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The Concept of Demand Articulation: How It Was Effective and How It Will Remain Useful

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Abstract: After reviewing how the concept of "demand articulation" has been appreciated in marketing science, the origin of this concept is revisited. Thereafter, this paper demonstrates how the concept was effective in formulating government policies for accelerating the commercialization process of emerging technologies. Specifically, this paper describes a historical case in the area of the U.S. defense policy and of the Japanese industrial policy.

Furthermore, the author tries to give some thoughts on how this concept will remain effective and useful in a forthcoming digital economy. For this purpose, the author presents several case studies on how the commercial products are invented in digital economy and how IoT (Internet of Thing) is evolving. Based on these case studies, it is discussed how the concept of demand articulation can survive in quite a new environment.

Keywords: Innovation; Demand articulation; Nuclear Development; Integrated Circuits; IoT

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According to Sheth and Sisodia (1999), *market-driving* firms seek to *uncover* the latent *undiscovered* needs of current and potential customers, while *market-driven* firms reinforce *existing* frameworks. Indeed, the common view of the customer as offering marketers a *fixed* target is systematically *violated*. Competitive advantage, therefore, results from the ability to *shape* buyer *perceptions*, preferences, and decision making. This *market-driving* view, moreover, suggests an *iterative* process in which marketing strategy *shapes* as well as *responds* to buyer behavior. By doing so, the firm obtain a competitive advantage, which *in turn* shapes the *evolution* of the marketing strategy.

Given this, we have to find a new and *accurate* way of describing the *dynamic* process of technology development (Warsh, 1992). We have to give science policy administrators and research managers a *vocabulary* and a framework for talking *proactively* about the choices they must make in the high-tech environment. In this context, we have to conceptualize "a sophisticated translation skill that *converts* a vague set of *wants* into well-defined products." To do so, we will come to the concept of "demand articulation."(Kodama, 1992) Sheth and Sisodia (1999) summarized that "demand articulation" is an important *competency* of market-driving firms. Most firms are more comfortable in a world of *pre-articulated* demand, wherein customers know exactly what they want, and the firm's challenge is to *unearth* that information. Firms that are able to sustain success over a long period of time, therefore, need to be market driven and market driving *simultaneously*; most corporate cultures, however, are attuned to one or the other orientations. In an open-innovation paradigm, indeed, the concept of demand articulation might become more proactive and preemptive than before: a good *business model* rather than a good technology is the determinant to a successful innovation (Chesbrough, 2001).

In order to better understand the concept of "demand articulation," first of all, in this paper I will revisit the origin of this concept. Thereafter, I will demonstrate how the concept of demand articulation was effective in formulating government policies for accelerating the commercialization process of emerging technologies. Specifically, I will describe a historical case in the area of the U.S. defense policy and of the Japanese industrial policy. Furthermore, I will try to give some thoughts on how this concept will remain useful in a forthcoming digital economy. In order to demonstrate the effectiveness of demand articulation and of its updated version, business model creation, I will present several case studies on how the commercial products are invented in digital economy and how IoT (Internet of Thing) is evolving. Based on these case studies, I will discuss how the concept of demand articulation can survive in quite a new environment. At the end, I will speculate that IoT is going beyond the Schumpeterian formulation of innovation.

1. Context and Definition of Demand Articulation

The *marketing discipline*, has generated an impressive body of knowledge over the past *75* years. This knowledge base has been founded on the widely accepted concepts and thousands of empirical studies. In the 1960s, most markets were relatively *homogeneous*, based on a mass-production and mass-consumption society. The marketing discipline responded to this situation by developing and refining theories that centered on *customers* and *markets*. They labeled these theories as *market-centric* concepts (market segmentation, customer satisfaction), and a *market-driven* orientation (Sheth and Sisodia, 1999).

In recent years, a significant contribution to the marketing literature has come from researchers studying the concept of *market orientation*. It is defined as "the organization-wide generation of market *intelligence*, *dissemination* of the intelligence across departments. They summarized that the market orientation literature's core message as "be close to your customers—listen to your customers." One of the *innovation* literature's core messages, however, is "being *too close* to the customer can *stifle* innovation." This dichotomy needs to be resolved by studying the applicability of the *market-driven* and *market-driving* mind-sets (Sheth and Sisodia, 1999). From the technologists' viewpoint, Kline and Rosenberg (1986) argues that innovation can be interpreted as a *search* and *selection* process among technical *options*. The sample population from which technical options can be drawn, however, varies over a wide spectrum of sources of innovation. In this *intricate* process, Nelson's "alternatives out there *waiting* to be found" is somewhat forced (Nelson & Winter, 1982). The most important element in technology development, therefore, is the process in which the need for a specific technology *emerges* and R&D effort is targeted toward developing and *perfecting* it.

In this context, we have come to the concept of "demand articulation." According to Webster's dictionary, *articulate* comes from the Latin *articulare*. The word "articulate" has two conflicting meanings: (1) to *divide* into parts; and (2) to put together by *joints*. Thus, the word encompasses two opposite concepts: analysis (decomposition) and synthesis (integration). In fact, both are necessary in technology development, and the heart of the problem concerning technology development is how to manage these conflicting tasks (Kodama, 1995). Now, we can define demand articulation as a dynamic *interaction* of technological activities that involves *integrating* potential demands into a product concept and *decomposing* this product concept into development agendas for its individual component technologies. Articulating demand, therefore, is a *two-step* process: market data must be *integrated* into a product concept, the concept must be *broken* into development projects. Potential demands are often derived from *virtual* markets and/or what Christensen and Raynor termed "nonconsumption." (Christensen and Raynor, 2003) The fact that the technology is still considered *exotic* should not be a deterrent in setting development agendas.

2. Origin of the Concept: Nuclear Projects

The importance of articulating the demand for technology development, I would argue, was demonstrated for the first time in the effort in utilizing the nuclear power as a source of *sustainable* energy. It was the US navy's development of nuclear *submarine*. Admiral Hyman G. Rickover played a critical role in this historic event where an explosive nuclear was successfully transformed into a sustainable energy source. Indeed, technology management was itself established as a discipline by Rickover's innovations and tactics. He could claim that the way he went about the project and the lessons his methods could teach were as important as the project itself (Lewis, 1980). However, rather than a good technology management, I would argue in retrospect, a good *articulation* of demand had been critical for the success of submarine project. How did Rickover articulate the demand for the submarine and succeed in managing this development process? Congress began debating the idea of an Atomic Energy Commission (AEC) in 1945 and finally passed a bill creating such a commission in 1946. By the end of 1946, however, the AEC and the Bureau of Ships had no policy regarding nuclear propulsion.

Meanwhile, the World Wars I and II had shown us that the *submarine* had been a decisive weapon. However, the *old* submarine of S-48, a creature of World War I technology, was a "cramped boat," limited in its submersion and speed capabilities. The submarine was powered by storage *batteries* when submerged and by *diesels* when surfaced. The submersion period was limited by battery life: the boats had to surface frequently to recharge the batteries and to resupply the crew with fresh air. In addition, a battery fire could produce toxic gases and multiple explosions. A submarine was almost called as "dangerous as the enemy." A central problem of submarines, indeed, was that as long as they relied on the *diesel* and the storage *battery* powered electric motor, they would be of limited utility. In 1947, the "true submarine" conference was organized and recommended operational criteria for the design of new submarines in the light of World War II experience. The "true submarine," then, would be an *underwater* craft that would *remain* submerged *indefinitely* and that would operate in the sea much as *aircraft* did in the sky. The submariners' conference recommended *nuclear* propulsion as the answer. The dramatic moment came when an Undersea Warfare Symposium was held and the Bureau was asked to provide speakers. Most of the AEC Commissioners were there. Admiral Earle W. Mills stated that the naval reactor hadn't really been given any *priority*, and closed by urging that the Commission establish a high priority naval reactor program as soon as possible. By the spring of 1948, the AEC had been brought to the Navy's position that the challenge of the naval propulsion reactor was a *distinctive* one. The Navy moved to bring the private contractors into line with the new militancy of the Bureau of Ships (Lewis, 1980).

By the end of 1950, the pressurized light-water thermal reactor known as *Mark I*, was being built by Westinghouse. On March 30, 1953, the Mark I went critical on its test stand. In the late spring it underwent a prolonged test which simulated a submerged trans-Atlantic voyage. This test was dramatic *evidence* that the world of undersea propulsion was fundamentally changed over. It was an extraordinary *achievement*. Under any circumstances it can be viewed as a *landmark* in the history of technology, for it was the first time that a nuclear reactor produced s*ustained and usable* amounts of energy. In terms of "demand articulation" scheme, meanwhile, we have to ask why the utilization of nuclear energy was first realized successfully in the submarine, rather than in the power station. It was because there was no alternative but nuclear as the energy source for realizing the ideal of "true submarine." In order to make the concept of demand articulation explicit, however, the context of technology developments should be contrasted with other application areas of nuclear energy, in particular, with the context within which the nuclear ship (fleets) projects were attempted and implemented among countries such as United States, Germany, USSR, and Japan.

The nuclear Navy was a growing reality. But President Dwight Eisenhower was dreaming: to develop the “Peaceful Atom” to counteract the image of *Hiroshima* as the atom’s only *legacy*. The United States organized the first several international “Atoms for Peace” conference and began negotiations that ended a year later in the establishment of an International Atomic Energy Authority. In other words, Eisenhower had been anxious to demonstrate as soon as possible some concrete action toward achieving the goal of commercialization of atomic energy. In 1955, President Eisenhower proposed building a nuclear-powered *merchant* ship as a showcase for his "Atoms for Peace" initiative (Rockwell, 1992). The next year, Congress authorized *Savannah* as a development project of the Atomic Energy Commission. In Germany, the construction of “Otto-Hahn” for the Ore Carrier was initiated in 1964. In 1969, Japan launched the “Mutsu” project for the purpose of constructing a nuclear ship for oceanographic observation. In a context that is somewhat different from the above-mentioned countries, the first nuclear ship program had been launched already by USSR in 1957. The purpose of the nuclear ship program, however, was to develop the *icebreaker*. The comparison of these programs was depicted in Table 1 below (Ando, 1996).

Table 1. Construction/Change/Termination of Nuclear Ship Programs in Various Countries (as of 1998)

Name	Country	Launched Year	Original Use	Changed Into	Terminated Year
Savanna	USA	1959	Cargo/ Passenger	Cargo	1971
Otto-Hahn	Germany	1964	Ore Carrier	Container	1982
Mutsu	Japan	1969	Oceanic Observation	Special Cargo	1996
Lenin	USSR	1957	Icebreaker	None	(Continued)

Among various programs, the Japanese nuclear ship was inaugurated on the basis of the definition which had been given at International Convention on Safety of Life at Sea, which was held in London, on June 17th, 1960. In this conference, Nuclear Ship was defined as: “A Ship with Nuclear Power Plant.” [1]

As seen in the table, we discover there was big and varied difference among these four countries concerning how the nuclear ship was to be used originally, how each country had changed the original purpose as the project progressed, and when the project was finally terminated. Compared with the case of nuclear submarine project described before, therefore, we can say that the demand for nuclear ship was far from being *articulated*, except the development in USSR where the objective was clearly set to build the *icebreaker*. In the frozen North-Sea, the cargo transportation is only possible by the nuclear icebreaker that has the long cursing range with the strong capacity of ice-breaking and that needs not any intermediate refueling. Indeed, the Russian project of nuclear ship is still alive today.

[1] It was also recorded: the use of nuclear was not explicitly specified for a propulsion driving force. *Source*: Ando (1996).

3. Integrated Circuit Projects: Policy Articulation

In the defense sector, the concept of demand articulation is effective for describing how product development challenges at the component and systems levels are addressed in the integrated manner. One important historical case is the impact that shifts in U.S. strategic defense policies had on I.C. (Integrated Circuit) development in the 1950s and 1960s. Moreover, the concept of demand articulation becomes even more powerful, when a national policy for commercializing VLSI (Very Large Integration) technologies is analyzed. The government-sponsored research consortia both in Japan and the United States, best illustrate demand articulation at the national/industry/company level. This suggests that national policy can be discussed better using the concept of a "national system of demand articulation" rather than the oft-cited concept of a national system of innovation (NRC, 1999).

3.1 Development in the US defense

According to Gaddis (2005), George Kennan maintained in *retrospect* that it would not be until the Kennedy administration that awareness of “the basic *unsoundness* of a defense posture based primarily on weapons accidentally *destructive* and *suicidal* in their implications," would begin to develop[2]. Indeed, the shift from a strategic stance emphasizing “massive retaliation” in the Eisenhower Administration to the Kennedy Administration's goal of achieving capabilities for “flexible response” put a *premium* on precision *delivery* of nuclear weapons, and highly survivable systems, including *missiles* and command and control systems (National Research Council, 1999).

Meanwhile, the OECD study (1977) concluded: although the two basic patents and key technological contributions that *underlie* IC technology in the United States were made by private companies *without* government support. These fundamental innovations were achieved because both companies sensed the *needs* of their various customers, present and hoped-for. These customers, however, were drawn mainly from the government via its military interests. In other words, although government influence helped create the *landscape* these companies viewed, it did not *dictate* the nature of the technological *route* to be taken. The need was *articulated*, the means to satisfy it was *not*. In short, breakthroughs were brought about by the in-house R&D efforts of those companies that responded to the *articulated* demand of the military. Prior to the development of IC technology, program sponsored by the US Department of Defense were driven by technology rather than by the *need* for a technology. In the case of the IC, however, the US Government *articulated* and *shaped* the problem which the innovative candidate technology was required to address. The resulting “articulated demand” for *miniaturization* and *reliability* in missile control systems went beyond what was possible using *vacuum tubes* or *transistors*, the available technologies at the time. Although they did not receive direct government funding for their work, Texas Instruments and Fairchild *responded* to this military demand in developing the first IC.

The chronology of defense strategic changes and of technology developments have been studied in-depth by the author (Kodama, 2015), by itemizing the strategic changes around the concept of “containment” (Gaddis, 2005) and the occurrences of IC related innovations (OECD, 1977), as described below:

1) Immediately after the WW. II, *Truman's strategy* would have required *readiness* to fight everywhere, with old weapons and with new weapons.

2) In 1951, the military services sponsored an effort to *improve vacuum tube* circuitry. The *first* major effort specifically in the *miniaturization* mode was "Project Tinkertoy,” [3] to miniaturize

[2] Original Source: George Kennan: Memoirs, 1925-1995, pp. 474-475.

[3] The Tinkertoy construction set is a toy construction set for children. It was created in 1914 by Charles

and *completely automate* the manufacture of selected electronic components.

3) TI initiated an *in-house* program to seek basic *new* directions. By mid-1953, the first IC, i.e., electronic components indivisibly *embodied within a semiconductor-material*, was demonstrated by TI.

4) John Foster Dulles explained how *strategic initiative* could be combined with *budgetary restraint*. It could be done by relying on the deterrent of "massive *retaliatory power*." We would be willing and able to *respond vigorously* at *places* and with *means* of its own *choosing*.

5) In 1958, the Air Force suggested a concept dubbed "molecular electronics." In brief, components using this technology would have various electronic functions *without* specifically *fabricating* such individual electronic parts as transistors, diodes, capacitors and resistors. The material used would *simulate* the electronic function of oscillators and amplifiers (OECD, 1977).

6) With much fanfare the Air Force awarded a contract to *Westinghouse*. The molecular electronics concept *per se* proved quite controversial and did not *achieve* its goals. However, it did *sensitize* the U. S. semiconductor components industry towards *new directions*.

7) Kennedy, possessed of an economic rationale for *disregarding* costs, placed his emphasis on minimizing *risks* by giving the United States sufficient *flexibility to respond* without either escalation or humiliation. He declared, "we believe in maintaining effective *deterrent strength*, but we also believe in making it do what we wish, *neither more nor less*." (Gaddis, 2005)

8) TI was awarded an Air Force contract. It built a *computer using* IC components. It offered impressive *advantages* and, served as a *showcase* vehicle to illustrate the IC's potential utility. It was a *reinforcement* of the IC *idea*, moving it one more step towards *reality*.

9) Cuban missile *crisis* between October 16th and 28th in 1962, made explicit the basic *unsoundness* of defense posture based on primarily on weapons accidentally destructive and suicidal in their implications (Allison and Zelikow, 1999).

10) The *Minuteman* contract to *utilize ICs* was announced, publicly stating that the advanced version of the ICBM (Intercontinental ballistic missile) would use these new components. Its orders were the largest IC *purchases*.

In order to demonstrate the dynamic interaction between defense policy *articulation* and technological *response*, Table 2 on the next page was edited as far as the IC development in the US defense sector are concerned.

3.2 Commercialization of VLSI by research consortia

As a technology shifts from the defense to the civilian sector, particularly, the development of manufacturing technology becomes more important because cost is a critical factor in the civilian sector. Many companies, in different industries, were involved in bringing the integrated circuit (IC) technology from the defense sector into consumer-products market. In Japan, the government played a significant role in this transition by organizing a research association for VLSI development. When first formed, the association called ERA (Engineering Research Association) for VLSI development included all of Japan's major computer manufacturers at that time, who then *articulated* their demand for manufacturing *equipment* for chip-making. The five member

H. Pajeau, Robert Pettit, and Gordon Tinker. Pajeau designed the toy after seeing children play with sticks and empty spools of thread. He and Pettit set out to market a toy that would allow and inspire children to use their imaginations. *Source*: Wikipedia.

companies established a joint research laboratory within the association. And, a great deal of the research and development carried out in the association, was subcontracted to *supplier* companies that were not members of the association, e.g., camera manufacturers, silicon crystal suppliers, and printing companies.

Table 2. The dynamic interaction between defense policy articulation and technological response, in the IC development in the US defense sector

Year	Defense Policy Articulation	Technological Response
1953	R*eadiness* to fight everywhere with old and new weapons	The *first* IC (components embodied within a semiconductor-material) was demonstrated by TI
1954	M*assive retaliatory power* to deter aggression	
1959		The Air Force suggested a "molecular electronics" concept. It did sensitize the U. S. industry towards new directions.
1961	*Flexible response* without *escalation* or *humiliation*	TI was awarded an Air Force contract to build a *computer using* ICs, and to construct an *IC pilot line.*
1962	*Unsoundness of* weapons *accidentally* destructive and *suicidal*	The Minuteman contract to utilize ICs was announced, stating that the ICBM would use these new components.

According to Rosenberg (1994), a *pervasive uncertainty* not only characterizes basic research, where it is generally acknowledged, but also the realm of government-sponsored development projects. Consequently, the pervasiveness of uncertainty suggests that the government *should* ordinarily *resist* the temptation to play the role of champion of any one technological alternative. Therefore, it would seem to make a great deal of sense to manage a deliberately diversified research *portfolio*, a portfolio that is likely to *illuminate* the range of alternatives in the event of a reordering of social and economic priorities. In this context, I argue, the power of research consortia had been manifested most vividly in exploring all the spectrum of possible equipment technologies. It used to be a mainstream method to let the mask of circuit-diagram contact directly the wafer and print on it. When the micro-manufacturing progressed further, a new idea emerged. In the late 1970s, GCA Corporation of United States had invented the step-and-repeat technology (Randazze, 1996). The original circuit-diagram is projected through the lens on the wafer by reduction ratios of one-tenth or one-fifth. In actuality, the wafer moves stepwise in four directions, while the mask stays in a fixed position. This equipment has become called as "stepper." However, direct printing by electron beam, and X-ray lithography, had already been much advanced and their prototype had been existent. Therefore, the stepper was assumed to be the *third* candidate. None could deny this priority, indeed, because no one did expect the *lens* technology that print 40 lines on the width of a hair.[4]

[4] What makes steppers into multi-million-dollar pieces of sensitive equipment is the need to maintain focus within a fraction of a micron and to control the wafer's position with similar accuracy.

Meanwhile, Nikon Co. had been confident on *three* kinds of critical technologies which made the "stepper" competitive: ultra-high resolution lens; the staging technologies moving the wafer; and, the censor of photo-electric tube.[5] As to the high *resolution* lens, Nikon had already developed a commercial hit product, which was about to be procured for lens of photo-mask manufacturing, specified both by domestic and overseas producers. As to the *staging* technology, Nikon had an experience to provide Tokyo University's astronomical observatory with the staging mechanism for precise positioning of the telescope.[6] Indeed, the specific activities of the Japanese ERA included the development of the lithography. One of the association's lithography laboratories contracted the research necessary for the development of the lithography to camera manufacturers including Nikon that owned the lens technology. Thus, Nikon succeeded in the development. Through the development process described above, the "stepper" has become a mainstream in the equipment for semiconductor manufacturing. In the same token, the stepper has become a major business line at Nikon.

After ten years of demand articulation efforts, Japanese companies in the upstream sector of chip manufacturing are beginning to emerge as dominant players in world production. Moreover, we will demonstrate that demand articulation is evident and visible beyond the national border in organizing the research consortia, by investigating the brief history of SEMATECH (Semiconductor Manufacturing Technology) consortia of the United States which was established in 1987. During the early and mid-1980s, the U.S. semiconductor industry lost about half of its global market share, particularly in memory chips to Japanese integrated-circuit producers. The decline in semiconductor manufacturing *equipment* by domestic makers was equally drastic. That was the background against which the principal American chip manufacturers organized the SEMATECH consortium to foster research and development on advanced semiconductor technology.[7] After struggling unsuccessfully for more than a year to organize a research program suitable to its diverse membership, the consortium focused in particular on *lithography* technology (Randazzese, 1996). Since SEMATECH was founded, we have seen an improvement in the competitive position of the U.S. semiconductor industry, and U.S. semiconductor manufacturing equipment companies once again held 50 percent of the global market. Something of a consensus has emerged that SEMATECH deserves much of the credit for these gains.[8] I would argue, the demand articulation had directly or indirectly changed the relations between chipmakers and suppliers of the United States.

Therefore, steppers use the sophisticated optical feedback mechanisms and the stringent control to keep the conditions across the surface of the wafer as uniform as possible.

[5] This was confirmed by Mr. S. Yoshida (2007), who had started his carrier as a telescope engineer and later became the CEO of Nikon Co.

[6] Within Nikon Co., Mr. Yoshida had started his career in designing the telescope, not in camera which was the major product line at that time. Yoshida S. (2007), *ibid*.

[7] SEMATECH is one of hundreds of consortia that have been ever organized since the 1984 passage of the National Cooperative Research Act, which gives companies engaged in cooperative research and development partial *exemption* from *antitrust* laws. Fearing that the integrity of the U.S. defense apparatus was threatened by a growing dependence on foreign semiconductors, the federal government agreed to contribute $100 million annually to SEMATECH's operations. Source: Randazzese (1996).

[8] These include an extended recession in Japan, the rising value of the yen, trade agreements in which Japan conceded that imports should account for 20 percent of its domestic semiconductor market, competition from low-cost Korean makers of memory chips, and the continued dominance of U.S. semiconductor companies in the microprocessor market.

4. Strategy Articulation in Digital Economy

It is widely held that a “new economy” has been emerging ever since 1990s. By this emergence, the conventional wisdom about the innovation process becomes obsolete. Since “new economy” can be easily translated into “digital economy,” we have to think about what is new about the “digital economy. In the 1999 Newsweek article entitled “Embracing a Millennium of Change,” indeed, the author of this paper was quoted by saying: In the analogue world, things cannot be easily combined. However, with digitalization, all sorts of combinations are possible and we can end up with something greater than the *sum* of the merger (Newsweek, 1999). Its implication is that the space of business/technology development is now wide open. In the age of digital economy, therefore, I would argue, companies can theoretically diversify their businesses into any area, as long as they can keep their original core competences alive.

Porter (1996) had once described: Japanese Companies Rarely Have Strategies. Most Japanese companies imitate and emulate one another, thus, driving themselves toward competitive *convergence*; and, they have been frustrated by their inability to translate those gains into *sustainable* profitability.[9] Porter’s characterization of the Japanese companies, however, had been far from the reality, when it comes to these Japanese *camera* companies such as Canon, Nikon, and Olympus. When it comes to their *trajectory* that diversified their business from the original camera-making, they differs substantially among them. All of them, in fact, skillfully utilized their core competences in optics for managing *different* trajectories of diversification: Nikon had extended its core competence of camera-making into the stepper in IC manufacturing; Canon had skillfully navigated its core competences into “copying” machines, and thereafter into “printer” businesses; and, Olympus has become the largest supplier of gastro-intestinal “endoscope,” by keeping almost 70% share of the global market. Then, what kinds of strategies were used for these diversifications? Or, did any strategic thinking not exist at all behind these successful Japanese diversification? Their strategic characteristics have come to be clear and be scientifically analyzed, when Christensen (1997) introduced the concept of “disruptive” innovation as contrasted to “sustaining” innovation. As described before, the stepper option was selected by the research consortia as the *third* candidate. In this context, the stepper was a *disruptive* innovation. In other words, the research consortia had *strategically* chosen the stepper option, while at the same time they contracted with Tokyo Electron Ltd., which kept a dominant position in the sustaining technology.

Behind Canon’s bold decision to enter into copiers and adopt a *PPC* (plain paper copier) instead of photosensitive coated paper, a future CEO of Canon once described about his decision:

What made up my mind was a report, published in the 1960's by the Arthur D. Little Corporation, a research company in the United States. It was a forecast of the copier market and predicted there would be no real rivals to Xerox in the 1960's and 1970's. Reading this, I had the feeling there were no limits in the world of technology and that there must certainly be other approaches. I felt that if an authoritative research company like this was making such a prediction, then other companies would not attempt to enter the PPC market. If we could break the first wall with new technology, we could take an oligopolistic position in the market with Xerox. I felt this was a challenge worth taking. (Yamaji, K. (1997): *One proposes, God disposes*, My curriculum Vitae, Nihon Keizai Shimbun, Inc. page 22.).

Indeed, this machine was quite successful as *desktop* copiers. Canon’s approach is obviously that of disruptive innovation. At the beginning of his book, Christensen stated clearly that he tried to

[9] Porter took a note: those that did -- Sony, Canon, and Sega, for example --were the *exception* rather than the rule.

explain, what he called as the saga of "good-companies-hitting-hard-times": well-managed companies that have their competitive antennae up, listen astutely to their customers, invest aggressively in new technologies, and yet still lose market dominance. Nikon was established in 1917 and kept a leading position in a high end camera market. And Olympus has been an optics technology-based company since 1919. And Olympus's development of endoscope was a result of disruption of the prevailing trajectory of X-ray photographing including CT scanners. Christensen's arguments (1997), therefore, could not explain the fact that these well-established companies had accomplished disruptive innovations. Indeed, these disruptive innovations might have been "sustaining" innovations to these established Japanese camera-based manufacturers.

Based on the characterization of Japanese camera companies, neither Porter's strategic positioning nor Christensen's disruptive innovations are effective in analyzing their successful diversification and/or transformation. We are going to make an in-depth analysis on what types of demand *articulation* has been made when Canon had skillfully navigated its core competences of optical technologies. In the case of Canon, their direction of diversification had been well *articulated* when they made decisions to extend their core competences of camera manufacturing into such product lines as copiers and printers. In the early 1960s, Canon was in a situation that they would come to a standstill if it stuck only to the camera and lens businesses. They needed to diversify into other fields. They first tried the auto-focus (AP) camera, and failed to create a market version, because the peripheral technology was not ready at that point. Then, the theme which became the main priority after surviving the recession of the 1960's was the *copying* machine (Yamaji, 1997). The launching the new project is said to have been based on the following logic of reasoning: copiers have a mechanism which is something like a large camera, containing a development system *inside*. Therefore, they thought it was a new field that seemed comparatively easy to enter for a camera maker (Yamaji, 1997). The first PPC Copier based on the new method that is different from that of Xerox Corporation was completed in 1970. They provided the photoreceptor *drum* and *developer* which had to be replaced at regular intervals free of charge, in addition to paper and repair parts.[10]

The response to the new product was good. In 1979 they developed the PPC copier which offer superior images and higher speeds in a full *desktop* model. Together with copiers, *printers* have come to form a pillar of Canon's non-camera operations. The metaphor used for launching the printer business was: the printers and copiers are closely related in terms of operating principles, with copiers copying from *documents* and printers from *memory*. They are the same in that they both reproduce information on paper (Yamaji, 1997). When the laser beam printer was exhibited at the 1975 NCC (National Computer Conference) in the United States, it proved to be a sensation. This Canon product became the first laser beam printer to be demonstrated to the public. In 1983, it was carried around the United States for demonstration and business talk. Apple was fastest in showing interest in the project. Steve Jobs, attended a demonstration and decided to use it on the *spot*, saying it was just the kind of printer he had been looking for (Yamaji, 1997). Hewlett-Packard was also quick to come to an agreement. They left development and production of laser beam printers in Canon's hands and concentrated on software and sales.

On the basis of the Japanese companies' experiences of diversification illustrated vividly by the case analysis of Canon, we have to find an appropriate *phrasing* beyond strategic positioning and disruptive innovations. I would call it "strategy articulation." It is defined as a kind of demand articulation which leads the company *strategically* to a right direction of diversification into emerging business area, and which sometimes implies a successful *metamorphosis* of the company

[10] Research and development and production of consumables were necessary to create a new type of copier. If it would be left the photoreceptor drum and developer in the hands of others, the inventor wouldn't have been able to create a new process.

as a whole. In strategy articulation, they choose strategically the path of disruptive innovation, by highly utilizing and advancing their core competences they owned in the past. Through the well-managed strategy articulation, these Japanese camera makers could see the opportunity of growth and of extending their core competences quite naturally, consistently, and *persistently*. In this context, the well-managed strategy articulation can make it possible for the company to become "persistent innovators," instead of "occasional innovators," the dichotomy presented by Malerba (1995). Their innovations are not based on conventional "creative destruction," but on "creative accumulation." (Suzuki and Kodama, 2004).

In short, "persistency" is the most valuable asset in surviving in radically changing technology and market environments. When entered into 1990s, we have come to the technological and business environments in which the "demand articulation" is better framed in a *proactive* and *preemptive* manner. It has also become clear to everyone that a new *business model* can be a source of discontinuity and disruption as well as that of technical breakthrough innovations (Kodama, 2000). It went also in parallel with the sophistication of information technologies. Indeed, Steve Jobs clearly described this situation in the following: People don't know what they want *until* you show it to them. That's why I never *rely* on market research. Our task is to *read* things that are not yet on the *page*. In this situation, the demand can be articulated by expressing *preemptively* what you think people want. Inventing the iPod innovation, Steve Jobs is quoted as saying: Our idea was to come up with a music *service* where you don't have to subscribe to it. You can just buy music at 99 cents a song, and you have great digital – you have great rights to use it. As is clear in this quotation, it is based on the creation of new *business model*. In adopting the multi-touch technology, he thought: So let's not use a stylus. We're going to use the best pointing *device* in the world. We're going to use our *fingers*. We're going to touch this with our fingers. And we have invented a new technology called multi-touch, which is phenomenal. It works like magic (Cupertino Silicon Valley Press, 2011).

In writing the book of "open innovation," Chesbrough is quite *articulate* in identifying the importance of business model. The economic value of a technology remains *latent* until it is commercialized in some way. The value of an idea or a technology depends on its *business model*. There is no inherent value in a technology *per se*. The value is determined instead by the *business model* used to bring it to market. An inferior technology with a better business model will often defeat a better technology commercialized through an inferior business model. According to Amit and Zott (2012), more recently, much of the innovations and cost savings that could be achieved have already been achieved. Our greatest focus is on business model innovation, which is where the greatest benefits lie. It's not enough to make a differences on product quality or delivery readiness or production scale. It's important to innovate in areas where our competition does not exist.

5. Articulation Agent in the Internet of Things

The Internet of things (stylized Internet of Things or IoT) is defined by Wikipedia as the internetworking of physical devices, "connected devices," "smart devices," buildings and other items (embedded with electronics, software, sensors, actuators), and network *connectivity* that enable these objects to collect and exchange data. The IoT allows objects to be sensed and/or controlled remotely across existing network infrastructure, creating opportunities for more direct *integration* of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit. A good example of IoT innovation can be found in a Japanese construction machinery supplier. Komatsu is the first company that introduced disruptive technologies such as RFID (Radio Frequency Identification) and GPS (Global Positioning system) for development of construction/building lots. In this system, RFID sensors are inserted inside their machines that are operating all over the world and all the data collected about their operating conditions are sent to Komatsu headquarters in Tokyo via *satellite* communication. The system Komatsu developed is called "KOMTRAX" system. Having KOMTRAX developed, Komatsu could enhance the customer service drastically by providing with timely exchange and repair of parts and also with theft prevention. The sales agents located around the world can also benefit by reducing their inventory.

Upgrading the use of KOMTRAX system to the *corporate* management system became possible. The data about operation conditions of their machines, which becomes available by KOMTRAX, are effectively utilized for their discussion on demand forecasting being conducted at the head office. Based on this demand estimate, production schedules and investment plans of equipment at each factory are decided. In 2004, for example, the Chinese economy was in downturn, due to the government financial policy implemented. The collected data by KOMTRAX showed clearly that the operating ratios of their machines in China were abnormally low. Before the recession was officially announced by the Chinese government offices, Komatsu halted their production for three months (Nikkei Business, 2007). Now, we are interested in what is the demand articulation in the area of IoT. The first question is how the process of demand articulation in IoT innovation differs from that of stand-alone product. We have already described that the process is gradual, incremental, and, most importantly, it is essentially *additive*, i.e. value is added continuously. The next question is what and who triggered the innovation process. We will find an interesting lesson by investigating Komtrax development in-depth.

The development of KOMTRAX, indeed, was not as *straightforward* as we can imagine. In the mid-1990s, the country's investment in construction business fell down significantly. Facing this reduced investment, companies had to revise the ways in which machinery was procured. This meant a shift away from ownership to *leasing* and *rental* (21% of machinery was either leased or rented by 1993, 30% by 1997, and 40% by 2006). At Komatsu, the business planning (and administration) office was staffed by people dispatched from various divisions. In 1997, the office had received a plan for a *business model* for remotely monitoring machinery, which was in effect the prototype of KOMTRAX system. (Nihon Keizai Newspaper, 2014). The company completed prototypes by 1998, and asked the owner of "Big Rental" (a rental company established in 1997at Koriyama of Fukushima prefecture), to test the 5 prototypes. At that time, the owner of Big Rental had been thinking about a brand-new rental *business model* that entailed using IT, thus, he agreed to take on the prototypes for testing. Thereafter, it was suggested at Komatsu that *fifty* pieces of equipment should be subsequently tested. However at a development meeting, supervising executives took a *negative* view regarding continued testing. Unfortunately though, it was decided at Komatsu that the remote monitoring system development should be cancelled. The Komatsu development team had not been able to *paint* a picture of a business model using KOMTRAX, because they did not have an understanding of its *inherent* value.

Nevertheless, the Big Rental's owner, who had understood the value of KOMTRAX, immediately wrote an order for 1,000 units--an order made despite of Big Rental's having only 500 pieces of rental construction machinery at the time. In those days, KOMTRAX units were *externally* attached. Thus, such a large order enabled KOMTRAX to sustain this viable business, and so development was continued informally within Komatsu. Then, the Big Rental grew rapidly and within 3 years became the *top* rental company in Fukushima prefecture. The capabilities and advantages of KOMTRAX in remote management of machinery and in work on construction sites, became widely known gradually. Komatsu filed the *business model patent* for rental businesses. The Big Rental's owner, meanwhile, was recruited to Komatsu Co. as an executive officer. This sequence of events described above in Komtrax innovation alludes to the fact that a new type of management is emerging in IoT innovation in digital economy. An interesting question, here, is who was the agent of demand articulation. The answer is the owner of a rental company. In this context, the demand articulation for Komtrax had been made externally, i.e. outside of Komatsu headquarter, but within the larger network which involves distribution, manufacturing, and parts supplying. The person talented with the demand articulation capability is found within the eco-system of construction network, but not necessarily in the core part of the system. But, after all, he or she is recruited to the central position of the system.

6. Concluding Remarks

In essence, IoT is characterized by: (1) the *internetworking* of physical devices, and; (2) its system itself is embedded with *network connectivity*. In 1926, as is well known, Joseph A. Schumpeter described: technologically as well as economically considered, to produce means to *combine* the *things and forces* within our reach. Every method of production signifies some such definite combination. In so far as the *new combinations* appears discontinuously, then the phenomenon characterizing development emerges. Development in our sense is then defined by the *carrying out* of new combinations (Schumpeter, 1926, 1983). As I have described so far, the essential characteristic of IoT innovation is the constant and consistent accumulation of values as it progresses. It is accomplished by *connecting* individual components by the network with sophisticated software. It is not attained by the economy of scale, nor by the economy of scope, but only by the *economy of connectivity,* if any. I would argue, therefore, *combination* should be replaced by (network) *connectivity* in digital economy.

In order for new combinations to be carried out successfully, Schumpeter argued that we never assume the carrying of new combination takes place by *employing* means of production which happen to be *unused*. As a rule the new combinations must *draw* the necessary means of production from some *old* combinations. Recently, Harvard Business School Scholars, Baldwin and Clark (2000), tried to use the computer as the powerful lens through which to observe and study the evolution of designs, and the development of an industry. They find out strikingly: the changes that can be imagined in a *modular* structure are spanned by *six*, relatively simple modular *operators*. These operators can generate all possible *evolutionary path* for the structure. The six modular operators are: splitting, substituting, augmenting, excluding, inverting, and porting. The “porting” operator, as the name suggests, *ports* modules to other systems. The other five operators only work within their respective system. Porting occurs when a hidden module "breaks loose" and is able to function in more than one system, under different sets of design rules, i.e., different *architecture*. As I described above, the Komtrax unit inserted in construction machinery, was *ported* into the corporate management system at headquarter for demand forecasting. Nowadays, the Komtrax units are ported into “smart construction,” i.e. semi-automation at construction sites. As indicated by this example, I would argue, “drawing the necessary means of production from some old combinations,” should be replaced by “porting of hidden module so that it can function under different architecture.”

By referencing the monumental work by Schumpeter, I am arguing the IoT revolution combined with the development of digital economy is truly bringing a fundamental change (Kodama, 2016). We should, therefore, attempt to reformulate innovation in a new light. The IoT innovation occurring in the automobile industry, for example, is a good illustration. It is not too much to say that “Renaissance” is proceeding as far as the automobile transportation. If so, the concept of demand articulation remains a critical element in the highly sophisticated techno-society.

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