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Surprising disadvantage of uncoupled design in staying competitive in the global market

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Abstract

Axiomatic design recommends uncoupled designs with independent functional requirements (FR) and minimum information in the design parameters (DP). When realized, such uncoupled designs should have advantages in production and business. When faced with trouble, namely, poorly configured parts are easy to identify, and later modifications are easy to implement. Conventional Japanese manufacturers, in contrast, have been producing heavily integrated products with intertwined FR and DP relations. Some, e.g., metallurgy and automobile industries, carry the coupled trend and continue to do so, whereas others, e.g., information device and home appliance steered their uncoupled product towards simplification and compatibility. When viewed from a pure design standpoint, uncoupled designs should be superb. The uncoupled design, however, turned out not so advantageous from the business perspective. Surprisingly, such uncoupled products are easy to copy. Some Japanese companies learned this shocking lesson against axiomatic design after they lost their businesses to new competitors in manufacturing.

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1. Skepticism about axiomatic design in Japan

Up until the Lehman Shock in 2008, such corporations like Sony or Canon were popular among engineering graduates. In the years that followed, companies in Canon group have well recovered, however, Sony is still in the red figures. Why is it that by now, Canon has succeeded and Sony has failed? Is there a significant difference in the engineers' skills in creating new design for developing new products?

The main difference is whether their main product design is uncoupled or coupled. The contrast is not due to engineering skills. Sony's main products of home electronics like LCD TV sets or IT devices like laptop computers have parts that are functionally independent and allow easy modular development and exchange as shown in Fig. 1(a). On the other hand, Canon has a main product line of office printers. This product has parts that have mutual chemical interference among exposure, image development, and image fixing as shown in Fig. 1(b). Exchanging, for example, the toner to cheap third party compatible part would influence the printed color. In other words, product development which takes in-house design of the whole printer as one module, thus, has long development phase and heavy cost. Countries that later entered the game hesitated in charging into this field.

Uncoupled design is easier to use, control, and service as Suh insisted [1] [3], but at the same time, easier to imitate. Coupled design, in contrast, is hard to manage, however, also hard to replicate. Fujimoto, in 2001, acknowledged this fact and claimed that "Integrated coupled design is the strength of Japanese companies" [2] [8] [9] [10]. His view was well accepted in the Japanese business world. He predicted that modular uncoupled design products, like home appliances or IT devices allow easy entrance into the market with new products by exchanging parts with compatible ones, and they will soon be caught up by new-comers in the competition. Japanese factories that produce semi-conductors, liquid crystal display (LCD) TV sets, solar batteries, cellular phone sets, and so on, as he envisioned, disappeared from our homeland.

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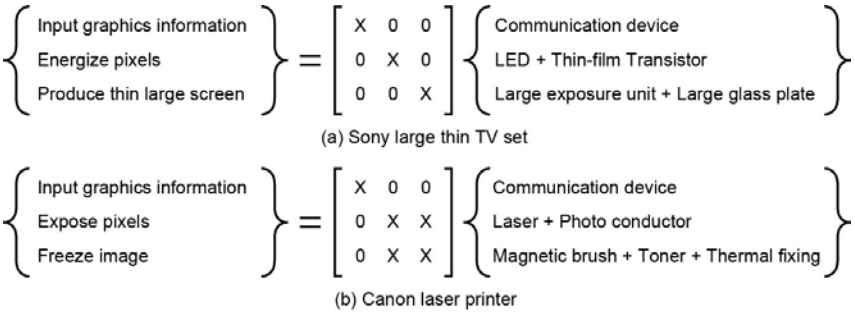

Fig. 1 Sony's product is uncoupled and Canon's is coupled.

Nakao and Hatamura introduced Suh's axiomatic design as translated in Japanese to spread the design methodology in Japan [1] [3]. Fujimoto's view, however, was better accepted in the Japanese industry and throughout our presentations, we always had to face opposing opinions that axiomatic design was misleading.

Fujimoto's idea of "integrated design" is what Toyota applies in its automobile production. For example, the hemi-cylindrical slide bearing for the crank shaft is picked out from a bin so that it has a thickness that matches the gap found by measuring the diameters of the shaft and the connecting rod. Up until year 2000, the piston was assembled into the engine after selecting the right one with a diameter that provided an adequate gap to the measured cylinder diameter. The assembly processes being so, when a bearing or piston breaks, the entire engine module has to be replaced. In Europe and the US, parts are controlled with dimensional tolerance and "on-the-spot mating" is a technique that is out of question in building airplanes or firearms. Toyota engineers, however, are against the integration methodology and say that Suh's axiomatic design is ideal (The author has been consulting Toyota about its production engineering for 15 years).

The cynical results, however, is that home appliance and IT device manufacturing have been forced out from Japan, and the Japanese industry is surviving in the material and automobile fields. Axiomatic design still has not gained popularity.

In section 1, this paper discussed the "disadvantage" of uncoupled design in the company or nation level. Of course, in the product or process level, the uncoupled design is better than the coupled one, as the axiomatic design theory proved the advantage of uncoupled design. Next section 2 explained the inevitable trend that the global manufacturing system will spread the technology, sooner or later, not only of uncoupled design but also of coupled one. Moreover, Section 3 discussed an effective business method to delay the spreading trend, explaining it with a design matrix. Lastly, Section 4 shows a new design method, which is familiar to young designers, to re-make the uncoupled design from an original redundant design using principal component analysis. This design method may solve any secret couplings.

2. Natural movement from global manufacturing to local production and consumption

Although intellectual property (IP) is well protected today, the system has loopholes for new technologies to get imitated and spread around the world. For example, in circa-2000, Japanese industries had about 30,000 patents for LCD; Korean 300, Taiwanese several. Japanese, however, reduced the share from 80% in 1997 to 13% in 2006. During the decade, Japanese industries could not make any large investments for next fifth generation of LCD, and most of Japanese IPs were only peripheral or process-related; whereas Korean or Taiwanese could import Japanese manufacturing devices protected by process-related IPs, and the original IPs of the US or Europe were expiring. In results, this trend of imitating was economically rational and we could not stop it. It is like enthalpy that keeps increasing. The IP should be protected by the compound strategy of process, product, asset, or investment. The modular uncoupled LCD had been produced in the new factory easily and rapidly.

Fig. 2 shows the history of Japanese industries, e.g., automobile, about how their overseas business models changed. The historical transition is not unique to Japan nor to its automobile industry. Advanced countries in Europe and the US had experienced similar transitions.

The first stage, shown in Fig. 2(a) was when the industries produced in domestic factories and exported the products. Japan was in this stage before 1985 in the 20th century. The FR was to "make sales in different regions" and the DP was local "sales offices." Because production took place only in Japan, the first column of the design matrix shows interference. The system was heavily constrained with making repair based on Japanese drawings and sales offices transferring their local sales to the headquarters in Japan.

From 1985 to 2010, foreign countries put political pressure on Japan who was forced to build assembly factories in those countries. This was the stage when only key components were manufactured in Japan to be exported. Many parts were, however, procured from various optimum areas overseas and the design matrix was full of interferences as in Fig. 2(b). If a problem arose in one area (e.g., the 2011 flooding in Thailand),