MIT MANAGEMENT SLOAN SCHOOL

The dynamics of competition and the diffusion of innovations

James Utterback

Calie Pistorius

Erdem Yilmaz

The question we are addressing….

MIT MANAGEMENT SLOAN SCHOOL

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

MIT MANAGEMENT SLOAN SCHOOL

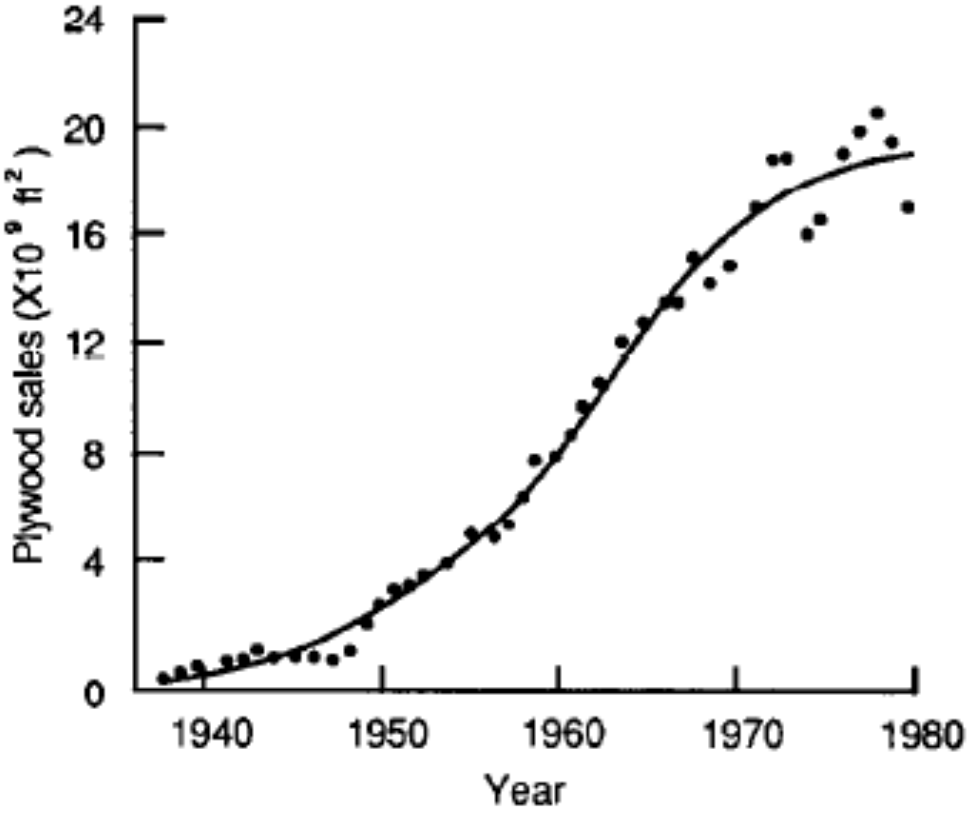
	Established Firms	New Firms
Core Memory	26	0
Plated Wire	8	0
Thin Film	5	1
Semiconductor	6*	7**
Total	31	8

* includes IBM

** includes INTEL

Source: J.M. Utterback and J. Brown, "Monitoring for Technological Opportunities," *Business Horizons*, October 1972.

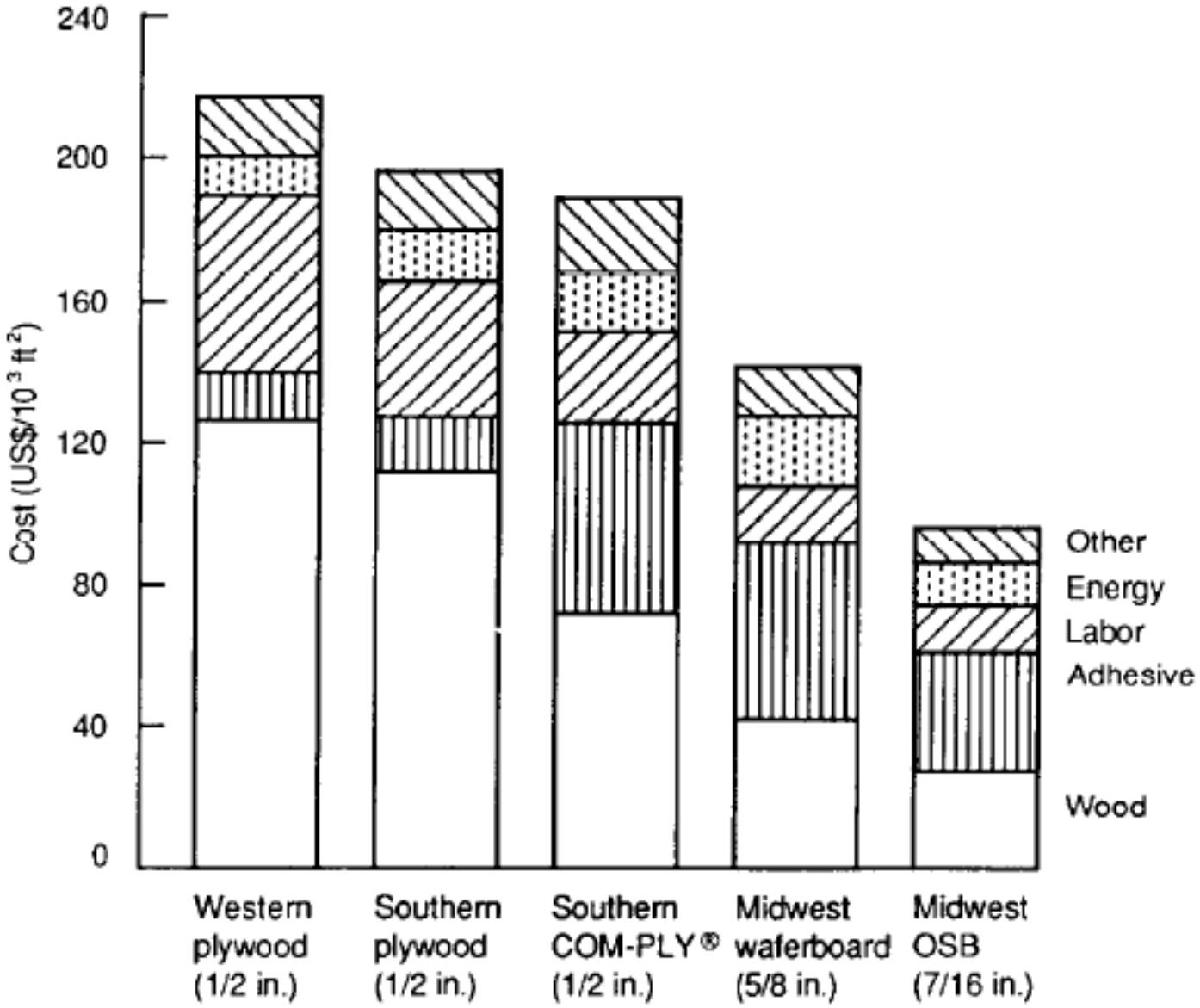
Declining Plywood Sales Through 1980



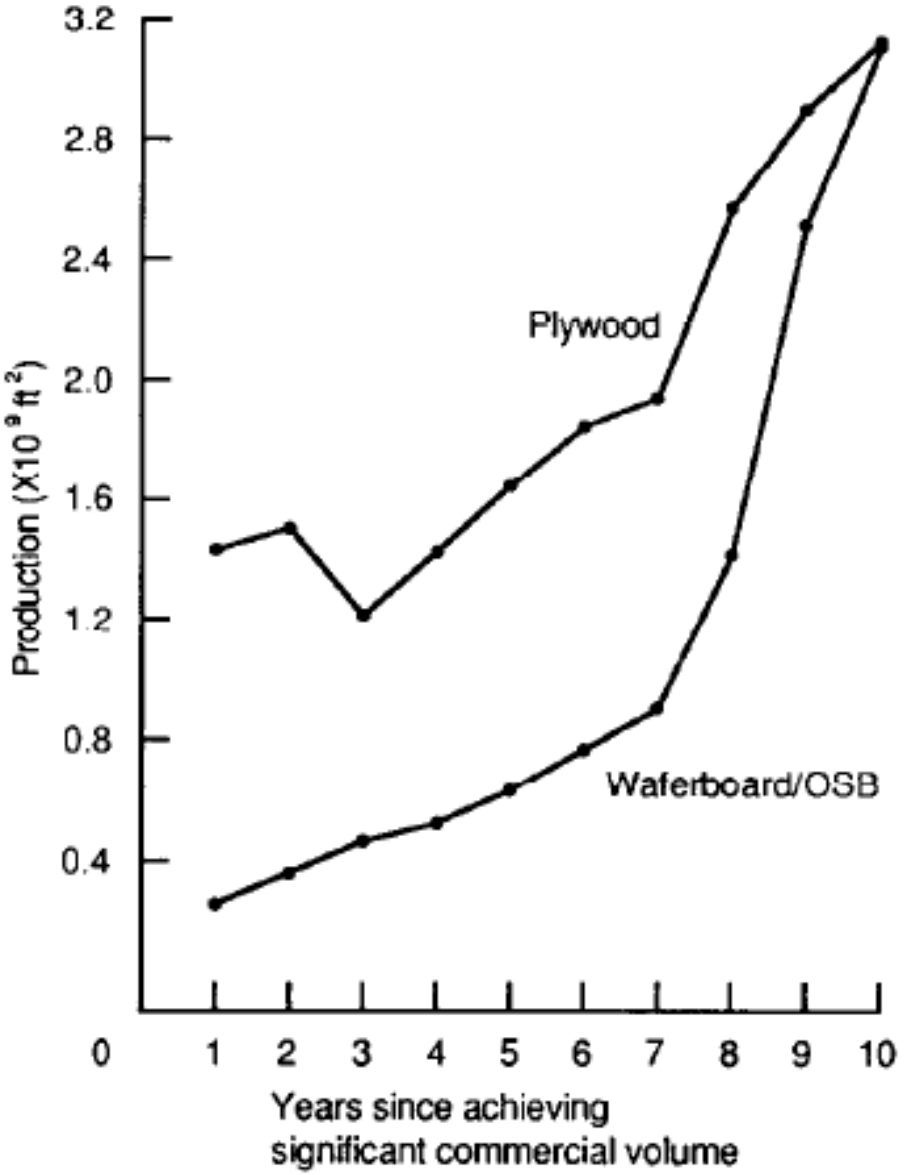
Montrey and Utterback, 1990

A New Product OSB "More from Less"

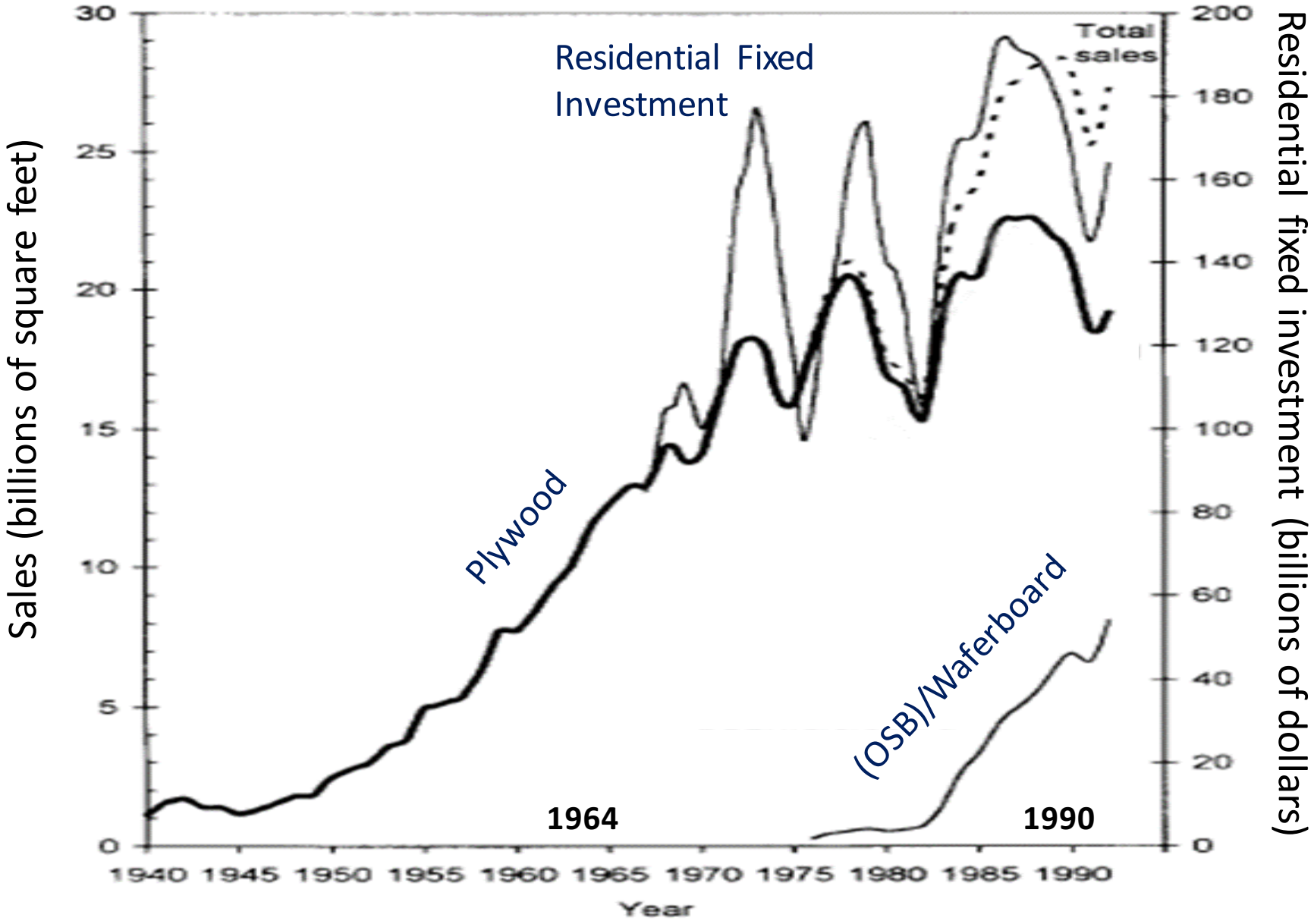
MIT MANAGEMENT SLOAN SCHOOL



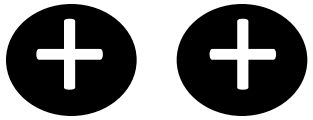
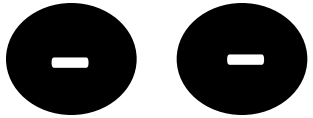
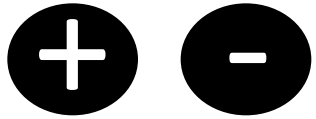
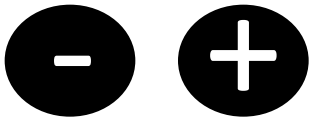
Growth Rates Compared



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

MIT MANAGEMENT SLOAN SCHOOL

- Modified Lotka-Volterra equations

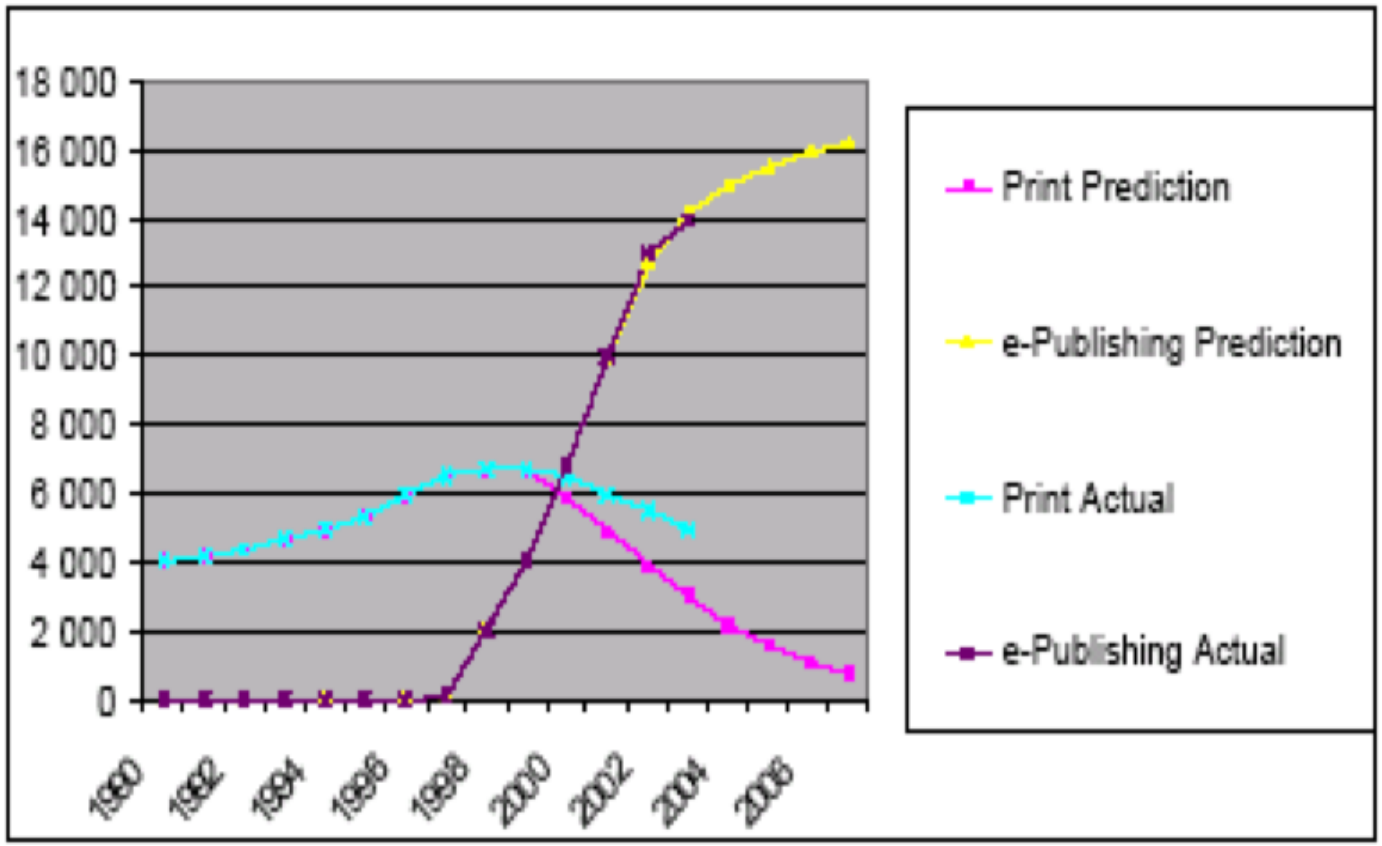
$$\frac{dN}{dt} = a_n N - b_n N^2 + c_{nm} NM \qquad \frac{dM}{dt} = a_m M - b_m M^2 + c_{mn} MN$$

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

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

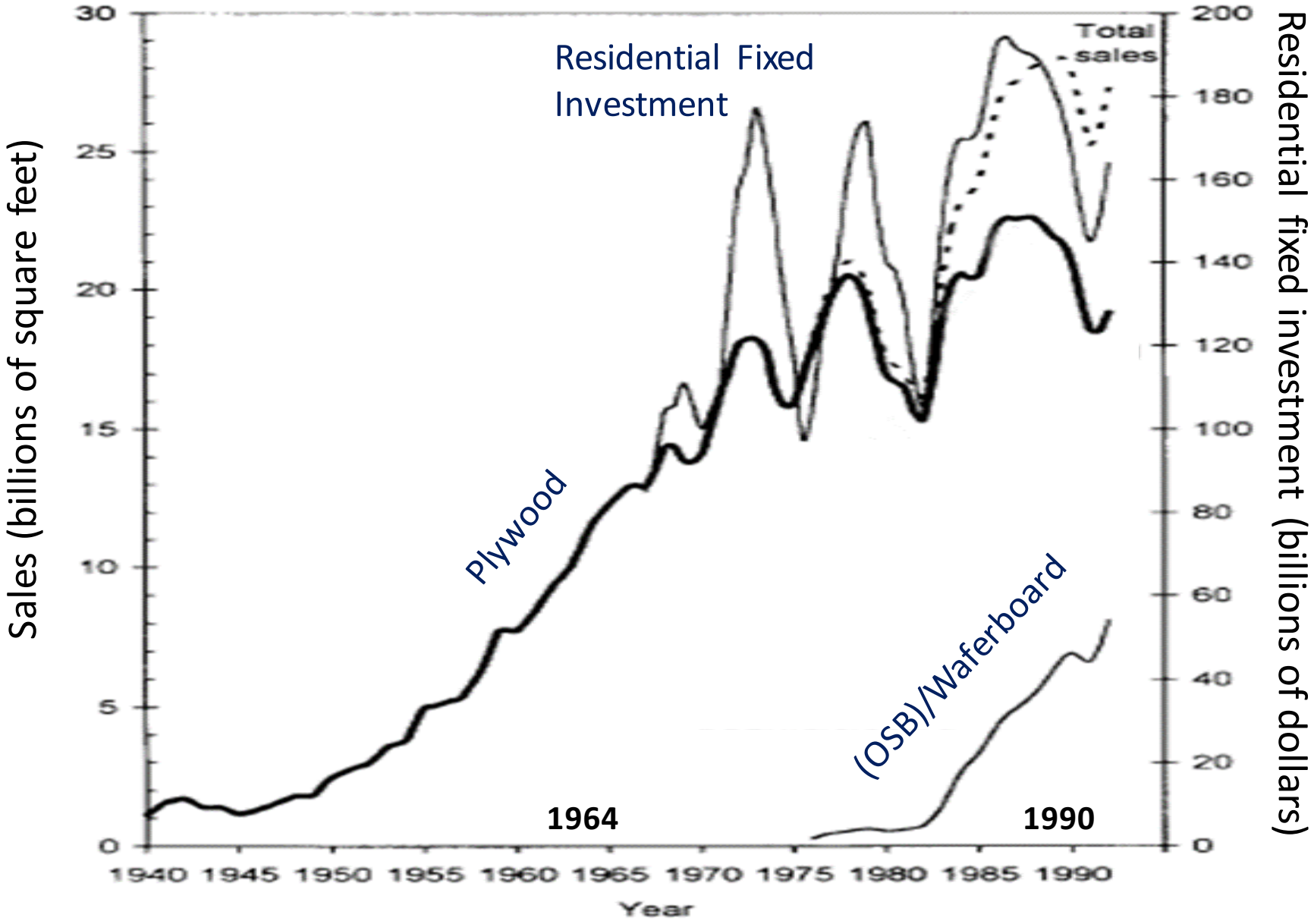
$$T_i(t+1) = \frac{e^{a_i} T_i(t)}{1 - \sum_{j=1}^{J} \frac{s_{ij} c_{ij(e^{a_i}-1)}}{a_i} T_j}$$

L-V Model used as a Class Exercise



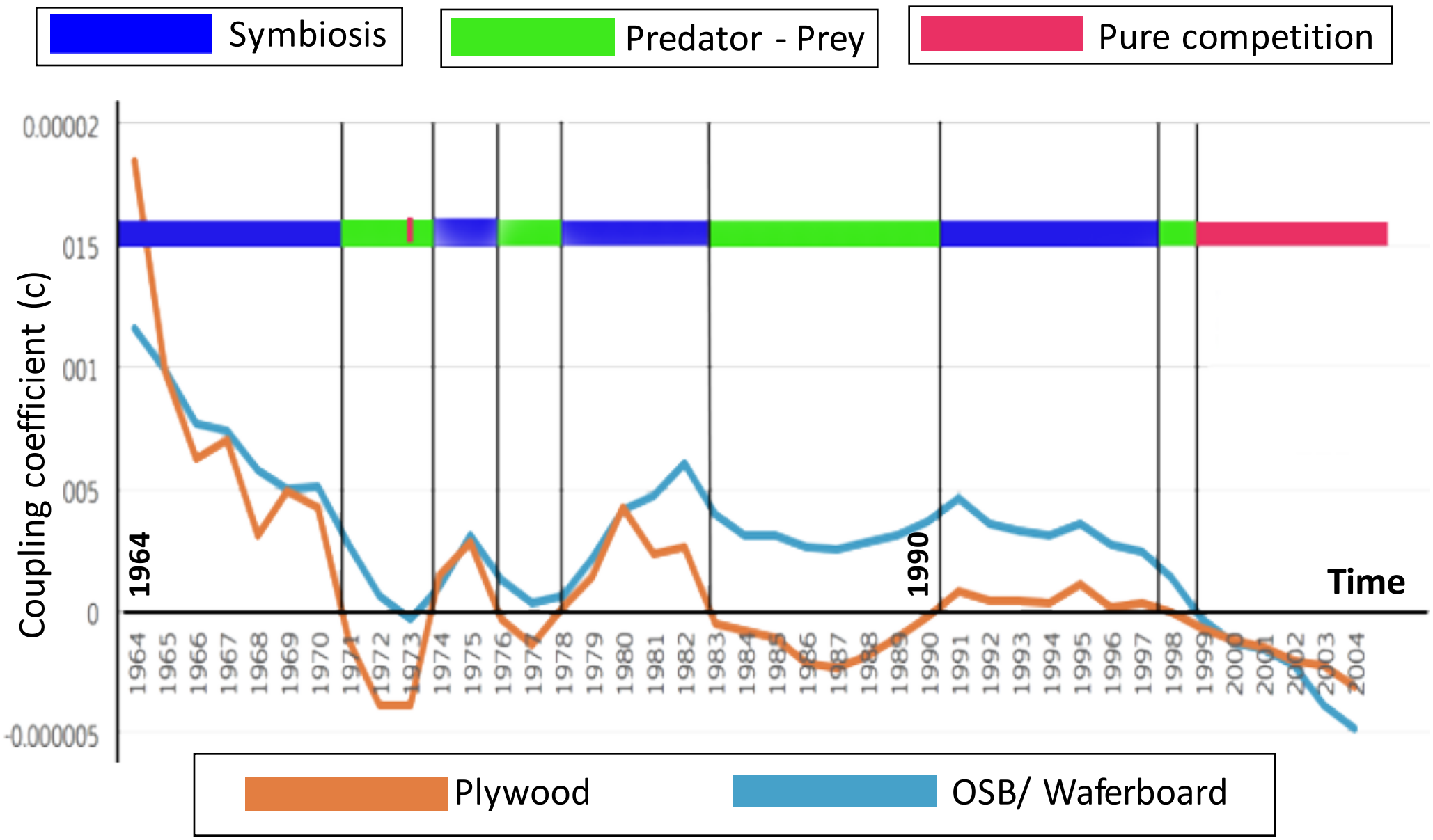
Source: 15.365 E-Publishing Project by Ethan Mollick, Tron Helgesen and Jone Smedsvig. 2004

Plywood vs Waferboard/OSB

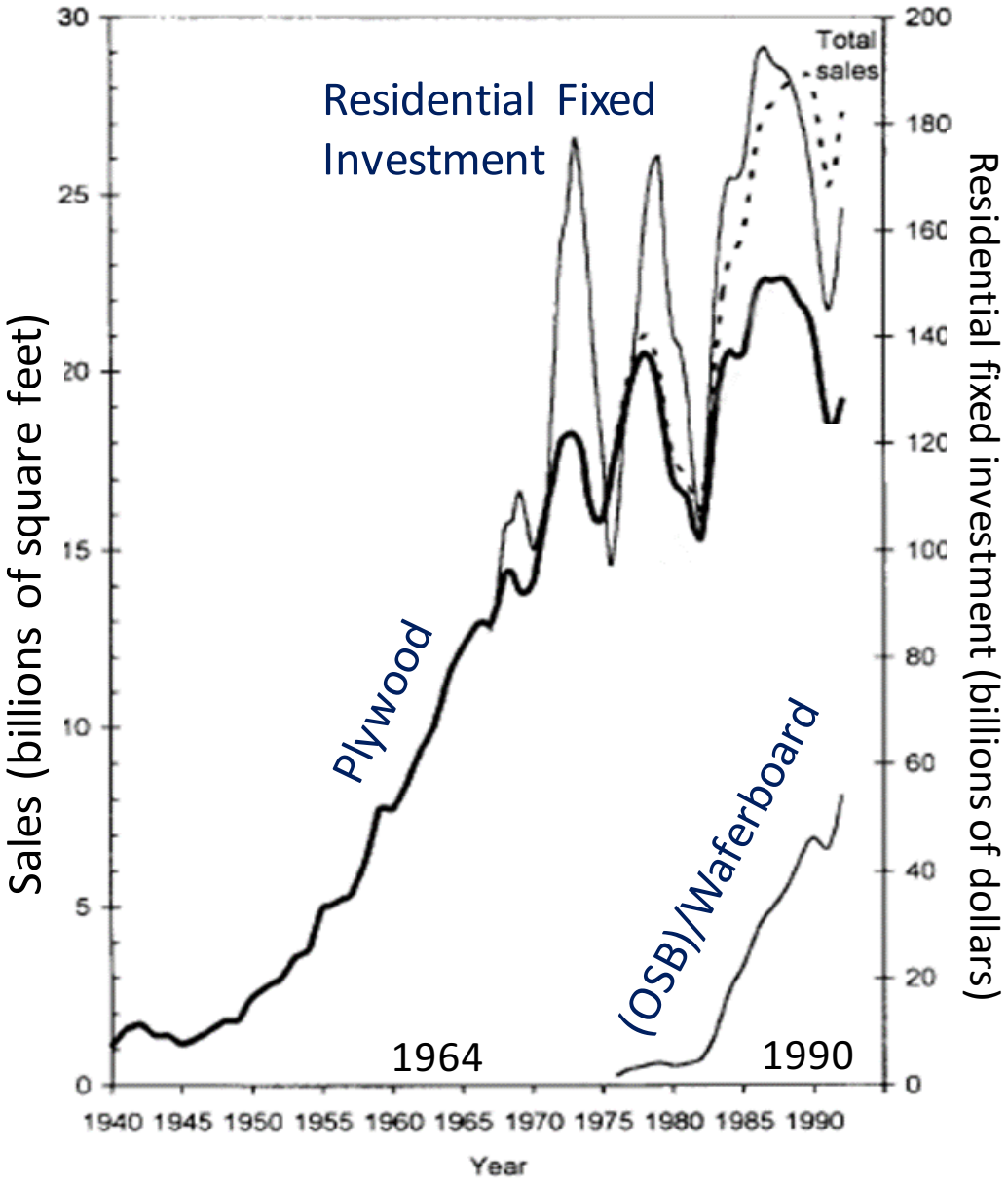


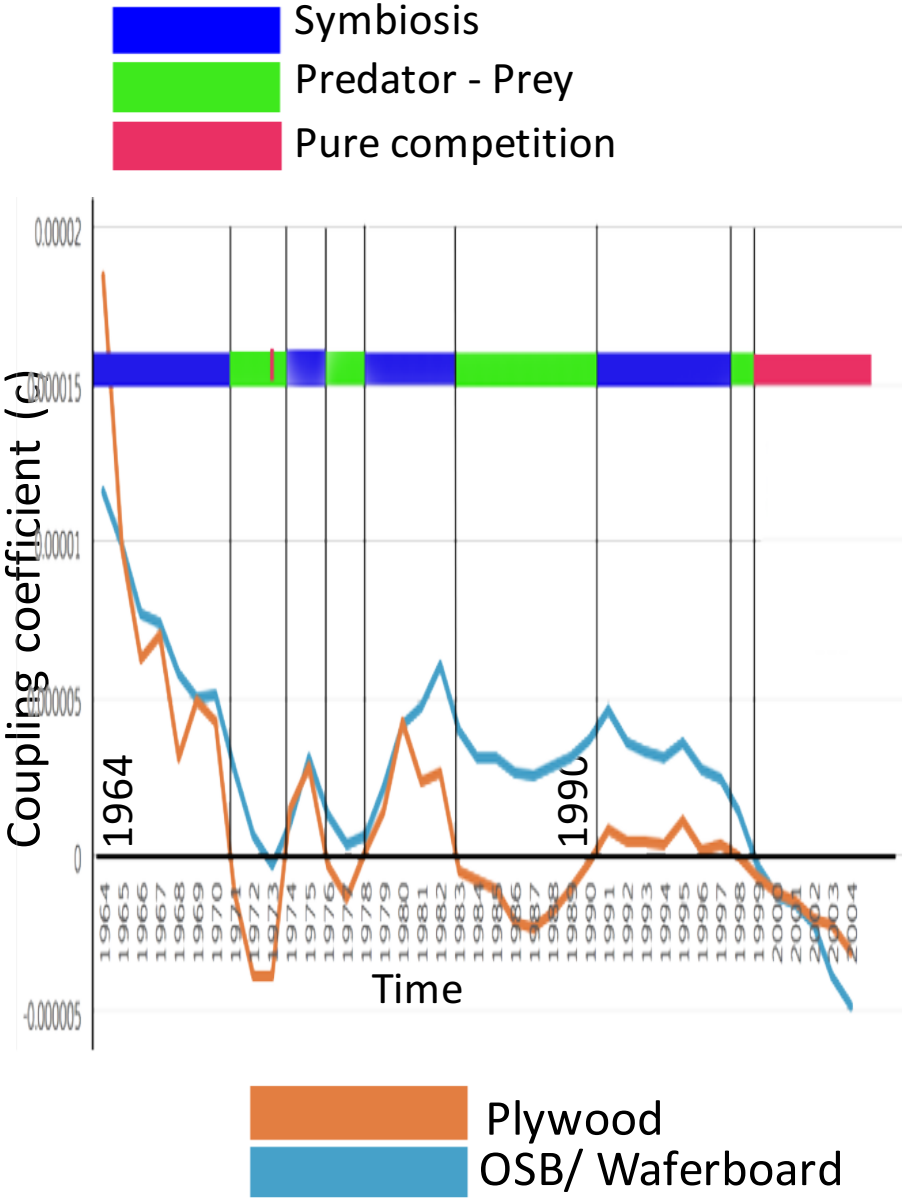
Plywood vs Waferboard/OSB (2)

MIT MANAGEMENT SLOAN SCHOOL



Plywood vs Waferboard/OSB (3)





Enter Matlab

MIT MANAGEMENT SLOAN SCHOOL

- 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

MIT MANAGEMENT SLOAN SCHOOL

- 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)

MIT MANAGEMENT SLOAN SCHOOL

- 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)

MIT MANAGEMENT SLOAN SCHOOL

- 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?

MIT MANAGEMENT SLOAN SCHOOL

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 …

Architect's rendering shows the new mass-timber residential building that will soon begin construction in Boston's Roxbury neighborhood.

Images: Generate Architecture and Technologies

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.

David L. Chandler | MIT News Office
March 4, 2020

RELATED

References

- James M. Utterback and James W. Brown, “Monitoring for Technological Opportunities,” ***Business Horizons***, October 1972, pp. 5-15.
- Henry Montrey and James Utterback, “Current Status and Future of Structural Panels in the Wood Products Industry,” ***Technological Forecasting and Social Change***, Vol. 39, No. 4, December 1990, pp. 15-35.
- Carl W. J. Pistorius and James M. Utterback, “The Death Knells of Mature Technologies,” ***Technological Forecasting and Social Change***, Vol. 50, 1995, pp. 133-151.
- Carl W. J. Pistorius and James M. Utterback, “Multi-Mode Interaction Among Technologies,” ***Research Policy***, Vol. 26, No. 1, March 1997, pp. 67-84.
- Carl W. J. Pistorius and James M. Utterback, “A Lotka-Volterra Model for Multi-Mode Technological Interaction,” ***Proceedings of the Fifth International Conference on the Management of Technology***, The University of Miami, Feb. 1996, Pp. 62-71.
- James M. Utterback, “Disruptive Technology: Predator or Prey?” invited “Distinguished Lecture” presented at the ***Academy of Management***, Seattle, Washington, August 4, 2003.
- Erdem Yilmaz, ***Technology Strategies for Transitioning from Products to Services***, MIT SM thesis in System Design and Management 2017

Source for the MatLab Code

- https://github.com/yilmazerd/LVM
- Erdem Yilmaz, *Technology Strategies for Transitioning from Products to Services*, MIT SM thesis in System Design and Management 2017