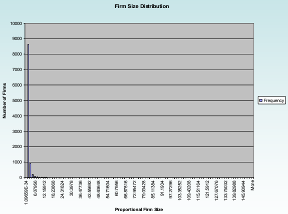
The Creation of a Computer Program which Simulates the Effect of Technological Progress on Fluctuations in the Business Cycle

By Dane Johnson



Background Information

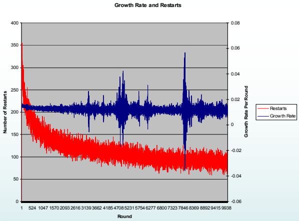
The goal of this project was exactly what the title implies; create a computer model of the effect of technological progress on macroeconomic fluctuations. The model is necessarily a dramatic simplification of the actual dynamics behind business fluctuations. In this model firms compete with one another for shares of a fixed nominal demand. Each firm's ability to capture market share is dependent upon its technological ability which is updated stochastically to simulate the unpredictable events in the market which determine technological progress. We then observe the effect these technological changes have of the growth of GDP. This was programmed in C++ using an object oriented approach in order to efficiently model a large number of heterogeneous agents.

The Firms

The model economy consists of 10,000 firms competing over a fixed nominal market demand. Firms differ in the amount of capital they possess and their technological abilities. Each firm has two technological attributes: production efficiency and product quality. Production efficiency determines the cost of each additional unit of production (the marginal cost). Product quality determines how appealing a firm's product is to the consumers, and thus how large a market share they can capture for a given price (market shares are derived from CES consumer preferences). These two technological attributes are updated each round according to a normal distribution. The mean is an increase of 3% with a standard deviation of 1%. This implies that technological setbacks are possible but rare.

Firm Size Distribution

What makes this model relatively unique is the departure from the standard representative agent approach to macroeconomic models (e.g., King and Rebelo, 1999). You will notice that, rather than defining the characteristics of a representative firm and using this to determine the aggregate, we have a heterogeneous population. Although firms start out exactly equal, the technological fluctuations and the resulting changes in market shares generate the skewed distribution in the histogram on the right. On the histogram we have proportional market share on the X-axis (for example the average firm would have 1, a firm with twice that would have 2, ect.) and the number of firms satisfying this proportion on the Y-axis. Although it is impossible to discern with the naked eye, we include such large proportions on the X-axis because there are a few firms way out on the tail possessing huge market shares. This distribution is similar to the power law distribution which empirical evidence suggests characterizes the true distribution of firm size in the U.S. (e.g., Axtell, 2001)



Bankruptcies

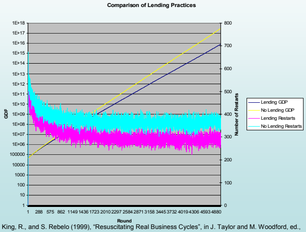
Each round firms are responsible for paying a fixed cost (representing the cost of staying in business) and a variable cost (representing the cost of labor and supplies) which is dependent upon the number of units being produced. If a firm has inadequate capital to afford these costs it declares bankruptcy and is replaced by a new firm. This is referred to as a "restart." This new firm possesses the minimum amount of capital to get started and the technological ability for it to capture exactly 1/10000 of the nominal market share. This process allows for firms which have fallen behind in the technological race to be replaced with more efficient, more competitive start-ups.

Lending

In order to make our model more realistic, we introduced a system in which firms with excess capital (more than they need to produce enough goods to satisfy their market shares) are able to use it to finance production by firms with capital shortages (inadequate capital to meet their market shares. The profit on the additional units produced is split between the firm producing them and the firm providing the capital. In a sense this is a venture capital system because there is no claim insurance in the case that the producing firm is unable to sell these goods and the capital is wasted. In this sense it is a risky venture, and firms will only elect to lend capital if they have witnessed this done successfully (a non-negative payoff) in the past. As displayed in the graph below, this behavior reduces the number of firms going bankrupt or "restarting." This is due to firms which are no longer technologically competitive being able to avoid bankruptcy by lending capital to more competitive firms. Naturally, this saves capital which would be spent on the additional start-ups in the model without lending. However, this also has a negative effect on GDP. This firms which are no longer productive are allowed to survive longer due to previous capital accumulation. On average, this prevents more efficient firms from entering the market, and thus reduces the growth rate of GDP.

Conclusion

By observing the graph to the left, we see that technological fluctuations in individual firms can cause significant fluctuations in the rate of GDP growth. Based on the law of large numbers, we would correctly assume that the cumulative effect of technological fluctuations in 10,000 similarly sized firms would come close to cancelling each other out in the aggregate. However, as indicated by the fat-tailed distribution in the upper left-hand corner, there are a few very large firms which, when shocked, have a non-trivial effect on the aggregate. I would like to express extreme gratitude to Professor Christophre Georges for his insight and patience throughout this project, as well as to Professor Alistair Campbell for assistance with the programming aspects



1. King, R., and S. Rebelo (1999), "Resuscitating Real Business Cycles", in J. Taylor and M. Woodford, ed., Handbook of Macroeconomics Volume 1B (Elsevier Science B.V., Amseterdam, The Netherlands) 927-1007
2. Axtell, R. (2001), "Zipf Distribution of U.S. Firm Sizes", Science Magazine 293:1818-1820.