Case study: On the financial viability of empirical and stratified medicine using Net Present Value Analysis

Aurélie C. Thiele

Abstract: Pharmaceutical companies, when evaluating drugs' financial viability using the classical Net Present Value (NPV) framework, face strong incentives to commercialize empirical drugs for large markets due to the need to recoup development costs. This can have severe consequences for other patients, for whom potentially life-saving drugs (either empirical drugs for small patient populations, or stratified drugs targeting patients with specific biomarkers) may not be brought to market if they are not deemed commercially viable. In this article, we investigate the concept of a drug's Minimum Viable Market Share (MVMS), which represents the market share a new drug must capture to break even in the NPV sense. Specifically, we study the impact of accelerated approval/fast track and time from commercialization to peak sales on MVMS in order to increase a drug's prospects. We show how those changes can improve the financial outlook of some of the drugs previously characterized as financially unviable, thus helping patients afflicted with less common diseases receive needed care.

The financial outlook of a drug plays a critical role when pharmaceutical companies decide whether to pursue or abandon development. To guide their analysis, they typically use a financial framework known as Net Present Value, which determines whether the expected value of cash inflows or net income, in

present value, exceeds the expected value of cash outflows or development costs, also in present value. (The present value of a sequence of cash flows discounts future cash flows to capture their value today, using the fact that a dollar available today has greater value than a dollar available in the future.) While expensive drug prices have received significant attention in the media[1,2], it is important to analyze prices within the context of NPV to assess the financial situation faced by pharmaceutical decision-makers when they attempt to bring new drugs to market.

Because drug development involves large fixed costs, such as clinical trial costs, that must be recovered when the drug is commercialized, the business case for empirical drugs targeting large patient populations is generally viewed as much stronger than that of drugs with a smaller patient base, whether empirical drugs for smaller patient populations or stratified drugs, i.e., drugs that target a subset of the patient population presenting a specific biomarker.[3] Stratified medicine, also sometimes called personalized medicine, has been the focus of substantial interest in the pharmaceutical research community due to improved diagnostic technologies and a better understanding of disease heterogeneity[4]; however, economic uncertainty remains substantial. In particular, stratified drugs for small markets face very challenging conditions in the traditional NPV framework, where they are not deemed financially viable.[5] Stratified medicine continues to face reimbursement challenges and a need to align all stakeholder interests both in the European Union and the United States.[6] Another challenge faced by stratified medicine lies in the low Intellectual Property protection granted to diagnostic tests, which are necessary to identify patients that would most benefit from the stratified drug.[7] This means that drugs that could bring

relief to patients afflicted with less common illnesses may not be brought to market if pharmaceutical companies believe they would not recover their costs.

The purpose of this article is to investigate a new drug's Minimum Viable Market Share, i.e., the market share needed to break even in an NPV sense, depending on its business characteristics (stratified or empirical, large or small patient population, low/medium/high price) in order to improve a drug's financial outlook without increasing its price. In particular, we argue that two factors can play a critical role in counterbalancing the negative effect of smaller patient populations: (i) accelerated commercialization, either through *accelerated approval* (where trials still have to be completed after FDA approval) or *fast track* (where clinical trials and review are compressed in time), and (ii) reduced time to peak sales, for instance because the improved effectiveness of stratified medicine fosters adoption by the subpopulation with the appropriate biomarker. Most importantly, our analysis shows that drugs previously characterized in the NPV framework as financially unviable can become financially attractive under quite reasonable conditions that do not involve price increases.

Regulatory and business landscape

Our primary model is the classical discounted cash-flow analysis used in the healthcare finance literature.[8] FIGURE 1 provides its building blocks.

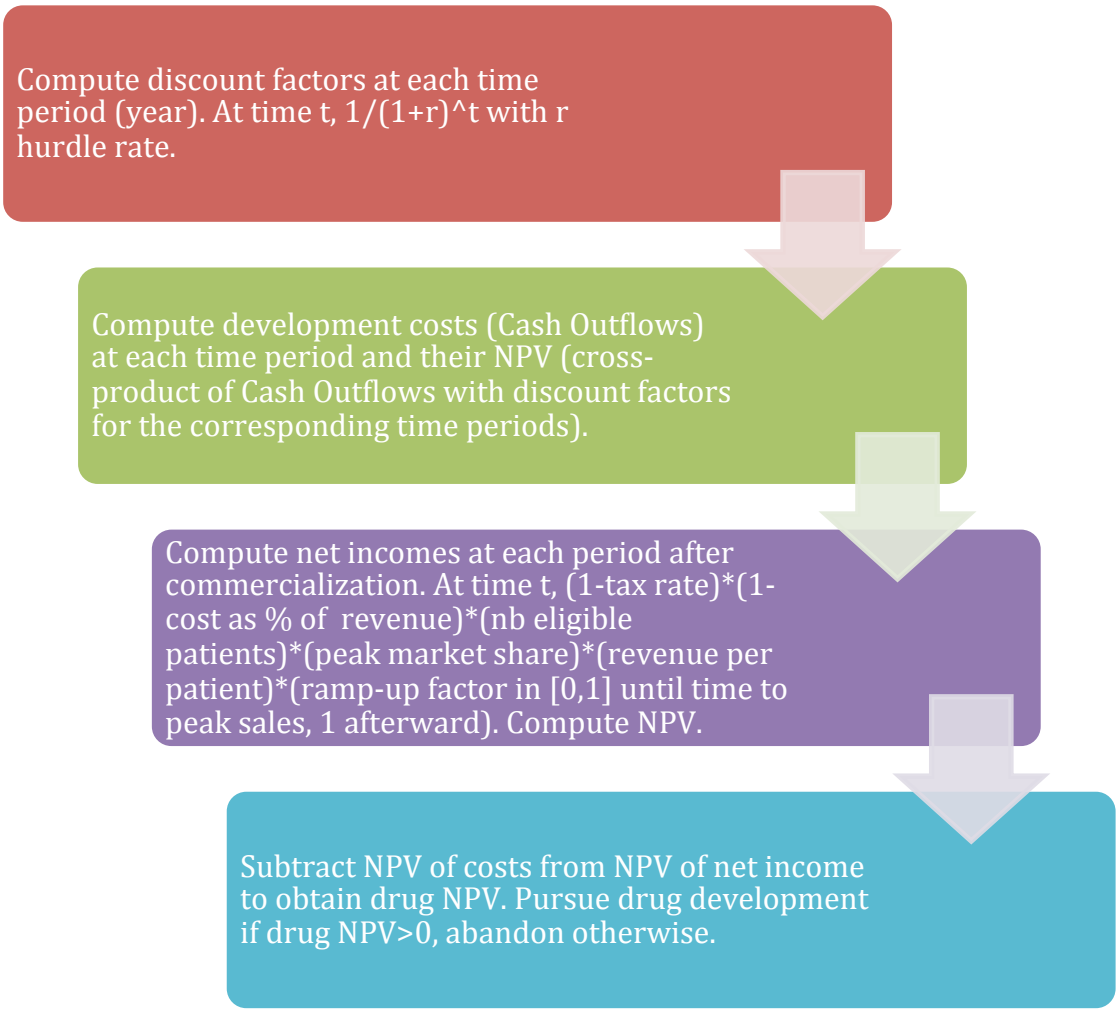

Figure 1 Building blocks of discounted cash-flow analysis

We align ourselves with the benchmark paper in the literature[5] in considering six scenarios in oncology, for which stratified medicine is most commonly used: three for large-population cancers, with patient populations between 70,000 and 200,000 patients per year (the low end of the range corresponds to skin, bladder, renal cancer or non-Hodgkin's lymphoma and the high end corresponds to lung, breast and prostate cancer), and three for small-population cancers, with patient populations between 7,000 and 20,000 patients per year (e.g., colon cancer).[9] For each cancer type, one scenario focuses on an empirical drug and two on stratified drugs under various price assumptions. Examples of stratified drugs include trastuzumab (Herceptin®, Roche/Genentech, CA. USA) for breast cancer and

cetuximab (Erbitux®, Bristol-Myers Squibb, NY, USA) for metastatic colorectal cancer, both of which treat relatively large patient populations, and crizotinib (Xalkori®, Pfizer, NY, USA), for lung cancer, which targets only the 5% of the patient population with a specific alteration in the ALK gene. The data and scenarios are summarized in TABLE 1 and TABLE 2. We have adjusted the monetary data for inflation between the publication year of the benchmark paper and 2014.

Because we are predominantly interested in the *sign* of the drug's NPV (which determines the continue/abandon decision), the insights are also applicable to settings where NPV of development costs and maximum revenue over the whole patient population are proportional to the baseline values in TABLE 1. Further, the Minimum Viable Market Shares obtained at the core of our analysis only depend on the ratio of maximum revenue to NPV of cost (or NPV of net income to NPV of cost), so that our conclusions extend to cases where that *ratio* is maintained, and can easily be updated by changing input parameters in an Excel spreadsheet otherwise. The value of our analysis lies in showing decision-makers how to compute MVMS and draw the appropriate insights from their results, in various regulatory and business environments determined by the commercialization process and the time to peak sales.

Parameter	Value
Cost of Development (US$ million)	500
NPV of Development Costs	374
Years of development	7
Years of commercialization	11-13 (starting Year 6-8)
Years to reach sales peak	0-6 (starting first year of commercialization)
Taxes	35%
Cost of revenue	40%
Discount rate	11%

Table 1 Parameters used in case study[5]

Scenario	Description	Number of eligible patients per year	Revenue per patient (US$)	Maximum net income (after tax & cost of revenue, US$ mil)
S1	Empirical, large cancer	200,000	25,000	5,000
S2	Stratified, large cancer	70,000	25,000	1,750
S3	Stratified, large cancer, low price	70,000	12,500	875
S4	Empirical, small cancer	20,000	25,000	500
S5	Stratified, small cancer	7,000	25,000	175
S6	Stratified, small cancer, high price	7,000	50,000	350

Table 2 Descriptions of scenarios[5]

Pharmaceutical companies have multiple ways to achieve early commercialization of certain drugs, in particular drugs that fill an unmet need. The main ways in the United States are: (i) accelerated approval, (ii) priority review, (iii) fast track, and (iv) breakthrough designation.[10] To be considered, drugs should meet qualifying criteria such as addressing an unmet medical need for a serious disease and providing a meaningful advantage over available treatments. The specific criteria depend on the type of expedited program considered. Those programs are non-exclusive, so that a pharmaceutical company can, for instance, apply both for fast track and priority review for a drug it is developing. Accelerated approval is an approval pathway while the other three are designations.

(i) *Accelerated approval* relies on the use of surrogate endpoints or intermediate clinical endpoints to predict a drug's clinical benefits, and requires subsequent confirmatory trials to verify the anticipated effect

of the drug. Crizotinib (Xalkori®, Pfizer, NY, USA) treats patients with metastatic non-small cell lung cancer whose tumors are anaplastic lymphoma kinase (ALK)-positive and was developed under accelerated approval.[11]

(ii) *Priority review* offers a shorter timeframe for the review of the marketing application (6 months instead of 10). Vemurafenib (Zelboraf®, Genentech, CA, USA), for patients with BRAF V600E mutation positive metastatic melanoma, and ivacaftor (Kalydeco®, Vertex Pharmaceuticals, MA, USA), for cystic fibrosis patients with the G551D mutation in the Cystic Fibrosis Transmembrane Regulator gene, were developed under priority review[12,13].

(iii) *Fast track* facilitates drug development and expedites the review of the marketing application by providing more frequent meetings with and written correspondence from FDA. It allows drugs to be developed and marketed up to 2.5 years faster so that the drugs may reach patients earlier. Zelboraf® also used fast track designation in its FDA approval process.

(iv) *Breakthrough designation* focuses on drugs that, according to preliminary clinical evidence, would provide substantial improvement over existing therapies. The FDA provides intensive guidance on efficient drug development. Ceritinib (Zykadia®, Novartis, Switzerland), for the treatment of anaplastic lymphoma kinase positive (ALK+) metastatic non-small cell lung cancer was developed following its Breakthrough Therapy designation by the FDA.[14]

Because the NPV is equal to discounted cash inflows (net income) minus discounted cash outflows, and because cash flows that occur earlier have a bigger impact because they are less discounted (have more value to the decision-maker today), a way to increase NPV – making drug development more attractive – is to shift cash inflows to earlier time periods through faster commercialization.

In this work, we investigate two such settings:

1. Commercialization is authorized before clinical trials are fully completed; however, trials must be finished after approval is received and the results communicated to the regulatory agency. This is closest to FDA's *accelerated approval*.
2. Review time is compressed due to close interactions with regulators, but total development costs remain the same, since the clinical trials simply take place on a shorter schedule at same cost. This is closest to FDA's *fast track*. (Breakthrough designation would also lead to a shorter schedule; however, our approach also works for drugs that have not received that designation.)

We do not consider priority review because a decrease in review time from 10 months to 6 months, while obviously important for the company commercializing the drug, is not significant enough to impact our NPV model where the time periods are in years.

In each of those settings, we also investigate the impact of achieving earlier sales peak, for instance due to the superior effectiveness of the drug being commercialized, for the six scenarios that represent the main business situations faced by pharmaceutical companies (see TABLE 2).

For illustrative purposes here, and to avoid making additional assumptions that would not add value to the analysis, we split risk-adjusted development costs and sales ramp-up evenly over the time periods considered. In practice, the manager may assign development costs to time periods based on historical data (our analysis only uses as input the *present value* of the development costs) or use more sophisticated models of innovation adoption, such as the Bass model, to capture sales ramp-up following commercialization.[15]

While the discounted cash-flow analysis has previously been used elsewhere to observe (among other things) that, for baseline parameters, all three small-cancer scenarios turn out to be financially unattractive as indicated by their negative Net Present Values (NPVs), we adapt this framework to determine the Minimum Viable Market Share (MVMS) for varying time to commercialization and time to peak sales. We define MVMS as the market share for which the pharmaceutical company will break even, i.e., its NPV is zero: The process to compute it is presented in FIGURE 2.

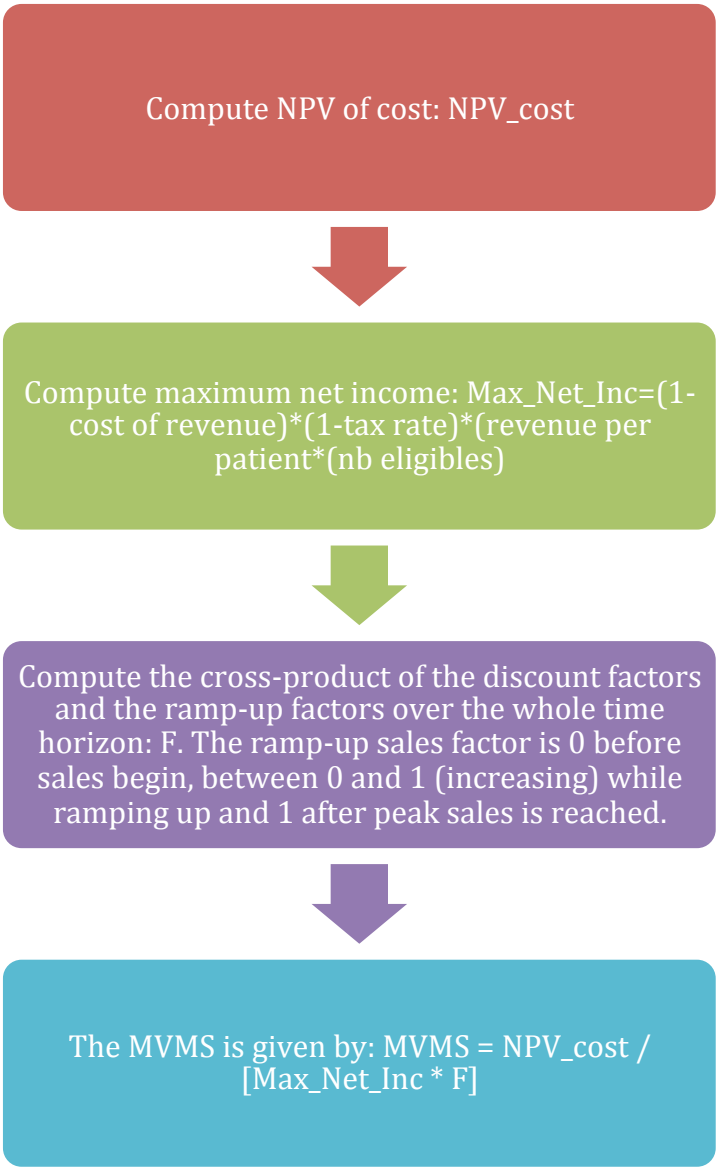

Figure 2 Computing the Minimum Viable Market Share

Case study – accelerated approval. Our results are presented in TABLE 3. We assume commercialization of a promising drug may begin while Phase III clinical trials are being completed, and thus can decrease first year of commercialization by up to two years. Spreadsheet cells representing market share less than 30% are shaded in green. Cells representing infeasible scenarios (market share greater than 100%) are shaded in red. Cells shaded in yellow, respectively orange, represent market share between 60% and 80%, respectively between 80% and 100%.

S1	Large population, empirical drug						
	0	1	2	3	4	5	6
6	4.04%	4.32%	4.60%	4.91%	5.23%	5.58%	5.94%
7	4.62%	4.94%	5.28%	5.65%	6.03%	6.45%	6.89%
8	5.31%	5.69%	6.10%	6.53%	7.00%	7.51%	8.05%

S2	Large population, stratified drug						
	0	1	2	3	4	5	6
6	11.56%	12.33%	13.15%	14.02%	14.95%	15.94%	16.98%
7	13.21%	14.12%	15.10%	16.13%	17.24%	18.43%	19.69%
8	15.17%	16.25%	17.42%	18.67%	20.01%	21.45%	23.00%

S3	Large population, stratified drug, low price						
	0	1	2	3	4	5	6
6	23.11%	24.66%	26.30%	28.04%	29.90%	31.87%	33.97%
7	26.42%	28.25%	30.19%	32.27%	34.48%	36.85%	39.39%
8	30.34%	32.51%	34.83%	37.33%	40.01%	42.89%	46.00%

S4	Small population, empirical drug						
	0	1	2	3	4	5	6
6	40.45%	43.15%	46.02%	49.08%	52.32%	55.77%	59.44%
7	46.24%	49.43%	52.83%	56.47%	60.35%	64.49%	68.93%
8	53.09%	56.89%	60.96%	65.33%	70.02%	75.07%	80.50%

S5	Small population, stratified drug						
	0	1	2	3	4	5	6
6	115.56%	123.29%	131.49%	140.22%	149.49%	159.35%	169.84%
7	132.12%	141.23%	150.95%	161.33%	172.42%	184.27%	196.94%
8	151.69%	162.54%	174.17%	186.65%	200.06%	214.47%	229.99%

S6	Small population, stratified drug, high price						
	0	1	2	3	4	5	6
6	57.78%	61.64%	65.75%	70.11%	74.75%	79.68%	84.92%
7	66.06%	70.61%	75.48%	80.67%	86.21%	92.13%	98.47%
8	75.85%	81.27%	87.08%	93.33%	100.03%	107.24%	115.00%

Table 3 Minimum Viable Market Share for all six scenarios, with first year of commercialization between 6 and 8 and ramp-up to peak sales between 0 and 6 years – accelerated approval.

We observe that:

1. For the large-population cancer, empiric drug (S1) or stratified drug with medium price (S2), or in some scenarios for the large-population cancer,

stratified-drug with low price case (S3), the MVMS remains below 30%. Specifically, it remains at or below 8.05% for S1 (empirical drug) and 23% for S2.

2. In all scenarios, achieving commercialization two years early (from Year 8 to Year 6) with an immediate peak sales at Year 6 cuts the MVMS in half.
3. An empirical drug for a small cancer (S4) has a MVMS ranging from 40% to 81% depending on the parameters considered, with a greater effect achieved if commercialization happens one year earlier rather than if peak sales happens one year earlier. Even with earliest commercialization in Year 6, if the number of years to sales peak does not change, the pharmaceutical company will need to achieve a market share of about 60% to break even in developing this drug.
4. The development of a stratified drug for a small-population cancer at a "reasonable" price (S5) is never economically feasible. Even if commercialization occurred in the earliest possible year (Year 6) and the sales peak happened immediately, the required MVMS would be of 116%, far higher than the total patient population for that disease.
5. If the stratified drug for the small-population cancer is reimbursed at a high price (S6), the MVMS is quite high but is at least feasible, i.e., less than 100%, in eighteen of the twenty-one scenarios. Early commercialization at Year 6 and time to sales peak divided by two (to Year 3), however, still lead to a MVMS of at least 70% for the drug to be financially viable. This may indeed be attainable in settings where there is no comparable alternative or currently available treatments are unsatisfactory.

Case study – fast track

The MVMS in the second case ("fast track") are presented in TABLE 4.

S1	Large population, empirical drug						
	0	1	2	3	4	5	6
6	5.66%	6.04%	6.44%	6.87%	7.33%	7.81%	8.32%
7	5.39%	5.77%	6.16%	6.59%	7.04%	7.52%	8.04%
8	5.31%	5.69%	6.10%	6.53%	7.00%	7.51%	8.05%

S2	Large population, stratified drug						
	0	1	2	3	4	5	6
6	16.18%	17.26%	18.41%	19.63%	20.93%	22.31%	23.78%
7	15.41%	16.48%	17.61%	18.82%	20.12%	21.50%	22.98%
8	15.17%	16.25%	17.42%	18.67%	20.01%	21.45%	23.00%

S3	Large population, stratified drug, low price						
	0	1	2	3	4	5	6
6	32.36%	34.52%	36.82%	39.26%	41.86%	44.62%	47.56%
7	30.83%	32.95%	35.22%	37.64%	40.23%	43.00%	45.95%
8	30.34%	32.51%	34.83%	37.33%	40.01%	42.89%	46.00%

S4	Small population, empirical drug						
	0	1	2	3	4	5	6
6	56.63%	60.41%	64.43%	68.71%	73.25%	78.08%	83.22%
7	53.95%	57.67%	61.64%	65.88%	70.40%	75.24%	80.42%
8	53.09%	56.89%	60.96%	65.33%	70.02%	75.07%	80.50%

S5	Small population, stratified drug						
	0	1	2	3	4	5	6
6	161.79%	172.60%	184.09%	196.30%	209.29%	223.09%	237.78%
7	154.14%	164.77%	176.11%	188.22%	201.15%	214.98%	229.76%
8	151.69%	162.54%	174.17%	186.65%	200.06%	214.47%	229.99%

S6	Small population, stratified drug, high price						
	0	1	2	3	4	5	6
6	80.90%	86.30%	92.05%	98.15%	104.64%	111.55%	118.89%
7	77.07%	82.38%	88.06%	94.11%	100.58%	107.49%	114.88%
8	75.85%	81.27%	87.08%	93.33%	100.03%	107.24%	115.00%

Table 4 Minimum Viable Market Share for all six scenarios, with first year of commercialization between 6 and 8 and ramp-up to peak sales between 0 and 6 – fast track

For each scenario, the third row of TABLE 4 contains the data for the baseline setting common to both accelerated approval and fast track, and thus is identical to the third row of TABLE 3. In the fast track case, development ends the year

before commercialization begins, while for accelerated approval, the number of years in development was kept constant, independently of the beginning of commercialization.

We observe that:

- In the fast-track case, the MVMS *increases* as the first year of commercialization decreases from Year 8 to Year 6, i.e., completing the trials more slowly to launch the drug afterward helps the decision maker in the sense that he will need a smaller market share to break even. This is the opposite of what happens for accelerated approval. The compressed timeline of fast track leads to the company incurring more costs sooner, and thus increases the NPV of development costs, more than the earlier commercialization increases the NPV of net income. (This is because costs happen first and thus are discounted less.)
- The MVMS decreases when the number of years to peak sales decreases, for any first year of commercialization. This matches our intuition, since the decision maker reaches his top revenue earlier.
- The MVMS is always at least as large in the fast-track case as in the accelerated approval case for the same parameters (commercialization and sales peak). This means a pharmaceutical company developing a drug under fast track faces, in an NPV sense, a more challenging business environment than under accelerated approval because it needs to achieve higher market share to break even. Again, this is because the compressed timeline increases the NPV of the costs;

however, a fast track designation is preferable to no expedited process at all.

Sensitivity analysis. We also present, in TABLE 5 and TABLE 6, updated MVMS results if the reimbursement price is decreased by 25% due to adverse regulatory or political environment. The MVMS results are also valid if the prices remain the same but development costs increase by 25% due to the increased difficulty in bringing new drugs to market. We observe that this change would significantly endanger the financial viability of stratified drugs, with most cases requiring Minimum Viable Market Shares superior to the whole market size, as depicted by the red cells in S4, S5 and S6.

S1	Large population, empirical drug						
	0	1	2	3	4	5	6
6	5.06%	5.39%	5.75%	6.13%	6.54%	6.97%	7.43%
7	5.78%	6.18%	6.60%	7.06%	7.54%	8.06%	8.62%
8	6.64%	7.11%	7.62%	8.17%	8.75%	9.38%	10.06%

S2	Large population, stratified drug						
	0	1	2	3	4	5	6
6	14.45%	15.41%	16.44%	17.53%	18.69%	19.92%	21.23%
7	16.51%	17.65%	18.87%	20.17%	21.55%	23.03%	24.62%
8	18.96%	20.32%	21.77%	23.33%	25.01%	26.81%	28.75%

S3	Large population, stratified drug, low price						
	0	1	2	3	4	5	6
6	28.89%	30.82%	32.87%	35.05%	37.37%	39.84%	42.46%
7	33.03%	35.31%	37.74%	40.33%	43.10%	46.07%	49.23%
8	37.92%	40.63%	43.54%	46.66%	50.01%	53.62%	57.50%

S4	Small population, empirical drug						
	0	1	2	3	4	5	6
6	50.56%	53.94%	57.53%	61.35%	65.40%	69.72%	74.31%
7	57.80%	61.79%	66.04%	70.58%	75.43%	80.62%	86.16%
8	66.36%	71.11%	76.20%	81.66%	87.53%	93.83%	100.62%

S5	Small population, stratified drug						
	0	1	2	3	4	5	6
6	144.46%	154.11%	164.37%	175.27%	186.86%	199.19%	212.30%
7	165.15%	176.54%	188.69%	201.66%	215.52%	230.33%	246.17%
8	189.61%	203.17%	217.71%	233.31%	250.07%	268.09%	287.49%

S6	Small population, stratified drug, high price						
	0	1	2	3	4	5	6
6	72.23%	77.05%	82.18%	87.64%	93.43%	99.59%	106.15%
7	82.57%	88.27%	94.34%	100.83%	107.76%	115.17%	123.09%
8	94.81%	101.59%	108.86%	116.66%	125.04%	134.05%	143.74%

Table 5 MVMS, with first year of commercialization between 6 and 8 and ramp-up to peak sales between 0 and 6 years – accelerated approval, 25% decrease in price.

S1	0	1	2	3	4	5	6
6	7.08%	7.55%	8.05%	8.59%	9.16%	9.76%	10.40%
7	5.39%	5.77%	6.16%	6.59%	7.04%	7.52%	8.04%
8	5.31%	5.69%	6.10%	6.53%	7.00%	7.51%	8.05%

S2	0	1	2	3	4	5	6
6	20.22%	21.58%	23.01%	24.54%	26.16%	27.89%	29.72%
7	15.41%	16.48%	17.61%	18.82%	20.12%	21.50%	22.98%
8	15.17%	16.25%	17.42%	18.67%	20.01%	21.45%	23.00%

S3	0	1	2	3	4	5	6
6	40.45%	43.15%	46.02%	49.08%	52.32%	55.77%	59.44%
7	30.83%	32.95%	35.22%	37.64%	40.23%	43.00%	45.95%
8	30.34%	32.51%	34.83%	37.33%	40.01%	42.89%	46.00%

S4	0	1	2	3	4	5	6
6	70.78%	75.51%	80.54%	85.88%	91.56%	97.60%	104.03%
7	53.95%	57.67%	61.64%	65.88%	70.40%	75.24%	80.42%
8	53.09%	56.89%	60.96%	65.33%	70.02%	75.07%	80.50%

S5	0	1	2	3	4	5	6
6	202.24%	215.75%	230.12%	245.38%	261.61%	278.87%	297.22%
7	154.14%	164.77%	176.11%	188.22%	201.15%	214.98%	229.76%
8	151.69%	162.54%	174.17%	186.65%	200.06%	214.47%	229.99%

S6	0	1	2	3	4	5	6
6	101.12%	107.88%	115.06%	122.69%	130.80%	139.43%	148.61%
7	77.07%	82.38%	88.06%	94.11%	100.58%	107.49%	114.88%
8	75.85%	81.27%	87.08%	93.33%	100.03%	107.24%	115.00%

Table 6 MVMS, with first year of commercialization between 6 and 8 and ramp-up to peak sales between 0 and 6 years – fast track, 25% decrease in price

Key insights. We make the following comments based on our analysis:

- Discount factors significantly dampen the impact of cash flows in later time periods in the NPV analysis, so that the ability to go to market early under accelerated approval or fast track can make a drug much more financially attractive, in terms of decreased Minimum Viable Market Share.
- Lower time to peak sales can also help improve the financial outlook of the drug, although the marginal impact of earlier commercialization is greater than that of earlier peak sales.
- Decision makers should assess the competitive landscape to determine whether the number of years to peak sales as input to the model and the Minimum Viable Market Share obtained as output are realistic in their business environment.
- Because both number of years to peak sales and MVMS are, to some extent, exogenous and not completely under the decision makers' control, it is best to go ahead with commercialization when the market share the manager hopes to achieve exceeds the MVMS obtained for multiple values of the parameters presented, and by a given excess margin.
- Everything else being equal, the accelerated approval designation is more advantageous than its fast track counterpart, i.e., the Minimum Viable Market Share under accelerated approval is decreased.
- A shorter time to sales peak can substantially improve a drug's financial viability when the peak is achieved on or before Year 3. This suggests the need for continued discussions between regulators, pharmaceutical companies, healthcare providers and patient advocates to better raise

awareness of the most promising drugs, especially those filling an unmet need for small population illnesses, as soon as they are authorized for commercialization.

- In the case study presented, it is *never* optimal to commercialize a stratified drug for a small-population cancer, unless its price is high *and* at least one of the following conditions is satisfied: (i) commercialization happens early (before Year 8), (ii) time to peak sales is reduced by at least half from its baseline. If additional marketing costs are involved, they need to be incorporated as an added cost in the NPV calculation.

Because high prices may not be sustainable in the current payer environment, different analytical tools and frameworks need to be developed to make stratified drugs in small markets commercially viable (S4 scenario, currently never economically appealing). The key tool we recommend in that setting is Decision Tree Analysis, a rich modeling framework that captures information revealed over time to the manager, and helps make stratified drugs for small patient populations cost-effective in more complex environments not captured in the NPV framework.[16]

Conclusions

Traditional financial analysis techniques suggest that the development of drugs for small-population illnesses, whether empirical or stratified, is not financially viable under baseline conditions. In this work, we argue that factors such as earlier commercialization, due to accelerated approval or fast track designations, and shorter time to sales peak can in fact make some of those drugs much more

financially attractive without increasing price by decreasing the market share they need to achieve to recoup development costs. This suggests important benefits for all stakeholders, especially patients for whom current treatments are inadequate.

Aurélie C. Thiele, CHFP, PhD is the co-director of the Analytical Finance program, an affiliate faculty member of the Healthcare Systems Engineering program and an Associate Professor in the Industrial and Systems department at Lehigh University in Bethlehem, PA, USA. aut204@lehigh.edu

Competing interests statement

The author has no competing interests to declare.

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[1] The Economist. Hard pills to swallow: Arguments over cost of new medicines are growing. Print

[2] The Economist. Costly cures: an American fight over expensive new treatments has global implications. Print edition. June 7 2014

[3] Trusheim M. Berndt E. Douglas F. Stratified medicine: strategic and economic implications of combining drugs and clinical biomarkers. *Nature reviews drug discovery*. 6:287-293 (2007)

[4] McKinsey & Company. *Personalized medicine: the path forward*. (2013)

[5] Trusheim M. Berndt E. Economic challenges and possible policy actions to advance stratified medicine. *Personalized Medicine* 9(4):413-427 (2012)

[6] Fugel H-J, Nuijten M, Postma M. Stratified medicine and reimbursement issues. *Frontiers in Pharmacology* 3:181 (2012).

[7] Academy of Medical Sciences. *Optimizing stratified medicine R&D: addressing scientific and economic issues.* http://www.acmedsci.ac.uk/viewFile/publicationDownloads/120151486883.pdf (2007)

[8] Gapenski L. Pink G. *Understanding healthcare financial management*. 6th ed. Health Administration Press (2010)

[9] American Cancer Society. Cancer Facts & Figures 2014. http://www.cancer.org/acs/groups/content/@research/documents/webcontent/acspc-042151.pdf Accessed July 13 2014.

[10] Federal Drug Administration. *Guidance for industry: expedited programs for serious conditions – drugs and biologics*. http://www.fda.gov/downloads/Drugs/GuidanceComplianceRegulatoryInformation/Guidances/UCM358301.pdf May 2014. Accessed July 14 2014.

[11] FDA. *Drug approvals and databases: approved drugs. Crizotinib.* http://www.fda.gov/Drugs/InformationOnDrugs/ApprovedDrugs/ucm376058.htm Accessed July 14 2014.

[12] FDA. *FDA approves Zelboraf and companion diagnostic test for late-stage skin cancer.* http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm268241.htm Press release, August 17 2011. Accessed July 14 2014.

[13] FDA. *FDA approves Kalydeco to treat rare form of cystic fibrosis.* http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm289633.htm News release, January 31 2012. Accessed July 14 2014.

[14] FDA. FDA approves Zykadia for late-stage lung cancer. http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm395299.htm April 29 2014, accessed July 14 2014.

[15] Bass F. A new product growth model for consumer durables. *Management Science*. 15(5):215-227 (1969)

[16] Sloand J, Thiele A. *Assessing the financial viability of stratified medicine using Decision Tree Analysis.* Working paper. Lehigh University, Bethlehem, PA (2014)