SWN: SHALE GAS GROWTH[1]

1. INTRODUCTION

Claudia Gomez has recently joined the corporate finance department of an independent gas development company, Southwestern Energy Company ("SWN"), which has developed substantial shale gas reserves in Arkansas and Appalachia. SWN claims to be one of the lowest cost developers of natural gas reserves in the U.S. Her first assignment is to provide support for Juan Lopez, SWN CEO, who believes that the required "SEC" disclosure of the present value of proven reserves discounted at 10%, and with constant prices, way undervalues the proven reserves.

Over the past four years proven developed reserves had increased, although reserves and present values declined significantly in 2016, when average natural gas prices reached a record low due to surplus gas production from SWN and other shale gas producers. **Table**

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1 shows the disclosed proven reserves, forecast future cash flows, production costs, future development costs, and other items.

Table 1

SWN PROVEN GAS RESERVES MMMcf Gas Only				
	2016	2015	2014	2013
PD				
BEGIN	5,474	5,675	4,237	3,196
END	4,789	5,474	5,675	4,237
PUD				
BEGIN	443	4,134	2,737	821
END	77	443	4,134	2,737
AVERAGE PRICE ASSUME	2.48	2.59	4.35	3.67
FUTURE CASH FLOWS $000000				
INFLOWS	9,064	11,887	41,812	22,624
COSTS	-5,880	-7,376	-16,477	-8,896
DEVELOP COSTS	-485	-792	-5,750	-3,626
INCOME TAX			-4,743	-3,223
NET CASH FLOWS	2,699	3,719	14,842	6,879
5% DISCOUNT	-1,034	-1,302	-7,299	-3,143
SEC NET CASH FLOWS	1,665	2,417	7,543	3,736
ANALYSIS OF SEC STANDARDIZED MEASURE $000000				
SEC BEGIN	2,417	7,543	3,736	2,051
PRODUCTION	-574	-1,082	-2,084	-1,774
CHANGES IN PRICES	-415	-8,075	1,192	1,853
E,D & OA	45	162	1,049	1,454
ACQUIRE	0	28	1,897	5
SALE	-10	-244		
REVISIONS	-140	-1,385	622	349
DISCOUNT ACCRETION	242	946	513	232
CHANGE IN TAXES	0	1,915	-522	-1,120
CHANGE DEVELOP COSTS	185	2,882	925	27
CHANGE TIMING	-85	-273	215	659
SEC END	1,665	2,417	7,543	3,736
SEC END CROSS CHECK	1,665	2,417	7,543	3,736

SWN has stated that "pre-tax PV-10 value of the estimated cash flows related to our estimated proven reserves is a useful supplement disclosure…we understand securities analysts use pre-tax PV-10 as one measure of the value of a company's current proven reserves and to compare relative values among peer companies without regard to income

taxes". Juan believes that in addition using a 10% discount rate, historical average gas prices, ignoring the improvements over time in production and reserve development costs, and indeed ignoring unproven reserves very substantially undervalues the SWN exploration, development and production portfolio.

Nevertheless, SWN values the PV methodology, as their rule for success appears to be invest when PV(10%)>1.3 Investment Cost. Although Lopez is not a big supporter of real option methodology, he wondered whether this now somewhat dated methodology might be useful in valuing proven undeveloped reserves (PUD) and unproven reserves (UN). Natural gas prices have been very volatile in the US over the last few years, and there seemed to be times when developing reserves was hardly profitable at current gas prices. Is this volatility increasing or decreasing over time? See **Figure 1** compared to **Figure 2**.
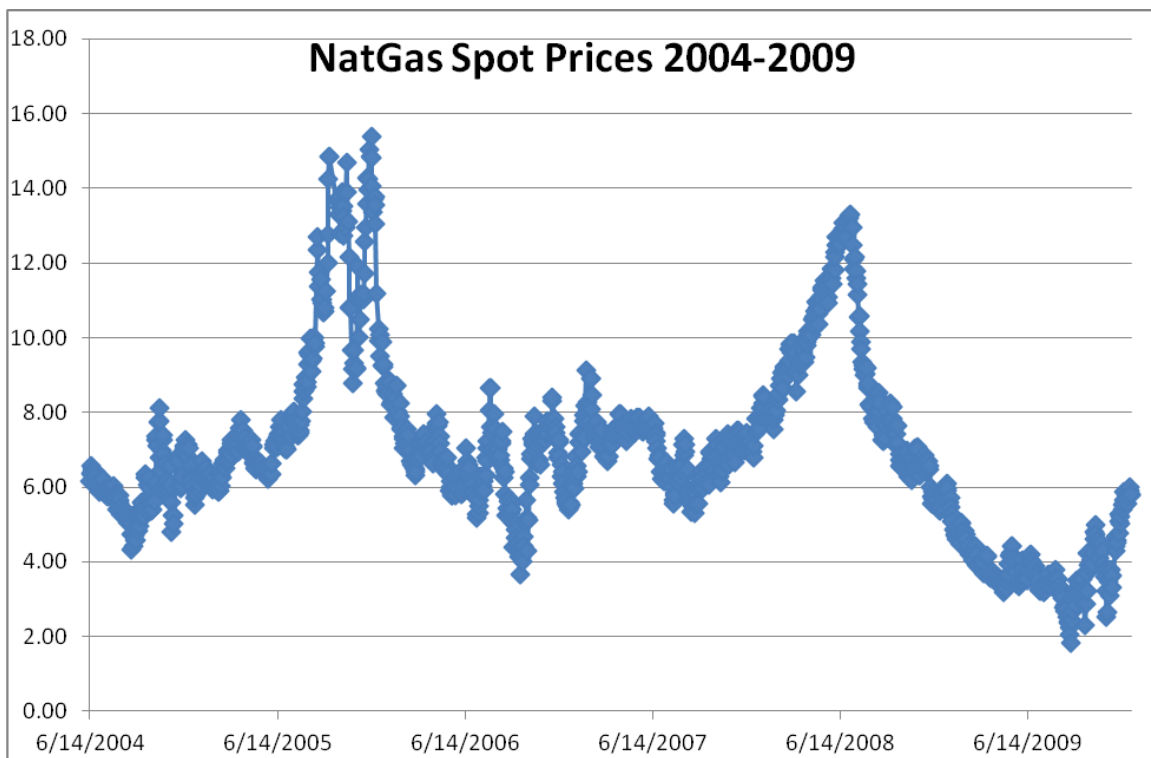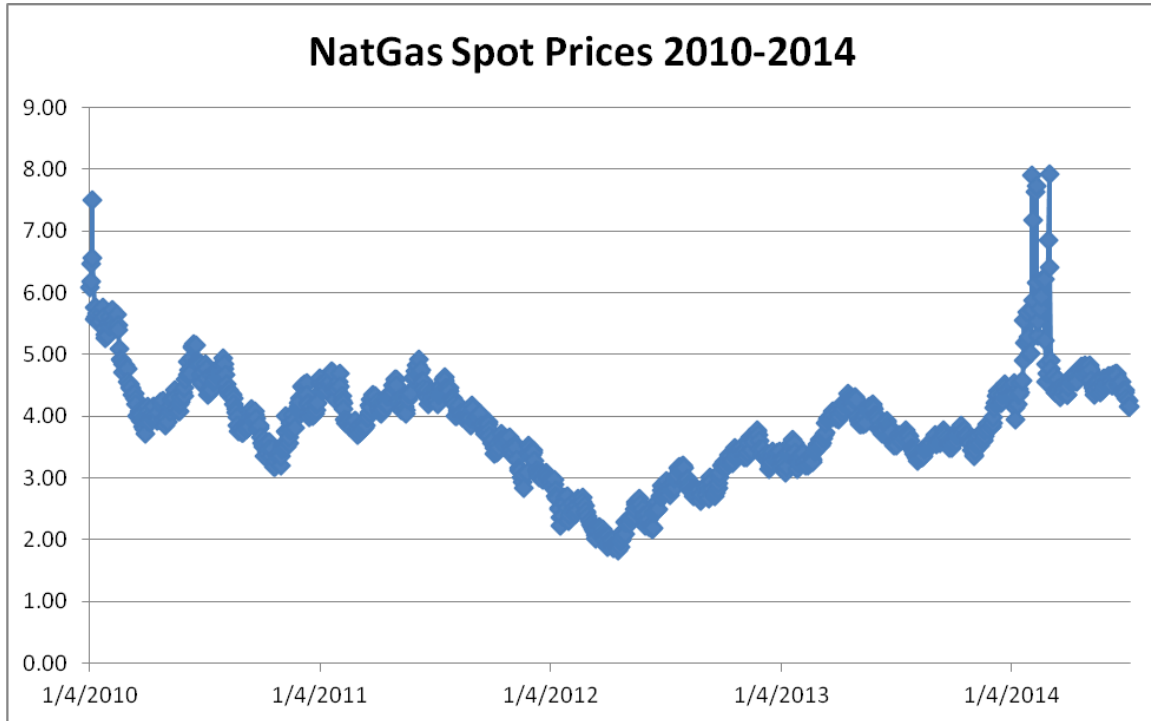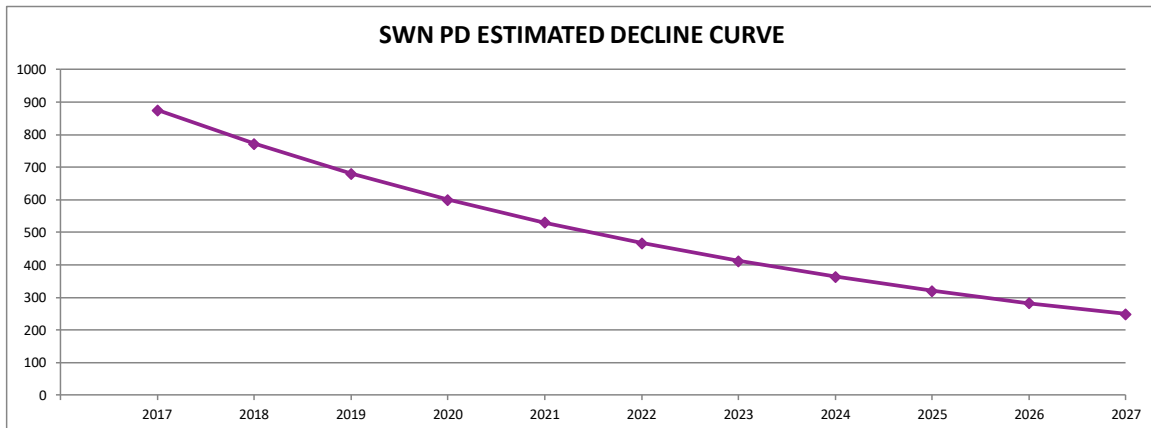
Figure 1

Figure 2

Claudia wonders whether long-term volatility best approximated by daily spot volatility, due to seasonality. Given the low risk of developing reserves for SWN, Lopez thinks that Claudia will be occupied sufficiently working out the model analysis and appropriate parameter values so she will produce little to surprise him over the next year "out of harm's way". The SWN people want to get on with their more important work continuing to develop reserves and sell gas in a difficult market. So while Claudia might come up with a higher value of the PUD reserves than the SEC methodology, little else will change. However, Claudia had taken an introductory course in real options, where it was argued that "not only is the NPV rule wrong, but substantially wrong, in the face of uncertainty".

2. SWN RESERVE ANALYSIS

Before trying to readjust the SEC standardized measure of reserve present value, it is first necessary to estimate the production decline curve, on which the pre-tax PV 10% of $1.6 billion is based. An external estimate shown in **Table 2** is only approximate, assumes production ends after year twelve, production costs are $.83/MCF +$60, and production next year of 875 MMCF. If production declines at a hyperbolic rate of -.8 per annum, the gas price is constant at $1.50, the total BCF almost equals the SEC disclosure, and the 10% PV is $1.6 billion. **Figure 3** shows the estimated decline curve.

Figure 3

In **Table 3**, a similar decline curve is projected for the PUD but starting at a slightly higher gas price, and with production next year set at arbitrary figure of 20% of disclosed SEC PUD reserves. When discounted at 10% the PUD production cash flow has a present value of -$11 million, or slightly less than the PV of the disclosed investment cost. The 10% PV of PD and PUD is close to the pre-tax 10% PV figure reported by SWN. Of course, Claudia would have more accurate figures than these estimates.

Substituting these 10% PV estimates for the accounting book value of proven reserves in the December 2016 SWN balance sheet, adding the book value of other assets and subtracting the real liabilities results in net assets per share of some $1.80, as shown in **Table 4**. Then it is assumed that the gathering system assets would be worth ten times operating profits, the unproven properties shown in the 10K of $ 2105 million are assumed to be worth slightly more than the book value, and the PUD ROV should be from **Table 5**. What is your net "appraised" value per share, adjusting **Table 4** ?

Table 4

SWN 12/2016	ASSETS	LIAB	
CURRENT	1872	1064	
UNPROVEN	2105	4612	LTD
PD	1651	483	OL
PUD	1		
OTHER ASSETS (GATHERING)	1,448	918	NA
TOTAL BOOK BASIS	7,077		
SHARES	509	**$1.80**	
ALTERNATIVE VALUES		EXCESS PER SHARE	
GATHERING	970	-$0.94	?
PD PV	1	-$3.24	?
PUD ROV	1	$0.00	?
UNPROVEN ROV	2105	$0.00	?
TOTAL ROV		**-$2.38**	?
REFERENCE GAS PRICE		**$1.50**	?

3. THE SWN REAL OPTION

Claudia thinks a primary real option at SWN is the option to defer the investment decision, even if there are standard holding costs such as leasing or work requirements. Claudia is aware of several real option deferral models applied to petroleum projects, such as Tourinho (1979) and Bjerksund and Ekern (1990)[2]. Tourinho seemed the easiest model to comprehend (perhaps even Lopez could grasp the simple maths). Claudia believes if the Tourinho model as amended in Adkins and Paxson (2013) did not justify the project, greater model sophistication would be a practical waste of time. Tourinho (amended) states that the value of being able to perpetually defer an investment decision with an underlying "fundamental value" of V, when the risk less interest rate $=r$, the convenience yield$=\delta$, annualized lease holding costs$=\eta$ and the volatility of the project$=\sigma$, is:

$$F(V) = AV^{\beta_1} \qquad (1)$$

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[2] See Adkins, R. and D. Paxson (2013), "The Tourinho Model: Neglected Nugget or a Receding Relic", European Journal of Finance, 19, 604-624; Bjerksund, P. and S. Ekern (1990),"Managing Investment Opportunities under Price Uncertainty: From 'Last Chance' to "Wait and See' Strategies", Financial Management, 19 (3), 65-83. Note Tourinho, O.A. (1979), "The Valuation of Reserves of Natural Resources: An Option Pricing Approach", Ph.D. Dissertation, University of California, Berkeley, assumed the real option holder would be required to pay an annual holding cost to maintain the concession during the deferral period.

where $\beta_1 = \dfrac{1}{2} - \dfrac{(r-\delta-\eta)}{\sigma^2} + \left\{ \left[\dfrac{(r-\delta-\eta)}{\sigma^2} - \dfrac{1}{2} \right]^2 + \dfrac{2r}{\sigma^2} \right\}^{\frac{1}{2}} > 1$ (2)

$$V^* = \dfrac{\beta_1}{\beta_1 - 1} K \qquad (3)$$

$$A = \dfrac{V^* - K}{(V^*)^{\beta_1}} \qquad (4)$$

Initially Claudia inputs a riskless interest rate of 10%, a long-term convenience yield of 10% which is at least in "the right direction" with the current backwardation (long-term futures prices less nearby futures), a lease holding cost of 0% and a volatility of 50%. As illustrated in **Table 5**, when V=275, K=235, the real option value ROV= 112 and V*=683, which is the value of the project which would justify commencing the investment.

Table 5

	A	B	C	D	E
1			**PERPETUAL AMERICAN CALL**		
2	**Inputs:**				
3	Holding Cost		0		
4	V	$	275.00	Template	
5	K	$	235.00	Template	
6	σ		50%	Template	
7	r		10%	Template	
8	δ		10.0%	Template	
9	**Outputs:**				
10	ROV	$	**111.92**	IF(B4<B13,B14*(B4^B15),B11)	
11	V-K	$	40.00	B4-B5	
12	F'(V)		0.62	IF(B4<B13,B14*B15*(B4^(B15-1)),1)	
13	V*	$	682.88	(B15/(B15-1))*B5	
14	A		0.02	(B13-B5)/(B13^B15)	
15	β₁		1.52	0.5-(B7-B8-B3)/(B6^2)+SQRT(((B7-B8-B3)/(B6^2)-0.5)^2 + 2*B7/(B6^2))	
16					
17	ODE		0.00	0.5*(B6^2)*(B4^2)*B18+(B7-B8-B3)*B4*B12-B7*B10	
18	F''(V)		0.00	IF(B4<B13,B14*B15*(B15-1)*(B4^(B15-2)),0)	
19	F'(V*)		1.00	B14*B15*(B13^(B15-1))	
20	F(V*)	$	447.88	IF(B4<B13,B14*(B13^B15),B11)	
21	V*-K	$	447.88	B13-B5	
22	ROV-NPV	$	71.92		

Claudia believes there are two major implications of her initial work. That indeed PUD are worth more than the PV figure, but the development of these reserves should be delayed until either more reserves are projected for the same investment cost, or natural

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gas prices increase. She believes the 10% discount rate is not realistic in today's low interest rate environment, and that the arbitrary 50% volatility is much too high. The convenience yield is also a problem, with an easy calculation for specific natural gas future prices:

$$\delta_V = r - LN(\frac{F_t}{F_{t-1}}) \tag{5}$$

where F_t is the futures price for year t, and F_{t-1} is the futures price for the previous year. One problem is that the convenience yield is uncertain and complicated by seasonality as shown in Figure 4, and another is that the convenience yield refers to different time periods in the future.
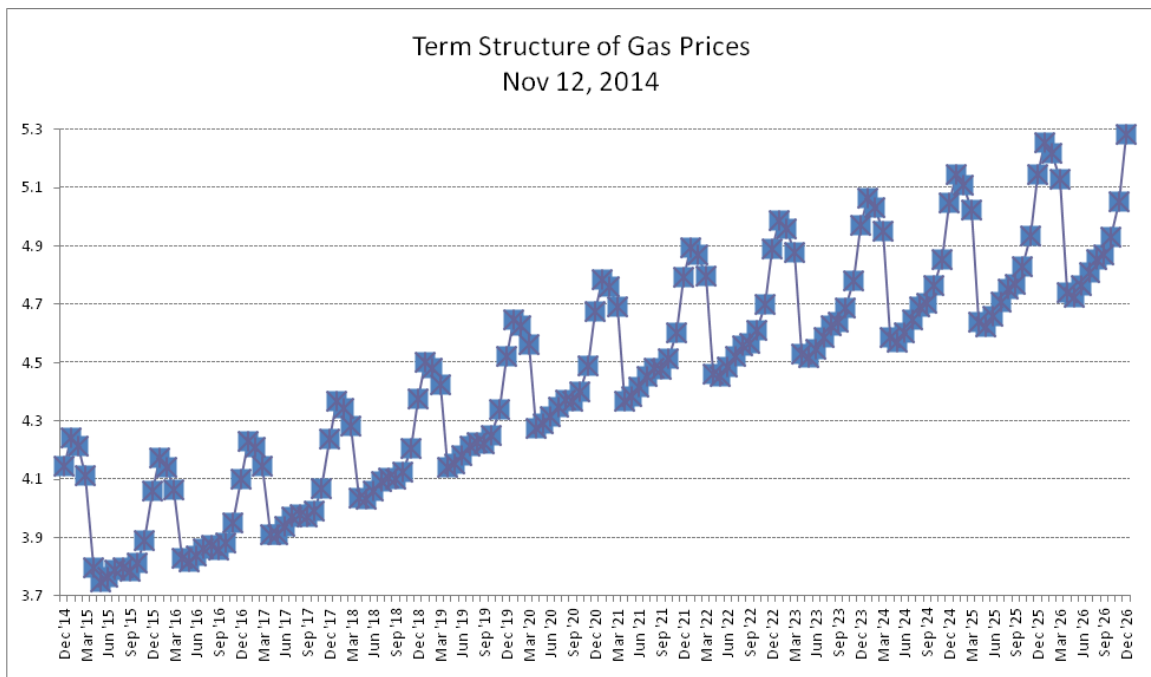
Figure 4

Term Structure of Gas Prices
Nov 12, 2014

Table 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1					**SWN PROVEN DEVELOPED RESERVES**									
2	TIME	Dec-16	1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.80												
4	GAS PRICE	$ 1.50												
5	LOC	0.83												
6	LOC Fixed	60.00												
7	DISCOUNT	10%												
8	YEAR		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
9	PRODUCTION (Bcf)		875	772	681	600	530	467	412	363	320	283	249	220
10	REVENUE	8,658.00 $	1,312.50 $	1,157.63 $	1,021.04 $	900.56 $	794.30 $	700.58 $	617.92 $	545.01 $	480.70 $	423.98 $	373.95 $	329.83
11	COSTS	5,510.76 $	786.25 $	700.56 $	624.98 $	558.31 $	499.51 $	447.65 $	401.91 $	361.57 $	325.99 $	294.60 $	266.92 $	242.51
12	FCF	3,147.24 $	526.25 $	457.08 $	396.06 $	342.25 $	294.79 $	252.93 $	216.00 $	183.44 $	154.71 $	129.38 $	107.03 $	87.32
13	COSTS	$B$6+$B$5*C9												
14	INVESTMENT	$485												
15	PV	$2,091 NPV(B7,C12:N12)												
16	NPV PV 10 PreTax	**$1,606**												
17	SEC	5,772												
18	TOTAL BCF	5,772	0											
19	SOLVER: C18=0, CHANGE B3													
20	HYPERBOLIC	SINH	Returns the hyperbolic sine of a number.											

Table 3

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
2	TIME		1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.75												
4	GAS PRICE	2.00 PD!$B$4+0.3												
5	LOC	0.70												
6	LOC Fixed	58.50												
7	DISCOUNT	5%												
8	YEAR		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
9	PRODUCTION (Bcf)		$89	$72	$59	$48	$40	$32	$27	$22	$18	$15	$12	$10
10	REVENUE	886	$177	$145	$119	$97	$79	$65	$53	$43	$35	$29	$24	$19
11	COSTS	1012	$121	$109	$100	$92	$86	$81	$77	$74	$71	$69	$67	$65
12	FCF	-126	$57	$36	$19	$5	-$7	-$16	-$24	-$30	-$35	-$40	-$43	-$46
13	PRODUCTION (Bcf)	0.2*B17												
14	INVESTMENT	-$36 B15/1.3												
15	PV	-$47												
16	NPV	**-$11**	-$11											
17	SEC	443												
18	TOTAL BCF	443	0											
19	SOLVER: C18=0, CHANGE B3													

SWN CASE QUESTIONS

1. What is the volatility of natural gas prices and interest rate that Claudia should use?

2. What should she provide Lopez as the best estimate of the ROV of PUD & UN updated from the recent SWN 10K Dec 2017, possibly 1Q 2Q 2018?

3. How sensitive are the real option values to changes in Claudia's assumptions?

4. What is SWN really worth, compared to the 13 April 2018 market price, using the updated account and reserve figures from SWN?