2.009 Product Engineering Processes
2.009 Product engineering processes

Today

business case the (very) basics
2.009 Product engineering processes

Sets
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Sets
RSVP

update

you (students in class) do not need to RSVP

2 family/SO or 1 friend

use your email link for family guests or send invitations to others

lotteries Friday, Tuesday and Thursday
And now!
a mini quiz

please use the small index card

i) a ______ is a powerful tool for design a presentation/narrative

ii) a consistent ______ layout structure helps to make slides coherent and understandable

iii) in the final presentations, slides will be ________ proportion
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 \( \times (1+r)^n \)

\[
\begin{align*}
\text{Present Value} & \quad \text{Future Value} \\
1 & \quad \text{Future Value of 1} \\
1 & \quad \rightarrow \text{Future Value at } t = 1 \\
1.1 & \quad \rightarrow \text{Future Value at } t = 2 \\
1.21 & \quad \rightarrow \text{Future Value at } t = 3 \\
& \quad \vdots \\
$(1+r)^n & \quad \rightarrow \text{Future Value at } t = n
\end{align*}
\]

\( r = 10\% \)
Concept 1

Discount rate

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?

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

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

\( i \) = investment
Concept 3
IRR or ROI

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
very long term ~ 6% for short term government bonds
since 2000 typically much less, ~ 2%
Return expectations
Differ with type of investor

venture investment
strategic partner

angel investment
crowdfunding
question:
How to convince people to give you money?

answer:
Have a credible business proposal

What’s a proposal about?
value propositions
getting your product to users
Value proposition(s)
Part 1: product point-of-view

glow is the interactive yoga mat that allows users to practice yoga in their own home as if they were in a studio

not a list of user needs!
what is your product?
who is your user?
how does the user benefit?
where and when would this product be used?
why would someone want this product?
Value proposition(s)
Part 2: business point-of-view

can you deliver?
your product’s value proposition
clear target market
know why purchasers will buy/adopt
know why purchasers will not buy – competition
a desirable return (monetary or otherwise)
your confidence, enthusiasm, and trustworthiness
Business Proposal

Important take away messages

**Product value proposition**
*We have a desirable, competitive product*
what is the product
what are its unique benefits

**Business value proposition (we can deliver that product)**
*We have an attractive market*
market size $, and 3-year growth rate
profitability and/or other killer 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
Take Away Message
A competitive product value proposition

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

killer attributes
attribute 2
attribute k
Business Proposal

Important take away messages

(product value proposition)
We have a desirable, competitive product
what is the product’
what are its unique benefits

(business value proposition)
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We have a viable business
IRR xx% with initial investment of $ xx
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reach steady state in yy months
Take Away Message

Attractive market

target market

who will buy it and how they relate to product? (<25 words)

market characteristics

where and how will it be bought: store, sales rep, etc?
how will buyers know about your product?
why is your price attractive?
Business Proposal

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Take Away Message
A viable business

Getting a handle on your return

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

ideally:
cost and price both decline,
margin increases
Cost

A mini quiz!

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?
Gettting 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>( \ldots )</th>
<th>( T_k )</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales revenues</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>materials cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>manufacturing cost</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>gross profit</strong></td>
<td>( \textit{should be monotonic increasing} )</td>
<td>( \textit{should be monotonic increasing} )</td>
<td>( \textit{should be monotonic increasing} )</td>
<td>( \textit{should be monotonic increasing} )</td>
</tr>
<tr>
<td>R&amp;D expense</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sales expense</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gen. admin. expense</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NEBT (net earnings before tax)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interest exp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>taxes</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
- \( \$ \) paid for engineers and equipment & stuff
- \( \$ \) paid for sales people, customer lunches, travel ...
- \( \$ \) paid for office, insurance

\[ \text{NEAT} = \text{gross profit} - \sum \text{expenses} \]

Use a 4-year time horizon.
## Costs and Expenses

### Examples

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>69.7%</td>
</tr>
<tr>
<td>materials, labor, overhead</td>
<td></td>
</tr>
<tr>
<td>Expense SG&amp;A</td>
<td>24.3%</td>
</tr>
<tr>
<td>sales general and administrative</td>
<td></td>
</tr>
<tr>
<td>Expense</td>
<td>3.6%</td>
</tr>
<tr>
<td>R&amp;D, interest, taxes</td>
<td></td>
</tr>
<tr>
<td>Profit</td>
<td>2.4%</td>
</tr>
<tr>
<td>NEAT: net earnings or profit after taxes</td>
<td></td>
</tr>
</tbody>
</table>

- **Income Structure**
  - Fabricated metal
  - SIC 3499
  - (normalized to 100% of revenue)

### Notes
- Cost: materials, labor, overhead
- Expense SG&A: sales general and administrative
- Expense: R&D, interest, taxes
- Profit: NEAT: net earnings or profit after taxes
# Revenue, Cost and Expenses

Estimate based on ratios

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

manufacturing cost = materials cost (at volume)

tax rate on earnings (NEBT) = 50%
Get a handle on your return

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

Take Away Message
A viable business
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 $\geq 0$, 1-3 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>$$CE_b$</td>
<td>...</td>
<td>$$CE_{k-1}$</td>
<td>$$CE_k$</td>
</tr>
<tr>
<td>Mat’s and mfg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SG&amp;A expenses</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R&amp;D, interest, taxes</td>
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</tr>
</tbody>
</table>

Initial investment estimate: $I_0 = \$CE_1 + \$CE_2 + ... + \$CE_b$
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
But wait…
What about crowdsourced fund raising?

raise directly from your potential customer 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
Business Proposal

Important take away messages

**product value position**
We have a desirable, competitive product
what is the product?
what are its unique benefits

**business value position (we can deliver that product)**
We have an attractive market
market size $, and 3-year growth rate
profitability and/or other killer 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
But wait
There are different types of business proposals!

patent & license (company, NGO)
joint development
toll manufacture or contract manufacture

patent & sell (for-profit or not-for-profit)
Developing a business case

Step-by-step

identify product value proposition

identify business value proposition
create a development and sales timeline
estimate cost to manufacture
determine the path for product to reach customers

think about how to communicate the business case!
Communicate your story in 2.009

ROI is analogous to a detailed design calculation. It’s not the business case!

A credible path for your product to reach its users! In 10-15% of your presentation time.

It’s a product launch, not a business pitch.

If you don’t understand a question, don’t pretend to!

Answer informatively and concisely.
And finally

coming up...

**Thursday** 7 PM: Costing tutorial: assembly drawing

**Thursday** 8-10 PM: 15 minute business concept meetings: have some concepts for how to reach user

**Friday class:** Consulting in Pappalado: product and presentation