Towards studying the impact of business incubation on regional economic performance: a high-level overview and preliminary experiment.

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Abstract In this paper we present a preliminary study on the regional impact of business incubation in an ecosystem of knowledge-based firms. We seek an answer to the question, "can incubation of a subpopulation of firms result in an increase to the economic growth and performance of the entire region?" To answer this question we use a simple idea model of innovation ecosystems in which agents exist in a spatial environment, possess technologies that allow them to transform resources from one type to another, and where the population evolves to adapt to the current technological space. Evolutionary advances that introduce technologies novel to the population are interpreted as innovations. The dynamics of our model and its associated performance measures center around the flow of resources between individual agents at the micro level. Our early results suggest that business incubators can have a substantial impact regional economic performance, but only if the support provided by an incubator is tailored to the individual firms.

Keywords Agent-based modeling · Business Incubation · Complexity Economics · Economic Growth

1 Introduction

It has been identified that approximately only one-third of all new businesses in the US survive more than a decade beyond their startup date [18]. Economists have theorized several possible reasons for this high failure rate, including a lack of legitimacy and competitive advantage, poor connectivity to external resources, low levels of institutional support, internal lack of coordination, and poor employee role clarity [4, 19–21]. One approach taken by

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emerging entrepreneurs to address these reasons for failure is to improve their associations with legitimate institutions and strive for proximity to potential resource providers [1,14,15]. Business incubators provide one way for entrepreneurs to increase the survival chances of their start-up companies by providing them with the support and resources they need to compete against established companies or survive in new markets. This support is especially critical during times of economic hardship and can mean the difference between profitability and bankruptcy [14].

In addition to increasing firm survival, it is now widely accepted by the business community, although not proven, that business incubators, especially those that work with technology companies, are a good means for fostering economic growth through job creation [14–17]; however, there is little scientific evidence to support the claims that incubation programs increase firm performance (as measured by long term employment and sales numbers) and viability in the market [1]. Even more interestingly, there is no evidence that we are aware of that can be used to answer questions about whether or not business incubators increase the economic performance and growth of an entire region. It is this latter issue of the impact of business incubation on regional economic performance that we start to examine in this paper using a complexity economics [9] approach. As part of our examination, we provide preliminary results of our findings.

2 Research Question and Methodology

Our goal is to study the regional impact of business incubation in an ecosystem of knowledge-based firms. We seek an answer to the question, "can incubation of a subpopulation of firms result in an increase to the economic growth and performance of the entire region?"

To answer this question we employ agent-based modeling and simulation under the framework of complexity economics [2, 5, 6, 10, 12, 13, 22]. This approach is justified for two primary reasons. First, the data required for a purely statistical approach is either prohibitively difficult to come by, or simply does not exist; and second, there does not appear to be a coherent mathematical framework or theory that can be used to model the effects of incubation on regional economic effects. Thus, given the gap between the desired information and tools and the available information and tools, an agent-based model is the best way to answer our research question. [3, 7].

2.1 Model Overview

Our model is a simple agent-based idea model of innovation ecosystems that is based on the general ideas behind the resource-based view of firms [23], the Schumpeterian principle of creative destruction [12], deeply rooted in the concept of transformation networks [11], and inspired by Epstein's Sugarscape model [8]. Agents exist in a spatial environment, possess technologies that allow them to transform resources from one type to another, and where the population evolves to adapt to the current technological space. Evolutionary advances that introduce technologies novel to the population are interpreted as innovations. The dynamics of our model and its associated performance measures center around the flow of resources between individual agents at the micro level.

Within the population, agents form an interaction network with the spatially local neighbors and compete with each other for finite resources. A generalized notion of money is used to facilitate trade among agents. Agents are removed from the ecosystem if their quantity

of money ever reaches zero. To compensate for the loss of agents, we make use of a "copy-with-error" mechanic to introduce new agents into the ecosystem. At each simulated time step, so long as there is physical space in the environment, every agent that is considered economically viable is copied. During this copy process there is a probability that the technology will be copied incorrectly, resulting in a modified transformation rule; but, all other agent characteristics are guaranteed to be unmodified. Economic viability is determined by how much money an agent has, how successful it has been at selling its resources, and how successful it has been at buying the resources it needs for transformation.

Resources are generated exogenously at fixed locations in the environment and enter the ecosystem once they are discovered roaming agents and then either traded away or transformed. The exchange of resources and money between agents allows the performance of an entire ecosystem to be summarized by a simplified version of Gross Domestic Product (GDP). This "regional" GDP measures the total value of all transactions that occur within the ecosystem at any given point in time.

2.2 Methodological Overview

We conduct a series of simulated experiments to generate the appropriate data for a meaningful analysis. We directly compare the simulated performance of an ecosystem with and without incubated agents. As the method of incubation, agents are given either money, which they can use to buy resources and pay upkeep costs; or they are given resources specific to their technology, which they can then sell or transform. The agents selected for incubation are drawn from either the "best" agents or the "worst" agents as determined by a simple fitness function that accounts for economic viability, or uniformly at random. In total, we conduct 7 experiments at 5 replications each.

3 Results

Our model is still in the early stages of development and as such, has not yet been fully validated. Despite this, our preliminary results based on our initial experiments are promising. They suggest, above all else, that the method of support offered by an incubator does in fact matter.

3.1 Analysis

We use a Welch Two Sample t-test to examine the differences between the final values of the cumulative GDP of ecosystems under each set of experimental conditions.

Let H_0 be the null hypothesis that the mean cumulative GDP of wealth incubation is less than the mean cumulative GDP of the baseline and let H_1 be the null hypothesis that the mean cumulative GDP of wealth incubation is less than the mean cumulative GDP of resource incubation. Then for the three sub-conditions of incubation on the best, worst, and randomly chosen agents the p-values corresponding to H_0 are, respectively, $p = 0.6804$, $p = 0.9953$, and $p = 0.8095$ and for H_1 they are $p = 0.9993$, $p = 0.9979$, $p = 1$. Likewise, let H_2 by the null hypothesis that the mean cumulative GDP of resource incubation is less than the mean cumulative GDP of the baseline. Then for the same three sub-conditions of

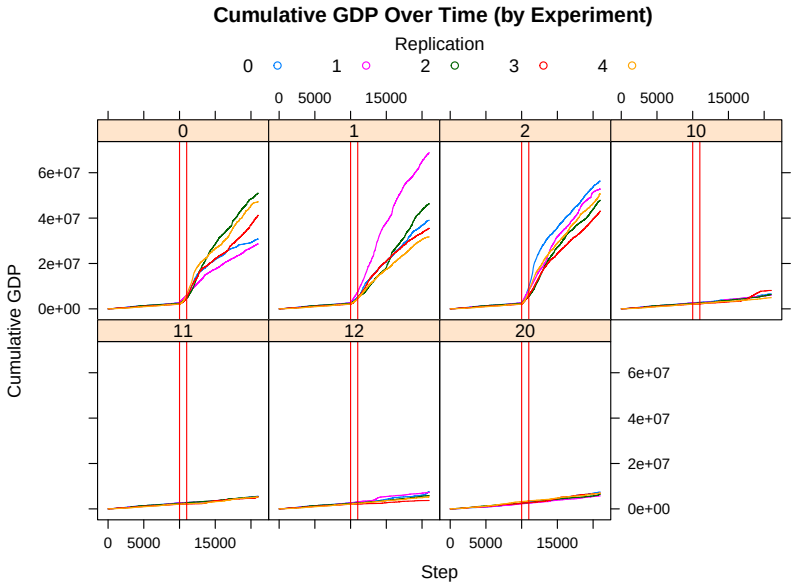

Fig. 1 The cumulative sum of the GDP over time broken down by replication. The vertical lines section off the period of incubation from the pre- and post-incubation periods. It can be observed that the GDP related to incubation via resources (panels 0, 1, and 2) far exceeds incubation via wealth (panels 10, 11, 12) and the baseline case of no incubation (panel 20).

incubation on the best, worst, and randomly chosen agents the p-values corresponding to H_2 are, respectively, $p = 0.0008$, $p = 0.0023$, $p = 0.0000$.

Figure 1 is a visualization of the impact that incubation has on the regional economic performance within the simulator. The x-axis is the simulation time as the number of steps taken by the simulation since initialization. The y-axis is the cumulative GDP of the system at each tick of the simulation clock. Each panel is the plot of data from a single experiment. Panel 1 is the experiment with resource incubation to the best agents, panel 2 is resource incubation to the worst agents, panel 3 is resource incubation to a random subset of agents. Panel 10 is wealth incubation to the best agents, panel 11 is wealth incubation to the worst agents and panel 11 is wealth incubation to a random subset of agents. Panel 20 is the baseline experiment with no incubation. Each line in a panel is a single replication of the associated experiment, colored by replication ID. The two vertical lines in each panel highlight the incubation period of 1000 steps. From this visualization, it is clear that providing the resources needed for production has a much larger impact than providing wealth or doing nothing.

3.2 Discussion

Providing agents with money is not as beneficial as providing resources, and roughly as good or worse than not incubating at all. On the other hand, providing agents with resources is much more beneficial than either providing agents with money or not incubating at all. A study of the system dynamics suggests that these differences arise because the incubation of agents with resources results in a fundamental change to the technology distribution in

population of the ecosystem; where as the incubation of agents with money only serves to keep alive, artificially, a set of agents that would otherwise be removed once they crease being economically viable.

The population change initiated by resource incubation occurs because a positive feedback loop is created between the existing agents and the copy-with-error mechanism. When agents are incubated with resources, they are guaranteed to have have something that can be either sold, or transformed and then sold. So long as an agent either has or produces resources that are in demand, and those resources are being sold to others, the agent will be deemed economically viable and eligible for copying. Because agents created via the copy-with-error mechanism are likely to be identical to their blueprint, the associated technology will continue to be replicated. This behavior results in a replicator dynamic that increases the number of agents with successful technologies while letting those with unsuccessful technologies die out.

Over time, the entire population shifts so that agents possess a set of technologies that are compatible with one another; where the output resource of one agent is the input resource of a neighboring agent. It is the flow of trade through agents in these chains that increases the ecosystem's economic performance. This same behavior appears to occur even when the ecosystem is incubated with money, and when the ecosystem receives no incubation, but it takes much longer for technological compatibilities to self-organize. Incubation with resources provides a shock that works to align the population by ensuring that there is a constant stream of incoming resources which can be used as the foundation for a technological shift. Unfortunately, a full discussion of how the technology distribution of the population changes is beyond the scope of this current paper.

4 Conclusions

Business incubators are an important research topic in the post-recession economy, but little is known about their actual effectiveness. We have chosen to investigate whether or not it is possible for business incubators to have an impact on not just their clients, but also the entire regional economy in which their clients exist. To conduct this investigation we make use of agent-based models and simulation experiments. Our early results are positive. Not only do they suggest that incubation can enhance a regional economy, but they also provide an explanation as to how such an enhancement might occur.

Because this work is preliminary, our model is still undergoing validation. In the future, we plan to expand our approach to be predictive as well as exploratory. Our long term goal is to apply the results of our research to economic and business policy, particularly with an emphasis on optimizing the regional impact of incubator activity.

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