Discussion paper on Nissan's Global Supply Chain Management

Roles of Mother Plants and the Global Production Engineering Center in Japan

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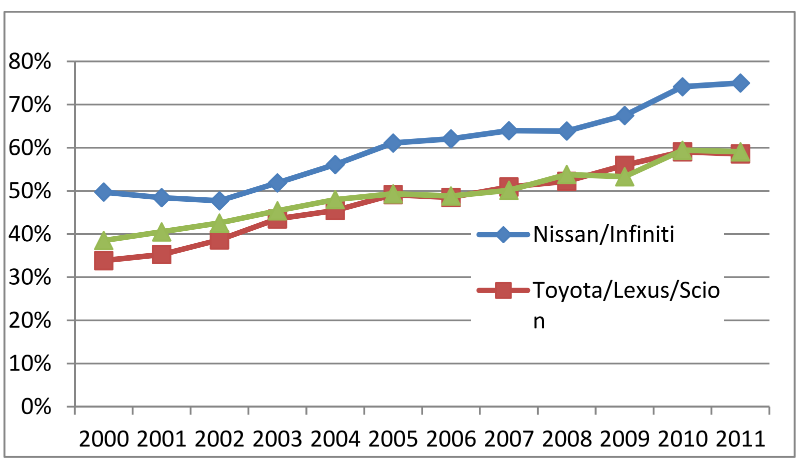
1. Introduction

When I joined Nissan in 1984, the share of its automobile production that was sourced overseas was just 9%. Since then this share has increased dramatically, year by year, and in recent years, it has reached 75% in FY2011 (Figure 1), which is16% higher than the average share of total Japanese automobile production made overseas. As Karl Ulrich, Professor of Operations and Information Management at the Wharton School, indicated, automobile designs are “integral” in the spectrum of product architectures with tightly linked, complex mappings from functional elements to components and where component interfaces are coupled. He insists that the organizational implications that reflect “integral” products require tight coordination of design tasks. Also, the Modularity-Maturity Matrix by Pisano and Shih implies that, regardless of the degree of process maturity, for items with less modularity such as automobiles, the design and manufacturing functions should be integrated. With this in mind, if we simply apply this concept to Nissan’s current global manufacturing footprint (26 automobile manufacturing plants and 25 powertrain plants overseas, and 5 and 2 plants, respectively, in Japan), Nissan should have comparable number of local R&D functions that would allow it to support the recommended integrated approach. Although the number of Nissan global R&D centers has been increasing to support local model developments, centers that can develop global models, new technologies, new platforms and powertrains are still limited to Japan, where about 70% of the global engineers are located. Can we explain Nissan’s high overseas production ratio despite the fact that the design and manufacturing plants are located far away from each other? I hypothesize that there must be a sort of “glue” that allows Nissan to integrate design and manufacturing across geographical distances on a global scale.

Figure 1: Overseas Production Ratios of Japanese Automakers[1]



[1] Source: Japan Automotive Manufacturing Associations, Inc., Financial Announcement of Nissan Motor Co., Ltd., Financial Results of Toyota Motor Corporation.

From an economic and shareholder point of view, Nissan cannot justify its 25% manufacturing footprint in Japan, particularly given the impact of the recent strong yen to dollar. If the value of integrating product design with manufacturing is low then the outsourcing of manufacturing makes sense. In FY2011 Nissan's domestic sales was just 14% of global sales. It is reasonable that their shareholders would have required Nissan to reduce its domestic production levels to 14% of overall production especially given the strong yen. However, amidst speculation that automakers should shift production away from Japan, Carlos Ghosn, CEO of Nissan, has remained committed to building at least 1 million Nissan cars and trucks, annually, in Japan. By the same token, Akio Toyoda, CEO of Toyota Motor Company, repeatedly denied speculation that Toyota would move more production abroad and has vowed to keep production of 3 million vehicles in Japan. Toyota's domestic production share in FY2011 was 41% of total production and their domestic sales share was 17% in CY2011, excluding Daihatsu and Hino. Without strategic value for domestic production beyond retaining domestic employment, it is reasonable to suggest that both Nissan and Toyota do not have to commit to keeping domestic production shares greater than the composition of domestic sales versus global sales. In this paper we will explore the rationale and mechanisms behind this decision from the perspective of Nissan.

The paper consists of five sections. Section 2 explains Nissan's new common module family strategy and discusses its implications in terms of the design architecture. Section 3 describes what Nissan's sourcing decision principles are. Section 4 explains the role of mother plants in Japan by describing Nissan's Oppama plant. Section 5 analyzes the role of Nissan's Global Production Engineering Center as the "glue" that facilitates the matching of design and production in remote regions. Section 6 summarizes the key points and finishes with closing remarks.

2. Nissan's new Common Module Family Strategy and Architecture Type of Design Information

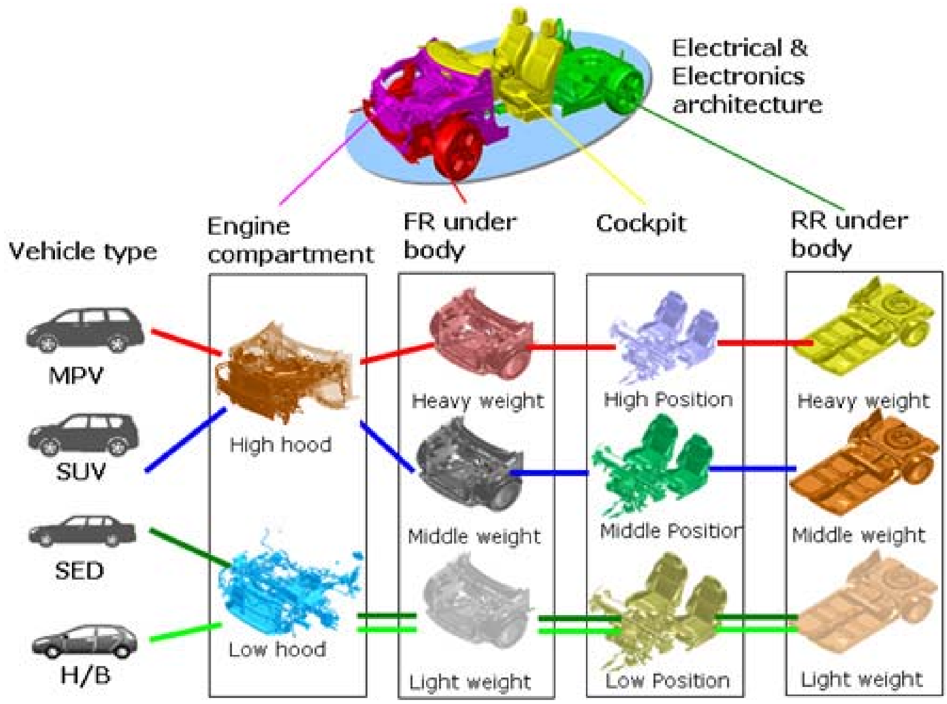
How then can automakers expand their overseas production while keeping design and manufacturing separate? One possible answer is that it is because automobile production is becoming more modular. In fact, several automakers are seriously developing new modular concepts. These include the VW group, Nissan in 2012, and Toyota – which has recently announced its Toyota New Global Architecture program. The motivations behind these modular concepts are clearly to leverage economies of scale by sharing common parts and components across models.

In February 2012, Nissan announced its next-generation vehicle engineering concept, called the Nissan Common Module Family (CMF). Nissan vehicles developed under the CMF strategy entered the marketplace in 2013. Each new vehicle that is developed in this program requires distinctive characteristics, improved fuel economy, passenger safety and IT features, along with rapid application of the latest technologies into the development process. At the same time, volume efficiencies need to be achieved through extensive leverage of common vehicle structures, components and parts. Until now, these contrasting elements have been difficult to balance. To contend with these challenges, Nissan is implementing its next-generation "Nissan CMF" vehicle engineering strategy.

The application of Nissan CMF entails the use of four vehicle modules – the engine compartment, cockpit, front underbody and rear underbody - as well as the architecture for electronic components, with each module having appropriate variations. Vehicles are designed by combining these modules in different ways. Depending on the module configuration, a variety of vehicles - compacts, large-sized vehicles through to tall SUVs - can be designed efficiently. One point to highlight is that Nissan is committed to developing a common architecture for electronic components. They were historically either model specific or company specific and were treated as a black box even within R&D. Between Nissan and Renault, there had been large disparities in terms of this architecture. For example, the control of speed adjustments and compressors of air conditioners; Nissan had been using engine control units, while Renault had been controlling them through different units. Now both companies can adopt a common architecture.

Since interfaces among modules strongly affect safety and vehicle noise, they are the core know-how of automobile companies and are integral to product performance. Although Nissan and Renault are aiming to develop common interfaces among models, model specific interfaces to differentiate from other models remain to avoid less characteristic, montage-like cars. Nissan has been discussing what the optimal balance is between the two types of interfaces with Renault. The automobile is still categorized as being “Closed integral”. CMF, however, looks like a Personal Computer in terms of its design architecture and it has been compared to the modularity of LEGO blocks by the head of Nissan R&D. More accurately, although the architecture is “Closed Integral”, CMF allows Nissan to leverage economies of scale through the extensive use of common parts and components like other modular type products.

Figure 2: Nissan Common Module Family (CMF)



3. Nissan's Sourcing Principles

Nissan's sourcing principles are based on five factors – 1) Ability to assemble and source in/near the market. 2) Adjustability of investments variables; i.e., the smaller the expected volume production, the smaller the investment. 3) Using leading competitive countries (LCC) to minimize variable costs. 4) Maintaining sustainable global Monozukuri[2] mother (JPN 1 M production) 5) Producing the Infiniti at certified plants. The objective of sourcing is to optimize total manufacturing cost and investments. Moreover, Nissan is committed to developing and cultivating sources of advantage for the future through Monozukuri and to enhance the Nissan/Infiniti brand value.

In order to optimize total manufacturing cost and investment, Nissan makes sure that it balances between automation and "manualization". In developing countries where the labor costs are low and competitive, Nissan puts high priority on labor intensive manufacturing and less on automated tools. In contrast, in developed countries where the labor costs are high, Nissan shifts to automated production. In China where the labor costs were originally low but have been increasing in proportion to the country's economic growth, Nissan has shifted from less automated production to more automated ones.

Regarding sustainable global Monozukuri mother plants (JPN 1 M production); Nissan has

[2] For the definition of "Monozukuri", please refer to the web site of Japan Close-Up http://jcu.export-japan.com/index.php?page=monozukuri-making-things

three types of mother plants in Japan. For the Kanto region (Oppama/Yokohama/Zama), by leveraging the proximity to the global R&D center, those factories which include the Automotive Energy Supply Corporation (AESC), battery suppliers for electric vehicles (EV), and engineering centers play the following roles.

- EV Development base
- Global launch and introduction base for new technology and new manufacturing methods
- Preparation for producing new global models and new powertrains.

In light of the modularity-maturity matrix, the process maturity of the above-mentioned products is low; in particular, EVs are based on a completely new technology and are categorized as a Process-Driven Innovation box. Even EV production, with a cumulated knowledge of two-years of production in Japan, was transplanted to the US this February. After being transplanted, however, the domestic manufacturing and engineering, together with key suppliers such AESC, were envisioned to jointly evolve products and therefore gradually move toward a process-embedded innovation box.

Nissan has positioned its Kyushu plant as a total cost competitiveness leader base by taking maximum advantage of LCC parts. One reason Nissan chose Kyushu as its strategic production base was that wages in the region are estimated to be 20% lower than those in the greater Tokyo area. In October 2010, Nissan announced a plan to spin off the Kyushu facility as a separate firm, underscoring its intention to limit the rise in wages at the plant. Another reason for the factory's importance is its proximity to South Korea and China, from which Nissan can easily purchase lower-priced parts. The Kyushu plant plans to eventually raise the share of overseas-sourced parts to 40-50%. An increase in overseas procurement, however, would not directly increase the plant's competitiveness. The factory is working to reinforce its domestic suppliers on the premise that an unchecked increase in the imports of parts would stifle local suppliers, which could then erode the foundations of the Kyushu plant. Nissan hopes that by making the plant's domestic and overseas suppliers compete against each other, product quality will rise and procurement costs will fall.

The Tochigi/Iwaki region of Nissan is in charge of the Global quality leader base (INFINITI Quality), since this factory manufactures the Infiniti models and the GT-R, a high-end sport car. The GT-R requires a high level of body precision through matching activities between the design and manufacturing functions. This is also an example of a Process-Driven Innovation product which do not easily allow production to be transplanted overseas.

4. Nissan Oppama plant and the "Oppama Challenge"

With the exceptions of sustainable global Monozukuri mother (JPN 1 M production) and the Infiniti production at certified plants, most sourcing decisions are made based on economic considerations. Labor costs in Japan are approximately seven times greater than wages in the Leading Competitive Countries (LCCs). In addition, the yen had been, until recently, very strong against the dollar. As a result, the Nissan Oppama plant had been struggling and had lost internal deals to overseas Nissan plants. In the summer of 2006 when the yen was 115 yen to the dollar, the "Oppama Challenge" was announced by the Oppama plant manager. The Oppama plant had historically produced small entry level vehicles such as the March, and –also had played the role of being a cost competitive plant. Due to the high cost structure of Japan's operations and high yen to dollar exchange rate, the plant lost its leadership status to the Nissan Mexico Plant for new vehicle cost and to the Nissan Manufacturing plant in UK for productivity. With this in mind, the "Oppama challenge" was seen as a "strategy for survival" which was needed for the plant to regain production volume of global cars.

The accomplishments of the "Oppama challenge," were to improve the cost competitiveness against LCC countries despite the 115 yen to dollar situation (at that time), to capture the allocation of a new global model, Cube, and to improve the utilization share of the Oppama factory. The Oppama plant brought an additional 7% manufacturing cost reduction through implementing some 454 ideas. This was in addition to normal cost cutting through commercial purchasing and technical VA/VE. The Oppama plant also achieved a 57% improvement in investment recovery rates. For direct labor costs, the plant achieved a 20% product improvement, which meant a 20% labor cost reduction, between FY2006 and FY2010. The success of these initiatives stemmed from three key drivers.

The first key driver of the "Oppama challenge" was the adoption of innovative integrated factory automations (iFA) to achieve the most advanced cost reduction. iFA targets the smooth flow of materials through frugal automation. To do this, it integrates the following:

- Manufacturing Genba (Shop floors) & material handling
- Factory & suppliers
- Genba (Shop floors) & information technology (IT)
- IT & product / production design
- Production engineering & manufacturing
- Processes & shops

Let us illustrate a few examples of iFA. First, lets look at the Trim and Chassis operations. Imagine retrieving a part from parts assembly. Previously this required many unnecessary activities such as selecting parts, walking to get the parts, handling containers etc…. With the new kitting supply system and the development of an automated parts-package transferring equipment system and automated guided vehicles, the flow of material was simplified. The next example is the air cleaner. Previously only two finished air cleaners per box had been delivered to the factory as the size of the complete air cleaners was large. However, if these cleaners were divided into several parts and delivered separately and assembled in the Oppama plant (on-site), the cleaners could be tracked down, cutting significant costs and variation. This required close collaboration between suppliers and the Oppama plant production engineering and manufacturing entities. The factory shop floors required engineers to change the minimum component units to be assembled in the factory. Another example is the cockpit module case which was perfectly adapted to the same process as the air cleaner case. Before the challenge, cockpit modules had been assembled by the first tier supplier at remote sites located some distance from the Oppama plant. The Oppama challenge led to the final assembly of the module parts <u>on a supplier's line in a Nissan plant</u>. In such cases, the suppliers were also motivated by retaining half of the cost reduction benefits generated by this collaboration.

Second, total manufacturing costs became a strong catalyst for change. This included newly developed key metrics for each model and for the parts outsourced from suppliers in particular. Nissan plants used to manage only in-house cost reduction efforts and did not manage the costs of purchased parts, vendor tooling, and the supplier logistics. Since 60% to 70% of parts were sourced by suppliers, this scope change, from just in-house costs to total manufacturing costs including supplier costs, was revolutionary. Recently I had a chance to observe Mitsubishi Motors Corporation, a partner for strategic cooperation with Nissan. We have a joint venture for developing mini cars in Japan. During my visit I found that their plant was managing in-house costs only and that their manufacturing shop floors simply prioritized on the basis of ease of installation without managing the total cost of finished parts. From Nissan's point of view, this is a traditional silo management style that does not capture any systematic integrated activities between engineering and the factory or suppliers. Mitsubishi Motors Corporation asked their suppliers to deliver parts in a more assembled condition to reduce their sub-assembly effort and to improve their productivity at the plant, but this has resulted in a significant increase in delivery cost. In fact this increase in delivery cost outweighed the cost savings derived from productivity improvements on the shop floor. The Mitsubishi plant previously did not see this logistics cost increase from their suppliers, since they did not manage total manufacturing costs at the plant level. Through joint benchmarking activities with Nissan, Mitsubishi discovered these cost saving opportunities and is now trying to introduce the Nissan approach. With the introduction of the total manufacturing cost management as a metric, Nissan has successfully bridged across different functions and suppliers. Since 60% to 70% of parts are assembled by suppliers, just focusing on in-house cost leads to "tunnel vision" which misses the opportunity to cut total manufacturing costs.

Thirdly, the Oppama plant manager took on full responsibility to decide any measures, associated with total manufacturing cost management, and to optimize costs by ensuring dedicated support from the purchasing and design functions. In fact, the representatives from these two functions were committed to the stated objectives of the challenge as it related to total manufacturing cost. The plant manager was fully responsible for total manufacturing cost and also had strong degree of ownership and a sense of urgency to win continuous allocation of new models to the plant, based on better plant utilization and employment. As a result, the manager provided leadership for breaking the barriers between functional silos and was able to help optimize costs based on the premise that many ideas stemmed from the shop floor.

More importantly, the Nissan Oppama plant introduced this cost saving model to other Nissan plants including ones in Russia, Morocco, and India and elsewhere. A core tenet of Nissan's manufacturing global learning is to have open internal bench marks. Although each plant competes against each other to receive new model allocations, all plants can access benchmark data on the web. In other words, each site can easily grasp its own plant position and compete with other regional plants globally. This helps each plant grow autonomously by leveraging the system of monitoring KPIs and sharing best practices. Nissan calls this arrangement "Global Friendly Competition." Through exposure to such internal benchmark data and the widespread knowledge that the Oppama Plant had made great strides in terms of improving KPIs – as well as had good expertise in areas such as iFA, other regional plants came to Oppama to learn the methodology. The Oppama plant willingly held seminars for the trainees. In early 2008, the number of Nissan employees having iFA expertise was 194 abroad and 74 for Japan. Also, in order to raise the basic skills of workers, as a part of its mother plant role, Nissan located their Global Training Centre (GTC) at the Oppama plant. GTC has been working closely with Regional Training Centers and has 20 Global Master Trainers in Japan who also train 200 master trainers by inviting them from all over the world. These master trainers develop local trainers who also develop the local operators. With this structure, overseas plants develop "human resources" autonomously by utilizing Master Trainers. This allows Nissan to train 20 times more quickly than through former direct training. To facilitate this high level of information exchange and global learning among global plants, the Nissan Production Way (NPW), which is the backbone of Nissan's production method developed in 1994, has been instrumental. Unlike other competitors' methods, NPW is successful in that know-how is codified and converted to explicit knowledge from tacit knowledge; thus, know-how is communicable across countries.

5. Roles of Nissan's Global Production Engineering Center (GPEC)

When formulating a concept for vehicle mass production, most automobile companies focus on two key processes; design and engineering trials. GPEC is responsible for engineering the trial and verification process using the same level of equipment that is being used in the mass-production plants (Master machines). Then, GPEC copies the 4M (Man, Machine, Material, and Method) conditions in the plant to ensure high quality mass-production.

Prior to conducting such engineering trial processes, Nissan executes digital processes consisting of three phases; digital design, digital testing, and digital production engineering analysis. Digital processing starts, after determination of product design, planning and styling. By using CAD, GPEC conducts digital design, testing, and trial simulations, sequentially, and completes drawing data. The design department produces drawing data for parts based on standardized know-how that incorporates past experiences. The vehicle test and production engineering departments repeat digital tests and digital trials simultaneously with the design departments in order to guarantee completeness of the data. In addition, they study, in parallel, the production facility including vendor tooling. Finally, the digital phase digitizes all of the equipment, machines, JIGs, and even technicians' operation methods in order to conduct virtual trials. Production engineers check the data, by taking into account the actual plant production environment. These processes guarantee the quality of data that is used by the production preparation department. This digital phase allows design and production engineering departments to install data into the master machines installed at the GPEC facility.

Proceeding to the next physical phase, GPEC makes actual parts and equipment in a short time frame. This physical phase, GPEC has four major roles. The first one is to verify the data itself by using 3D measurement machines to check the quality of actual trial products. The second role is to make intensive trials and verifications of the master machines operated by GPEC which use the same equipment that is used in global mass production plants. These two roles are related to "matching" processes which are indispensable for integral products. Third, with these verifications conducted on the master machines, the process is copied and transferred to the 4M (Man, Machine, Material, and Method) conditions present in each mass production plant in order to assure high quality and efficient production. 4M conditions are transferred by both software and hardware. Software includes facility data, JIG & tooling drawing data, robot teaching data, operations sheets, and quality control sheets, while hardware consists of dies, JIGs & Tools, and Inspection tools. Nissan manages this accumulated insight, not only for mass production, but also for feedback for the digital phase.

Copying and transferring 4M conditions to local plants is not enough to create mass production; this is especially true for those plants that operate in emerging countries. GPEC trains overseas process engineers and shop floors foremen on how to structure Quality Control, to check actual lines and operations, to measure parts accuracy and to analyze incidents. On top of this, based on the maturity of the engineering capabilities at the plants, GPEC sends some Japanese process engineers either for short-term assignments (about 6 -12 months) or through business trips (about 3 months) to support product launch preparations. Since plants in North America, Europe, and China have their own process engineering teams, in most cases, consisting of all local members, they have no Japanese engineers. For some time, Nissan has been conducting launches that are carried out by local staff only as much as possible, by training and exposing this staff at GPEC in order to launch many vehicles globally in a short time.

It is also critical to manage quality improvement activities for suppliers and the purchased parts they provide. Each supplier joins GPEC for trials. The "Joint check activity" provides them with initial feedback before they start the trial. After assessing prototype cars against the Alliance

Vehicle Evaluation Standard (AVES), Nissan's worldwide quality evaluation system ensures that every vehicle meets these same exacting standards, and each supplier confirms the quality status of the vehicles at the GPEC. All countermeasures must be confirmed before the completing of the prototype stage for vehicles. If Nissan's overseas plants in developing countries conduct engineering trials locally, the feedback given to their suppliers would not be at a high enough level which is required to enhance the performance of local suppliers. GPEC provides them with higher level of feedback which allows us to produce better quality vehicles.

The impacts of GPEC are substantial. Market demand in emerging countries has soared and Nissan would have lost such manufacturing opportunities if it had continued to use prior traditional approaches that were adopted when it t launched vehicles firs in Japan and then transplanted methods to the factories in developing countries. When Nissan launched the new March/Micra, it decided to launch the model in Thailand first. It planned to start in Thailand and export to Japan and thereafter move production to India and China. The March/Micra was truly a global model launched in multiple plants within a short six-month period. Since the March/Micra is a part of the entry level car segment for developed countries and volume segments for developing countries, cost competitiveness is crucial. Therefore, starting production in emerging countries was critical. GPEC played a key role by acting as the "glue" between design and trial production in Japan. Afterwards this process has been transferred and copied using 4M conditions to recreate the mass production plant in Thailand. Without GPEC, this production method could not have been adopted globally.

6. Conclusion

Nissan's mid-term plan, the Nissan Power 88, has as a goal 51 new model introductions between FY2012 and 2016. This plan translates into one new model introduction every six weeks, and one project every 10 days (if we define the same model that is manufactured in different countries as an additional project.) As previously indicated, Nissan has already reached a 75% overseas production share, which is the highest among all of the Japanese automakers along with Honda. Without a doubt, GPEC plays a significant role in enabling rapid increases in overseas production as compared to other automobile companies. In the case of Mitsubishi Motors, for example, their overseas production share in FY2011 was 48% and they are now in the process of boosting their production in Thailand. When they launched the new Mirage in 2012, a strategic global small car, they dispatched 60 Japanese engineers and technicians before the launch and increased this number to 110 just after the launch of the product in order to buttress the shop floors of their local plants. This approach is not sustainable if they need to expand their footprint to other countries. In the case of launching the March/Micra in Nissan Thailand, we dispatched fewer than 40 expatriates before the launch and the maximum number was around 45. Also, the number of the Japanese dispatches decreased after the launch to a level of 35 within four months.

Let us return to the modularity-maturity matrix, introduced by Pisano and Shih who argued that design cannot be separated from manufacturing for those products with little modularity and high process maturity such as automobiles, especially when manufactured in emerging countries. GPEC and design closely work together in Japan. In other words, design and trial engineering cannot be separated. This is because the high level matching process between the digital phase and the physical phase which are well integrated as simultaneous engineering in Japan, could be physically separated between trial engineering and mass production by enabling GPEC to copy and transfer data relating to the 4M to mass production. With this in mind, GPEC acts as the "glue" between design and mass production.

The role of regional R&D centers located in major emerging countries, however, should not be underestimated. This is especially true for life cycle management of various models. Nissan has plans to strengthen the regional R&D centers by increasing the head count of local engineers to support development of market-suited products and to collaborate with local production sites. This is because these local sites will be expected to contribute to enhancing product quality by incorporating market feedback into quality improvement with their teams of manufacturing, purchasing, and local engineers. Also, strong regional involvement in product specification is essential to keep products fresh by quickly incorporating local inputs. This can be done by optimizing features through interactions between local product planning and the technical requirements introduced by local R&D.

The digital and physical phases of Nissan illustrate the case for combining the relative strengths of people and digital technologies to achieve good business results. Even the digital phase involves people, design staff, product engineering, testing, and suppliers through the synchronization of product development through digital collaboration. Digital engineering fully integrates design and production engineering through the involvement of suppliers which then hand over the production trial to GPEC. Through digital and physical phases, man and machines can become well-coordinated in the design process.

For those products which have less modularity and low process maturity, such as automobiles equipped with new technologies or new manufacturing methods, design and manufacturing should not be separated. The Japanese plants can play the role of mother plant. For those automobiles with conventional technology, and where the process maturity is high, the role of mother plants is reduced if GPEC and design are well collaborated in Japan. The case of the "Oppama challenge" which created innovation through iFA, indicates that those activities seen as mature processes still have room for innovation through a change process, since process technologies, though mature, are still highly integral to product innovation.

One key point that we should not overlook was that the "Oppama challenge" was a cost challenge for Japan where the labor cost was 7 times higher than those costs in the LCCs. Initially cost challenges in Japan might seem extreme, but in fact true innovation took place due to the

“Oppama Challenge”. Because of the high-yen against the dollar exchange rate, at below 90 yen per dollar which continued for three years after the Lehman Shock from FY 2010 to FY 2012, the mother plant role of cost leaders was handed over to the Nissan Kyushu plant. If Nissan gives up its cost leadership role in Japan for domestic operations, executives, viewing manufacturing mainly as a cost center, wouldn’t have considered manufacturing to be part of the company’s innovation system. Then, the iFA, derived from the Oppama challenge, would not have been transferred to other plants in other regions.

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