacturer, and including 7 years as CPPS. |
| D      | 45  | Bachelor  | Working 18 years in automotive manufacturer, and including 8 years as CPPS. |
| E      | 37  | Master    | Working 8 years in automotive manufacturer, and including 8 years as CPPS. |
| F      | 37  | Master    | Working 8 years in automotive manufacturer, and including 6 years as CPPS. |

Note: CPPS = Car Product Planning Specialist

Table 4. Assessment Framework after Interview / Final Framework.

| Aspect | Criterion |
|--------|-----------|
| Market | Customer Needs, Market Analysis, Marketing Strategies, Influences from Society, Environment and Government Regulations |
| Product | New Product Strategy Planning, Level of Mastering Patent of New Product |
| Finance | Financial Analysis and Management, Return on Investment of New Product |
| Organization | Cross-Functional Project Team, Communication among Organizations |
| R&D | Technical Capability of New Product, New Product Design, Integration of Manufacturing Resources, Sufficiency of R&D Resources, Development Process of New Product, Scheduling Control |

Analytic Network Process (ANP) vs. Decision Making Trial and Evaluation Laboratory (DEMATEL)

In 1996, Saaty learned that the items for evaluating and criteria aren’t independent of each other, so Analytic Network Process (ANP) was proposed. This process allows more complex interdependence among hierarchies and elements to happen. Networks are used for displaying the dependences and feedbacks instead of hierarchies. Four major steps are involved in ANP [12, 16]: (1) To construct the model and problem; (2) To get the matrix from pairwise comparison and the priority vector; (3) To form the supermatrix; (4) To determine the critical elements.

DEMATEL was first used for studying perplexing global issues, such as races, hunger, environment protection and energy, by Geneva Research Centre of Battelle Institute in 1973. This method effectively combines expert knowledge to learn the causality among variables and to convert causalities among criteria into a clear structural model, to process a series of criteria’s internal interdependency and the interdependent degrees and relation among various criteria. Causalities and degree of influence are computed by scrutinizing pairwise influence between criteria and using matrix and some mathematical theories. DEMATEL causal diagram is found to be effective to display the causal relation of a complex problem. The computing process of DEMATEL is: (1) Defining elements and their relation; (2) Producing direct-relation matrix; (3) Computing normalized direct-influence matrix $X$; (4) Calculating total-influence matrix $T$; (5) Setting for obtaining threshold values of NRM; (6) Drawing the causal diagram.

Research Scope and Object

The scope of this research is focused on new compact and substantially-modified compacts of small van products. Meanwhile, the objects are the 10 experts who have been working over 5 years in K company.
**Result and Analysis**

**Key Aspect**

The objects of this research are 10 experts who have been working as new car product planning specialists over 5 years in K company. The procedures and results are: 1. Building direct-relation matrix (Z) (Table 5); 2. Building normalized direct-relation matrix (X) (Table 6); 3. Building total influence-relation matrix (Table 7); 4. Calculating degree of importance and degree of cause (Table 8); 5. Normalizing total influence-relation matrix to generate weighted supermatrix (Table 9); 6. Generating limit supermatrix to get the weight and the ranking (Table 10).

### Table 5. Direct-Relation Matrix (Aspect) (Z).

| Aspect | Market (A) | Product (B) | Finance (C) | Organization (D) | R&D (E) |
|--------|------------|-------------|-------------|------------------|--------|
| A      | 0.0000     | 4.0000      | 2.3000      | 1.6000           | 3.2000 |
| B      | 3.4000     | 0.0000      | 3.1000      | 1.9000           | 3.4000 |
| C      | 2.2000     | 2.9000      | 0.0000      | 2.4000           | 3.1000 |
| D      | 1.6000     | 2.2000      | 2.1000      | 0.0000           | 2.8000 |
| E      | 2.7000     | 3.8000      | 2.9000      | 2.8000           | 0.0000 |

### Table 6. Normalized Direct-Relation Matrix (Aspect) (X).

| Aspect | Market (A) | Product (B) | Finance (C) | Organization (D) | R&D (E) |
|--------|------------|-------------|-------------|------------------|--------|
| A      | 0.0000     | 0.3101      | 0.1783      | 0.1240           | 0.2481 |
| B      | 0.2636     | 0.0000      | 0.2403      | 0.1473           | 0.2636 |
| C      | 0.1705     | 0.2248      | 0.0000      | 0.1860           | 0.2403 |
| D      | 0.1240     | 0.1705      | 0.1628      | 0.0000           | 0.2171 |
| E      | 0.2093     | 0.2946      | 0.2248      | 0.2171           | 0.0000 |

### Table 7. Total Influence-Relation Matrix (Aspect).

| Aspect | Market (A) | Product (B) | Finance (C) | Organization (D) | R&D (E) | d   |
|--------|------------|-------------|-------------|------------------|--------|-----|
| A      | 0.9873     | 1.4472      | 1.1678      | 0.9735           | 1.3663 | 5.9421 |
| B      | 1.2346     | 1.2593      | 1.2590      | 1.0280           | 1.4255 | 6.1982 |
| C      | 1.0754     | 1.3226      | 0.9600      | 0.9745           | 1.2979 | 5.6303 |
| D      | 0.8960     | 1.1070      | 0.9507      | 0.6919           | 1.1097 | 4.7554 |
| E      | 1.2159     | 1.5060      | 1.2598      | 1.0929           | 1.2385 | 6.3132 |
| r      | 5.0492     | 6.6421      | 5.5891      | 4.7608           | 6.4379 |

### Table 8. Degree of Importance and Cause (Aspect).

| Aspect      | d     | r     | d+r   | Ranking of d+r | d-r   |
|-------------|-------|-------|-------|----------------|-------|
| Market (A)  | 5.9421| 5.0492| 11.3514| 2              | 0.5329|
| Product (B) | 6.1982| 6.6421| 12.8404| 1              | -0.4439|
| Finance (C) | 5.6303| 5.5891| 11.2194| 4              | 0.0412|
| Organization (D) | 4.7554| 4.7608| 9.5162 | 5              | -0.0055|
| R&D (E)     | 5.9421| 5.0492| 11.3514| 2              | 0.5329|

Note: (d+r) is degree of importance, indicating the relation strength of factors in an issue. Higher values mean greater importance and vice versa. (d-r) is degree of cause. Positive value means the factor tend to be “proactively influencing” and would be classified to “cause”. Negative value indicates the factor tend to “being influenced” and would be classified to “effect”.

### Table 9. Weighted Supermatrix (Aspect).

| Aspect | Market (A) | Product (B) | Finance (C) | Organization (D) | R&D (E) |
|--------|------------|-------------|-------------|------------------|--------|
| A      | 0.1825     | 0.2179      | 0.2089      | 0.2045           | 0.2122 |
| B      | 0.2282     | 0.1896      | 0.2238      | 0.2159           | 0.2214 |
| C      | 0.1988     | 0.1991      | 0.1718      | 0.2047           | 0.2016 |
| D      | 0.1656     | 0.1667      | 0.1701      | 0.1453           | 0.1724 |
| E      | 0.2248     | 0.2267      | 0.2254      | 0.2296           | 0.1924 |
Table 10. Weights and ranking from Limit Supermatrix by DANP (Aspect).

| Aspect     | Market (A) | Product (B) | Finance (C) | Organization (D) | R&D (E) |
|------------|------------|-------------|-------------|------------------|---------|
| Weight     | 0.2054     | 0.2155      | 0.1952      | 0.1649           | 0.2190  |
| Ranking    | 3          | 2           | 4           | 5                | 1       |

DEMATEL generates degree of importance (d+r) while DANP generates weights. Yet, when defining key factors, importance and weights should not be the sole consideration. Accordingly, this research added the sequences (Table 8 and 10) and then remade the ranking of aspects as shown in Table 11.

Table 11. Overall Ranking (Aspects).

| Aspect     | Ranking of DEMATEL (I) | Ranking of DANP (II) | I+II | Overall Ranking |
|------------|-------------------------|----------------------|------|-----------------|
| Market (A) | 2                       | 3                    | 5    | 3★              |
| Product (B)| 1                       | 2                    | 3    | 1★              |
| Finance (C)| 4                       | 4                    | 8    | 4               |
| Organization (D) | 5                  | 5                    | 10   | 5               |
| R&D (E)    | 2                       | 1                    | 3    | 1★              |

At last, through the weights of DEMATEL and DANP, the key aspect selected by this research are: Market (A), Product (B), and R&D (E). Then, they were combined with total influence-relation matrix of aspect (Table 7) to make the key aspect cause-effect diagram as in Fig. 2. Fig. 2 shows that Product (B) and R&D (E) are inter-influencing while Product (B) is one-way influencing the market (A).

Figure 2. Cause & Effect Diagram of Key Aspects.

Key Criterion

The procedures are the same as section 4.1 and the results are shown from Table 13 to Table 19.

Table 13. Direct-Relation Matrix (Criterion) (Z).

|       | A1 | A2 | A3 | A4 | B1 | B2 | C1 | C2 | D1 | D2 | E1 | E2 | E3 | E4 | E5 | E6 |
|-------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| A1    | 0.0| 4.0| 3.9| 2.3| 3.7| 1.8| 2.0| 2.3| 1.7| 2.0| 2.6| 3.4| 1.5| 1.9| 1.6| 2.4|
| A2    | 3.9| 0.0| 3.4| 2.4| 3.4| 2.3| 2.0| 2.1| 1.9| 2.6| 3.2| 1.4| 1.6| 1.6| 2.2|    |
| A3    | 3.3| 3.2| 0.0| 2.6| 3.5| 2.5| 2.2| 2.2| 2.4| 2.1| 2.0| 2.6| 1.2| 1.5| 1.6| 1.9|
| A4    | 2.2| 2.4| 2.8| 0.0| 3.0| 2.6| 1.6| 2.2| 1.8| 1.7| 2.8| 3.0| 1.2| 1.4| 2.0| 2.2|
| B1    | 3.4| 3.0| 3.4| 2.4| 0.0| 2.1| 2.1| 2.2| 1.9| 2.0| 3.0| 3.0| 1.9| 2.1| 2.4| 2.8|
| B2    | 1.2| 1.4| 2.0| 2.1| 2.3| 0.0| 1.8| 1.8| 1.7| 1.3| 2.3| 2.6| 1.6| 1.8| 1.9| 2.2|
| C1    | 1.8| 1.8| 2.1| 1.7| 2.4| 1.8| 0.0| 2.5| 2.0| 1.8| 2.4| 3.0| 2.5| 2.7| 2.1| 1.9|
| C2    | 1.7| 1.7| 1.6| 1.5| 2.2| 2.2| 2.0| 1.7| 0.0| 2.9| 2.4| 2.5| 2.8| 2.3| 2.7|    |
| D1    | 1.7| 1.6| 2.2| 1.5| 1.6| 1.6| 1.6| 1.6| 3.3| 0.0| 2.2| 2.4| 2.8| 2.2| 2.6| 2.6|
| D2    | 1.6| 1.6| 2.2| 1.4| 2.5| 1.6| 1.6| 1.6| 3.3| 0.0| 2.2| 2.4| 2.8| 2.2| 2.6| 2.6|
| E1    | 2.7| 2.2| 2.6| 3.0| 2.7| 2.0| 2.3| 2.2| 2.2| 0.0| 3.5| 2.5| 2.5| 2.9| 2.5|    |
| E2    | 3.3| 2.8| 2.7| 3.2| 2.8| 2.5| 2.5| 2.5| 2.2| 3.2| 0.0| 2.8| 2.6| 2.9| 2.4|    |
| E3    | 1.2| 1.2| 1.5| 2.0| 1.8| 2.2| 2.3| 2.9| 2.9| 2.5| 2.7| 0.0| 2.6| 2.9| 2.7|    |
| E4    | 1.5| 1.3| 1.5| 1.7| 2.4| 2.0| 2.5| 2.4| 2.6| 2.4| 2.8| 3.1| 2.8| 0.0| 3.2| 2.7|
| E5    | 1.3| 1.3| 1.4| 2.0| 2.4| 1.6| 2.2| 2.3| 2.7| 2.8| 2.7| 2.8| 2.6| 2.9| 0.0| 2.8|
| E6    | 2.1| 1.8| 2.4| 1.9| 2.9| 2.2| 1.9| 2.0| 2.8| 2.8| 2.5| 2.4| 2.5| 2.4| 3.0| 0.0|

Note: Customer Needs (A1), Market Analysis (A2), Marketing Strategies (A3), Influences from Society, Environment and Government Regulations (A4), New Product Strategy Planning (B1), Level of Mastering Patent of New Product (B2), Financial Analysis and Management (C1), Return on Investment of New Product (C2), Cross-Functional Project Team (D1), Communication among Organizations (D2), Technical Capability of New Product (E1), New Product Design (E2), Integration of Manufacturing Resources (E3), Sufficiency of R&D Resources (E4), Development Process of New Product (E5), Scheduling Control (E6)
Table 14. Normalized Direct-Relation Matrix (Criterion) (X).

|    | A1  | A2  | A3  | A4  | B1  | B2  | C1  | C2  | D1  | D2  | E1  | E2  | E3  | E4  | E5  | E6  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A1 | 0.00| 0.09| 0.09| 0.05| 0.06| 0.20| 0.04| 0.04| 0.03| 0.04| 0.03| 0.07| 0.03| 0.04| 0.03| 0.05 |
| A2 | 0.09| 0.00| 0.07| 0.05| 0.05| 0.20| 0.04| 0.04| 0.04| 0.04| 0.06| 0.07| 0.03| 0.03| 0.03| 0.05 |
| A3 | 0.07| 0.07| 0.00| 0.06| 0.08| 0.05| 0.05| 0.05| 0.04| 0.04| 0.06| 0.02| 0.03| 0.03| 0.04| 0.06 |
| A4 | 0.05| 0.05| 0.06| 0.00| 0.06| 0.06| 0.03| 0.05| 0.04| 0.03| 0.06| 0.02| 0.03| 0.04| 0.05| 0.06 |
| B1 | 0.07| 0.06| 0.07| 0.05| 0.06| 0.04| 0.04| 0.04| 0.04| 0.06| 0.04| 0.04| 0.04| 0.05| 0.06| 0.06 |

Table 15. Total Influence-Relation Matrix (Criterion).

|    | A1  | A2  | A3  | A4  | B1  | B2  | C1  | C2  | D1  | D2  | E1  | E2  | E3  | E4  | E5  | E6  | E7  |
|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A1 | 0.23| 0.30| 0.32| 0.26| 0.36| 0.25| 0.27| 0.27| 0.26| 0.31| 0.16| 0.05| 0.05| 0.29| 0.25| 0.29 |
| A2 | 0.30| 0.21| 0.31| 0.25| 0.26| 0.26| 0.27| 0.27| 0.25| 0.31| 0.24| 0.25| 0.25| 0.28| 0.25| 0.27 |
| A3 | 0.28| 0.27| 0.22| 0.19| 0.24| 0.25| 0.25| 0.25| 0.26| 0.28| 0.27| 0.28| 0.28| 0.25| 0.28 | 0.29 |
| B1 | 0.30| 0.30| 0.28| 0.27| 0.26| 0.27| 0.28| 0.27| 0.28| 0.26| 0.26| 0.26| 0.28| 0.28| 0.29 | 0.30 |
| B2 | 0.20| 0.19| 0.22| 0.20| 0.21| 0.20| 0.21| 0.21| 0.22| 0.20| 0.20| 0.20| 0.20| 0.21 | 0.22 | 0.23 |
| C1 | 0.23| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25 | 0.25 |
| C2 | 0.24| 0.24| 0.26| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25| 0.25 | 0.25 |
| D1 | 0.23| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| D2 | 0.23| 0.23| 0.23| 0.23| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| E1 | 0.28| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29| 0.29 | 0.29 |
| E2 | 0.31| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32| 0.32 | 0.32 |
| E3 | 0.23| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| E4 | 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| E5 | 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| E6 | 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24| 0.24 | 0.24 |
| r  | 4.01| 4.01| 4.01| 4.01| 4.01| 4.01| 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 | 4.01 |
Table 16. Degree of Importance and Cause (Criterion).

| Criterion | d   | r    | d+r  | Ranking of d+r | d-r  |
|-----------|-----|------|------|----------------|------|
| A1        | 4.5946 | 4.1042 | 8.6988 | 5 | 0.4905 |
| A2        | 4.4665 | 3.9525 | 8.4190 | 8 | 0.5141 |
| A3        | 4.2924 | 4.3415 | 8.6339 | 6 | -0.0491 |
| A4        | 4.0765 | 3.7458 | 7.8223 | 15 | 0.3307 |
| B1        | 4.6427 | 5.0633 | 9.7060 | 2 | -0.4206 |
| B2        | 3.4846 | 4.0042 | 7.4888 | 16 | -0.5195 |
| C1        | 4.0177 | 3.8685 | 7.8862 | 14 | 0.1492 |
| C2        | 4.1140 | 3.9941 | 8.1081 | 11 | 0.1199 |
| D1        | 4.0410 | 4.2254 | 8.2664 | 10 | -0.1844 |
| D2        | 3.9702 | 4.0127 | 7.9829 | 13 | -0.0425 |
| E1        | 4.6240 | 4.7144 | 9.3385 | 3 | -0.0904 |
| E2        | 4.9955 | 5.2001 | 10.1956 | 1 | -0.2046 |
| E3        | 4.0056 | 3.9979 | 8.0035 | 12 | 0.0078 |
| E4        | 4.2833 | 4.0742 | 8.3576 | 9 | 0.2091 |
| E5        | 4.1563 | 4.4075 | 8.5638 | 7 | -0.2512 |
| E6        | 4.3606 | 4.4197 | 8.7803 | 4 | -0.0590 |

Table 17. Weighted Supermatrix (Criterion).

|       | A1   | A2   | A3   | A4   | B1   | B2   | C1   | C2   | D1   | D2   | E1   | E2   | E3   | E4   | E5   | E6   |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0.0   | 0.781 | 0.755 | 0.694 | 0.715 | 0.657 | 0.668 | 0.681 | 0.641 | 0.661 | 0.675 | 0.696 | 0.633 | 0.654 | 0.632 | 0.671 |
| 0.0   | 0.751 | 0.716 | 0.684 | 0.687 | 0.666 | 0.652 | 0.655 | 0.645 | 0.641 | 0.659 | 0.672 | 0.613 | 0.623 | 0.616 | 0.647 |
| 0.0   | 0.701 | 0.716 | 0.684 | 0.687 | 0.666 | 0.652 | 0.655 | 0.645 | 0.641 | 0.659 | 0.672 | 0.613 | 0.623 | 0.616 | 0.647 |
| 0.0   | 0.636 | 0.636 | 0.494 | 0.622 | 0.636 | 0.584 | 0.613 | 0.584 | 0.583 | 0.621 | 0.617 | 0.557 | 0.567 | 0.590 | 0.600 |
| 0.0   | 0.731 | 0.733 | 0.703 | 0.562 | 0.677 | 0.679 | 0.681 | 0.658 | 0.669 | 0.698 | 0.685 | 0.662 | 0.671 | 0.677 | 0.696 |
| 0.0   | 0.500 | 0.522 | 0.545 | 0.520 | 0.421 | 0.524 | 0.521 | 0.509 | 0.493 | 0.528 | 0.529 | 0.510 | 0.519 | 0.517 | 0.530 |
| 0.0   | 0.585 | 0.589 | 0.585 | 0.587 | 0.585 | 0.485 | 0.622 | 0.589 | 0.584 | 0.597 | 0.609 | 0.623 | 0.631 | 0.591 | 0.580 |
| 0.0   | 0.613 | 0.621 | 0.598 | 0.612 | 0.628 | 0.650 | 0.496 | 0.590 | 0.579 | 0.612 | 0.609 | 0.617 | 0.631 | 0.616 | 0.596 |
| 0.0   | 0.579 | 0.566 | 0.575 | 0.580 | 0.607 | 0.601 | 0.581 | 0.489 | 0.647 | 0.599 | 0.591 | 0.644 | 0.614 | 0.624 | 0.622 |
| 0.0   | 0.566 | 0.586 | 0.561 | 0.585 | 0.567 | 0.571 | 0.567 | 0.651 | 0.482 | 0.581 | 0.578 | 0.635 | 0.600 | 0.610 | 0.609 |
| 0.0   | 0.681 | 0.669 | 0.693 | 0.686 | 0.705 | 0.672 | 0.684 | 0.672 | 0.678 | 0.557 | 0.702 | 0.695 | 0.692 | 0.701 | 0.682 |
| 0.0   | 0.758 | 0.739 | 0.755 | 0.739 | 0.754 | 0.743 | 0.739 | 0.730 | 0.722 | 0.749 | 0.602 | 0.753 | 0.741 | 0.744 | 0.721 |
| 0.0   | 0.546 | 0.540 | 0.570 | 0.567 | 0.582 | 0.609 | 0.609 | 0.636 | 0.644 | 0.599 | 0.594 | 0.489 | 0.627 | 0.631 | 0.618 |
| 0.0   | 0.586 | 0.589 | 0.616 | 0.617 | 0.626 | 0.659 | 0.648 | 0.653 | 0.650 | 0.646 | 0.644 | 0.674 | 0.520 | 0.678 | 0.651 |
| 0.0   | 0.571 | 0.569 | 0.616 | 0.602 | 0.590 | 0.627 | 0.627 | 0.643 | 0.656 | 0.626 | 0.617 | 0.649 | 0.659 | 0.505 | 0.641 |
| 0.0   | 0.625 | 0.645 | 0.637 | 0.649 | 0.646 | 0.634 | 0.636 | 0.672 | 0.680 | 0.641 | 0.626 | 0.665 | 0.656 | 0.675 | 0.526 |
Table 18. Weight and ranking from Limit Supermatrix by DANP.

| Criterion | A1   | A2   | A3   | A4   | B1   | B2   | C1   | C2   |
|-----------|------|------|------|------|------|------|------|------|
| Weight    | 0.0675 | 0.0655 | 0.0631 | 0.0598 | 0.0683 | 0.0512 | 0.0590 | 0.0604 |
| Ranking   | 4    | 5    | 7    | 11   | 2    | 16   | 13   | 10   |
| Criterion | D1   | D2   | E1   | E2   | E3   | E4   | E5   | E6   |
| Weight    | 0.0593 | 0.0582 | 0.0679 | 0.0734 | 0.0587 | 0.0628 | 0.0610 | 0.0640 |
| Ranking   | 12   | 15   | 3    | 1    | 14   | 8    | 9    | 6    |

Table 19. Overall Ranking (Criterion).

| Criterion | Ranking of DEMATEL (I) | Ranking of DANP (II) | I+II | Overall Ranking |
|-----------|-------------------------|----------------------|------|-----------------|
| A1        | 5                       | 4                    | 9    | 4★              |
| A2        | 8                       | 5                    | 13   | 6★              |
| A3        | 6                       | 7                    | 13   | 6★              |
| A4        | 15                      | 11                   | 26   | 12              |
| B1        | 2                       | 2                    | 4    | 2★              |
| B2        | 16                      | 16                   | 32   | 16              |
| C1        | 14                      | 13                   | 27   | 14              |
| C2        | 11                      | 10                   | 21   | 10              |
| D1        | 10                      | 12                   | 22   | 11              |
| D2        | 13                      | 15                   | 28   | 15              |
| E1        | 3                       | 3                    | 6    | 3★              |
| E2        | 1                       | 1                    | 2    | 1★              |
| E3        | 12                      | 14                   | 26   | 12              |
| E4        | 9                       | 8                    | 17   | 9               |
| E5        | 7                       | 9                    | 16   | 8               |
| E6        | 4                       | 6                    | 10   | 5★              |

This research selected the key criteria based on the weights by DEMATEL and DANP, which are Customer Needs (A1), Market Analysis (A2), Marketing Strategies (A3), New Product Strategy Planning (B1), Technical Capability of New Product (E1), New Product Design (E2), and Scheduling Control (E6). Then, they were combined with total influence-relation matrix of Criterion (Table 15) to create key criteria cause-effect diagram (Fig. 3). Fig. 3 shows that Technical Capability of New Product (E1) and New Product Design (E2) are inter-influenced, New Product Design (E2) one-way influences Scheduling Control (E6) and Customer Needs (A1), Customer Needs (A1) one-way influences Market Analysis (A2), Marketing Strategies (A3) and New Product Strategy Planning (B1).

Performance Analysis

This research further analyzed the performances of 7 key criteria and invited fore-mentioned 10 experts to score the performances on these key criteria. 0 is for extremely poor, 25 for poor, 50 for mediocre, 75 for good, and 100 for excellent. The average scoring is shown in Table 20. After
discussing with experts, this research decided to take the scoring 80 as the threshold value of satisfaction.

Table 20. Performance of Key Criteria.

| Key Criterion                        | Average Performance | Status                   |
|--------------------------------------|---------------------|--------------------------|
| Scheduling Control (E6)              | 87                  | Keep going               |
| New Product Design (E2)              | 86                  |                          |
| Technical Capability of New Product (E1) | 84                  |                          |
| Marketing Strategies (A3)            | 83                  |                          |
| Customer Needs (A1)                  | 79                  | Require measurable improvement |
| Market Analysis (A2)                 | 75                  |                          |
| New Product Strategy Planning (B1)   | 74                  |                          |

Conclusion and Suggestion

For developing new car models, the result shows that the key aspects are: Market (A), Products (B), and R&D (E), and the key criteria are: New Product Design (E2), Strategy Planning for New Products (B1), Technical Capability of New Products (E1), Customer Needs (A1), Schedule Control (E6), Market Analysis (A2), and Marketing Strategy (A3).

On the other hand, from Fig. 4 (key criteria cause-and-effect diagram) and Table 20 (performance values of K company’s 7 key criteria), we can learn that the R&D aspect (Technical Capability of New Products (E1), New Product Design (E2), and Schedule Control (E6)) is the fundament of developing new car models. Accordingly, if the performance of key factors is to be improved, it would be more efficient to start from Technical Capability of New Products (E1) or New Product Design (E2) due to the fact that Schedule Control (E6) has been the best performed. This research finally decided to start from Technical Capability of New Products (E1) and the ground is to take the techniques for the fundament and the design for use, which means that it would be more effective if it is initiated from the fundamental techniques. This research also proposes the suggestions for improving Technical Capability of New Products (E1): “Keep introducing new technologies and new products” and “Keep strengthening the developing capability and scope of R&D center”. In addition, for the aspect of Market and Product (Market Analysis (A2), Customer Needs (A1), and Strategy Planning for New Products (B1)), the improvement of Customer Needs (A1) can also better Market Analysis (A2) and Strategy Planning for New Products (B1). On this ground, the suggestions of this research for improving Customer Needs (A1) are “Strengthening the cooperation between manufacturing and selling” and “Expanding the frequency and extent of probing customer needs”.

The limit of this research and suggestions for future research is that this research only took K company as the object due to time, manpower and resources. Accordingly, it is suggested that future researches could aim at other automotive brands and do more study on it based on this frame to learn if there are differences in the key factors weights and sequences.

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