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MA Financial Management
Final Thesis Project

Decision Support via Real Options Analysis
Financial Products / Services Analysis (FPSA)

***NOTE*: Abridged from original due to removal of confidential commercial information**

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

1.1 SUMMARY OVERVIEW

This project proposes a comprehensive Real Options Analysis (ROA) based project risk management process for end-to-end new technology development, planning, implementation, and commercialization. The ROA process allows for integrated project valuation via the formal quantification of uncertainty. A practical case involving an R&D bioethanol project associated with a European materials conglomerate serves as a practical example.

Key recommendations resulting from the following analysis:

- <u>WACC</u>

  Many R&D projects use the risk free rate or 5% as a default

- <u>Hedging</u>

  Simulation revealed distinct project risks associated with the Euro/$ exchange rate and core commodity price fluctuations (corn, bioethanol). Such risks can be actively 'hedged' via derivative instruments.

- <u>Commodity Analysis</u>

  Considering the importance of relevant commodity prices to the core business scenario, a deeper analysis of commodity trends and forecasts is justified (i.e.: comprehensive regression analysis and forecasting). Considering the value destroying and enhancing power of commodity prices to the project profit/loss profile, spending time to anticipate commodity price movements and reacting accordingly has a very high cost/benefit ratio.

- <u>Customer Finance</u>

  Biofuel plants are a capital intensive and risky line of business. Consider the example of other firms in similar lines of business who have created Customer Finance facilities to proctor customers and create advantageous markets

- <u>Market Competition Simulations</u>

  A rudimentary market simulation is conducted. It is recommended that a more refined market simulation, validated by internal stakeholders, would prove quite valuable in guiding strategy formation for the productization of innovations.

- <u>Biofuel Plant NPV Monte Carlo Model</u>

  It is suggested the BIO-INC. White Biotech consider building and maintaining a generic, biofuel plant NPV model. This would serve as a platform for staging future NPV analysis, valuing prospective products, measuring costs, evaluating new processes, and judge revenues.

- <u>ROA as Process / Project Risk Management</u>

  ROA as a process can be considered an aspect of the formal discipline of Project Risk Management, which is ideally an organizational process. ROA assumes a structured dialogue with key stakeholders and adoption of the premises and techniques associated with ROA into existing organizational decision making processes.

- <u>Validation Process / Decision Making</u>

  This case study demonstrates an example ROA exercise; comprehensive conclusions should not be drawn from the models demonstrated without an internal validation process by internal stakeholders to verify assumptions made.

Keywords

Industrial biotechnology, white biotechnology, second generation biofuel, (bio-)ethanol, corn fiber, NPV, Monte Carlo simulation, Real Options, ROA, R&D, Project Risk Management

1.2 QUALITATIVE MANAGEMENT SCREENING

In the course of planning commercialization of its second generation bioethanol process innovation, BIO-INC. White Biotech management is confronted with a number of areas of uncertainty regarding the associated new products, technologies and markets. Based on interviews with BIO-INC. White Biotech management, areas of particular deployment decision making uncertainty were documented and categorized (U = uncertainty):

U1) Revenue Forecasting:

Given the uncertainties of such macroeconomic factors as interest rates, currency exchange, market share, demand, and competition, revenue streams in the future have an embedded uncertainty range.

- How can the range of products and services be broken, categorized and priced?
- How might a range or basket of product be optimally bundled and priced?
- How will pricing variability effect demand factors?
- What can be anticipated concerning the expected subsidy factor?

U2) Process Cost Analysis:

Revenue less costs yields profit in a cash flow analysis. Although the cost parameters of the more developed processes are known, the innovative processes have relatively unknown variable and fixed factors (given the uncertainties of the new techniques and unknowns of industrial scaling). As well, some input costs have uncertain sub-elements (i.e.: cost of production derived from variances in power, chemical prices, labor, etc.). In particular, the raw material commodities employed, chiefly corn and corn fiber byproducts, have become covariant to oil prices (and thus highly volatile) due to the massive upsurge in corn-based bioethanol production. Understanding how raw material commodity pricing impacts the cost of goods manufactured is otherwise crucial.

- How will raw material supply and costs vary?
- What are geographical and regional variable costs (labor, raw materials, taxes, etc.)?
- How will oil and biofuel pricing volatilities affect profit margins?

U3) Target Process to Employ:

In converting corn to bioethanol, BIO-INC. and PROCESS-CO. together have many processes options (treatments, pretreatments, chemicals, enzymes, etc.) which can be deployed to achieve the bioethanol end product. Some of the processes are innovative and largely unproven, thus requiring investment in development. Some new treatments have a high anticipated development cost, but promise greater efficiency. Other processes are well-understood, but promise less of a potential profit upside as markets are thoroughly developed. Some treatments result in less bioethanol, but produce valuable byproducts.

- What are costing variabilities when scaling processes?
- How to identify the most efficient process or set of processes?
- How to cross-identify the most efficient process with those most potentially profitable?

U4) Product Strategy:

Amongst several processes, there are a range possible byproducts and potential paths to reap revenue. While known processes / byproducts have well-defined markets, the more innovative approaches have a broad potential range of profit scenarios (i.e.: licensing, partnering, implementation sales and services). For instance, a potential choice is to abandon second generation biofuel production and to sell corn fiber into recognized, existing markets (i.e.: animal feed). Alternatively, pursuing the innovative conversion of corn fiber to bioethanol opens a range of possible future products and services to sell, as the process involves a new market.

- How will competitive products affect marketshare and pricing?
- What percentage of the market will competitors likely seize give a certain timeframe?

- What is the optimal timeline for releasing products when considering competition?
- How do adequate development time and quality concerns balance with time to market?
- What are comparative risk / value profiles for owning a plant, selling / constructing plants, selling equipment, selling services, selling patents, partnering, licensing, or selling components?
- What inherent value do partnership investment stakes (options to expand) contain?

U5) Research & Development Planning:

Amongst several possible approaches, how much time, effort and money should be invested in testing and developing new techniques? How can risk and costs be managed effectively in R&D project management? A central assertion of this paper is that R&D uncertainty can be comprehensively quantified and managed via comprehensive risk analysis of the surrounding layers of uncertainty (U1 – U4). This concept will be expanded upon throughout the course of the paper; it should otherwise be noted that initial analysis will focus on layers U1 – U4, with the ultimate intention of quantifying and managing layer U5. The unified process is the conduct of Real Options Analysis, or ROA.

- How can projects, some being covariant, be valued in a portfolio framework in order to gate?
- What are success and failure probabilities associated with research initiatives?
- When should projects be expanded, contracted, or abandoned within a portfolio of projects?
- Concerning multivariate time horizons, when to wait and when to accelerate projects?
- How can the complex interlinked components in scaling efforts be tracked?

Rather than proposing these uncertainty categories and vexing questions as an enumeration of frustration and despair, this paper proposes that the formal specification of these interlinked categories is a step towards control and management. From a metaphorical standpoint, the set of uncertainties, when treated as a whole, can be considered to be a mathematical optimization problem, whereby running interlinked simulations and systematically reducing the uncertainties upon themselves will result in a targeted ‘most likely’ (or most efficient) set of recommended paths. In order to narrow and move towards formal quantification and control of uncertainty (and thus active risk control and management), a set of modeling and analysis ‘targets’ were enumerated.

1) **Development Valuation:** R&D Decision Making / Project Management Valuation

- Valuing project options to expand, wait or abandon development (beyond traditional NPV)
- R&D binomial decision tree analysis (i.e.: observing popular Pharma R&D models)
- Project risk profiling / assigning values to uncertain projects and project steps
- Portfolio optimization / portfolio approach to project selection and gating (comparative valuation amongst competing efforts / projects)
- Risk correlation between project elements (co-variance in project risks)
- Determining which projects to expand, contract, or abandon within a portfolio
- Project timing: when to wait, when to accelerate

2) **Modeling Costs:** Costing / Expenditure Management

- Costing variability (simulation / sensitivity amongst cost of production elements)
- Multi-period capital budgeting (how to allocate development costs most rationally over time)
- Determining plant capacity (simulating productivity given sensitivities in production chain)
- Simulating pro forma financial statements (based on variance ranges and covariance)
- Commodity price variability simulation (i.e. biofuel pricing variability based on range of factors)
- Given a complex of crops, enzymatic treatments and yeast treatments, which have the most promising production figures concerning cost, speed and yield

3) **Modeling Marketshare:** Competition Factors

- Nonlinear pricing simulation (optimal pricing in competitive environment)
- New product simulation (marketplace pricing competition given variables and sensitivities)
- Determination of product market share (given sensitivities in competitive marketplace)

4) Modeling Revenues: Product Individuation and Pricing

- Scenario analysis of subsidy factor in terms of pricing influence
- Pricing scenario modeling (comparing and optimizing revenue models)
- Ownership, licensing / leasing versus liquidation scenario comparisons
- Valuation of licensing and partnerships (option to expand)
- Using simulation to value licensing agreements (valuation of licensing scenarios)
- Price / product bundling optimization (scenarios for baskets of products & services with add-ons)
- Valuing intellectual property, patents, etc. (based on derivation from NPV and option chains)
- Pricing a subscription based service

The categorized list was then used as a guide for researching and identifying available specific analysis and modeling techniques. From here, 30 specific algorithms, analysis models or simulation techniques were identified and documented (see Appendix A: Financial Analysis and Simulation Models with Applicability to BIO-INC. White Biotech). From these, seven of the most promising were identified and presented to BIO-INC. White Biotech stakeholders (as highlighted in green in Appendix A). Finally, a overarching analysis framework, or process was researched and identified: Real Options Analysis (ROA).

ROA was identified as a methodology capable of addressing and controlling the U1 – U5 layers of uncertainty identified. ROA is underpinned by valuation modeling and simulation analysis. From here, a practical ROA was carried out from beginning to end. Several NPV revenue scenarios were composed based on active BIO-INC. White Biotech bioethanol projects. These then can be 'front-ended' onto Real Options 'decision trees' as guides to optimal development project decision making for Project Risk Management.

1.3 ROA FINANCIAL ANALYSIS FRAMEWORK

Within the context of the U1 – U5 uncertainties categorized, this paper presents a recommendation for an integrated structured decision-making process utilizing financial analysis and grounded by the principles of Project Risk Management: Real Options Anlaysis (ROA). The recommended process involves an integrated set of three financial analysis techniques:

P1) Scenario-Based Valuation (NPV) Modeling:
Give that there are a range of (U1) revenue possibilities, (U2) cost factors, (U3) process choices, and (U4) product options, the paper proposes that an integrated set of Net Present Value (NPV) base-case models be developed which can be easily modified to fit several possible future scenarios. NPV is a standard method for 'proving worth' for corporate initiatives by valuing a stream of forecasted cash flows according to the firm-weighted time-value of money (i.e.: Weighted Average Cost of Capital or WACC). The NPV ideally draws reference to the corporate financials as a whole. Thus, R&D initiatives originating within a division, as in the BIO-INC. White Biotech case, should carefully consider the assumptions made concerning such items as changes in working capital, depreciation, labor costs, and WACC. NPV scenarios and models are ideally validated and enhanced via robust internal feedback sessions involving key internal experts. Developing NPV scenarios is a worthy exercise in itself as it demonstrates the potential virtues or weaknesses of different business models and highlights assumptions.

P2) Volatility Simulation:
Typically a single, static value is applied to each variable in an NPV model. However, when forecasting, most variables in an NPV scenario can be realistically considered to have a probabilistic range or distribution. When a number of elements in the NPV are enhanced with probabilistic ranges as opposed to static values (for example, a best and worst case scenario with associated probabilities), the composite NPV case, as a whole,

can be analyzed using simulation methods. Monte Carlo simulation is a useful and widely used method. This algorithmic technique runs multiple iterations of a probabilistic scenario. A NPV model simulated in this fashion takes the form of a probabilistic 'layer cake', which, when run, is akin to a massive optimization problem. The result is an aggregate probabilistic volatility for the composite NPV case: the 'risk factor' associated with a particular project or scenario. Simulation-based sensitivity analysis is a useful and insightful exercise in itself, often clarifying previously unconsidered risks and sensitivities that might otherwise remain dormant in a static NPV model.

P3) Core Real Options Analysis (ROA):
This paper advocates a Real Options-based approach, ROA, to guide decision making under uncertainty. ROA draws upon techniques used to value financial derivatives to value the 'optionality' inherent in volatile, uncertain project outcomes. Given a set of NPV end-point scenarios and their associated volatilities, a set of possible future decisions can be traced which will end at each of the possible NPV scenarios. This is known as a decision tree. Along the decision tree branches, a decision to 'invest' or to continue a project should always be taken as long as there is an option-valued positive NPV path open with a reasonable probability of success (as moderated by the decision-makers' appetite for risk at that juncture). When all option-valued positive NPV's are gone, the project should be abandoned as there is no chance open to realize a profitable future from the effort. Uncertainty from this perspective can be specified formally amongst a set of interlocking variables and used as a component in valuing and guiding managerial decision making flexibility, which is particularly useful for R&D-related projects. Of note, option tracking is a living and ongoing process: as time unfolds, probabilities narrow or widen, requiring periodic updates to the outcome estimations (and thus 'optionality valuations' along the decision branches as they shorten and the end-points approach).

ROA intrinsically requires a valuation analysis and a quantification of uncertainty as volatility in order to produce results. Thus, it can be said that the P1 – P3 process as a whole is an integrated ROA exercise. This project treats steps P1 – P2 as discrete predecessor as they are valuable stand-alone exercises in-of-themselves: conducting them in isolation allows both for proper rigor to be applied and for results to be properly considered in isolation. However, for a proper ROA analysis to occur, the preliminary steps should ideally be conducted with planning for and deference to the goals of ROA: identifying the value of managerial flexibility and managing uncertainty.

In conducting steps P1 – P3 as an integrated ROA exercise, the recommended ROA methodology of Johnathan Mun, a noted Real Options authority and practitioner, was followed (2006: 103):

1) Qualitative management screening
2) Time-series and regression forecasting
3) Base-case net present value analysis
4) Monte Carlo simulation
5) Real options problem framing
6) Real options modeling and analysis
7) Portfolio and resource optimization
8) Reporting and update analysis

A step-by-step summary of the ROA conducted according to this process will be covered in the section following. In this framework, P1 can be considered to be equivalent to step 3 and P2 to step 4.

Lastly, implicit in the integrated P1 – P3 process is advocacy for financial risk management as a component in a formal, structured organizational decision making process (including ongoing tracking and periodic revisiting). While this paper demonstrates an example approach, a working process assumes that key personnel would be closely involved in the crucial processes of:

1) Validating NPV assumptions and scenarios,
2) Specifying uncertainties (risks) as variablities,
3) Clarifying key future decision points (and implications of those decisions), and
4) Periodically reviewing and responding to the decisions recommended by the analysis.

BIO-INC. has a formal internal R&D-associated Project Management Process; possible opportunities for integrating ROA into this process will be treated in the conclusion, but is otherwise considered out-of-scope as this topic is broad enough to deserve dedicated research and treatment.

In order to demonstrate a working ROA process, a sample NPV case is offered and enhanced by simulation to drive a Real Options decision model. The model, when connected to relevant timelines, planned decisions, slated investments, and perceived risks, can serve as a living guide for making the "most rational" (from a corporate finance perspective) project decisions. If adopted as an integrated organizational process, the Real Options model, accompanied by the foundation of NPV analysis and simulation, is regularly updated to provide fresh insight as information is clarified along the time / uncertainty continuum.

1.4 ANALYSIS PROCESS SUMMARY

In "Real Options Analysis", J. Mun describes an integrated multi-step approach to conducting ROA (2006: 103). This framework was applied in conducting the BIO-INC. White Biotech ROA exercise. In order to introduce the analysis in detail, it is useful to provide a summary specifying the high-level actions carried-out at each step of the process as a guide and background:

1) **Qualitative management screening**
As documented previously in section 1.3, between November of 2008 and May of 2009, interviews with key project stakeholders from BIO-INC. White Biotech were conducted. A general project scope and frame was formulated and refined via periodic presentation and feedback. Background research was conducted concerning the scientific and business challenges facing the group. This led up to an initial scoping white paper and project proposal presentation for key project stakeholders. Final feedback set a frame for the subsequent objective: RO analysis of BIO-INC. White Biotech's partnership project with PROCESS-CO. to create corn fiber from ethanol using advanced yeast.

2) **Time-series and regression forecasting**
Key project variables were identified, researched, and analyzed via simple trending methods. These included historical price data for oil, bioethanol, corn and corn fiber as well as the Euro € /US$ exchange rate (see Step 1 in Figure 2, below).

3) **Base-case net present value analysis**
Scope was further narrowed to focus on two particular corn fiber to ethanol project processes under consideration: I) Dry Mill without Fractionation, and II) Dry Mill with Fractionation / Wet Mill. These became the target for subsequent NPV analysis. An existing NPV case was extended for one project and used as a basis to analyze the second. The two NPV cases were then extended to encompass valuation of a hypothetical post-PROCESS-CO. partnership licensing strategy on the open market (see Step 3 in Figure 2, below).

4) **Monte Carlo simulation**
A robust Monte Carlo simulation model was setup for the two NPV base-cases and licensing scenarios. The simulations were run, refined iteratively, and thenanlayzed and documented (see Step 2 in Figure 2, below – used to subsequently enhance Step 3).

5) **Real options problem framing**

Specific decision open to management regarding the projects were identified in order to frame decision trees. Interviews were conducted and supporting internal artifacts were examined (GANTT project plans, process documentation, market research).

6) **Real options modeling and analysis**
Based on volatility estimates from the Monte Carlo analysis, a Binomial Tree was created for the selected rollout scenario. The tree was then enhanced with decision points to specify a decision tree (see Steps 4 and 5 in Figure 2, below).

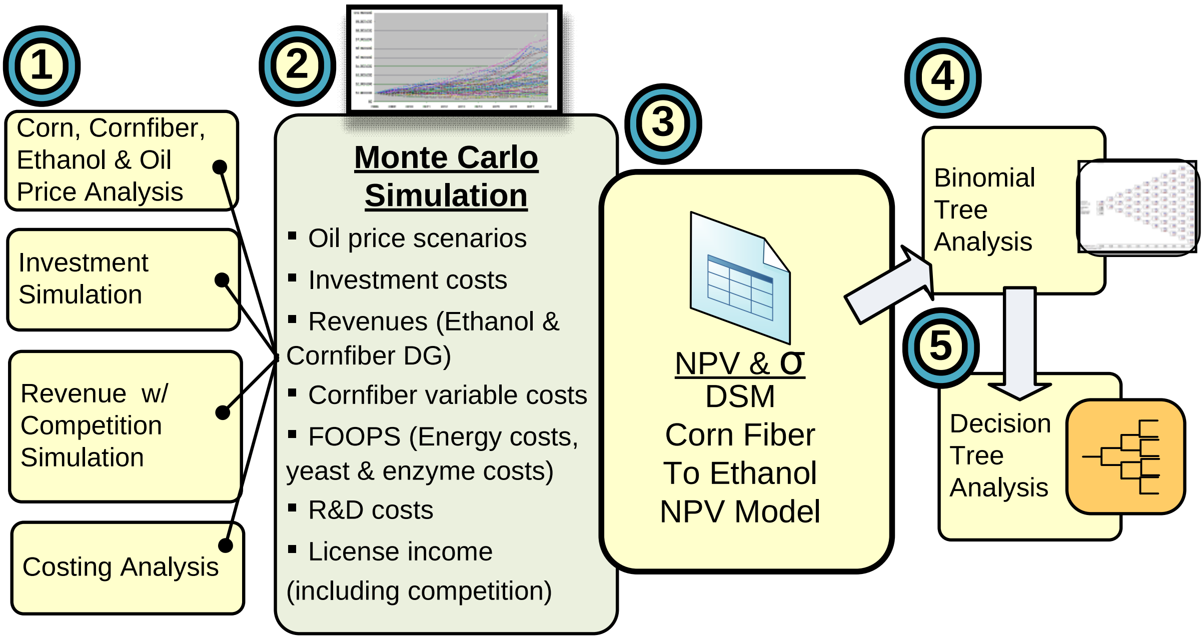

FIGURE 2: High-Level Real Options Analysis (ROA) Process

7) **Portfolio and resource optimization**
This step involves cross-comparison of the ROA results at a firm-wide level. As BIO-INC. currently does not have a firm-wide ROA program, this step was not conducted. Opportunities for adopting firm-wide ROA procedures were documented in the paper conclusion.

8) **Reporting and update analysis**
This paper was composed to report on the results of the ROA. As well, a final summary presentation for the BIO-INC. White Biotech Management Team is planned. Next steps might include a hand-over of the models and basic training for internal staff to track, maintain, and update the unified model.

2. P1: SCENARIO-BASED NPV MODELING

2.1 NET PRESENT VALUE MODELLING

The recognized standard for financial decision making is Net Present Value (NPV) analysis, defined as the aggregate present value of all expense adjusted cash flows for a particular business initiative, including staged investments. NPV provides a measure of profit potential beyond earnings projections alone, which are susceptible to accounting subtleties. While NPV analysis is a useful exercise in itself, it is presented here as the first step in an advanced valuation process aimed at high-risk, high profit potential ventures, such as those faced by the BIO-INC. Innovation Center (of which the White Biotech group is a member).

NPV is generally considered a more thorough and informative approach to valuation than other common methods such as Return on Investment (ROI), which does not regress cash flows to a net present value state and thus ignores the time value of money. Similarly, another common valuation measure, Internal Rate of Return (IRR), sets a benchmark percentage return hurdle without allowing for the cost of capital and thus cross-comparison amongst mutually exclusive projects (Brealey, Meyers, & Allen, 2006: 95). Economic Value Added (EVA) provides a proprietary alternate process which further avoids accounting manipulations in determining profit by clarifying directional cash flows. As long as an identical Weighted Average Cost of Capital (WACC) is utilized, EVA will resolve equivalently to NPV (Saint-Pierre, 2009). NPV is used both by PROCESS-CO. and BIO-INC. to justify and plan new initiatives and it has been employed here to value the initiatives under analysis.

The basis for NPV rests on a statement of Free Cash Flow (FCF), which, simplified, charts periodic financial performance as operating cash flow minus capital expenditures. The resulting Net Present Value (NPV) of an investment (or project) is the difference between the sum of the expected present value discounted FCF's and the similarly discounted project investments. The core calculation can be represented as such in Table 1 (Damodaran, 2005):

Revenues
- Cost of Goods Sold
--
Gross Margin
- Personnel Cost
- Depreciation & Amortization
- General & Administrative Expenses
--
Earnings Before Interest & Taxes (EBIT)
- Taxes Over Operating Assets
--
Net Operating Profit After Taxes (NOPAT)
+ Depreciation & Amortization
+/- Changes in Working Capital
- Capital Expenditures
--
Free Cash Flows (FCF's)
Sum of Present Value (PV) FCF's (via WACC*)
- Sum of PV Investments (via WACC*)
--
Net Present Value (NPV)

* Weighted Average Cost of Capital (WACC)

TABLE 1: Basic Free Cash Flow Model

NPV is thus an expression of the aggregate present value potential of a business investment (or set of investments) in an initiative. If the NPV method results in a positive value, the project should be undertaken. Amongst several projects, the highest NPV should take precedence as the most profitable and rational option, even amongst projects of differing scale.

2.2 BIOETHANOL MARKET AND SCIENCE SUMMARY

Prior to pursuing the NPV analysis, a brief detour is necessary to understand the basic market and process science surrounding bioethanol. BIO-INC. White Biotech is developing a process to make bioethanol using advanced, proprietary yeast to ferment cellulosic plant material. Bioethanol is a fuel product suitable for blending with gas for use in common engines.

US $65-75 per barrel is an often cited 'target' production cost figure for bioethanol, as at this level commercial profitability is feasible as related to mean-reverting historical oil pricing. As per Table 2 below (Economist Staff, 2008), first generation (food-stuff derived) biofuels are cheaper to produce (their sugar content is relatively more 'accessible' and thus easier to convert). However, a global governmental and moral backlash against utilizing foodstuffs for fuel production has oriented subsidies, and thus private industry, toward second-generation, non-foodstock derived bioethanol. Beyond this, second-generation biofuels yield roughly 80 percent net energy, compared to the 30 percent yield for first-generation biofuels (Ratliff, 2007).

Out of thin air 5

Biofuel costs compared with prices for oil and oil products, cents per litre

Fuel	2006
Price of oil $/barrel	50-80
Petroleum products pre-tax price	35-60
Petroleum products retail price*	150-200 in Europe, 80 in US

Biofuel	2006	Long-term about 2030
Ethanol from sugarcane	25-50	25-35
Ethanol from maize	60-80	35-55
Ethanol from beet	60-80	40-60
Ethanol from wheat	70-95	45-65
Ethanol from lignocellulose	80-110	25-65
Biodiesel from vegetable oils	70-100	40-75
Fuels made from "syngas"	90-110	70-85

Source: The Royal Society *Taxes included

TABLE 2: Comparative Oil and Biofuel Pricing

Utilizing yeasts to produce ethanol follows a staged process not dissimilar from brewing beer. For an intuitive overview of basic industrial biotechnology process, an animated instructive film is available at: http://www.kluyvercentre.nl/content/movie.html. Although there are many approaches and variations, the basic second generation bioethanol production process involves extracting cellulose from plant material, adding enzymes to convert the cellulose into sugars (noting some processes do not employ enzymes), fermenting the sugars with yeast(s) and distilling the resulting alcohol into refined ethanol fuel (Ratliff, 2007).

Basic yeast-based production of bioethanol from feedstock is a long-known process on a small scale. The uncertain challenge involves scaling to industrial production levels (speed, volume and efficiency), as current production techniques are not cost effective from an overhead standpoint in the market context of comparable petroleum pricing. In particular, cellulosic processing requires aggressive treatments to break the base molecule into sugar compounds suitable for downstream fermentation processing (typically via specialized enzymatic treatment or other energy intensive procedures).

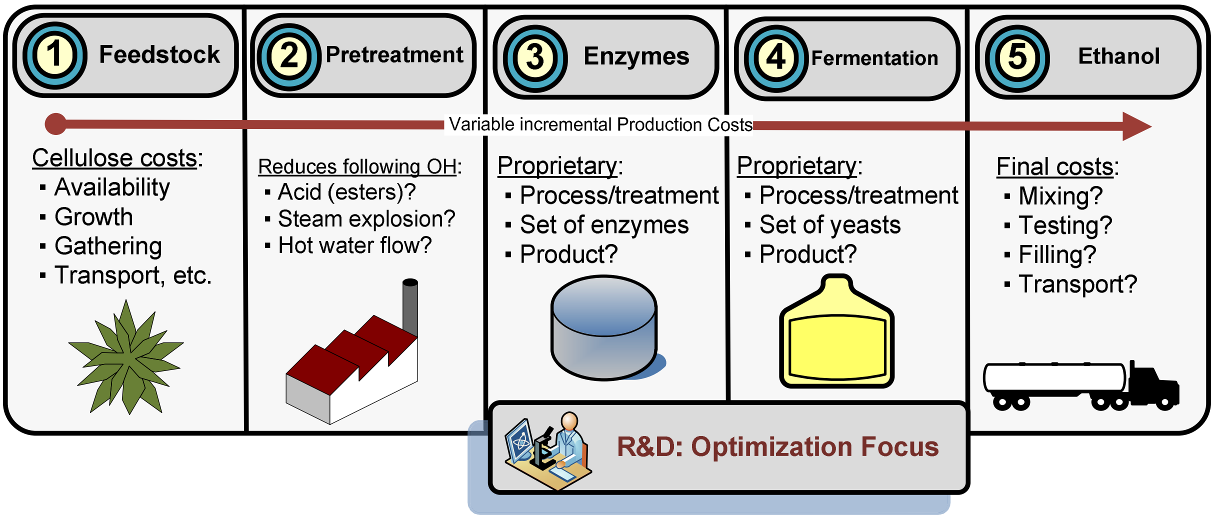

FIGURE 3: High-Level / Generalized Bioethanol Production Process

The BIO-INC. White Biotech Yeast and Enzymes BioProduct group is thus focusing R&D efforts on optimizing the bioethanol industrial-scale production process (in particular on stages three and four as outlined in Figure 3, above). Enzymatic processing (stage three) involves breaking down the treated cellulosic material to resolve component sugars for follow-on fermentation (C5 and C6 sugars in particular). The more efficacious the set of enzyme treatments, the more efficiently produced sugar byproducts for follow-on fermentation (and thus lesser downstream aggregate cost overhead). However, the particular sets of enzymes utilized need to operate efficiently within the context of an industrial scale concerning speed, quality and volume (Ratliff, 2007). Stage four, Fermentation, involves treatments by proprietary yeast(s) that resolve the sugars from stage three into downstream ethanol. Here again, efficiency and efficacy of the yeast(s) and associated scalability are crucial from an incremental cost overhead perspective.

2.4 NEW MARKETS AND NEW BUSINESS MODELS

For BIO-INC. White Biotech, beyond the challenge of developing cost-effective, industrial-scale production processes for the PROCESS-CO. partnership, sits the question of post-partnership business strategies for capitalizing on the innovations realized (and investments made). Beyond a discrete 'proof-of-concept' plant, BIO-INC. White Biotechnology is currently not anticipating moving into the business of building and operating full-scale bioethanol production plants as a core strategic business activity. Thus, a major open consideration concerns where and how particular products, licenses and/or services can be derived from the emerging industrial process being defined. As the markets and associated technologies are new, a range of profit strategies are possible in a variety of combinations, raising an open question as to how to individuate the profit elements for analysis.

BIO-INC. White Biotech stakeholders expressed an admirably broad openness and flexibility to new business models, in keeping with the broad charter of the BIO-INC. Innovation Center and Vision 2010. A range of creative profit scenarios were discussed, including the licensing of new processes (as a lump sum or percentage of EBIT), bundling professional services assistance on a contract basis, selling component technologies (plant, equipment and microorganisms / enzymes), selling 'subscriptions' to enzymes and yeast, selling plant and biotech microbiological components as a 'turn-key' solution, co-development partnerships, selling 'guaranteed output' contracts (i.e.: an assured stream of bioethanol given adherence to prescribed operating parameters), etc.

An ad hoc listing of creative, free-form models for extending the technical and process innovations tied to NPV Cases I and II were documented. From these a range of flexible product, service and/or licensing profit scenarios are thus available for discussion, potentially in combinatory ‘baskets’ with add-ons or optional extensions. Some of the models proposed take the form of novel extensions, others are metaphoric comparisons to business models in other industries:

Jet Engine Provider: A recent article in *The Economist* on how Rolls-Royce’s jet engine division profits from its activities bears consideration: “Instead of selling airlines first engines and then parts and service, Rolls-Royce has convinced its customers to pay a fee for every hour that an engine runs. Rolls-Royce in turn promises to maintain it and replace it if it breaks down. ‘They aren’t selling engines, they are selling hot air out the back of an engine,’ says an investment analyst” (Economist Staff, 2009). The implication for BIO-INC. White Biotech would be to sell an integrated assurance contract for the supply, maintenance, and management guidance of a working second generation bioethanol facility. Such a model would offload the risk of tying up substantial capital in a full-scale biofuel plant and taking on the associated liability of owning and operating the plant. However, it would put BIO-INC. White Biotech in the frame in terms of attaching to a steady stream of cash flows from a working plant.

Hotel Industry: The high-end hotel business has a similar pattern to the biofuel plant in that there is high capital overhead required for construction and resulting infrastructure requires specialized expertise to manage effectively (profitably). Firms such as Four Seasons, Hilton, and Sheraton partner with investors in order to fund the building of a new hotel. The operator, the hotel management company, subsequently focuses on their core strength, building and managing hotels, profiting off a share of the resulting cash flows, but avoiding the risk of entrenched investment and the liability of property ownership. In the case of second generation bioethanol innovation, and particularly the Dry and Wet Mill plant technological and process innovation, BIO-INC. could potentially act as a “luxury refinery operator”, so to speak. For a development and subsequent management fee, all enforced via carefully structured contracts, BIO-INC. would convert and subsequently supply and, potentially, staff (via dedicated staff and/or a training program) the plant. The contract would include covenants concerning productivity provided particular operational parameters are maintained. Another hotel industry innovation is the partial ownership concept, whereby small investors can buy ownership interest in hotel complexes which gives them right of visit at other hotels. Considering the great interest in biofuel, the metaphor would be offering restricted direct ownership shares in biofuel plans, which would provide the owner with access to a regular profit dividend payment.

Franchising: This is quite similar to the hotel model, but has a greater emphasis on maintaining a dedicated supplier relationship. McDonalds and other fast food related chains are obvious examples, whereby the franchiser supplies raw materials to the franchise on a regular basis. The franchiser is tightly involved in all aspects of franchise operations, from initial funding, construction, management and training to staged improvement. It is worthy to note that McDonalds has an immensely valuable global real estate portfolio. As opposed to the hotel model, fast food and retail franchises often own the underlying real estate, or at least are active in the purchase and sale of property such that they profit from transfers of ownership.

Brewery Industry: Arnold and Shockley, in their journal article “Value Creation at Anheuser-Busch: A Real Options Example”, outline how the brewer Anheuser-Busch rapidly increased firm value by setting up small partnership deals with a range of brewers in emerging regions (China and Brazil in particular). In exchange for investment, equipment, and brewing operations expertise, the brewer would gain partial ownership rights in foreign breweries with options to expand. Similarly, BIO-INC. might consider this model: establishing partial ownership in biofuel plants in exchange for expertise, guidance, and dedicated provisioning. The long-term future benefit would be the option to expand or sell ownership stakes as the value of the operation expanded or contracted. In this way, the risk of full ownership is avoided via the flexibility to change course (a core ROA value concept). The result would be a portfolio of biofuel plant ‘options’ which could be valued and subsequently expanded or contracted much like a portfolio of financial derivatives.

Pharmaceuticals: Pharma is active in licensing IP, as well as in contract manufacturing. A closer examination of business development practices in this particular industry might provide insightful.

Proprietary Software: Software licenses are a mechanism whereby a purchaser has the restricted right to utilize the software on a computer. Fee based licenses are specified by an End-User License Agreement (EULA). If the metaphor is carried to the biofuel plant, the intellectual property embedded in a new process could be considered as a type of EULA with specific provisions. This protects the IP and may enforce a contractual obligation to utilize specific supplies and equipment, for instance.

Open-Source Software: Open-Source is free software. The Open-Source agreement comes with certain fair use provisions and may bind the user into a community review process should they wish to modify or extend the software. Open-Source software, such as Linux, has proven profitable for companies that provide consulting expertise related to the software. A biofuel plant Open-Source license could take the form of freely offered IP which then would lead the user to access BIO-INC. for supplies and consulting expertise. The additional benefit here is that the concept would likely generate a great deal of media attention, and thus potentially play well with investors in the equity markets.

Expertise / Consulting: This would involve providing consulting expertise in setting-up, operating, and improving plants. This could extend to construction, project management, financial and project management, etc. It could also take the form of outsourcing or offering contract-based labor, or brokering permanent staffing via international labor networks.

Machinery and Equipment (Sales and Leasing): This is largely self-explanatory. It is worthily to observe that in many 'economic manias', the seller of supporting goods, supplies, and equipment were the main economic beneficiaries (i.e.: 1630 Dutch Tulip Mania, 1850 California Gold Rush, 1920 Stock Mania, 2000 Dot-Com Bubble, 2008 Housing Bubble). This is not to imply that biofuel is a bubble, only to observe that during a chaotic and uncertain growth phase, avoiding the liability of owning property and equipment, but profiting from the sale of supporting equipment and services is a solid business strategy.

Partner 'Match Making': Acting as an intermediary or clearing house between suppliers, operators, downstream customers. BIO-INC. for instance could situate itself as an aggregator between a corn supplier and a petroleum company to realize pricing advantages and enabling client plants.

Market Making: An advanced market extension of the previous example, British Petroleum has a highly active energy trading side business. Similarly, BIO-INC. could develop a corn and bioethanol commodities trading desk, giving them pricing power in the market and empowering them to enable key customers.

Price Hedging: The bioethanol business is strongly tied to commodity pricing. The ability to actively hedge oil, ethanol (via tight coupling to the gas market), corn, and corn fiber commodities could be offered as an add-on financial service to customers. As well, to the degree BIO-INC. becomes exposed to the risk inherent in commodity price fluctuations, it would be advantaged in being able to hedge such risks.

Leasing Equipment: Offering a service to setting-up or install equipment via a lease arrangement is one method to enabling a new market quickly. This reduces the high capital overhead restricting customers or investors from rapidly entering a new market.

Reverse Lease: In this model, plant and equipment can be 'provisionally owned' as collateral by BIO-INC.. This is similar to a pawn shop model, where the owner of a plant could provisionally transfer contingent ownership rights to BIO-INC. in return for an up-front cash payment (with the understanding the money would purely be used for reinvestment in the business). The original owner would then be responsible for maintaining a steady stream of payments issuing from operation of the plant, likely with a declining mortgage aspect whereby the plant could eventually be repurchased.

Customer Finance Facility: A number of the facilities suggested above assume or imply a dedicated corporate Customer Finance facility. This is a common corporate function in highly capital intensive, high risk industries, where a corporation is incentivized to extend to customers advanced resources for affording the products they sell (while, again, avoiding the risk and liability of ownership themselves). Such a program could conceivably extend to providing financing support, for instance: arraigning for loan packages. BIO-INC. could also, for a fee, act as a project steward in arranging funding for a new plant (much as a movie producer or project finance consultant). The downstream benefit is that of establishing a customer for the broader product range and, potentially, having preferred options on formal partnering opportunities. There would be sensitive margins, so careful financial analysis would need to undergird each assumptions established in contractual obligations. A danger would be the highly volatile fluctuations of the underlying commodities involved (chiefly ethanol, corn, corn fiber). However, as mentioned previously, these might be hedged via financial instruments as part of a complete financing package. Corn and ethanol prices can be actively hedged such that guarantees are inserted in the contract concerning costs and revenues within a specified time frame.

Clearly there are ranges of downstream possibilities open to BIO-INC. concerning the new technologies it is considering developing. Each business models offered has compelling aspects as well as potential challenges or downsides. At this point BIO-INC. White Biotech is in an active 'brainstorming' phase concerning future opportunities. It may be useful to conduct a structured set of stakeholder discussion sessions to elicit and progressively narrow options. An agreed set of target strategies could then be analyzed and compared using the techniques outlined in this paper (valuation, simulation, and option analysis). However, such an exercise is out-of-scope for the current project. Hopefully, the above list offers some 'talking points' for future discussion and brainstorming.

As the objective here is to complete a working ROA model, it is necessary to identify a specific product strategy and to use this as the basis for downstream analysis. Concerning and returning to the two core business cases outlined, 1) Dry Mill No Fractionation and 2) Dry Mill Fractionation / Wet Mill, licensing was a reoccurring theme in interviews and discussions. As well, it is an aspect of many of the broader hypothetical business strategies covered above. In the end, simplicity and scope were a major factor in focusing on the licensing business model. Each of the above models would require additional research and advanced simulation. A simple licensing case can be easily modeled.

It was resolved that a simple percentage of revenue from the base PROCESS-CO. production case could serve as a rough measure for license pricing. In this model, customers, biofuel plant operators chiefly, would pay a license fee to BIO-INC. in exchange for the right to implement and use the process innovation. A simple percentage of EBIT from the core PROCESS-CO. / BIO-INC. partnership NPV case was established to price a license. This approach is simple and allows for a quick method of valuing a hypothetical commercialization strategy for each innovation being proposed. Market competition is a factor that will be analyzed via simulation in phase P2.

2.4 NPV MODELING AND ANALYSIS

The two cases identified were subsequently documented as standard, cross-comparable NPV's. Of great benefit, NPV Case II, Dry Mill with Fractionation or Wet Mill, benefitted from having an existing NPV case. This NPV was reviewed, streamlined, and extended. Once the NPV had been reviewed and reformatted, II. Dry Mill with Fractionation or Wet Mill, was similarly prepared in the same format. In this case, a worksheet sketching the general parameters for the project was adopted and fitted to the NPV framework.

All figures used were drawn from the original PROCESS-CO./BIO-INC. NPV case and edited as needed based on discussions with BIO-INC. White Biotech staff. The original NPV was quite complex, with multiple worksheets and nested conversions and formulas. An attempt was made to standardize and structure the NPV case so that it can be maintained and edited more easily in the future. The core NPV cases were supported with broken out revenue statements, cost tracking statements, investment profiles, commodity pricing analysis, Euro/US $ exchange rate analysis, and conversion sheets for frequently used formulas.

Finally, each NPV model, once complete, was extended in a new version to include a licensing rollout case with rough figures to indicate market competition. As well, investments required to support the rollout were added to the model. Key aspects of the four resulting models have been documented herein in Figures 10 – 18 following. Table 3, below, provides a reference guide to the various NPV aspects documented here. The full scale spreadsheets are available upon request (note that a working copy of Palisade @Risk 5.0 or higher is required to view and edit the models).

Concerning the models, the NPV is itself run through a notable ‘filter’: all costs and revenues are halved and converted from US$ to Euros. This signifies that the core business activities will be occurring in America at the PROCESS-CO. location (in the base case). PROCESS-CO. will share 50% in all costs and revenue (in the initial assumption, although this figure can be changed easily on the NPV case). The 50% dollar profits (as well as costs) are converted to Euros via a static €/$1.32 exchange rate. The projects are assumed to begin in 2010 and run for 12 years to 2021. Investments for both projects are made early in the project and drop-off. Finally, it can be remarked that the investment and return scale for project I. Dry Mill No Fractionation is substantially larger in terms of investment requirements and projected cash flows.

NPV CASE / COMPONENT	FIGURES
I. Dry Mill No Fractionation Base Case NPV	
NPV and Initial Investment Profile	Figure 10
Revenues	Figure 11
Costs	Figure 12
II. Dry Mill with Fractionation/Wet Mill Base Case NPV	
NPV and Initial Investment Profile	Figure 13
Revenues	Figure 14
I. Dry Mill No Fractionation Base Case + Post-PROCESS-CO. Rollout	
NPV	Figure 15
License Revenues with Competition	Figure 16
II. Dry Mill with Frac./Wet Mill Base Case + Post-PROCESS-CO. Rollout	
NPV Case and Investments Required	Figure 17
License Revenues with Competition	Figure 18
Correlation Matrix: Covariance Amongst Commodity Prices	Figure 19

TABLE 3: NPV Cases – Figures Documented

Initial observations are that corn (for Project I) and corn fiber (for project II) costs are substantial overall cost contributors. Corn price volatility thus is likely a large risk factor in both projects. The models include a full price analysis variance and covariance analysis between the major commodities from 2004 – 2009.

As per the NPV Base Case results (Figures 10 – 14), Project I Base Case yields € 9.49m versus € 2.68m for Project II (28% of Project I NPV). Where level of investment is ambivalent, the NPV rule is to always take the larger NPV, indicating Project I: Dry Mill No Fractionation. However, Project I does tie-up nearly €62m in NPV investment, whereas Project II occupies nearly €11m of PV investment spread over two years. An open question is as to whether Project II could be scaled such that a larger investment would yield a greater return. This might bear further modeling, as Project I yields a 25% gross return from investment PV of €2.68m to NPV €10.62m, whereas Project II yields 15% gross return on €9.49m PV investment for €61.73m NPV. Although Project II has a higher face value NPV, it might be worthwhile to consider the cost/benefit in terms of tying up substantial capital versus other potential projects.

Examining the post-PROCESS-CO. licensing rollout NPV scenarios (Figures 15 – 18), the gap between the projects widens, as Project I Base Case yields € 1.75m versus € 0.14m for Project II (8% of Project I NPV). This can be accounted for by the larger projected market (thus potential revenues) for Project I. Based on these un-validated example results, Project I, Dry Mill No Fractionation, emerges as the recommended candidate for advancement.

FCF CASE (€)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency	*€/$ Exchange Rate**	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Investments	Total Investments	*61.73*	0	0	0	0	0	0	0	0	0	0	0
Revenues	Total EtOH prod (W1+W2) [M$/y]*	80.61	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39
	DDGS Revenues [M€/Mt]*	13.05	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59
	CO2 [M€/y]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Subsidy Cellulosic Ethanol	3.20	3.18	3.20	3.19	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
	Subsidy Blenders Credit	0	0	0	0	0	0	0	0	0	0	0	0
	Total Revenues	*96.87*	*95.17*	*95.19*	*95.18*	*95.18*	*95.18*	*95.18*	*95.18*	*95.18*	*95.18*	*95.18*	*95.18*
COGS	Corn Costs	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83
	Total Energy Costs	14.07	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85
	Pretreatment Costs (W1.5)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Yeast & Enzymes	2.14	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
	Chemicals	2.08	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
	Others	5.62	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54
	Fixed Costs*	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83
	Total Costs	*83.69*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*
Gross Margin	**Gross Margin**	*13.17*	*11.82*	*11.85*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*
	Depreciation & amoritization*	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
EBIT	**EBIT**	*9.06*	*7.71*	*7.73*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*
	US Corp Tax Rate*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
NOPAT	**NOPAT**	*9.06*	*7.71*	*7.73*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*	*7.72*
	Non-Cash Exp (Dep & Amort)	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
	Operating Cash Flow	*13.17*	*11.82*	*11.85*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*	*11.84*
	Investment expenditures*	-61.73	0	0	0	0	0	0	0	0	0	0	0
FCF	**-61.73**	***13.17***	***11.82***	***11.85***	***11.84***	***11.84***	***11.84***	***11.84***	***11.84***	***11.84***	***11.84***	***11.84***	***11.84***

DSM Base EtOH Share	**50%**
NPV *	**9.49**
IRR *	**14.4%**

**** Case excluding terminal value; assumes investment beginning period 1***

**** WACC:*** **13%**

**** Assumes 8% interest, WACC reinvestment rate***

INVESTMENTS [GPC+DSM $]	
Investments for Startup	
Investment per name plate W1 plant [$/Gal EtOH/y]	1.40
Total Investments W1 plant	151.74
Additional Investments W1.5 plant	10.00
Total investments [$]	163.14

FIGURE 10: I. Dry Mill No Fractionation Project: NPV Base Case and Initial Investment Profile

Ethanol Production												
Ethanol Production Revenues [$ MMGY]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Corn-EtOH Convert Efficiency [Gal/bu]	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68	2.68
CF-EtOH Convert Efficiency [Gal/bu]	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23	0.23
Name plate EtOH Prod capacity [MMGY]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Factor of name plate capacity	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Total EtOH Prod Base Case [MMGY]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Corn consumption [Mil bu]	37.27	37.27	37.27	37.27	37.27	37.27	37.27	37.27	37.27	37.27	37.27	37.27
EtOH per bu w/fiber conv [Most Likely]	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91	2.91
Tot EtOH per bu w/fiber conv [Gal/bu]	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***	***2.91***
EtOH Price ($)	1.97	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94	1.94
W1 Ethanol production [MMGY]	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
W1.5 Ethanol production [Most Likely]	8.39	8.39	8.39	8.39	8.39	8.39	8.39	8.39	8.39	8.39	8.39	8.39
W1.5 Ethanol production [MMGY]	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***	***8.39***
W1.5 Ethanol production [%]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Total EtOH prod [Mean]	108.39	108.39	108.39	108.39	108.39	108.39	108.39	108.39	108.39	108.39	108.39	108.39
Total EtOH prod [StDev]	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Total EtOH prod (W1+ W1.5) [MMGY]	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**	**108.39**
Ethanol Revenues [M$/y]	**213.03**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**	**209.80**
DDGS/bushel [lb/Bu]	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00
DDGS production [Mt]	228745	228745	228745	228745	228745	228745	228745	228745	228745	228745	228745	228745
eDDGS Price [$/Mt]	150.75	145.47	145.47	145.47	145.47	145.47	145.47	145.47	145.47	145.47	145.47	145.47
DDGS Revenues [M$/y]	**34.48**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**	**33.28**
Subsidy Cellulosic EtOH [$/Gal]	1.01	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Cumulative Average	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
Total Subsidy Cellulosic EtOH	**8.47**	**8.41**	**8.47**	**8.44**	**8.45**	**8.45**	**8.45**	**8.45**	**8.45**	**8.45**	**8.45**	**8.45**
Blenders Credit [$/Gal EtOH]	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Share of Blenders Credit	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Subsidy Blenders Credit	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
CO2 extracted per Bu [lb/Bu]	18.33	18.33	18.33	18.33	18.33	18.33	18.33	18.33	18.33	18.33	18.33	18.33
CO2 production [Mt] [Most Likely]	310186	310186	310186	310186	310186	310186	310186	310186	310186	310186	310186	310186
CO2 production [Mt]	308118	308118	308118	308118	308118	308118	308118	308118	308118	308118	308118	308118
CO2 price [$/Mt]	7	7	7	7	7	7	7	7	7	7	7	7
CO2 [M$/y]	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**	**2.05**
TOTAL REVENUES	**258.04**	**253.55**	**253.60**	**253.57**	**253.58**	**253.58**	**253.58**	**253.58**	**253.58**	**253.58**	**253.58**	**253.58**

FIGURE 11: I. Dry Mill No Fractionation Project: NPV Base Case Revenues

COSTS						
Heating Energy Costs						
	2010	**2011**	**2012**	**2013**	**2014**	**201**
BtU's of heat per gal EtOH	18000	18000	18000	18000	18000	1800
Average energy price, $/1,000,000 BtU	5.07	5.07	5.07	5.07	5.07	5.0
Total Celulosic Ethanol Production	213.03	209.80	209.80	209.80	209.80	209.8
TOTAL	*19.43*	*19.13*	*19.13*	*19.13*	*19.13*	*19.1*
Yearly EtOH Production Rates	**2010**	**2011**	**2012**	**2013**	**2014**	**201**
Total Celulosic Ethanol Production	0.00	0.00	0.00	0.00	0.00	0.0
Percent of maximum cumulative average	**1.02**	**1.00**	**1.00**	**1.00**	**1.00**	**1.0**
Gas Costs	**2010**	**2011**	**2012**	**2013**	**2014**	**201**
W1 Gas Costs (excl. Drying DDGS) [M$/y]	*8.59*	*8.46*	*8.46*	*8.46*	*8.46*	*8.4*
W1.5 Gas Costs (excl. Drying DDGS) [M$/y]	0.71	0.70	0.70	0.70	0.70	0.7
Gas Costs For DDGS Drying [M$/y]	4.16	4.10	4.10	4.10	4.10	4.1
TOTAL	13.46	13.26	13.26	13.26	13.26	13.2
W1&1.5 Electricity Costs [M$/y]		**Min**	**Max**	**Average**		
kWh per gal denatured (range)		0.75	1.2	0.975		
kWh tariff ($) (range)		0.025	0.09	0.0575		
W1 Electricity Costs [M$/y]		3.46	4.04	3.75		
	2010	**2011**	**2012**	**2013**	**2014**	**201**
W1 Electricity Costs [M$/y]	3.81	3.75	3.75	3.75	3.75	3.7
kWh per gal denatured	0.98	0.98	0.98	0.98	0.98	0.9
kWh tariff ($)	0.06	0.06	0.06	0.06	0.06	0.0
Total Cellulosic Ethanol Production	8.39	8.39	8.39	8.39	8.39	8.3
TOTAL	*4.28*	*4.22*	*4.22*	*4.22*	*4.22*	*4.2*
TOTAL ENERGY COSTS	**37.17**	**36.61**	**36.61**	**36.61**	**36.61**	**36.6**
Pretreatment costs	**Variable**	**Min**	**Max**	**Average**		
Caustic [$/Gal EtOH]	0.02	0.015	0.025	0.02		
Sulphuric Acid [$/Gal EtOH]	0.02	0.015	0.025	0.02		
Total Preatreatment Costs W1.5	0.04					
TOTAL	*0.34*	*0.34*	*0.34*	*0.34*	*0.34*	*0.3*
Yeast & Enzyme costs						
	2010	**2011**	**2012**	**2013**	**2014**	**201**
W1 Yeast & Enzymes costs	3.55	3.5	3.5	3.5	3.5	3.
W1.5 EtOH Y+E costs	2.11	2.08	2.08	2.08	2.08	2.0
TOTAL	*5.67*	*5.58*	*5.58*	*5.58*	*5.58*	*5.5*

Chemicals [M$/y]						
Chemicals W1.5	**Variable**	**Min**	**Max**	**Average**		
Other chemicals and antibiotics [$/gal EtOH]	0.020	0.017	0.023	0.02		
Boiler & Cooling tower chems [$/gal EtOH]	0.001	0.0007	0.0013	0.001		
Water [$/gal EtOH]	0.001	0.001	0.001	0.001		
Denaturant [$/gal EtOH]	0.028	0.024	0.032	0.028		
Total chemical costs [$/gal EtOH]	0.050					
Chemicals W1		**Min**	**Max**	**Average**		
W1 Chemicals Costs [M$/y]		4.62	5.38	5		
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
W1 Chemicals Costs [M$/y]	5.076967135	5	5	5	5	5
Total Cellulosic Ethanol Production [MMGY]	8.39	8.39	8.39	8.39	8.39	8.39
W1.5 Chemicals costs [M$/y]	0.42	0.42	0.42	0.42	0.42	0.42
TOTAL	*5.50*	*5.42*	*5.42*	*5.42*	*5.42*	*5.42*
Others						
Others W1.5	**Variable**	**Min**	**Max**	**Average**		
Maintenance & repairs [$/gal EtOH]	0.038	0.038	0.038	0.038		
Labor [$/gal EtOH]	0.032	0.032	0.032	0.032		
Management & QC [$/gal EtOH]	0.025	0.025	0.025	0.025		
Real estate taxes [$/gal EtOH]	0.014	0.014	0.014	0.014		
Licences, fees and Insurances [$/gal EtOH]	0.006	0.006	0.006	0.006		
Miscellaneous [$/gal EtOH]	0.020	0.02	0.02	0.02		
Total Others [$/Gal EtOH]	0.135					
Others W1		**Min**	**Max**	**Average**		
W1 Others [M$/y]		12.46	14.54	13.5		
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
W1 Others [M$/y]	13.71	13.50	13.50	13.50	13.50	13.50
Total Cellulosic Ethanol Production [MMGY]	8.39	8.39	8.39	8.39	8.39	8.39
Total Others [$/Gal EtOH]	0.135	0.135	0.135	0.135	0.135	0.135
TOTAL	*14.84*	*14.63*	*14.63*	*14.63*	*14.63*	*14.63*
Fixed Costs						
		Min	**Max**	**Average**		
Depreciation basis (years) [M$/y]		9.33	10.67	10		
Interest expenses [M$/y]		5.04	5.76	5.4		
	2010	**2011**	**2012**	**2013**	**2014**	**2015**
Depreciation basis (years) [M$/y]	10.00	10.00	10.00	10.00	10.00	10.00
Interest expenses [M$/y]	5.40	5.40	5.40	5.40	5.40	5.40
TOTAL	15.40	15.40	15.40	15.40	15.40	15.40

FIGURE 12: I. Dry Mill No Fractionation Project: NPV Base Case Costs

FCF CASE		50%	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency €/$*		1.34	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Investments	Yeast & Enzymes @ GPC location		0.37	0.76	0	0	0	0	0	0	0	0	0	0
	Pretreatment, fermentation @ GPC		3.95	7.27	0	0	0	0	0	0	0	0	0	0
	Total Investments		*4.32*	*8.03*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
Revenues	Ethanol [M€/y]		0.00	1.71	3.41	6.14	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82
	DDGS Wet Revenues [M€/Mt]*		0.00	0.08	0.16	0.29	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
	Total Revenues		*0.00*	*1.79*	*3.57*	*6.43*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*
COGS	Corn Fiber		0.00	0.29	0.57	1.03	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
	Energy		0.00	0.12	0.25	0.45	0.50	0.50	0.50	0.50	0.82	0.82	0.82	0.82
	Pretreatment		0.00	0.04	0.07	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	Yeast & Enzymes		0.00	0.59	1.00	1.49	1.49	1.31	0.95	0.95	0.95	0.95	0.95	0.95
	Chemicals		0.00	0.04	0.09	0.16	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	Others*		0.00	0.12	0.24	0.43	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Total Costs			*1.20*	*2.22*	*3.69*	*3.92*	*3.75*	*3.39*	*3.39*	*3.71*	*3.71*	*3.71*	*3.71*
Gross Margin	**Gross Margin**		**0.00**	**0.59**	**1.35**	**2.74**	**3.22**	**3.39**	**3.75**	**3.75**	**3.43**	**3.43**	**3.43**	**3.43**
	Depreciation & amoritization*		0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EBIT	**EBIT**		**0.00**	**-0.22**	**0.55**	**1.94**	**2.42**	**2.59**	**2.95**	**2.95**	**2.63**	**2.63**	**2.63**	**2.63**
	US Corp Tax Rate*		*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
NOPAT	**NOPAT**		0.00	-0.22	0.55	1.94	2.42	2.59	2.95	2.95	2.63	2.63	2.63	2.63
	Non-Cash Exp (Dep & Amort)		0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	Operating Cash Flow		*0.00*	*0.59*	*1.35*	*2.74*	*3.22*	*3.39*	*3.75*	*3.75*	*3.43*	*3.43*	*3.43*	*3.43*
	Investment expenditures*		-4.32	-8.03	0	0	0	0	0	0	0	0	0	0
FCF		-10.62	0.00	0.59	1.35	2.74	3.22	3.39	3.75	3.75	3.43	3.43	3.43	3.43

DSM Base Share	**50%**
NPV *	**2.68**
IRR	**15.1%**

*** Case excluding terminal value; assumes investments beginning period 1**

** WACC:* 13%

*** Assumes 8% interest, WACC reinvestment rate (same as hurdle)**

INVESTMENTS [GPC+DSM M$]		
Investment Based On Plant Characteristics		
Crushing Capacity [Bu/day]	200000.0	
Crushing Capacity [M Bu/y]	73.0	
Total Available Fiber [Mt]	85000.0	
Total Cellulosic Ethanol Production [MMGY]	9.4	
Investment per name plate W1.5 plant [$/Gal EtOH/y]	3.0	
Investments W1.5 plant	28.1	
OTF enzymes and propagation unit	3.0	
Start-up Costs	0.5	
Tech development GPC	0.3	
Total Investments Cumulative	**31.9**	
Investments @ GPC Location		
Investments @ GPC Location	**2010**	**2011**
Yeast & Enzymes @ GPC location	1.000	3.000
Pretreatment, fermentation @ GPC	10.617	21.233
Total investment expenses	**11.617**	**24.233**

FIGURE 13: II. Dry Mill with Frac. or Wet Mill: NPV Base and Initial Investment Profile

REVENUES												
Fiber Availability - Base Case												
Total Yearly Available Fiber Base [Mt]*	85000	** NOTE: Original case 100,000*										
Fiber Availability Yearly Variance	3%											
Conversion & Production Variables												
Corn-Fiber-to-Ethanol Conversion efficency	**Variable**	**Min**	**Max**	**Most Likely**	**Variance**							
Gal EtOH/Mt CF(DM)[Gal/Mt]	**110.0**	107.8	112.2	110.0	2%							
Corn-Fiber DG Production efficency	**Variable**	**Min**	**Max**	**Most Likely**	**Variance**							
CF DG Production per unit	**0.28**	0.27	0.29	0.28	2%							
Ethanol Production Revenues [$MMGY]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Production Levels	0%	25%	50%	90%	100%	100%	100%	100%	100%	100%	100%	100%
Total Available Fiber [Mt]*	0.00	21250.00	42500.00	76500.00	85000.00	85000.00	85000.00	85000.00	85000.00	85000.00	85000.00	85000.00 *
EtOH Price ($)	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93
Total Cellulosic EtOH prod [MMGY]	*0.00*	*2.34*	*4.68*	*8.42*	*9.35*	*9.35*	*9.35*	*9.35*	*9.35*	*9.35*	*9.35*	*9.35*
Ethanol Revenues [M$/y]	**0.00**	**4.51**	**9.01**	**16.23**	**18.03**	**18.03**	**18.03**	**18.03**	**18.03**	**18.03**	**18.03**	**18.03**
Corn Fiber DG Production Revenues [M$/y]	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Total Available Fiber [Mt]*	0	21250	42500	76500	85000	85000	85000	85000	85000	85000	85000	85000 *
Corn Fiber Wet DG Price [IA $/Ton]	39	39	39	39	39	39	39	39	39	39	39	39
Corn Fiber Wet DG Price [IA $/Mt]	35	35	35	35	35	35	35	35	35	35	35	35
Total Corn Fiber DG production [Mt]	*0*	*5950*	*11900*	*21420*	*23800*	*23800*	*23800*	*23800*	*23800*	*23800*	*23800*	*23800*
Corn Fiber DG Revenues [M$/y]	**0.00**	**0.21**	**0.42**	**0.76**	**0.84**	**0.84**	**0.84**	**0.84**	**0.84**	**0.84**	**0.84**	**0.84**
Revenue Total [M$/y]	**0.00**	**4.72**	**9.44**	**16.99**	**18.87**	**18.87**	**18.87**	**18.87**	**18.87**	**18.87**	**18.87**	**18.87**

FIGURE 14: II. Dry Mill with Fractionation or Wet Mill Project: NPV Base Case Revenues

FCF CASE (€)		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency	*€/$ Exchange Rate**	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Investments	GPC Partnering Investments	61.73	0	0	0	0	0	0	0	0	0	0	0
	DSM Rollout R&D [100% DSM €]	12.35	6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Investments	*74.08*	*6.17*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Revenues	Total EtOH prod (W1+W2) [M$/y]*	80.61	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39	79.39
	DDGS Revenues [M€/Mt]*	13.05	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59	12.59
	CO2 [M€/y]	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78	0.78
	Subsidy Cellulosic Ethanol	3.20	3.18	3.20	3.19	3.20	3.20	3.20	3.20	3.20	3.20	3.20	3.20
	Subsidy Blenders Credit	0	0	0	0	0	0	0	0	0	0	0	0
	Post-GPC Rollout Gross Revenues	0.00	0.00	9.19	18.35	27.54	36.72	45.90	55.08	64.26	73.44	82.62	91.80
	Total Revenues	*97.64*	*95.94*	*95.96*	*95.95*	*95.96*	*95.96*	*95.96*	*95.96*	*95.96*	*95.96*	*95.96*	*95.96*
COGS	Corn Costs	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83	53.83
	Total Energy Costs	14.07	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85	13.85
	Pretreatment Costs (W1.5)	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	Yeast & Enzymes	2.14	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11	2.11
	Chemicals	2.08	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05
	Others	5.62	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54	5.54
	Fixed Costs*	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83	5.83
	Total Costs	*83.69*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*	*83.34*
Gross Margin	**Gross Margin**	*13.95*	*12.60*	*12.62*	*12.61*	*12.62*	*12.61*	*12.62*	*12.62*	*12.62*	*12.62*	*12.62*	*12.62*
	Depreciation & amoritization*	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
EBIT	**EBIT**	*9.84*	*8.49*	*8.51*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*
	US Corp Tax Rate*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
NOPAT	**NOPAT**	*9.84*	*8.49*	*8.51*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*	*8.50*
	Non-Cash Exp (Dep & Amort)	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12	4.12
	Operating Cash Flow	*13.95*	*12.60*	*12.62*	*12.61*	*12.62*	*12.61*	*12.62*	*12.62*	*12.62*	*12.62*	*12.62*	*12.62*
	Investment expenditures*	-74.08	-6.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FCF	*-78.91*	***13.95***	***18.77***	***12.62***	***12.61***	***12.62***	***12.61***	***12.62***	***12.62***	***12.62***	***12.62***	***12.62***	***12.62***

DSM Base EtOH Share	**50%**
NPV @ 13%*	**1.75**
IRR *	**13.2%**

** WACC:* 13%

**** Case excluding terminal value; assumes investment beginning period 1***

**** Assumes 8% interest, 13% reinvestment rate (same as hurdle)***

FIGURE 15: I. Dry Mill No Frac. Project: Base Case NPV + Post-PROCESS-CO. Rollout NPV

ROLLOUT SIMULATION: 100% DSM [M€]	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Market Size [# Pos. Licensees]	0	0	120	126	132	139	146	153	161	169	177	186
Num of DSM Signed Licensees	**0**	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**
Remaining Available Licensees	0	0	117	120	120	118	113	108	104	100	96	93
New Competitor Entrants	0	0	1	1	1	0	0	0	0	0	0	0
Competitors (Begin Year)	0	0	0	1	2	3	3	3	3	3	3	3
Num of Comp. Signed Licensees	0	0	0	3	9	18	27	36	45	54	63	72
2xEBIT (GPC+DSM) [M€]	0	0	17.01	16.99	17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Revenues	0	0	10.21	20.39	30.60	40.80	51.00	61.20	71.40	81.60	91.80	101.99
Costs	0	0	1.02	2.04	3.06	4.08	5.10	6.12	7.14	8.16	9.18	10.20
Total Profits	**0**	**0**	**9.19**	**18.35**	**27.54**	**36.72**	**45.90**	**55.08**	**64.26**	**73.44**	**82.62**	**91.80**
Total NPV Profit [M€]	**€ 176.17**											

** Bigger potential market than DM Frac / WM*

*** Assumption here is that DSM receives 100% revenue stream*

FIGURE 16: I. Dry Mill No Frac.: Base NPV + Post-PROCESS-CO. Rollout Revenues w/Competition

FCF CASE		50%	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency €/$*		1.34	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Investments	Yeast & Enzymes @ GPC location		0.37	0.76	0	0	0	0	0	0	0	0	0	0
	Pretreatment, fermentation @ GPC		3.95	7.27	0	0	0	0	0	0	0	0	0	0
	DSM Rollout R&D [100% DSM €]		1.50	0.75	0.45	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Total Investments		*5.82*	*8.78*	*0.45*	*0.23*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
Revenues	Ethanol [M€/y]		0.00	1.71	3.41	6.14	6.82	6.82	6.82	6.82	6.82	6.82	6.82	6.82
	DDGS Wet Revenues [M€/Mt]*		0.00	0.08	0.16	0.29	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
	Post-GPC Rollout Gross Revenues		0.00	0.00	0.39	2.79	5.22	7.46	10.61	12.73	13.23	15.12	17.01	18.90
	Total Revenues		*0.00*	*1.79*	*3.57*	*6.43*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*	*7.14*
COGS	Corn Fiber		0.00	0.29	0.57	1.03	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
	Energy		0.00	0.12	0.25	0.45	0.50	0.50	0.50	0.50	0.82	0.82	0.82	0.82
	Pretreatment		0.00	0.04	0.07	0.13	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	Yeast & Enzymes		0.00	0.59	1.00	1.49	1.49	1.31	0.95	0.95	0.95	0.95	0.95	0.95
	Chemicals		0.00	0.04	0.09	0.16	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
	Others*		0.00	0.12	0.24	0.43	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48
	Total Costs		*0.00*	*1.20*	*2.22*	*3.69*	*3.92*	*3.75*	*3.39*	*3.39*	*3.71*	*3.71*	*3.71*	*3.71*
Gross Margin	**Gross Margin**		**0.00**	**0.59**	**1.35**	**2.74**	**3.22**	**3.39**	**3.75**	**3.75**	**3.43**	**3.43**	**3.43**	**3.43**
	Depreciation & amoritization*		0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
EBIT	EBIT		**0.00**	**-0.22**	**0.55**	**1.94**	**2.42**	**2.59**	**2.95**	**2.95**	**2.63**	**2.63**	**2.63**	**2.63**
	US Corp Tax Rate*		*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*	*0%*
NOPAT	NOPAT		0.00	-0.22	0.55	1.94	2.42	2.59	2.95	2.95	2.63	2.63	2.63	2.63
	Non-Cash Exp (Dep & Amort)		0.00	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
	Operating Cash Flow		*0.00*	*0.59*	*1.35*	*2.74*	*3.22*	*3.39*	*3.75*	*3.75*	*3.43*	*3.43*	*3.43*	*3.43*
	Investment expenditures*		-5.82	-8.78	-0.45	-0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FCF		-13.15	0.00	0.59	1.35	2.74	3.22	3.39	3.75	3.75	3.43	3.43	3.43	3.43

DSM Base Share	50%
NPV @ 13%*	**0.14**
IRR	**13.1%**

** WACC:* 13%

**** Case excluding terminal value; assumes investments beginning period 1***

**** Assumes 8% interest, 13% reinvestment rate (same as hurdle)***

INVESTMENTS - 100% DSM Rollout [M€]												
Investments @ GPC Location	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
R&D Yeast W1.5	1.50	0.75	0.45	0.23								
R&D Enzymes W2 (no charged allocation)	0.000	0	0	0.0								
Total investment expenses (100% DSM M€)	**1.500**	**0.750**	**0.450**	**0.225**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Total Investment NPV	**€ 2.36**											

FIGURE 17: II. Dry Mill Frac/Wet Mill: Base + Post-PROCESS-CO. Rollout NPV & Investments

ROLLOUT SIMULATION: 100% DSM [M€]												
License Revenue [EBIT Multiplier]	20%											
COGS Factor	10%											
Yearly Entrant Probability	**20%**											
Yearly Market Growth Rate	5%											
Starting Market Size	**30**											
Yearly Worst New Licensees	**0**											
Yearly Most Likely New Licensees	**1**											
Yearly Best New Licensees	**2**											
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
Market Size [# Pos. Licensees]	0	0	30	32	33	35	36	38	40	42	44	47
Num of DSM Signed Licensees	**0**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Remaining Available Licensees	0	0	29	30	29	28	25	23	21	19	17	16
New Competitor Entrants	0	0	1	1	1	0	0	0	0	0	0	0
Competitors (Begin Year)	0	0	0	1	2	3	3	3	3	3	3	3
Num of Comp. Signed Licensees	0	0	0	1	3	6	9	12	15	18	21	24
2xEBIT (GPC+DSM) [M€]	0	0	0.22	0.77	0.97	1.04	1.18	1.18	1.05	1.05	1.05	1.05
Revenues	0	0	0.22	1.55	2.90	4.14	5.90	7.07	7.35	8.40	9.45	10.50
Costs	0	0	0.02	0.15	0.29	0.41	0.59	0.71	0.74	0.84	0.95	1.05
Total Profits	**0**	**0**	**0.20**	**1.39**	**2.61**	**3.73**	**5.31**	**6.37**	**6.62**	**7.56**	**8.51**	**9.45**
Total NPV Profit [M€]	**€ 17.68**											

FIGURE 18: II. Dry Mill with Frac/Wet Mill: Base + Post-PROCESS-CO. Rollout Revenues w/ Competition

CORRELATION MATRIX: ABSOLUTE VALUE CORRELATION					
	Corn	**DDG Dry**	**DDG Wet**	**Crude**	**Ethanol**
Corn	1	0.906	0.896	0.818	0.669
DDG Dry	0.906	1	0.860	0.733	0.574
DDG Wet	0.896	0.860	1	0.734	0.654
Crude	0.818	0.733	0.734	1	0.713
Ethanol	0.669	0.574	0.654	0.713	1

FIGURE 19: Correlation Matrix Showing Covariance Amongst Commodity Prices

2.5 COMMENTS CONCERNING NET PRESENT VALUE

NPV is a common method for arguing the business case for commercial projects or ventures, especially those deemed risky or uncertain. A strong NPV case tells a detailed story concerning planned cash flows sunk into and generated by a project towards an uncertain future. As such, once agreed upon amongst the stakeholders in a new venture, it takes on the aspect of a loose contract or set of expectations surrounding expenses and revenues to be generated by a new venture.

Inherently, NPV analysis assumes reference to the cash flows of the wider business through explicitly identifying relevant line-items such as changes in working capital, corporate tax, depreciation and amortization, and interest charges. However, when a project is being conducted by a division in a larger company, it can be difficult to explicitly break-out (or subdivide in, as the case may be) these line items. An R&D venture undertaken by a division typically involves an investment and a set of potential future cash profits. However, items such as labor expenses, interest charges, tax benefits, capital infrastructure utilization and subsequent depreciation are typically too complex to break-out from a large operating corporate context to that of a division or group. The group benefits generally from corporate financial support, yet the full financial context of the investments can be difficult to track in terms of the larger relevance to depreciation and amortization, changes in working capital, tax structure, etc. When a partnership between two large firms is at play, such as the case between BIO-INC. and PROCESS-CO., the matter becomes exponentially more complex.

As such and in addition to, the WACC (Weighed Average Cost of Capital) for a large firm may not be cross-applicable to a division taking on a risky venture. If the division is not easily able to reference the NPV enhancing (as well as constraining) line items of the larger firm, it may not be appropriate to force the division to apply a firm-weighted WACC. WACC is derived from the Capital Asset Pricing Model (CAPM), which derives a hurdle rate based on weighted firm-wide debt and equity levels. This point is often neglected, but is serious and important for divisional groups conducting NPV analysis, particularly those involved in new product development and/or R&D efforts.

An R&D unit conducting an NPV analysis using the firm-weighted WACC is disadvantaged in not being able to situate the risk of their venture within the context of all corporate cash flows as well as important NPV line-items such as changes in working capital, tax subsidies, building and equipment depreciation and the like. Applying the same hurdle rate to a R&D division and a group managing an established product line sorely hobbles the ability of the firm to take on R&D risks. As expressed by M. Rees, “the discount rate in the presence of flexibility should be different to the one that may be initially derived when using (CAPM). The ability to react to flexibly to different outcomes generally reduces the risk and so, perhaps, a lower discount rate should be used than if the flexibility were not considered” (2008: 192).

As a work around, in the case of BIO-INC. White Biotech, it may be worthy to consider an NPV case which assumes its R&D initiative as undertaken by an autonomous business, for instance an autonomously operating biofuel plant. In this way, the NPV case gains the advantage of a proportionately smaller WACC as well as the ancillary line-items such as depreciation and the taxation benefits of debt interest charges befitting the scope of their R&D project. Beyond this, once built, the same independent NPV analysis can serve as a base-case for valuing hypothetical products. Many firms struggle to price new products and services. In the BIO-INC. White Biotech case, having an atomic, working biofuel plant NPV case on hand allows them to situate the new product in the plant financial case to determine the highest possible pricing threshold. This approach becomes exponentially more powerful when the ability to run active simulations as added, as shall be examined in the section following.

As an additional consideration, as is common with many biotech and petroleum R&D projects, the risk free rate could be used in the place of WACC. This would have a dramatically positive effect on BIO-INC. White Biotech’s NPV results. For example, changing the BIO-INC. project WACC from 13% to 5% (nearer to the market risk free rate), results in more than a 20%

chance of the project achieving a positive NPV (results as per Monte Carlo simulation which will be examined in the next section).

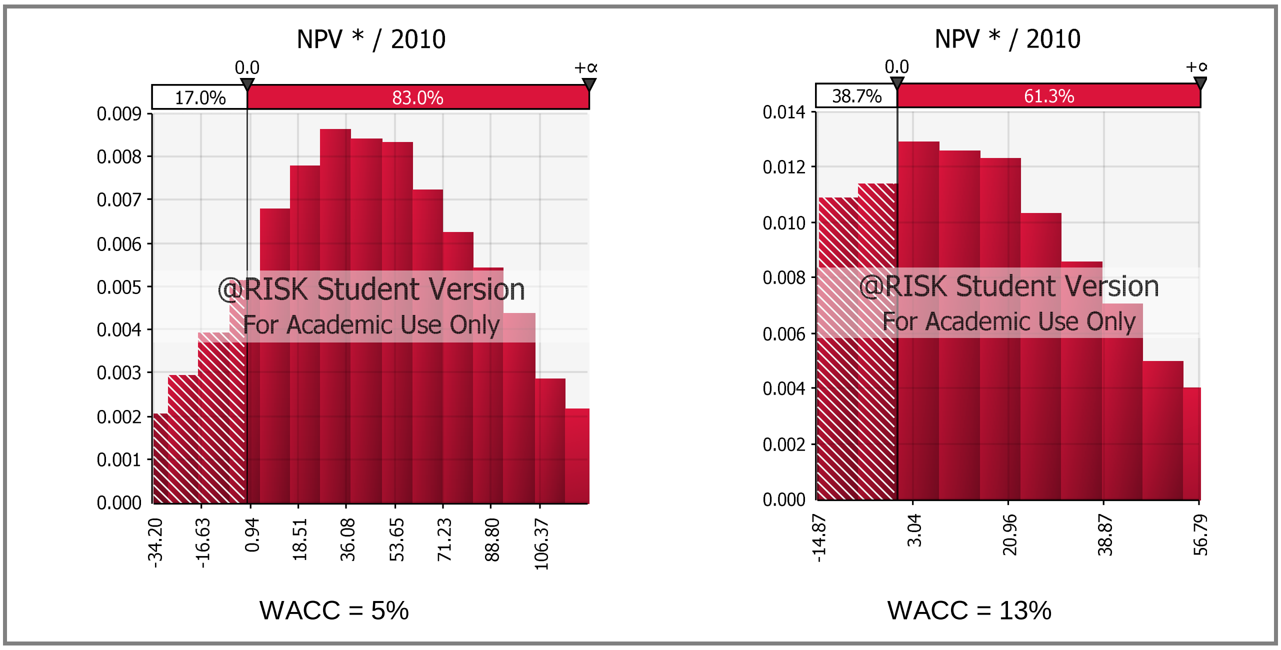

FIGURE 20: Differential Positive NPV Probability for Project I: 5% versus 10% WACC

The intention here is not to discount NPV analysis, but rather to make an important point concerning the context and use of NPV. NPV analysis conducted for an R&D-related venture within a larger corporation can often be misleading and frequently disadvantages the division with unfair expectations and thresholds. It is not uncommon for groups in such a circumstance to subsequently 'juice' or otherwise wishfully enhance their NPV assumptions. The downside of this is that the NPV-case then becomes an artifact or contract with corporate upper-management. A particularly conservative board may monitor development of the business venture and subsequently get 'cold feet' should projected cash flows fail to materialize or should expenses over-run based on the unrealistic NPV.

The best defense in preparing the NPV is transparency and explicitly noting where an NPV case is disadvantaged. Much as in the same way a corporate annual report contains important notes and line-item commentary, it is appropriate to enhance an NPV case by attaching notations. In this manner, alternate assumptions can be inputted such as applying a lower WACC. WACC in particular significantly affects the NPV break-even case. A lower WACC can be utilized by a division and be justified as compensation for not having the advantage of corporate debt tax benefits, building depreciation, changes in working capital and the like.

Additionally, although NPV is the generally recognized ideal method for making corporate investment decisions, a recognized disadvantage is that it does not account for flexibility / uncertainty after the initial project decision is made (Value Based Management.net., 2009). The high degree of uncertainty in the NPV analysis is not well accommodated in the linear NPV calculation. Allowing for flexibility / uncertainty is the domain of ROA, and thus this project recommends NPV be extended to utilize this method. Rather than enhance a low NPV by unduly exaggerating cash flows, which creates a heavy and frequently unreasonable future managerial expectation, ROA can be used to extend the NPV base-case.

Projects and initiatives which involve a high-degree of uncertainty, research and development initiatives or projects associated with new and/or unstable markets, are faced with particular challenges in composing a reliable NPV analysis. Indeed, Real Options has gained growing popularity for application to R&D NPV cases in order to enhance NPV projection by valuing the potential to expand into new markets and product ranges brought about by an otherwise risky R&D venture. Thus the petroleum (De Maeseneire, 2006: 9; Koller, Goedhart, and Wessels, 2005: 560; Rees, 2008: 192) and pharmaceutical (Brealey et al., 2006: 257; McGrath, 2004; Shockley, Curtis, Jafari, & Tibbs, 2001) sectors have become particular adopters of ROA as their core activities inherently involve high-risk, high potential reward projects (oil exploration and drug development). Given the huge investments involved and high failure rates, traditional NPV analysis would typically shut-down most oil and drug development projects. However, as they are both profitable and viable sectors, clearly there is value inherent in taking large and, on the surface, unreasonable R&D risks. Real Options is the preferred method to value projects with high risks and high potential rewards.

3. P2: VOLATILITY SIMULATION

3.1 BEYOND STATIC NPV

This project advocates ROA to enhance organizational decision making and risk analysis. An effective ROA rests on a firm valuation case, NPV being the most common valuation method utilized. However, NPV is not an exhaustive analysis technique, and certainly not a prescient forecasting method. An NPV case is a static and biased perspective founded upon informed guesses; it is characterized by a combination of uncertain variables on which didactic values have been forced. However, the underlying 'real world' scenario, in most all cases, implies dynamic, shifting variables with probabilistic ranges. Thus, there is implicitly a great degree of variability possible in even the simplest of NPV cases, not a static, singular final value called NPV. This section takes several of the BIO-INC. NPV cases and expands them via the technique of computer-based probability simulation modeling.

Most NPV analysis ends with reduction to a single, static NPV number which, if positive and subsequently agreed upon, becomes tacit assent for project approval. Particularly as the NPV forecast projects several years into the future, the accuracy possible in anticipating future variables decays rapidly with time. Forecasting cash flows ten years into the future, can be quite arbitrary, particularly when dealing with uncertain markets and/or technologies. When commodity prices and new markets are involved, a long term static NPV can take on the suspicious countenance of a fool's errand. However, it is not the assertion here that NPV analysis is a waste of time and effort, rather that it should be *extended* appropriately. As all companies need to plan for the uncertain future, throwing one's hands up in despair is the equivalent of relegating planning to intuition and innuendo, which, particularly in large companies, can lead to tunnel-vision or even mystical thinking. Going through the exercise of building an NPV case does impose a necessary and valuable planning discipline and provides artifacts around which to focus organizational consensus building.

Weather forecasting can be thought of as an apt metaphor: giving up on weather forecasting because many forecasts have a high error rate would be clearly folly, as well as a broad disservice to farmers, fishers, sports enthusiasts, and holiday makers everywhere. The science of meteorology has embraced uncertainty in its models and methods, admitting a level of uncertainty, yet narrowing forecasts and improving reliability steadily with advanced computer-based analysis and simulation. Regardless of whether the weather is forecasted, it unfolds in time. Likewise, regardless of whether revenue forecasting is conducted, cash flows emerge in business. However, to allow the future to unfold absent an attempt at planning is to surrender to the vagaries of rain, chaos, and chance, to the ultimate detriment of all types of human endeavor. In business, to abandon planning is to allow a competitor to plan for and capitalize on your eventual missteps: getting caught in an unforeseen storm.

NPV cases are forecasts, and as such can be considered to be informed guesses, with many of the contributing variables having a range of *possible* values. For instance, though a corporate tax rate is typically treated as a static percentage, there is a chance that a tax rate may raise or fall several years in the future. Similarly, a revenue stream in the future is susceptible to variable competition and demand factors. When several elements in an NPV are attributed with a range of possible values and probabilities characterizing their observed dynamic range, the NPV case becomes an aggregate range of potential values, itself with aggregate associated probabilities. In particular, advanced simulation allows for a quantification of uncertainty or risk. This is the goal and sphere of advanced computer-based simulation.

A quantification of the 'uncertainty factor' in a project is a necessary ingredient for performing ROA. The 'unknown' aspect of an NPV value provides for additional potential value beyond NPV (as an NPV forecast has an upside and downside at all times). Once project uncertainty, or volatility (in the form of an NPV standard deviation, for example), has been quantified as a constant over a particular time period, a set of possible managerial decisions can be specified along the timeline such that the flexibility to shape the future NPV outcome can be formally valued (i.e.: the option to expand, delay, or abandon a project). In simpler terms, the active flexibility to "change one's mind" during the course of a project quantitatively adds tangible upside value. A manager can fine-tune the emergence of a project as it evolves, preventing degeneration or disaster, or enhancing value and upside by expanding.

ROA depends on developing an understanding of the volatility attached to a particular NPV case. Volatility, as a formal quantitative measure, specifies a likely range of possible values associated with an NPV figure. Specifically, in NPV terms, volatility is one standard deviation measure from the mean NPV (or the possible NPV value at the 34% range above the mean in a normal distribution encompassing all possible project NPV values). Formal volatility is a measure of the risk associated with an exposure (risk, in a casino context, also entailing exposure to a potential reward). Thus, a project with a high standard deviation will have very high and very low possible NPV outcomes.

Volatility, from a formal mathematical as well as a heuristic standpoint, is the "work horse" of a proper ROA, but, and of equal value, should also be considered as an enhancement and extension to a valuation exercise. Understanding volatility, or more simply, the range and probability of a project delivering a range of possible NPV returns, allows for a conceptual window to be opened: that a project involves many unknowns, that these unknowns can lead to both positive and negative future developments, and that, by tracking these unknowns and attempting to understand them comprehensively, they can be actively managed to optimize the upside potential.

Sensitivity analysis via computer-based simulation is an excellent method to quantify project volatility, for instance by modeling and simulating a range of probabilistic NPV scenarios. As stated by Brealey et al., "sensitivity analysis allows you to consider the effect of changing one variable at a time. By looking at the project under alternative scenarios, you can consider the effect of a *limited number* of plausible combinations of variables. **Monte Carlo simulation** is a tool for considering *all* possible combinations. It therefore enables you to inspect the entire distribution of project outcomes." (2006: 252).

The broader business use of simulations has grown exponentially with the brute strength of computers and developments in the sophistication of supporting software tools, not to mention the advancement of mathematical algorithms and techniques. Optimizations of complex quantitative models often required large mainframe computers fifteen years ago, and thus were relegated to those with the proper mix of impetus and resources: defense, government, and large financial institutions. "The ability to find optimal solutions quickly has grown by leaps and bounds… Fifteen years ago, you had to have mainframes and cluster computing to do any of this. Now you just need a person in a cubicle" (De Aennle, 2009).

A key concept advocated here is that each element of a valuation exercise is open to question. However, by taking a structured approach in characterizing the particular aspects of uncertainty, the aggregate uncertainty reduces. This is the case both for individual variables and for the aggregate NPV case. In simpler terms, a stream of revenues may be an arbitrary guess when first contemplated, yet when considered under scrutiny, much can be done to get a better and better forecast – the uncertainty can be defined, contained, and, ideally, then managed. Past data, other product in similar markets, and the opinion of experts can all be marshaled to move from an informed guess to a quantitatively sound (given available data and analysis) argument. Crucially, given a complex model, a set of mere "best guesses", when combined in aggregate and simulated via massive computer trial and error, can reduce uncertainty to a remarkable extent.

3.3 NPV MONTE CARLO SIMULATION

As a component in the P1 – P3 ROA, Monte Carlo simulation was conducted in order to quantify the volatility (risk) inherent in the previously developed NPV cases. The four project NPV cases were developed into Monte Carlo simulations via the Palisade @Risk software tool. The software tool allowed probability distributions of different types to be setup for key variables and for some variables, such as the covariant commodity prices, to be linked via a covariance matrix (which ensures that simulated pricing motions will be probabilistically covariant with linked partners). The tool allowed variables with historical data, such as the €Euro/$US exchange rate, to be analyzed in order to determine the best probabilistic distribution for future iterations. As well, the software allowed simulations to be run (in the many 1000's of iterations) and for aggregate results to be analyzed and graphed.

The implementation was carried out by converting appropriate variables to applicable distributions. First all component variables making up the NPV case were examined and classified. The following categories emerged and were treated respecively:

1) **Structural Variables:**
   Aggregates and transformations (i.e.: EBIT, COGS, Gross Revenue) – kept as-is, though in some cases implemented as a 'risk output' to analyze aggregate distributions at that level (i.e.: COGS, Gross Revenues, NPV).

2) **Market Variables:**
   Commodities and exchange rates (i.e.: oil price, corn fiber price, €Euro/$US exchange) – Analyzed to determine mean and standard deviation, established as probabilistic distribution variable (i.e.: corn price implemented as a normal, mean reverting distribution with a mean price of $3.8/yr and a standard deviation of $0.56/yr).

3) **Cumulative Aggregators and Variants:**
   Variables which accumulate or diminish probabilistically according to an array of other variables and variants, sometimes decision factors associated (i.e.: yearly total market demand, caped at a particular level) – Implemented with a probability or as the combination (i.e.: sum or difference) as one or more probabilistic variables.

4) **Cumulative Market Variables:**
   A special case of cumulative aggregator, where the variable develops according to a probabilistic distribution based on the prior time series (leading to a probabilistic 'random walk') – this method was superimposed on all commodity prices and the €Euro/$US exchange rate such that each year's development was the basics for the next year's starting value (which then iterated probabailistically)

5) **Simple Variants:**
   Variables with simple best, worst, most likely scenario ranges (i.e.: investment cost) – Implemented as triangular distributions (with a peaked probability of achieving the most likely value).

Of particular note, while initially a number of variables were outfitted with specialized distributions (i.e.: lognormal or gamma distributions), this often led to extreme and unexpected results. While technically the correct approach, it was felt that give the strong impact of unusual distributions on the aggregate model, more in-depth econometric analysis would be required before items such as the €Euro/$US rate should be implemented with a specialized distribution. As such, the defacto distribution selected was the normal distributions, which mathematically and in statisitical observation, has the broadest overall correlation with random, mean reverting variables (particularly market-driven values such as commodity prices and the like). This did influence the aggregate resulting NPV distribution towards strong normality.

Finally, variables that could be statistically proven (using regression analysis) to have covariant relationships with other variables were bound into a correlation matrix (see Figure 19). This applied to the commodity price variables oil, ethanol, corn, dry corn fiber (Dry DDGS), and wet corn fiber (Wet DDGS).

3.4 NPV MONTE CARLO RESULTS

Beyond quantifying volatility, Monte Carlo simulation in-of-itself is a worthy and valuable exercise. It is worthwhile to briefly review some key results from the analysis before proceeding to the Real Options analysis. Indeed, as the purpose of the Real Options analysis is to recommend optimal future decisions, the Monte Carlo sensitivity results should be considered crucial context for understanding the subsequent ROA.

Project I (Dry Mill No Fractionation Base Case) revealed that there is a 61.3% chance that the project will achieve a positive NPV rate.

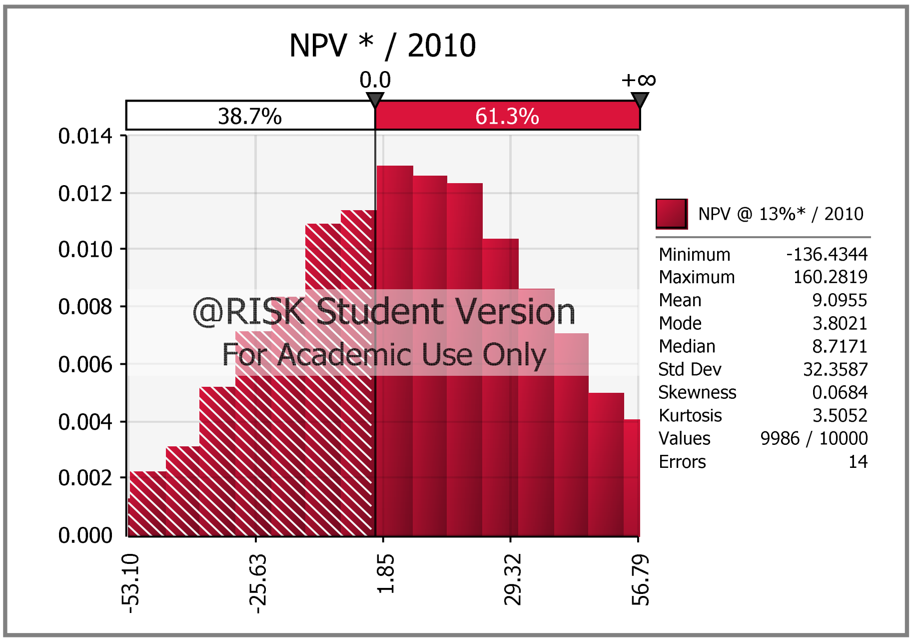

FIGURE 21: NPV Probability Density for I. Dry Mill No Fractionation Project: 61.3% Positive NPV

In the case of project profile II, an even greater probability of achieving positive NPV emerges: 85.8%. This would suggest Project II as far less risky.

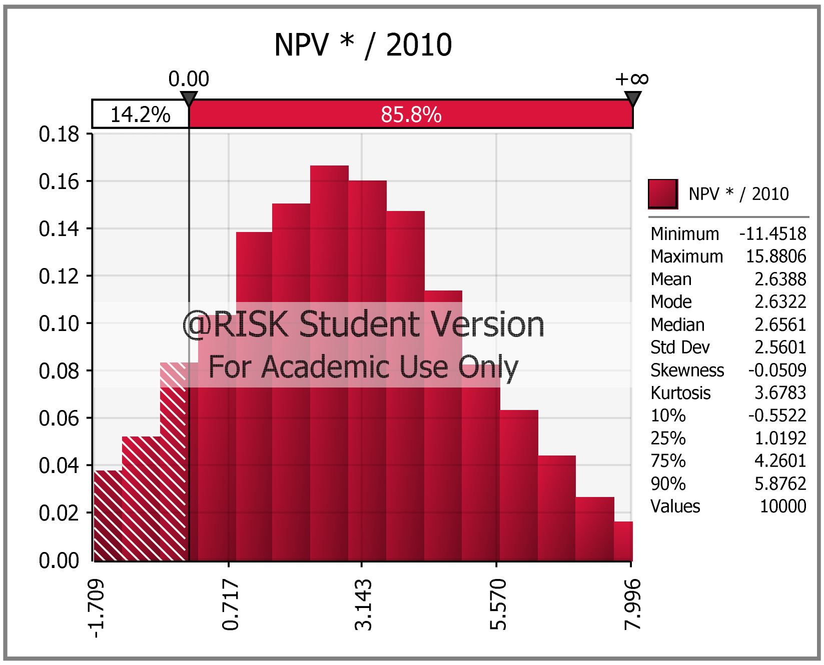

FIGURE 22: NPV Probability Density for II. Dry Mill with Fractionation or Wet Mill

An insightful artifact issuing from typical Monte Carlo sensitivity simulation is the Tornado Graph. Each bar signifies either a positive or negative effect on NPV: when the input factor changes by +1 standard deviation, the output (NPV) will change by that percentage of the output (NPV) standard deviation either positively or negatively, as indicated. The tornado graph displays the most influential variables on core NPV. Thus, for Figure 23 below, for each 1 standard deviation increase in the price of 2010 corn (a change of +0.79 US cents), the standard deviation of the NPV will DECLINE by -0.3 standard deviation (€33m x 0.3 = €9.9m). This is valuable information as it clearly shows where the central risk (and opportunity) points are regarding NPV value. Typically, after a set of key influential variables are identified, additional focused analysis and simulation is undertaken to understand how best to manage the risk (for instance, to hedge disaster scenarios or to exploit desirable outcomes to the fullest). In this example, the suggestion would be to use futures derivatives to hedge a rise in the price of corn (i.e.: buying and continually rolling corn future call options at a target price for a specified period of time according to a refined hedging strategy).

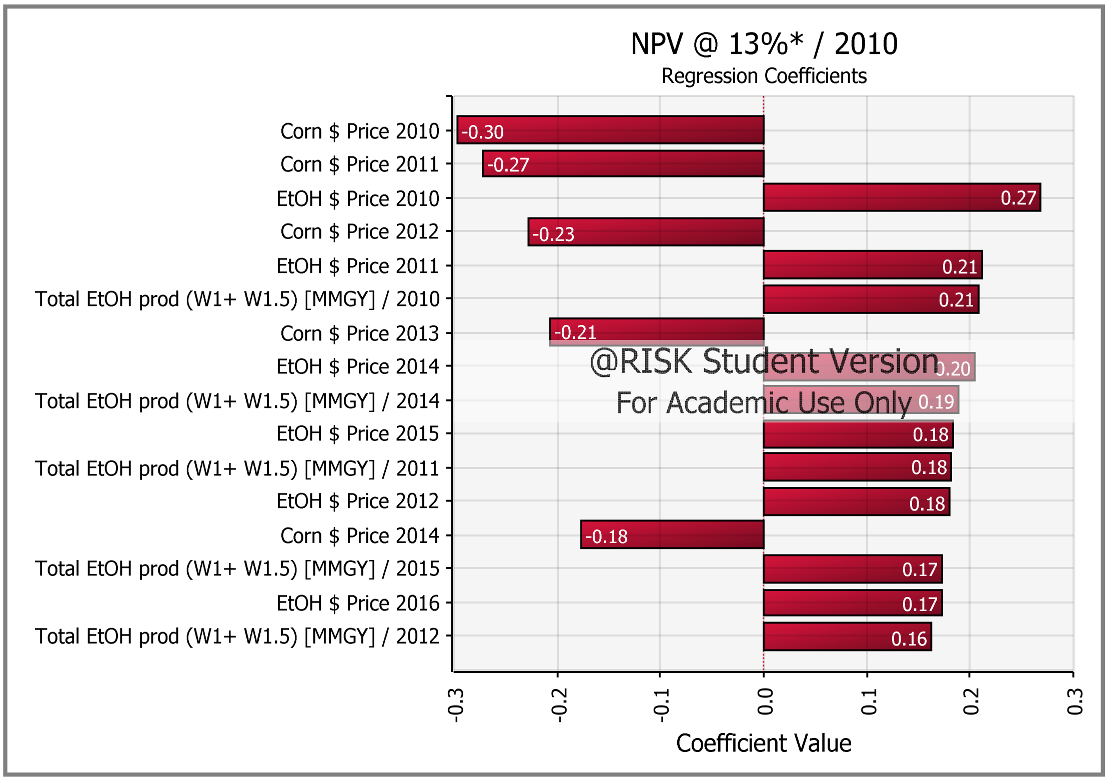

FIGURE 23: Regression Coefficients for I. Dry Mill No Fractionation

Regarding Project II, Dry Mill Fractionation / Wet Mill, as per Figure 24 below, a one standard deviation increase in 2010 €/$ exchange rate (€0.19) increases NPV by .38 standard deviations (€2.63m * 0.38 = €0.99m). Thus the Euro rising from the historical mean of €/$1.32 (as applied in the model) to €/$1.51 would increase NPV by approximately 38% to €3.62m. This is explained by the fact that the most substantial project investment, BIO-INC.'s 50% share in a $24.23m investment or $12.11m (€8.03m estimated at €/$1.32), is made at the beginning of 2011 based on the 2010 Euro/$ exchange rate (as per the model specification). Thus, a strong Euro (a high €/$ exchange rate) at this point early in the project lifecycle would require less Euros to cover the required US$ investment, which would reduce the hit to the core NPV. As this payment occurs near the beginning of the project in year two, it is also strongly impactful as it is only discounted for two years at the operative 13% WACC rate. Were the investment to occur much later in the project, the time value of money would lessen the impact on NPV due to discounting. A €10m Euro investment paid out in year two of a ten year project has a negative €7.8 impact on NPV, whereas the impact is €2.94 if paid out in year 10 (PV = 10/(1.13)^10).

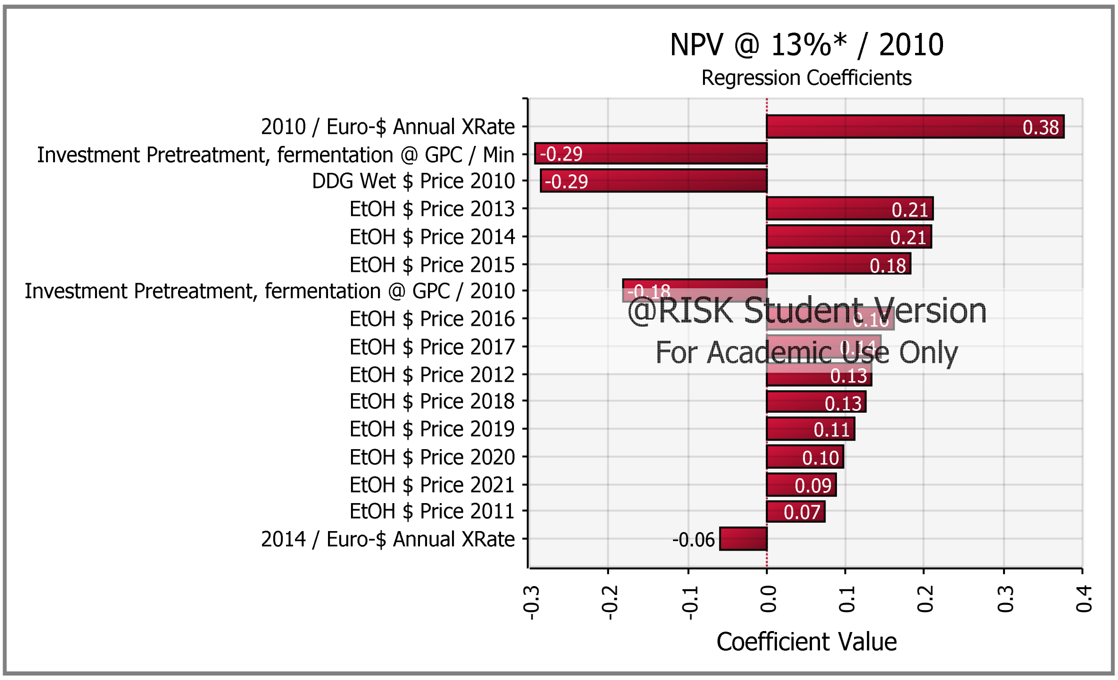

FIGURE 24: Regression Coefficients for II. Dry Mill with Fractionation or Wet Mill

The rest of the variables can be similarly interpreted. Thus, again, as per Figure 24 above, an increase in the required fermentation pretreatment investment would impact NPV in a reverse, negative fashion. Other impactful variables are the negative impact of the DDGS Wet price early in the project and the positive potential impact of Ethanol price rises starting early in the project and extending in a downward slopping fashion throughout the project lifecycle.

From the Tornado Graph, we turn to a similar measure, the Correlation Coefficient Graph. This measure shows the variables most correlated with, or tied to, the NPV value. A positive indication (rightward pointing) bar indicated that for each 1 standard deviation increase in the measure indicated (i.e.: EtOH $ Price 2010), the NPV will be positively effected by the indicated standard deviation multiplier (i.e.: 0.34 of 1 NPV standard deviation for Project I).

As per Figure 25 below, it can clearly be seen that Ethanol price is a singularly bound to the NPV value, for Project I (Dry Mill No Fractionation), meaning an imminent rise in Ethanol price bodes well for the NPV, whereas a price decline suggests the project will move into the red. This would be a clear indication that the price of bioethanol should be consistently hedged throughout the life of the project (likely through gas futures). For a case study on the beneficial use of derivatives to hedge NPV, Southwest Airlines realized huge profits in the early 2000's due to their active jet fuel hedging program (against price rises). Whereas several major carriers were driven into bankruptcy by spiraling oil prices due to speculative buying, Southwest was able to secure jet fuel as a pre-negotiated barrier price, and thus buy at a premium when competitors were paying exorbitant prices.

Although this project has a huge upfront investment compared to Project II, nearly €63m, the 29-cent US$ annual standard deviation observed in the price of ethanol is a stronger long-term influence on future NPV than the investment outlay. This can be taken as a positive indication that the initial investment is reasonable: it offsets the investment by exposing the cash flows directly to the biofuel market. Clearly one would want to take careful stock of their outlook on the oil market (as a strongly covariant influence on biofuel prices), even undertaking a comprehensive econometric analysis of the market with a view to understanding how best to hedge forecasted price risks.

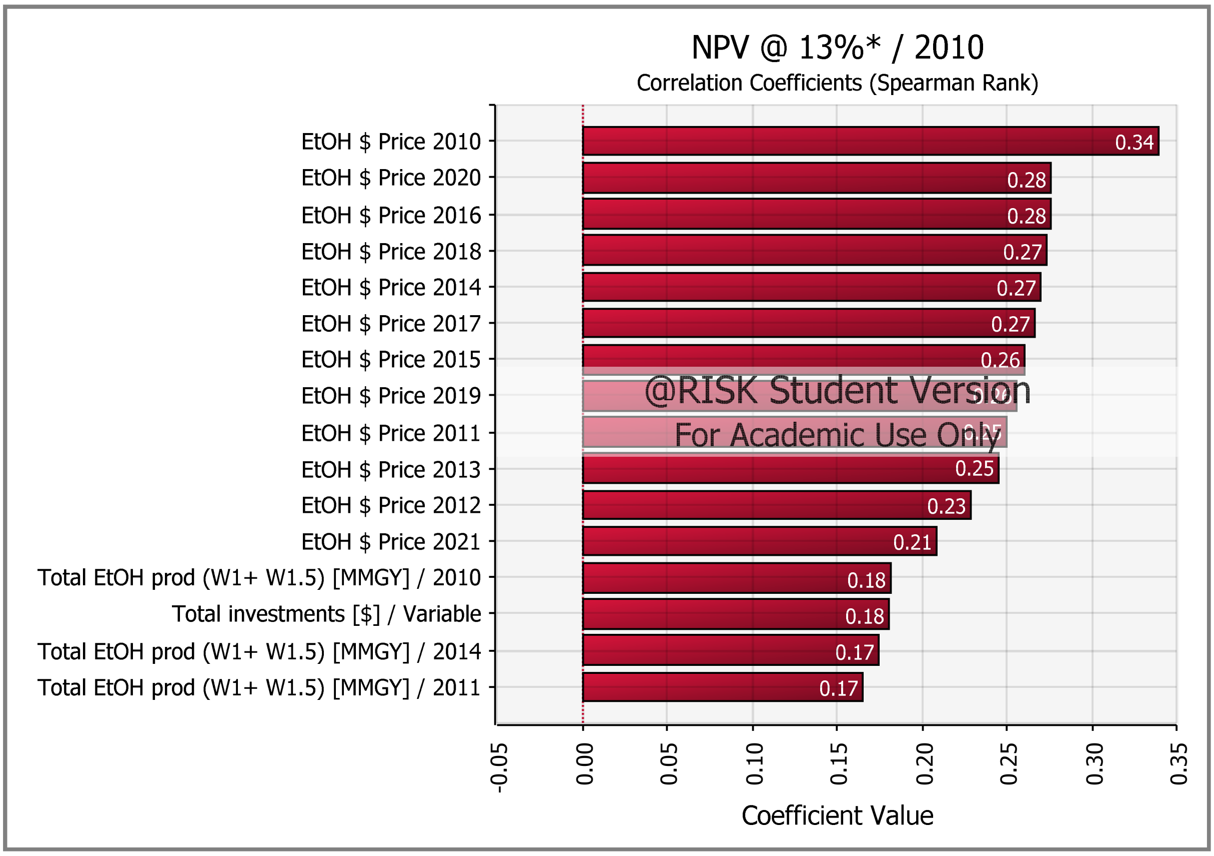

FIGURE 25: Correlation Coefficients for I. Dry Mill No Fractionation

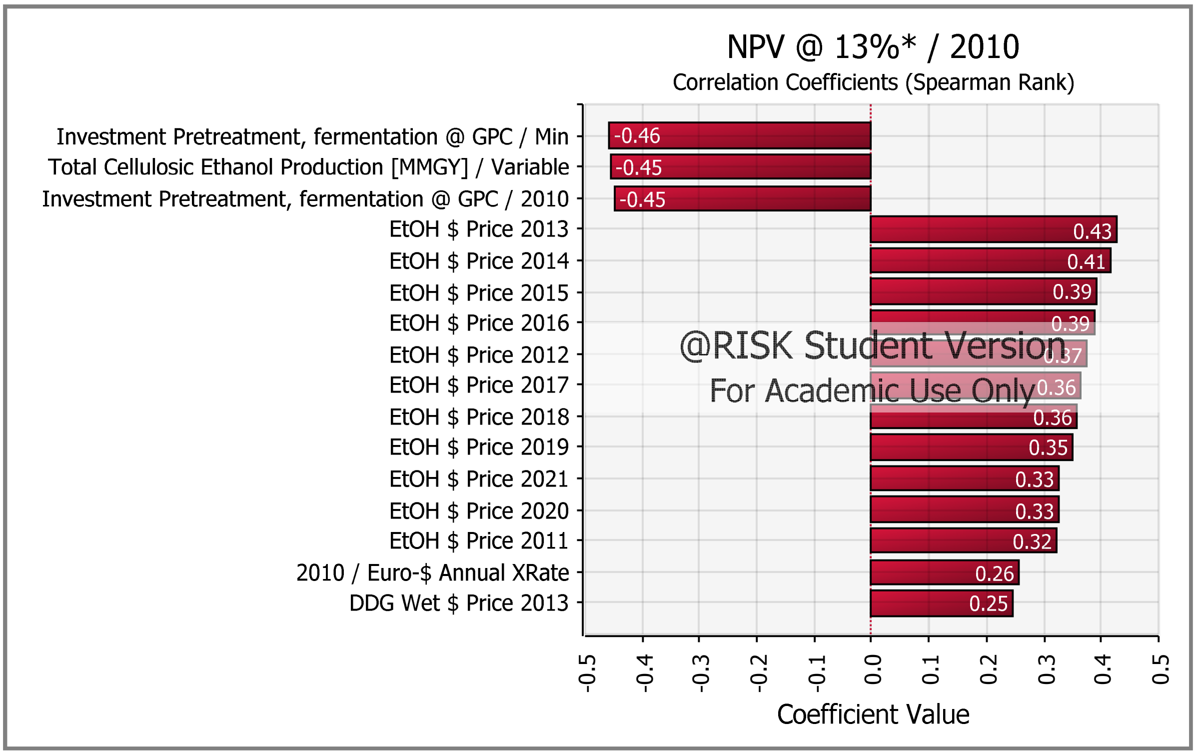

FIGURE 26: Correlation Coefficients for II. Dry Mill with Fractionation or Wet Mill

Lastly, we examine the equivalent Correlation Coefficient for project II (see Figure 26, above). A result of interest to project stakeholders is that the €/$ exchange rate is a key factor in future profitability, to the degree that annual costs and revenues are exchanged periodically between the two currencies. A stronger Euro (a higher €/$ rate) means that profits will be proportionately lower when re-imported to the Euro zone. While paying costs with a higher value Euro converted to US$ balances the effect, the exchange rate can affect the profit premium when revenues are returned.

Examining the distribution of weekly Euro to US$ exchange rates throughout the history of the Euro (1999 – present), the resulting distribution fits into a clean normal curve, with a mean of 1.17 and a current rate of 1.43 at the time of this report. This is typical of market traded commodities and financial instruments: there is a tendency to revert to their long-term mean value, to conform to the standard normal distribution observed throughout nature and the markets.

Without an active hedging strategy or strategic exchange program (which might time cost payments for high Euro rate points and revenue importation for low Euro rates), the project stands to give up valuable margins. To illustrate, if Euros are, forecast blind and unhedged, exchanged in lump sums on a periodic basis to export funds for paying costs and to import revenues, the intuitive tendency is to assume they are naturally cancelling exchanges. However, in addition to their being an outflow from transaction fees, the opportunity to realize valuable margins by timing the payments separately is lost.

Additionally, and more significantly, in the case of the collaboration, there is a disproportionate timing aspect to the NPV balance of currency imports and exports. Early in the project there are two years of proportionally high investments which, it is assumed, will require disproportionately high Euro to Dollar exports early in the project relative to low revenues in the early stages. A project danger is that the Euro drops in 2010 and 2011 and rises subsequently. The result would be a relatively expensive export of Euros for the initial project investments followed by weakened subsequent revenue imports (see Figure 27, below).

FCF CASE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency €/$*	1.40	1.40	1.30	1.25	1.20	1.15	1.15	1.15	1.15	1.15	1.15	1.15
NPV @ 13%*	**1.14**											
IRR	**14.0%**											
FCF CASE	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Currency €/$*	1.25	1.20	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
NPV @ 13%*	**-1.55**											
IRR	**11.6%**											

FIGURE 27: Effects on NPV of Two Extreme Euro-to-US$ Exchange Rate Scenarios

The simulation analysis identified fluctuating Euro-US$ currency exchange rates risk as a risk (as well as potential upside) to the project NPV's. Historical €/$ exchange rate analysis revealed the Euro to be relatively overvalued currently. As the rate has a clean normal distribution over a ten year future and, as with many commodities, market traded instruments, and economic factors, there is a high likelihood that the rate will decline closer to its historical mean (see Figure 28, below).

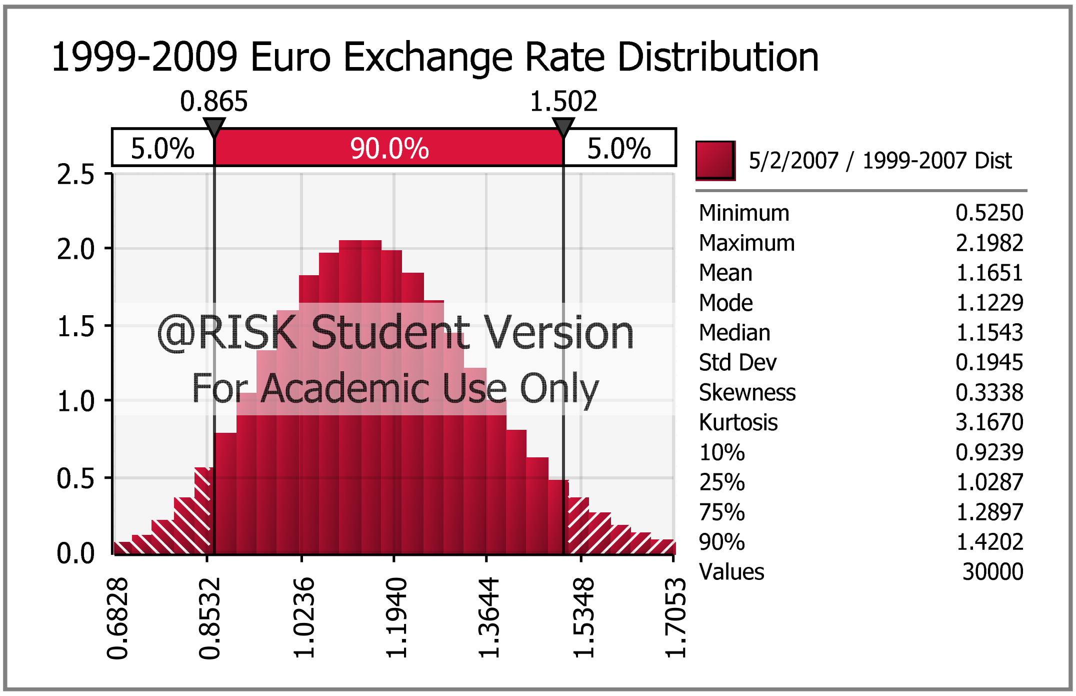

FIGURE 28: Euro-to-US$ Exchange Rate Distribution 1999-2009

Currency exchange risk can be mitigated in this project by working with the BIO-INC. Treasury to identify an ideal hedge strategy against a decline in the current high Euro€-to-US$ exchange rate so the two-year downside is protected. Available hedge approaches include using financial instruments (forward and future exchange contracts), corporate finance mechanisms (leading and logging or netting), banking products (swaps, forward rate agreements), or partner firm contracts (negotiated settlement agreements) (Saunders & Cornett, 2008:708).

Similarly, simulation for both NPV cases revealed sensitivity to corn and ethanol prices. Corn and ethanol price risk can be hedged using futures contracts in the commodities market (with unleaded gasoline providing a proxy for ethanol due to a tight historical price correlation). Feedstock in particular is regarded as accounting for 50 to 80% of biofuel production costs, thus having a disproportionately high effect on returns (Ceasar, Riese, & Seitz, 2007: 55). Corn costs accounted for approximately 65% of the I. Dry Mill No Fractionation case and Wet Corn Fiber accounted for approximately 30% of gross long-term production costs in the II. Dry Mill Fractionation / Wet Mill case.

The remarks made concerning the Euro exchange rate have general applicability to corn prices and corn product prices, such as wet corn fiber (pricing being tightly covariant with corn). Developing a hedging strategy for the commodity to insulate against future corn price rises via futures hedging would be wise. It is likely PROCESS-CO. Treasury is already active in this regard and can provide guidance. As per corn price distribution analysis (see Figure 29 following), there is a heavy positive skew (or long upward tail), indicating a bias to higher prices. With a standard deviation of 94 US cents and a mean of $4.02 per bushel, indications are that prices stand to break upwards from the 2009 average of $3.74 per bushel. For the Dry Mill No Fractionation case, this would lead to a 15% rise in annual costs and would seriously impact NPV.

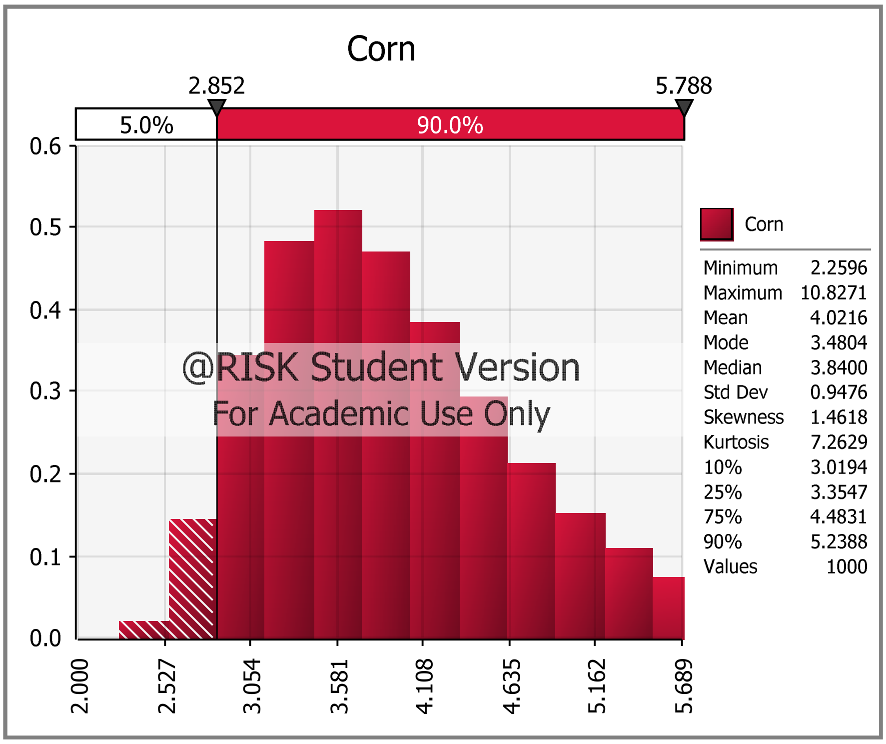

FIGURE 29: Yellow Corn Iowa Prices (US$/bushel) Oct 2006 – Jun 2009

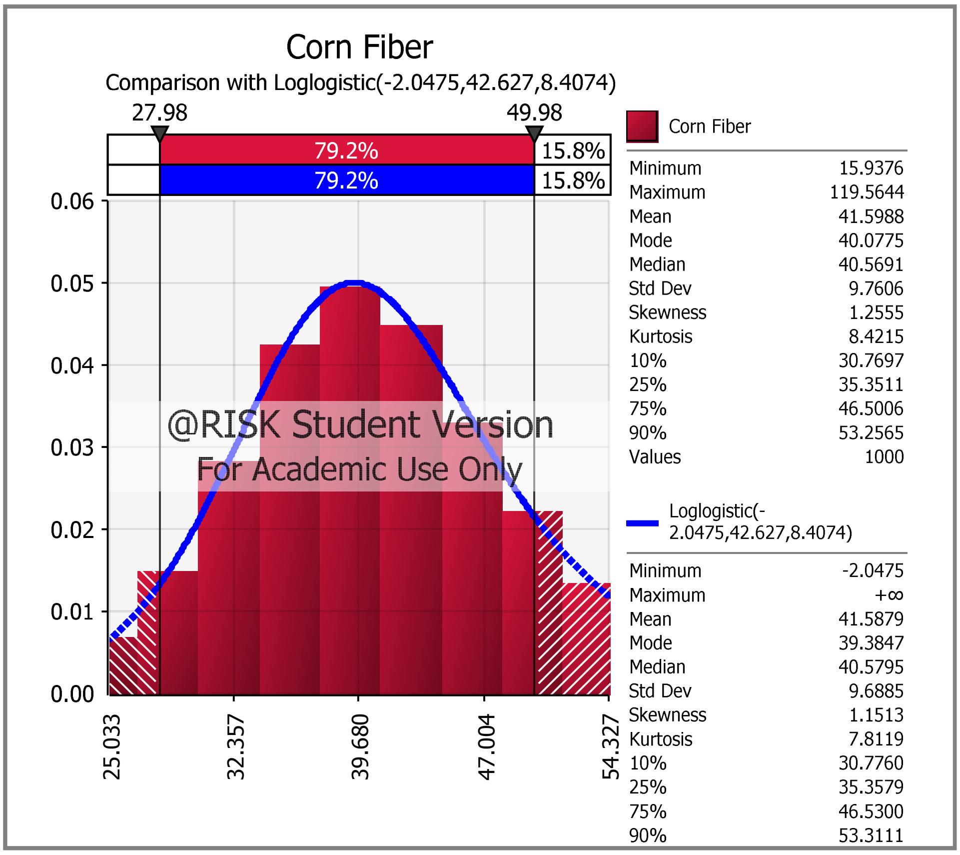

FIGURE 30: Modified Wet Distillers Grain Iowa Prices (US$/ton) Oct 2006 – Jun 2009

Similarly, the price distribution analysis for Wet Corn Fiber (Modified Distillers Grain with 50-55% moisture) reveals an upward skewed profile with a mean of $41.60 per ton and a standard deviation of $9.76. However, accounting for approximately 30% of costs for the Dry Mill

Fractionation / Wet Mill case means price rise impact would have a lesser impact on NPV (around 7%).

Finally, concerning the value of commodity and currency price analysis, the conduct of econometrics, the question arose from several team members as to whether forecasts were worthwhile. There was an opinion that prices and rates will go up and down randomly and thus forecasting ultimately ‘cancels out’. It would be useful to review concepts such as normality, reversion to the mean, and econometrics / regression analysis, especially with reference to the time value of money / cash discounting over long periods of time. This is especially the case as the BIO-INC. White Biotech group is involved in a commodities focused project, where actively strategizing against price swings in core commodities will be key to achieving profitability.

3.4 PROJECT VOLATILITY

The diversion to examine the Monte Carlo simulation results was undertaken to demonstrate that simulation in-of-itself is a valuable exercise. Whether for formal project risk management or generalized decision making guidance in environments of uncertainty, simulation results in many potentially useful insights. Ideally simulation is refined in active dialogue with key stakeholders: for instance, particular variables can be over or under-sensitized in the simulation model to investigate alternate outcomes. While this can be abused if genuinely impactful variables are taken out of the equation, the process of refining and strengthening the model to fit the perceptions of project stakeholders instills a considerable discipline. By thinking about the project as a set of dynamically interacting probabilities, particular items can be targeted for active monitoring and perhaps hedged.

However, it can also be remarked that a downside of simulation is that it is time consuming and that it has the potential to distract the wider goals of active project risk management. In this case, the end goal is to build a ROA model. The main point of the Monte Carlo simulation was to get a core volatility reading for the project. This is available via manipulating the @Risk Probability Density chart such that the registered raw Standard Deviation reading is cross-referenced with the Mean.

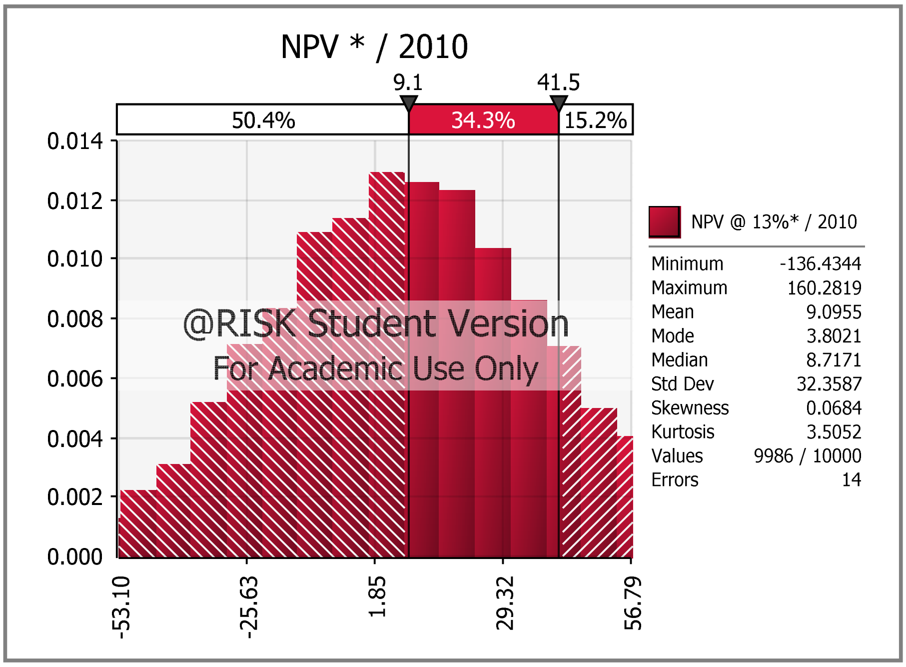

FIGURE 31: Project Volatility for I. Dry Mill No Fractionation: 34.3% (1 SD above Mean)

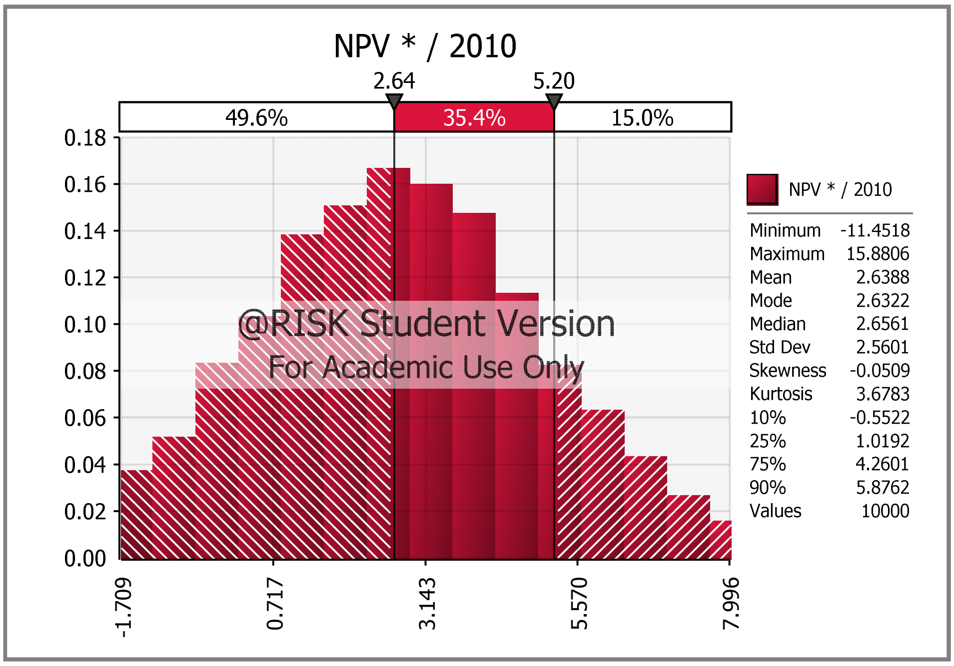

FIGURE 32: Project Voatility for II. Dry Mill with Frac. or Wet Mill NPV: 35.4% (1 SD above Mean)

A key observation is that the distributions for both projects evidence a high degree of normality. To wit, one standard deviation for a perfect standard normal curve is 34.1%. The fact that the simulated standard deviations for the two projects are very close to this range indicate that there are strong underlying normalizing factors at work. One interpretation would be that the key elements revealed in the correlation coefficient analysis, biofuel prices, corn prices, DDGS prices, and the euro exchange rate, are themselves strongly normal. This would be in keeping with the observation that market traded commodities and instruments themselves tend towards a normal distribution. More than this, it is also significant that normal distributions were selected to represent the commodities in the simulation model. The mean and standard deviations characteristic of each commodity were implemented via a normal distribution curve. Conducting deeper econometric analysis would likely lead to selecting more representative distributions (i.e.: lognormal). This is a topic for possible future expansion: refining the distributions representing the key commodities. It is also a caveat to the conduct of simulation: do not mistake the simulation results for the real world without understanding the inherent biases of the model.

The conclusion that could be taken here, if normality holds upon deeper analysis, is that the project itself will likely itself tend toward 'mean reversion'. That is, whatever perturbations and risks are evidenced in particular years, the profile of the project will, over time and by nature, tend to revert back to the *mean* cash flows indicated in the NPV simulation. More than reassuring, this can potentially be a profitable strategy to the degree that management decides to actively hedge underlying commodities involved in the project. If speculation is permitted, it is likely that biofuel pricing, euro rates, and corn prices can be aggressively countered when they stray from their mean values, providing a potential profit upside. However, the strong caveat is that the mission of corporate finance hedging is simply to hedge, not to speculate. It may be enough to benefit from this advice as strategic risk control guidance (and to avoid the risks of speculation).

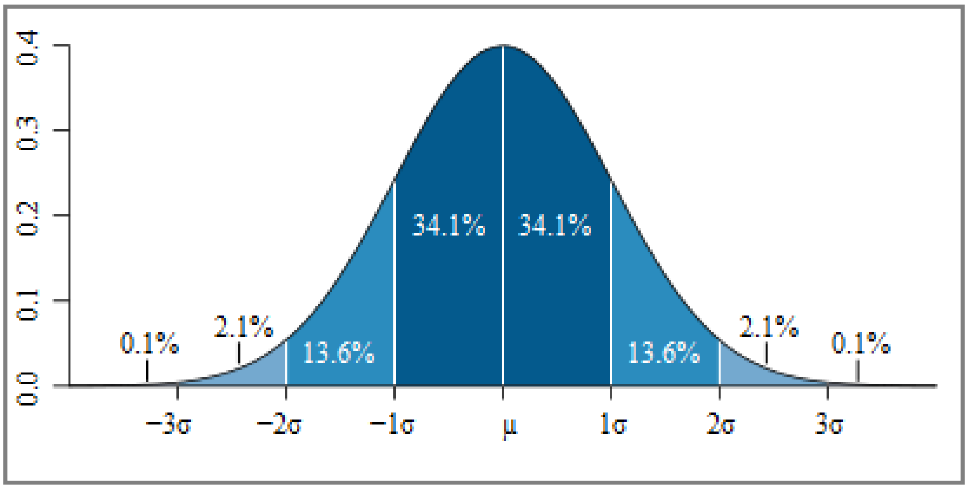

FIGURE 33: Standard Normal Curve (Wikipedia, 2009)

3.5 NEW PRODUCT AND NEW MARKET SIMULATIONS

With the effort to scale a process for of cellulosic bioethanol production in partnership with PROCESS-CO., competitive pressures are at play. Chief competitors at this stage include: Novozyme, Dupont / Danisco and a number of start-ups and smaller entities (Ratliff, 2007; Industrial Biotechnology Staff, 2008). As BIO-INC. White Biotech considers the products and services that it could potentially deploy from the development work underway, they must anticipate how competitive forces will apply pressure to their future product range, pricing, costing and market share (potential revenues). Indeed, BIO-INC. White Biotech management expressed a particular interest in developing competitive market simulations.

In order to quantify a hypothetical, potential future market, a competitive 'new market simulation' was designed and embedded in the post-PROCESS-CO. rollout Project I and II models. Costs and gross revenues were embedded in the new market model and the resulting total profits were fed directly to the related NPV model in the revenue section (thus altering the NPV picture). Given assigned market parameters, the associated business uncertainties of the competitive simulation iterate randomly within designed boundaries, being co-related in complex ways.

The simulation calculated revenues directly in Euros (thus bypassing exchange, an element which should be repaired) and assumed that BIO-INC. would retain 100% of projected earnings (subject to discussion). Beyond this, assumptions were made concerning the initial market size (the number of customers based on rough notions of deploying in the corn biofuel market in Iowa, USA). Assumptions were made about market growth over time, percentage COGS, revenue per license (a percentage of EBIT from the PROCESS-CO. case, itself simulated), and the yearly probability that competitors would enter the market. Finally, a yearly triangular distribution was implemented to determine the yearly probability of gaining new customers from the available pool of customers. Each year an irregularly increasing number of competitors would take available customers from the market based on a randomized probability. The basic variables supporting the model can be viewed below in Figure 34.

A key difference in the implementation between Project I and II market simulation is that Project I - Dry Mill No Fractionation has a much larger starting market, 120 customers (potential licensees) versus 30 in the case of Dry Mill No Fractionation / Wet Mill (starting in the first deployment year 2012). The result of the combined probabilities, varying randomly, intends to simulate the unpredictable nature of a new marketplace. Also, an assumed investment requirement was added to the NPV case for each Project NPV case to support R&D efforts to enable rollout capability.

ROLLOUT SIMULATION: 100% DSM [M€]			
License Revenue [EBIT Multiplier]	20%		
COGS Factor	10%		
Yearly Entrant Probability	20%		
Yearly Market Growth Rate	5%		
Starting Market Size	120		
Yearly Worst New Licensees	1		
Yearly Most Likely New Licensees	3		
Yearly Best New Licensees	5		
	2010	2011	2012
Market Size [# Pos. Licensees]	0	0	120
Num of DSM Signed Licensees	**0**	**0**	**3**
Remaining Available Licensees	0	0	117
New Competitor Entrants	0	0	1
Competitors (Begin Year)	0	0	0
Num of Comp. Signed Licensees	0	0	0
2xEBIT (GPC+DSM) [M€]	0	0	17.01
Revenues	0	0	10.21
Costs	0	0	1.02
Total Profits	**0**	**0**	**9.19**
Total NPV Profit [M€]	**€ 176.17**		

** Bigger potential market than DM Frac / WM*
*** Assumption DSM receives 100% revenue stream*

ROLLOUT SIMULATION: 100% DSM [M€]					
License Revenue [EBIT Multiplier]	20%				
COGS Factor	10%				
Yearly Entrant Probability	20%				
Yearly Market Growth Rate	5%				
Starting Market Size	30				
Yearly Worst New Licensees	0				
Yearly Most Likely New Licensees	1				
Yearly Best New Licensees	2				
	2010	2011	2012	2013	201
Market Size [# Pos. Licensees]	0	0	30	32	3
Num of DSM Signed Licensees	**0**	**0**	**1**	**2**	
Remaining Available Licensees	0	0	29	30	2
New Competitor Entrants	0	0	1	1	
Competitors (Begin Year)	0	0	0	1	
Num of Comp. Signed Licensees	0	0	0	1	
2xEBIT (GPC+DSM) [M€]	0	0	0.22	0.77	0.9
Revenues	0	0	0.22	1.55	2.9
Costs	0	0	0.02	0.15	0.2
Total Profits	**0**	**0**	**0.20**	**1.39**	**2.6**
Total NPV Profit [M€]	**€ 17.68**				

FIGURE 34: Project I (left) & II (right) Post-PROCESS-CO. Rollout Market Simulation with Competition

The complete NPV simulations were then re-run for both Projects, producing aggregate effects on the core NPV (10,000 simulations each). This resulted in a new project volatility (standard deviation) reading for both post-PROCESS-CO. product rollout NPV models. Please see Figures 35 and 36 below for the results: 34.2% and 36%, respectively for Project I and II volatility. Additionally, the new NPV mean was €1.2m and €0.09m, respectively for Project I and II. The projected investment required for the rollout thus brought Project II – Dry Mill Fractionation / Wet Mill nearly to a negative NPV point. Thus the results of this particular simulation were to advocate Project I – Dry Mill No fractionation, largely due to the proportionately larger market involved (hence larger potential revenues) overcoming the investment level required for rollout. The investment and market assumptions would need to be refined and validated before conclusions could be drawn as this was a demonstration model.

Thus, Project I – Dry Mill No Fractionation is selected for subsequent core ROA analysis, to be covered in the following section, 4. P3: Real Options Analysis.

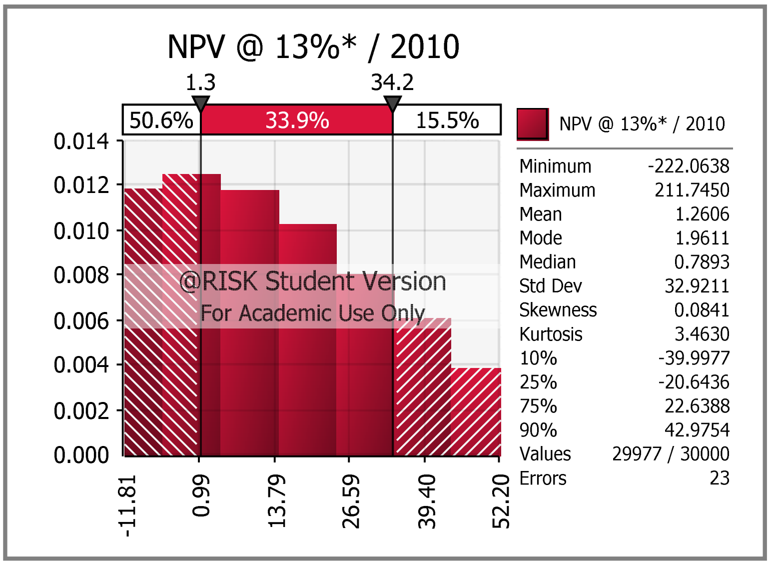

FIGURE 35: Advanced Project Volatility for I. Dry Mill No Fractionation: 34.2%

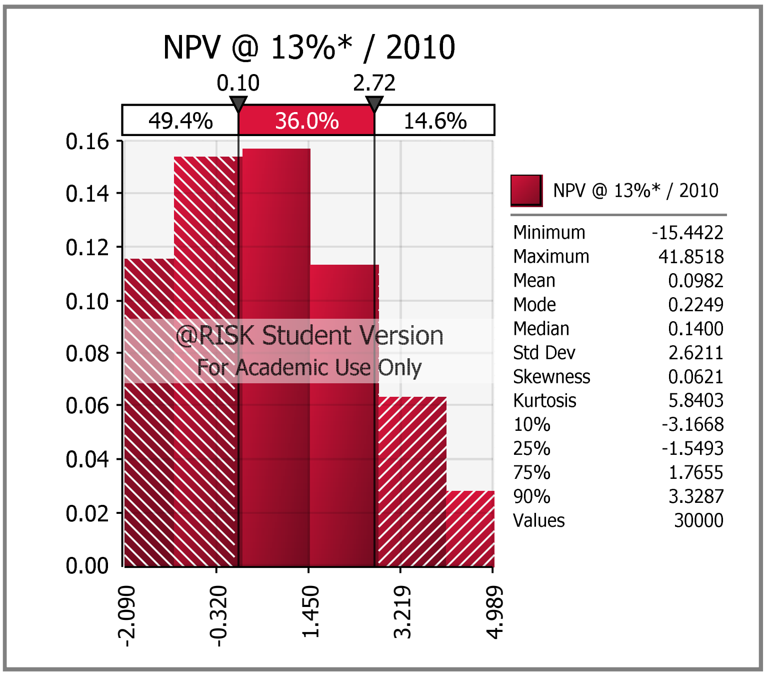

FIGURE 36: Advanced Project Volatility for II. Dry Mill with Fractionation or Wet Mill NPV: 36%

3.6 COMMENTS CONCERNING SIMULATION

Simulation is a powerful technique for understanding the evolution of dynamics and sensitivities in complex models such as NPV. It gives a window into variability and dynamic movement, whereas static snapshots can blind viewers to danger lurking on the periphery (such as disadvantageous €Euro/$US scenarios, as demonstrated here). It is a worthy exercise in itself, as risk levels and potential lurking dangers are revealed in business cases. However, the expression ‘garbage in, garbage out’ is applicable: a proper simulation exercise requires careful groundwork, data collection, model preparation, testing, revision, and frequent interchange with stakeholders and experts to validate assumptions (Brealey et al., 2006: 255).

Effective sensitivity simulation model development depends on iterative refinement: the ideal development process for a simulation model involves repetitively re-running a simulation, each time changing the parameters of one (or several) of the distributions and improving based on observations made and conclusions drawn. Crucially, the distributions and assumptions made concerning the tendencies of variables should be reviewed and validated with key stakeholders. A poorly conceived or refined simulation can be inherently destructive if it misleads management. Proper simulation is thus by nature time consuming, which goes lengths to explain why such techniques are applied sparingly in business: the associated overhead of conducting simulation must be justified by the costs involved and balanced by the riskiness of a particular venture. A modest investment or R&D project likely does not justify the time and expense of conducting a full-fledged simulation.

For this case study, the main objective was to develop and demonstrate an integrated ROA approach via a linked NPV, NPV Monte Carlo simulation, and core ROA modeling exercise. A set of Monte Carlo simulations were here developed as examples to underpin the core ROA. The simulations developed were relatively complex, involving many independently and dependent variables iterating to compose a probabilistic NPV case. The simulation, component variables as well as the working whole, should ideally go through an organizational validation process by key stakeholders. In the example simulations developed, a comprehensive internal validation was out-of-scope due to time restrictions. Thus, internal review and validation of the simulation model would still be required before comprehensive conclusions could be drawn.

4. P3: REAL OPTIONS ANALYSIS

4.1 OVERVIEW OF REAL OPTIONS

At this point in the ROA process, an NPV analysis (P1) and volatility simulation (P2) have been conducted. This leads to core ROA (P3) as the final step in the integrated ROA. As will be explained in this section, the formal results of the P1 and P2 steps provide a quantification of uncertainty (or risk), a necessary ingredient to drive the quantitative methods of the final core ROA. In addition to a quantification of uncertainty, one more element is needed for core ROA to be carried out: non-linearity - the flexibility to chose or react according to risky outcomes so that new outcomes are made possible (Rees, 2008: 189).

Real Options is a business decision-making / valuation methodology which extends traditional methods, namely Discounted Cash Flow (DCF) and Net-Present Value (NPV). Real Options analysis has been gaining popularity, especially for evaluating business conditions which involve inherent uncertainty, such as research & development, startups and/or new markets.

As has been discussed, NPV is, in essence, a proposed forecast of uncertain future situations and events. However, being rigid and static, NPV does not provide for flexibility, and, as such, does not propose to quantify risk per se. A core NPV also does not quantify the value of being able to change course mid-project. As expressed by M. Rees, "traditional net present value calculations are often performed using a static assumption as to what is most likely to happen in the future. Where a business situation involves additional decisions that may be taken after the start of a project and in accordance with the development of the project's success (e.g. where a decision may be taken to expand, or abandon a project as future conditions deem appropriate), then very often such a static approach will incorrectly value (undervalue) the project" (2008:198).

Thus, it can be said that NPV is a good first step in valuation, but that it must be extended to value change and flexibility via ROA. Valuing decision making flexibility is the bailiwick of ROA. ROA allows for the option to change course depending on future conditions to be discretely quantified in a valuations exercise. Indeed, it is the ability to actively manage the future that provides most companies with their intrinsic value. As noted by R. Shockley: "the market valuation of most firms cannot be explained by the present values of their current free cash flows. The present value of *growth options* – future opportunities to invest in positive NPV projects – represents a substantial fraction of the value of many firms" (2001: 61).

Furthering this point, as noted by Koller et al.: "Managerial flexibility can substantially alter the value of a business because it lets managers defer or change investment decisions as the business develops… Managers react to changes in the economic environment by adjusting their plans and strategies… This flexibility represents a certain value, but a single projection or even multiple scenarios for cash flows cannot calculate what that value is" (2005: 559).

However, once the uncertainty of the initiative has been quantified (the risk as characterized in P2 as volatility), the ability to change course or make decisions along the path of uncertainty can be mapped onto the uncertainty. From a Monte Carlo standpoint, this results metaphorically in the ability to choose one of the optimal paths outlined in the simulation by making reactive decisions during the project as future elements become clearer. This ability to choose optimal paths, known as managerial flexibility in ROA literature, can then be formally valued using financial mathematics originating from derivatives pricing models.

Given a set of NPV end-point scenarios and their associated volatilities, a set of future possible paths can be traced which will end at each of the possible NPV's. Amongst the possible paths, a set of decisions can be charted – these are the points of future 'managerial flexibility' where the final outcome can be affected. Uncertainty, from this perspective, is specified formally in terms of 'decision trees': a set of decisions, staged investments and probabilities of success. Once charted, the decision tree becomes an artifact for future decision making: as time unravels. A decision to 'invest' or to continue a project should always be taken as long as there is an option-valued positive NPV path open. When all option-valued positive NPV's are gone, the project should be abandoned as there is no chance open to realize a profitable future from the effort.

Determining when and how to invest during an R&D effort, and crucially, when to abandon or expand a line of risky development, is otherwise a key use of ROA. Project planning artifacts (i.e.: GANTT charts, risk mitigation plans), enumerated project risks, alternative choices, decision points, etc. are all input factors that can assist in structuring the decision tree to quantify the value of project uncertainty. Uncertainty from this perspective can be specified formally amongst a set of interlocking variables and used as a component in valuing and guiding managerial decision making flexibility.

The future ability to alter course, should prospects for success contract or expand, can itself be quantified using options valuation methods taken from the discipline of financial derivatives (2005: 560). At the simplest level, Real Options Analysis (ROA) utilizes methods directly applied to valuing financial derivatives (put and call options) to capital budgeting decision making problems.[1] A financial option gives the owner the right (but not the obligation) to buy or sell an asset before or on a pre-specified date (the exercise date), for a pre-specified amount (the exercise price). A call option is the right to buy an asset; a put option is the right to sell an asset (Dassen, 2008; McGrath, 2004: 2).

Investing in a project can be treated, in an example from the ROA perspective, as buying a call option on a stock: owning the call option gives the owner the right, but not the obligation, to purchase the underlying stock at a set price. If a stock goes up in price, a call owner has the option to realize a premium upon exercising the call option and purchasing at the established lower price. Similarly, investing in a project gives a business an option to achieve a possible positive NPV value. However, before that point, the project can conceivably be expanded, delayed or abandoned depending on how indications for project success unravel in the future. Similarly, given a choice between building a fully-functioning factory and building a test factory beforehand as a trial case, the test factory often potentially has greater inherent value as, by nature, it protects against a catastrophic loss if the 'straight shot' build fails. Real Options analysis extends traditional static valuation analysis by quantifying the value of 'optionality': the option to expand, to discontinue, or to wait (amongst several common possible project decisions) (McGrath, 2004).

De Maeseneire, evoking and extending concepts raised by Trigeorgis, cites and describes several key flexibility options:

- Time to build/deferral option
- Option to alter operating scale
- Option to abandon
- Shutdown Option
- Input Flexibility
- Output Flexibility
- Growth Options

(De Maeseneire, 2006: 64-73; Trigeorgis, 1995)

Two central ROA methods are noted by Koller et al: real-option valuation binomial tree and decision tree analysis (DTA). Both are focused on quantifying present value cash flows given the value enhancing flexibility of management to change course. Of the two, DTA is the most intuitive, offering visual representations of available decisions and the value enhancing power of such decision making flexibility. Figure 37 at the end of this section offers a practical example of how the flexibility to test, expand, or abandon increases the value of a biofuel plant construction project. By interposing the various decisions available and estimated probabilities of success before deploying a full-scale plant, project NPV value is enhanced and a

[1] The foundation for the valuation of financial derivative instruments is the Black-Scholes formula, proposed by Fischer Black and Myron Scholes in their 1973 paper "The Pricing of Options and Corporate Liabilities". The formula was itself derived from the discipline of physics, observing that market price movements follow a geometric Brownian motion with constant drift and volatility (as described by a heat transfer equation originally derived by Albert Einstein) (Kritzman, 2000: 127).

recommended, most rational path is identified. The binomial tree method will be demonstrated comprehensively in the following section.

ROA often has the effect of increasing NPV value as it adds the formally quantified value of decision flexibility. In particular, Faulkner notes the following project profiles in particular are likely to benefit from an ROA approach:

- Future commercialization investment is high relative to the R&D investment
- Substantial uncertainty exists regarding future earnings
- Duration of research phase is long and there is uncertainty concerning future earnings
- Future information will resolve some uncertainty (i.e.: market demand, competition, etc.) (1996: 54)

At a high-level, while ROA can be quite useful as a decision-making aid and NPV enhancement, particularly for highly uncertain projects (i.e.: R&D initiatives), it is uniquely dependent on the quality of a rigorous preliminary NPV analysis (ideally accompanied by active dialogue, multiple models and simulation). As well, proper implementation of ROA, as is the existing case in the pharmaceutical biotech (Brealey et al., 2006: 257; McGrath, 2004; Shockley, Curtis, Jafari, & Tibbs, 2001) and oil exploration sectors (De Maeseneire, 2006: 9; Koller, Goedhart, and Wessels, 2005: 560), involves an organizational commitment to integrate ROA in a standardized, structured decision making process.

The aforementioned industries have a high incentive to adopt ROA: highly uncertain project outcomes (high risks) married to high potential NPV's (high potential returns). As well, both industries have highly developed and structured R&D processes which can be cleanly mapped to ROA methods (i.e.: decision and binomial trees). In "Applying 'Options Thinking' to R&D Valuation", T. Faulkner (1996) makes several recommendations for applying options thinking to R&D strategy:

- *Explicitly recognize uncertainty about the future by considering "optimistic" and "pessimistic" scenarios, and identify critical future uncertainties that can be monitored over time to help us understand which scenario is unfolding.*

- *Identify downstream decisions that can be made after we learn more about these future uncertainties and explicitly recognize these as opportunities to adjust course.*

- *Distinguish between "project investments" and "options investments." Project investments tend to be lower in risk and have a commitment to a fixed time line. Options investments tend to be exploratory and higher in risk.*

- *In reviewing planned investments, we should use "flexibility" as one of the criteria and consider how these investments might position us to move one way or another (within the bounds of our uncertainty) as uncertainty is resolved over time.*

- *Build a "phased approach" into the strategy that makes future investments conditional on the downstream decisions. We must explicitly recognize that future course changes are probable and plan for "active management" that will allow us to quickly adapt.*

Finally, it can be noted that ROA is especially suited to commodity-driven businesses as they involve tradable assets with observable market prices which can be directly mapped to costs and revenues (Koller, Goedhart, and Wessels, 2005: 560). This advocates for the application of ROA to the current case, as it is indeed tied to a number of market-traded commodities (ethanol, corn, corn fiber, chemicals, etc.) as well as being influenced by the euro/dollar exchange rate.

Lastly, it is worthy to make note that with any intelligence and information gathering program, there is intrinsically associated expense and overhead. Thus BIO-INC. White Biotech must consider the point at which there is a comfortable match between ROA overhead and the risk/return ratio associated with a portfolio of typical projects. Otherwise, potential high return R&D ventures are generally a good match for ROA and are indeed being used increasingly in this capacity beyond the core industries mentioned.

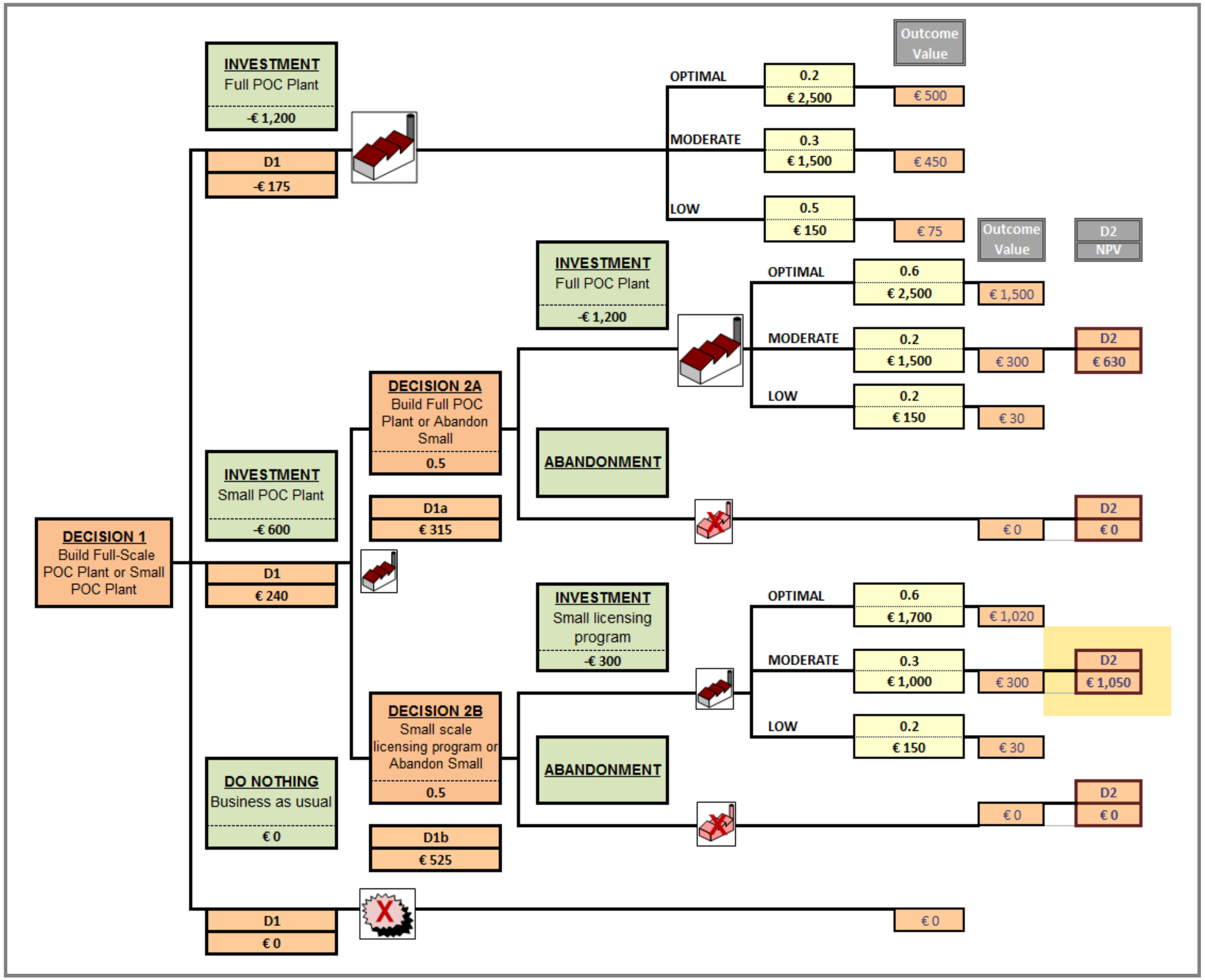

FIGURE 37: 'Option to Expand' RO Decision Tree Analysis (DTA) Example for Biofuel Plant Project

4.2 REAL OPTIONS PROBLEM FRAMING

Having proceeded through NPV analysis and Monte Carlo simulation, we have selected the combined PROCESS-CO. / post-PROCESS-CO. licensing rollout scenario for Project I – Dry Mill No Fractionation for Core ROA analysis. The project has shown that, though there is a substantial investment involved, the proportionately larger future market offers a profitable potential set of future cash flows. Although the static NPV of €1.75m (simulated mean NPV of €1.2m) is not remarkably high, the project has a high 'uncertainty value' in that the future licensing market is potentially large. This is evidenced in the large standard deviation, or volatility, of 34.2%, or €32.2m. This implies a potential 'best case' NPV of €33.4m, largely due to the possibility, captured via Monte Carlo simulation, of exposure to a large, new market.

One caveat before proceeding: the selection and profile is the result of a market simulation and R&D investment estimate that has not been fully validated by internal staff. Thus, the core NPV Monte Carlo simulation would need to be reviewed and validated before the conclusions could be considered comprehensive. That said, the numbers fall in line with qualitative feedback gathered in interviews: that the Dry Mill No Fractionation project is risky and expensive, but offers a large potential upside in being attractive to a range of customers with little present competition (though that is anticipated to change in the 2012-2013 timeframe, hence some urgency amongst staff in charting a path).

Arnold and Shockley comment that "the first step in working through any real option valuation is determining what the underlying asset actually is, and then determining the value of that asset if we were to commit to the investment *immediately*. The underlying asset is always what you get if you exercise the option" (2001: 55). The core asset can be defined as such: 50% share in a hybrid first and second generation biofuel plant with a subsequent rollout investment in the core technology and resulting future licensing profits (as simulated) with an NPV of €1.75m (composing 12 years of cash flows starting in 2010). The NPV is tied to a committed 2010 investment of €63.43m and a 2011 investment of €4.45m (PV of €66.9m).

Management is concerned about the high level of investment and the associated high risks (the high standard deviation results in a worst case loss of €30.45m if the project is recklessly 'run into the ground' over 12 years). Clearly, BIO-INC. White Biotech Management would act to prevent such an eventuality were the project to degenerate. The project could be 'wound down' or abandoned completely, in which case there would be a small salvage value likely associated. Management also believes there is an ability to optimize the upside of the project: if the licensing market explodes, rollout speed and reach can be expanded to take advantage of the situation.

This type of management flexibility, the ability to shape the future rollout of a project to optimize fortune and to diminish poor performance, has a quantifiable value via Real Options, which, as covered previously, applies the value of derivatives to the sphere of project risk management. Given BIO-INC. White Biotech's belief and desire to take advantage of a number of options to actively manage the project, the type of option that will be demonstrated is the *chooser* option.

The chooser option values the flexibility of management to choose to either continue as is, expand, contract, or abandon the project to advance commercial rollout given future performance. This is a realistic scenario for BIO-INC. White Biotech, as they are interested in the large potential market for Dry Mill No Fractionation technology, but with to avoid the downside potential (especially, for instance, if pricing in the commodity market turns against the NPV, such as a consistently low ethanol price and high corn price). Overall, there is a concern about the high investment required, though balanced by an awareness of the potentially large and lucrative market (which was previously embedded in the NPV Monte Carlo case as a market simulation).

4.3 REAL OPTIONS MODELING AND ANALYSIS

In conducting the core ROA, we will subsequently follow the four-step process for valuing flexibility utilizing Real Options as outlined by Koller et al. in ‘Valuation’, as popularized by McKinsey & Company:

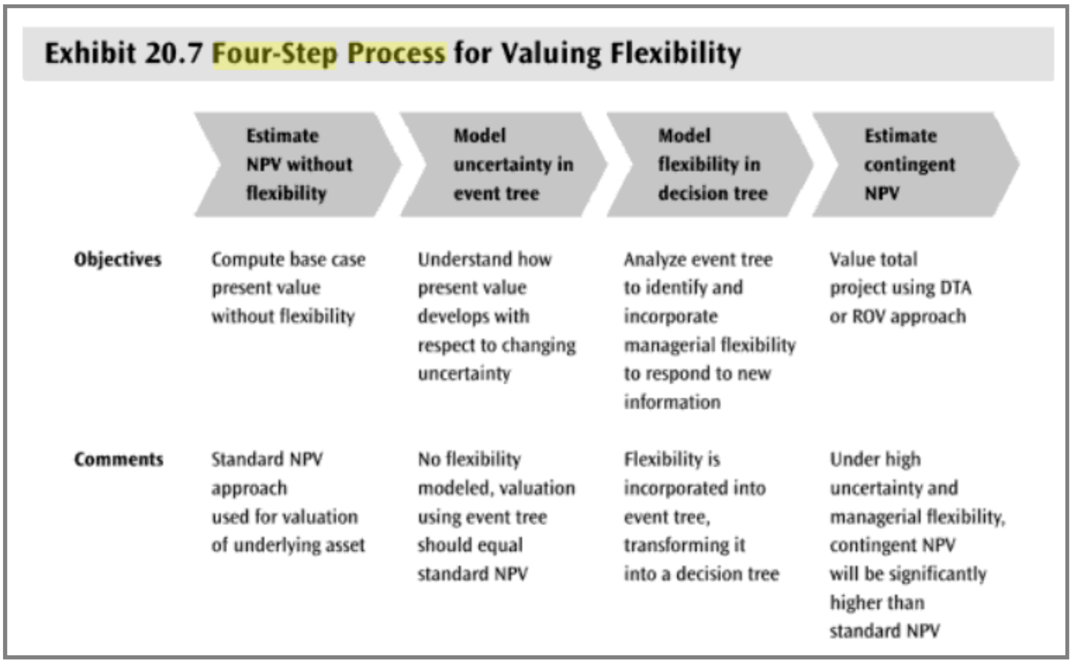

FIGURE 38: Four-Step Process for Valuing Flexibility (Koller et al., 2005: 576)

1. Estimate NPV without Flexibility

Core Asset: 50% share in a hybrid first and second generation biofuel plant with a subsequent licensing rollout of the core technology and resulting future licensing profits (as simulated) an NPV of €1.75m (composing 12 years of cash flows starting in 2010). The NPV is tied to a committed 2010 investment of €63.43m and a 2011 investment of €4.45m (PV of €66.9m).

NPV or S_0: **€1.75m (Based on core NPV case)**

2. Model Uncertainty in Event Tree

NPV or S_0: **€1.75m (NPV)**

Time Frame: **5 years**

Std Dev σ: **34.2%**

The lattice shows the differing possible values for the project over time based on the volatility. All possible paths, up and down combinations from left (now) to right (5 years in future), reduce to a PV of €1.75m (represented by leftmost node).

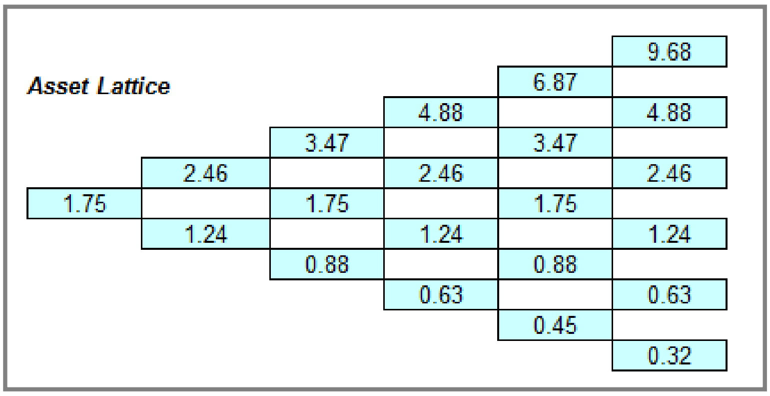

FIGURE 39: Basic Option Lattice Value Distribution

3. <u>Model Flexibility in Decision Tree</u>

Over the 5 year time span, management has the flexibility to continue as-is, expand, contract, or abandon.

Option Type: **Chooser Option**

NPV or S_0: **€1.75m (NPV)**

RFR: **13% (WACC)**

Std Dev σ: **34.2%**

Expansion Factor: **x2**

Contraction Factor: **.50**

Contract Savings: **€0.25**

Salvage Val: **€0.25**

4. <u>Estimate the Value of Flexibility</u>

By valuing the flexibility to choose to continue, expand, contract, or abandon the project each year, the value of the PV of the project grows from €1.75m (NPV) to €2.56m. This quantifies the value of being able to change course and react appropriately to fortune or poor performance. As mentioned previously, the calculations are those used to value financial options.

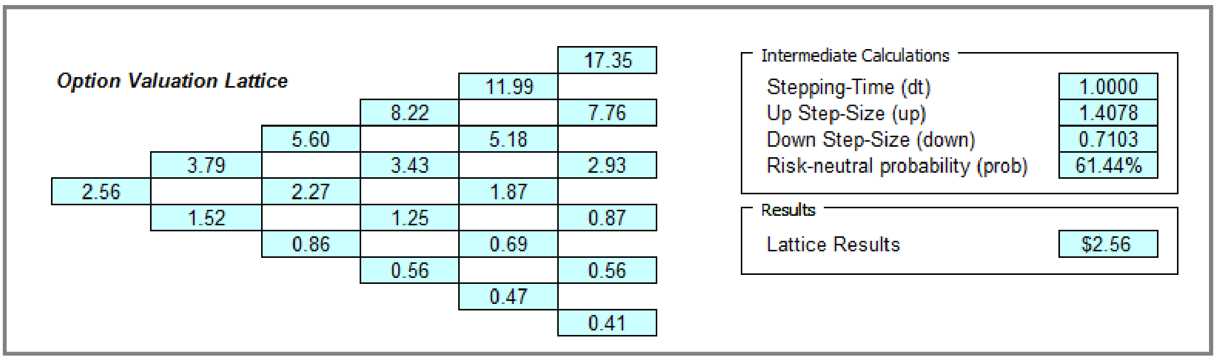

FIGURE 40: Chooser Option Lattice Value Distribution

Based on Figure 39, above, decisions would occur year-to-year based on the evolution of yearly performance. If the project dipped to a point where the NPV was challenge, this indicates the 'contraction' plan should be put in place. If good fortune provides outsized profit, at a particularly threshold the decision to invest additional money in the project is justified (expand).

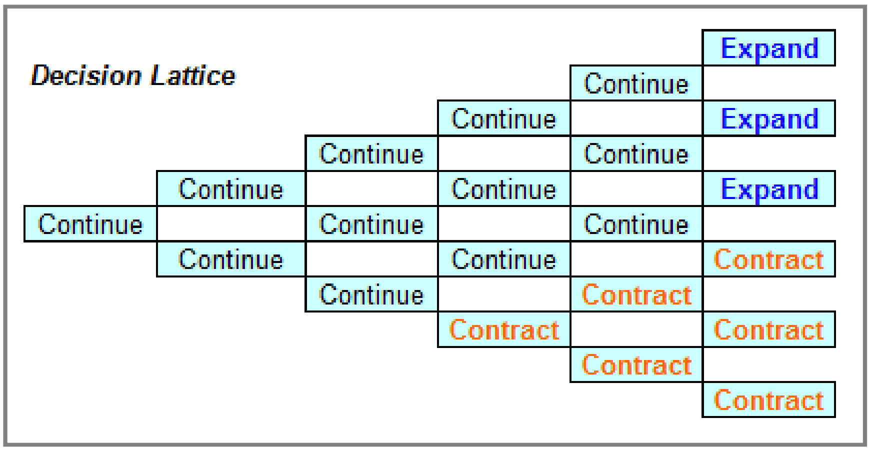

FIGURE 41: Most Rational Decision Paths Based on Options Valuation

4.4 COMMENTS CONCERNING ROA

There are many complex ROA techniques that can be utilized to manage uncertainty in projects. Different types of options can be combined. Trees can have multiple paths. The more intuitive, graphical Decision Tree Analysis method can be applied. As well, technical and market risk can be separated and treated distinctly via ROA. The import point is that stakeholders understand the main concept that decision flexibility can be quantified in project valuation, and thus actively controilled. From there, decision frameworks applicable to specific projects can be elicited and modeled. Beyond often improving NPV, ROA imposes a disciplined and rational approach to project management: once stakeholders grasp the core concepts, risks and uncertainties become quantities to identify and actively manage, rather that lurking, unmanageable gremlins.

ROA is a powerful and growing new paradigm for advanced valuation. It is worthy to quote De Maeseneire at length from '*The Real Options Approach to Strategic Capital Budgeting and Company Valuation'*: "The real impact of real options thinking has come from a change in the corporate mindset about uncertainty and risk. Rather than treating risk as something to be avoided, real options thinking encourages managers to view volatility as a potential source of value with profound implications for the design of projects and corporate strategy. Valuable options can be created by staging large projects, investing in information acquisition, modular manufacturing, etc. From a risk-return perspective there is also growing recognition that the risk profiles of projects differ considerably based upon whether the projects are early stage investments in creating options or later stage expenditures that involve exercising options to complete investment in a project" (2006: 206).

The point has been made repeatedly that ROA depends firmly on well grounded NPV modeling and volatility simulation, that it is an extension of FCF, DCF, NPV, and simulation. The upshot is that ROA not only extends existing methods of valuation, but it rests on-top-of the other models, forming the capstone to a dynamic super-model. However, the resulting super-model is inherently complex, having many moving parts. Brealey et al. warn that the complexity and focused dedication of time required for such modeling means that many decision makers delegate ROA to external parties (as was the case in this study). Unfortunately if the model is not comprehensively reviewed so that the decision makers agree to its premises, the resulting model runs the danger of becoming a black box (2006: 257).

5. RECOMMENDATIONS AND CONCLUSION

5.1 ROA AS AN INTEGRATED PROJECT RISK MANAGEMENT PROCESS

This project has focused on two key points: 1) ROA as an exercise depends upon and extends a strong valuation case, and 2) modeling RO's clarifies and quantifies uncertainty so that it can be actively managed. On these points, Arnold and Shockley comment: "we have found that the greatest potential benefit of real options analysis is not in the point estimates of project values that result, but rather in the *discipline* that the options model imposes on management thinking. In other words, the real options model gives management the ability to go beyond arguing that investments have 'strategic value' and helps them quantify the assumptions that are necessary for *strategy* to actually be *valuable*" (2001: 58).

Managers face challenges in gaining and holding support for stratecic vision. As noted by Chatterjee et al., "strategy is about making resource commitments before the relationship between these commitments and their potential performance outcomes are fully understood" (1999). ROA, as a method for managing uncertainty such that the risks and rewards attached to committing future resources is quantified clearly, thus offers a central methodology to aid the conduct of strategy. However, in order quantify strategic risks effectively, ROA the ability to cross-compare strategy at the firm-wide scale.

Properly adopted, ROA should be conducted as a contributing methodology in an organizational portfolio decision making process. In Mun's eight step ROA process (as enumerated initially in Section 1.4), step seven, 'portfolio and resource optimization', advocates that ROA be implemented at an organization-wide portfolio level so projects can be compared like-to-like across the organization. ROA highlights how managerial decision making provides value in the form of flexibility, which has inherent value as opposed to fixed path situations. However, as with management itself as a discipline, the conduct of ROA as a process needs to be tied into organizational decision making as a process to operate effectively. Ideally, ROA is adopted at a global portfolio level so that optionality is embedded as a concept in firm valuation and decision making. This is advocated for the same reasons raised in discussing caveats concerning NPV: without reference to the firm as a whole, valuation becomes complicated and challenged, especially in regard to risky ventures.

The pharmaceutical sector has a highly structured drug development process which adapts cleanly to ROA (Brealey et al., 2006: 257; McGrath, 2004; Shockley, Curtis, Jafari, & Tibbs, 2001). The sector must conform to a strict, staged regulatory process. In addition, pharmaceutical product development entails high risk (low relative chances of success) and high potential rewards (immensely profitable markets). BIO-INC. is active as well in biopharmaceuticals, so this may be an opportunity to integrate ROA methods into R&D and project management. Beyond this, BIO-INC. has a standardized and structured company wide 'Project Management Decision Making Process' which would be ideally suited for integrating with ROA as a process.

5.2 TACTICAL AND STRATEGIC ADVICE

In conclusion, T. Faulkner offers a quote summarizing the powerful ability of RO to manage uncertainty: "An options thinking approach brings a dramatically new view of uncertainty. It allows us to recognize that there are situations where uncertainty is good, and helps us to understand that the larger the amount of uncertainty, the greater the opportunity for value creation. Options thinking expands our understanding and helps us to identify the characteristics of those investment opportunities where uncertainty represents a potential for future gain rather than a risk of loss" (1996: 53). Actively quantifying and managing uncertainty is a topic of strong interest to BIO-INC. White Biotech. In this spirit, and in parting, a summary of key recommendations made herein is offered:

- <u>Which WACC?</u>

Question whether the BIO-INC. 13% firm hurdle rate is appropriate: many R&D projects use the risk free rate (or 5% as a default)

- <u>Deep Commodity Analysis</u>

  Simulations and analysis conducted were insightful but rudimentary. Considering the importance of commodity prices such as biofuel and corn to the core business case, a deeper analysis of trends and forecasts is justified (i.e.: intensive regression analysis and forecasting). Spending time to anticipate commodity price movements has a high potential cost/benefit ratio.

- <u>Hedging Away</u>

  Simulation revealed project risks associated with the Euro/$ exchange rate. Commodity price fluctuations alone have the power to destroy NPV projections. Such risks can be actively hedged via derivative instruments.

- <u>Customer Finance</u>

  Biofuel plants are a capital intensive and risky ventures. Consider the example of firms in other similarly high risk / high reward industries that have created Customer Finance facilities to bolster customers and foster sensitive markets.

- <u>Market Competition Simulations</u>

  The market simulation conducted was revealing, but cursory. A refined market simulation, validated by internal stakeholders, could prove valuable in strategic planning regarding the productization of innovations.

- <u>Biofuel Plant NPV Monte Carlo Model</u>

  It was suggested the BIO-INC. White Biotech consider building and maintaining a generic, dynamic biofuel plant NPV case / Monte Caro simulation. This would serve as a platform for staging future NPV analysis. The argument is that BIO-INC. White Biotech should value products, measure costs, evaluate processes, and judge revenues according to an idealized representation of its canonical customer.

- <u>ROA as Process / Project Risk Management</u>

  ROA as a process can be considered an aspect of the formal discipline of Project Risk Management, which is an organizational process. Any usage of ROA assumes a structured dialogue with key stakeholders and adoption of the premises and techniques associated with ROA into existing organizational decision making processes. As well, in order to conduct strategic planning, ROA ideally is fluently understood and emplyed at the firm-wide project portfolio management level.

- <u>Validation Process / Decision Making</u>

  Lastly, as mentioned several times previously, this case study has served to present an *example* ROA model and conclusions should not therefore be comprehensively drawn without models undergoing an internal validation process by internal stakeholders to verify assumptions made.

It is hoped that this paper has served the goal to give a basic, practical, scenario-based introduction to the use of ROA as an advanced valuation and decision making process in an environment of uncertainty. ROA is potentially a powerful tool for quantifying and actively managing uncertainty. BIO-INC. White Biotech, operating at the nexus of multiple sources of uncertainty, stands to empower itself by choosing to actively quantify and manage this risk.

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APPENDIX A: Financial Analysis & Simulation Models

#	Ref	Cat	Category	Summary	Method	What is Achieved	Data / Variables Required	Assumptions Implicit
1	I.217	1	**R&D Decision Making**	Risk adjusted NPV value for uncertain, multi-stage R&D program with sensitivity analysis	Set of triangular random variables processed through Monte Carlo simulation	• Most likely cost of multi-stage R&D program (NPV) based on range of possible costs, range of possible timelines and associated probabilities with associated confidence level • Regression tornado graph showing relative sensitivities of major factors (i.e.: how NPV effected by standard deviation changes in key variables): thus shows where most fruitful / sensitive value stages are in terms of achieving higher NPV and reducing costs	• Cost (investment) for each stage, time required for each stage, final revenues, WACC; (for each variable: best, worst and most likely scenarios with probability for each) • GANTT project breakdown • Basic understanding of probabilities of success, time, etc.	• Time, cost & probabilities are independent (is there are dependencies, they can be modeled separately though) • In most cases profit earned only if all stages successful (can accommodate multi-stage / multi-success points otherwise)
2	0.1	1	**R&D Decision Making**	Optimal R&D decision making path given range of directions / decisions	Decision tree analysis	• Breakdown of optimal NPV based on range of possible decisions • Understanding of most rational (in terms of NPV) decision given choice to proceed or abandon an initiative with uncertain final outcome	• Understanding of key decisions to be made given range of possible decision paths • Investments (costs) associated, probabilities of success, and profits from each decision	• Understanding of investments required for each step and final profit (final NPV value achievable) • Where uncertainty, can develop multiple scenarios • As preliminary, can run NPV, cost and risk simulations to refine understanding
3	II.213 II.223	1	**R&D Decision Making**	Optimal R&D decision making path given range of directions / decisions	Binomial Tree	• Current NPV incorporating value of option to expand or abandon • More structured / detailed breakdown than Decision Tree (yes/no decisions only and equal time spans) • Breakdown of optimal NPV based on range of possible decisions: optimal decision path • Understanding of most rational (in terms of NPV) decision given choice to proceed or abandon an initiative with uncertain final outcome	• Understanding of key decisions to be made given range of possible decision paths • Decision points with yes/no, values, probabilities of success • Investments (costs) associated, probabilities of success, and profits from each decision	• Understanding of investments required for each step and final profit (final NPV value achievable) • Where uncertainty, can develop multiple scenarios • As preliminary, can run NPV, cost and risk simulations to refine understanding
4	I.101	1	**R&D Decision Making**	**Determine optimal set of investments given range of possible projects and limited capital budget**	Optimization problem via solver	• Based on a set of projects (independent or dependent; indivisible or divisible), optimal combination of projects (or project parts) to maximize NPV	• Budget constraints • NPV from projects • Nature of projects (independent or dependent; indivisible or divisible)	• Understanding of NPV for each project (or for component contribution when several possible options to single NPV goal)
5	I.131	1	**R&D Decision Making**	**Project portfolio optimization**	Markowitz portfolio optimization	• Traditionally used to maximize return and minimize risk in constructing optimal stock investment portfolios • For projects, used to build optimal (risk/variance minimized) combination of projects given multiple possible projects in a portfolio context • Calculates overall adjusted mean return and variance (risk) of combined recommended project portfolio • Variation/extension to model allows for scenario analysis given uncertainty of outcomes (see I.113)	• Return expected from portfolio (i.e.: % over WACC) • Standard deviation of return for each project within portfolio • Correlation (dependency) between project components (can be estimated)	• NPV return expected from project (desired return) • Risk level (variability of success) • Covariance (dependency) between project components (can be estimated)
6	0.3	1	**R&D Decision Making**	**Project portfolio optimization**	Black-Litterman portfolio optimization	• An extension to Markowitz, allows for custom 'views' opinions) relating to likely outcomes to be inserted into Markowitz optimization process	• NPV return expected from project • Risk level (variability of success) • Covariance (dependency) between project components (can be estimated)	• NPV return expected from project • Risk level (variability of success) • Covariance (dependency) between project components (can be estimated)

•#	Ref	Cat	Category	Summary	Method	What is Achieved	Data / Variables Required	Assumptions Implicit
7	I.135	1	R&D Decision Making	Project portfolio optimization (above and beyond NPV-driven criteria)	Analytic Hierarchy Process and Optimization (via Solver)	• Determines relative importance of set of project objectives in a portfolio context • Resource usage (i.e.: cost, man hours) required for each project • Optimal scoring of projects within portfolio based on total benefit and bearing in mind resource constraints • Understanding of how changing input parameters effects total benefit achievable	• Relevant objectives for each project in portfolio • Weighting scores for each objective attached to each project (i.e.: NPV, Market Growth, Likelihood of Technical Success, Likelihood of Regulatory Approval) • Cost, work hours required, NPV	• Portfolio can be broken into discrete, scorable projects or sub-projects
8	II.155	1	R&D Decision Making	Modeling New Product Profitability	Triangular random variable, regression analysis, sensitivity analysis, simulation	• Estimation of profitability and riskiness of new product • Incorporates uncertainties / ranges such as development cost, development timeline, sales life, market size, market share, price, and variable cost	• Ranges for: development cost, development timeline, sales life, market size, market share, price, and variable cost	
9	II.203	1	R&D Decision Making	Valuing an R&D Project	Real Options, Sensitivity Analysis	• Current project value based on model frequently used in multi-stage pharmaceutical R&D decision making • Provides optimal decision making path with investment cap at each major decision step	• Decision (project steps), duration of steps, estimated probability of success, activity duration, revenue from success, revenue from failure, resulting value, probability of success, cost of stage; + WACC & RFR; sensitivities (ranges) possible	• Understanding of final NPV value of realized product • Understanding of phases and decisions in project, along with general probabilities of success
10	I.274 I.405	1	R&D Decision Making	Valuing the option to expand or abandon	Binomial tree	• Identifies optimal decision making path (in terms of maximizing NPV) • Values the option to expand or abandon in project	• Current price (value) • Exercise price (price to expand) • Risk-free rate • Volatility • Duration (tree-steps)	• Based on American Option pricing (assumes decision to expand or abandon can occur at any time)
11	I.209	2	Cost Analysis	Plant Production Capacity Given Output Uncertainty	Optimization / Maximization	• Maximization of risk adjusted NPV given cost of building annual unit of capacity and annual operational cost per unit	• Annual cost to operate one unit of capacity • Cost to build one unit of annual capacity • Range of feasible capacities	• Assumes a linear relationship between cost and scale
12	I.141	2	Cost Analysis	Resolving Cost of Producing Product	Sampling, regression analysis and optimization	• Based on sampled (incomplete, generalized and/or global) component cost information, determine optimized total cost of product production • Given incomplete information on costing, regression analysis allows for targeted product costing with statistical confidence level	• Data on cost components of product • Sample data on cost components (can also be based on similar / related processes)	• Main cost drivers are categorized • Data is available for sampled costs
13	II.147	2	Cost Analysis	Forecasting Structural Costs and Timing	Forecasting simulation	• Predictions (with confidence levels) concerning capital costs (and timing of costs) given uncertainty surrounding specifics in building prototype, plant, or machinery	• Time needed for various projects • Time after completion until cash flows begin • Cost of expenditure • Range of values for above (lowest, most likely, highest)	
14	I.149 II.309	3	Product Pricing	Profit Maximizing Price Given Exchange Rate Fluctuations	Determination of demand curve, elasticity, and optimal foreign currency price	• Given cost of production and price elasticity in native currency, determine optimal price variance given currency exchange fluctuations	• Cost of product production • Demand for product • Estimated elasticity in native currency • Range of possible currency exchange rate values	• Linear product demand (though non-linear can be modeled using add-on techniques)

•#	Ref	Cat	Category	Summary	Method	What is Achieved	Data / Variables Required	Assumptions Implicit
15	I.152	3	Product Pricing	**Optimal Product Pricing Utilizing Tie-Ins**	Supply & demand curve optimization	• Optimal pricing when there is a tie-in amongst products (i.e.: yeast, equipment, enzymes which are frequently used together) • Example: maintenance contract bundled with sale of turn-key solution	• Price and projected demand for set of products	• Real or estimated price and demand figures available
15	I.155	3	Product Pricing	**Nonlinear Pricing Profit Maximization**	Optimization	• Establish optimal pricing (profit maximization) when variable mechanisms are attached to price, for example thresholds (tariffs, entry fees, setup costs, etc.) and discounts (volume discounts, discount timing windows) are part of pricing model • Example: two-part tariff: entry fee + reduced price per usage	• Price customer is willing to pay at different price thresholds	• Data on customer pricing preferences based on different product volumes / am
16	I.163	3	Product Pricing	**Price Bundling Profit Maximization**	Optimization	• Establish optimal pricing (profit maximization) when products bundled (or offered both individually and as a set with discount)	• Market size • Reservation price (for market segment) • Price for product	• Assumptions about market size and pricing when real market data missing
17	I.199	3	Product Pricing	New Product Profitability Simulation	Simulation based on uncertain market parameters	• Estimates average profitability and riskiness of new products • Gives confidence probability of holding certain market size • Projected revenues • NPV projection with confidence levels • Sensitivity analysis (Tornado Graphs) concerning most impactful factors effecting NPV • Scenario analysis with optimal scenario profiles	• Number of potential customers • Growth rates for market (with confidence level) • Entry point of competition and variable effect on market share (with probability)	• Not predictive, offers better understanding of variabilities and sensitivities
18	I.263	3	Product Pricing	**Modeling Sales Volumes for New Products**	Simulation based on past (non-normal) patterns	• Modeling share, price, volume and cost uncertainty based on data from similar equivalent past products	• Equivalent past data available to obtain estimates of key variables: year 1 sales volume & subsequent changes	• Assumes data is available for a roughly applicable past product / market
19	I.266	3	Product Pricing	**Modeling Market Share Based on Competition**	Simulation and conjoint analysis	• Long-run market share forecast for new product given competitive pressures	• Rating index assigning competitive strength to own and competitors products • Simulation of market share based on past products (see I.263)	• Idea of when competition will enter market
20	I.271	3	Product Pricing	**Modeling Price Uncertainty**	Simulation, Regression Analysis	• Product pricing based on variability in competition and long-run market fluctuations	• Product price at time T and 0 • Number competitors	• Competition and pricing fluctuations based on past data or other simulations
21	II.200 II.241 II.250 II.255 II.259 II.281	3	Product Pricing	**Valuing a Pioneer Option**	Black-Sholes (European Option) Pricing Model	• Calculates the value of investing in a new technology / product in terms of follow-on expansion / profit value potential • Allows quantification of 'trapped value' of being able to expand into new market / opportunity in future (whereas otherwise current investment might be negative on NPV basis alone)	• Current price (value) • Exercise price (price to expand) • Risk-free rate • Volatility • Duration (time to decision point)	• Understanding of NPV • Understanding of potential future value and volatility of future value
22	II.263	3	Product Pricing	**Valuing a Licensing Agreement**	Black-Scholes, Simulation	• Used to price licensing fee for a product based on profitability simulation and risk neutral valuation • Produces lognormal random DCF	• Current value • Risk free rate • Exercise price • Volatility • Duration (timeframe)	• NPV value for product • Concept of risk / volatility in pricing
23	II.285	3	Product Pricing	**Estimating Product Demand**	Optimization, trend curve fit	• Produces quadratic curve suggesting profit-maximizing price	• Price range (high, medium, low), demand in regions, unit cost	• Data (potentially estimations) available on demand at several price points

•#	Ref	Cat	Category	Summary	Method	What is Achieved	Data / Variables Required	Assumptions Implicit
24	II.289	3	Product Pricing	Pricing for Subscription-Based Service	Trend curve optimization	• Optimized price of required hardware and subscription • Produces Excel trend curve analysis: annual percentage of market that will purchase HW for lowest, highest & middle price • Produces annual churn rate for low, high, and middle pricing levels	• Price of hardware, price of monthly subscription fee • Sensitivity of demand for hardware to hardware price, sensitivity of churn rate to monthly subscription rate	
25	II.295	3	Product Pricing	Optimal Product Bundling	Evolver (genetic algorithm tool)	• Pricing on different bundled combinations of products	• Data (or estimations) on pricing demand with different amounts of product bundled	• Data (or estimations) on pricing demand
26	II.303	3	Product Pricing	Optimal Quantity Discounts	Evolver (genetic algorithm tool)	• Optimal discount pricing on different combinations of products	• Volume demand price thresholds given various levels of demand	• Assumes each customer will purchase number of units to maximize consumer surplus
27	II.309	3	Product Pricing	Optimal Product Design	Conjoint Analysis, Optimization	• Provides optimized mix of product features given various features, aspects, and add-ons available • Determination of product market share	• Ranked data on various product features in terms of customer desire / preferences • Segment, intercept, brand	• Some customer preference data is available
28	I.347	3	Product Pricing	Modeling Mean Reverting Processes	Regression analysis (autoregression & lags)	• Powerful statistical analysis calculating tendency of particular variables to revert to mean • Possible application to commodity prices (oil, ethanol, feedstocks), interest rates, exchange rates, etc.	• Historical prices / values for variable under examination	• Variable has independent mean reversion tendency • However, dependencies can also be quantified via regression analysis (i.e.: oil to bioethanol covariance)
29	I.235	4	Financials	Simulating Pro Forma Financial Statements	Simulation of financials	• Used to run simulations with different financials • Results in net income resulting with different confidence levels	• IS: Revenue, non-interest exp, depr, EBIT, interest, taxes, net income • CF: operating cash flow, borrowing, stock issues, total sources, increase in net working cap, investment, etc. • BS: Net working capital, fixed assets, total assets, debt, book equity, total liabilities	• When historical figures not available, can be based on ranges and several simulations can be run
30	II.121	4	Financials	Simulating Proforma / FCF	Simulation (with circular resolution) / Monte Carlo	• Simulation of proforma statements and FCF given uncertainties	• Balance sheet model (with growth assumptions and ratios)	