Finamatics & Innovation in Product Development Designs of Technology Companies

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Abstract

This article suggests that new technologies and the ever evolving market for technology companies require an approach that goes beyond the conventional bounds of finance and investment knowledge. Due to ever evolving customer needs, technology companies are inclined to engage in continuous product development and improvement. On the other hand, financial margins for technology companies are steadily shrinking; which renders conventional approaches to deal with investment projects as insufficient. In this paper we put forward a new approach, namely *Finamatics*, to deal with such situations. *Finamatics* explains the costs and benefit dynamics of the product development process significantly better than the conventional approaches. *Finamatics* explain the whole process and the factors involved in greater detail and clarity which is otherwise impossible with conventional approaches. Without *Finamatics* many promising technologies and products may never see daylight and look commercially unfeasible. *Finamatics* can visualize and account for the value of a project or product which is beyond the conventional value.

Keywords: Finamatics, technology management, investment appraisal, innovation, product development process.

Introduction

The product development stage is a crucial turning point given that it involves substantial insecurity with respect to the various factors affecting the worth of these investment opportunities. Normally one will think of factors like a potential product's success or failure, expected demand, product prices and other manufacturing costs involved. In the case of many technology companies, the uncertainty factor is puffed up by the substantial delay between the time when money is invested in the product's development stage and the timing of potential future cash inflows from the successful launch of the new product.

This article suggests that new technologies and an ever evolving market for tech-companies require an approach that goes beyond the conventional bounds of finance and investment knowledge. Given the fact that companies are inclined to engage in continuous product development and improvement scenarios, and ever evolving customer needs, in addition to shrinking financial margins for tech-companies, unconventional approaches to deal with investment projects are necessary. In this paper we suggest that *Finamatics*, an approach explained later in this article, explains the costs and benefits of the product development process significantly better than conventional approaches. Finamatics explain the whole process and the factors involved in greater detail and clarity which is otherwise impossible with conventional approaches. Without finamatics many promising technologies and products may never see daylight and look commercially unfeasible.

Finamatics can visualize and account for the value of a project or product which is beyond the conventional value. The value is not only the immediate payoff or the cash inflows; Finamatics see product development and innovation paying off in a number of ways. These additional payoffs may be the secondary use of technological innovation or the additional technical learning which may help in future development or cost savings. It happens so as innovation allows for additional technical learning about these future payoffs before a final decision on the product's launch is made and sound and promising investments are undertaken.

Technology Companies – The Trends

Technology companies are faced with a certain set of business circumstances which are peculiar to these companies. The nature of the market, the product life cycle and the market of the companies are major determinants of the product development designs of leading technology companies. The market is ever evolving and customer requirements are continuously changing; hence companies feel forced to engage in a never ending battle for maintaining or improving their share of the market. That is true in reverse too, when companies, in order to keep their leading position, cannot stop developing newer products in order to stay ahead. In this way, they fashion the market for themselves and even for many other players in the market.

However, a recent insight into the ways the technologically intensive companies adapt while developing new products, reveals something not that conventional. First, the product development risk for such companies has much wider implications than it would for other businesses typically. Technological advancements are essential to the success of a new product developed by the technology companies; hence there is great deal of uncertainty with respect to how efficient or commercially viable these technological advances will be. Secondly, development of the product may not necessarily be guided by the business potential, at least until the final product is developed and passed for market, which remains relevant by the necessity to revamp/upgrade or serialize an existing product. That is where the concept of *dream value* comes into the picture of product development strategies of technology companies.

The Dream Value

The most important product development driver for technology companies, especially for the large ones, has been found to be the dream value. More often than not, it is the dream value that determines the product development scenarios rather than the conventional investment evaluation prognosis. The challenge of going by dream value is seriously taken in leading technology companies especially those in the semi-conductor or electronic equipment making businesses. These firms are particularly forced to stay in a perpetual cycle of product development as their product's life cycles are usually very short, from 1 to 4 years maximum; hence the need to keep developing. Surprisingly, the dream value concept seems to be working for these leading technology companies who find it important to keep developing in order to retain their leading position in respective technologies; hence relegating *conventional finance* subordinate to the dream value associated with the product development.

This is certainly a most perplexing scenario for continuous product development strategies; where the end product prices are facing a continuous price decline while the technology needs to be refined and improved with an ever increasing R&D expenditures requirement. In the next section we shall see how the need for continuous innovation, or at times renovation of an existing product leads to a scenario where consumers' willingness to pay for innovation is on a declining scale and product developers are forced to continue spending on R&D on an increasing scale.

Product Development – Innovation or Renovation

The development of a technological product is usually a multistage process, with every stage as uncertain as the end product. At every stage, the company may be facing a cut-and-run scenario going by conventional finance; it is only a perceived dream value that drives a relentless pursuit of the *dream product* so as to stay on the top. Some analysts would be tempted to deal such a scenario or product development choice analogous to real options. However uncertainty inherent in the product development stages compels us to look beyond the conventional approach like real options. Real options might be an option when the alternative scenarios carry a cash flow stream which can be ascertained with relative ease or certainty. The dream value carries a lot more uncertainty and requires a treatment beyond the conventional techniques.

The situation can be exemplified by the case of laser development process in semi conductor industry, as the process starts much earlier from the stage of a wafer and goes through numerous sub-stages before it is converted into a laser. The semiconductor industry is by and large characterized by tremendous vacillations in demand, with semiconductor production equipment (SPE) makers' earnings often influenced by the silicon cycle. Tapping on the silicon cycle at the right time for the right product is very crucial for the success of SPE makers. The picture below shows the minimum number of stages a wafer must go before it is transformed into the final laser product to be used in some game console or a computer.

Figure 1 Laser Development Stages

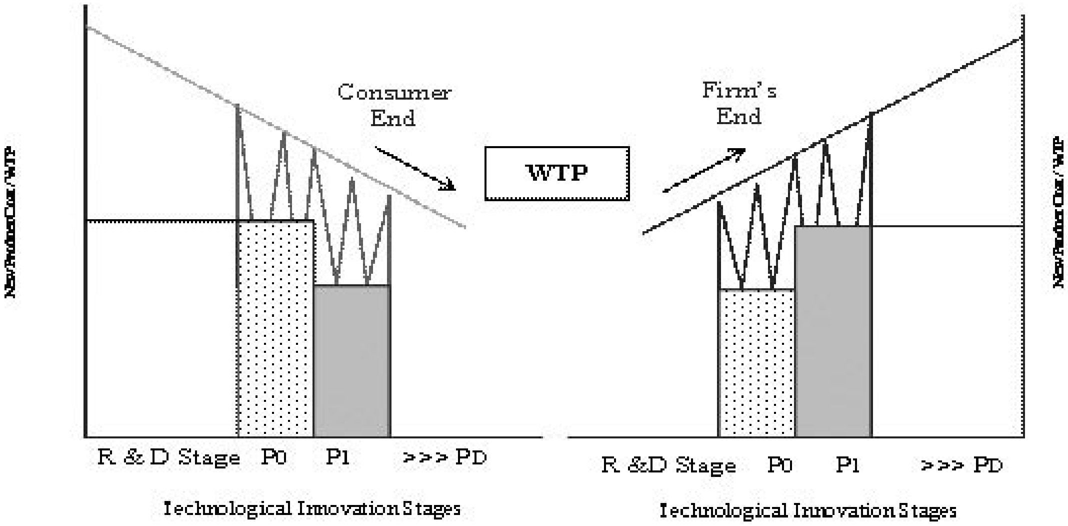
Similarly, buried capacitor development involves many uncertain and irregular stages before being perfected to be integrated into a practical printed circuit board (PCB) design which is business worthy. In the upcoming sections of the paper we shall explain how this type of product development design makes the technology companies look for unconventional treatment of the investment opportunities. But, before we do that, we have to understand the dynamics of firm-to-consumer relationship in the background of shifting financials of the technology products as mentioned in the end of last section. The next section explains the dilemma faced by most technology firms today, namely the willingness to pay (WTP) *Fix*.

WTP Fix & Finamatics

It has been observed that while technology companies are engaged in a continuous struggle to innovate and develop newer and improved products; the prices that consumers are willing to pay for such products are experiencing a steady decline. The left side of Figure 2 explains this phenomenon of declining willingness to pay (WTP) of the consumers. The right half of the figure, however, paints a different picture for the firms that are engaged in the development and production of these products. Consumers want not only better and improved products, they also want to see the prices fall. The high tech. consumer goods are no more taken as a novelty; rather those are being treated like household items. This in turn requires the products to be updated and provided more like consumer products than a top of the line high tech gadget. This situation puts the technology companies in a double crunch. As competition is increasing, the end product is fetching a lesser market price. On the other hand, tough competition and a desire to retain leading position in the product market require companies to come up with newer and innovative ideas requiring lager R&D outlays. Increased outlays in turn mean an increased cost of the final product development.

So, the dilemma is how the technology companies are going to survive as they develop newer products, engaging in innovation or renovation of the existing products which are commercially less valuable than the earlier generation of the products.

Figure 2 Technological Innovation and WTP



WTP *Fix* is the core issue of the product development in today's cut throat competition; however the conventional finance is unable to deliver the solution. The solution requires a holistic approach that considers the product development process in conjunction with all underlying aspects that come with such a process. Such an approach should be able to consider market risk as well as the idiosyncratic risk of the firm's product development process. At the same time, such an approach should also be able to underline the learning potential of the technical innovation and development process as well as the secondary use of technologies in a comprehensive fashion. Our proposed approach is based upon *Finamatics*, a brand new approach that is capable of providing a holistic treatment of the technological innovation and consequent product development. This approach is discussed in upcoming sections. However, before we discuss the potential of Finamatics, it is appropriate that we discuss the conventional financial approaches that were developed over the last few decades to deal with such scenarios. It is advisable to note that most of these approaches were developed in an era in which WTP *Fix* was not as acute as it is today. So, it should not come as surprise if in the end our findings lead to a conclusion that conventional approaches are inadequate or inappropriate to deal with today's product development situation faced by technology firms. The conventional financial approaches that were designed to cater for technology companies' product development scenarios will be referred as *conventional finacology*.

The Conventional Finacology

Even before Robert & Weitzman (1981) made significant strides towards solving the puzzle of a substantive model of product development and investment evaluation, Lucas had (1971) presented his model for the optimal allocation of effort throughout the development stage of the project. He presented his model in a setting where effort is controllable and time to completion is haphazard. However, in Lucas's model there is no way to incorporate the possibility of technical learning and all uncertainty is non-market.

Later, Roberts and Weitzman (1981) presented their model, where the firm is continuously learning about the payoffs of a project as it invests through time and space. Based on a proportionality assumption between cumulative investment and total uncertainty resolved, they derived a dispersion equation which explained that the expected benefits of a project should follow. Since they do not incorporate market uncertainty in their model, their innate results will only be applicable for investment opportunities whose value is not significantly impacted by market considerations.

McDonald and Siegel (1986) analyzed the value of waiting to invest. Their analysis is handy when the time to develop a product is insignificant or when the product has already passed the development stage, and the commercial launching is being compared with rather favorable market timing.

Grossman and Shapiro (1986) provided a few interesting research and development models that deal with product development scenarios under certainty and uncertainty with regard to progress and time to completion. In their models also, the market element is again absent and the distribution of the project's time to completion is independent of idiosyncratic actions taken by the firm and absolutely exogenous to the model.

Majid and Pyndick (1987) presented a continuous investment with time to develop model. According to their model, the only role of investment is to bring a project closer to completion. Moreover, all uncertainty is tradable. They also excluded the possibility of learning by investing from their model. Later on, Pyndick (1993) developed his model further to take into account market and technical uncertainty in a coherent framework. He assumed that revenues are fixed and costs are driven by both idiosyncratic as well as market sources of risk. His model, however, does not distinguish between the project's development and commercial phase.

Messica and David (2000) analyzed the impact of the life cycle of a project's future revenues on the optimal investment allocation in its development stages. Schwartz and Moon (2000) extended the analysis to include project revenue related uncertainty and the possibility of haphazard events, which disrupt the research effort. Cortazar et al. (2001) focused on optimal exploration investments in a mine under price and geological uncertainty. Bach and Paxson (2001) modeled investment in the drug development process. Schwarz and Soraya (2003) analyzed investment in the information technology industry both in acquisition and development projects. Miltersen and Schwartz (2002) additionally introduced strategic competition in a duopolistic market to the appraisal framework.

Finally, Errais and Sadowsky (2005) used approximate dynamic programming techniques to value sequential investments in the development phase of a product. In their model, completion of the development phase requires a series of lump investments and funding decisions are made at a set of fixed points in time. However, they limit their decision variable to a go-no go decision. Thus, their focus is on the investment thresholds rather than the optimal level of investment as in the case of this paper. The enormous limitations and the inadequacy of existing approaches necessitates the development of a technique that has a quantum advantage over them; *Finamatics Model* is one such treatment of the issues that we are going to present in the next section.

The Finamatics Model

We are going to consider a firm, its product development process and technological rate of change through the product development process analogous to the situation in which various bodies move around and change their position with or without some external force being applied through time and space. As our firm, that is engaged in technological development and innovation process, is also striving for a certain location or destination namely the dream point where it is able to develop and market a *Dream Product* (P_D). We call it a dream product because, if the firm is able to develop that product, it carries a dream value. This dream value is the commercial value or the commercial value differential that our firm is willing to forego because the P_D takes it way ahead of the peer companies and its leadership in the industry is established for a fairly long period of time.

Getting to P_D would require a lot of kinetic energy, total of which, as we understand from our learning in an early course in kinematics, should always be positive. For our firm, the kinetic energy is analogous to the sum total of funds and efforts laid out for the development of P_D instead of P_0 (see Figure 3) and the consequent payoff from the development process. P_0 represents a product which is not a significant improvement over the existing products, or is just the outcome of renovation rather than innovation.

For our purpose we are going to call all the force spent and payoff collected as *Finatic Energy (Fin En)*. The holistic and innovative approach that is based upon financial kinematics will be called *Finamatics* in this paper.[1]

It is important to note that conventional finance would rather use an evaluation approach like NPV which should be greater than zero to pass acceptance criteria. But in

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1 Application of Finamatics to product development scenarios (PDS) can be of great help. Finamatics is the kinematics replicated for financials involved in PDS. PDS involves moving from a current situation (P0) to a desirable situation i.e. being able to develop dream product (PD). This requires displacement (*d*) of PDS through time (*t*) and space. The finatic energy involved would allow displacement from P0 to PD. Basic kinematics can be applied to ascertain *d*, the directional speed i.e. velocity (*v*) and time required to achieve that desired displacement. Displacement (*d*) can be calculated as:

$$d=v_o t+\frac{1}{2}at^2$$

The directional speed i.e. velocity (initial velocity for V_0)or the rate of R&D (accompanied by decreasing uncertainty and increasing technical learning) can be ascertained as:

$$v_o=\frac{d}{t}-\frac{1}{2}at$$

The time needed to achieve that level of Δ PDS can be ascertained as follows:

$$t=\frac{-v_o\pm\sqrt{v_o+2ad}}{a}$$

However if the initial velocity is zero, i.e. the firm is originally at PPVD, instead of PPV0, then time required to achieve that level of Δ PDS will be simplified as follows:

$$t=\sqrt{\frac{2d}{a}}$$

Here, acceleration (a) is:

$$a=\frac{2(d-v_o t)}{t^2}$$

our firm's case, not every investment outlay as well as payoff can be calculated in cash for certainty; hence we shall resort to the Finamatics approach that allows cash as well as non-cash payoffs like technical learning *(TL)*, the magnitude of uncertainty spread *(UcSp)* and *dream value (DV)* to be accounted for. If we are willing to ignore these very important components of the finatic energy, we may relegate to conventional finance; but then we should not expect our firm to reach the dream land where it can produce PD, the dream product that establishes it superiority over peer firms in the industry.

As *total finatic energy* should always be positive (kinetic energy for physical bodies), we need to see that product development process results in a sum total of finatic energy that is greater than zero.

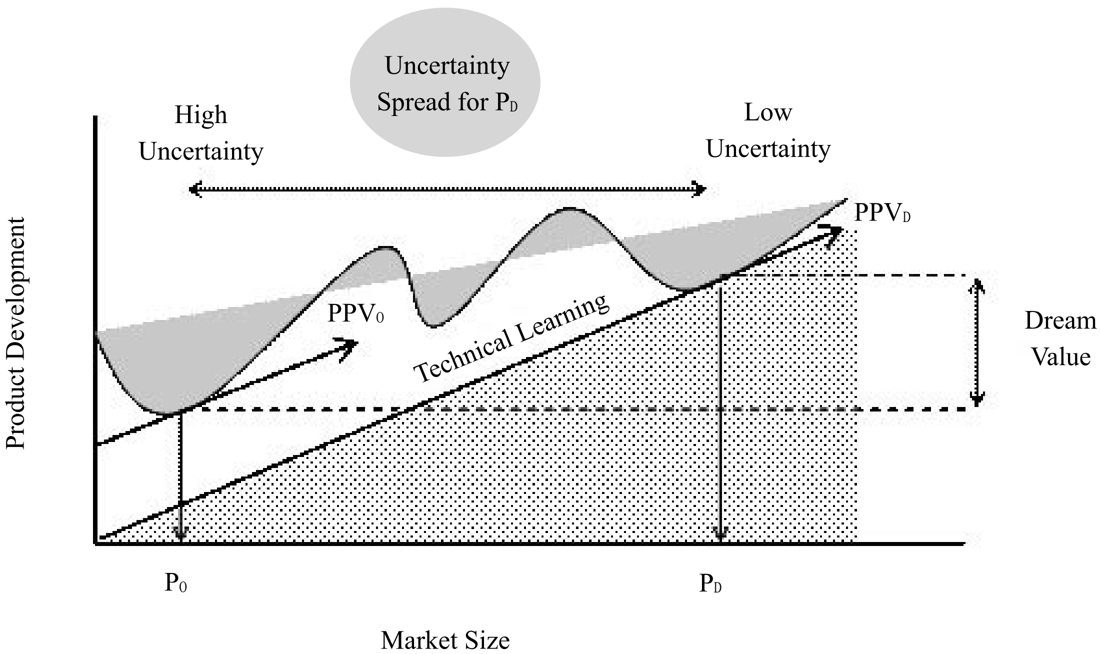
$$Fin\ En > 0$$

Whereas,

$$Fin\ En = DV + UcSp + TL$$

So, if the product development process results in finatic energy (*Fin En*) that is greater than zero or positive, the firm should be willing to go ahead with the product development.

Figure 3 Finamatics and Production Possibility Vectors



Market uncertainty, representing systematic risk, and firm's individual technical risk affect the commercial value of the project. The unpredictability driving uncertainty spread, as shown in Figure 3, is a function of the investment decisions taken by the firm at various product development stages. Thus, unlike in standard financial markets, the firm can move from obvious product development possibilities towards not very obvious but possible product development possibilities, hence reaching the target of developing a dream product. The process of moving from P_0 to P_D is fraught with uncertainty (*Uc*) and would require a lot of finatic energy, strong enough to move the product Production Possibility Vector (*PPV*) from PPV_0 to PPV_D. That added energy would be represented

by increased financial outlays on R&D and increased uncertainty. In fact, the uncertainty spread (*UcSp*) is the result of shifting from PPV_0 to PPV_D.
Thus,

$$UcSp = f(\Delta PPV)$$

Also,

$$UcSp \approx UcPD - UcP0 + \Delta TL$$

Here UcP_0 is the uncertainty magnitude at the P_0 level, whereas UcP_D is the uncertainty magnitude at P_D level.

However, the *UcSp* will be compensated by increased technical knowledge which in turn will lessen the magnitude of the uncertainty spread as the firm moves from PPV_0 to PPV_D. On the other hand, PPV_D will allow the firm to achieve P_D; hence the dream value will be added to total finatic energy involved in the process. Reaching P_D itself will be an indication as to the positive finatic energy generated.

Technical learning and the possibility of launching a profitable and commercially viable product are the main sources of the value of the investment opportunities present in the product's development stage. Technical learning can be defined in the most general way as the reduction of uncertainty with respect to the production possibility vector of a firm. As the firm moves towards advanced stages of the product development, the uncertainty decreases and the technical learning increases. This amounts to a double reward for moving towards later stages in the product development process (Figure 3).

Only by exploiting the potential of technical learning and the strength of dream product, Finamatics can allow a firm to bridge the WTP *Fix* and be able to produce a product for which consumers are willing to pay. This scenario will also allow the firm to justify its increased spending on R&D required for moving from P_0 to P_D.

Unlike technical uncertainty, which can be reduced by investing in the development stage of a product, market uncertainty is mostly beyond the control of the firm and, at least somewhat correlated with economic fundamentals.

Our two production possibility vector investment model to value product development possibilities in a context where both commutable market risk and technical risk related to product development are present is inherently superior to conventional models which were unable to offer a comprehensive treatment of the factors involved. Technical learning will be estimated upon a scale that relates investment and resolution of technical uncertainty. This scale delineates whether marginal technical learning associated with the product development is diminishing or growing.

Conclusion

WTP Fix in which most technology companies find themselves today requires application of financial approaches which are genetically superior to conventional approaches. As seen earlier, the conventional approaches do not provide a holistic treatment of all the factors involved that come with today's product development challenges. The technology companies are forced to spend more and more on R&D both to bring down the production costs as well to come up with newer and better products. Usual discounting approaches will not be able to account for all the costs and benefits that are spanned over the product development process. Finamatics are superior as they allow us to account for both idiosyncratic as well as systematic risks involved in the product development process. Also, measuring the whole spectrum of costs and benefits in terms of finatic energy allows us to consider the investment in the product development beyond the bounds of discounting based approaches; as we can consider apparently non financial gains like technical learning and dream value.

Our approach accounts separately for technical and market uncertainty in the product development scenarios. Finamatics allow us to find dynamic form solutions for the value of the option to innovate and develop in order to reach the optimal production possibility. This approach looks at how value of the investment opportunity and the optimal investment decision are affected by changes in the technical learning, the system and technical uncertainty coefficients. Even changing prices and all other market factors, a positive evolution of this technical uncertainty will boost the ultimate output/input quotient of the firm, which in turn will lead to an increase in the value of the project under consideration. Non financial costs and benefits are significant drivers of the urge to develop a new product. These factors keep evolving through time and space, a phenomenon that makes technical learning more or less relevant in different scenarios.

Last but not the least, this approach obviously has enormous potential as it can be applied to a whole lot of scenarios. The finamatics can be extended to move forward or backward in investment evaluation scenarios by applying *forward finamatics* or *inverse finamatics*. We plan to keep developing these seminal concepts and in the process plan to demonstrate that the finamatics has a key role to play in a world that is increasingly dependent on technological advancements and is still evolving.

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