AC 2012-4882: A NANOTECHNOLOGY MODULE WITHIN THE CURRENT COURSE IN ENGINEERING ECONOMY

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Big money in an infinitesimal world - A nanotechnology module within the current course in Engineering Economy

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Abstract: For the past couple of years, the college of engineering has been offering a minor program in microsystems and nanotechnology. This has recently been upgraded to a major. Concurrently, efforts are underway to introduce this new field in existing courses, so as to entice student's interest. This study deals with creating a nanotechnology module in our course in Engineering Economy. A typical course work in engineering economy includes employing valuation tools and benefit-cost analysis (among many others) to study the financial feasibility of engineering projects. Unfortunately, for projects involving nanotechnology, the finances are mainly speculative since commercial applications of nanotechnology are mainly at its infancy. Hence, we targeted small and medium enterprises (SME's) dealing with nanotechnology related products and listed at NASDAQ. This is because such companies would have their financial statements freely available on the internet. The module consists of designing sample valuation problems of the SME's created from their income statement. The problems in this module were first offered in fall 2011. It helped students comprehend financial statements, draw cash flow diagrams, undertake valuation analysis, and understand the future sway of nanotechnology related products in markets as well as the volatility (risk) faced by the start-up companies.

Nanotechnology 101

Nanotechnology is the study of manipulating matter at the nanoscale (10^{-9} m). This would involve studying material behavior at the atomic and molecular level. Therefore, it encompasses diverse areas such as surface science, organic chemistry, molecular biology, semiconductor physics, microfabrication etc.

Nanotechnology has the potential to create many new materials and devices with a vast range of applications such as medicine, electronics, biomaterials, and energy production. Therefore, it becomes imperative to introduce and train our new generation of engineers to this exciting field. In this regard, the College of Engineering has recently upgraded its minor program in micosystems and nanotechnology to a major program.

In order to draw students towards this new major program, a nanotechnology module as been incorporated into the coursework of Engineering Economics. This is because this is a course taken college wide and fulfills the objective of a wider audience. Besides, it also introduces the students towards the initial commercialization of this new technology and the volatility of the related startup enterprises.

This paper describes the initial steps taken to develop the module. We begin with a section describing the contents of a typical engineering economics course. This is followed by a section describing the steps taken to develop a module. An essential part of the module will be in

comprehending financial statements and constructing sample valuation problems and the subsequent sections describes them.

Engineering Economy 101

Engineering economy is the study of viability of engineering projects from a financial point-of-view. The decision on viability of the projects primarily stems from three type of analysis (among many others)[1] –

1. Valuation analysis: Based on the financial data, we calculate the present worth (or annualized worth or future worth) at prevailing interest rate. If we are dealing with a single project, we choose the project if the valuation is positive. Otherwise, we shall choose the "do nothing" option. If we are dealing with a multitude of projects, we choose the project with the maximum positive value or the least negative value.

2. The internal rate of return (IRR) analysis: The internal rate of return is the interest rate at which the cash flow of the project breaks even, ie., the interest rate at which valuation is zero. If we are dealing with a single project, we execute the project if the IRR exceeds the market interest rate. Else, we "do nothing". Again, if we are dealing with a multitude of projects, we choose the project with highest IRR (assuming all IRR's exceed the market rate).

3. Benefit-Cost analysis: If we know the dollar value of the benefits associated with a project, we compute the ratio, benefit/cost (or the difference, benefit-cost). If the ratio is greater than one (or if the difference is positive), the project is executed.

Engineering Economy of Nanotechnology Related Companies (or Projects)

It is very difficult to undertake an engineering economic analysis for a nanotechnology related company (or project). This is because commercial applications of nanotechnology are still in its infancy and therefore many financial data is merely speculative. Besides big corporations undertaking nanotechnology related projects (such as General Electric, IBM, and Intel etc.) do not state the finances specific to the project.

In order to circumvent the lack of financial data, we focused our attention on NASDAQ listed small and medium enterprises (SME's). The rational for doing this is – (i) such companies are solely devoted to developing and marketing nanotechnology related products; and (ii) since they are listed in NASDAQ, they have financial statements – income statements, cash flow statements, and balance sheet statements, in the public domain on the internet.

Most of the financial statements – income statements, cash flow statements, and balance sheet statements have a myriad of financial data. Some of these data describe the operational income and expenses, whilst others are related to accounting practices. The financial data for an engineering economic analysis are mainly associated with operating income and expenses. Therefore, we use an income statement for our analysis.

In the subsequent section we shall briefly describe an income statement and the financial data we are concerned with. This will be followed by a section describing the model problems we devised for an engineering economy analysis. Finally, we conclude by describing the future direction of this study.

Understanding an Income Statement

The purpose of an income statement is to provide investors the most accurate description of the company's profitability over a set period of time, usually a fiscal quarter (3 months) or a fiscal year (12 months). This includes an estimate of the firm's sale, costs, increase or loss in intangible value, taxes, outstanding shares, and how the resulting net profit is divided among shareholders.

But as stated earlier, we would be dealing with operational costs. Among them are[2] –

(a) Total Revenues: This is the amount of money earned by selling the product.

(b) Cost of Sales (or cost of revenues): These are direct costs of production. They may include manufacturing employee salaries, cost of raw materials, cost of electricity and other utilities to run the factory, packaging material, and so forth.

(c) Research & Development: In order to consistently produce faster and better products, the company has to spend a lot of money on development labs, engineering resources, prototyping products etc. These expenses are recorded here.

(d) Marketing (or selling), General, and Administrative: These include advertising expense, executive salaries, stock options, and any other costs that cannot be grouped elsewhere.

(e) Income Tax Expense: Here the accountants calculate what they believe the tax rate would be and set aside a portion of profits (revenues) to pay taxes.

Designing an engineering economy module for nanotechnology companies (or projects)

Since engineering economy is best understood by solving problems, the students can have a better understanding of the importance of nanotechnology in a future economy by devising problems, and applying the procedures of economic analysis (described earlier) to study them. This will help students make educated inferences about how nanotechnology products will help drive future markets. Sample problems related to three NASDAQ listed SME's are described below –

Problem 1:

Nonvolatile Electronics, Inc. (NVE Corporation, NASDAQ: NVEC) is based in Edina Prairie, MN. Founded in 1989, the company is a market leader in nanotechnology sensors, couplers, and MRAM intellectual property (Magnetoresistive Random Access Memory).

NVE's technology enables the transmission, acquisition, and storage of data across a broad array of applications, including implantable medical devices, mission critical defense weapons, and industrial robots.

The financial health of the company (all number in 1000's) as described in its income statement is as follows[3] –

Year	3/2008	3/2009	3/2010	3/2011
Total Revenue	$20,528	$23,372	$28,147	$31,197
Cost of Sales	$6272	$6250	$7923	$9372
Research & Development	$1487	$1218	$1121	$1269
Selling, General, & Administrative Expenses	$2158	$2177	$2414	$2474
Income Taxes	$3892	$4644	$5917	$6330

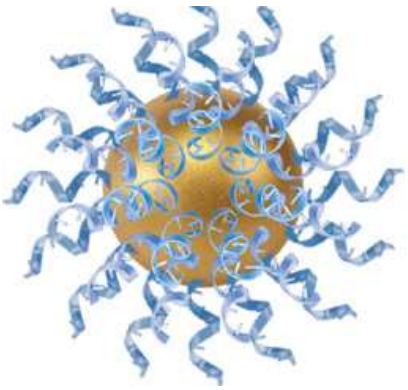
(a) Based on the above data, calculate the present worth of the company. Use an interest rate of 4% per annum. NOTE: We are assuming here that the data is a projection into the future.

(b) Calculate the IRR and based on the IRR analysis, would you like to invest in the projects of this company.

NOTE: It should be noted that because of no sign change in the cash transactions, IRR cannot be calculated. But the students need to find this out on their own using Descartes' rule of signs.

WARNING: In real life, any decision on whether to invest or not, will depend on more factors than those presented above.

Problem 2:



Nanosphere, Inc. (NASDAQ: NSPH) is a nanotechnology based healthcare company, offering a range of proprietary breakthrough technologies that provide a unique and powerful solution to greatly simplify diagnostic testing.

Founded in 2000, based upon nanotechnology discoveries at Northwestern University in Illinois by Dr. Robert Letsinger and Dr. Chad Mirkin, the company is involved in consistent manufacturing and functionalization of gold particles with oligonucleotides (DNA or RNA), or antibodies that can be used in diagnostic applications to detect nucleic acid or protein targets, respectively.

The financial health of the company (all number in 1000's) as described in its income statement is as follows[4] –

Year	12/2007	12/2008	12/2009	12/2010
Total Revenue	$1167	$1366	$2214	$2026
Cost of Sales	$2487	$2468	$1391	$865
Research & Development	$21,364	$23,675	$18,607	$18,821
Selling, General, & Administrative Expenses	$13,443	$13,615	$14,471	$22,007
Income Taxes	$1,977	$2080	$1257	$274

(a) Based on the above data, calculate the future worth of the company. Use an interest rate of 4% per annum.

(b) Based on the future worth, would you like to invest in the projects of this start-up company?

(c) Calculate the IRR and based on the IRR analysis, would you like to invest in the projects of this company.

WARNING: In real life, any decision on whether to invest or not, will depend on more factors than those presented above.

Problem 3:

Veeco Instruments Inc. (NASDAQ: VECO) based in Plainview, NY, is a leading supplier of process equipments for nanotechnology labs in industry, university, and government laboratories. Some of the equipments deal with metal organic chemical vapor deposition (MOCVD) for LED's and solar cells, and molecular beam epitaxy (MBE) products.

The financial health of the company (all number in 1000's) as described in its income statement is as follows[5] -

Year	12/2007	12/2008	12/2009	12/2010
Total Revenue	$402,475	$442,809	$380,149	$933,231
Cost of Sales	$203,223	$251,871	$211,463	$478,370
Research & Development	$61,174	$60,353	$57,430	$71,390
Selling, General, & Administrative Expenses	$90,972	$92,838	$85,455	$91,777
Income Taxes	$3651	$1892	$1347	$10,472

(a) Based on the above data, calculate the future worth of the company. Use an interest rate of 4% per annum.

(b) Based on the future worth, would you like to invest in the projects of this company?

(c) Calculate the IRR and based on the IRR analysis, would you like to invest in the projects of this company.

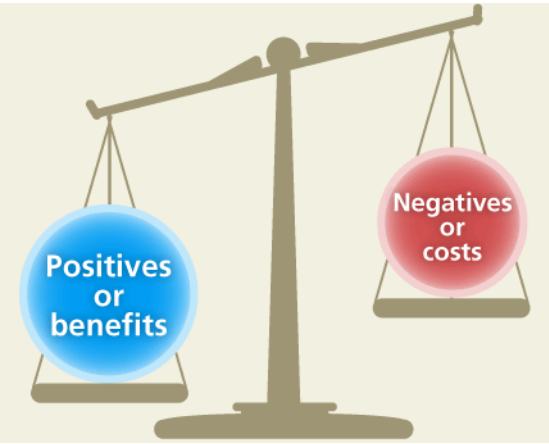
WARNING: In real life, any decision on whether to invest or not, will depend on more factors than those presented above.

Discussion and Future Directions

This engineering economy module for nanotechnology has been designed in order to introduce this new innovative field to undergraduate students from an economic standpoint of view. Since commercial applications of nanotechnology are still in its infancy, data from financial literature is speculative at its best. Therefore, we focused solely on nanotechnology based small and medium enterprises (SME's) listed at NASDAQ. This was because their business is exclusively based on nanotechnology and their financial statements (and specifically income statements) is readily available on the internet.

There have been many advantages when such a module was administered within the existing course in engineering economy in fall 2011. The financial statements were introduced immediately after cash flow diagrams. Usually textbook problems make it explicit that financial transactions are always at the end-of-the year. If we get rid of the phase "end-of-the-year", a common error when drawing a cash flow diagram is placing the financial transaction "before" instead at "end of the year". However, the financial statements not only gave an understanding of the nature of the finances, but also improved their cash flow diagrams.

The problems also helped understand how nanotechnology related products can have a sway on the markets in future. Also, the students learned about the vulnerability (or volatility) of start-up companies, all based on valuation analysis.



A complete economic study should include benefit-cost analysis. But to undertake such an analysis, one should have data on the dollar-value of the benefits of nanotechnology related products.

For example, consider the company NVE Corporation. Their MRAM (magneto-resistive random access memory) intellectual property will play a big role is saving data in a computer when there is abrupt disruption of power supply. This is the benefit of their product. But in economic

terms, the benefit would be the “dollar value” of the money saved due to prevention of data losses in a computer whenever there is abrupt disruption of power supply. Currently we lack such data and are continuing our study of related literature.

Since the commercial applications of nanotechnology are still in its infancy, we need to do more detailed analysis of financial literature to collect such data on benefits. This shall be the goal of future studies in this topic.

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