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 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 five 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**

[1] © Dean A. Paxson, 2018. Parts of this case are from SWN 2017 10K, but the characters are fictitious. This case is not intended as an illustration of either good or bad business practices, and mixes hypothetical and actual data and names.

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 (2016-2013)					
	2017	2016	2015	2014	2013
PD					
BEGIN	5,176	5,474	5,675	4,237	3,196
END	7,920	4,789	5,474	5,675	4,237
PUD					
BEGIN	77	443	4,134	2,737	821
END	6,855	77	443	4,134	2,737
AVERAGE PRICE ASSUME	2.98	2.48	2.59	4.35	3.67
FUTURE CASH FLOWS $000000					
INFLOWS	36,576	9,064	11,887	41,812	22,624
COSTS	-18,390	-5,880	-7,376	-16,477	-8,896
DEVELOP COSTS	-4,676	-485	-792	-5,750	-3,626
INCOME TAX	-1,312			-4,743	-3,223
NET CASH FLOWS	12,168	2,699	3,719	14,842	6,879
10% DISCOUNT	6,606	-1,034	-1,302	-7,299	-3,143
SEC NET CASH FLOWS	5,562	1,665	2,417	7,543	3,736
ANALYSIS OF SEC STANDARDIZED MEASURE $000000					
SEC BEGIN	1,665	2,417	7,543	3,736	2,051
PRODUCTION	-1,191	-574	-1,082	-2,084	-1,774
CHANGES IN PRICES	1,963	-415	-8,075	1,192	1,853
E,D & OA	1,715	45	162	1,049	1,454
ACQUIRE		0	28	1,897	5
SALE		-10	-244		
REVISIONS	1,721	-140	-1,385	622	349
DISCOUNT ACCRETION	166	242	946	513	232
CHANGE IN TAXES	-222	0	1,915	-522	-1,120
CHANGE DEVELOP COSTS	55	185	2,882	925	27
CHANGE TIMING	-310	-85	-273	215	659
SEC END	5,562	1,665	2,417	7,543	3,736
SEC END CROSS CHECK	5,562	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 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

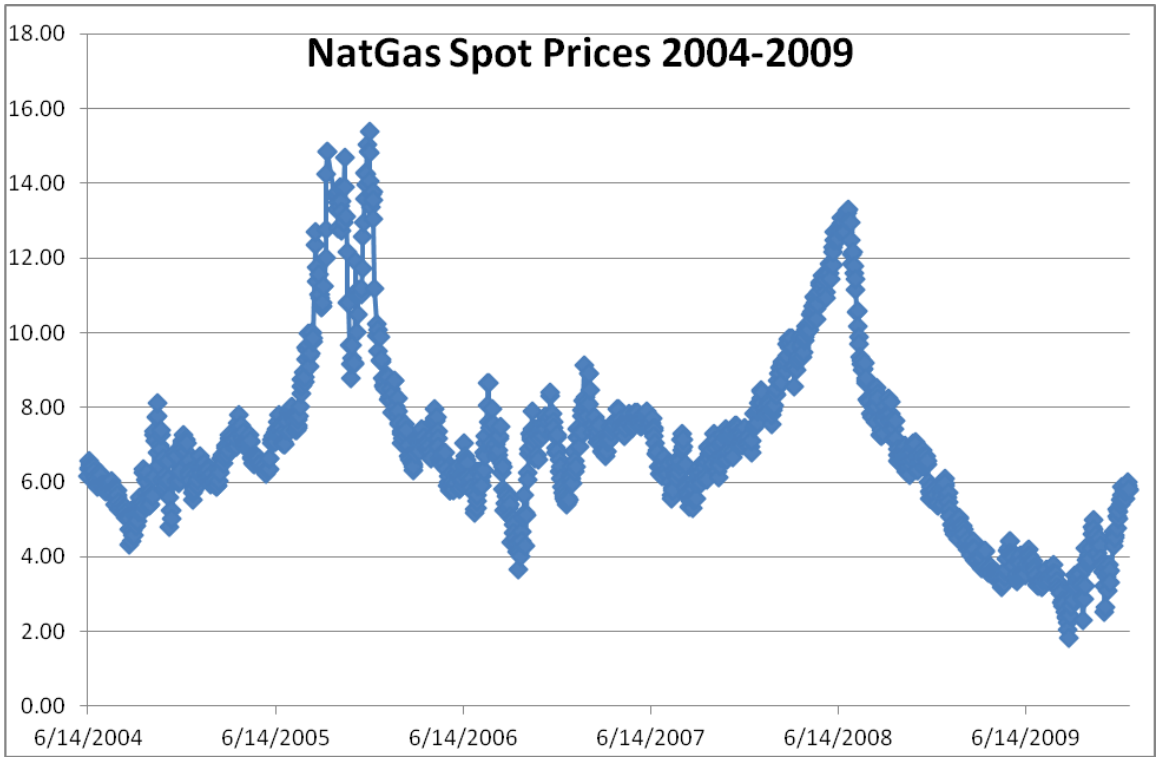
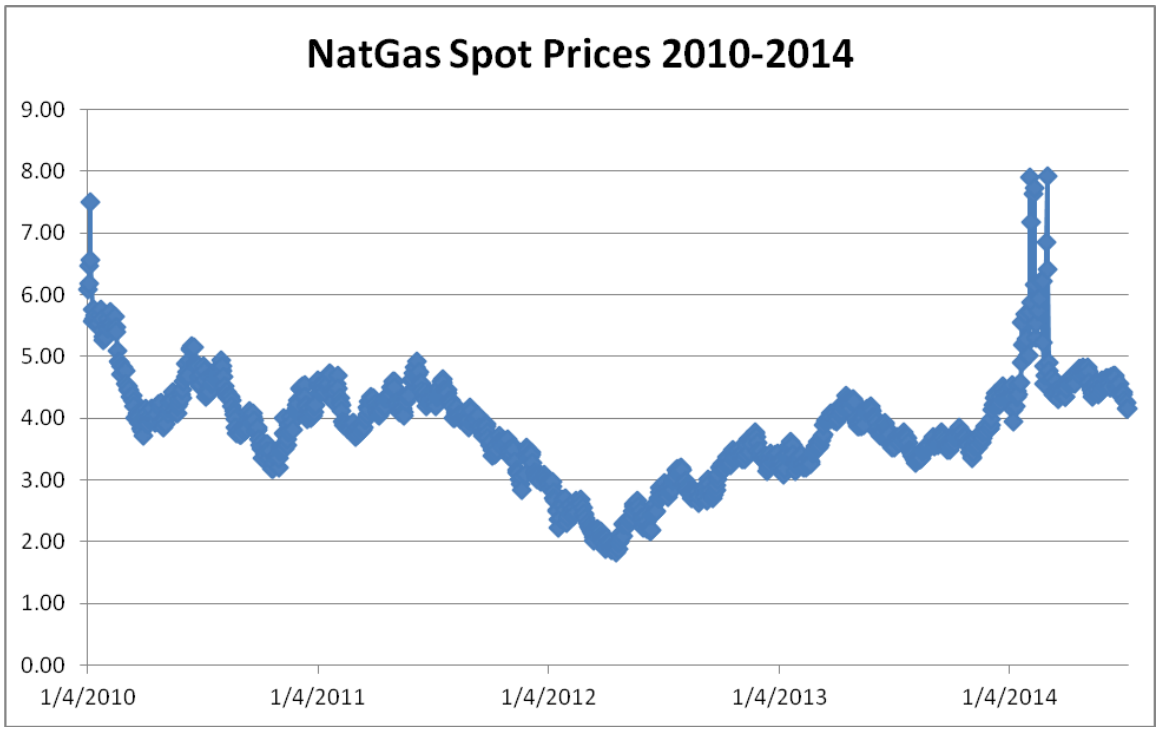


Figure 2



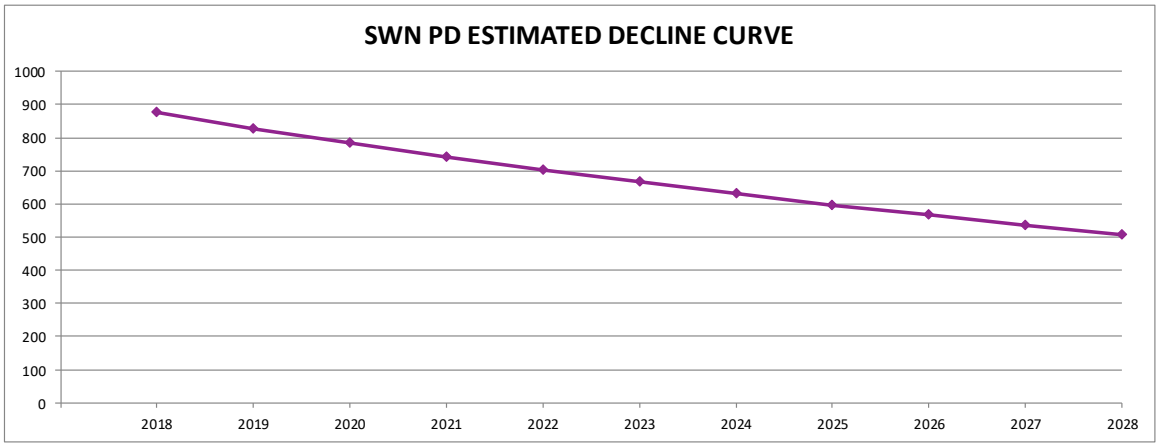
Claudia wonders whether long-term volatility is best approximated by daily spot volatility, due to seasonality. Given the low risk of developing reserves for SWN, Lopez thinks that Claudia will be occupied sufficiently working out the model analysis and appropriate parameter values, so she will produce 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 natural gas, and latterly natural gas liquids, reserves. 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 $5.6

billion is based. An external estimate shown in **Table 2** is only approximate, assumes production ends after year twelve, production costs are as specified, and production next year of 875 MMCF. If production declines at a hyperbolic rate of -.84 per annum, the gas price is constant at $2.62, the total BCF equals the SEC disclosure, and the 10% PV for PD is $4.9 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 (but now SWN has provided illustrative decline curves, so this assumption is outdated). When discounted at 10% the PUD production cash flow has a net present value of $915 million. 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 2017 SWN balance sheet, adding the book value of other assets and subtracting the real liabilities results in net assets per share of some $9.76 per share as shown in **Table 4**. Then what are your assumptions for the value of the gathering system assets, the unproven properties, and the PUD ROV (from **Table 5, adjusted for your sensible assumptions, not the template).** What is your net "appraised" value per share, adjusting T**able 4**?

Table 4

	A	B	C	D	E
9	SWN 12/2017	ASSETS	LIAB		PV10
10	CURRENT	1509	780		
11	UNPROVEN	1817	4391	LTD	
12	PD *	1750	371	OL	4910
13	PUD	326			915
14	GATHERING **	1,315			
15	OTHER ASSETS	804			
16	TOTAL BOOK BASIS	7,521	1,979	NA	
17					
18	SHARES	587	**$3.37**		3749
19	ALTERNATIVE VALUES		EXCESS PER SHARE		**$6.39**

The PV10 for PD and PUD is now separately disclosed in Exhibit 99.1 (end of 10K) by NSAI (greater than the SEC required disclosure page 111 due the PV of taxes, and slightly different from the SWN figures on page 7, which allocates the PV 10 among the three geographical areas). The Fama-French type book value ("net capitalised costs" on page 107) is around 2076, (assumed to be allocated to PD in the same proportion as PV10), or around 3749=$6.39 per share. Book value is much less than the PV10. At the April 2018 MP=$4.25, the market/book ratio is 126%, while based on PV10 is 89%. Which ratio should you use in asset pricing models?

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=δ, annualized lease holding costs=η and the volatility of the project=σ, is:

[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.

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

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

$$V^* = \frac{\beta_1}{\beta_1 - 1} K \tag{3}$$

$$A = \frac{V^* - K}{(V^*)^{\beta_1}} \tag{4}$$

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 10% and a volatility of 50%. As illustrated in **Table 5**, when V=5166, K=4251, the real option value ROV= 1452 and V*=7888, the value of the project justifying commencing the investment.

Table 5

	A	B	C	D	E
1	**PERPETUAL AMERICAN CALL**				
2	**Inputs:**				
3	Holding Cost		0.1		
4	V	$	5,165.95	PUD!$B$15	
5	K	$	4,250.91	PUD!$B$14	
6	σ		50%	Template	
7	*r*		10%	Template	
8	δ		10.0%	Template	
9	**Outputs:**				
10	ROV	**$**	**1,452.39**	IF(B4<B13,B14*(B4^B15),B11)	
11	V-K	$	915.05	B4-B5	
12	F'(V)		0.61	IF(B4<B13,B14*B15*(B4^(B15-1)),1)	
13	V*	$	7,887.72	(B15/(B15-1))*B5	
14	A		0.00	(B13-B5)/(B13^B15)	
15	β_1		2.17	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*)	$	3,636.81	IF(B4<B13,B14*(B13^B15),B11)	
21	V*-K	$	3,636.81	B13-B5	
22	ROV-NPV	$	537.34		

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

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:

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

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

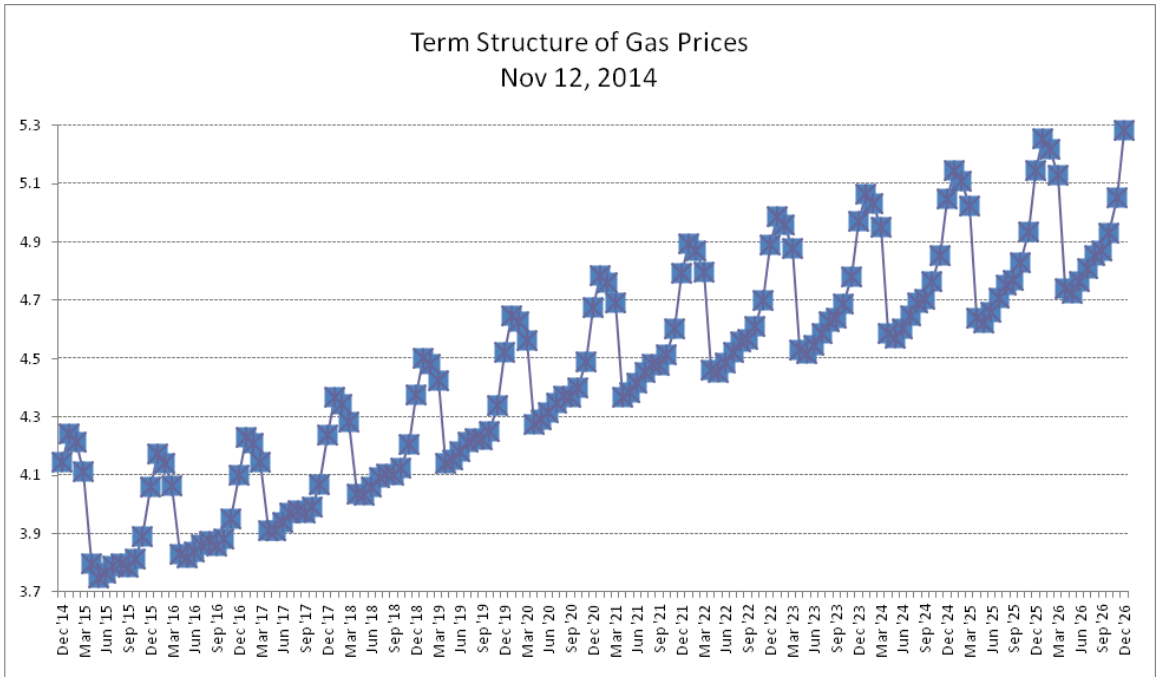


Table 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**SWN PROVEN DEVELOPED RESERVES**													
2	TIME	Dec-18	1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.84												
4	GAS PRICE	$ 2.62												
5	LOC	1.45												
6	LOC Fixed	100.00												
7	DISCOUNT	10%												
8	YEAR		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
9	PRODUCTION (Bcf)		875	829	785	743	704	666	631	598	566	536	507	481
10	REVENUE	20,766.24	$ 2,294.25	$ 2,172.62	$ 2,057.44	$ 1,948.36	$ 1,845.06	$ 1,747.25	$ 1,654.61	$ 1,566.89	$ 1,483.82	$ 1,405.16	$ 1,330.66	$ 1,260.12
11	COSTS	12,684.00	$ 1,368.75	$ 1,301.49	$ 1,237.79	$ 1,177.47	$ 1,120.34	$ 1,066.25	$ 1,015.02	$ 966.51	$ 920.57	$ 877.07	$ 835.87	$ 796.86
12	FCF	8,082.24	$ 925.50	$ 871.13	$ 819.65	$ 770.89	$ 724.72	$ 681.00	$ 639.59	$ 600.38	$ 563.25	$ 528.09	$ 494.79	$ 463.26
13	COSTS		$B$6+$B$5*C9											
14	INVESTMENT	$0												
15	PV	$4,910	NPV(B7,C12:N12)											
16	NPV PV 10 PreTax	**$4,910**	$4,910											
17	SEC	7,920												
18	TOTAL BCF	7,920	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
1	**SWN PROVEN UNDEVELOPED RESERVES - NEW**													
2	TIME		1	2	3	4	5	6	7	8	9	10	11	12
3	HYPERBOLIC	-0.75												
4	GAS PRICE	2.67	PD!$B$4+0.15											
5	LOC	1.43												
6	LOC Fixed	100.00												
7	DISCOUNT	10%												
8	YEAR		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
9	PRODUCTION (Bcf)		1,371	1,121	917	750	614	502	411	336	275	225	184	150
10	REVENUE	18317	$3,663	$2,996	$2,451	$2,005	$1,640	$1,341	$1,097	$897	$734	$600	$491	$402
11	COSTS	11027	$2,065	$1,708	$1,415	$1,176	$980	$820	$689	$581	$494	$422	$363	$315
12	FCF	7289	$1,598	$1,289	$1,036	$829	$660	$522	$408	$316	$240	$178	$128	$86
13	PRODUCTION (Bcf)		0.2*B17											
14	INVESTMENT	$4,251	-RESERVES!$B$15/1.1											
15	PV	$5,166	NPV(B7,C12:N12)											
16	NPV	**$915**	$915											
17	SEC	6,855												
18	TOTAL BCF	6,855	0											
19	SOLVER: C18=0, CHANGE B3													
20	Note to be updated on 10K and disclosed decline curves.													

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 2018?
3. How sensitive are the real option values to changes in Claudia's assumptions?
4. What is SWN really worth, compared to the 22 March 2019 market price, using the updated account and reserve figures from SWN?