Remove or Retrain Agent Model Description

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1 Introduction

As customers become more aware of modern slavery there is increased incentive for organisations to ensure that their supply chain is ethically staffed. Buyers have three possible responses to discovering slavery in their supply chain: 1) ignore it, 2) remove the supplier, 3) fix the supplier by requiring them to undergo some sort of retraining or other rectifying process.

Remove.nlogo is an agent-based model of a supply network which can be used experiments on Remove versus Retrain. We use middle knowledge to create strong experiment controls. Middle knowledge allows us to control all variables during data collection and means we do not need to use a multivariate analysis approach such as linear regression. This in turn means there is no unwanted statistical bias. Middle knowledge uses the nature of agent-based models and the ways computers generate random numbers to run two or more identical simulations where only the treatment variable is varied. It creates pairs or higher sets of observations that can be compared robustly. In the model, at a point in a run before a certain choice is taken, the model state is saved along with all random numbers that will later be used. Choice A is made (the choice being to use the remove strategy) and the results are observed; the model is then ‘rewound’, Choice B is made instead (to use the retrain strategy) and again results are observed. Note that this is subtly different from—and analytically stronger than—running the model again repeatedly with different parameter values each time. Here two identical situations are created with only one difference, the choice of A or B. A paired statistical test can then be used without the need for any statistical controls.

1.1 Experiment conditions and parameters

There are five parameters that give the model runs variability: s, r, t and the number of buyers and suppliers. The first, s is the probability that a company uses slavery and is used as a proxy for the prevalence of slavery in an industry–we can create a more unethical industry by setting a high s. The second, r is the percentage of Tier 1 suppliers that a buyer is prepared to remove when using the remove strategy before they switch to retrain, acknowledging that a buyer cannot remove all its suppliers. The last, t is the probability that retraining a supplier actually works and convinces it to 1) remove slavery from itself and 2) audit its own Tier 1 suppliers.

1.2 The model

One model run is as follows:

1. A number of tiers is randomly chosen. This dictates the length in tiers of all supply chains.
2. Buyers are instantiated and given a random amount of an end product that they want to buy.
3. Suppliers are instantiated and randomly given a supply chain network tier, a capacity (the maximum amount of a material they can sell) and a binary ethical position, with unethical having probability s.
4. Buyers start placing orders with Tier 1 suppliers. Orders will be placed with as many suppliers as are needed to buy the required amount of the product.
5. Tier 1 suppliers will then place orders with Tier 2 suppliers to buy in the amount of materials they need to fulfill their orders with buyers.
6. This continues with Tier 2 buying from Tier 3 and so on for the selected number of tiers.

For convenience the size of the orders are such that 1 end product purchased by a buyer will require 1 material from Tier 1, which will require 1 material from Tier 2, which will require 1 material from Tier 3 and so on for the length of the supply chain. This is illustrated in Fig 1. We assume that all products supplied in a tier are identical. Steps 1 through 6 could create buyers who did not manage to create a complete supply chain (they might not be able to find a Tier 4 supplier for example). This is illustrated in Figure 2 and if it happens that chain collapses and is removed from the supply chain network. There are practical problems with doing this in the real world; how these have been solved in the agent model are explained in Figure 3.

7. When all orders are placed a buyer is chosen at random to conduct an audit of their Tier 1 suppliers. At this point the model state is saved so that middle knowledge can be used.

8. The buyer starts with the remove strategy. Any supplier found to be acting unethically is removed along with all of their suppliers. If this happens the buyer attempts to replace them using the procedure described in Steps 1-6. The buyer will then continue to remove unethical Tier 1 suppliers, repeating this process until $r\%$ of their Tier 1 suppliers have been removed. After this the buyer switches to a retrain strategy: any unethical suppliers will be required to undergo retraining. Any suppliers that are retrained will with probability t become ethical. Ethical suppliers will audit their own Tier 1 suppliers (which is the buyer's Tier 2) using the same process described in this step (starting with remove and if necessary switching to retrain). This continues throughout the supply chain. The output is recorded.

9. The model is then reset to the saved state and run again. This time the buyer uses the retrain strategy. It forces unethical Tier 1 suppliers to retrain which succeeds with probability t. Successfully converted unethical suppliers audit their own Tier 1 and so on through the supply chain. The output is again recorded.

The dependent variable is the number of players in the supply chain network that act ethically, ethical count. The independent variable is a binary variable – the strategy, remove or retrain. A typical analysis strategy might be a linear model to test the IV impact on the DV including suitable controls, something like:

*ethical count = coeff1 * strategy + coeff2 * r + coeff3 * s + coeff4 * t + error*

By using middle knowledge we can discard all of the control variables and still produce an accurate estimate for coeff 1, the standard error and a p-value to test whether the coefficient is different from zero (the above regression model would also produce a theoretical intercept value but this would have no meaning with a binary DV).

The output is created in a file called RResults.txt. To calculate the coefficient produce the mean ethical count under the remove strategy minus the mean ethical count under the retrain strategy. The standard deviation of the ethical count under the remove strategy minus the ethical count under the retrain strategy is the standard error. A p-value can be generated from a correlation test.

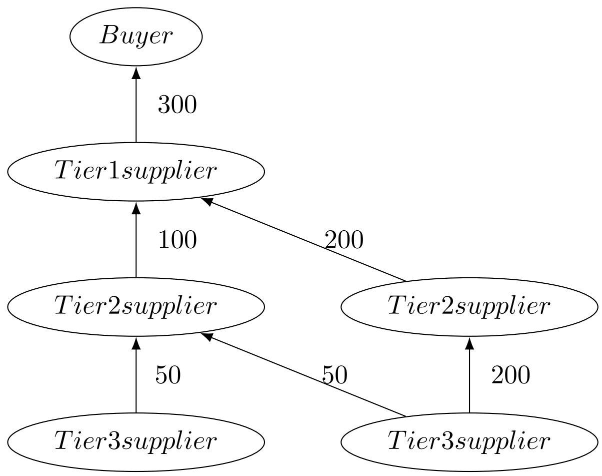

Figure 1: A single supply chain.

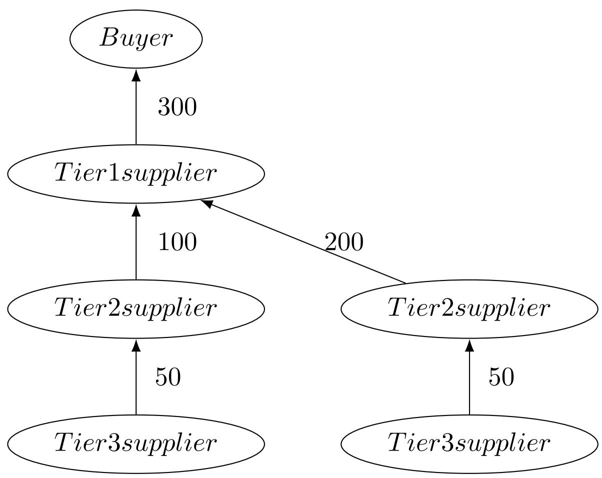

Figure 2: If simulated, this chain would collapse. However if a buyer does not get everything they want or a supplier isn't using their full capacity, it would not.

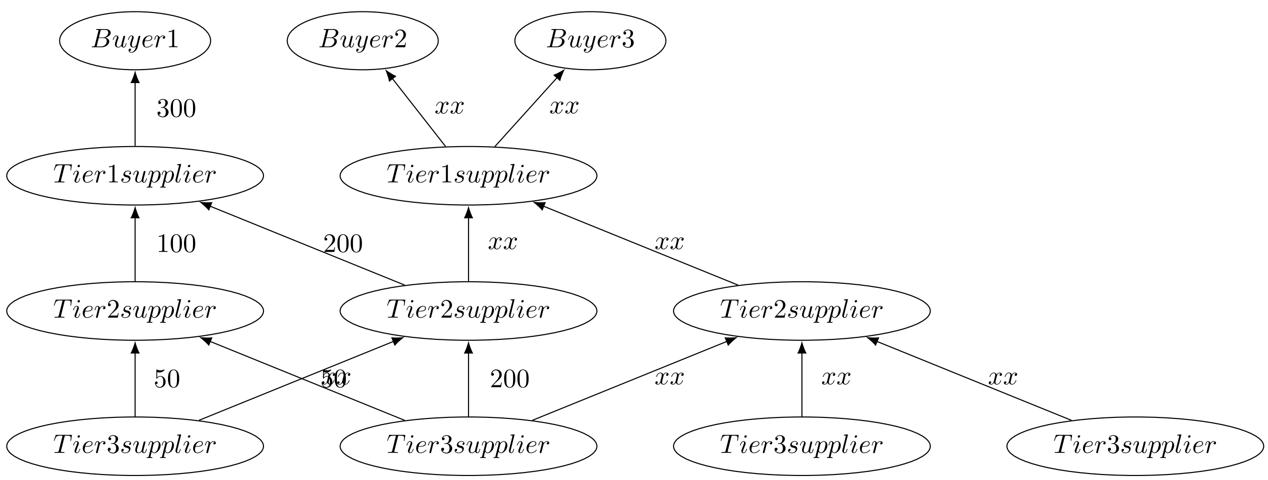

Figure 3: A supply chain network. With this network diagram it is impossible to say with certainty who exactly in Tiers 2 and 3 is supplying Buyer 2 for example. Our model untangles this by recording contracts - a Tier 3 supplier is contracted to supply a specific Tier 2 who supplies a Tier 1 all for a specific Buyer.