Maximizing Owner's wealth under uncertainty and volatility: A system dynamics approach using evidence from Norwegian Oil Sector

Abstract

This analysis focuses on maximizing firm value in presence of uncertainty and volatility in the oil market considering investment, financing and dividend policies as decision tool under different market conditions. Using system dynamics, we have developed a model for financial and physical processes of a leading firm in oil sector to grasp the dynamics and test policies in an effort to maximize the owner's wealth. Assuming market growth condition, investment policy seems to add most to the firm value. However, the combination of policies helps best to maximize the firm value.

1. Introduction:

Maximization of owner's wealth is the main and ultimate objective of a firm. Achievement of this objective is challenging in a competitive world with complexities surrounding its operations and the various options to decide on. This objective seems even more challenging when it comes to energy sector where the investment decisions are generally huge and irreversible whereas market prices are uncertain and volatile and of cyclical nature (Bloom et al, 2001). This is very true especially in the context of Norwegian continental shelf where oil is to be extracted from the seabed with relatively heavy irreversible investments. It is contributing almost 21.5% of the Norway's GDP, 29.5% to the state revenue, 30.7% of the total investments are done in petroleum sector and 48.9% of the exports (Figures from 2014 from Norwegian Petroleum Directorate). Petroleum industry is a knowledge intensive industry due to its complexity of operations. It took long years in Norway to reach a certain level of knowledge in order to be able to explore and develop oil and gas reserves and reap the benefits from production. Investment in oil industry is characterized by features that represent investment models under uncertainty such as longer planning horizon, irreversibility of the physical capital (under seabed in Norwegian case) and volatility and uncertainty of the price (Hvozdyk and Blackman, 2010). Given these complexities, achieving the objective of maximization of owners' wealth is a challenging task. According to the financial management theory, there are three major decisions including investment, financing and dividend which ultimately determine the value of the firm (Haris and Raviv, 1991). Once the amount of investment needed is determined in capital budget, the managers then take financing or capital structure decision that determines sources of financing of the capital budget. The complexity surrounding the intertwining feedback relationships of the market prices, the capital budget and the capital structure decisions makes owners' wealth maximization objective even more challenging when the important decision variables are distant in time and space.

System dynamics modeling is a useful tool to model such dynamic and complex interrelationships which are non-linear and involve feedback relationships. Through system dynamics, important variables can be endogenized to see the impact of policies. System dynamics is based on systems thinking and creating a clear picture of the whole system in order to solve a problem or define a policy. Therefore, this study is an attempt to address the issue using system dynamics.

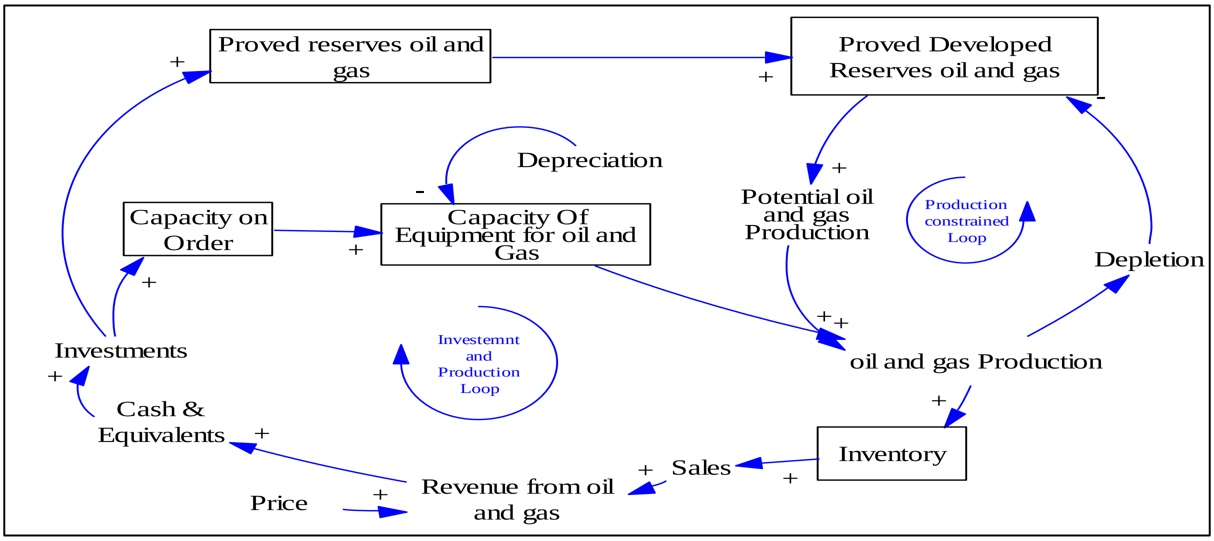
In order to understand these complex dynamics, we have used system dynamics by modeling the physical processes and linking them to financial processes with a feedback structure using data of Statoil. The rest of the paper is organized as follows: part 2 explains the model structure, part 3 describes the parameter estimation of some important parameters used in the model, part 4 presents model calibration. Policy design is explained in part 5 with discussion of results in part 6. The paper is concluded in part 7.

2. **Model Structure**:

System dynamics model presents causal structure of the processes rather than relying on the historical correlations to build the model. System dynamics model is capable of incorporating nonlinearities and delays which better explain the physical processes in petroleum industry (Sterman, Davidsen (P.69, 1990). Therefore, using system dynamics we have modeled physical processes and their financial co-flows using data from a leading firm in the energy sector in Norway.

2.1. Oil and Gas Production

For physical processes, we have modelled the production procedure and linked it with financial part through feedback process to better understand the dynamics. Figure 1 represent the structure diagram for oil and gas investment and production.



Investment and production loop represents the main reinforcing loop for the physical and financial processes. Firms need to invest in order to explore the reserves for oil and gas. When reserves are proved to be there with the possibility of extraction, further investment is needed to enable them ready for production. After development process reserves are converted to proved developed reserves from which oil or gas could be extracted. These developed reserves along with the capacity for production lead to production of oil and gas which accumulates in inventory stock. The outflow from inventory leads to sales which along with price represent revenue. Revenue generates cash which again leads to investment needed. Capacity represents the constraint in terms of production as more than capacity to extract cannot be produced. Production constrained loop represents the balancing loop which is depleting the reserves because the oil or gas which is being extracted is depleting the reserve and more investment is needed to stabilize the production in the future and there is need to explore more reserves.

2.2.The Balance Sheet

For modeling the financial processes, we have modeled the financial statements including balance sheet, income statement and cash flow statement. The financial statements are modelled in compliance with generally accepted accounting principles (GAAP) as well as system dynamics rules to represent the financial dynamics of the energy company. The structure diagram for balance sheet is given below.

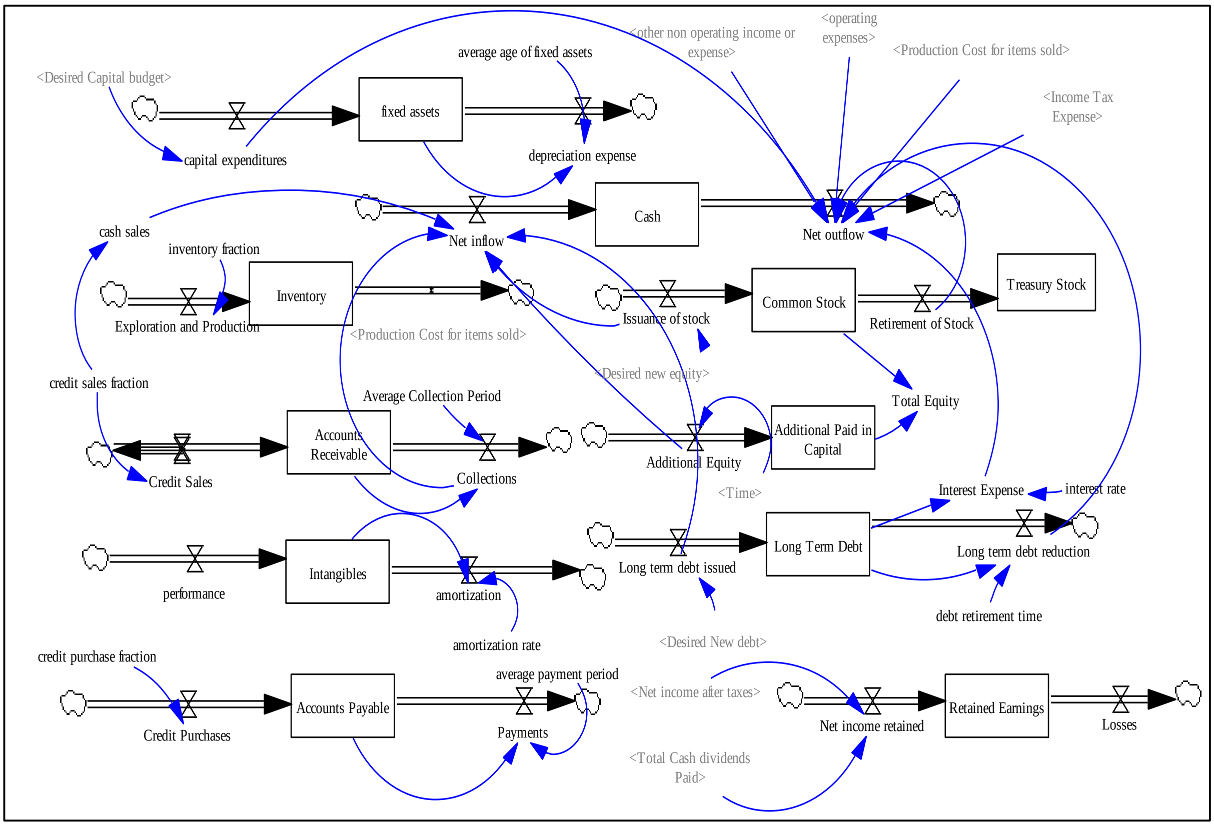


Figure 2: The Balance Sheet

The balance sheet is structured according to the accounting principles of assets equal liabilities and owner's equity. Cash is a stock with inflows and outflow from physical cash transactions. Inflows include net income retained (dividends are already subtracted from), common stock issued and debt issued. Outflows include payments for accounts payable, debt repayment, common stock purchased back and capital expenditure. Accounts receivable and fixed assets represent other items on the left hand side of the equation besides cash. Long term debt, common stock, accounts payable and retained earnings represent the right hand side of the equation that is liabilities and owner's equity.

2.3. The Capacity Planning

In order to plan for capacity, market price is the determining factor as how much capacity we need in the future. Using expected revenue, we have formulated the desired capital budget which drives the investments for future production capacity.

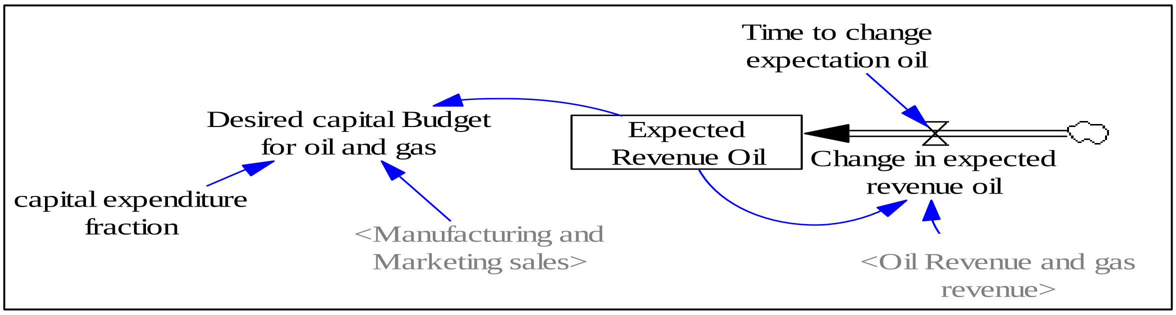


Figure 3: The Capacity Planning

2.4.The Financial Planning

Here we are assuming that desired capital budget is financed through first internal financing and then external financing. Debt to capital employed ratio determines how much debt and equity is required. The structure for financial planning is given in figure 4 below.

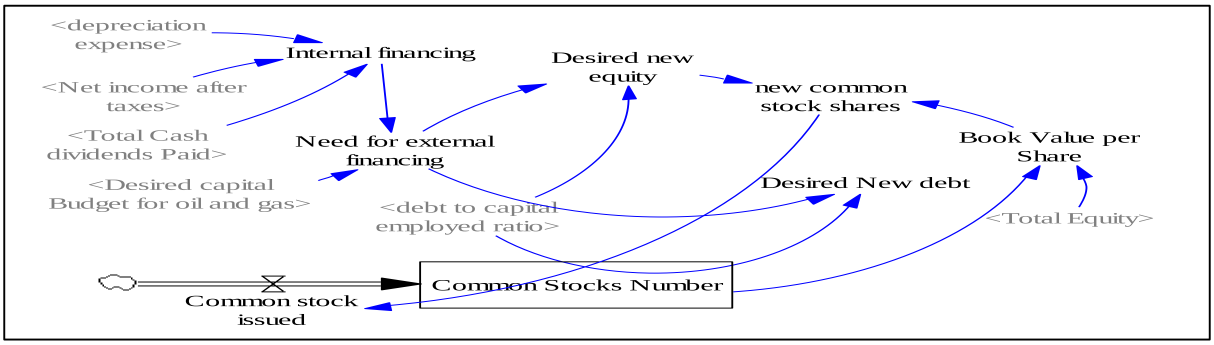


Figure 4: The Financial Planning

3. Parameter Estimation:

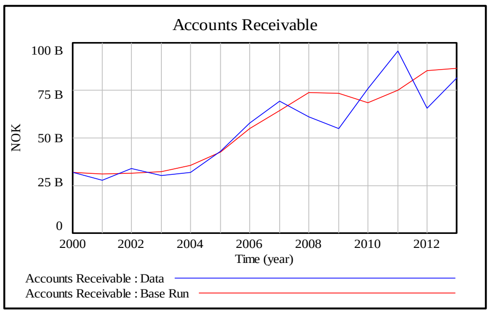
In system dynamics, parameters are used in formulation of equations in order to describe some distinctive recognizable characteristic of the actual system. Therefore, parameters should be set adequately accurate in order to fulfill the purpose of the system. Some parameters and their used values are given in table 1.

Parameter	Value
Interest Rate	10%
Dividend Payout Ratio	30%
Debt to capital employed ratio	40%
Tax Rate	64%
Capital Expenditure Fraction	15%
Time to change Expectation	5 years

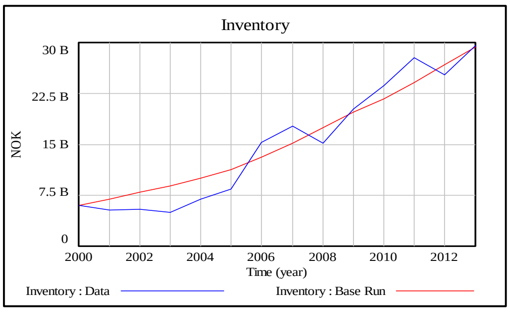
Table 1: Parameter Values

4. Model Calibration:

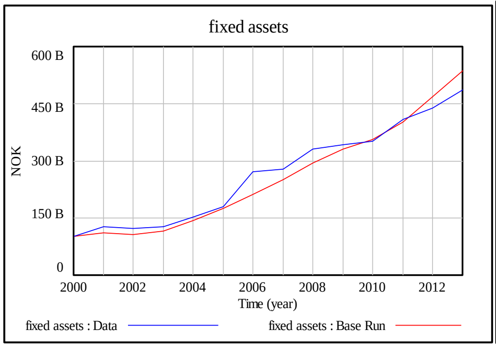
Building a system dynamics model involves the process of searching and analyzing data in order to support the development. The more accurate and comprehensive the collected information would be used, the higher would be the prospective quality of the quantitative model. Below are some graphs which represent the reference mode and calibrated model.



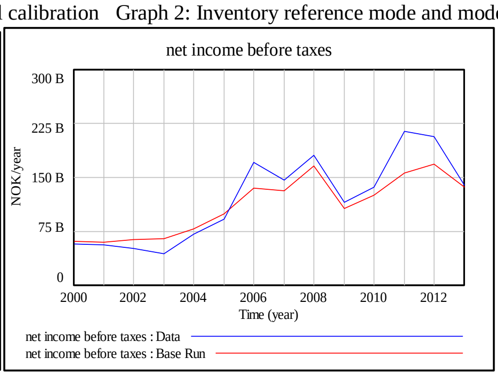
Graph 1: Accounts Receivable reference mode and model calibration



Graph 2: Inventory reference mode and model calibration



Graph 3: Fixed Assets reference mode and model calibration



Graph 4: Net Income before taxes reference mode and model calibration

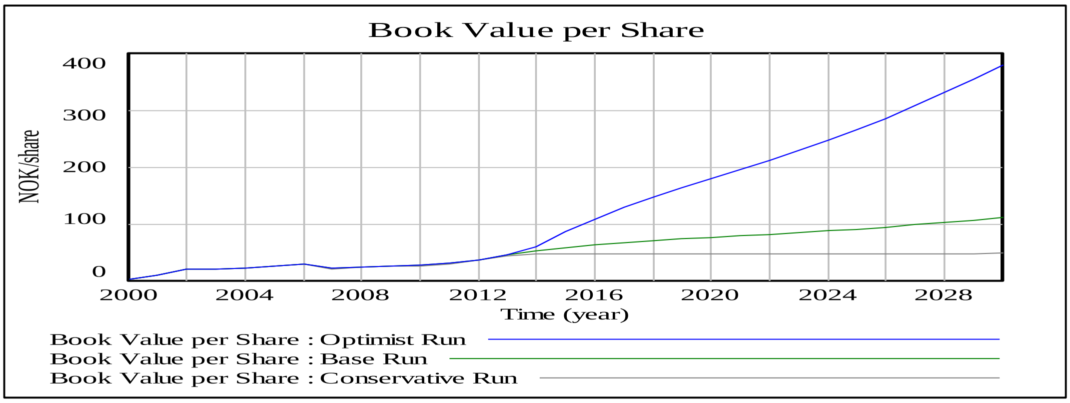
5. Policy Design:

This study designs policies for investment, capital structure and dividend decision of the firm under stable, growing and declining product market given the cyclic nature of oil market. Table 2 gives the detail of policy variables and optimist and conservative scenarios.

	Variable	**Optimist Scenario**	**Base Case**	**Conservative Scenario**
Oil Price	Average Price Oil	5% Growth	Average Price	-2.5 Growth
Gas Price	Average Price Gas	5% Growth	Average Price	-2.5 Growth
Investment Policy	Capital Expenditure Fraction	25%	15%	10%
Debt Policy	Debt to Capital Employed Ratio	20%	40%	60%
Dividend Policy	Dividend Payout Ratio	15%	30%	45%

Table 2: Policy variables and Scenarios

The three policies investment, financing and dividend are crucial decisions in maximizing the firm value. We have tested the three policies in order to see which policy maximizes the firm value. The price represents the market condition which is stable and repeating the historical trend in base run, growth of 5% in a growing product market and decline of 2.5% in conservative market. Under these market situations, we have built three scenarios with policies of investment, capital structure and dividend represented by policy variables of capital expenditure fraction, debt to capital employed ratio and dividend payout ratio respectively. The graph below represents the results of three scenarios.



Graph 5: Book Value under three scenarios Optimist, Base and conservative cases

5.1. Investment Policy:

Reference investment policy which is based on empirical investigation has the capital expenditure fraction of 15%. For optimist and conservative case, the fraction is 25% and 15% respectively. When tested in isolation, investment policy is most crucial in maximizing the value of the firm given the product market growth.

5.2.Financial Policy:

Financial policy of the firm reveals that firm has less debt than the capacity in the capital structure. Debt to capital employed ratio is 40% in the reference policy whereas 60% and 20% in conservative and optimist policy respectively.

5.3.Dividend Policy:

Reference dividend policy has dividend payout ratio of 30% which means that company pays out dividend to its shareholders. In optimist policy the ratio is 15% and 45% in conservative case.

6. Results and Discussion:

The objective of this analysis is to test which type of capital structure, investment and dividend policies help maximize the firm value given stable, growing and declining oil market conditions. To identify the best policies that maximize the book value, policies were tested in isolation and combinations. Through system dynamics, we have tested the impact of these policies in combinations as system dynamics takes into account nonlinearities and is capable of better explaining the complex systems and dynamics as in case of policies a firm has to take. In isolation, investment policy contributes most to the firm value given the growing oil market. The assumption of growing oil market is important as prices have significant impact on investments (Elder and Serletis, 2010). This policy outcome confirms to the nature of investments in the oil sector as investments irreversible and long term and prices are volatile and uncertain. In order to maximize the value, firm needs to invest to keep up the capacity of production to meet the demand today and in the long term as it takes many years to build the capacity for production in the oil sector. Regarding debt policy, firm is operating with less debt than its capacity and relying more on internal funds. The risk of the firm is low. The debt policy in our model has positive impact on the firm value in optimist case. Dividend policy of firm currently is to pay dividends to shareholders. So, the policies in the model assume dividends but with less percentage in optimist case and more percentage in conservative case. These policies yield best result when they are in combination and add to the book value significantly as evident from the graph above that optimist scenario case maximizes the book value of the firm given the market growth condition.

7. Conclusion:

This analysis focuses on maximizing the firm value considering the cumulative effect of investment, financing and dividend policies given the different market conditions. Through system dynamics, we have built physical as well as financial processes model in an effort to reflect the dynamics in the energy market where uncertainties are involved and prices are volatile. After testing the policies, the analysis reveals that a bit higher investment in building the capacities is most effective policy towards maximizing the firm value. Because of the sound financial condition, the firm value is not very sensitive to the debt policy but less debt in the capital structure mix adds to the firm value.

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