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What is behind mirroring hypothesis? Dynamics between modularity and integration in the market creation: case from electric vehicle industry

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INTRODUCTION, BACKGROUND AND LITERATURE

Although firms in many industries have pursued vertical integration for scope expansion and corresponding product integrality constraints for over a century, the strategy seems to have lost its traction over the last few decades. The main contributor to this change, according to research in organizational economics and strategic management, is outsourcing and its direct consequence on the evolution toward more modular product architectures (Baldwin, 2008; Fine, 1998; Schilling, 2000). This relationship between the degree of integration in an industry and the product architecture comprising integrality and modularity is presented as the “mirroring” hypothesis in the literature (Colfer & Baldwin, 2016). The modularization of products leads to vertical disintegration in many industries. Conversely, the integrality of product architecture is associated with integration of component products of the firm.

Modularity is a design strategy to complex systems (Baldwin & Clark, 1997). In its topology definition, a modular product has a simple, i.e. one-to-one, function to component structure and decoupling interfaces (Fujimoto, 2007; Ulrich, 1995). Modularity and integrality are two ends in the continuum of product architecture. A substantial body of empirical literature on technology management suggests that modularization has largely influenced new product development processes in different industries, such as computers (Baldwin & Clark, 2000), and autos (Fujimoto, 2007; MacDuffie, 2013). Scholars argue that modular architecture decreases the need for coordination in a complex system and thus lower associated transaction cost, especially the decoupling interfaces give the possibility that component designs, manufactures and innovates autonomously and therefore disintegration becomes a prevailing choice for modular products (Baldwin, 2008; Colfer & Baldwin, 2016). However, the role of another dimension of modularity, i.e. function component structure, in the mirroring process is rather unexplored and less tested. The only study found that integral function- component allocation “increase[s] in synergistic specificity” (Fixson & Park, 2008: 1309) in order to have competitive advantages.

Furthermore, as there are two separate dimensions in the definition of modularity, i.e. interface and function component structure, it inevitably engenders the situation that a product has rather modular interfaces and a rather integral function component structure. How will the firm boundary shift when a product has increasing modular interfaces but function component structure remains integral? I focus on the market creation period of a technology innovation especially, the system-wide functions are critical in creating a market. I consider product architecture and mirroring hypothesis as not only engineering issues but also strategic choices open to top management of the firm.

The empirical setting of this paper is in Electric Vehicle (EV) industry (explained in the next section). It attempts to explore the two dimensions of mechanism behind mirroring hypothesis in the setting of market creation for EV, i.e. the role of interface and function component structure in shaping the firm boundary: 1) how the two dimensions of modularity level shift in EV ecosystem architecture respectively? 2) How these two dimensions navigate the boundary of firm in the market creation of EV? This proposal intends to understand what are the drivers and the mechanisms behind mirroring hypothesis, especially, what is the dynamic of modularity and integration in the market creation.

SETTINGS, METHODS AND EXPECTED FINDINGS

The empirical setting of this paper is on Electric Vehicle (EV) industry, which is considered as a radical innovation and facing market creation challenges. EV is an extension to the automobile industry, thus the mirroring hypothesis is a relevant theoretical framework. EV has challenged current automobile product architecture, as it involves new components inside the vehicle to replace the old ones (e.g. battery and electric motor) and sets a new ecosystem that requires the commitment from electricity and recharging system. With new product architecture and new components, EVs re-trigger and extend the long lasting debates in the auto mobile industry, that is, modularization and corresponding outsourcing. Scholars believe that EV itself tends to have more modular interfaces, as a result of the relaxation on the space, OEM's intention to reduce production cost, and technology uncertainty (Christensen, 2011; Luccarelli, Matt, & Spena, 2015). Scholars also claim that EV in the ecosystem level, face more complicated demand, such as range anxiety problems (Chen, Chowdhury, Donada, & Perez, 2016; Fujimoto, 2016), especially for the battery electric vehicle (BEV).

To substantiate my arguments, I chose BMW I, Tesla Motor, Renault, Nissan and their flagships I3, Model S, Zoe, and Leaf, which, according to the analysis, four most successful BEVs in the market. They all shows interesting shifts in their product architecture and boundary choices, especially on recharging system. For example, BMW i3 has been increasingly strategical, financial and technically involved in fast charging technology since 2014. My approach generates theory insights from multiple case study (Yin, 2013) based on qualitative data. I collected data on their products architecture and their integration choices. I uses archival data (mainly firm's annual reports, industrial journals and websites), covering the period from 2007 (BMW project I started) to 2017, and conducted 15h interviews with top managers from BMW I, Renault and Nissan, in order to capture the product architecture (interfaces and function component structure) in EV ecosystem architecture, and the corresponding strategies.

The results finds that BMW I, Tesla Motors, Nissan Leaf and Renault Zoe have rather modular interfaces in the car, as a result of that they are purpose designed car and have more space in the vehicle and give the opportunity for engineers to design modular interfaces. The modular interfaces of components make firm can easily leverage the technology to other models (e.g. BMW) or sell to other firms (Tesla) and benefits from trade. The story also shows that the demand for the integral range anxiety reduction function cannot be satisfied by a disintegrating industry, i.e. independent recharging firms lack incentives to invest in fast charging technology and develop its network. This has led Tesla and BMW engaging in activities in developing fast charging network. However, it is firm's decision to choose on integration the involving activities and improve system-wide integral function to satisfy the demand. For example, a VP in Renault said that "fast charging technology and big battery are both important parts to satisfy user's demand on range" however "I believe there is a niche but Renault will not go for it".

The work contributes to the understanding of the mechanisms behind mirroring hypothesis. That is, the benefits for specialization and trade motive product shift to modular interface with the effort of engineers and managers, which is the necessary condition for disintegration; while the gap between demand for an integral function and the disintegrated system wide capabilities ask for the firm to integration of certain activities, however, a firm can make its decision on whether integrate the activities and satisfy the demand, which will lead to different scenarios in the competition in market creation.

References

- Baldwin, C. Y. 2008. Where do transactions come from ? Modularity , transactions , and the boundaries of firms. *Industrial and Corporation Change*, 17(1): 155–195.
- Baldwin, C. Y., & Clark, K. B. 1997. Managing in an age of modularity. *Harvard business review*.
- Baldwin, C. Y., & Clark, K. B. 2000. *Design rules: The power of modularity*. Cambridge, MA: MIT Press.
- Cabigiosu, A., & Camuffo, A. 2012. Beyond the “ Mirroring ” Hypothesis : Product Modularity and Interorganizational Relations in the Air Conditioning Industry. *Organization Science*, 23(3): 686–703.
- Cacciatori, E., & Jacobides, M. G. 2005. The Dynamic Limits of Specialization : Vertical Integration Reconsidered. *Organization Studies*, 26(12): 1851–1883.
- Chen, Y., Chowdhury, S., Donada, C., & Perez, Y. 2016. *Mirroring hypothesis and integrality in the electric vehicle industry: evidence from Tesla Motors*.
- Christensen, T. B. 2011. Modularised eco-innovation in the auto industry. *Journal of Cleaner Production*, 19(2–3): 212–220.
- Colfer, L. J., & Baldwin, C. Y. 2016. The mirroring hypothesis: Theory, evidence, and exceptions. *Industrial and Corporate Change*, 25(5): 709–738.
- Fine, C. H. 1998. *Clockspeed: Winning Industry Control in the Age of Temporary Advantage*. Basic Books.
- Fixson, S. K., & Park, J. 2008. The power of integrality : Linkages between product architecture , innovation , and industry structure. *Research Policy*, 37: 1296–1316.
- Fujimoto, T. 2007. Architecture-based Comparative Advantage—A Design Information View of Manufacturing. *Evolutionary and Institutional Economics Review*, 4(1): 55–112.
- Fujimoto, T. 2016. Architectural of green cars. *Gerpisa colloquium*. Puebla.
- Jacobides, M. G. 2005. Industry change through vertical disintegration: how and why markets emerged in mortgage banking. *Academy of Management Journal*, 48(3): 465–498.
- Luccarelli, M., Matt, D. T., & Spina, P. R. 2015. Modular architectures for future alternative vehicles.

International Journal of Vehicle Design, 67(4): 368.

MacDuffie, J. P. 2013. Modularity-as-Property, Modularization-as-Process, and “Modularity”-as-Frame: Lessons from Product Architecture Initiatives in the Global Automotive Industry. *Global Strategy Journal*, 3(1): 8–40.

Schilling, M. A. 2000. Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity. *Academy of Management*, 25(2): 312–334.

Ulrich, K. 1995. The role of product architecture in the manufacturing firm. *Research Policy*, 24(3): 419–440.

Yin, R. 2013. *case study research Design and Methods* (5th ed.). SAGE Publications.