Beyond Format Wars: Uncertainty and Dream Value - Neural Finamatics Modeling

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R&D Investment comes with a lot of uncertainty about the future outcomes for a business engaged in the research and development process. Whereas it may be important for businesses to engage in necessary R&D, the process is replete with enormous uncertainty and uncertain outcomes. However, very often R&D investment is carried out to assure that the business stays ahead and is not seen as taking business positioning lightly. This is where the concept of Dream Value comes into focus and encourages businesses to enter into uncertainties, hoping that outcome will be a Dream Product that will place them ahead of business rivals for fairly long period of time. The paper captures the concept of Dream Value citing practical situations and then presents ways to capture the Dream Value applying neural finamatics approach towards R&D investment decisions. Our approach shows that using neural finamatics approach it becomes possible to capture all possible product development scenarios. The paper also shows it is possible to capture value created or deleted in the process of moving from present locale to a future locale through time and space where a dream product production locale is within reach.

Key words: *R&D Investment, Neural Finamatics, Artificial Neural Networks, Dream Value, Investment Evaluation Approaches*

1. Introduction

If format wars between the electronics giants like JVC, Sony and Toshiba are any indication of how seriously they take investing in uncertain future, then this is ample evidence to suggest that dream value of yet unseen products cannot be ignored altogether. Any model proposed without putting forward a way to incorporate dream value, and entailing uncertainty would not be reflecting fully on the investment's value. Investment on research and development (R&D) for development of new products involves ample ambiguity which means considerable insecurity with respect to the various factors affecting the merit of latent or expected outcomes. More often than not, one will imagine of factors like potential end product's success or failure, the likely demand, product prices and other production costs involved. In an earlier paper we suggested that *finamatics* explains valuation of the product development process radically better from what conventional approaches can do. Finamatics approach explained the whole process and the factors involved in greater detail and clarity which was otherwise impossible with conventional approaches.

This paper explains that how the use of *neural finamatics* can help explain the potential value of uncertainty incumbent in most technology related R&D investment. *Neural Finamatics* is a finamatics approach aided by artificial neural networks (ANN).

Assigning value to uncertainty inherent in R&D investment in technological products through *neural finamatics* approach will go a long way in bringing out the complete financial worth of a potential product to be developed as a result of R&D investment. The *neural finamatics* can account for the value of a project or product that is still to be produced after a possibly successful product development process. By taking into account not only directly related and visible payoffs rather potential spill over payoffs too, finamatics approach can envision a much broader as well as more accurate financial value of the potential outcome.

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Assigning value to additional payoffs from technological innovation or R&D would be necessary as there may be additional payoffs in the form of technical learning which may help in future or parallel product development or cost savings. So, bringing the whole spectrum of product development and R&D outcomes into consideration would be more revealing and financially prudent. The key, however, is to take into account most value components of the process; however, most value components are blanketed by uncertainty about the future potential of the R&D outcome. An expensive and prolonged R&D process may end up having outcomes not very much desirable or directly contributing towards the R&D objectives; hence, it is also important to deal with the uncertainty inherent in an R&D process.

2. Format Wars: The Case in Point

In 1975 when Sony came up with Bet Amax format, it would have hoped a plain sailing as apparently there was no immediate rival, or at least for another year or so. It was next year, in 1976 when JVC introduced the VHS format, when the things started falling apart for Sony's Bet Amax dreams. Sony's dream of capturing the video recording technology market started running out of steam with slow but steady capturing of the market by rival JVC. Despite the major electronics manufacturer were split in the middle, things kept tilting towards VHS. While Bet Amax had Sony, Toshiba, Sanyo, NEC, Aiwa, and Pioneer as its followers, VHS impressed JVC, Matsushita (Panasonic), Hitachi, Mitsubishi, Sharp, and Akai. It is agreed still to this date that Bet Amax had a superior format; but it were the consumers and steady marketing by JVC that sealed the fate of Sony's dream of capturing the format market in 70s. It took another 30 years for Sony to come back in the ring to fight for another format war, this time it was DVD format and the opponent was Toshiba.

That shows Sony simply could not stop dreaming and was willing to take on another challenge and invest into another dream; as it would decide that who is going to lead the latest format world for another long time to come. This time however Sony was not willing to let Toshiba's HD DVD format to cripple its Blue Ray Disk format dreams easily. However, fighting for something so uncertain would not be easy especially when the company has already suffered a humiliating defeat in a past yet unforgotten. Convincing the investors and shareholder to put money into something that may turn out to be total failure would not be so easy. This is where the dream value concept come into play and put forward value component and investment evaluation dynamics that would help explain the potential of investing into dreams and R&D of dream products. The immediate success or failure of the product would become secondary, as dream value concept goes much beyond realizing readily marketable products.

Dream Value is present value of a future expected (or sometimes unexpected) value that needs to be captured to allow R&D spending. Sometimes DV can be cashed at present by abandoning in favor of a rival business working on similar product or product line

If DV is cashed as a negotiated value by negotiation with close rivals, it will be a present contractual value. If it is a future value realized as a result of continued R&D spending and a successful product realization. Then it will be the calculated as comparative advantage value that will give the developer long time superiority over close rivals until a rival product takes away the comparative advantage. It will not be difficult to simulate the expected corporate value in terms of business gains. ANN can be used to simulate the DV in future value terms which can therefore be discounted at an appropriate rate of discount. If major factors like ECF and DV can be quantified as explained earlier, then quantifying the whole product development scenario should be very difficult.

However, it is important to note here that the model does not mean to take into account the products that have already been commercialized; rather it is all about a product which has not yet been commercialized. That is why we are talking about R&D spending meant to develop a product that is still in the process of making. However, once the product has been developed, commercialized phase of production should not be difficult to be dealt with usual investment evaluation techniques, as by that time most of uncertainties would have been resolved.

3. Dream Value, R & D & Uncertainty

R & D and dream value are inseparable if one wants to evaluate and recognize full financial value of investment in research and development. Dream value allows flow of funds into R&D of many product development projects which many not see the light of day if one follows normal evaluation techniques. The dream value drives R&D investments by many leading technology companies like those in the semi-conductor or electronic equipment making businesses. Relatively shorter shelf life of such products forces the companies to stay in an unending cycle of product improvement; hence the need to keep investing on R&D. Dream value concept is it important to allow continuous investment on R&D as the companies endeavor to retain their leading position in respective technology. Assigning value to dream value out of inherent uncertainty, we shall see that how product developers can to continue spending on R&D on an increasing scale in order to pursue continuous innovation, or at times renovation of an existing product, while consumers' willingness to pay for innovation is on a declining scale.

4. Dream Value & ANN

Uncertainty engulfs every stage of the development of a technological product which is usually a prolonged and multistage process. Uncertainty forces the companies to consider alternative scenarios for every stage and the companies may be tempted to cut and run early; however, a perceived dream value drives continuous R&D investment. On the other hand, the dream value carries a lot of more uncertainty and requires a treatment beyond the conventional evaluation approaches. We need to need to account for the dream value in a way that does not diminish or deter the process of innovation and continual pursuit of better products. The mainstay of ANN modeling is the atypical structure of the information processing system that is composed of An ANN is an information processing model (IPM) that is inspired by the way biological Artificial Neural Networking (ANN) is one approach that can help exemplify the a large number of highly interconnected processing elements (HIPE), also know as neurons. ANNs, like BNS, learn by example through pattern recognition, data classification, or through an adaptive learning process.

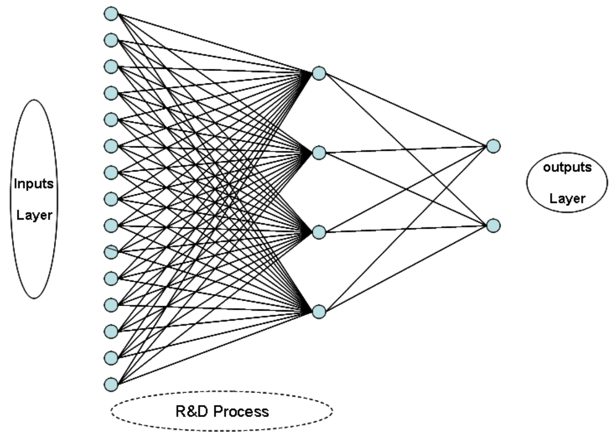

Figure 1: Uncertainty Reduction & ANN

It is the adaptive learning process (ALP) in ANNs that make them an important component of our *neural finamatics* based evaluation model; as adaptive learning is a significant component of our investment in R&D value stream. ANN adaptive learning involves calibrations to the synaptic links just like the synaptic connections that exist between the BNSs. The ANNs have shown ample caliber in predicting or simulating outcomes based upon a given set of inputs whereby the process may lead to unpredictable outcomes or outputs. It has been applied in various situations ranging from data pattern recognition, industrial process control, sales forecasting, market analysis, data validation and risk management to name a few.

ANN can be a powerful way of recognizing in advance various outcomes that R&D may lead to. It will allow us to assimilate the value of learning and reduction of uncertainty associated with the process within the overall process valuation (Figure 1). The adaptive learning process will allow overall uncertainty reduction. The added learning through adaptation will be crucial in harvesting uncertainty reduction through the use of ANN. The R&D aimed at developing newer technological products much earlier from the stage of a wafer and goes through numerous sub-stages when 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. 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, dilemma is that how the technology companies are going to survive, as they develop newer products, engaging in innovation or renovation of the existing products which are marginally less valuable than the earlier generation of the products. The solution requires a holistic approach that considers the product R&D 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 R&D process.

Also, the secondary use of technological knowledge gained during the process should be taken into consideration in a comprehensive fashion. In this sense, *Neural Finamatics* is a brand new approach that is capable of a holistic treatment of the technological innovation and consequent product development.

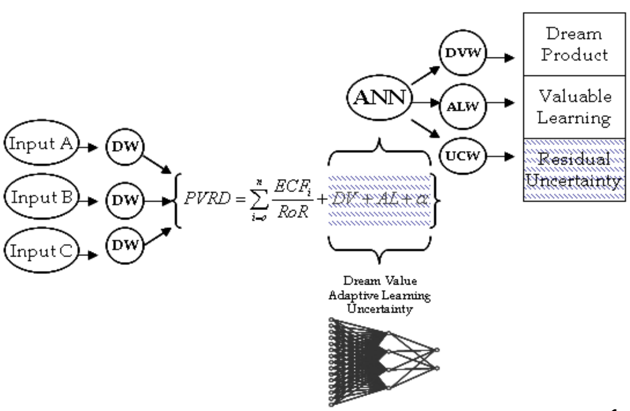

Figure 2: DV Valuation Process & Neural Finamatics[1]

5. Traditional Approaches

Lucas (1971) presented his model for the optimal allocation of effort throughout the development stage of the project. [0] His model was presented in a setting where effort is controllable and time to completion is chaotic. However he did not explain any way to incorporate the possibility of technical learning. Also in his model all uncertainty is non-market. Lucas was followed by Robert & Weitzman (1981) who made significant strides towards solving the puzzle of a substantive model of R&D and investment evaluation. [0] They assumed a scenario where the firm is continuously learning about the payoffs of a project as it invests through time and space. By applying a proportionality conjecture between cumulative investment and total uncertainty resolved, they derived a dispersion equation to explain expected benefits of a project should follow. However, their innate results will only be applicable for investment opportunities whose value is not significantly impacted by market considerations as they disregarded the market uncertainties. Grossman and Shapiro (1986) put forward a few exciting R&D models that deal with product development scenarios under certainty and uncertainty with regard to progress and time to completion. [0] 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.

Treatise by McDonald and Siegel (1986) investigated the value of waiting to invest. [0]Their study is helpful when the time to develop a product is trivial or when the product has already passed the development stage, and the business initiation is being compared with relatively complimentary market timing.

On the issue of a continuous investment with time to develop, we are also helped by Majid and Pyndick (1987) model.0] According to their model, the only role of investment is to bring a project closer to completion while all uncertainty is commutable while the possibility of learning by investing is excluded from their model.

Zahedi (1993) emphasized that expert systems and Artificial Neural Networks offer qualitative methods for business and economic systems that traditional quantitative tools in statistics and econometrics cannot quantify due to the complexity in translating the systems into precise mathematical functions. [0]

Pyndick (1994) remodeled his treatise further to take into account market and technical uncertainty in a coherent framework. This was done by assuming that revenues are fixed and costs are driven by both idiosyncratic as well as market sources of risk.000] This later model, however,

[1] **Captions used in Figure 2:** ECF = Expected Cash Flows, AL = Adaptive Learning, DW = Dream Weight, PVRD = Present Value of R&D, RoR = Required Rate of Return, DV = Dream Value, DVW = Dream Value Weight, , ALW = Adaptive Learning Weight, UCW = Uncertainty Weight, α = Residual Uncertainty

does not distinguish between the project's development and commercial phase.

Later, Messica and David (2000) scrutinized the impact of the life cycle of a project's future revenues on the optimal investment allocation in its development stage.0**00**] Schwartz and Moon (2000) broadened the analysis to include uncertainty related to the project revenue and the possibility of haphazard events, which disrupt the research effort.[00]On similar lines, Cortazar et al. (2001) bore focus on optimal exploration investments in a mine under price and geological uncertainty.[0] Brach and Paxson (2001) modeled investment in the drug development process.[0] Schwarz and Zoraya (2003) analyzed investment in the IT industry both in acquisition and development projects.[**0**] Miltersen and Schwartz (2002) also introduced strategic competition in a duopolistic market to the appraisal framework.[0]

Eyemen and Sadowsky (2005) used approximate dynamic programming modeling to value sequential investments in the R&D phase of a product. In this model, completion of the development phase requires a series of investments and funding decisions are made at a set of fixed points in time. [**0**] However, they limit their decision variable to a go-no go decision. In a final analysis, their focus is on the investment thresholds rather than the optimal level of investment.

6. Neural Finamatics Modeling for R & D

Technological rate of change throughout the product development process is akin 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. *Neural finamatics* seeks to predict the R & D progression as the innovating firm is striving for a certain production locale or production possibility tangent namely the dream point where can develop and market a *Dream Product* (PD). We call it dream product because, if the firm is able to develop that product, it carries a dream value. The dream value is the commercial value or the commercial value differential that our firm is willing to forego. Dream Product (PD) places our firm significantly ahead of the peer companies and its product leadership in the industry is established for a fairly long period of time.

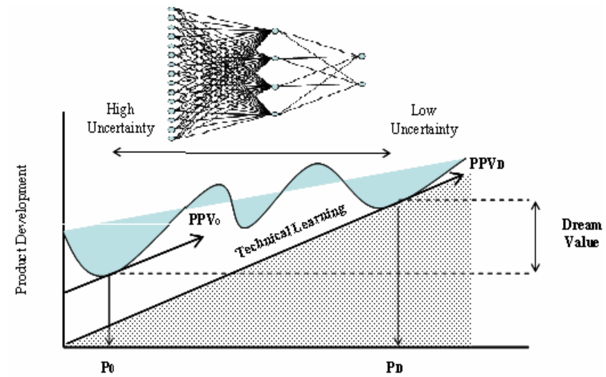

Figure 3: Neural Finamatics Valuation & Uncertainty Reduction

In order to reach the PD locale, the R&D process would require a certain magnitude of kinetic energy, total of which should always be positive. *Neural finamatics* will be needed in order to understand the complexity of the R&D process and various outcomes that it may bring to fore. For our firm, the finatic energy is analogous to the some total of funds and efforts laid out for the development of PD instead of P0 (Figure 3) and the consequent payoff from the development process.[2] P0 embodies a redundant production locale which does not lead to a significant improvement over the existing products, or is just the outcome of renovation rather than innovation. Initially PPV takes a downwards shift to allow a greater push towards future development by a surge in fanatic energy in order to tap production possibilities scenarios. Without a downwards shift, the PPVO will move into no production possibilities arena, though there will be less uncertainty. But at the same time there will be no dream product to be had. For our purpose we are going to call all the force spent and non-cash payoffs (dream position, uncertainty residual and adaptive learning) collected as *Finatic Energy (Fin En).* Once end product production is materialized, cash payoffs can be evaluated at an appropriated discount rate. The holistic and innovative approach that is based upon financial kinematics will be called *Finamatics* in this paper.[3]

[2] *Finatic Energy* is the financial equivalent of human or physical kinetic energy used in acquiring a desired displacement across time and space. It is desired in the paper to use the term *Finatic* as much as possible; fanatic energy is the total R&D spending used over a period of time to move production possibilities from Po to Pd by allowing PPV (Production Possibilities Vector) to shift from PPV_O to PPV_D.

[3] 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

For an ongoing R&D Process, it is not easy to calculate all relevant cash flows with certainty; hence we resort to *Neural Finamatics* approach that allows precise estimation and consideration of cash as well as non-cash payoffs like technical learning (*TL*), the magnitude of uncertainty spread (*UcSp*)[4] and *dream value* (*DV*)[5].

We know that *total finatic energy (TFin En)* 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.

TFin En>0

Whereas,

TFin En = DV +UcSp + TL

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

Further, the market uncertainty, i.e. the systematic risk, and firm's individual technical risk affect the commercial value of the project. The fickleness driving uncertainty spread, as shown in Figure 3, is a function of the investment decision taken by the firm at various product development stages. Thus, the R&D process push the firm from obvious product development possibilities towards not very obvious but possible product development possibilities, hence reaching the target of developing a dream product.

However, the R&D process of moving from P0 to PD is laden with uncertainty (*Uc*) and would require a lot of *finatic* energy, strong enough to move the product Production Possibility Vector (PPV) from PPV0 to PPVD. 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 PPV0 to PPVD.

Thus,

UcSp = f (∆PPV)

Also,

UcSp ≈ UcPD – UcP0 + ∆TL

Here *UcP0* is the uncertainty magnitude at the *P0* level, whereas U*cPD* is the uncertainty magnitude at *PD* level. The *UcSp,* on the other hand, will be compensated by increased adaptive technical learning which in turn will lessen the magnitude of the uncertainty spread as the firm moves from PPV0 to PPVD. On the other hand, PPVD will allow the firm to achieve PD; hence the dream value will be added to total f*inatic* energy involved in the process.[6]

Reaching PD itself will be an indication as to the positive f*inatic* energy generated. Technical learning and the possibility of launching a profitable commercial viable product are the main sources of the value of the investment opportunities present in the product's

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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:

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

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

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

The time needed to achieve that level of ∆ 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 ∆ PDS will be simplified as follows:

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

Here, acceleration (a) is:

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

4 UcSp can be measured in different ways for different business e.g. software and system developers assign a certain value to each code/codec in system development process. Successful development of successive codes/codec is measured in terms of reduced uncertainty magnitude towards end product development stage. Each product development process will have to define its own product development milestones and will have to assign them an appropriate process value.

5 Dream Value is present value of a future expected (or sometimes unexpected) value that needs to be captured to allow R&D spending. Sometimes DV can be cashed at present by abandoning in favor of a rival business working on similar product or product line e.g. Toshiba abandoning in favor of Sony's Blue Ray Disk at an earlier stage without developing HD DVD format. In that case as the negotiated value would be captured at present not in future, so it is important to deal DV as a separate value in the PVRD model. If DV is to be cashed in future, then obviously it can easily be discounted at an appropriate required rate of return. In that case the model would be easily adjustable to allow time value discounting of the DV. Same is the case for AL and uncertain outcomes represented by α.

6 The case of Format wars between JVC & Sony and then between Toshiba and Sony is a very relevant example. The Section number of the paper explains in detail about the history of this case example. Moving through uncertain and unchartered territories is like moving from current to not very obvious but possible scenarios is where we shall need to consistently apply a certain magnitude of fanatic energy to acquire the needed displacement from PPV_o to PPV_d.

development stage. Adaptive 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 R&D process, the uncertainty decreases and the adaptive technical learning mounts, which amounts to a twofold reward for moving towards the later stages in the R & D process.

Only by exploiting the potential of technical learning and the strength of dream product, *Neural Finamatics* can allow a firm to 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 P0 to PD. 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.

The twin production possibility vectors R&D investment evaluation model to value product development possibilities, in a context where both commutable market risk and technical risk related to product development are present, is intrinsically superior to conventional models. Adaptive Technical Learning will be anticipated upon a scale that relates R &D investment and resolves the dilemmas of technical uncertainty. This scale delineates whether marginal technical learning associated with the R&D process is on a diminishing scale or is on the rise.

7. Conclusion

Although the format wars is the raison deter for this paper, but they do put forward interesting case study to look into for the ways in which the concept of dream products and dream value can be assimilated into investment valuation models. Assigning value to technological R&D requires application of financial approaches which are genetically superior to usual approaches. Investment on R&D of technological products cannot be accounted by applying usual discounting approaches as these will not be able to account for all the costs and benefits that are spanned over the product development process. *Neural Finamatics* are superior as they allow us to account for both idiosyncratic as well 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 holistically the investment in the product development as we can consider non financial gains like adaptive learning and dream value.

Neural Finamatics approach allows separate value assignment to technical and market uncertainty in the product development scenarios. *Neural Finamatics* also 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 how the value of the investment opportunity and the optimal investment decision are affected by changes in the technical learning, the system and technical uncertainty coefficients. 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. They 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 neural finamatics* or *inverse neural finamatics*. Remember Toshiba lost in this latest format battle, but dream war is not over yet. If Sony's Blue Ray Disk success is any thing to learn from, then Toshiba can see a silver lining on the horizon in times to come.

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