Managing supply chains is an essential part to obtain competitive advantages. Especially, activity configuration and activity coordination in the supply chain are critical elements for competitive advantage (Porter 1986). Activity configuration is to determine whether each value activity disperses or concentrates within the supply chain. Activity coordination is to coordinate among the divided value activities within the supply chain through sharing and accumulating information, know-how, and expert knowledge.

Meanwhile, the concept of modularisation is not just sub-assembly at the supplier side but also module development or systemization that suggests the best system with idea and design. Systemization type module means that module makers do not physically assemble some related parts, but develop the lighter, the better, and the more qualified module with less number of parts. For such a systemization-oriented mod-
ularisation, the value activity coordination through sharing the information and knowledge is most needed. Thus, the necessary conditions of advanced modularisation in terms of quality include definite support of IT (Information Technology) as a tool of activity configuration. In the present auto industry, modularisation is used as a tool for value activity configuration among supply chains, while e-SCM (electronic Supply Chain Management) is used as a tool for activity coordination.

Modularisation has 3 different dimensions, which are modularisation in product architecture, modularisation in production, and modularisation in inter-firm systems (Takeishi and Fujimoto 2001). Modularisation in product architecture indicates shifting to integral architecture. Modularisation in production means standardization of component design within an automaker and functional independence/interface simplification. Modularisation in inter-firm systems is to outsource subsystems in larger units to outside suppliers.

In an automobile industry, one vehicle needs around 20,000 of 5,000 kinds parts through various processes like design, production, and assembly. It is impossible for one company to handle all these parts and processes. Thus, automobile assembly companies and part companies are complementing their value activities each other. This fact implies that the automobile is a system product which is integrated with different categories of activities. Configuration in the automobile industry changes cell-based configuration to module-based configuration in value chains. Modularisation comes from classical configuration like deal of complexity (Baldwin and Clark 1997). As current automobiles are more complex than those in the past, the module as a sub-system provides with higher flexibility to designers, manufacturers, and users by dividing complex systems into several pieces. These pieces, which are called modules, play a role of outsourcing assembly functions to the company. Modularisation refers the idea to develop a group of parts with independent units by designating the interface. Module makes complex systems or processes by linking other sub-system based on its own rules.

This study has a purpose to verify the model empirically to explain correlation between modularisation strategies as a tool of configuration. This will develop the process of coordination and configuration to obtain competitive advantage.

Conceptual Framework and Research Setting

Takeishi and Fujimoto (2001) suggested the three facets of modularisation which are modularisation in product architecture, modularisation in production, and modularisation in inter-firm systems. Figure 1 shows the three modularisation types and its trends.

The data on the trends of modularisation were collected from Korean automobile 1st tier suppliers. The survey questionnaires were mailed from June 1, 2002 to August 31, 2002. In order to obtain more responses, a follow-up letters and follow-up calls were delivered to the designated respondents after the initial questionnaire administration. 450 survey questionnaires were sent out to Korean automobile 1st tier suppliers (a survey was administered for each 1st tier supplier of the four major car makers in Korea: Hyundai-Kia, GM-Daewoo, Ssang-Yong, and Renault-Samsung). Among 182 responses, 5 were classified as being inadequate due to incomplete answers or void responses. 177 responses were used for the analysis. The descriptive statistics of the valid 177 samples are shown in Table 2, 3, and 4. Overall, the spread by OEM
customer mirrors production volumes by these manufacturers, and thus eliminates any concerns regarding a bias towards a certain vehicle manufacturer.

Table 1 outlines the number of major customers by supplier. In our view, this is a critical prerequisite in developing in-depth and collaborative relationship with customers, because multi-customer suppliers will always face concerns with loyalty and confidentiality.

Table 2 outlines the products supplied by the companies surveyed. Again, the spread of components is important to avoid any bias towards a certain component cluster, production technology or process (e.g., metal pressing or plastic molding).

**Modularisation Trends in Korea: Compared with Japanese Suppliers**

This study analyzed the overall trends of modularisation-related factors in automobile industries. In order to find out what the modularisation efforts result in detail, comparing with transactions four years ago. This study used questionnaires with 7-point Likert type scales. However, to compare the trends between Korea and Japan, 7-point scales was mathematically changed into 5 point scale by \( Y = (X - 4) / 2 / 3 \). Also, Japanese results are based on the study of Takeishi and Fujimoto (2001). 4 factors for trends of modularisation suggested by Takeishi and Fujimoto (2001) are as follows.

1) Standardization of component design within an Automaker
2) Architectural integrality
3) Functional independence
4) Expansion in sub-Assembly Scope

This study tried to make a comparison with Japanese results of Takeishi and Fujimoto (2001). As a result the biggest changes modularisation characteristics in product architecture over the last four years was a shift to integral architecture not only in Korea but also in Japan. In the trends at the modularisation in production, Japan is at relatively higher level than Korea. However, in the trends at the modularisation in inter-firm systems, Korea showed relatively higher level than Japan. That means Korean suppliers have made more attempts towards modularisation in inter-firm system.

As shown in the above Table 3 and Figure 2, Korea and Japan have similar trends in modularisation in product architecture. However, both countries show big differences in modularisation in production and modularisation in inter-firm system. In detail, Japan has higher level of standardization and functional independence, which are required in modularisation in production, than Korea. But, modularisation in inter-firm system has opposite result. Korea has higher level of expansion in sub-assembly scope, which indicates modularisation in inter-firm system. The following figures explain this situation in a different way.

Today, modularisation provides new challenges for the automobile industry. It becomes a big practical issue, irrelevant of architecture issue of the automobile industry. Particularly, Korean automobile industry, mainly
Hyundai and Kia, is aggressively pushing for modularisation. They are pursuing to reduce costs and increase productivity through module type suppliers such as Hyundai Mobis that focus on developing systemized modules with new materials and function integration. Subsequently, modular design is accelerated in part industries and improved three factors of competitiveness in automobile industries: cost saving, time saving, and quality improve-
ment. Korea automobile company improved the effectiveness of product design and manufacturing.

The following figures explain the trends in detail. According to Figure 4, Korea has higher levels of modularisation in product shifting to integral architecture. Especially, Korea is more likely to need structural coordination with other components such as checking matching and interference, while Japan decreased component steps and costs to assemble the component with the adoption of integrally-molded parts.

Figure 5: Modularisation in Product: Shift to Integral Architecture

- **Note:**
  - 17. Production of the component became more complex (with more function required).
  - 18. Need for functional coordination with other components increased.
  - 19. Need of structural coordination with other components (such as checking matching and interference).
  - 5. Component steps and costs to assemble the component decreased with the adoption of integrally-molded parts.

Figure 6: Modularisation in Production: Standardization of Component Design within an Automaker

- **Note:**
  - 6. Component design was shared by different models of the same automaker.
  - 7. Component design was shared between different variations of the same model.
  - 13. Designs of interfaces (such as contact points) were shared by different models of the same automaker.
  - 14. Designs of interfaces (such as contact points) were shared between different variations of the same model.

Figure 7: Modularisation in Production: Standardization of Component Design Across Different Automakers

- **Note:**
  - 8. Component design was standardized across different automakers.
  - 10. The number of variations within a vehicle model decreased.
According to Figure 7, comparison between Korea and Japan reveals big difference in standardization of component design across different automakers. Korea has higher levels in the number of variations within a vehicle model than in standardized component design across different automakers. However, in the case of Japan, the levels are similar.

FIGURE 8
Modularisation in Production: Functional Independence / Interface Simplification

Note: 1. Size of the component reduced with the same basic structure.
11. The number of interfaces (such as contact points) with other components decreased.
12. Designs of interfaces (such as contact points) with other points were simplified.
15. Designs of interfaces (such as contact points) were standardized across different automakers.
16. Function of the component became more self-contained (independent).

When comparing both countries in terms of functional independence and interface simplification in modularisation in production, Japan has much higher levels than Korea. The reduced size of the component with the same basic structure shows big difference between two countries. In both countries, function of the component became more self-contained (independent) to a similar degree.

Comparison between current and earlier models reveals opposite results between both countries. Korea has used standardization of component design by component sharing between current and earlier models. But, Japan has rarely did.

In figure 10, Korea has expanded sub-assembly scope in modularisation in inter-firm system. In detail, unlike Japan, Korea has increased the number of parts making up the component, increased the number of assembly process steps for the component, and incorporated component into another assembly component.

FIGURE 10
Modularisation in Inter-firm System: Expansion in Sub-assembly Scope

Note: 2. The number of parts making up the component increased.
3. The number of assembly process steps for the component increased.
4. Component has been incorporated into another assembly component.

Conclusion

Through questionnaire survey empirically comparing the case of Korea and that of Japan, this study found out that Korean and Japanese automobile industry showed differences in modularisation development path. Korean product architecture is shifting to outsourcing sub-system with the strong cooperative inter-firm system, while Japanese prod-
uct architecture is shifting to insourcing sub-system. Typically, mega suppliers such as Hyundai Mobis produce module systems, along with an efforts to develop them and OEMs purchase the module systems. Meanwhile, Japanese 1st tier suppliers develop and provide the customized parts to OEM and Japanese OEMs purchase the parts from them and assemble complete car as a whole. Thus, while Japan is focusing on organizational integral architecture and modular product architecture of parts, Korea is focusing on modular organizational architecture based on supply chain and integral product architecture of module developed by mega module supplier.

REFERENCES


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[한국어 요약(Korean Abstract)]

본 연구는 경쟁우위 창출을 위해 가치사슬 내 활동배치의 도구인 모듈화 전략(modularisation)을 후지모토(Fujimoto)의 연구모형을 기반으로 한국과 일본의 완성차업체의 사례를 통해 비교·분석하였다. 한국의 완성차업체는 모듈형 공급사를 발전시키면서 외부 부품업체에게 서브 시스템을 아웃 소싱하는 방식으로 부품업체 간 시스템에 바탕을 둔 모듈화를 진행하고 있다. 그 결과 현대 모비스와 같은 전형적인 대형부품업체를 발전시켜 나가고 있다. 한편, 일본 자동차업체의 모듈화 추세는 표준화된 제품을 완성차업체가 주도적으로 내부화하고 서브 시스템화하는 형태로 진행되고 있다.

한국과 일본이 추구하는 모듈화 전략은 상이한데, 그 공통점과 차이점을 정리하면 다음과 같다.첫째, 부품 간 구조적/물리적 상호연결성이 점차 중요해짐에 따라 모듈화는 한국과 일본 완성차업체에서 공히 추구되고 있다.둘째, 일본은 지속적인 부품 최적화 설계를 위해 기업 내 혹은 부품업체 간 부품설계에 있어 표준화를 추구하는 반면, 한국은 과거에 설계한 부품을 지속 사용하고 있어 부품설계의 표준화 추구율이 일본보다 낮은 것으로 나타났다.셋째, 부품 및 모듈의 크기에 있어서, 일본은 부품의 기본구성이 유지하면서 크기를 줄이고 있으며 차체 마운팅 설계도 단순화된 것으로 나타난 반면 한국은 모듈 크기에 큰 변동이 없으며 마운팅 설계에도 큰 변화가 없는 것으로 나타났다.마지막으로, 서브 어셈블리(sub-assembly), 즉 단위 장치·모듈 조립에 있어서 한국이 일본보다 해당 부품을 구성하는 부품 수가 많고 다른 부품의 하위 조립에 들어가는 부품화 비율이 높은 것으로 나타났다. 연구 결과를 종합해 보면, 한국의 자동차산업은 공급사슬 아키텍처에 기반하여 서브 시스템을 아웃소싱하는 기업 간 시스템에서의 모듈화를 취하고 있는 반면, 일본의 자동차산업은 완성차업체 내에서 조립의 최적화를 위한 부품설계와 인터페이스의 표준화를 통한 생산의 모듈화를 추구하고 있다.

결론적으로, 한국의 모듈화는 서브 어셈블리 시스템을 통합함으로써 원가절감과 조립시간 단축, 공정 내 불량률을 낮춰 품질 향상에 기여하고 있다. 하지만, 기존 부품의 공용화보다는 부품 간 인터페이스를 최적화하고 경량화할 수 있는 혁신 부품을 개발해야 하는 과제를 두고 있다. 이러한 부품의 최적화를 통해 부품업체 간 모듈화문제를 해결할 수 있는 원성차업체 내에서의 공정한 인터페이스까지 최적화를 이룰 때 한국 완성차업체 만의 생산의 모듈화는 성숙의 단계로 진화할 것이 다.