2.009 Product engineering processes

business case  the (very) basics

hand it over. voluntarily please!
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 \( \times (1+r)^n \)

\[ \begin{align*}
\$1. & \uparrow \\
\$1.1 \uparrow & \uparrow \\
\$1.21 & \uparrow \\
\vdots & \vdots \\
\$(1+r)^n & \uparrow \\
0 & \ 1 & \ 2 & \ \vdots & \ n \\
\end{align*} \]

\( r = 10\% \)
Concept 1

Discount rate

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

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 $> 0.2$ (n=1)

wait for $1200$, your $r$ per year is $\leq 0.2$ (n=1)

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!

…and 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
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
~ 2-3% for short term government bonds
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 is 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
Product Value Proposition
A competitive product value proposition

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

killer attributes
attribute 2
attribute k-1
Business Proposal

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Business Value Proposition

Attractive market

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

market characteristics

the market
$xx \, n\%
$yy \, m\%
$zz

Year 1
Year 2
Year 3

top 3 competitors
$xx
abc
$xx
$xx
def
$xx
rpq

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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Business Value Proposition

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
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

$\text{cost}$

$\text{price}$

$3X$

$5X$

$\text{time}$
Revenue
Other possible sources

the value of goodwill?
strategic positioning?
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>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>gross profit</td>
<td></td>
<td></td>
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<tr>
<td>R&amp;D expense</td>
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<td></td>
</tr>
<tr>
<td>sales expense</td>
<td></td>
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<tr>
<td>gen. admin. expense</td>
<td></td>
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</tr>
<tr>
<td>NEBT (net earnings before tax)</td>
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<tr>
<td>interest exp.</td>
<td></td>
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<tr>
<td>taxes</td>
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</table>

Use 4-year time horizon

- **Price** × 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 - Σexpenses

**should be monotonic increasing**

**better be monotonic increasing**
Costs and Expenses

Examples

Income structure
fabricated metal
SIC 3499
(normalized to 100% of revenue)

Cost
materials, labor, overhead 69.7%

Expense SG&A
sales general and administrative 24.3%

Expense
R&D, interest, taxes 3.6%

Profit 2.4%
NEAT: net earnings or profit after taxes
# Revenue, Cost and Expenses

Estimate based on ratios

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

manufacturing cost = materials cost (at volume)

tax rate on earnings (NEBT) = 50%
Business Value Proposition

A viable business

Getting a handle on your return

but first

Determine your revenue, costs, expenses, and 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>Cost+Expenses</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>Mat’s and mfg.</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>SG&amp;A expenses</td>
<td></td>
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<tr>
<td>R&amp;D, interest, taxes</td>
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<tr>
<td>Total</td>
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</tbody>
</table>

Initial investment estimate: $l_0 = [\$CE_1] + [\$CE_2] + \ldots + [\$CE_b]$
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

<table>
<thead>
<tr>
<th>Cash Flow</th>
<th>$CF_0$</th>
<th>$CF_1$</th>
<th>$\cdots$</th>
<th>$CF_b$</th>
<th>$\cdots$</th>
<th>$CF_{k-1}$</th>
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<tr>
<td><strong>Revenues</strong></td>
<td>$T_0$ $</td>
<td>$T_1$ $</td>
<td>$\cdots$</td>
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<td>$T_{k-1}$ $</td>
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<tr>
<td><strong>Costs</strong></td>
<td>$\cdots$</td>
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<td>$\cdots$</td>
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Solve for $R$: 

\[
\frac{CF_1}{(1+R)^1} + \frac{CF_2}{(1+R)^2} + \cdots + \frac{CF_k}{(1+R)^k} - I_0 = 0
\]
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?
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**business value position (we can deliver that product)**
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market size $, and 3-year growth rate
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**We have a viable business**
IRR xx% with initial investment of $ xx
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But wait
There are different types of business proposals!

- patent & license (company, NGO)
- joint development
- toll manufacture (provide materials/components for a fee)
- contract manufacture (your label on product someone else makes)

- 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!

ROI chart in presentation?  likely not
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!
is 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