

CSI 500 Capstone Paper - Diffusion of Innovation

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In this research paper, we use ACM template in overleaf.com and Latex features for importing and displaying image files. The paper is about The Diffusion of Innovation theory, and examines the adoption of smart phone technology within a suburban community, seeking to understand the factors influencing early adopters' decisions to integrate these devices, particularly focusing on how perceived social influence and environmental concerns impact their adoption behavior; this paper investigates the key motivators behind early adoption of smart phone technology, specifically exploring How social norms and environmental consciousness play a role in the decision-making process among residents of a suburban neighborhood.

Research Questions:

How do social norms and perceptions of peer adoption influence the decision to adopt smart phone technology among early adopters in a suburban community?

What role does environmental consciousness play in motivating early adoption of smart phone devices?

What are the key factors that distinguish early adopters from later adopters in terms of their attitudes towards smart phone technology and environmental sustainability?

Methods and Data:

A mixed-methods approach was employed such as Python, R, and NetLogo, including in-depth interviews with early adopter residents and a survey distributed to a wider sample within the community to gather sale data on their attitudes towards smart phone technology- iPad, social influence perceptions, and environmental awareness.

Main Findings:

The research revealed that early adopters were significantly motivated by the desire to improve using mobile phone efficiency and perceived social pressure from peers who had already adopted smart phone technology, highlighting the importance of social influence and environmental concerns in driving early adoption. Using an iPad has several advantages that contribute to its popularity.

CCS Concepts: • **Social and professional topics**; • **Computing methodologies**; • **Applied computing**;

Additional Key Words and Phrases: Python, R, NetLogo, Diffusion of Innovation, Ipad sale prediction

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1 BACKGROUND

One of the pioneers in the field of Diffusion of Innovation was Robertson [1], later work in the field included Robertson (new version) [2] and Rogers [3].

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2 METHODS

The Diffusion of Innovation literature, primarily developed by Everett M. Rogers, is a social science theory that examines how new ideas, technologies, or practices spread through a population over time, outlining the factors influencing the rate and pattern of adoption within a social system, including the characteristics of the innovation itself, communication channels, and the different adopter categories within a population.

The model explains the initiation phase that motivates employees to explore new opportunities and the maintenance phase that forms a sustainable infrastructure, which are integrated into a coherent foundation for continuous improvement and excellence. We discuss the actions taken to create a supportable infrastructure to promote innovative behavior by employees and managers and analyze different aspects of innovation strategy[1]. Diffusion research has played an important role in helping put social structure back in the communication process. Network analysis and field experiments are promising tools in diffusion studies[2].

By using Net Logo agent-based model, Diffusion of Innovation was the same as the result when using Python with adjusted beta and gamma. People who adopted an innovation early have different characteristics than people who adopted it later. In Net Logo, simulating diffusion of innovation typically involves creating a network of agents (turtles) where each agent represents an individual within a population, and then programming rules that govern how these agents interact and influence each other to adopt a new idea, product, or behavior, often based on the "Diffusion of Innovation" theory, which identifies different adopter categories like innovators, early adopters, early majority, late majority, and laggards.

Key aspects of agent-based modeling in diffusion of innovation:

- a. Individual agents: Each person or entity in the system is represented as an agent with their own attributes like awareness of the innovation, attitude towards it, social connections, and decision-making rules.
- b. Agent interactions: Agents interact with each other within the simulated environment, influencing each other's decisions to adopt or reject the innovation based on their social connections, opinions, and perceived benefits.
- c. Emergent behavior: By simulating the interactions between individual agents, the model can produce complex, emergent patterns of innovation diffusion across the entire population, which may not be readily apparent from traditional modeling approaches.
- d. Heterogeneity: Agent-based models allow for the inclusion of diverse characteristics and behaviors among individuals, capturing the real-world variation in adoption rates and motivations.

3 DATA

In this section, we use show data of iPad sales, see table ??

By applying theta and gamma in R, we can model the transition among 3 class population. Beta is transition rate from potential to adopter, and gamma is transition rate from adopter to disposer. We setup the transition matrix by using a 3x3 matrix, insert our probabilities, express beta and gamma as constants so we can easily change them later. We iterate over the time range, compute change in population, update the current population, vector N, print messages for information and keep track of pop sizes for plots later.

Fiscal Quarter	iPad Sales (M Units)
Jan-10	0.00
Mar-10	0.00
Jul-10	3.27
Oct-10	4.19
Jan-11	7.33
Apr-11	4.69
Jul-11	9.25
Oct-11	11.12
Jan-12	15.30
Apr-12	11.80
Jul-12	17.00
Oct-12	14.04
Jan-13	22.86
Apr-13	19.48
Jul-13	14.62
Oct-13	14.08
Jan-14	26.04
Apr-14	16.35
Jul-14	13.28
Oct-14	12.32
Jan-15	21.42
Apr-15	12.62
Jul-15	10.93
Oct-15	8.88
Jan-16	16.12
Apr-16	10.25
Jul-16	9.95
Oct-16	9.27
Jan-17	13.08
Apr-17	8.90

Table 1. US iPad Sales from 2010 to 2017

4 RESULTS

Yes, population size (N) significantly impacts model behavior, particularly in ecological models, as it directly influences the intensity of competition for resources within a population, leading to changes in growth rate and overall population dynamics, especially when approaching the carrying capacity of the environment; larger populations generally experience slower growth due to resource limitations, while smaller populations can grow exponentially with readily available resources.

Yes, the rate of adoption is the pace at which a new technology is acquired and used by the public. This rate can be represented by the number of members of a society who start using a new technology or innovation during a specific period of time. The rate of adoption is useful for making comparisons. Does the disposal rate γ seem to make any difference in the model behavior? Yes, in a series of diffusion studies across multiple areas, Rogers found that innovations that have these 5 characteristics -high relative advantage, trial-ability, observability, and compatibility,

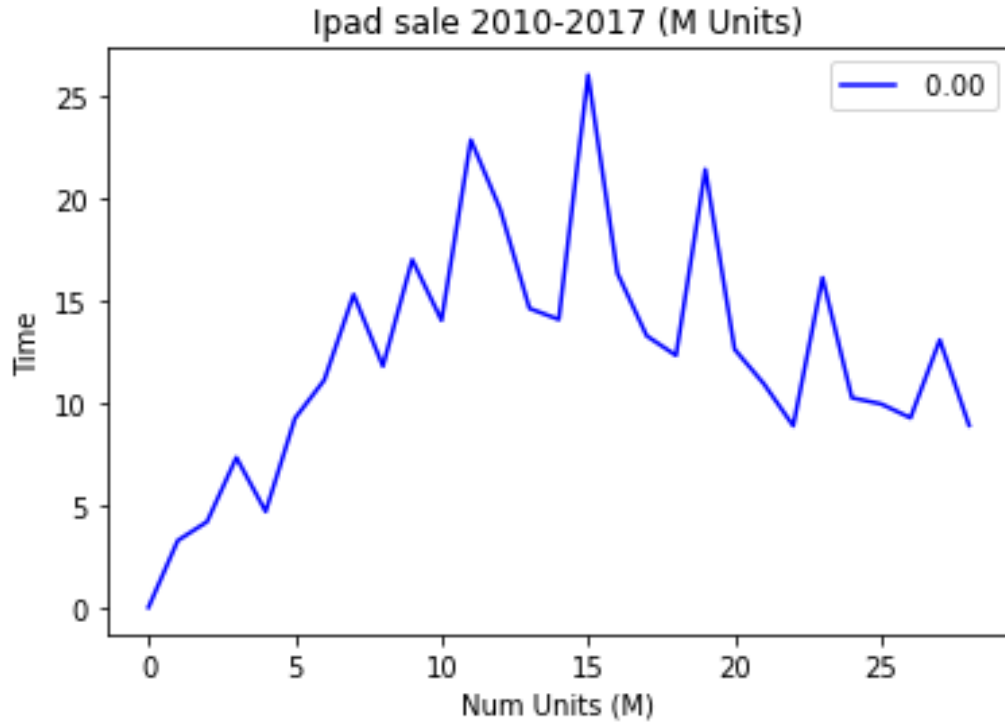


Fig. 1. The sale numbers of iPad between 2010 to 2017 in million units by using Python.

and low complexity- are likely to succeed over innovations. The disposal rate γ seem to make a difference in the model behavior.

Yes, Researchers have found that people who adopt an innovation early have different characteristics than people who adopt an innovation later. The new product/service must fit within the established norms and values of individuals' social system. The final element—time—is the fourth element of the diffusion process. Time refers to length of time until the introduction and an individual or firm adopts a new product/service.

Yes, it is used to predict new product diffusion patterns. It is based on a mathematical model to predict new product adoption patterns adopted in a market. I'm part of a campus iPad pilot. Proposing a good pedagogical use for the technology wasn't difficult. What has been difficult is being a good steward of my new gadget; pilots are meant for guiding decisions about more widespread adoption, after all. Today's traditional-aged college students are "digital natives"—comfortable with languages, behaviors, and aptitudes inherent to social media. They value technological mobility, and consider digital multitasking part of their DNA. Those babies using iPad seems to suggest what these students will be like—not to mention breed anxiety for college administrators. The iPad has become iconic in these discourses. With most colleges facing severe budgetary constraints, it's common to treat students as fickle customers, even while racking our brains trying to maintain quality and integrity.

By creating model the transition, we developed a transition matrix that shows movement from Potential to Adopter, and from Adopter to Disposer. By varying the key flow rates Beta and Gamma, we can change the shape of the diffusion curve to adopt the real time sale of iPad between 2010- 2017.

By using the random mixing model in NetLogo, it shows the expected proportion of adoption. This however can be a greatly limiting factor and many similar models have been abandoned.

By using agent base model in NetLogo, the early adopters of the new adopters seeds tended to be growing consumers with more highly educated technology. Larger ages are more able to take on increases risk of loosing their loyalty, and more education may contribute to a better understanding of the potential pay off.

A NetLogo agent-based modeling approach simulates the spread of a new idea or product by representing individual actors (agents) within a system, allowing for complex interactions and decision-making at the individual level, which can reveal emergent patterns of adoption across the population, unlike traditional aggregate models that only look at overall trends; this approach is particularly useful for exploring how factors like social networks, personal characteristics, and environmental context influence adoption rates.

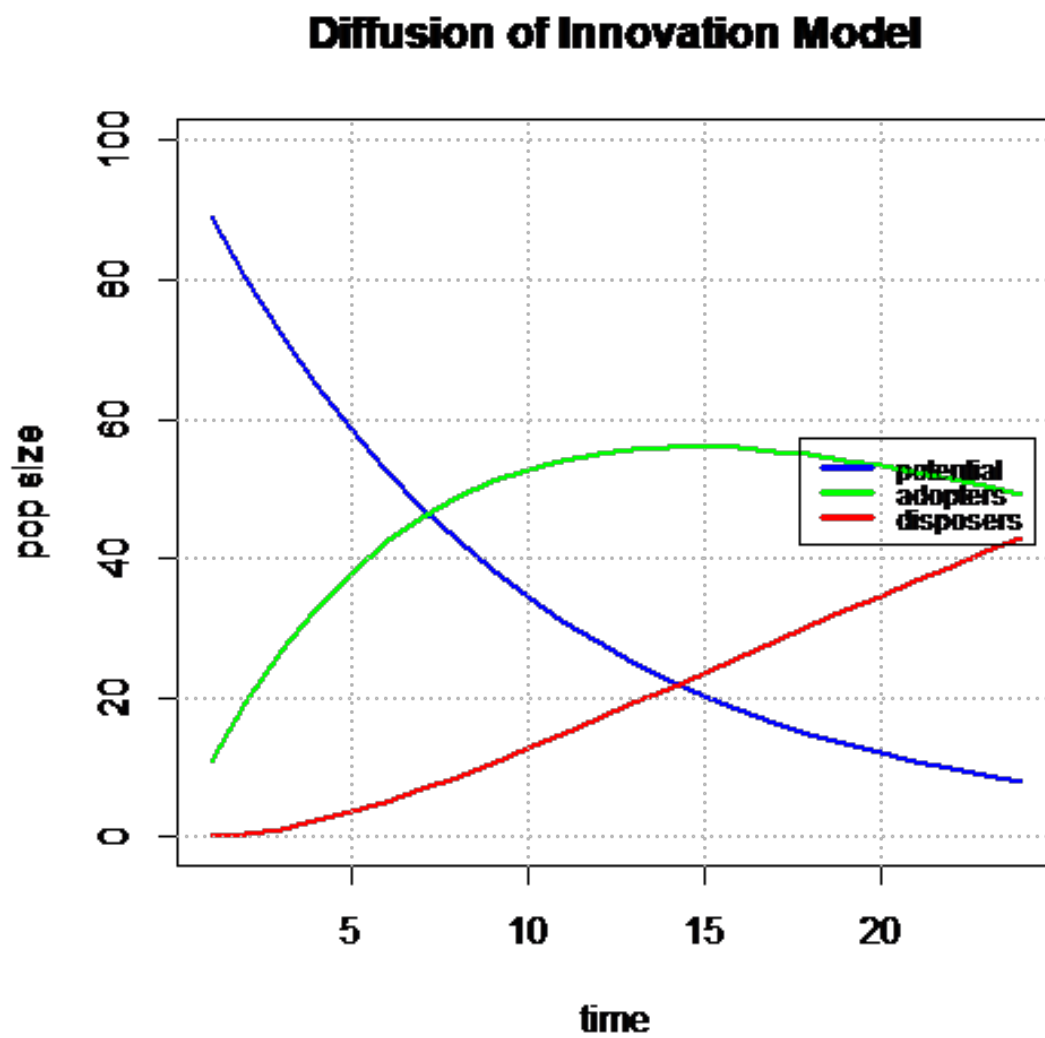
5 DISCUSSION

Benefits of using random agent-based models in diffusion of innovation research is that:

- Detailed analysis of individual decision-making: By simulating the decision process of each agent, researchers can gain insights into the factors influencing adoption at the random individual level.
- Exploration of complex social dynamics: Agent-based models can incorporate social network structures and influence mechanisms to study how social ties impact innovation diffusion.
- Testing policy interventions: Researchers can use simulations to evaluate the potential effects of different policies aimed at accelerating or slowing down the adoption of an innovation.
- Modeling the spread of new technologies in a community: Simulating how adoption of a new technology like iPod then smart watch use might spread through a neighborhood, school system, teenagers, social media based on social interactions and perceived benefits.
- Investigating the role of opinion leaders in innovation diffusion, examining how influential individuals like influencers, stokers, within a social network can impact the adoption of a new product or idea.
- Analyzing the impact of marketing strategies on adoption rates: Testing different marketing campaigns within a simulated environment to see how they influence consumer behavior.

6 CONCLUSIONS AND FUTURE RESEARCH

While individual preferences and needs vary, the combination of user experience, ecosystem integration, security, app quality, performance, and design makes the smart phone technology - iPad - a compelling choice for many users. Diffusion is the process of movement of molecules under a concentration gradient. It is an important process occurring in all living beings. Diffusion helps in the movement of substances in and out of the cells. The concept of peer networks is important in the Diffusion of Innovation theory. It is the critical mass achieved through the influence of innovators and early adopters who serve as opinion leaders that sparks the initial "take off" point in the innovation adoption process. By utilizing the diffusion of innovation theory, firms can predict which types of consumers will purchase their product/service and create effective marketing strategies to push acceptance through each category.



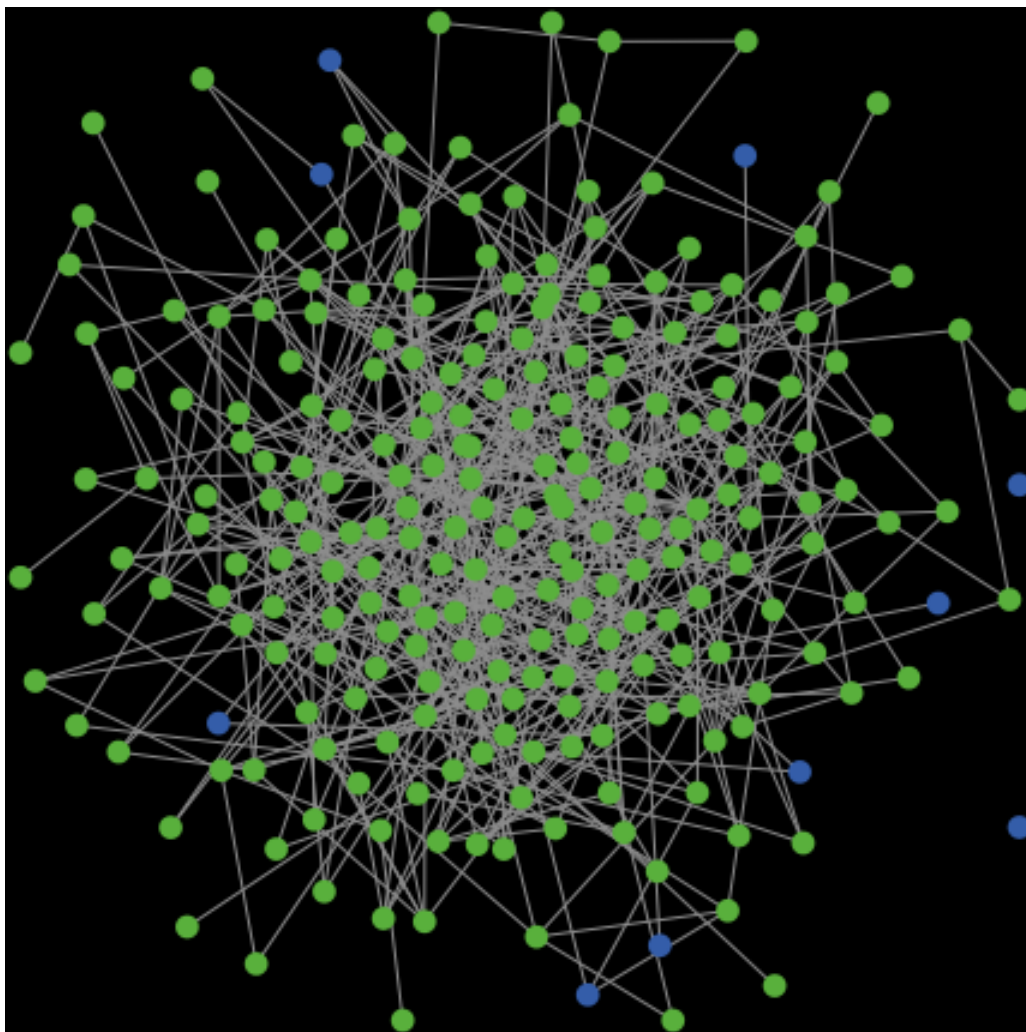


Fig. 3. Random Mixing or Social network DOI mode view by using NetLogo

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