6 12 1999

SURVEY - MASTERING STRATEGY Part 11:

Modular strategies in cars and computers By MARI SAKO & Fiona MURRAY

Summary

The focus of many European and American companies is currently on "modular" strategies in product design and production. A modular product has individual elements which are designed independently but function together as a seamless whole. In this article **Mari Sako** and **Fiona Murray** compare the experiences of the computer industry - where modularity was consumer led - with that of the automobile industry where the impetus for adoption has come from cost and complexity reduction. They discuss the strategic choice between integration and modularisation for original equipment manufacturers, note the changing role of suppliers, and conclude by describing recent research which highlights regional differences.

The automobile industry has been the source of major strategic thinking throughout this century. Ford's moving assembly line, for example, first standardised work, while Taiichi Ohno's Toyota Production System and, more recently, lean production techniques were important managerial innovations. The design, manufacture and distribution of the automobile capture the key strategic challenges associated with a complex and technologically sophisticated product with the result that companies in other sectors have sought inspiration and lessons. Now the focus of many European and American manufacturers is on so-called modular strategies in product design and production. This article assesses the success of this new development and its value as a strategic weapon in the search for new sources of competitive advantage in manufacturing industries.

What is a modular strategy?

A modular strategy is a strategy that leverages the advantages of modular product architecture. A modular product is a complex product whose individual elements have each been designed independently and yet function together as a seamless whole. This kind of product has been rapidly adopted in the computer industry where the modules might be thought of as including hard disk drives, operating systems, and microprocessors. By adopting a modular strategy, International Business Machines was able to achieve dramatic reductions in the lead times for designing and manufacturing its System 360. However, the definition and subsequent standardisation of the modules led to the success of Microsoft and Intel, as value was captured not by the architects of a modular strategy but by the modular suppliers. Nevertheless, the distribution of the profits resulting from the adoption of a modular strategy is driven by different industry specific characteristics, as the following contrast between computers and automobiles show (see Figure 1)

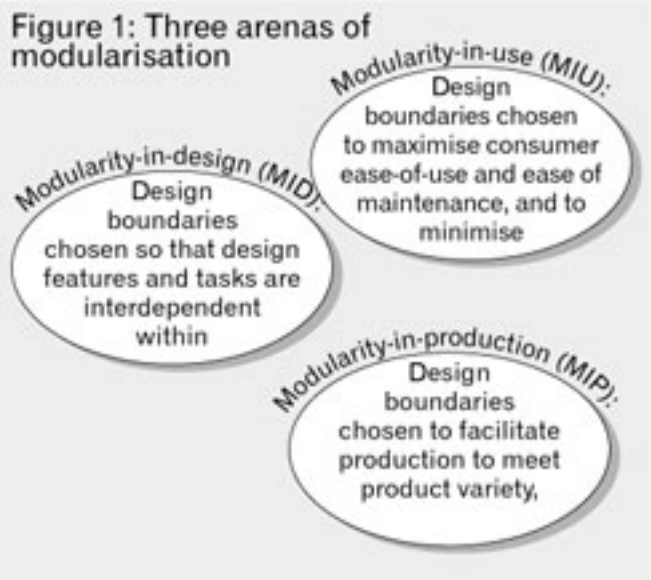

Figure 1

Drivers of modularity:
computers vs. autos

The main impetus towards modular computer products was modularity-in-use: consumers were demanding compatibility, upgradability and retention of elements of their existing computer systems. This starting point led to much investment of time and effort in the creation of global design rules and standardised interfaces between modules. Modular product architecture in turn led to a modular business organisation with independent design teams. In the US at least, the eventual disintegration of the industry into modular suppliers was facilitated by the availability of venture capital for start-ups and the mobility of technical labour between firms.

By contrast in the car industry the impetus to adopt modules was production, rather than demand led. The attraction of modular production systems is that they reduce the complexity, capital assets and cost of assembly. In modular assembly, production tasks are broken down into separable elements that can be carried out independently. The final product is then assembled from these large sub-assemblies. While Italy's Fiat adopted an in-house modular production system in the 1980s in order to increase automation in the face of labour problems, it can also be used as a step towards the outsourcing of production. Outsourcing shifts complexity, assets and cost to suppliers. The next logical step after modularity in production is to design products with modularity in mind. Modular design separates the design task into separable units, which may or may not follow the same elements as the separable production units. These clearly defined product boundaries also present the ultimate manufacturers with considerable opportunities to outsource the design process and reduce the complexity of the design activity (see Figure 2).

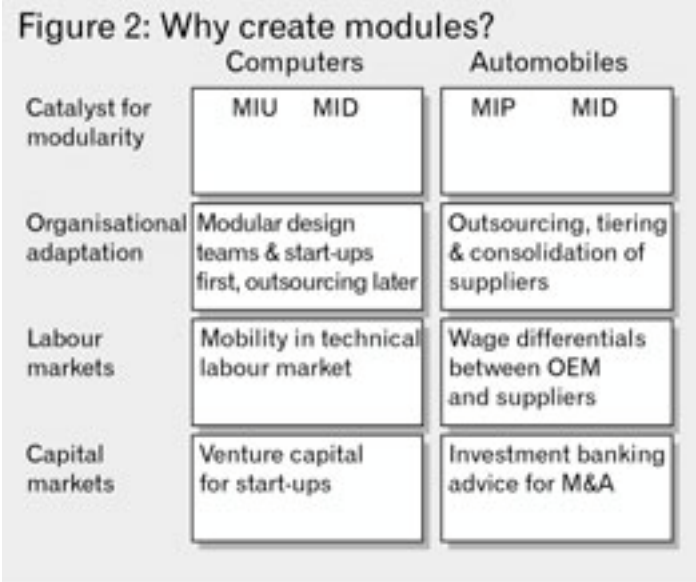

Figure 2

In response to this pressure from vehicle manufacturers, suppliers in the automotive industry are consolidating to create a broader and deeper base of technical knowledge and financial resources. Companies such as Delphi Automotive Systems (formerly General Motors parts division) have expanded their technical capabilities to incorporate fibre optics, multimedia, energy systems, and electronics. Some suppliers are changing their business strategy in order to provide much greater levels of technical expertise than they have done traditionally, so as to become involved in the design of modules. These companies are also increasingly involved in the production of modules and sub-assemblies. Rather than shipping components to the Manufacturer's plant, they are setting up sub-assembly product lines which are off site but typically only a few kilometres away from the final assembly site. In Alabama, for example, Delphi assembles the cockpit for the new Mercedes M class car with a 120 minute window for assembly and delivery onto the final assembly line. Until it reaches the line, the cockpit is still owned by Delphi and it is Delphi which remains responsible for its quality.

In short, there are two quite distinct stages in the shift towards modular products. The first is to separate the product into discrete modules either for design or for production. The second is to consider whether to outsource these activities to suppliers. The separation of the car into distinct production elements is relatively straightforward. Indeed there has been an ongoing process of simplification and separation since Henry Ford first adopted the principle of standardised work on his moving assembly lines :

However, the design process is more difficult to separate because the car is at once a group of physically contiguous sub-assemblies and a series of systems - climate control, safety, electronics and so on. System integration is essential to performance and yet systems may criss-cross physical sub-assemblies to a degree that renders their separate design almost impossible without sacrificing performance.

The contrast with computers is instructive in comparing the strategic outcomes of creating modular products. As noted earlier, the main catalyst for modular computer

products was modularity in use. Design work at IBM strove to meet this goal. IBM found that the electro-mechanical system was susceptible to separation without significant performance reduction (although it is interesting to note that the most high performance computers are not designed with modular hard drives, operating systems, etc.). Modularity in production was not a major driving force in the computer industry, and IBM's conscious decision to outsource the development and the production of the operating system to Microsoft and the chip to Intel for personal computers came much later than its decision to adopt a modular product architecture.

Despite significant differences between the two industries, the IBM experience also raises important lessons in the possible consequences for industry organisation, industry power and profits that can come from the changing shape of product architecture. The value added from computers shifted rapidly from the overall product architect, namely IBM, to the designers and producers of modular system elements such as Intel and Microsoft. Are the same trends likely in the auto industry and in other industries? And what are the strategies that the auto manufacturers and suppliers ought to follow?

Modular strategy and competitive advantage

The strategic choice facing original equipment manufacturers or OEMs is whether to remain integrated or to become modular. Integrators will retain control of the entire design and production processes. They will continue to make a wide range of investments in both capabilities. Close control over the entire design process gives an Integrator the advantage of retaining technological leadership. This will be hard to manage if technologies become standardised and controlled by dominant module suppliers. An Integrator will also control the entire production process and therefore has control and oversight of quality and complexity.

The problems with this strategy are the problems that OEMs typically face as the automobile comes to incorporate a wider range of technologies – overly stretched R&D, problems associated with technical diversity, costly capital investment in new plants and complex production. One step towards alleviating these problems is to retain technical control of R&D and design but to shift to highly modular production processes with a considerable reliance on suppliers. Mercedes seems to fit this model. It conducts substantial R&D in-house while shifting production complexity to large suppliers who produce modules and make investments close to final assembly plants.

Modularisers lie at the other end of the spectrum. They will shift the complexity of production to suppliers and in so doing also follow a path towards modular design that facilitates modular production. They will then increasingly rely on suppliers to provide not only production expertise but also design and technical expertise. Modularising OEMs will lose technical leadership and may risk undermining the source of value added as technical control shifts to the suppliers. OEMs' retention of "shadow engineering" in-house attests to this fear. However, Modularisers can retain value through brand, customer service, product styling and innovative overall product concepts (the Smart car, Mercedes' entry into the small car sector, is a good example here). They can also retain value through global presence, facilitated by the reduced investment that outsourcing enables them to bear. In fact, Modularisers might be

primarily interested in adopting modules as a cost cutting or asset minimising strategy.

To summarise the OEM's strategic choice, sustainable profits come from the control of assets and market position. Competitive advantage may derive from a number of sources, including technological innovation, standard setting, and brand management. But in the shift towards modularisation, the source of control is not yet clear in the global auto industry. It is too early to say whether there has been a decisive shift in the balance of power within the industry.

Where do these strategies leave the suppliers? We often think of company strategies in isolation from the rest of the industry. But in fact, supplier and OEM decisions are inextricably linked. Major European and US suppliers are making active decisions to pursue a modular strategy. This means broadening the range of their technical skills, and making investments in design and system capabilities and R&D, in order to be able to bring a unique range of design concepts to the table well in advance of specific design competitions. For these strategies to pay off, modular suppliers must first target the modularising OEMs. They will be their early customers.

If modular suppliers start to own intellectual property that can shape the industry, they will have greater leverage over the integrators. The reason that IBM was forced to abandon the operating system market was because the supplier of the operating system "module" - Microsoft - owned the industry standard. Only a few suppliers, however, can earn their living by designing modules and setting standards. Whilst a first-tier module supplier which trades directly with OEMs can earn higher profits than lower-tier suppliers, the latter may be component suppliers which have a separate competitive advantage in the shape of its focused R&D and specialist knowledge. Just as an OEM Integrator requires the co-operation of specialist component suppliers to realise its strategy, a modular supplier also relies on strategic alliances with other suppliers that have complementary technical capabilities.

Implementing modular strategies

Modular production has been largely pioneered in greenfield site projects. In the absence of existing constraints from plants, labour contracts, and local suppliers, modular suppliers can be brought together around the production plant as seen in the Smart plant and VW's Resende plant in Brazil. With brownfield sites, existing physical and human assets inevitably limits the extent to which modularity can be used in production. Union opposition to outsourcing is a typical constraint faced by many OEMs.

Even in a greenfield site, however, modular design needs to be organised by engineers and R&D managers from the core organisation. Modular design changes the roles of these individuals, from one of part design and part specification to one of high-level systems integration and module performance specification. Despite recent moves towards integrated product development teams, functional specialisation ('chimneys') still exists in some OEMs. For example the design of a cockpit requires at a minimum technical capabilities in plastic moulding, electronics, audio, and electrical engineering. In the same way that greenfield sites have provided an opportunity to experiment with modular production, so modular design at companies such as BMW

(with the Z3), Mercedes (with its M class and Smart models) has tended to start life as innovative non-core projects.

Organisational history necessarily influences how modular strategies are implemented. These different paths ultimately lead OEMs to retain, develop and discard different capabilities. Take a car manufacturer that has a non-modular product design and whose production is highly vertically integrated. This car company has a choice of three trajectories for moving from the current position to the ultimate position of modular design and outsourced production. The paths are: (1) by designing modules and producing them in-house first before outsourcing them; (2) by outsourcing non-modular components before moving towards modular design; and (3) by simultaneously implementing modular design and outsourcing. Each path leads to a different set of capabilities and performance outcomes for the supply chain.

In the first path, modular design is likely to be adopted only if it brings about significant performance improvements and solutions to problems arising from ergonomics and complexity. By the time modules are outsourced, suppliers would benefit from the solutions found by the car manufacturer. In the second path, outsourcing rather than modularisation is the initial driver, and it is unclear whether the car manufacturer or the suppliers will end up taking a lead in proposing modular design and the integration of components. In the third case, a simultaneous implementation of modular design and out-sourced production may not necessarily lead to the reduction of complexity if the task of dealing with complexity is merely passed on from the car manufacturer to the supplier.

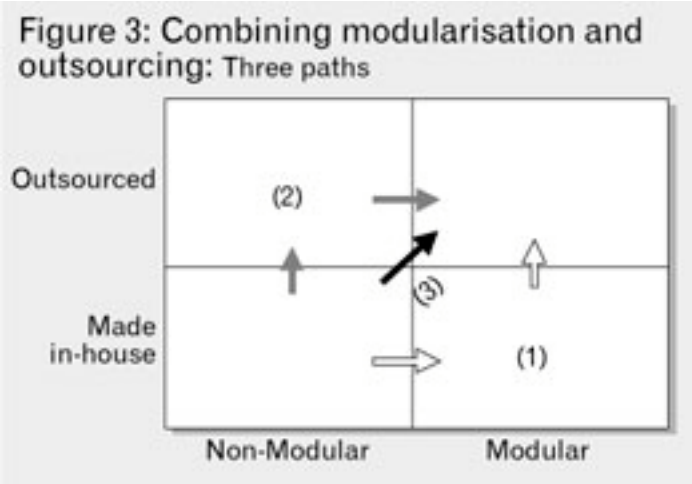

Figure 3

Thus, is the overall level of complexity in the supply chain reduced as a result of modularisation and outsourcing, or does it remain the same as the car firm externalises complexity down the supply chain? The answer depends on the boundary of the organisation for which the architect has optimised their objectives. A car company that produces modules in-house or has solutions to be implemented by suppliers is likely to benefit from an overall improvement as a result of modularisation. By contrast, a car firm which outsources modules without an in-house set of solutions may end up not reducing the amount of complexity in the total supply chain and therefore pay more dearly for the modules than if they were produced in-house.

In Japan, the production of components was outsourced a long time ago. But so far, Japanese companies within Japan are generally very cautious about outsourcing modules. While modular assembly is being considered by some OEMs, it is largely kept in-house (i.e. Path (1) in Figure 3 is dominant). In Europe, by contrast, the outsourcing of components is a relatively recent phenomenon, and there is sufficient push by some car manufacturers to outsource modules to suppliers (Path (3) in Figure 3). Also, some existing component suppliers are asked to form a consortium to supply a module (thus completing Path (2)).

The global forces that lead to modularisation - the need to make large global investments without expanding fixed costs dramatically, and the problems of managing complex global organisations - may well have different implications in different regions. It need not automatically lead, as some commentators argue, to homogeneous managerial styles and industry structures. For example, our research sponsored by the International Motor Vehicle Programme (IMVP) shows that in Europe and the United States suppliers are making significant investments in order to compete as module suppliers. They are spurred on by the demanding requirements of the financial markets and the need to raise their contribution to the value added in automobile development and production. This suggests a possible shift in these regions from adversarial supplier relationships to ones of active contracting based not solely on price-per-part but on innovation, speed, and access to intellectual property. In contrast, our Japanese colleagues have found limited willingness on the part of Japanese OEMs to embrace modularisation. They prefer instead to stay with the close but hierarchical supplier relationships they have built up over a long period. However, as they too expand globally and build greenfield sites overseas, Japanese OEMs are also becoming Modularisers, or at least Production Modularisers.

We might therefore see strategies that vary by country of origin of the OEM, with Japanese companies following a different path to US or European ones, predicated on their history and embedded capabilities. However, the pattern is complicated by the geography of operations. In other words, OEMs may follow one strategy in established plants but use greenfield sites and new car models as opportunities to experiment with modularity in production and/or modularity in design. This leaves a complex tapestry of industrial organisation and company strategies. The strategy of OEMs will be contingent on country of origin, country of operation, and country of the suppliers. Profitable suppliers must be sufficiently flexible to offer a range of modular options, from production only to a complete design and production package, catering for multiple OEMs.