The dynamics of competition and the diffusion of innovations

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The question we are addressing....

A perplexing question is “why, when faced with superior new alternatives, do large and long lived competitors resist change?”

Venerable firms are actually often seen to continue investing in and improving older alternatives long beyond the point when that makes any economic or strategic sense
Why is diffusion important?

• Innovation = Invention + Diffusion
  • For ideas to matter, they must not only be reduced to practice but their application must also spread among users (‘adoption’)

• Dynamic modes of competition
  • Emerging technologies do not ‘just replace’ mature technologies
  • Very often displacement leads to new applications and broader use
  • (Symbiosis and Predator-Prey as well as Pure Competition)

US computer memory manufacturers (1970) A Class Project on Emergence

<table>
<thead>
<tr>
<th></th>
<th>Established Firms</th>
<th>New Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Memory</td>
<td>26</td>
<td>0</td>
</tr>
<tr>
<td>Plated Wire</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Thin Film</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Semiconductor</td>
<td>6*</td>
<td>7**</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>31</strong></td>
<td><strong>8</strong></td>
</tr>
</tbody>
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* includes IBM
** includes INTEL

Declining Plywood Sales Through 1980

Montrey and Utterback, 1990

A New Product OSB “More from Less”
Growth Rates Compared

Plywood vs Waferboard/OSB
Diffusion of technologies

• A more nuanced look at diffusion
  • Abandoning the idea of a zero-sum game between new and established practices

• Multi-mode interaction
  • Impact on growth rates
    • Symbiotic: + +
    • Pure competition: − −
    • Predator – Prey: + − [and − + + ]
    • Dynamic: Modes change over time
      • ‘Amplitude’ of interaction and sign

Modelling multiple technologies

• Modified Lotka-Volterra equations

\[ \frac{dN}{dt} = a_n N - b_n N^2 + c_{nm} NM \]
\[ \frac{dM}{dt} = a_m M - b_m M^2 + c_{mn} MN \]

This formulation can easily be generalized to model the interaction of multiple technologies

\[ \frac{dT_i}{dt} = a_i T_i + \sum_{j=1}^{J} s_{ij} c_{ij} T_i T_j \]

\[ T_i(t + 1) = \frac{e^{a_i T_i(t)}}{1 - \sum_{j=1}^{J} \frac{s_{ij} c_{ij} (e^{a_i - 1})}{a_i} T_j} \]
L-V Model used as a Class Exercise

Source: 15.365 E-Publishing Project by Ethan Mollick, Tron Helgesen and Jone Smedsvig. 2004

Plywood vs Waferboard/OSB

Residential Fixed Investment

Sales (billions of square feet)

Total sales

Residential fixed investment (billions of dollars)

Year

1964

1990

Plywood

(OSB)/Waferboard
Enter Matlab

- Matlab solution
  - Replaces the need for the iterative approach
  - ‘Quick and easy’ to run (also for multiple technologies)
  - Ability to estimate (coupling) coefficients
    - Amplitude (strength of interaction)
    - Signs of the coefficients
      - Indication of the mode of interaction
        Symbiotic
        Predator-Prey
        Pure competition

Note: The Matlab software will be made available as a resource

Contributions

- Main contributions
  - Developed a model for the diffusion of technology, which accounts for symbiosis, pure competition as well as predator-prey modes
  - The model can accommodate multiple technologies
    - Earlier models (such as Rogers and Norton/Bass) can be shown to be special cases
  - By relaxing the assumption of pure competition, the changing modes can be shown (calculated) as they evolve over time
Contributions (2)

• Main contributions (2)
  • Similarly, by relaxing the need to estimate a total market or niche a priori, market penetration can be calculated as time progresses
  • The model is readily path dependent, providing varying results depending on the starting point (as is evident in the phase diagrams)
  • An easy to use software package (based on Matlab) is made available publicly, that will enable other researchers to investigate more cases

Contributions (3)

• Main contributions (3)
  • Using this software, we analysed 50 years of data from the engineered wood products industry, and have shown a practical case of how the modes change in an expected pattern over time
  • Using data from 40 years of music recording we have illustrated the use of the L-V model in simulating an analog to digital product and business model transition

• Discussion
  • Areas for future work
A New Phase of Symbiosis?

A movement has started from the sale of panels of different sizes to the provision of larger parts and modules to be assembled into entire structures made of composite cellulose material.

The structures are seen as “aggressively green,” as being formed of sustainable materials and as sequestering large amounts of carbon. Some examples …

New approach to sustainable building takes shape in Boston

A five-story mixed-use structure in Roxbury represents a new kind of net-zero-energy building, made from wood.
Feature Story

The passive house that’s aggressively green

About Adoption and Diffusion

The Tall T3 Office Tower in Minneapolis.

“We’re past the tipping point in the acceptance of wood,” said Thomas Robinson, founder of the Portland, OR, firm Lever Architecture … “The people who are the innovators, looking for the next thing, a richer experience for their employees or how they live, they’re turning to mass timber.”

At the end of last year, the International Building Code was changed to allow wood buildings of up to 270 feet tall, or the equivalent of about 18 stories, from 85 feet. The United States code won’t adopt the revised standards until 2021, but some states will allow projects based on the new criteria to be submitted before then.


References

Source for the MatLab Code

- [https://github.com/yilmazerd/LVM](https://github.com/yilmazerd/LVM)