2.009 Product Engineering Processes
2.009 Product engineering processes

Today

business case the (very) basics

give me your money (please)

Acknowledgments: Victor Tang
A proposition

I will give you $1000 today!

or

I will give you $1200 next year!

factors in making your decision?

- current financial/life circumstances
- trust in the monetary source
Concept 1
Time value of money

A dollar now is worth more to you than a dollar in the future.

Interest rate \( r = \% \) per period \( n \)

Future value = present value \( \times (1+r)^n \)

\[
\begin{align*}
\text{t = 0} & \quad \text{\$1.} \\
\text{t = 1} & \quad \text{\$1.1} \\
\text{t = 2} & \quad \text{\$1.21} \\
\text{\ldots} & \\
\text{t = n} & \quad \text{\$} \,(1+r)^n
\end{align*}
\]

\( r = 10\% \)
Concept 1
Discount rate

$1. \quad $1.1 \quad $1.21 \quad \ldots \quad $(1+r)^n$

0 \quad 1 \quad 2 \quad \ldots \quad n \quad t

your personal, discount rate $r$ per period $n$ is …

$(1+r)^n = \text{future value/present value}$

when you perceive present and future value to be equivalent

so, if you decided to:

take $1000$ from me now, your $r$ per year is $> 0.2$

wait for $1200$, your $r$ per year is $\leq 0.2$

personal discount rates tend to be high!
Concept 2
Net present value (NPV)

Future cash flows can be converted into a present day value using an appropriate discount rate.

\[
NPV = \sum_{n=1}^{m} \frac{c_n}{(1+r)^n}
\]

- \(c_n\) is cash flow in period \(n\)
- \(r\) is discount rate per period \(n\)
- \(m\) is total number of periods (3-5 years typical)
Another proposition

please give me $1000 today

and I promise…

I will give you $1300 next year!

…at least I am quite sure that I will pay you but there is some chance that I might lose it and won’t pay you back at all.
**Concept 3**

**Internal rate of return (IRR)**

a.k.a. **return on investment (ROI)**

At what discount rate will future cash flows have the same NPV as your initial investment?

\[ i = \sum_{n=1}^{m} \frac{c_n}{(1+r)^n} \]

- \( i \) = investment
- \( c_n \) is cash flow in period \( n \)
- \( m \) is total number of periods
- \( r \) is the IRR

\( c_1/(1+r) \)
\( c_2/(1+r)^2 \)
\( \cdot \cdot \cdot \)
\( c_5/(1+r)^5 \)
If you gave me $1000 now expecting $1300 next year, an expected IRR of 30% was enough for you to invest:

\[ 1000 = \frac{1300}{(1+r)^1} \]

If you did not give me $1000 now, an expected IRR of 30% was not enough.
Expectations
IRRs and risk

30+%  for risky new ventures
20%   for new products
15%   for extensions/improvements to existing product
10%   for cost improvement to existing product

risk-free rate-of-return
historically ~ 6% for short term government bonds
since 2000 typically much less
question: How to convince people to give you money?

answer: Have a credible business proposal

Proof points
product is not “me-too”
clear target market
know why customers will buy/adopt
know why customers will not buy – product issues, competition
anticipate a desirable return on investment or benefit
you are confident, enthusiastic, and trustworthy
Business Proposal

Important take away messages

We have an attractive market
market size $, and 3-year growth rate
profitability and/or other killer benefits

We have a competitive product
what makes the product different
what are its unique benefits

We have a viable business
IRR xx% with initial investment of $ xx
break-even at units in xx months
reach steady state in yy months
Business Proposal

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Take Away Message

Market opportunity

target market

what is your product and who will buy it? (in 25 words or less)

market characteristics

where and how they are going to buy: store, sales rep, etc?
how will they find out about your product, its features, and benefits?
why is your price attractive?
Business Proposal

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reach steady state in yy months
Take Away Message
A competitive product

competition can be another product ... or simply old way of doing things.

**killer attributes**
attribute 2
attribute k

<table>
<thead>
<tr>
<th>attribute 1</th>
<th>attribute 2</th>
<th>attribute 3</th>
<th>attribute 4</th>
<th>...</th>
<th>attribute k-1</th>
<th>attribute k</th>
</tr>
</thead>
<tbody>
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</table>

abc
def
lmn
009
Business Proposal
Important take away messages

We have an attractive market
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what makes the product different
what are its unique benefits

We have a viable business
IRR xx% with initial investment of $ xx
break-even at units in xx months
reach steady state in yy months
Get a handle on your return

but first
Determine your revenue, costs, expenses, and initial investment

Take Away Message
A viable business
Revenue

i) simplified sales estimation

Assume volume, $Q_{009}^{\text{max}} = 180K$
4 years to reach asymptote .... and

guestimate intermediate points
Revenue

ii) develop pricing strategy

price $\neq$ cost

ideally:
cost and price both decline, margin increases
What is the relationship between the cost of an alpha prototype and the product’s cost?

answer:
there is no relationship
Revenue

ii) develop pricing strategy

price ≠ cost

ideally:
cost and price both decline, margin increases
Revenue
Other possible sources

the value of goodwill?
strategic positioning?
'(Take Away Message)

A viable business

Getting a handle on your return

but first

Determine your revenue, costs, expenses, and initial investment
## Revenue, Cost and Expenses

**Simplified profit and loss statement**

<table>
<thead>
<tr>
<th></th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>...</th>
<th>$T_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>sales revenues</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>materials cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>manufacturing cost</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gross profit</strong></td>
<td><strong>should be monotonic increasing</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>R&amp;D expense</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>sales expense</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gen. admin. expense</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>NEBT (net earnings before tax)</strong></td>
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</tr>
<tr>
<td><strong>interest exp.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>taxes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NEAT (net earnings after tax)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Price $ \times $ quantity**
- $ paid for parts
- $ paid for labor, capital
- sales rev.-material cost-manufacturing cost
- $ paid for engineers and equipment & stuff
- $ paid for sales people, customer lunches, travel ...
- $ paid for office, insurance
- gross profit - $ \Sigma expenses

use 4-year time horizon

Better be monotonic increasing
Costs and Expenses

Examples

Cost
- Materials, labor, overhead: 69.7%

Expense SG&A
- Sales general and administrative: 24.3%

Expense
- R&D, interest, taxes: 3.6%

Profit
- NEAT: net earnings or profit after taxes: 2.4%

Income structure (normalized to 100% of revenue)
- Fabricated metal (SIC 3499): 009
- Cost: 69.7%
- SG&A: 24.3%
- Profit: 2.4%

NEAT: net earnings or profit after taxes
Costs and Expenses

References: ratios for different industries

Tutorial on how to read financial statements.

**Industry Norms & Key Business Ratios, D & B 2000.**
Excellent source of information, down to the four digit SIC code.

Alternative to above, also very useful.

**Annual Statement Studies, 2000-2001.** rma publishing.
More business ratios by 4 digit Sic code.

## Revenue, Cost and Expenses

**Estimate based on ratios**

<table>
<thead>
<tr>
<th></th>
<th>( T_0 % )</th>
<th>( T_1 $ )</th>
<th>( \ldots )</th>
<th>( \ldots )</th>
<th>( T_{k-1} $ )</th>
<th>( T_k $ )</th>
</tr>
</thead>
<tbody>
<tr>
<td>units sold</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>sales revenues</td>
<td>( 100% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>returns, etc.</td>
<td>( &lt;2% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>materials cost</td>
<td>( \approx 17% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>manuf. cost</td>
<td>( \approx 17% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>depreciation</td>
<td>( \approx 5% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>gross profit</td>
<td>( \approx 60% )</td>
<td>( f=a-(b+c+d+e) )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>( \approx 10% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>sales expense</td>
<td>( \approx 20% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>gen admin exp</td>
<td>( \approx 5% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
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<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>NEBT</td>
<td>( \approx 20% )</td>
<td>( j=f-(g+h+i) )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>interest exp</td>
<td>( \approx 10% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>taxes</td>
<td>( \approx 5% )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
<tr>
<td>NEAT</td>
<td>( \approx 5% )</td>
<td>( m=j-(k+l) )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
<td>( \ldots )</td>
</tr>
</tbody>
</table>
Revenue, Cost and Expenses

First order estimation heuristics

manufacturing cost = materials cost (at volume)

tax rate on earnings (NEBT) = 50%
Take Away Message
A viable business

Getting a handle on your return

but first
Determine your revenue, costs, expenses, and initial investment
Take Away Message

Initial investment

Estimate a base-line for required investments
Target an initial break-even time, $T_b$ (first period in which profit $\geq 0$, 1-2 years)

<table>
<thead>
<tr>
<th></th>
<th>$T_1$</th>
<th>$T_2$</th>
<th>…</th>
<th>$T_b$</th>
<th>…</th>
<th>$T_{k-1}$</th>
<th>$T_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost+Expenses</td>
<td>$CE_0$</td>
<td>$CE_1$</td>
<td>…</td>
<td>$CE_b$</td>
<td>…</td>
<td>…</td>
<td>…</td>
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<tr>
<td>Mat’s and mfg.</td>
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<tr>
<td>SG&amp;A expenses</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>R&amp;D, interest, taxes</td>
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</tr>
</tbody>
</table>

Initial investment estimate: $I_0 = [CE_1] + [CE_2] + \ldots + [CE_b]$
Take Away Message
A viable business

Getting a handle on your return

but first
Determine your revenue, costs, expenses, and initial investment
Internal Rate of Return (IRR)

Solve for $r$, ~4 years out

\[
\frac{\$CF_1}{(1+R)^1} + \frac{\$CF_2}{(1+R)^2} + \cdots + \frac{\$CF_k}{(1+R)^k} - I_0 = 0
\]
Question:
How do you know when you have the right answer?

Answer:
Fiddle with sales, costs, expenses, investment until business looks reasonable

Or:
Fiddle until you have no belief that your business can credibly look reasonable
Three slide business proposal

Important take away messages

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market size $, and 3-year growth rate
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# For-profit vs. not-for-Profit

## What’s the difference?

<table>
<thead>
<tr>
<th>For-profit</th>
<th>Not-for-profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>investor</td>
<td>funder/donor</td>
</tr>
<tr>
<td>customer</td>
<td>client</td>
</tr>
<tr>
<td>products and services</td>
<td>program</td>
</tr>
<tr>
<td>profit and loss</td>
<td>financial activities</td>
</tr>
<tr>
<td>balance sheet</td>
<td>financial position</td>
</tr>
<tr>
<td>convince investors that your product is a better bet than alternatives</td>
<td>convince funders that your program is a better bet than alternatives</td>
</tr>
</tbody>
</table>

IRR = bank rate
Anticipate Questions

About risks

What are they and what is your strategy to handle?

Market Risks
[risk 1]
[risk 2]
[risk 3]

Technical Risks
[risk 4]
[risk 5]
[risk 6]
And Almost Finally

Remember…

You need to have a reasonable strategy that makes sense for your value proposition, no matter what it is.

Need to address this issue clearly and sensibly…

But, 2.009 final is not business plan presentation (roughly 15% of your presentation time)

If you don’t understand a question, don’t pretend to
But wait…
What about crowdsourced fund raising?

raise directly from your potential user base
nearly 50% of kickstarter projects get funded

**pros:** *just do it*
don’t need to fit the pattern of typical venture funding

**cons:**
don’t need to fit the pattern of typical venture funding

75% of hardware/design projects don’t complete on time
And Finally

coming up...

Friday 5 PM: UI design

due Friday 5 PM: peer review, team review

Team areas: noon-5 Saturday

Monday
30 minute design review with each team
not make-work!