New Approaches to Pre- and Post-Revenue Asset Valuation in Drug Development

Yorick Chen, Yiran Liu, Michael J. Kane

The Drug Development Valuation Process

$$NPV = \sum_{t=0}^{N} \frac{B_t \, \tau}{(1+i_t)^t} - \sum_{t=0}^{N} \frac{C_t \, \tau}{(1+i_t)^t}$$

- t is the time of the cash flow.
- N is the total number of periods.
- B_t is benefit or cash inflow at period t.
- C_t is the cost or cash outflow at period t.
- i_t is the discount rate.
- τ is the *stopping time* at which development (review or before) fails.

Drug Development NPV is a Stochastic Process

$$NPV = \sum_{t=0}^{N} \frac{B_t\,\tau}{(1+i_t)^t} - \sum_{t=0}^{N} \frac{C_t\,\tau}{(1+i_t)^t}$$

- τ is a random binary process ($\{0,1\}$) and has value 0 at the end of the time when the drug fails in development (1 otherwise). If it does not fail, then it retains a value of 1 during monetization (post-revenue).
- During drug development $C_t >> B_t$.
- If the drug is monetized then $B_t >> C_t$.
- i_t changes depending on the the time-period.
- B_t, C_t, and τ are stochastic processes adapted to the natural filtration.

Challenges to Estimation

Relatively easy to estimate

- i discount rates are relatively standard for phase.
- C_t is relatively standard for each phase of drug development and is easily incorporated post revenue.

Difficult to estimate:

- τ - this depends on the probability of success during development.
  - Value changes during each phase of drug development.
  - Varies across indications.
  - Varies by drug program.
- B_t - how much revenue will the drug generate in the market?

The “Epidemiology” Approaches to Estimating Post-Revenue Inflow

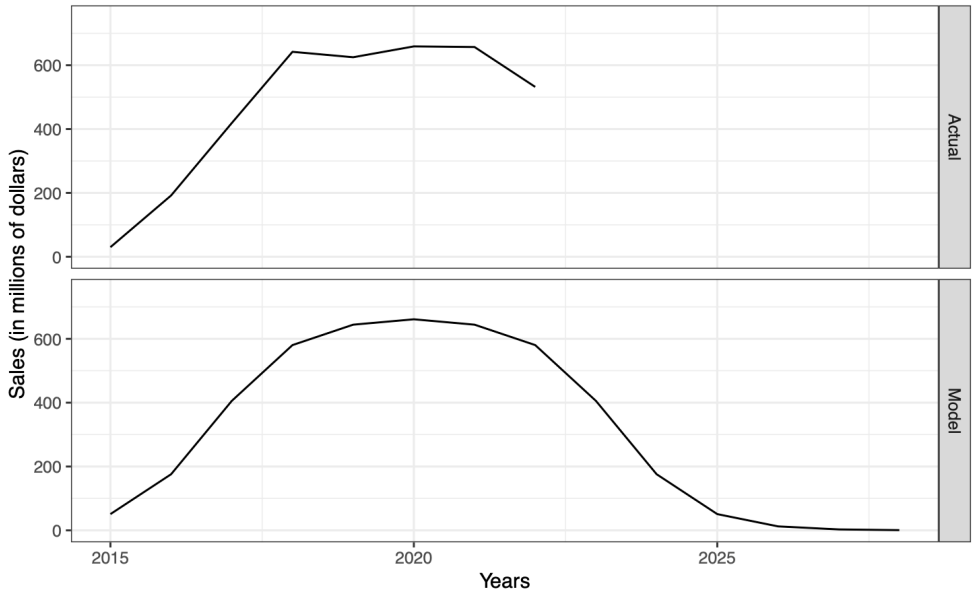
Preface: Literature is sparse. Construction is based on conversations (lore).

$$B_{total} = \sum_{t=0}^{N} \frac{B_t \, \tau}{(1+i)^t} \simeq S_d * p_a * R_p * r_p$$

- S_d the size of the disease population
- p_a the proportion of the disease population that will be given the therapy.
- R_p revenue per patient.
- r_p other post-revenue risks.

We are modeling B_{total} with four new random variables, some of which have high variance. It’s not clear how to build in time.

A Typical Sales Curve



Sales of Pfizer's Inflectra (Pfizer Crohn's Disease Therapy).

An Alternative Approach to Post-Revenue Inflow

Use the most similar post-revenue indication (by disease population).

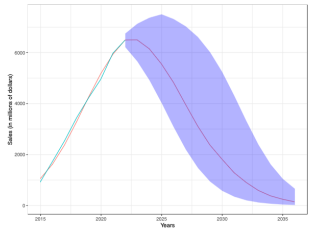
$$B_t = \frac{s \times 1_{\{t \le t_s\}}}{1 + e^{\beta_0 + t\beta_1}} + \frac{s \times 1_{\{t > t_s\}}}{1 + e^{\beta_0 + 2t_s - t\beta_1}}$$

- S is the saturated value of sales (max sales).
- t_S is the time of saturation. It's is at most the time when the drug loses IP protection but may occur before this.

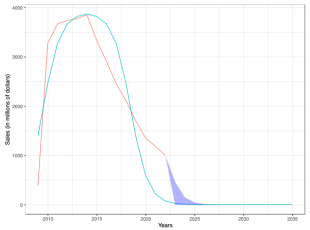
This is a piece-wise, scaled logistic regression.

- We will estimate β_0 and β_1.
- If we haven't reached saturation, we will estimate s and t_s.
- We will assume drop off in sales is symmetric with "ramp-up".

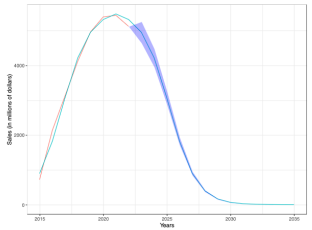
Estimates of Six Pfizer Drugs



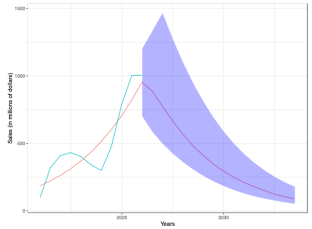
(a) Eliquis



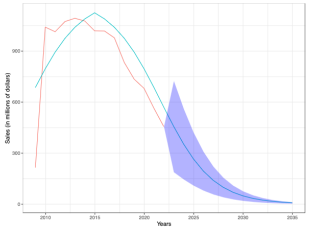
(b) Enbrel



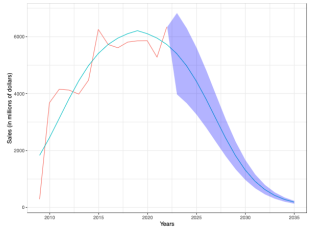
(c) Ibrance



(d) Inlyta



(e) Premarin family



(f) Prevnar family

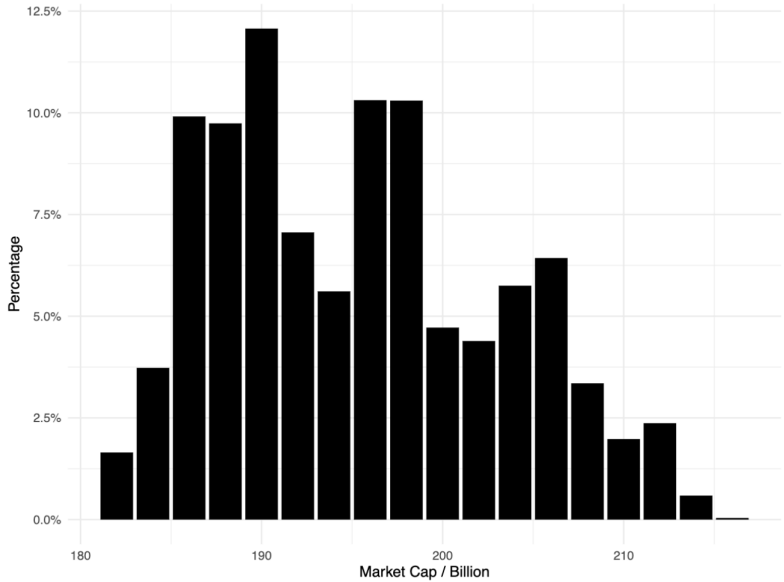
Actual and Estimated Sales of six Pfizer drugs.

The Backtested Portfolio Accuracy

Assets	Differences(%)			
% Saturation	25%	50%	75%	100%
Prevnar family	-13.4 (19.9%)	-11.4 (17.0%)	2.12 (3.15%)	0.371 (0.550%)
Ibrance	-6.89 (22.2%)	-2.93 (9.45%)	-0.114 (0.360%)	0.225 (0.720%)
Xeljanz	-12.1 (86.6%)	-8.96 (64.3%)	-1.29 (9.23%)	0.376 (2.70%)
Chantix/Champix	-3.76 (31.4%)	0.837 (6.97%)	-11.9 (99.4%)	0.946 (7.88%)
Enbrel	28.4 (81.8%)	9.26 (26.7%)	9.65 (27.8%)	11.1 (31.8%)
Sutent	-6.74 (43.2%)	-7.33 (47.0%)	-10.2(65.6%)	2.92 (18.7%)
Premarin family	9.05 (76.8%)	1.97 (16.7%)	2.09 (17.7%)	2.23 (18.9%)
Inflectra/Remsima	-1.58 (42.1%)	-0.711 (19.0%)	0.367 (9.78%)	0.0510 (1.35%)
Xalkori	-2.86 (56.5%)	-0.299 (5.90%)	0.184 (3.64%)	0.146 (2.88%)
Portfolio	-9.82 (-5.03%)	-19.6 (-10.0%)	-9.15 (-4.69%)	18.3 (9.38%)

Pfizer’s backtested portfolio accuracy.

The Forward-Asset Value of Pfizers Post-Revenue Portfolio



The forward-asset value of Pfizer’s Post-Revenue Portfolio. Pfizer’s market cap is $148.4 billion and liabilities are $137.2 billion as of 2024-04-11

Pre-revenue Application: MAGENTA

- Autologous T-Cells Expressing a Second Generation CAR for Treatment of T-Cell Malignancies Expressing CD5 Antigen (MAGENTA) (NCT03081910)
- Rare indication (most cases are B-Cell Lymphoma)
- Trial is currently in Phase 1
- Company is likely targeting an exit after successful Phase 2.

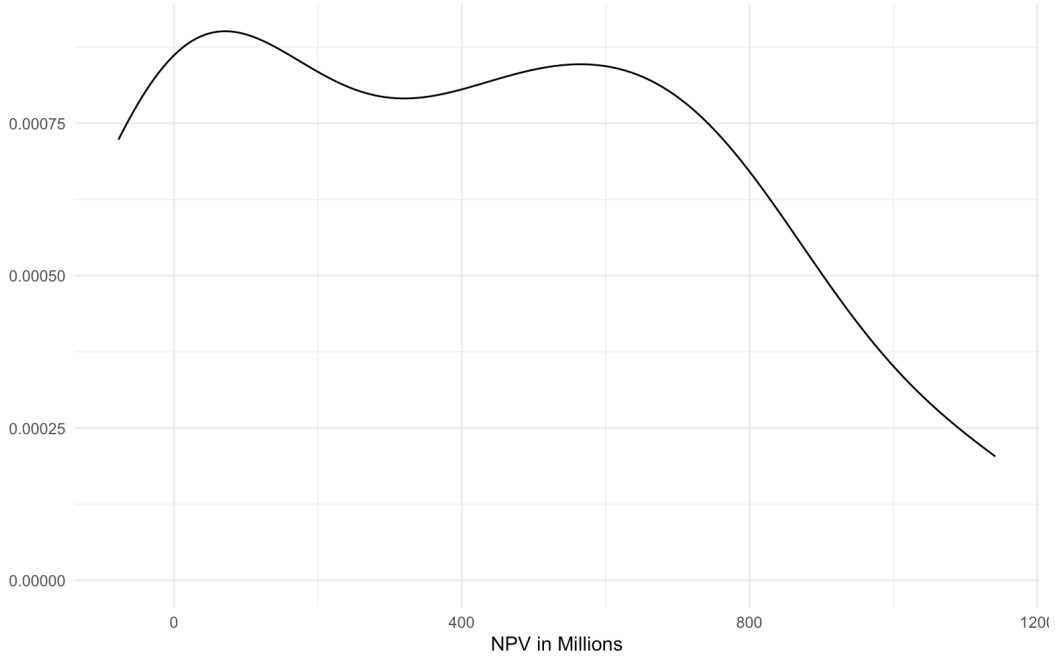
Valuation Parameters

- We estimated the POS of the program to be 28% (distribution mean)
  - Phase 1: 65%
  - Phase 2: 43%
  - Phase 3: 42%
  - Review: 90%
- Current therapy is B-cell treatment
  - Total sales for Yescarta (Gilead) estimated $56.5 billion
  - Total sales for Breyanzi (BMS) $16.30 Billion
- T-cell prevelance is 15% of all Lymphoma
- Assume a discount rate of 15%

Valuation

Valuation after a successful Phase 2 (see below): $385 Million (38, 690).

Total sales conditioned on program success: $9.9 Billion (discount of 10%)



The NPV Distribution for MAGENTA

Summary

Post-revenue sales provides a basis for estimating pre-revenue income.

Pros:

- Fits into the NPV framework.
- Based “real-world” sales for a given disease population.
- Intuitively, estimates probably have lower variance (less risk) compared to epidemiology approaches.

Cons:

- Requires sales for an existing indication or a reasonable analogue.
- Assumes the sales curve for pre-revenue indication will be similar to post-revenue.

THANKS