Optionality: Puts and Calls

October 26, 2016

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Agenda

In the following slides, we will discuss the following:

- What is a Call Option?
- What is a Put Option?
- How are Puts and Calls Priced?
  - *The Put-Call Parity*
  - *The Black-Scholes Model*
- The Long Straddle
  - *Case: Amicus Therapeutics*
- Appendix

What is a Call Option?

Call options give the buyer the *option* to *purchase* an asset in the future at a specified price

Call Option: an option to buy an asset on or before a particular date known as the **expiration date** at an agreed upon **strike price**

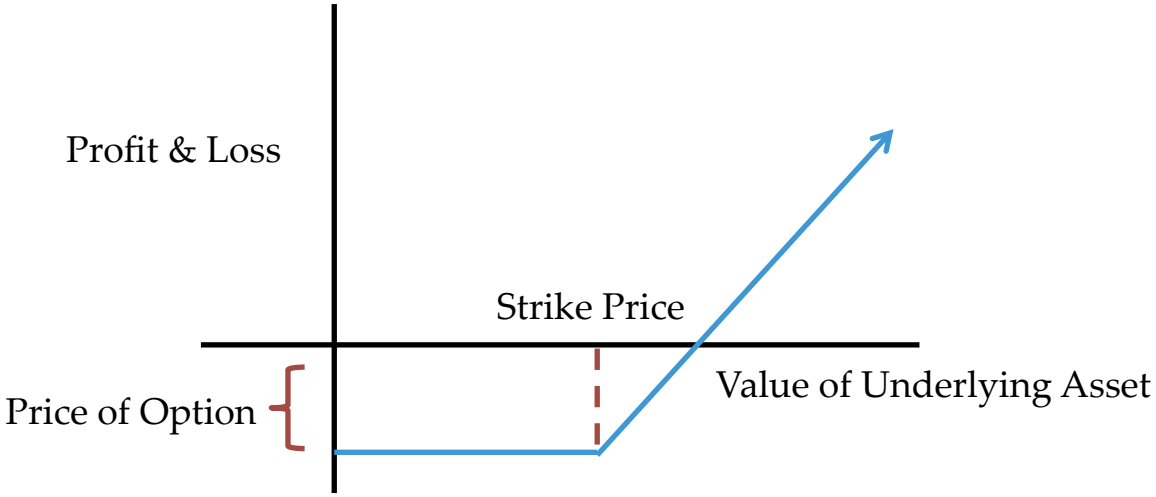
Strike Price: the strike price is the price at which the option holder can purchase the underlying asset

In, At and Out of the Money:

i. *In the Money*: S > X, where S is the spot price of the underlying asset and X is the option's strike price
ii. *At the Money*: S = X
iii. *Out of the Money*: S < X

What is a Call Option?

Call options give the buyer the *option* to *purchase* an asset in the future at a specified price



Call Option Payoff

$$P = \begin{cases} 0, S < X \\ S - X, \text{else} \end{cases}$$

What is a Call Option?

Call options give the buyer the *option* to *purchase* an asset in the future at a specified price

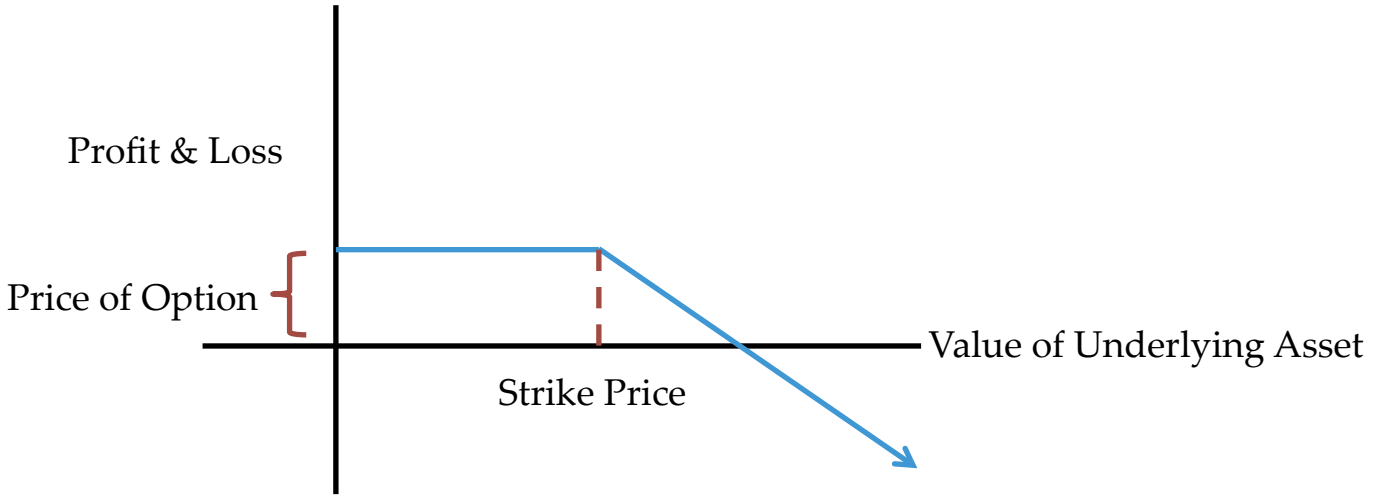
Is it possible to short a call option?

What is a Call Option?

Call options give the buyer the *option* to *purchase* an asset in the future at a specified price

Is it possible to short a call option?

YES. In this case it is not termed "shorting," but rather "writing" Essentially, to short a call option means to write a call option contract and sell it to someone who wants to long a call



Two Types of Call Options:

i. American Call

ii. European Call

What is a Put Option?

Put options give the buyer the *option* to *sell* an asset in the future at a specified price

Put Option: an option to sell an asset on or before a particular date known as the **expiration date** at an agreed upon **strike price**

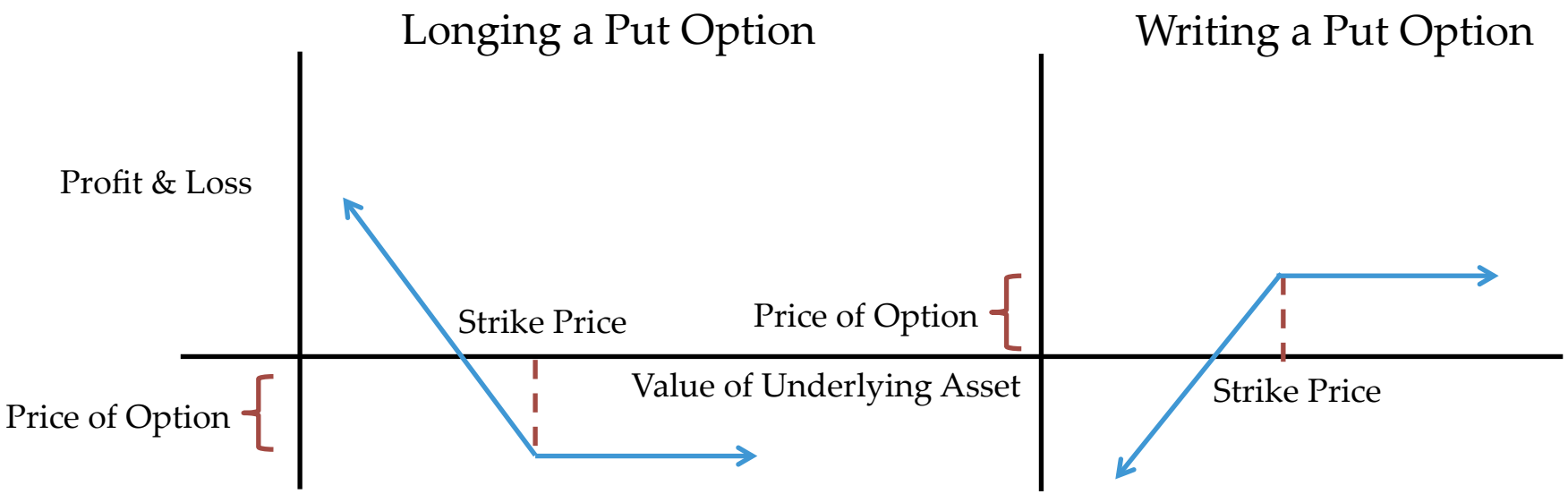
Strike Price: the strike price is the price at which the option holder can sell the underlying asset

In, At and Out of the Money:

i. *In the Money*: $S < X$
ii. *At the Money*: $S = X$
iii. *Out of the Money*: $S > X$

What is a Put Option?

Put options give the buyer the *option* to *sell* an asset in the future at a specified price



Put Option Payoff

$$P = \begin{cases} 0, & S > X \\ X - S, & \text{else} \end{cases}$$

How Can One Value an Option?

There are multiple methodologies used to estimate the value of an option

We will discuss two different approaches to pricing options:

i. ***The Put-Call Parity***
ii. ***The Black-Scholes Model***

In order to continue it is necessary to understand the following:

American Options: We have only discussed American Options thus far. They are options that can be exercised at *or before* the expiration date

European Options: A European Option only differs from an American option in that a European Option *CANNOT* be exercised before its expiration date

What are some thoughts as to how this would change an option's valuation? Which type of option is more valuable?

The Put-Call Parity

The Put-Call Parity is a simple equation that directly relates call and put prices

$$C + PV(X) = P + S$$

C = price of the *European* call option
PV(X) = the present value of the strike price (discounted at the risk-free rate)
P = price of the *European* put option
S = the spot price (the current value of the underlying asset)

In words, this equation states that longing a call and holding enough cash to buy at the strike price must be equally valuable than longing the underlying asset and purchasing a ***protective put***

Protective Put: a put purchased alongside the underlying asset as to hedge downside risk of the underlying asset

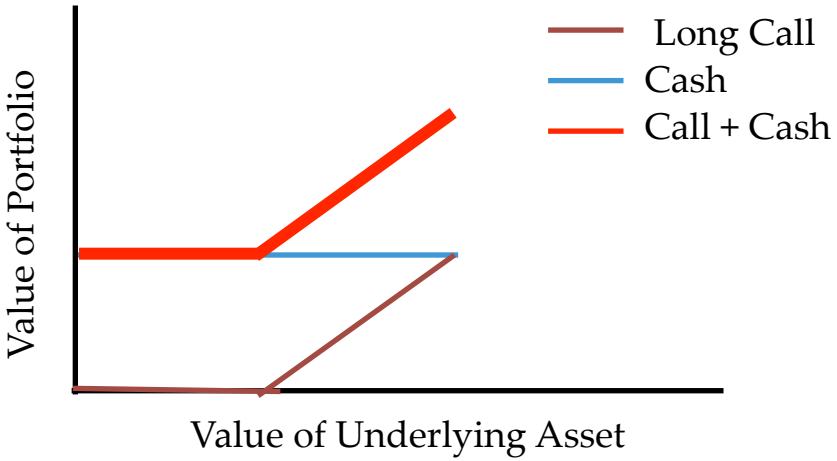
Assumption

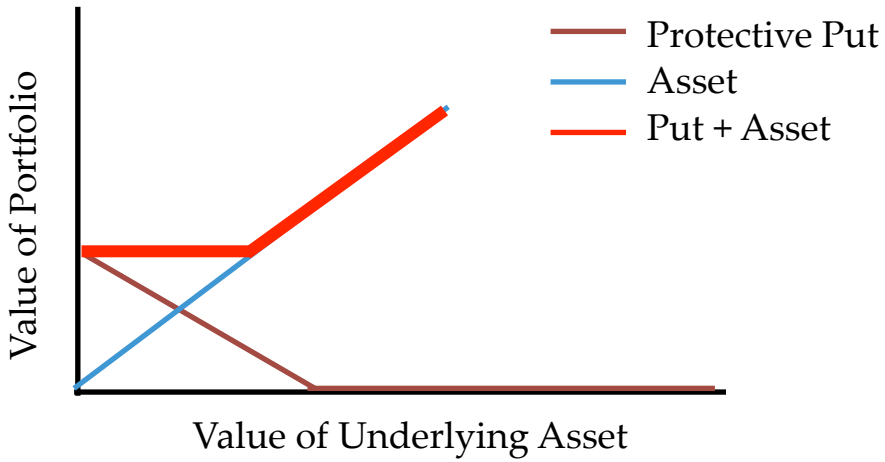
Their exist a call and the put have the same strike price and expiry on the same asset

The Put-Call Parity

The Put-Call Parity is a simple equation that directly relates call and put prices

$$C + PV(X) = P + S$$





As demonstrated, if this equation were to not hold, an investor could obtain a risk free profit (arbitrage) by longing one side of the function and shorting the other.

The Put-Call Parity

The Put-Call Parity is a simple equation that directly relates call and put prices

$$C + PV(X) = P + S$$

Risk-free rate = 4%
S = $10
X = $15

C + (15/1.04) = P + 10

4.42 = P - C

What if puts are trading at $12 and calls $7?

$7 + 14.42 < 12 + 10$

$21.42 < 22$

How could an investor take advantage of this?

The Black-Scholes Model

Using the underlying asset's historical variance, the BS Model attempts to value options

Historical Background

- The Black-Scholes Model is used to price the values of European Puts and Calls
- It was first introduced in the 1973 paper "The Pricing of Options and Corporate Liabilities" in the *Journal of Political Economy*
- The equation was formed by three economists: Fischer Black, Myron Scholes and Robert Merton
- Both Merton and Scholes were awarded the 1997 Nobel Prize in Economics for their derivative valuation function (Black, who had recently passed away, was recognized for his role in the formula's development)

Assumptions

- The underlying asset is a stock
- The options are European and can only be exercised at expiration
- No dividends are paid out throughout the life of the option
- Efficient Markets (i.e. no arbitrage or insider knowledge)
- The returns on the underlying asset are normally distributed
- The risk free rate is known and constant

The Black-Scholes Model

Using the underlying asset's historical variance, the BS Model attempts to value options

$$C = S.\ N(d_1) - X\ e^{-rT}\ N(d_2) \qquad P = X\ e^{-rT}\ N(-d_2) - S.N(-d_1)$$

C = call premium
S = stock's market value
X = the strike price
t = time to expiration
r = risk-free rate
N = cumulative standard normal distribution
s = standard deviation of the stock (estimate)

$$d_1 = \frac{\ln\left(S/K\right) + \left(r + s^2/2\right)t}{s \cdot \sqrt{t}}$$

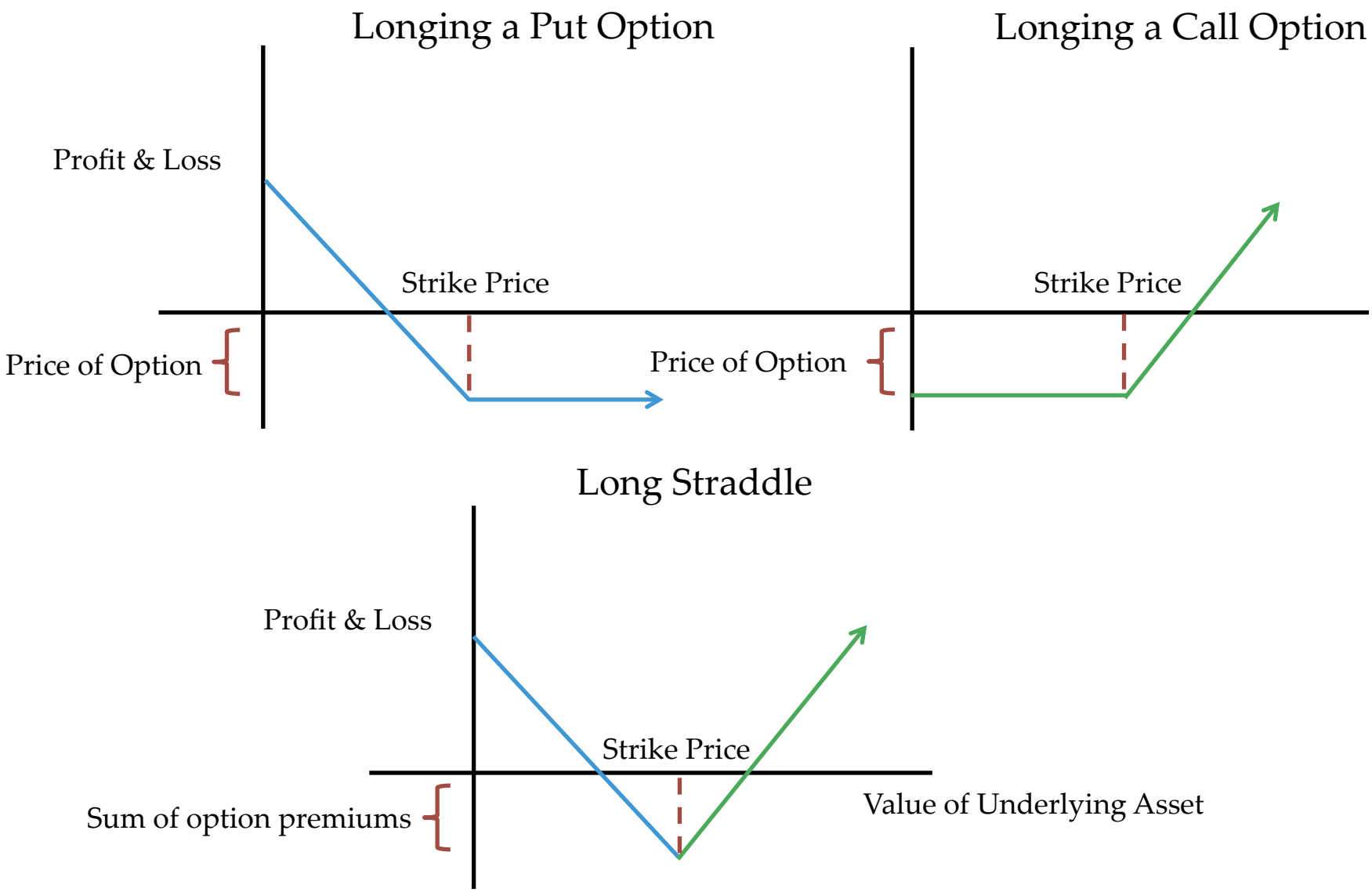
$$d_2 = d_1 - s \cdot \sqrt{t}$$

In their original paper, neither Black, Scholes nor Merton interpret the meaning of $N(d_1)$ or $N(d_2)$
In their 1985 paper, Cox and Rubenstein address the meaning of the variables using the proofs from the 1983 piece by Jarrow and Rudd

$N(d_1)$: represents the probability that the option expires *in the money*. Therefore, $SN(d_1)$ can be interpreted as the present value of the stock if and only if the option expires in the money
$N(d_2)$: represents the present value of paying the exercise price in the even that $N(d_1)$ holds

Application: The Long Straddle

When an investor expects a large value change, a long straddle is a viable strategy



Case Study: Amicus Therapeutics (FOLD)

Biotechnology companies are frequently good targets for a long straddle

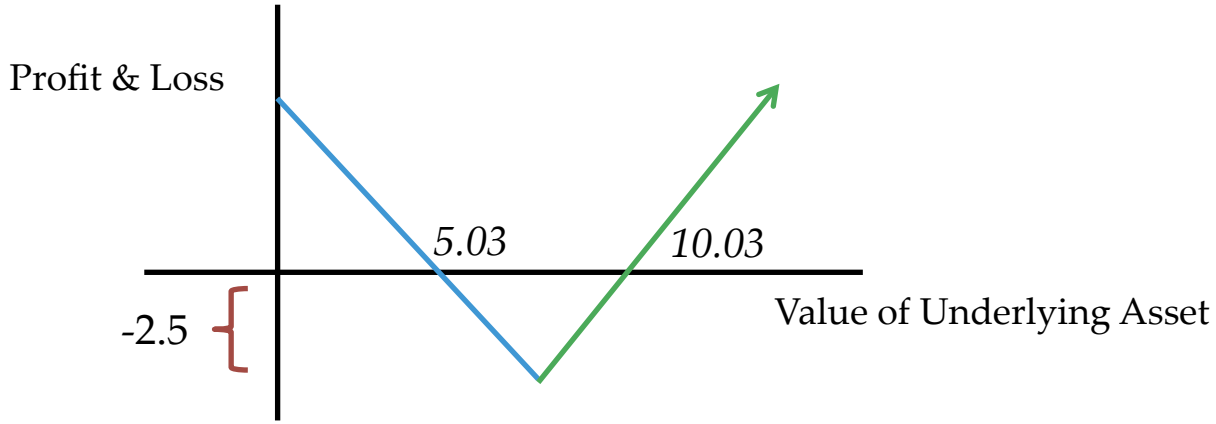
Amicus Therapeutics®

Amicus Therapeutics is a pre approval stage biotechnology company
A large increase/decrease is expected pending regulatory results

S = $7.53
C = $1.55
P = $0.95
X = $7.00

Case 1: Approval
S = $10.86
π = $0.83
33.2% return

Case 1: Rejection
S = $3.80
π = $1.23
49.2% return



Conclusion

Beyond just limiting risk, options can be manipulated in many ways

Options can be utilized to accomplish goals beyond that of just insurance:

Protective Put

Covered Call

Options can be used independent of their underlying assets to allow an investor to expose themself to a unique situation

The Long Straddle

Pricing Options, however, has always been a difficult topic and it wasn't until the Black-Scholes model that a somewhat comprehensive method existed

ANY QUESTIONS?

Appendix

Galafold base case

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Notes
	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Off-Patent
Sales:															
Patients	29,750	31,624	33,300	34,732	35,878	36,704	37,181	37,441	37,703	37,967	38,233	38,500	38,770	39,041	
Patient Growth Rate	6.3%	5.3%	4.3%	3.3%	2.3%	1.3%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	
Diagnosis Rate	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	
"Amenable" - Eligibility	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	35.0%	
Treatment Rate	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	
Potential Market	3,722	3,957	4,167	4,346	4,489	4,593	4,652	4,685	4,718	4,751	4,784	4,817	4,851	4,885	
Penetration Rate	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	65.0%	
Actual Market	**2,420**	**2,572**	**2,708**	**2,825**	**2,918**	**2,985**	**3,024**	**3,045**	**3,066**	**3,088**	**3,110**	**3,131**	**3,153**	**3,175**	
Market Share															
Cost Per Day	0	0	548	548	548	548	548	548	548	548	548	548	548	548	
Days of Use	0	0	365	365	365	365	365	365	365	365	365	365	365	365	
Revenue Per Patient	0	0	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	
Compliance Rate	0.0%	0.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	
Total Revenue	**$0**	**$0**	**$422,503,831**	**$440,671,496**	**$455,213,655**	**$465,683,569**	**$471,737,456**	**$475,039,618**	**$478,364,895**	**$481,713,449**	**$485,085,444**	**$488,481,042**	**$491,900,409**	**$495,343,712**	

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Notes
	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Off-Patent
Costs:															
COGS	0	0	154,753,916	118,981,304	122,907,687	125,734,564	127,369,113	128,260,697	129,158,522	130,062,631	130,973,070	131,889,881	132,813,110	133,742,802	
SG&A	7,459,333	7,854,678	8,192,429	8,462,779	8,657,423	8,769,970	8,831,360	8,893,179	8,955,431	9,018,119	9,081,246	9,144,815	9,208,829	9,273,290	
Marketing Expense	63,375,575	63,375,575	63,375,575	66,100,724	68,282,048	69,852,535	70,760,618	71,255,943	71,754,734	72,257,017	72,762,817	73,272,156	73,785,061	74,301,557	
Research Expense	7,540,950	7,540,950	75,410	75,410	75,410	75,410	75,410	75,410	75,410	75,410	75,410	75,410	75,410	75,410	
NDA/FDA Fees							0	0	0	0	0	0	0		
In-Licensing Royalty															
Total Costs	**$78,375,858**	**$78,771,203**	**$226,397,329**	**$193,620,217**	**$199,922,568**	**$204,432,478**	**$207,036,500**	**$208,485,228**	**$209,944,097**	**$211,413,178**	**$212,892,542**	**$214,382,262**	**$215,882,410**	**$217,393,059**	
Pre-Tax Cash Flow	-78,375,858	-78,771,203	196,106,502	247,051,279	255,291,087	261,251,091	264,700,955	266,554,390	268,420,798	270,300,272	272,192,902	274,098,780	276,017,999	277,950,653	
Taxes (20%)			-39,221,300	-49,410,256	-51,058,217	-52,250,218	-52,940,191	-53,310,878	-53,684,160	-54,060,054	-54,438,580	-54,819,756	-55,203,600	-55,590,131	
Orphan Tax Credit			1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	
Net Cash Flow	-78,375,858	-78,771,203	157,998,201	198,754,023	205,345,870	210,113,873	212,873,764	214,356,512	215,849,639	217,353,217	218,867,321	220,392,024	221,927,399	223,473,522	

NPV	**830,002,439**
rNPV	**747,002,195**

$7.06

FOLD MODEL

Appendix

Migalastat with ERT base case

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	Phase 2	Phase 3	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue
Sales:															
Patients	29,750	31,624	33,300	34,732	35,878	36,704	37,181	37,441	37,703	37,967	38,233	38,500	38,770	39,041	39,315
Patient Growth Rate	6.3%	5.3%	4.3%	3.3%	2.3%	1.3%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Diagnosis Rate	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
"Amenable" - Eligibility	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Treatment Rate	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%	55.0%
Potential Market	8,181	8,697	9,158	9,551	9,867	10,093	10,225	10,296	10,368	10,441	10,514	10,588	10,662	10,736	10,812
Penetration Rate	25.0%	25.0%	25.0%	25.0%	26.0%	27.0%	28.0%	29.0%	29.0%	29.0%	29.0%	29.0%	29.0%	29.0%	29.0%
Actual Market	**2,045**	**2,174**	**2,289**	**2,388**	**2,565**	**2,725**	**2,863**	**2,986**	**3,007**	**3,028**	**3,049**	**3,070**	**3,092**	**3,114**	**3,135**
Market Share															
Cost Per Day	0	0	0	0	548	548	548	548	548	548	548	548	548	548	548
Days of Use	0	0	0	0	365	365	365	365	365	365	365	365	365	365	365
Revenue Per Patient	0	0	0	0	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000	200,000
Compliance Rate	0.0%	0.0%	0.0%	0.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%	78.0%
Total Revenue	**$0**	**$0**	**$0**	**$0**	**$400,187,829**	**$425,138,001**	**$446,615,343**	**$465,803,852**	**$469,064,479**	**$472,347,930**	**$475,654,366**	**$478,983,946**	**$482,336,834**	**$485,713,192**	**$489,113,184**

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	Phase 2	Phase 3	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue
Costs:															
COGS	0	0	0	0	108,050,714	114,787,260	120,586,142	125,767,040	126,647,409	127,533,941	128,426,679	129,325,665	130,230,945	131,142,562	132,060,560
SG&A	7,459,333	7,459,333	7,459,333	7,459,333	7,630,898	7,730,100	7,784,210	7,838,700	7,893,571	7,948,826	8,004,468	8,060,499	8,116,922	8,173,741	8,230,957
Marketing Expense	0	0	0	0	60,028,174	63,770,700	66,992,301	69,870,578	70,359,672	70,852,190	71,348,155	71,847,592	72,350,525	72,856,979	73,366,978
Research Expense	7,540,950	7,540,950	7,540,950	7,540,950	754,095	754,095	754,095	754,095	754,095	754,095	754,095	754,095	754,095	754,095	754,095
NDA/FDA Fees															
In-Licensing Royalty															
Total Costs	**$15,000,283**	**$15,000,283**	**$15,000,283**	**$15,000,283**	**$176,463,881**	**$187,042,155**	**$196,116,749**	**$204,230,413**	**$205,654,747**	**$207,089,051**	**$208,533,396**	**$209,987,851**	**$211,452,487**	**$212,927,376**	**$214,412,589**
Pre-Tax Cash Flow	-15,000,283	-15,000,283	-15,000,283	-15,000,283	223,723,948	238,095,846	250,498,593	261,573,439	263,409,732	265,258,879	267,120,970	268,996,095	270,884,346	272,785,815	274,700,595
Taxes (20%)					-44,744,790	-47,619,169	-50,099,719	-52,314,688	-52,681,946	-53,051,776	-53,424,194	-53,799,219	-54,176,869	-54,557,163	-54,940,119
Orphan Tax Credit			1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000
Net Cash Flow	-15,000,283	-15,000,283	-13,887,283	-13,887,283	180,092,158	191,589,677	201,511,875	210,371,751	211,840,786	213,320,103	214,809,776	216,309,876	217,820,477	219,341,652	220,873,476

NPV	**728,814,770**
rNPV	**218,644,431**

$2.07

FOLD MODEL

Appendix

Zorblisa base case

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	Phase 3	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Off-Patent
Sales:															
Patients	35,000	35,245	35,492	35,740	35,990	36,242	36,496	36,751	37,009	37,268	37,529	37,791	38,056	38,322	38,591
Patient Growth Rate	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%	0.7%
Diagnosis Rate	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Treatment Rate	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%	80%
Potential Market	26,600	26,786	26,974	27,163	27,353	27,544	27,737	27,931	28,127	28,323	28,522	28,721	28,922	29,125	29,329
Penetration Rate	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
Actual Market	**25,270**	**25,447**	**25,625**	**25,804**	**25,985**	**26,167**	**26,350**	**26,535**	**26,720**	**26,907**	**27,096**	**27,285**	**27,476**	**27,669**	**27,862**
Market Share															
Cost Per Day	0	0	0	27	329	329	329	329	329	329	329	329	329	329	329
Days of Use	0	0	0	365	365	365	365	365	365	365	365	365	365	365	365
Revenue Per Patient	0	0	0	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Compliance Rate	0.00%	0.00%	0.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%	78.00%
Total Revenue	**$0**	**$0**	**$0**	**$201,274,268**	**$202,683,188**	**$204,101,970**	**$205,530,684**	**$206,969,399**	**$208,418,185**	**$209,877,112**	**$211,346,252**	**$212,825,676**	**$214,315,455**	**$215,815,664**	**$217,326,373**

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
	Phase 3	Approval	Approval	Ramp	Ramp	Ramp	Ramp	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Off-Patent
Costs:															
COGS	0	0	0	54,344,052	54,724,461	55,107,532	55,493,285	55,881,738	56,272,910	56,666,820	57,063,488	57,462,932	57,865,173	58,270,229	58,678,121
SG&A	7,459,333	7,459,333	7,459,333	7,511,549	7,564,130	7,617,078	7,670,398	7,724,091	7,778,159	7,832,606	7,887,435	7,942,647	7,998,245	8,054,233	8,110,613
Marketing Expense	0	0	0	30,191,140	30,402,478	30,615,296	30,829,603	31,045,410	31,262,728	31,481,567	31,701,938	31,923,851	32,147,318	32,372,350	32,598,956
NDA/FDA Fees															
In-Licensing Royalty															
Total Costs	**$7,459,333**	**$7,459,333**	**$7,459,333**	**$92,046,741**	**$92,691,068**	**$93,339,906**	**$93,993,285**	**$94,651,238**	**$95,313,797**	**$95,980,994**	**$96,652,861**	**$97,329,431**	**$98,010,737**	**$98,696,812**	**$99,387,689**
Pre-Tax Cash Flow	-7,459,333	-7,459,333	-7,459,333	109,227,527	109,992,120	110,762,064	111,537,399	112,318,161	113,104,388	113,896,118	114,693,391	115,496,245	116,304,719	117,118,852	117,938,684
Taxes (20%)				-21,845,505	-21,998,424	-22,152,413	-22,307,480	-22,463,632	-22,620,878	-22,779,224	-22,938,678	-23,099,249	-23,260,944	-23,423,770	-23,587,737
Orphan Tax Credit				1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000	1,113,000
Net Cash Flow	-7,459,333	-7,459,333	-7,459,333	88,495,022	89,106,696	89,722,652	90,342,919	90,967,529	91,596,510	92,229,895	92,867,713	93,509,996	94,156,775	94,808,081	95,463,947

NPV	**$366,351,781**
rNPV	**$183,175,890**

$1.73

FOLD MODEL