Studying Innovation in the Cell Phone Market with Agent-Based Modeling

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Abstract: The goal of our research this summer was to advance an economic model that simulates the cell phone market. This model allows firms (service providers, such as AT&T or Verizon) to make innovations, create new models, and stop production of models that are no longer profitable. It also allows consumers to choose which phone they would like to purchase based on the utility they would receive.

Innovation Procedure:

1. Firms "hatch" a new model and randomly assign it a quality between the current lowest quality in the market and the maximum feasible quality.

2. Firms calculate the price of the new model based on the market.

3. Firms then conduct "market research" to estimate what the profit from this model would be.

4. Next, the cost of introduction is assigned to the model, based on its quality and the current market prices and qualities.

5. If the estimated profit of the model is greater than the introduction cost, than the model will enter the market. If the estimated profit is less than the introduction cost, however, the model dies.

Introduction Cost Multiplier: Changes the cost of introducing a new phone from a fixed cost to a variable cost, depending on the quality of the phone.

Deposit Fee: Essentially a "rebate" the consumer gets back if the phone is recycled rather than thrown in a landfill.

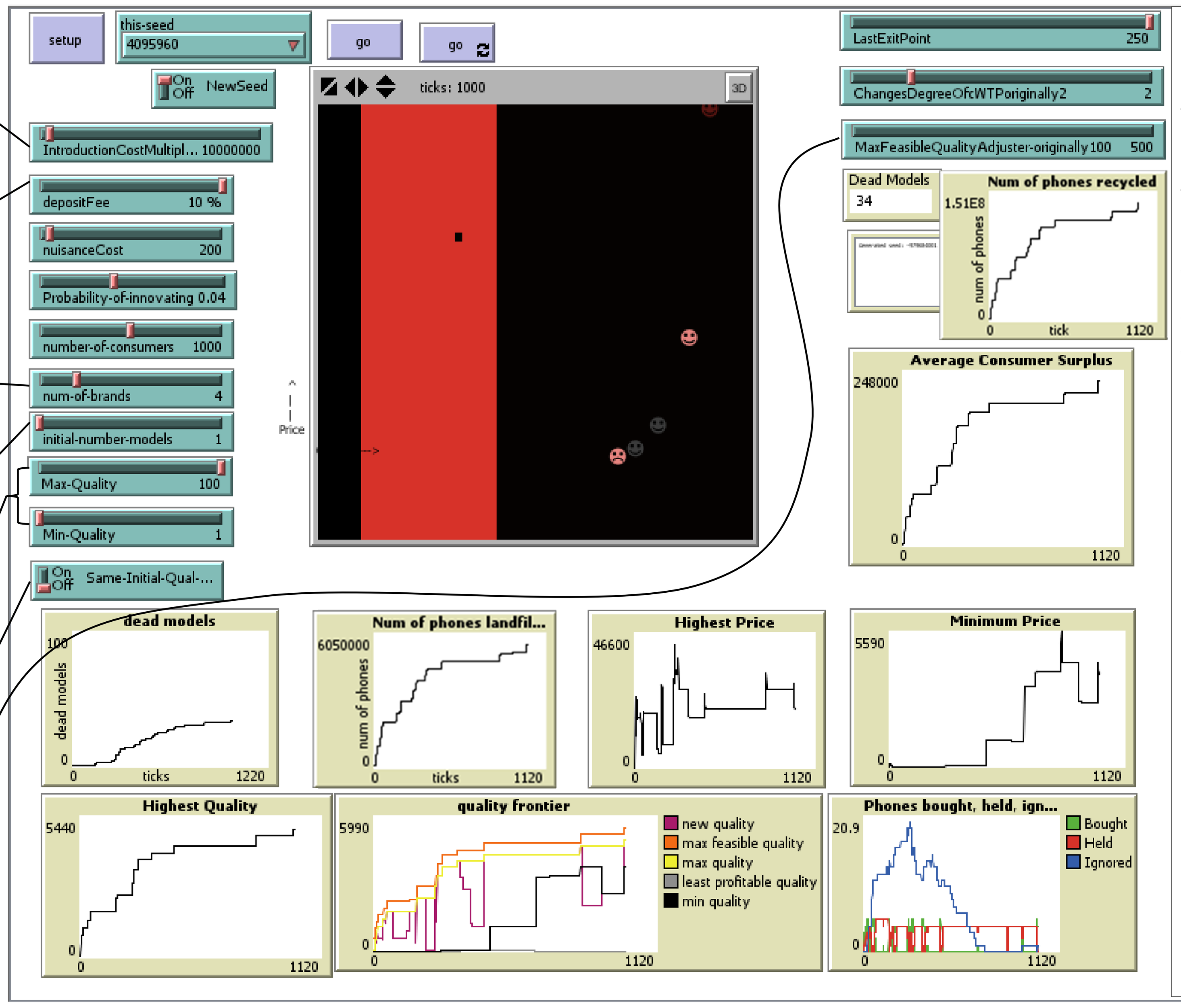
Number of Brands: The number of service providers in the market. Examples could include AT&T, Verizon, and Sprint.

Initial Number of Models: The number of cell phone models each "brand" has at the start of the run.

Initial Max- and Min- Quality: The highest and lowest values of quality each brand's initial phone(s) may have.

Same Initial Quality Switch: Determines whether any two new phones are allowed to have the same quality.

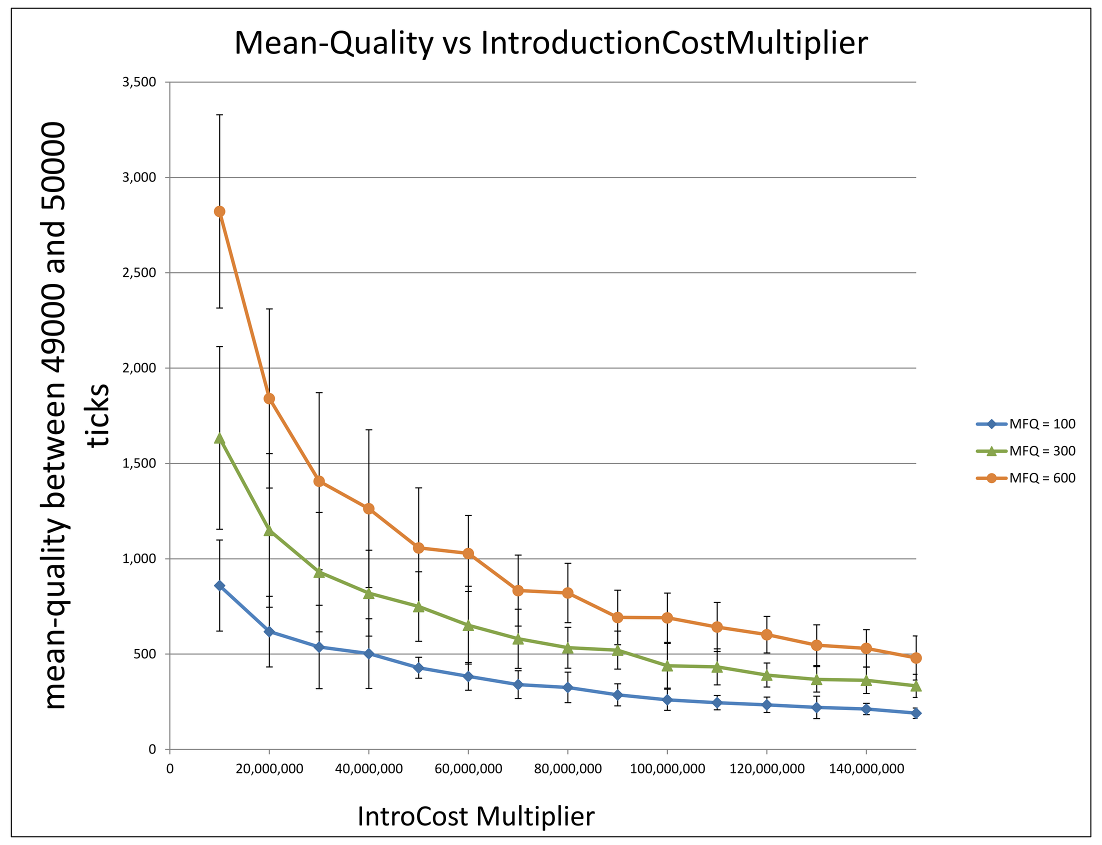
Max Feasible Difference in Quality: Determines how much higher than the current highest quality the quality of a newly innovated cell phone may be.



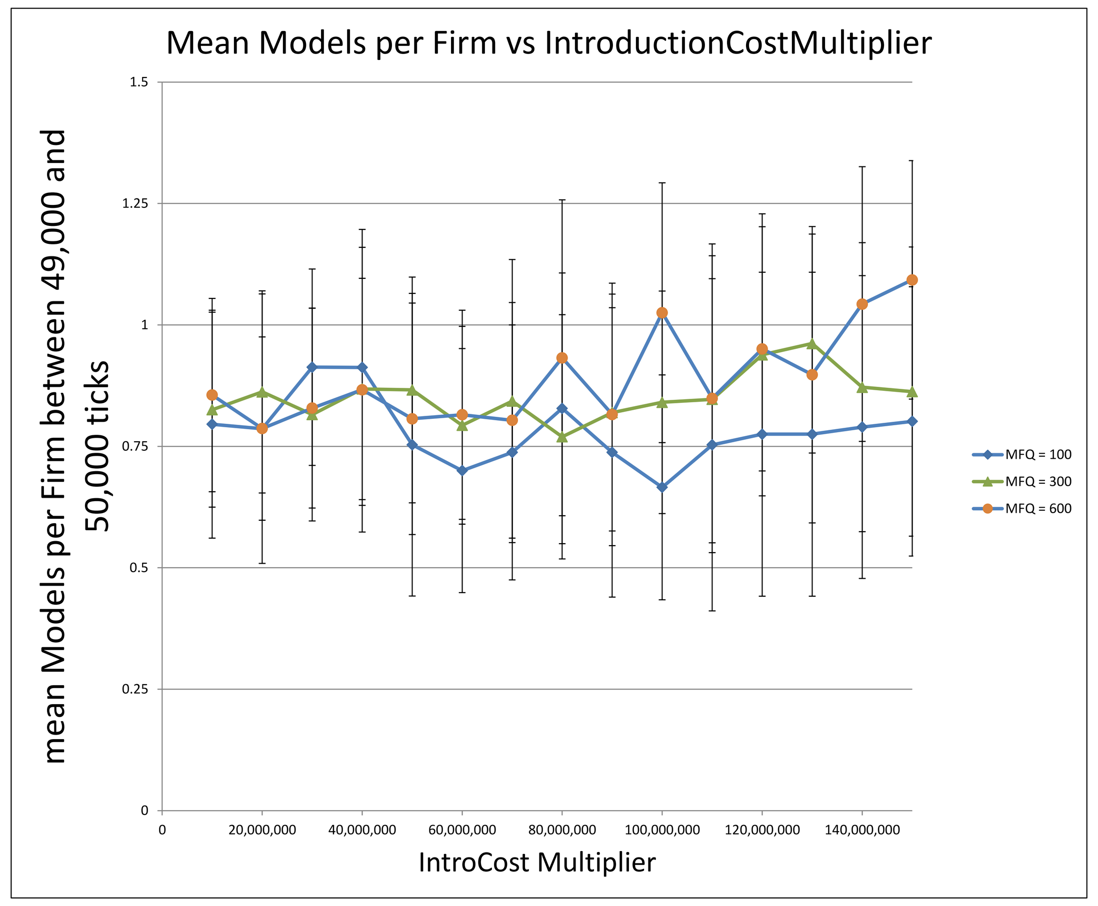
Originally, the cost of introducing a new model into the cell phone market was fixed for all qualities of phones. This means it would cost the same for a firm to introduce the latest smartphone as it would to introduce a near-useless flip phone. One innovation we considered this summer was to allow introduction cost to depend on quality; where at any given time it would be more expensive to introduce a phone with higher quality. In addition, the cost of production decreases over time. The cost of introducing a new phone now follows an equation (below) based on the quality of the phone, and is multiplied by the "IntroCost Multiplier," which is on the x- axis of the plots to the right. This has a similar shape to the marginal cost equation, but is scaled with the multiplier.

S = Quality of New Model
t = ticks (unit of time)

$$\text{Introduction Cost} = \left(\frac{s_j^2}{s_j + \frac{t}{10}} + \frac{1}{1+t} \right) * \text{Introcost Multiplier}$$

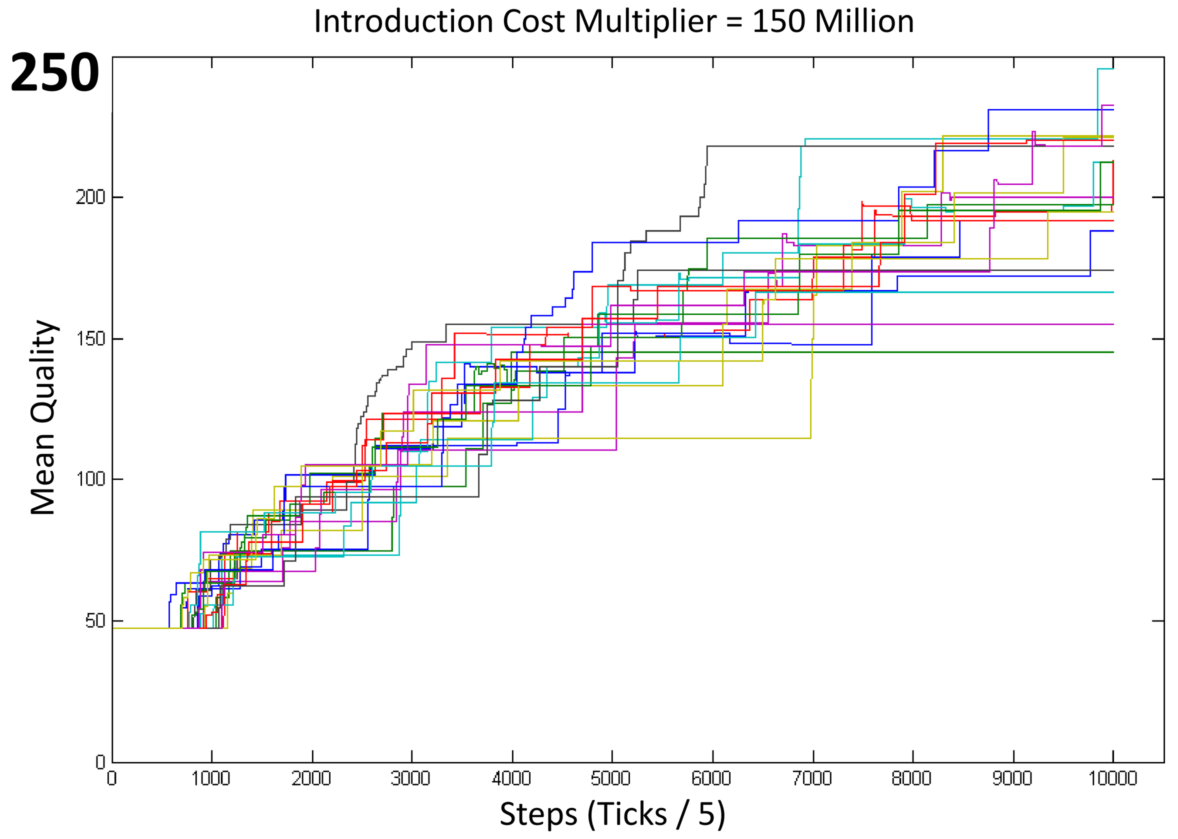


This chart shows the effect of the cost of introducing a new model on the mean quality of all phones in the market during the final 1000 "ticks" (unit of time). Note that the introduction cost *multiplier*, the constant value multiplied by the introduction cost equation, is on the x- axis. Since introduction cost directly related to quality, the hypothesis was that as the multiplier goes up so will the introduction cost, and mean quality will decrease since it is cheaper for firms to produce a model of lower quality than one of higher quality. This test was run at various Maximum Feasible Qualities, defined above.



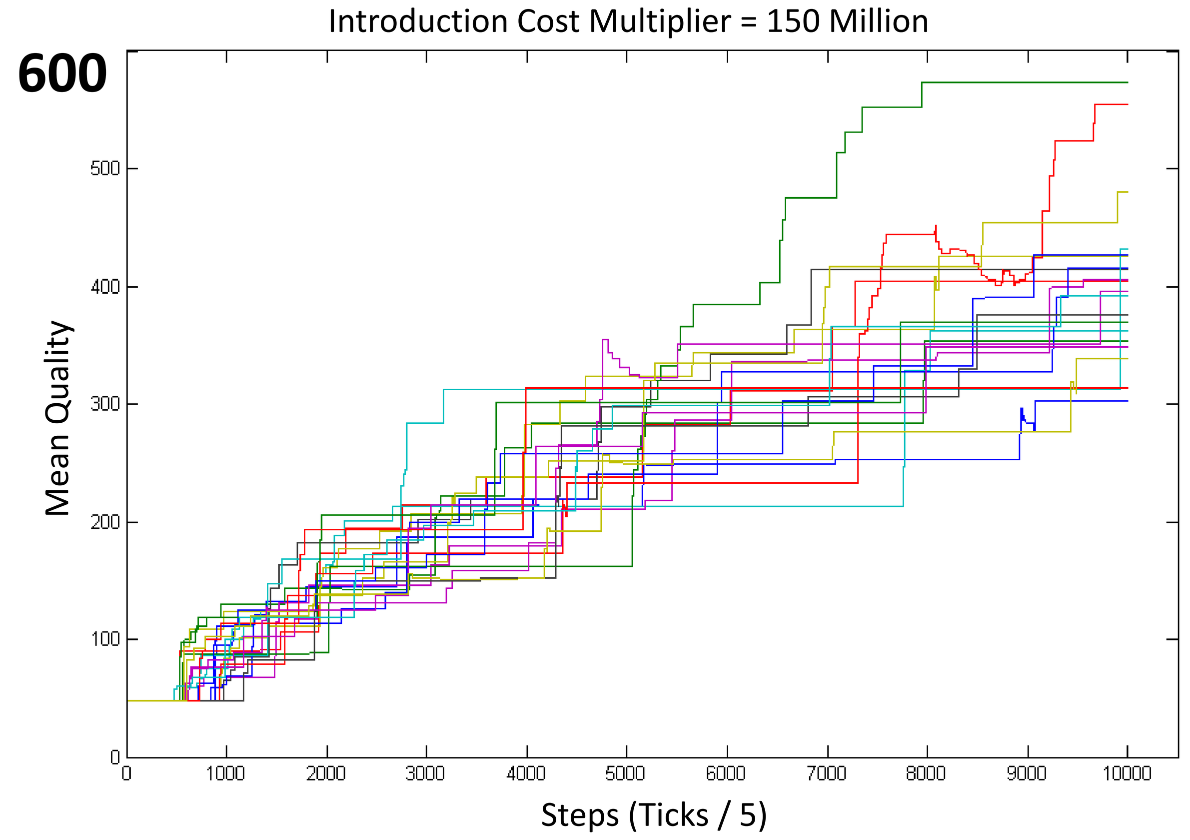
This plot shows the affect of the cost of introducing a new model on the average number of models per firm during the final 1000 ticks. The hypothesis was that over time, the number of models per firm would converge to 1. As is evident in the plot, that number fluctuates fairly consistently at slightly below 1 for several maximum feasible qualities.

Mean Quality over Time (20 runs)
Max Feasible Quality = 100
Introduction Cost Multiplier = 150 Million



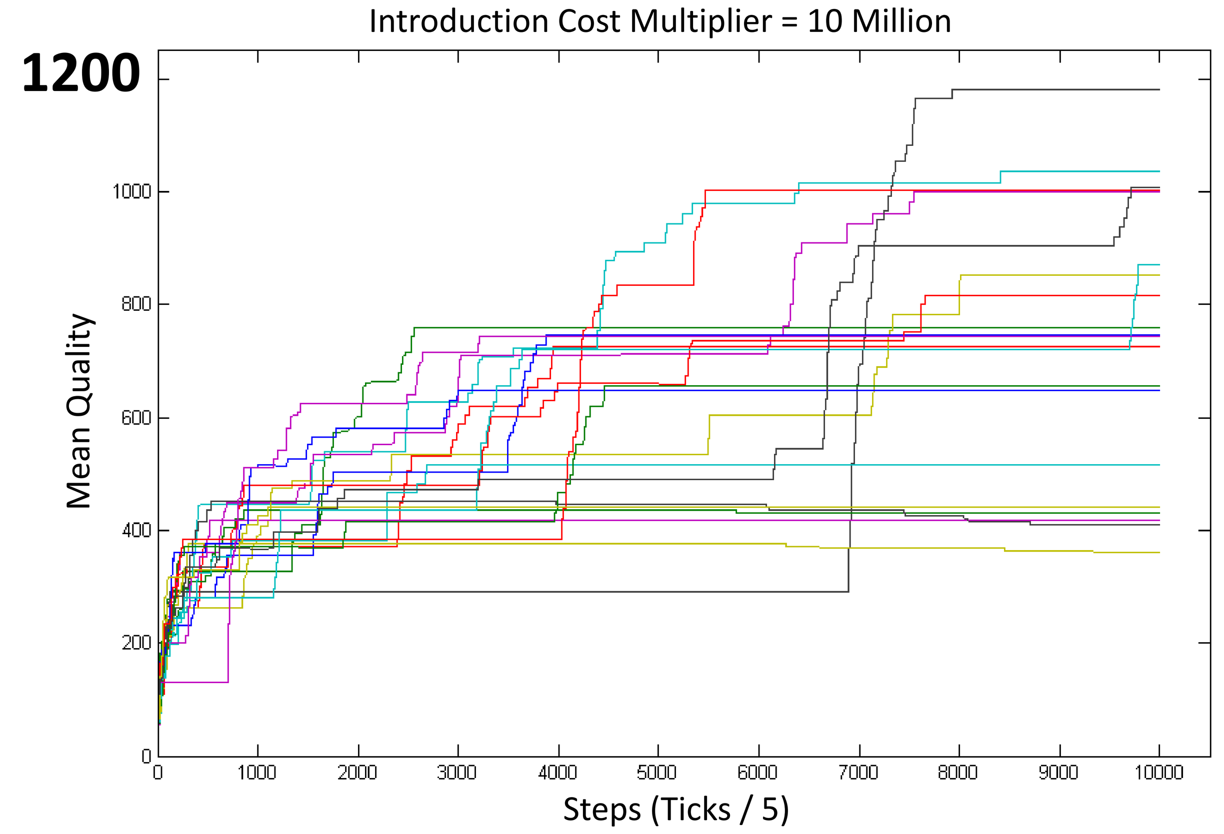
This plot shows the mean quality over 50,000 ticks, with the maximum feasible difference in quality at 100, and introduction cost multiplier at 150 million. Each line is a different trial, for a total of 20 trials. Notice the trend; average quality across all models increases over time, as does technology in real life as per Moore's Law.

Mean Quality over Time (20 runs)
Max Feasible Quality = 600
Introduction Cost Multiplier = 150 Million



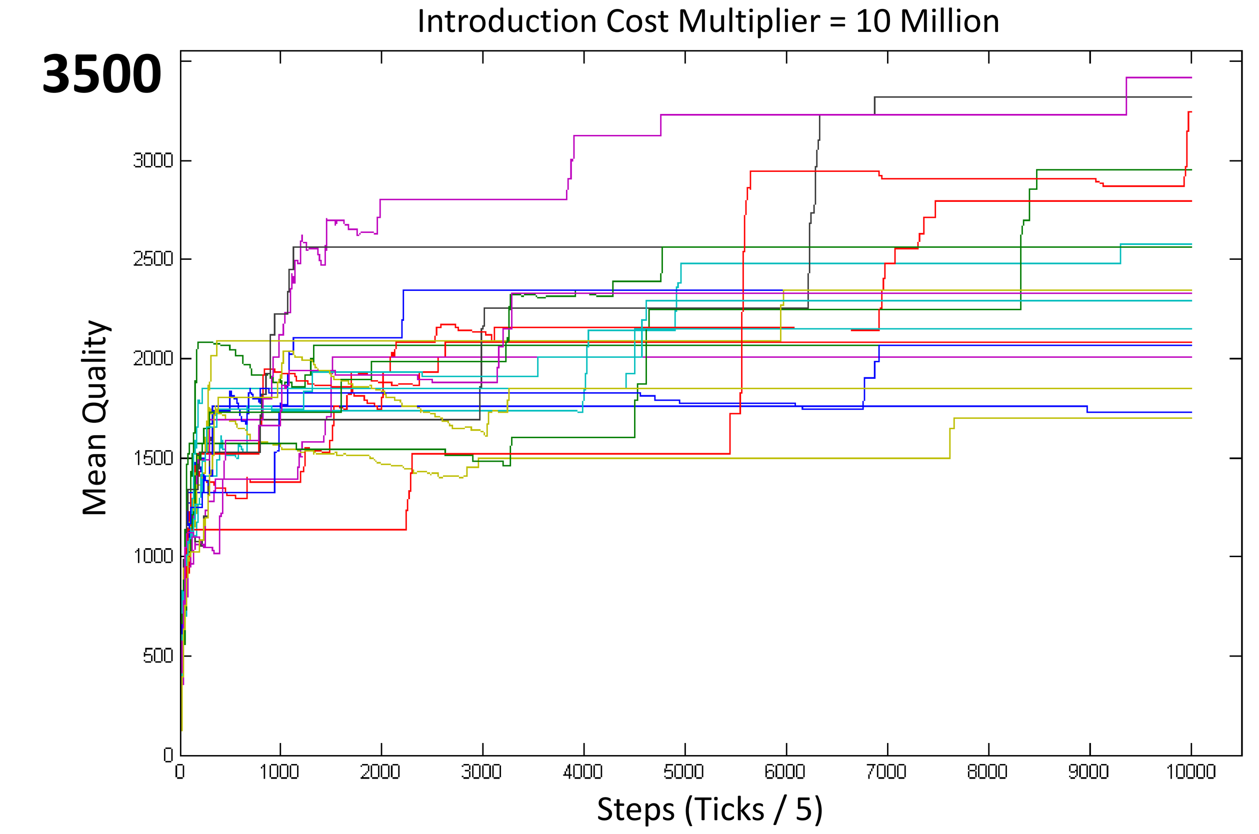
This plot shows the mean quality over 50,000 ticks, with the maximum feasible difference in quality at 600, and introduction cost multiplier at 150 million. Notice the scale on the y- axis: because the limit for innovation is much more lax than previously, and the introduction cost is relatively low, mean quality is higher.

Mean Quality over Time (20 runs)
Max Feasible Quality = 100
Introduction Cost Multiplier = 10 Million



This plot shows the mean quality over 50,000 ticks, with the maximum feasible difference in quality at 100, and introduction cost multiplier at 10 million. Notice the scale on the y- axis: it is not surprising that with a decreased introduction cost, mean quality rises noticeably since it is now easier and cheaper to innovate.

Mean Quality over Time (20 runs)
Max Feasible Quality = 600
Introduction Cost Multiplier = 10 Million



This plot shows the mean quality over 50,000 ticks, with the maximum feasible difference in quality at 600, and introduction cost multiplier at 150 million. Notice how much mean quality increases with a lax limit on innovation and low introduction costs.