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Financing for Technological Innovation Business Start-up: Real Option and Product Modularity

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Key Word

Finance, start-up, real option, disruptive innovation, modularity, SP/A theory

Abstract

Both entrepreneurs and investors are aware that startup that has innovation can create more growth and increase chance of success than not. And innovation that is disruptive, either low-end disruption or new-market disruption can create high growth and increase chance of success and survival of startup from incumbents' competition. To create disruptive innovation, reconfiguration of products can be done by modularized original design and take unnecessary parts out to reduce cost or add new complimentary components that serve needs of users.

But innovation also causes investors difficulties in valuing innovative startup business due to nature of uncertainty in technology and market. Real option is one of the proper approaches to value the financing of technological innovation business start-up due to nature of its consideration of value of flexibility to cope with uncertainty. Real option is also valuable when product structure is modular because it allows

reconfiguration to match with changes from uncertainties in technology and market.

However, investors' consideration of risk and return on the object (or startup) that investors finance could not fully reflect behaviour of investors in making risky choices. Investors with high risk aversion are normally prefer to give more weight to characteristics of technology and market of the startup that can provide more certainty that the startup shall survive so they would not lose their investment. On the other hand, investors with lower risk aversion are normally preferred to give more weight to characteristics of technology and market that can provide higher growth.

With combination of safety-first and anticipated utility, the SP/A (security-potential/aspiration) theory came in to picture because of its ability to address different mentality of investors for gain and loss. In the case for startup financing, it could be applied to address the concern of investor or financier on survival and growth of their investments in startup. The startup companies that can integrate and apply modularity for its product development, and apply real option strategy to achieve disruptive innovation, can create survival and growth level that satisfy investor preference of security and growth potential under SP/A theory.

This study proposed an integrated view of both investors and the startup by using investors' financial evaluation criteria under SP/A theory that concerns survival and growth of the startup to capture value creation of startups with real option that were enabled by corresponding modular operators to create disruptive innovation.

Investment in Startup

Financing for the startup companies is one of the major obstacles for promoting innovation. Key problems are about how to create innovation, how to value it, and how to let investors understand the value created from innovation.

Startup firms account for much of innovation creation, but access to capital was one of the most important issues for startup (Berger and Udell, 1998). The probability that an invention will be commercialized through firm formation is influenced by its perception importance of opportunity, radicalness of invention, and broad patent scope (Shane, 2001a). But capital constrains made them unable to exploit every potential profitable opportunities (Bollinger et al., 1983). Therefore, availability of financing support for startup should mitigate obstacles of creation of innovation.

Decision to invest or finance the startup by venture capitalists or business angle comprise of consideration on startup's growth potential and down-side risk protection, focusing on factors relating to product/technology, market, entrepreneur, target return (Macmillan et al., 1985, Tyebjee and Bruno, 1984, Zacharakis et al., 2007). In addition, in order to show to the investor that the startup can survive and grow, the startup has to show that it has knowledge and experience in industry, resources and skill to educate new market, and competitive rivalry (Shepherd, 1999).

Decision to invest or finance the startup mostly assists by financial tools. With the startup process that contain uncertainty of survival and incremental of choices, real option lens can be a useful tool to provide a view for investment that response to opportunity (Bowman and Hurry, 1993). Any investment than has stages or incremental investment, can be evaluate through option lens (Raynor, 2007). Real option can be used to provide financial logic for small investment that create right, but not obligation, to make further investment as new information revealed as planned. As a result, real option possess characteristic of flexibility and learning for business startup in pursuing opportunities with low risk, through amplifying the upside but contain the downside (McGrath and MacMillan, 2009).

Investment in Disruptive Innovation Startup

Disruptive innovation is one of the strategies than can predict how startup could create and sustain successful growth. To create new-growth business, the startup could choose either low-end disruption that focus on overserved customer, or new-market disruption that focus on noncustomer (Christensen and Raynor, 2003). The startup that could be a disruptive innovator must deliver nonprice value at a cost that incumbents could not match through either from a classic strategic differentiation, a new business model with a different productivity frontier or a new business model that push new productivity frontier outward by key enabling technology (Raynor, 2011).

Productivity frontier was defined as maximum value that company can offer product or service at given cost. It constitutes a trade-off between dimension of operation effectiveness and nonprice value. In order to deliver maximum value, firm can improve its operation effectiveness to obtain lowest relative cost position on one dimension, or improve its nonprice value through activities that create variety of product, satisfying various types of needs, and various ways of access to product on the other dimension. Strategic fit among systems of such activities can create sustainable competitive advantage (Porter, 1996).

To achieve new productivity frontier, the startup can reconfig its product or process to make its design become modularity. Modularity, when applies to existing product structure, can transform proprietary product architecture into new structure with common design rules and modules that enable lower cost from component reuse, improve bottleneck performance by substitute with new module, or add specific functions desire by specific niche market users. When product becomes modular, it creates option to design product in new ways that can change market value of previous design of product or process (Baldwin and Clark, 2000).

Real Options and Opportunity

Real option reasoning is a thought process for firm with entrepreneurial mindset or startup searching for opportunities (McGrath and MacMillan, 2000b). McGrath and MacMillan, (2000b) categorized options related to opportunities with consideration to different level of technical uncertainty and market uncertainty as core enhancement launches, platform launches, positioning options, scouting options, and stepping-stones options. However, for startup, there is no yet any core product to enhance. Therefore, the possible options for startup are positioning options, scouting options, and stepping-stones options.

Positioning options create right to wait and exercise when opportunities are clear. Investment in technological positioning options is valuable when there expected to be high potential market demand or opportunities but not yet clear which technology will dominate, lacking dominant design or standard, or lack of technology feasibility, or lack of regulatory to support such technology. The key is to make smallest number of positions by investing new technological capability at the lowest cost to hedge against making a wrong position The best course for startup that invest in new or uncertain technology to benefit from this technological positioning option can be in making small investments in that uncertain technology (McGrath, 1997, McGrath and MacMillan, 2000b, McGrath and MacMillan, 2000a). The learning and experiment shall be expected to be an improvement in efficiency of technology, cost reduction, and possibility to establish that new technological capability into new platform (Kogut and Kulatilaka, 1994) that enable new product or feature to be added or existing to be removed (Gawer, 2009).

Scouting options, or probing options, extend existing capabilities to new direction that there might be high market opportunities and uncertainties. Investment in market scouting option can be in varying current product feature and bundle different complimentary attribute,

peripherals, to test nature of demand, size and growth of future market. (McGrath and MacMillan, 2000b)

Stepping-stones options comprise of many stages of sequenced of real options, addressing to create new technology capabilities that might satisfy future market opportunities. It contains many small technological positioning options and market scouting options. The startup can initiate with small experiment in less challenging market niches that entrepreneur knows its customer who can provide feedback to improve technology and market offering, and use the experience gain there as stepping stones to build capabilities in another increasing challenging and attractive market (McGrath and MacMillan, 2000b). When the path of technology and market development are uncertain, there may be a chance that young companies which success in one business or market used it as a stepping-stone to success in other new products or new markets (Damodaran, 2009).

Real option reasoning was used as assessment tool to value technology positioning options. Value of technology option was proposed to be comprised of value of claim on potential upside less with cost to develop technical capabilities (option price) and cost to commercialize technology to market (McGrath, 1997, McGrath and MacMillan, 2000a). To value real options, binomial lattice model can represent uncertainty by showing evolution and changes of value of underlying asset through risk-neutral probabilities of outcomes as it pass in different stages from beginning until final date (Amram and Kulatilaka, 1999).

Real Options and Modularity

Modularity can be valued using real option because real options are embedded in designs, technologies, and production processes (Baldwin and Clark, 2000, Gamba and Fusari, 2009).

Baldwin and Clark, (2000) had identified six modular operators as splitting (complex system to many modules), substitution (old with new module), exclusion (unwanted modules), augmentation (by add new module), inversion (combine common elements), and porting (create shell to let module works with other modules).

In general, real options have been identified to be valuable in various dimensions and modularity has specified various functional to reconfigure product design to obtain higher option value. For startup, the entrepreneur needs to explore how to make use of these modular operators to create growth and sustainability. In addition, for investors in startup, they need to explore how to use real option to value the business and product after applying modular operators.

Design capabilities is capabilities form high level of knowledge of new/enable technology to focus on attribute that customer value and at lower cost (Ulrich and Eppinger, 2008). Product designed in Platform system that allow other product to be created on top of its product can create valuable product development option and given them away to other companies. More product developed for the platform, the more valuable the platform as increasing return economies (Arthur, 2007). As a result, product system architecture need to be designed to allow easy rework according to reflect change from actual market needs.

Technology components can be put together or combined into structure of final product from components, parts or assemblies (Arthur, 2007). Baldwin and Clark, (2000) had identified six modular operators to reconfigure product structure as splitting, substitution, exclusion, augmentation, inversion, and porting. The characteristics of real option in modular operators lie in implementation and testing whether the value of the new design after applying modular

operator is positive or not. When best outcome of experiment reveals best performance or value, then the option is deemed exercised (Baldwin and Clark, 2000).

Splitting operator change single-level design with interdependent parameters and converts into hierarchical structure design with core design and subsidiary modules. Substitution operator compliment splitting by allowing replacing existing module after split with new module that is better in design or performance (Baldwin and Clark, 2000). Splitting and substitution are basis for creating modular structure that contains flexibility to future changes.

Exclusion operator takes out unnecessary modules to create the simplest configuration or minimal system for specific purpose at lowest cost. Augmentation incorporate users requirement by adding new module to give system new type for functionality required by users. Exclusion and Augmentation are basis for reconfiguration, after modularized by splitting and substitution. With strategy of exclude-then-augment, market entry strategy for newly reconfigured product can be started as initial version with minimal system design and then introduce other module augmentation to add new features after core minimal system success in the market. Early sales should serve as establishment of system in the market place, and the payment for addition modules can come at later stage. (Baldwin and Clark, 2000).

Inversion operator takes previously hidden modules that commonly used by others and move it up the design hierarchy. By making the modules visible to others, it allows reuse of the inversed modules, therefore reducing component, increase efficiency and lower cost of new design. Porting operator breaks loose the hidden modules and extend to overlap to be used by other system. It also translates information to be used in another module. Both inversion

and porting reduce cost of design or redesign by not having to start from the beginning each time there is a need to use such module (Baldwin and Clark, 2000).

Real Options and Disruptive Innovation

Technology change had contributed to change of structure and relationship of firms and market. Without proper anticipation of value from commercialization of technology in such new market, opportunity arise from disruptive technology will be valued as unattractive economic and financial return. As a result, established firms did not allocate proper resource to disruptive product development and commercialization. Technology choices, therefore, should be made by firm to anticipate value to be generated from disruptive technology, which would influence the strategic action of firm (Christensen and Rosenbloom, 1995).

Identification of Disruptive innovation could be done by characteristics that define it (Raynor, 2011). They need new business model, enabling technology, and new trade-off between price and non-price value. For new business model, the startup must have a new business model that defines a different productivity frontier. It must be able to be profitable by serving customers that are unattractive to incumbent players even if incumbents chose to try to serve them. For enabling technology, the startup must be able to push the new frontier out by a technology or a set of process that incumbents are at a disadvantage in adopting. It be able to deliver higher levels of performance and complete for more demanding market segments, without changes to the business model. For new productivity frontier, the startup must create a new trade-off in price and non-price value that expanding at a rate and in a way that able to provide new level of non-price value at a cost that incumbents simply can not match, and finally drive up market to become new dominant. It must be able to deliver similar or higher levels of performance than incumbent providers at lower cost (Raynor, 2011).

By integrating modularity, real option, and disruptive innovation, we can conclude that augmentation operator can create new-market disruption by enable firms to deliver nonprice factors that added to satisfy customer needs with market scouting option. And exclusion and inversion operators can create low-end disruption by enable firms to deliver lower cost and better performance with technology-positioning option.

In conclusion, startup has choices to be made for technology development on commercializing such technology to either, in broad category of low-end disruption that likely to require shorter duration of investment, lower amount of investment, lower level of technology and market risk, and medium-to-high return expectation or new-market disruption that likely to require longer duration of investment, higher amount of investment, higher level of technology and market risk, and higher return expectation. Selection on which type of options to choose in some level depends on fit between startup strategy and capabilities.

Investment Criteria and Capabilities

Capabilities are underlying assets of firms that create valuable resource. Framing capabilities as real option create balance focus on exploitation of capabilities and exploration of opportunities that match with such capabilities (Kogut and Kulatilaka, 2001). Professional investors, such as venture capitalists, commonly use criteria of technology capabilities, market capabilities, and entrepreneur capabilities, together with expected financial return, to make decision about investment in startup (Tyebjee and Bruno, 1984, Macmillan et al., 1985, Shepherd, 1999, Zacharakis et al., 2007).

Technology Capabilities

Technological capability is ability to use technological resources to combine/recombine components, linkages between the components, methods, process and techniques, and underpinning core concepts to offer products (Afuah, 2002). Each product can be viewed as bundles of characteristics or attributes. Customer chose product of one firm over others' when that product offers better value or better performance. Customer value can be comprised of performance characteristics, physical characteristics, and product technology. Performance characteristics are benefit perceived by customer and fit in customer value network or system of activities (Christensen and Bower, 1996).

For entrepreneur to exploit such opportunity further through firm creation, key influential factors were found to be the nature of individual making decision, nature of industry in which opportunity would be exploited, and nature of the opportunity itself. In addition to that, the pace of technological change can also influences the rate of firm formation. Analysis on technological opportunity found that factors that influence probability of firm formation were the importance, radicalness and patented scope of technology. The importance was measured by the magnitude of economic value of invention, radicalness measured by the degree that invention differs from previous invention in such field, and patent scope measured by the scope of intellectual property protection (Shane, 2001a).

New technological opportunity will be commercialized in order to exploit profit from such innovation. In addition to just technology opportunity, the variation in technology lifecycle and appropriability conditions were found to be factors influenced probability of new technology to be commercialized through new firm formation. When technology is in early stage, age of technology is young and market is segmented, exploitation of technology through new firm formation is favoured due to low competition from incumbent as market

size is limited or unproved. The willingness to exploit an invention depends on ability to appropriate its value, which depending on effective of patent protection and complementary assets, such as distribution system or specialize manufacturing are not in advantage by incumbent firms (Shane, 2001b).

In the strategic technology assessment review (STAR), McGrath and MacMillan (2000a) described technological capabilities factors that corresponding to technological positioning option value as comprised of value of claim on potential upside less commercialization cost and less development cost. Value of claim on potential upside was a function of positive level of cash flow which were affected by structure of demand, speed of adoption, blocking potential, and a function of sustainability duration of cash flow which were affected by competitive response, ease of imitation, and standard capture. Commercialization cost was a function of investment to access market, investment to build infrastructure, parallel technology cost, and industry development costs. Development cost, or option cost, was a function of firm capabilities, spill over effects, and potential downside damage (McGrath and MacMillan, 2000a). Factors above, when categorized into dimension of technology and market, were found that more uncertainties lie on technology than on market. Investment in higher uncertainty of technology than market factors, and be best utilized technology positioning options.

Technology capabilities with design capabilities can provide exclusion and inversion operators to create low-end disruption by enable firms to deliver lower cost and better performance with technology-positioning option.

Market Capabilities

Market capabilities are complex bundles of skills and collective learning, exercised through organizational processes that ensure superior coordination of functional activities toward market and customers (Day, 1994). Subgroup of market capabilities are market-sensing and customer-linking capabilities. Market-sensing capabilities emphasize ability to learn about customer, competitors and channel members in order to continuously sense and act on events and trends in present and prospective market. Customer linking capabilities is ability to create and manage close customer relationship through continuously exchanging information about needs, problems, and emerging requirement and coordinate activities relating to customers' order (Day, 1994).

In order to create profitable growth, firms should deepening strategic position in making activities more distinctive and valuable to customer by providing more choice of product or service varieties, serving most or all needs of particular group of customers better, and preferred choice of customer access through product and product information (Porter, 1996).

Market capabilities with design capabilities can provide augmentation operator to create new-market disruption by enable firms to deliver nonprice factors that added to satisfy customer needs with market scouting option.

Entrepreneur Capabilities

Entrepreneur capabilities that is capable to withstand intense effort during startup was the highest weight factor from venture capitalists (Macmillan et al., 1985). With uncertainty in technology and market development, the most important job for startup is entrepreneurial leadership; technology and market insight, allocation resources, planning, and real option reasoning to see opportunity and exploit it (McGrath and MacMillan, 2000b). The

attractiveness of such opportunity depends on entrepreneur's ability to recognize market value of a particular technological innovation, which such ability was based on entrepreneur prior knowledge in solving customer problem in related market (Shane, 2000). For startup, entrepreneur can reconfigure its product offerings and redefine value chain, in order to withstand competition from incumbent (Porter, 1985). Modular operators can be used to reconfigures any product offering to either reduce cost or increase variety to offer to markets. As a result, entrepreneur capabilities can support the use of technology positioning options, market scouting options, or stepping-stone options, depending on level of entrepreneurial intensity that match with level of goal desired by investors.

Investors' Evaluation of Startup

Investment in startup from external investors such as venture capital or business angel are rare, because valuing companies early in life cycle is difficult partly due to lack of operating history and because of risk of survival (Damodaran, 2009).

Consideration of investor preference is very important factor in financing startup, especially for individual investors such as business angles. The importance of preferences for upside potential and limiting downside risk is considered to be more important to individual investors when investing in startup because they cannot diversify the risk out in capital market. Therefore, it is important for startup to structure its product structure to be in-line with tools and criteria that investor is using so that it can reflect valuation that match with investors' behaviour in making choice under uncertainty.

Investor's Evaluation and SP/A Theory

Investors evaluate the startup and making choice depending on indicative factors that could help predict survival and potential of growth (Macmillan et al., 1985). But general risk and

return derived from mean-variance tools might not fully be comprehended by individual investors who focus their objectives on survival and growth (Shefrin and Statman, 2000). Lopes and Oden, (1999) proposed SP/A (security-potential/aspiration) theory as a dual criterion model for investment choice under uncertainty which incorporate the analysis of investors seeking for security from its investment or potential of gain and aspiration level in avoiding poverty or seeking wealth. With modularity, entrepreneur could reconfigure product by split previous design structure into smaller modules through different modular operators that possess options in the way that enable security and potential of growth for investors' need.

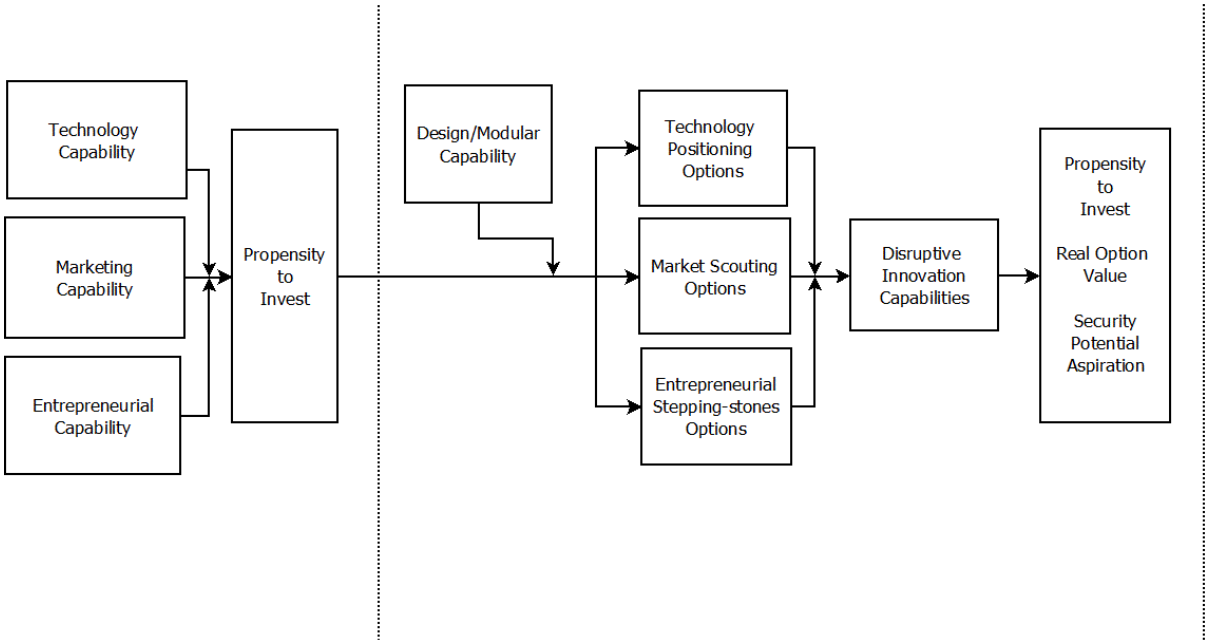
Integration Modularity, Real Option, Disruptive Innovation, and SP/A Theory

The integration of entrepreneurs in structuring their products to create disruptive innovation to match with investors' behaviour in making choice under uncertainty are important to bridge demand and supply for financing for innovation. Therefore, this study proposes to integrate real option and modularity to the way startup and entrepreneur utilize its capabilities, assess technology and market, seek opportunity, and choose between types of disruptive innovation.

However, calculation can be complex and divert away from real issue of managing proper strategy to cope with survival and growth. As a result, the proper tools should allow both investors and entrepreneurs to exercise both precise detail level valuation and also exercise broad view of strategy to enter market. As a result, this study proposes to apply SP/A (security-potential and aspiration) theory with various options and modular operators that security and growth for the startup.

Therefore, when use SP/A (security-potential/aspiration) theory to help investors understand proper value of startup, due to its coherent with modularity, real option and disruptive innovation, we propose the frame work as follows.

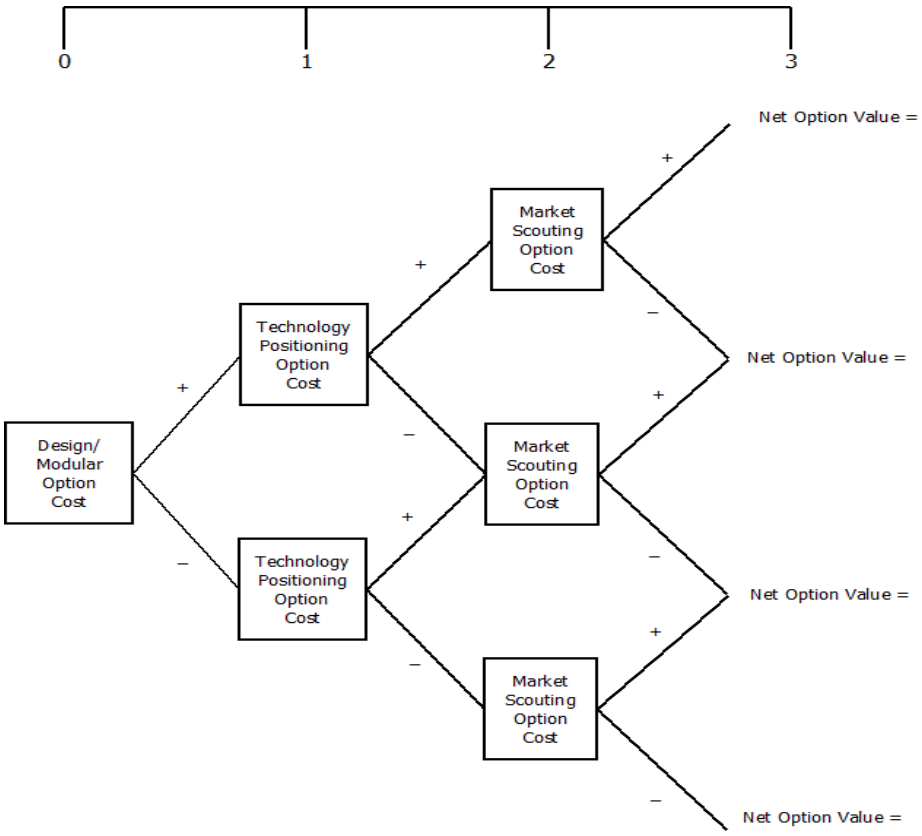
Figure 1: Valuing startup with real options created from design / modular capabilities



Under typical evaluation criteria, investors value the startup form technological, market, and entrepreneurial capabilities. With additional investment in design capabilities, startup can reconfigure product and process to enable options in technology positioning, market scouting, and entrepreneur stepping-stone option to create upside potential and reduce downside risk that corresponding to either low-end disruption or new-market disruption. Focusing on valuation process that describe capping downside risk and upside potential, the starup funding request should match with investors preference on meeting security need, growth potential needs, and match level of aspiration of wealth of investors with intensity of entrepreneur.

The concern of investor or financier on survival, sustainability and grow of the start-up, under criteria of investment choice under SP/A can be satisfied if new product is developed with option created from corresponding modular operators. It is hypothesized that in order for startup to survive the competition, it can use modular operators to split and exclude unnecessary module to have option to reduce cost and improve efficiency as low-end disruption. In addition, the startup may choose to have option to expand its current technology capabilities in different future market by using modular operators to add new modules that correspond to the need of new market as new-market disruption.

Figure 2: Real option valuation of startup with prior investment in design capabilities



At the stage of valuation under real option, investment in capabilities will provide options to enter into each choices either technology or market. However, investment in design capabilities that will create modular structure should be considered as initial investment that will further enable options in technology or market to occur.

Conclusion

The proposed model hypothesize the integration between startup capabilities, modularity design to help transform product and process to enable various options needed for making the business become either low-end disruption or new-market disruption. The modular operators such as splitting and excluding shall enable technology positioning option required by low-end disruptive innovation which improve survival chance of startup and satisfy security need of investors. And modular operators such as adding and inverting shall enable market scouting option required by new-market innovation which improve growth potential of startup and satisfy potential need of investors.

For individual investors, real option calculation may be complicate, and may be even complicate with SP/A theory. Simulation of value could be a good learning tool for both investors and entrepreneur to exercise various options related to investment in each capabilities. It could be a starting point for discussion and negotiation between entrepreneur in order to better explain the process of value creation and risk reduction.

Implications

Applying SP/A theory as valuation tools implies that there are further exploration in factors that affect directly on behaviour of both entrepreneurs and investors. On the other hands factors that occurred as biases on perception of goal by entrepreneurs and investors also worth further studies because both entrepreneur and individual investor are more sensitive to biases than institutional investors.

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