New McDonald: An Agent Based Probabilistic Choice Model of Patented Method Usage for Farming

Robert Moulder[1] and Luis Sanchez[2]

[1] University of Virginia,
Department of Psychology
Charlottesville, VA
[2] Instituto Politecnico Nacional
Department of Economics
Mexico

Abstract. This is a research report as part of the Graduate Workshop in Computational Social Sciences 2016. The objective is to build an agent based model for a hypothetical scenario with two farmers: one with a patent controlled means, and the other farmer with non-patent controlled means, from an economic perspective, i.e., the assumptions of the model and its interaction with an agent- consumer are price- based and for the simplicity sake the definition of patent controlled means is limited. The structure of the work is as follows:section 1 introduces our rational, section 2 introduces the formalization of the model, the results of this model are presented in section 3, conclusions and future directions are presented in section 4, and section 5 presents all figures.

1 Introduction

For this assignment we were tasked with modeling a system where individual farmers can use either patent-controlled methods (PC) or otherwise (Non-PC) to operate their farms. We choose to develop and agent based model of farm choice where farmers choose to switch between these methods with a certain probability. We believe that this probability would not just be influence by the farmers themselves, but also by how consumers choose to shop between farms using these methods. We believe that this best represents the real behavior of individuals in a farmer/consumer market system. We believe that based on these individual interactions between many farmers and many consumers that a given method preference will emerge for different properties of each farming method, farm type, and consumer.

2 Probabilistic Choice Model of Method Preference

In order to model the popularity of PC vs. non-PC methods, we created a probabilistic choice model based on the theoretical functions

$$P_f(Switch) = f(U_f, E) \qquad U_f = f(C, Price, PriceSwitch) \tag{1}$$

$$P_c(Switch) = f(U_c) \qquad U_c = f(Attr, Price) \tag{2}$$

where $P_f(Switch)$ is the probability that a farmer switches production method from their current method to the competing method, U_f is the utility a farmer gains by using their current method, E is the percent efficiency for which a farmer can produce a certain method, C is the number of consumers using the same method as the farmer, $Price$ is the price of a crop sold using a particular method, and $PriceSwitch$ is the price a farmer must pay to switch methods. Similarly, $P_c(Switch)$ is the probability that a consumer switches from buying goods from one kind of farm to another, U_c is the utility a consumer gains from buying from their currently chosen farm type, and $Attr$ is the percent of attractiveness a consumer has towards buying from their currently chosen farm type.

We choose to model these function as

$$P_f(Switch) = (1 - (U_f * E)) * (1 - \frac{C_c}{C_t}) \qquad U_f = \frac{(C_c * Price) - PriceSwitch}{C_t * Price} \tag{3}$$

$$P_c(Switch) = (1 - U_c) \qquad U_c = Attr * (1 - \frac{Price}{TotalPrice}) \tag{4}$$

where $TotalPrice$ is the sum of the price of a good from a PC farm and a good from a non-PC farm. We then created both farmer and consumer agents in an R script which had these qualities and recorded the number of farmers and consumers in each class of farm (PC or non-PC). We also employed a uniform random number generator from 0 to 1 for each agent at each step of our model. If at any step in our simulation $P(Switch)$ is greater than this random value then the agent switched method preference.

3 Settings for the Model

For building this model, the following categories were considered:

3.1 Constraints

- Many patented farming methods are from a class of production known as genetically modified organic food. Some individuals claim that these methods can produce collateral damage to other farm types. Given the lack of strong concluding and validated empirical evidence although the absence of evidence is not evidence of absence- we assume that patent controlled means do not produced collateral damage.

- Consumers have an unrestricted endowment, though their consumption keeps constant through time.

3.2 Agents

- Farmers: we consider two kind of farmers: farmers who use patent controlled means (PC) for farming and farmers who use non-patent controlled means (non-PC).

- Consumer: one representative consumer.

3.3 Rules

- Farmers can move between methods at will.

- Consumers can choose between farms at will.

3.4 Behaviors

- Consumers are price and utility sensitive.

- Farmers are profit and utility sensitive.

4 Results

We created an R Shiny app (https://robertgm111.shinyapps.io/FarmAgentApp/) for our agent based models. We then ran multiple agent based models while varying the number of agents starting in each type of farm, number of consumer agents for each type of farm, consumer attraction to a method, price, and method efficiency. We then recorded the progression of method preference over time. For the purposes of this model, we assumed that PC methods always had higher price and efficiency when compared to Non-PC methods. For initial values we assumed 100 farmers (50 PC & 50 Non-PC), 100% attractiveness for both methods, 50 consumers (50 PC & 50 Non-PC), PC price of 10, Non-PC price of 8, PC production efficiency of 100%, and Non-PC efficiency of 80%, and a cost of switching methods of 2.

4.1 Modulating Price

For these initial values, we see that farmers tend to choose the PC method as they can sell at a higher price, while consumers tend to choose the lower priced method, Fig.1.

When we increased the price of the PC to 15 consumers strongly preferred to buy from the lower priced Non-PC method while farmers choose to prefer the PC method as a proportion of consumers large enough to justify this behavior still bought at this higher price, Fig.2.

4.2 Modulating Efficiency

We dramatically lowered the efficiency of Non-PC methods to 40% and saw that customer preference did not change but farmers increased their likelihood of choosing the PC methods, Fig.3.

4.3 Modulating Attractiveness

We lowered attractiveness of the Non-PC method to 8o% (i.e., same attractiveness ratio as the price ratio of the two methods) and observed that the system became much harder to predict due to consumers now more randomly choosing which method they prefer, Fig.4.

5 Conclusions

According to the simulations presented in this paper, we find it is remarkable that the feature consumer price sensitive keeps consistent with the logic of a conventional economic model. Producers want to use the method which makes them the most money while consumers choose the method which gains them the most utility. Although it is important to keep our constraints; if we change the impact or possible collateral damage to the consumer's health, fixed the initial consumer endowment, or added a different risk preference for each consumer. Although this model has been applied to farming method preference, this method is a general model which could be applied to: spreading rumors, name brand loyalty, regulation policies, and heterogeneous consumers.

6 Figures

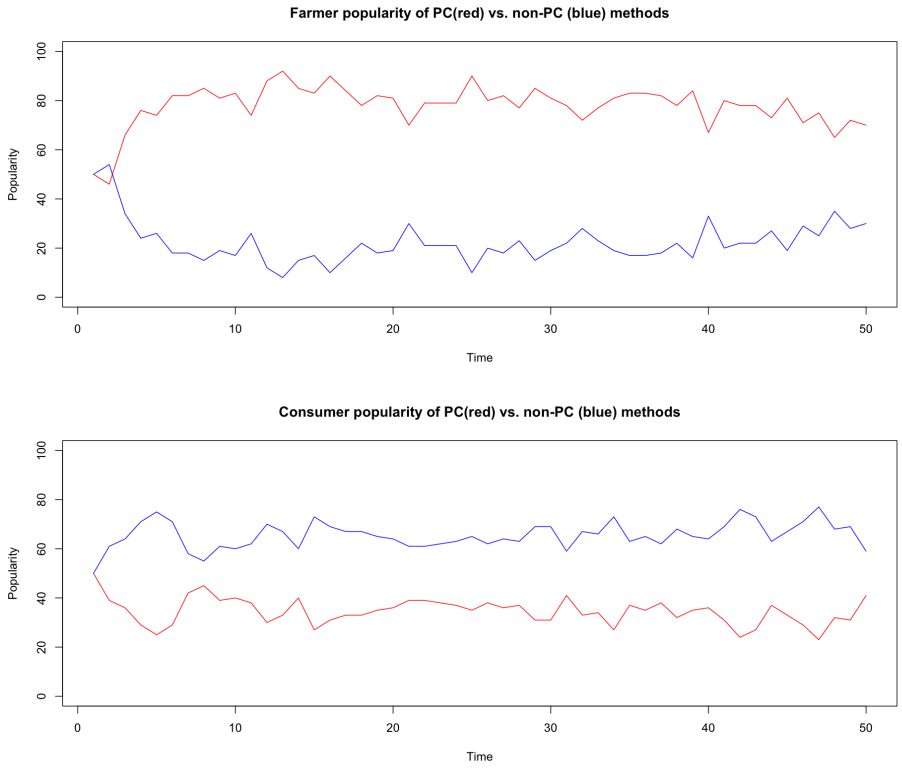

Fig. 1. Popularity of PC vs. Non-PC methods by farmers and consumers at initial conditions

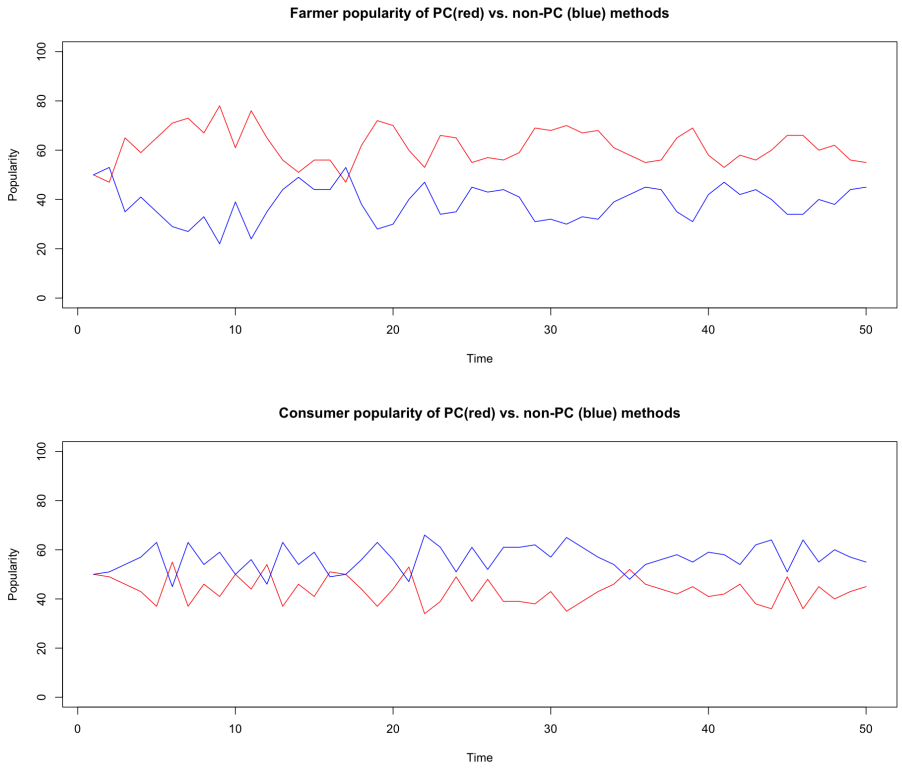

Fig. 2. Popularity of PC vs. Non-PC methods by farmers and consumers with PC price = 15

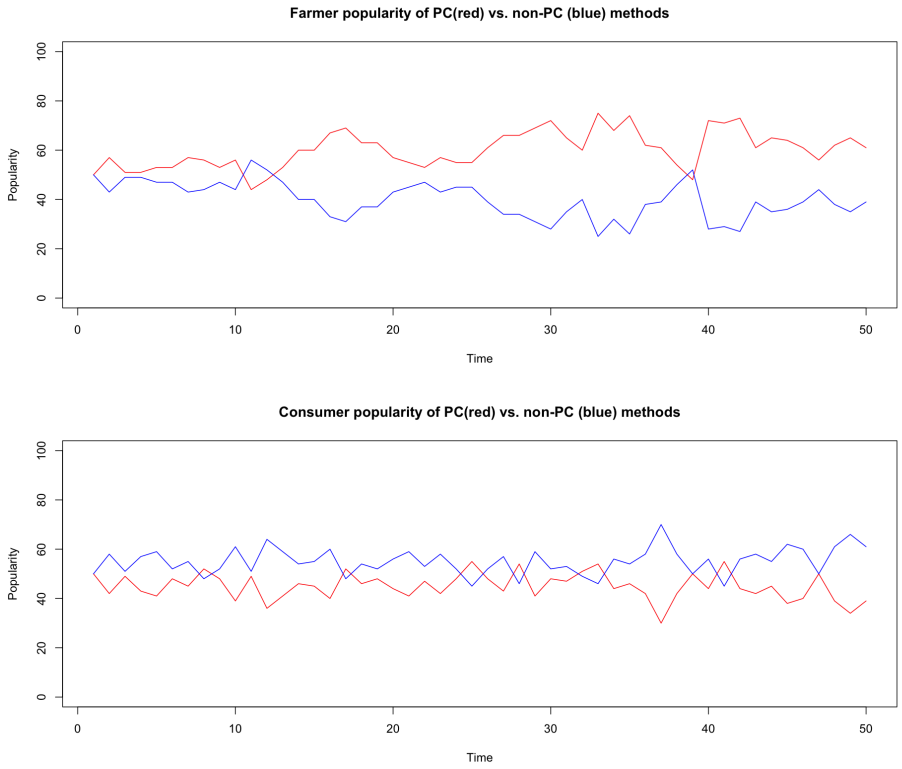

Fig. 3. Popularity of PC vs. Non-PC methods by farmers and consumers with Non-PC efficiency = 80%

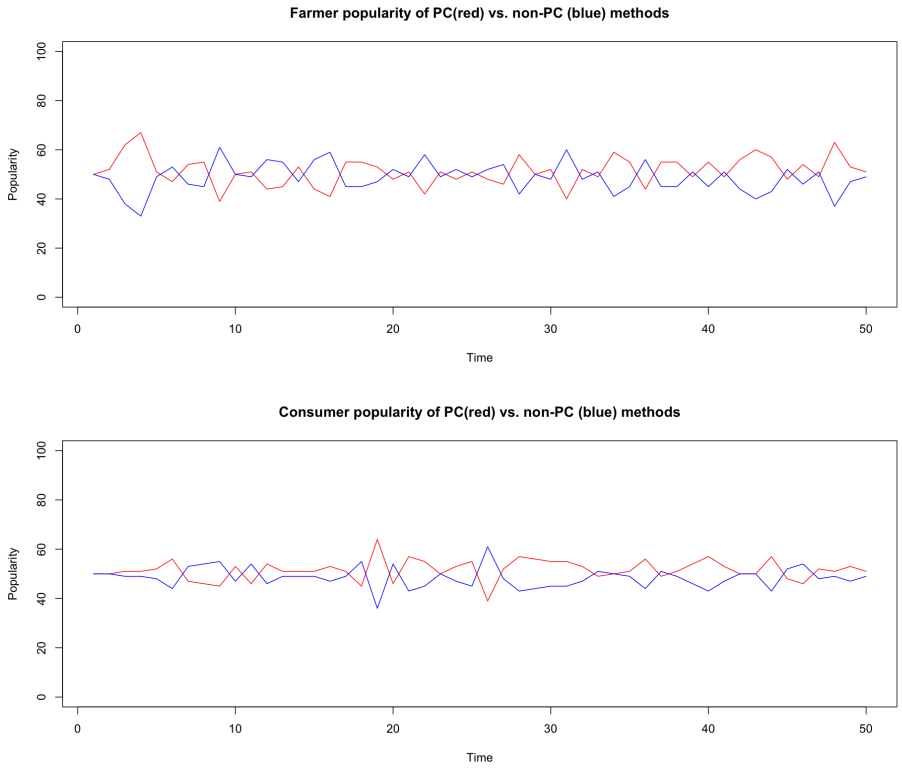

Fig. 4. Popularity of PC vs. Non-PC methods by farmers and consumers with Non-PC attractiveness= 80%