Development of Model Equations for Comparative Analysis of the Profitability of Gas Monetisation Technologies: A Case Study of GTL and LNG

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Abstract: **This paper developed model equations that aid in decision making process of selecting the optimum gas transportation medium using regression analysis as the method. In apply regression analysis, data generated from the economic analysis conducted were exported to Excel and with the aid of Excel data analysis toolpak, model equations in the forms of simple linear equations were developed. The gas monetization technologies considered were only gas to liquid (GTL) and liquefied natural gas (LNG). In the study, series of sensitivity analyses were performed, with each factor that impacts on the profitability of the considered gas monetization technologies, one at a time and the various data points gotten from the sensitivity analyses were exported to Excel for development of a correlation/model equation using regression analysis. For gas to liquid (GTL) technology, the factors affecting its profitability (NPV) include: capital expenditure (CAPEX), gas feedstock price, naphtha price and oil price. Whereas, for liquefied natural gas (LNG) technology, the factors affecting its profitability include: gas feedstock price, shipping cost and LNG price. From the results of the regression analyses, it was discovered that: for each unit increase in CAPEX, the profitability of the GTL technology increases with 0.1 units; for each unit increase in gas feedstock price, the GTL profitability decreases with 3.8 x 10-13 units; for each unit increase in naphtha price, the GTL profitability increases with 8.01 x 10-15 units and for a unit increase in oil price, the GTL profitability increases with 6.1 x 10-4 units. And for a unit increase in shipping cost, the LNG profitability increases with 1000 units and for a unit increase in LNG price, the LNG profitability increases with 1000 units. Gas feedstock price has zero effect on the profitability (NPV) of LNG technology.**

Keywords: **Model equations, GTL, LNG, Regression, NPV, Profitability.**

I. INTRODUCTION

Plagued by issues of insecurity, unstable demand, high initial development cost, bureaucratic bottlenecks and challenging terrains, the construction of new Gas transmission Pipelines has suffered a lot of setbacks leading to stalling of projects and in some cases abandonment by stakeholders. Furthermore, under certain conditions such as small gas reserve size especially for stranded gas reservoirs, it may not be economically viable to transport these gases via dedicated pipelines. While there are large quantities of global stranded gas, individual reserves may need to be of a certain reserve size to be viable candidates for monetization technologies.

Whether the gas is to be used in its natural state, or processed into other products, transportation from reserve to market is a major step in the monetization process. Multiple technologies exist for transporting natural gas from reserve site to market, but great distances involve large costs. Also, successful monetization of a gas reserve requires the existence of a willing market. For each technology, a demand must exist for the final natural gas product to be economically viable. Supply may be brought to markets using technologies like LNG and GTL. Both GTL and LNG appear uniquely posed to efficiently bring distant reserves to new markets. As the GTL industry expands, it will likely be placed in direct competition with LNG for access to natural gas supply (Garrouch, 2007). LNG is certainly at a competitive advantage due to its current state of development. However, significant market potential exists for GTL products. As the decision to develop either project comes into play, an economic valuation for each technology provides vital information for the pursuit of an efficient and profitable monetization strategy. This study focuses on developing model equations that aid in decision making process of selecting the optimum gas transportation medium to utilize.

II. METHODOLOGY

For gas to liquid (GTL) technology, the factors affecting its profitability (NPV) include: capital expenditure (CAPEX), gas feedstock price, naphtha price and oil price. Whereas, for liquefied natural gas (LNG) technology, the factors affecting its profitability include: gas feedstock price, shipping cost and LNG price. In the study, series of sensitivity analyses were performed, with each factor that impacts on the profitability of the considered gas monetization technologies, one at a time and the various data points gotten from the sensitivity analyses were exported to Excel for development of a correlation/model equation using regression analysis. The steps taken are described in the subsections below. The profitability of the technologies were measured in terms of net present value (NPV).

Net Present Value (NPV)

NPV is the sum of all cash flows, positive and negative, discounted to present value. As a base rule, an NPV greater than zero indicates a profitable investment, and a negative NPV indicates the opposite. Projects with negative NPV values should not be pursued. NPV calculation enables project ranking, with higher values being preferred (assuming other valuation measurements are held equal). A general equation for NPV is:

$$\boldsymbol{NPV} = \sum_{n-1}^{n} \left(\frac{C_n - C_o}{(1+i)^n}\right)$$

where, C_n = net cash inflow during the period n, C_o = total initial investment costs, i = discount rate, and n = number of time periods.

The NPV is the most theoretically correct method of all project appraisal tools. It involves the discounting of future cash flows (returns) of an investment (it determines their present value) and compares it with the present value of the investment outlay (payments). The difference between the two is the Net Present Value (NPV) of the investment.

In order to calculate the Net Present Value (NPV) of a project we simply discount all the cash flows, including the investment itself, to 'money of today'. An investment should be accepted if the PV of its future net cash flows exceeds the PV of its related cash outlay. In the case of two competing or mutually exclusive projects the one with the highest NPV should be accepted. In reality, however, the existence of 'risk' and the generally limited availability of funding mean that most businesses seek a substantially higher NPV depending of course on the risk and size of investment. A higher NPV indicates that the project or investment is more profitable (Clarke &Ghaemmghami, 2003).

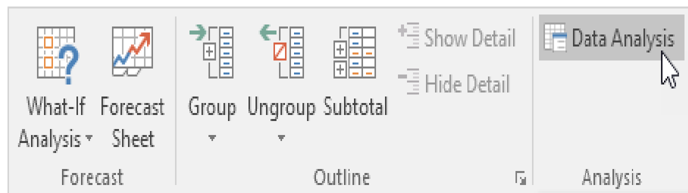
The Net Present Value Rule dictates that the only investments that should be made are those with positive NPV values (Ross *et al*., 1996). Generally, an investment with a positive NPV will be a profitable one and one with a negative NPV will result in a loss, and therefore should be avoided.

Regression Analysis

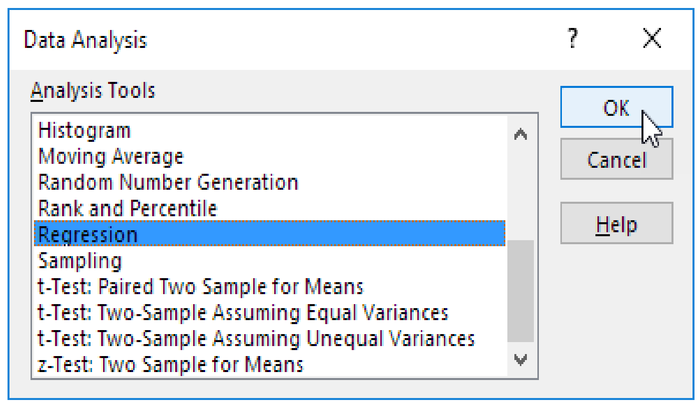
Regression analysis evaluates the relationship between two or more variables. It requires a dependent variable and several independent variables. Dependent variable represents the parameter that is to be predicted while independent variable are parameters or factors that affect the dependent variable. Regression analysis determines which of the independent variables have more influence on the dependent variable when any of the independent variable is varied or changed. This regression analysis is on the basis of Sum of Squares, a mathematical way used to determine the dispersion of data points. It is aimed at getting the smallest sum of squares and then it draws a line which gets close to the data (Seref& Ahuja, 2008).

The steps for regression analysis

1. On the Data tab, in the Analysis group, click Data Analysis.



2. Select Regression and click OK.



3. Select the Y Range. This is the predictor variable (also called dependent variable).

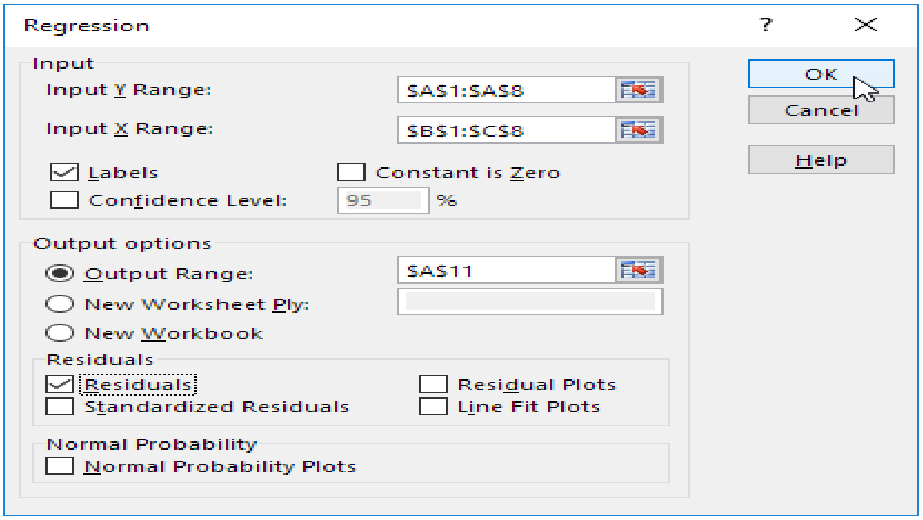
4. Select the X Range. These are the explanatory variables (also called independent variables). These columns must be adjacent to each other.

5. Check Labels.

6. Click in the Output Range box

7. Check Residuals.

8. Click OK (Seref*et al*., 2007).



After following these steps, Excel produces the summary output as shown in the result section. The closer to 1 of the R Square value, the better the regression line fits the data. To confirm if the results are reliable (statistically significant), the value of the Significance F must be less than 0.05. If Significance F is greater than 0.05, it is an indication to stop utilizing the set of independent variables. At which point, the user must delete a variable with a high P-value (greater than 0.05) and rerun the regression until Significance F drops below 0.05.

III. RESULTS

GTL Profitability (NPV)

Prior to the development of the model equations, economic analysis was performed in the study and the data generated was exported into Excel for further analysis.

Table 1: Regression Analysis Output for GTL variables

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	1				
R Square	1				
Adjusted R Square	1				
Standard Error	1.32E-13				
Observations	6				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	4	4375000	1093750	6.3E+31	9.44657E-17
Residual	1	1.74E-26	1.74E-26		
Total	5	4375000			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-2000	2.74E-12	-7.3E+14	8.73E-16	-2000
CAPEX	0.1	1.37E-16	7.3E+14	8.71E-16	0.1
Gas feedstock price	-3.8E-13	3.29E-12	-0.11504	0.927084	-4.21885E-11
Naphtha price	8.01E-15	2.55E-14	0.313909	0.806361	-3.16111E-13
Oil price	6.1E-14	7.65E-14	0.796728	0.571719	-9.11384E-13

LNG Profitability (NPV)

Table 2: LNG variables regression analysis output

SUMMARY OUTPUT					
Regression Statistics					
Multiple R	1				
R Square	1				
Adjusted R Square	0.5				
Standard Error	9.84877E-14				
Observations	5				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	788000	262666.7	4.06E+31	1.15341E-16
Residual	2	1.93997E-26	9.7E-27		
Total	5	788000			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*
Intercept	-5800	5.02413E-12	-1.2E+15	7.5E-31	-5800
Gas feedstock price	0	0	65535	7.5E-31	0
Shipping cost	1000	1.55723E-12	6.42E+14	4.73E-31	1000
LNG price	1000	6.88006E-13	1.45E+15	4.73E-31	1000

IV. DISCUSSIONS

From Table 1, a simple linear multivariate correlation was developed (see Equation 1 below) in this study using Microsoft Excel Data Analysis ToolPak and applying the principles of equation of a straight line (Y=mx+c). It is a correlation for the prediction of the profitability of GTL using the factors that affect GTL viability as the independent variables:

$$GTL_{NPV} = 0.1Capex - 3.8\,x\,10^{13}\,Gas_{feedstock} + 8.01\,x\,10^{-15}Naphtha_{price} + 6.1\,x10^{-4}Oil_{price} - 2000 \quad (1)$$

From equation 1, the relationship between the profitability of gas to liquid technology and gas feedstock price is inverse, implying that as gas feedstock price is increasing, the profitability of GTL is reducing. Whereas, the relationship between the profitability of GTL and CAPEX, Naphtha price and Oil price are all directly proportional, implying that the increase of these variables (CAPEX, Naphtha price and Oil price) also results to increase of GTL profitability.

To verify the reliability of the correlation (Equation 1), the R square and Significance F values, are assessed. The closer to 1 of the R square value, the better the regression line fits the actual data. If the value of the Significance F is less than 0.05, then the developed model is highly reliable.

From Table 1, R Square equals 1, which is a perfect fit and implies that 100% of the variations in the net present value of GTL is influenced by the independent parameters (CAPEX, gas feedstock price, Naphtha price and oil price). From Table 1 also, the Significance F is 9.4 x 10^{-17}, which is way below 0.05. Therefore, from the above stated criteria, Equation 1 is very reliable for the prediction of the profitability of GTL.

In developing the GTL profitability correlation (i.e. Equation 1), the values under the 'coefficient' column in Table1 were utilized. From Table 1, the intercept value was -2000, the coefficient of the CAPEX was approximately 0.1, the coefficient of the gas feedstock price was approximately -3.8 x 10^{-13}, the coefficient of Naphtha price was 8.01 x 10^{-15} and the coefficient of the oil price was approximately 6.1 x 10^{-4}.

Arranging these coefficients and the intercept, and putting them in the form of a straight line equation '$Y=Ax_1+Bx_2+C$' resulted to Equation 1.

Similarly, From Table 2, another simple linear multivariate correlation was developed (see Equation 2 below) using

Microsoft Excel Data Analysis ToolPak and applying the principles of equation of a straight line (y=mx+c) for the prediction of the profitability of LNG using the variables that affect LNG viability as the independent variables:

$$LNG_{NPV} = 1000Shipping_{cost} + 1000LNG_{price} - 5800 \quad (2)$$

From Equation 2, gas feedstock price has no effect on the profitability of LNG technology, however, the relationship between the profitability of LNG technology withshipping cost and LNG price are directly proportional, implying that as oil price and shipping cost increase, the profitability of LNG measured with NPV also increases.

To also confirm the reliability of the LNG correlation (Equation 2), the R square and Significance F valuesare assessed. From Table 2, R Square equals 1, which is a perfect fit and implies that 100% of the variations in the net present value of LNG is influenced by the independent variables (shipping cost and LNG price). From Table 2 also, the Significance F is 1.153×10^{-16}, which is way below 0.05. Therefore, based on these criteria, Equation 2 is very reliable for the prediction of the profitability of LNG measured in terms of NPV.

In developing the LNG profitability model equation (i.e. Equation 2), the values under the 'coefficient' column in Table 2 were utilized. From Table 2, the intercept value was -5800, the coefficient of the shipping cost was 1000, the coefficient of the gas feedstock price was 0, and the coefficient of LNG price was 1000. Arranging these coefficients and the intercept, and putting them in the form of a straight line equation '$Y=Ax_1+Bx_2+C$' resulted to Equation 2.

Based on these equations and for two competing projects, the one with a higher NPV should be selected over the other. Thus, with these equations, there will be no need to go through the rigorous and time consuming process of conducting robust economic analysis of the two technologies.

V. CONCLUSION

From the results of the regression analyses, it be concluded that:

1. For each unit increase in CAPEX, the profitability of the GTL technology increases with 0.1 units; for each unit increase in gas feedstock price, the GTL profitability decreases with 3.8×10^{-13} units; for each unit increase in naphtha price, the GTL profitability increases with 8.01×10^{-15} units and for a unit increase in oil price, the GTL profitability increases with 6.1×10^{-4} units.
2. For a unit increase in shipping cost, the LNG profitability increases with 1000 units and for a unit increase in LNG price, the LNG profitability increases with 1000 units.
3. Gas feedstock price has zero effect on the profitability (NPV) of LNG technology.

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