Limits to Entrepreneurial Growth: Impact on Firm Demographics and Employment[1]

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This paper describes a project for modeling what Schumpeter (1942) called the 'creative destruction' of business activities in a capitalist economy. This process is central to understanding fundamental dynamics in economic systems where private-sector entrepreneurship is a driving force for business formation, innovation, and economic growth. It is "...at the heart of the functioning of market-based economies.... Each day, new firms start up; existing firms expand, contract and eventually shut down; individuals are hired to fill new positions or to replace previous employees on existing jobs; others quit or are dismissed." (Bassanini and Pascal, 2009, 1).

The birth of new firms is the seminal event in this dynamic process. The research challenge is to offer a plausible endogenous explanation for the declining trend in the number of start-up firms in the U.S. economy and, more fundamentally, an explanation for the underlying decline in entrepreneurial productivity. It may be self-evident that the negative trend is problematic, but recent research provides strong statistical evidence. A sophisticated econometric analysis found a significant correlation between trends in the population-driven entry rate of start-up firms and some problematic stylized facts: increasing concentration of employment in older and larger firms, increasing firm exit rates, and the decline in workers' share of GDP (Hopenhayn, Neira, and Singhania, 2018).

Calibrated with an updated version of same data set used by Hopenhayen *et al.*, the system dynamics model described in this paper demonstrates a plausible structural framework that generates behavior consistent with their findings. Its contribution is the foundation it lays for development of an endogenous explanation of entry rates.

[1] *Corrected*. Online version of model posted at https://exchange.iseesystems.com/public/redact/cd

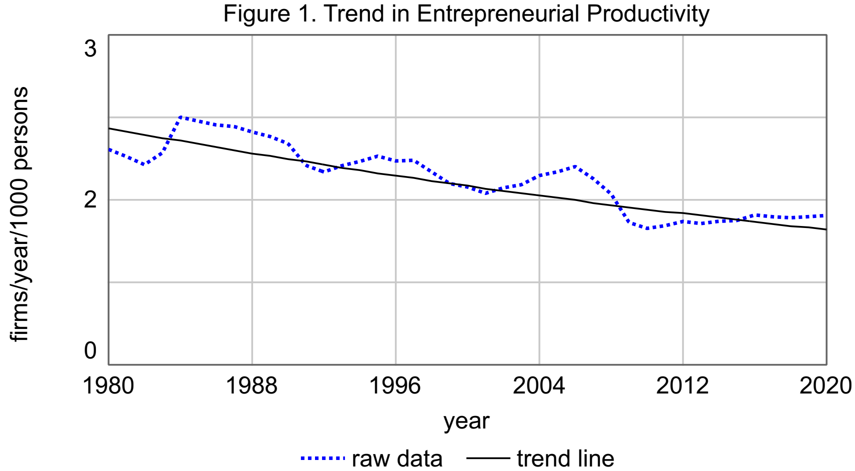
More generally, the model described here replicates and explains the trends and patterns observed in the Census Bureau's 'business dynamics' statistics (BDS, 2021)—the formation and closing of firms and their establishments, the historical transition from startups to mature firms and, eventually, the end of a business life. Relying on a 'modeling forwards' approach, the model also replicates the aggregate employment pattern associated with employment at age-specific business firm establishments.

It is, however, only the first model in a two-stage project. The second stage is an exercise in 'modeling backwards' to explain the declining flow of start-up firms as a function of endogenous entrepreneurial productivity and exogenous population growth. In short, the project aims to close the loop between the causes and effects of entrepreneurial activity and employment in the United States.

Declining Entrepreneurial Productivity

A business firm comes into existence -- is born -- when an entrepreneur creates it. In some nations, the socioeconomic culture reflects an entrepreneurial tradition. Historically, such a reputation has been ascribed to the United States. However, statistical evidence suggests there may be reasons for concern about the sustainability of American entrepreneurship, at least at its historical levels. The annual number of StartUps per 1000 people has been declining at an annual rate of 1.4 percent since 1980 (Figure 1).

Figure 1. Trend in Entrepreneurial Productivity



At that rate and if the U.S. population remained constant, the annual number of new StartUps would be reduced by half in 50 years. Of course, the U.S. population is still growing, but the rate has slowed considerably in the decades since the post-WWII baby boom. To get a feel for the potential dynamics of the declining start-up trend, assume a continuation of this century's current average population growth rate (3/4 of 1 percent) for the next 80 years. In that case, *despite population growth*, the annual number of StartUps would still decline by 40 percent between 2020 and 2100.

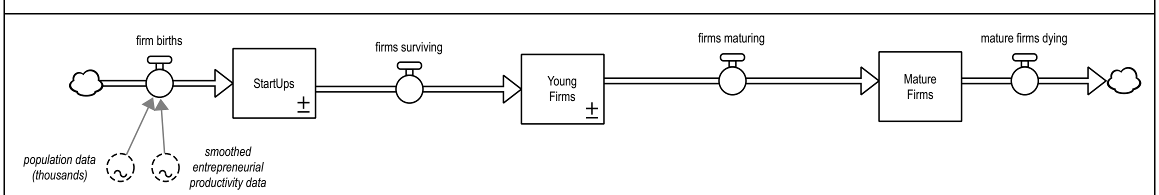
Like most extrapolation exercises, this one is useful only for its shock value. Slow population growth for the remainder of this century is not an unreasonable assumption. But it is near-sighted to assume that entrepreneurial productivity will decline over the next 80 years at the same rate as it has in the past 40. Indeed, the oscillating raw data pattern in Figure 1 can be easily associated with busts and booms in the early 1980s, early 1990s, early 2000s, and of course the Great Recession later in the first decade of this century. A plausible behavioral equation for entrepreneurial productivity should include some measure of ‘business conditions’ in addition to the size of the national population. That is why the model described in this paper—as important as it is for understanding the dynamics of firm demographics and employment—is only the first stage of our project.

This first simulation model has three components that are linked together, including
(1) an aging chain of firms grouped according to their age cohorts;
(2) a co-flow structure of the firms' establishments; and
(3) an employment stock that accumulates the number of workers at all establishments.

Modeling Firm Demographics

Figure 2 displays an overview of the aging chain of business firms in the model and the exogenous formulation of the equation for the ‘firm births’ inflow to StartUps.

Figure 2. Simplified View of Firms Aging Chain



Firms less than one year old are defined as StartUps. If they survive the first year, they flow into the Young Firms stock where they remain for five years, at most. If they reach the age of 6 years, they join the stock of older Mature Firms. Sooner or later, all firms reach an end to their operating lives and close; i.e., die. The model's equation for 'births' of new firms is:

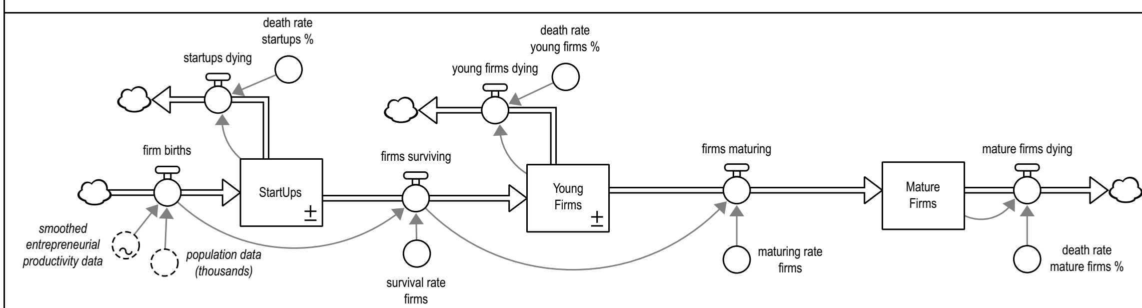
firm births = population data x entrepreneurial productivity data

where population is measured in thousands of people (e.g., 300 million = 300,000 thousand) and entrepreneurial productivity is the annual number of StartUps per 1000 persons.

Entrepreneurial productivity was nearly 2.2 firms/year/1000 persons in 1980, but fell to 1.2 by 2020. Despite a growing population, annual firm births actually declined during that period. As noted in the discussion of Figure 1, the productivity data have been smoothed to remove the fluctuations associated with the business cycles that will be analyzed later. However, the persistent decline itself may reflect a cumulative negative effect of serious recessions relative to the positive effect of recoveries. When we insert this model into the Supply Side of a larger macroeconomic model having a Demand Side, a complex feedback structure will then influence entrepreneurial productivity, and it will be endogenously determined within the model.

Figure 3 completes the picture of the aging chain.

Figure 3. Full Aging Chain of Firms

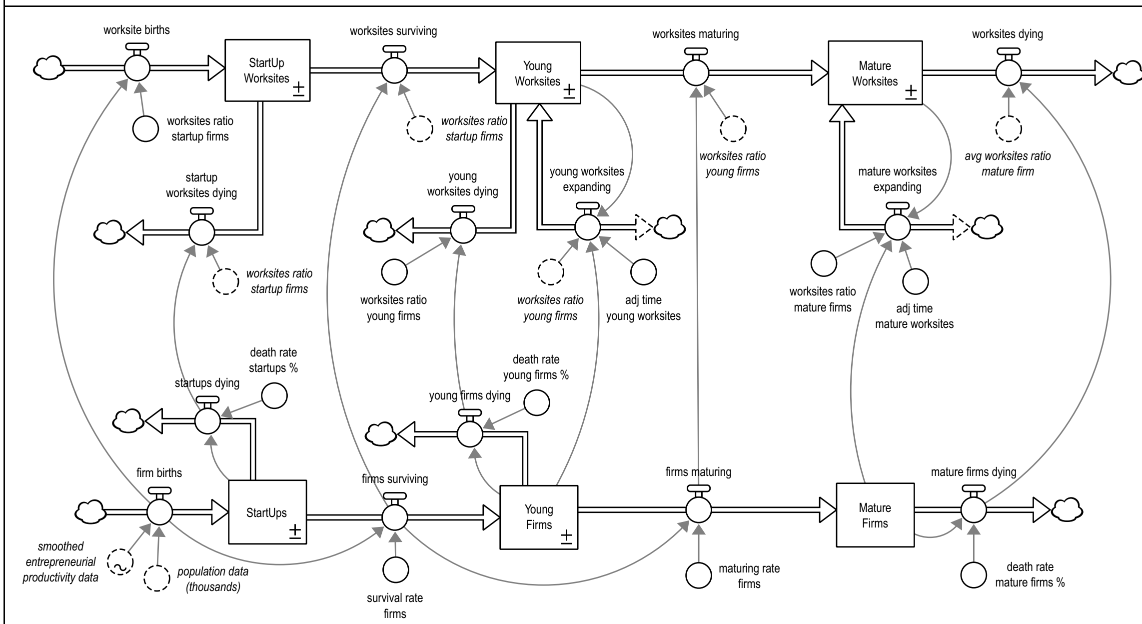


After firms are born, about half survive 1 year and become Young Firms. And about 40 percent of those survivors eventually reach the age of 6 and become Mature Firms. The number of 'firms maturing' is about 20 percent of the original number of 'firm births' six years earlier (50% x 40%).

The equations for 'surviving' and 'maturing' flows are based on the maximum time a firm remains in the age-specific stocks. A surviving firm must exit the StartUps stock in one year. Likewise, a maturing firm must exit the Young Firms stock in five years. The only exit from the Mature Firms stock is through death, and we model that outflow as a function of the size of the stock. Respectively, annual death rate estimates of 50, 10, and 1.5 percent for StartUps, Young Firms, and Mature Firms are consistent with the data.

In the model, the term 'worksites' is synonymous with the term 'establishments' used by the U.S. Census Bureau. Most are retail stores, but worksites also include facilities used for distribution, wholesaling, manufacturing, and mining. See Figure 4.

Figure 4. Establishments (called 'Worksites' in the Model)



Consistent with the Census Bureau definition, each worksite inherits the age of its parent firm. For example, Young Worksites are those owned by Young Firms. Inflows and outflows of worksite stocks are co-flows. They occur simultaneously with the flows of firms and reflect the number of worksites per firm.

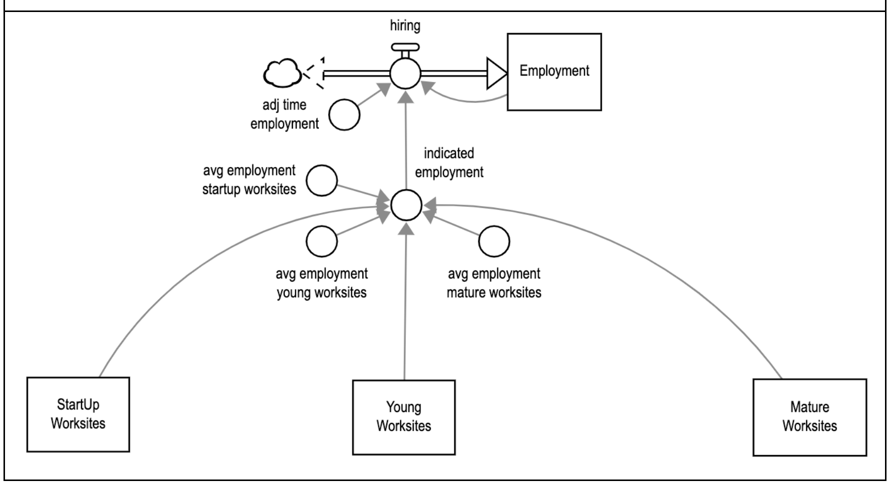
The number of worksites increases with the age of the parent firms. There are about 150 Mature Worksites for each 100 Mature Firms. In contrast, most younger firms have only one worksite. For StartUps and Young Firms, the number of worksites is about 101 and 104, respectively, for each 100 firms.

The 'worksites maturing' inflow to Mature Worksites reflects the number of worksites per *Young* Firm. In addition, there is worksite growth as Mature Firms age. This expansion of Mature Worksites is modeled as a stock-adjustment process. The expansion of Young Worksites is also modeled as a stock-adjustment process. To simplify the model structure, we have assumed that StartUps begin with their average number of worksites instead of expanding after start-up. The error introduced by this assumption is a small percentage of a small number, and the impact on the behavior of the model is negligible.

<u>Employment</u>

Employment, displayed in Figure 5, is the final sector in this version of the model.

Figure 5. Employment



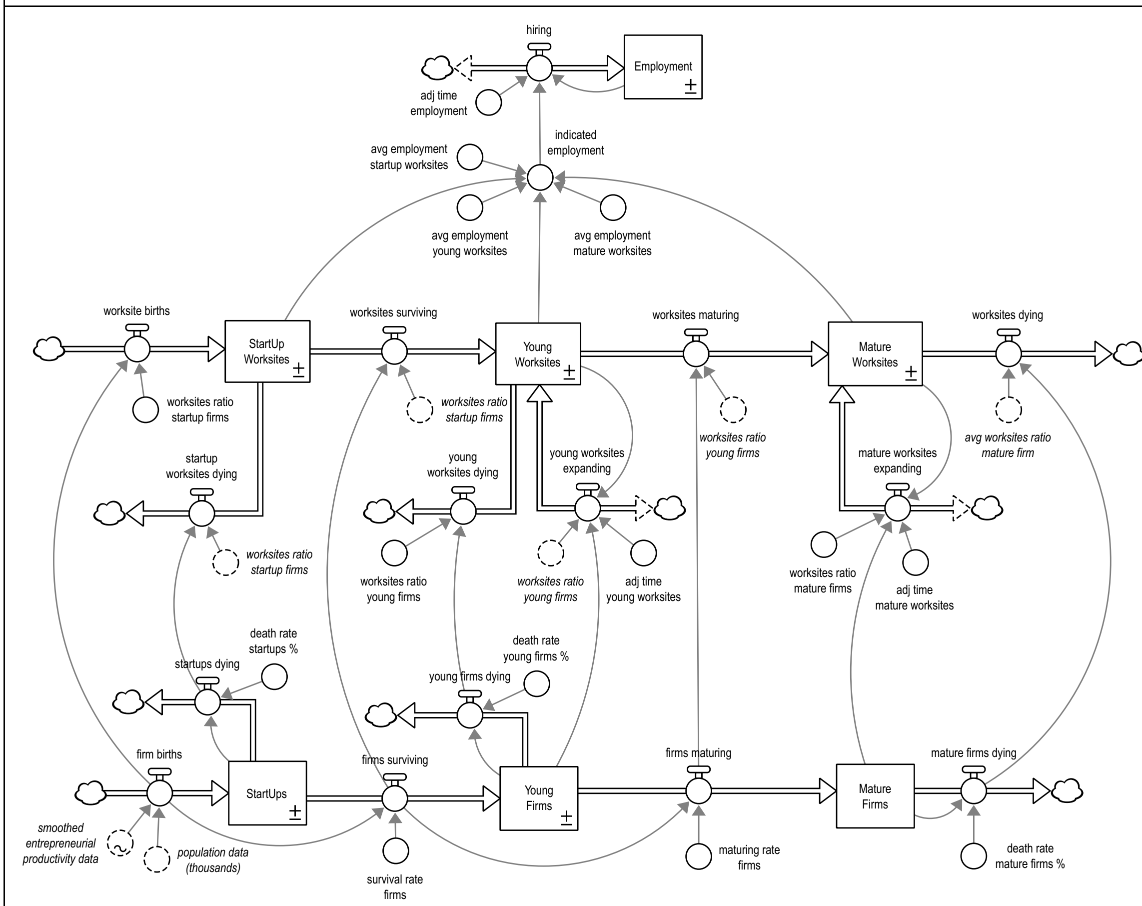
The Employment stock adjusts gradually toward the 'indicated employment' that reflects the average number of employees in worksites in the three age cohorts. The BDS data indicate that the average employment at StartUp Worksites, Young Worksites, and Mature Worksites is nearly 6, 9, and 22 workers, respectively.

As noted above, the next version of the model will close several feedback loops between employment and the business conditions that are expected to influence aspiring entrepreneurs' decisions about starting new firms.

Testing the Full Model

The structure of the full model is displayed in Figure 6. This section examines the behavior of the model.[2]

Figure 6. Model of Firm Demographics and Employment



[2] The discussion of challenging data issues has been placed in an appendix.

Figures 7, 8, and 9 display the behavior of stock values in the model: firms, worksites, and employment, compared with reference data patterns.

Figure 7. Behavior of Firms

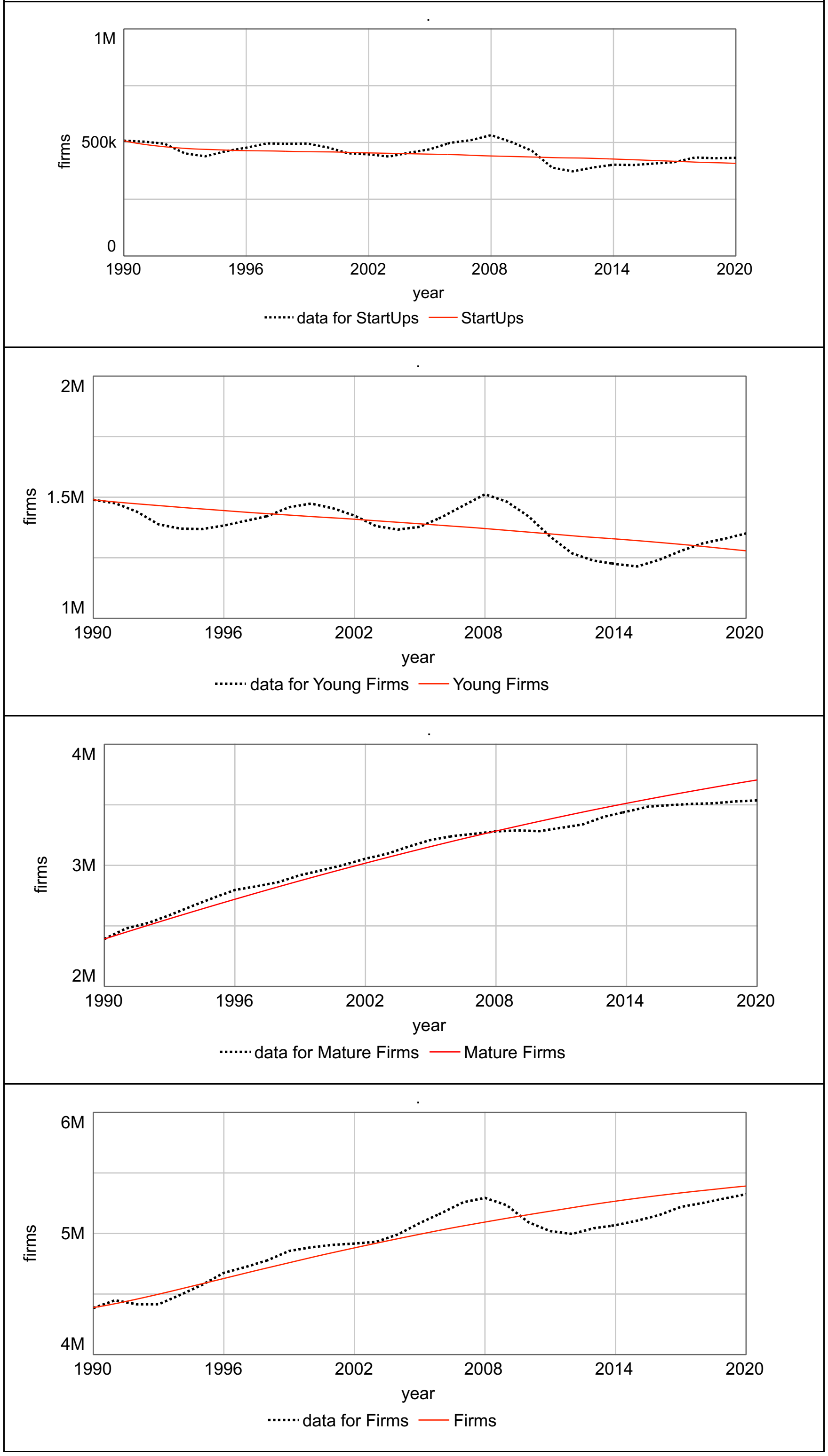


Figure 8. Behavior of Worksites (Establishments)

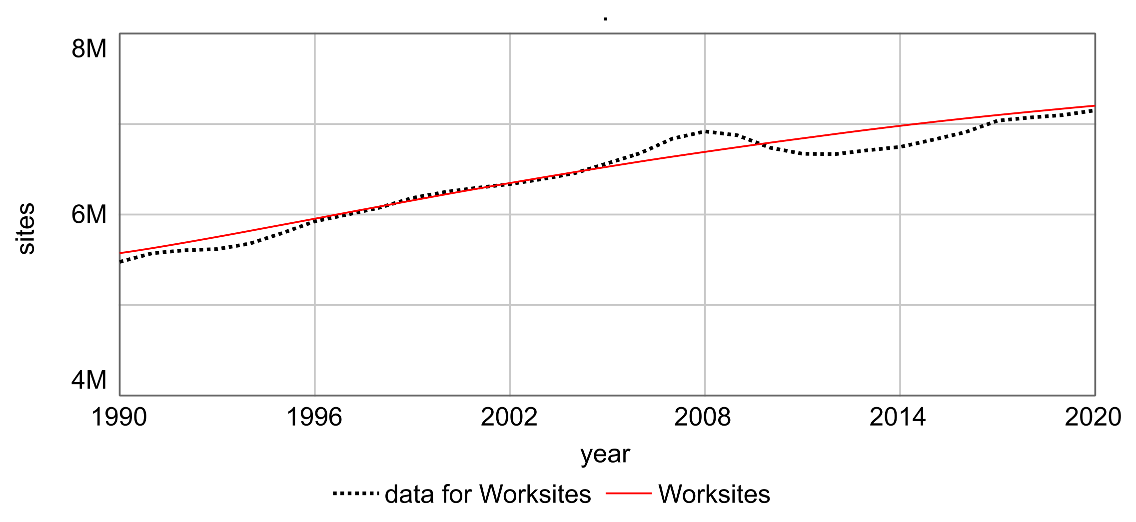


Figure 9. Behavior of Employment

Figures 7-9 reveal good data trend replication by the stocks in the model. Noticeably absent from the model behavior are the fluctuations in the data. And that is deliberate. As explained previously, the derived entrepreneurial productivity series was smoothed. The aim was to filter out the fluctuating business conditions effects.

Final Comments

Over the past decade, Khalid Saeed (2010 and 2015) has reminded SD modelers of the relevance of Joseph Schumpeter and the concept of creative destruction when modeling the dynamics of economic systems. The modeling project described in this paper was motivated by insights gained from careful study of his model. Perhaps because it is small and clear, Saeed's 'creative destruction' model reveals key structural components of an endogenous explanation of entrepreneurial behavior—specifically, what may convert potential entrepreneurs into active agents of both destruction of the 'old order' and creation of the new. Those insights will be useful in the next stage of this project.

The model presented in this paper will be integrated with other sub-models on the Supply Side of *MacroLab*, a large system dynamics-based macroeconomic model that is now in its 22nd year of use and continuous development. The existing capital and employment sub-models will be modified to incorporate essential features of the firm demographics model. The feedback structure in *MacroLab* will enable testing endogenous behavioral hypotheses for the impact of business conditions on entrepreneurial behavior.

In this 50th anniversary year of the publication of *The Limits to Growth* (Meadows *et al.*, 1972), it seems fitting to close with a rhetorical question about the main title of this paper: Limits to Entrepreneurial Growth. If we are in an historical period with seemingly fewer incentives for creating and growing a business, should that be seen as a welcome development from an LTG perspective often derided as anti-growth? I think not. I view that classic work as a clarion call for creative destruction in the best sense of that term. As communities and nations cope with the challenges foreseen by the LTG team, higher—not lower—entrepreneurial productivity should be helpful.

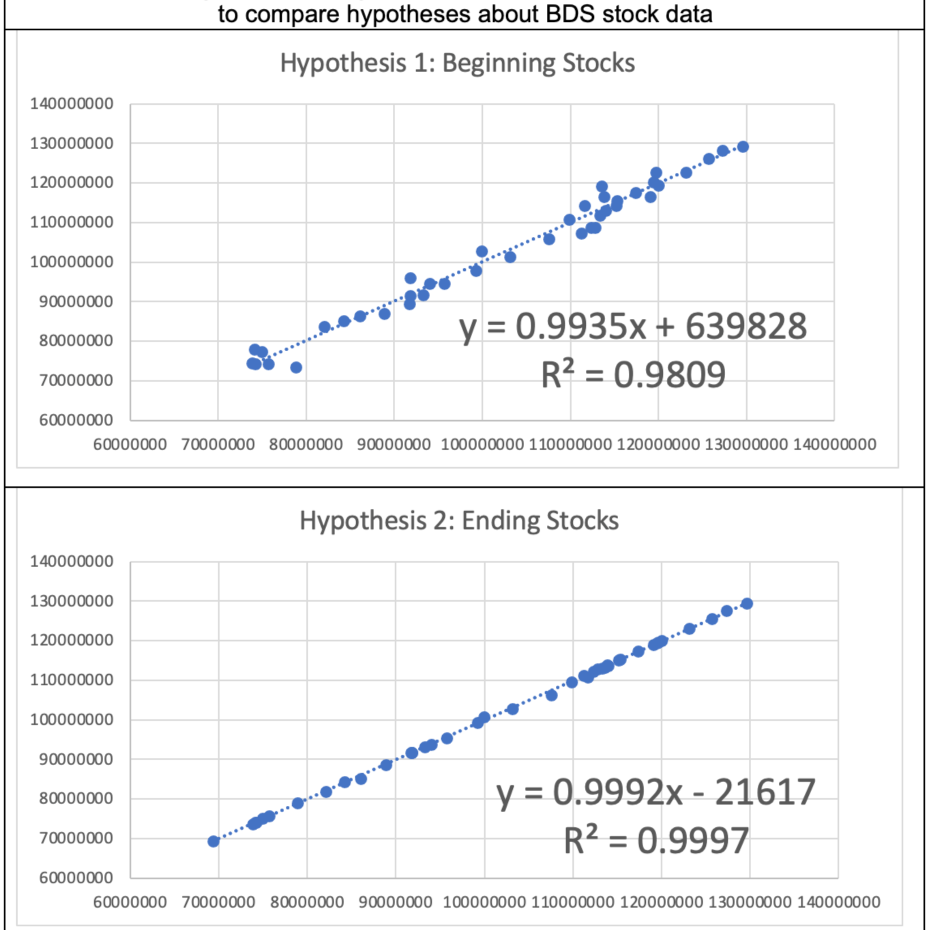
Appendix

Throughout the main body of the paper, we sometimes mentioned nice round numbers when describing parameter values in the model. In this appendix, it will become clear that the reality behind averaging and rounding was considerably more challenging than some readers might expect. And that was true for several aspects of data 'cleaning' and organization before building the model. Here, we focus on two issues: data gaps and data interpretation.

The BDS website describes the data coverage as beginning in 1978. And that is true for start-up firms and their establishments and employment. However, the age of any firm 'born' before 1976 is apparently unknown to the BDS; and that comprises a huge list of firms and their associated establishments and employment. As the 'year' in the database advances beyond 1978, the list of unknowns begins to shrink, partly because some of those firms cease operations; i.e., 'die.' That was a mixed blessing when trying to make sense of the data because something else was happening, more or less in lockstep with the steep declines in the unknown category. All age-specific cohorts (other than start-ups) have missing data in 1978 and for several years thereafter. The Young Firms in our model—those in the 1-5 year age cohort—appeared in the database in 1980. Firms between the age of 6 and 10 (part of the Mature Firms in our model) were added in 1984. And so on. The reasons for these step-wise additions to the database are not adequately explained in the BDS documentation. But the pattern of declines in the 'unknown' category suggests that the age of some 'unknowns' was being discovered or inferred, and that some were being shifted to specific age cohorts. All of this had implications for specifying the age cohorts used in the model, organizing reference mode data, estimating parameter values, and using the data to do reality checks on the model ('running the data' through the model to be sure the numbers correspond to the concepts in the model). The earliest possible coverage period of the firm, establishment, and employment stock data was 1984. However, for a few years after 1984, some stock data changed from year to year by amounts that seemed unreliable. Eventually, 1989 was selected as the start year for data usage and model calibration.

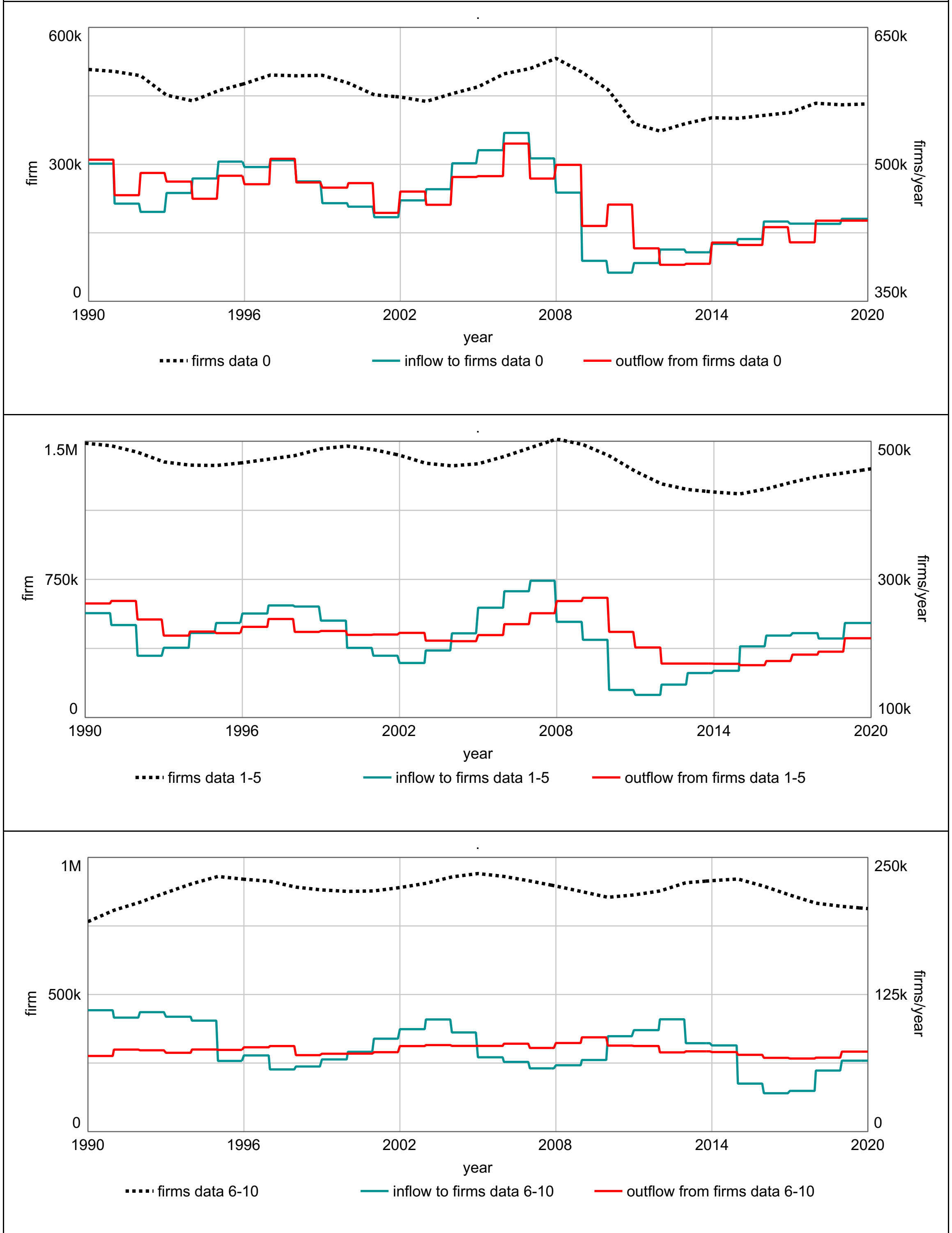
The other big issue concerned the interpretation of stock data. If the database showed 70 million people employed in 1978, a simple but important question was whether that number had been calculated at the beginning or the end of 1978. Finding the answer required very practical use of the change-in-stock definition: inflows minus outflows. In short, it was possible to use the flows listed in 1978 and 1979 and do the math with the stock listed in 1978 and compare the results. Figure A-1 shows the results of a simple regression model that proved helpful. The better fit is in the bottom cell of Figure A-1. It's more likely that the BDS employment stock data are end-of-year measurements. The data entry for the previous year would be the beginning-of-year value for the current year. This was also done for firms and establishments in the BDS data.

Figure A-1: Using Δ stock = inflow – outflow definition
to compare hypotheses about BDS stock data



Correct interpretation of the stock data 'year' is important for constructing time series data graphs that enable comparing stocks with inflows and outflows, such as those in Figure A-2.

Figure A-2. Time Series Data for Stocks, Inflows, and Outflows



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Model Equations

Employment(t) = Employment(t - dt) + (hiring) * dt
INIT Employment = jobs data UNITS: persons
Mature Firms(t) = Mature Firms(t - dt) + (firms maturing - mature firms dying) * dt
INIT Mature Firms = "firms 6+" UNITS: firm
Mature Worksites(t) = Mature Worksites(t -dt) + (worksites maturing + mature worksites expanding – worksites dying) * dt
INIT Mature Worksites = Mature Firms *worksites mature firms UNITS: sites
StartUp Worksites(t) = StartUp Worksites(t - dt) + (worksite births - worksites surviving - startup worksites dying) * dt
INIT StartUp Worksites = StartUps *worksites startup firms UNITS: sites
StartUps(t) = StartUps(t - dt) + (firm births - firms surviving - startups dying) * dt
INIT StartUps = firms data 0 UNITS: firm
Young Firms(t) = Young Firms(t - dt) + (firms surviving - firms maturing - young firms dying) * dt
INIT Young Firms = "firms data 1-5" UNITS: firm
Young Worksites(t) = Young Worksites(t - dt) + (worksites surviving + young worksites expanding- worksites maturing - young worksites dying) * dt
INIT Young Worksites = Young Firms *worksites young firms UNITS: sites
firm births = "population data (thousands)" *smoothed entrepreneurial productivity data UNITS: firms/year
firms maturing = maturing rate firms* HISTORY(firms surviving, TIME-5) UNITS: firms/year
firms surviving = survival rate firms *HISTORY(firm births, TIME-1) UNITS: firms/year
hiring = (indicated employment-Employment)/adj time employment UNITS: persons/year
mature firms dying = Mature Firms*death rate mature firms/100 UNITS: firms/year
mature worksites expanding = (Mature Firms*worksites mature firms-Mature Worksites)/adj time mature worksites UNITS: sites/year
startup worksites dying = startups dying *worksites startup firms UNITS: sites/year
startups dying = StartUps*death rate startups %/100 UNITS: firms/year
worksite births = worksites startup firms*firm births UNITS: sites/year
worksites dying = mature firms dying*avg worksites mature firm UNITS: sites/year
worksites maturing = firms maturing*worksites young firms UNITS: sites/year
worksites surviving = worksites startup firms *firms surviving UNITS: sites/year
young firms dying = Young_Firms*death rate young firms %/100 UNITS: firms/year
young worksites dying = young firms dying *worksites young firms UNITS: sites/year
young worksites expanding = (Young Firms*worksites young firms-Young Worksites)/adj time young worksites UNITS: sites/year
adj time employment = 2 UNITS: years
adj time mature worksites = 2 UNITS: years
adj time young worksites = 4 UNITS: year
avg employment mature worksites = 21.6 UNITS: persons/site
avg employment startup worksites = 5.6 UNITS: persons/site
avg employment young worksites = 8.5 UNITS: persons/site
avg worksites ratio mature firm = Mature Worksites/Mature Firms UNITS: sites/firm
death rate mature firms % = 1.5 UNITS: per year
death rate startups % = 50 UNITS: per year
death rate young firms % = 10 UNITS: per year
indicated employment = (StartUp Worksites *avg employment startup worksites + Young Worksites* avg employment young worksites + Mature Worksites *avg employment mature worksites) UNITS: persons
maturing rate firms = .4 UNITS: unitless
"population data (thousands)" = population data/1000 UNITS: persons
smoothed entrepreneurial productivity data = GRAPH(TIME) UNITS: firms/year/person
Points: (1980, 2.15), (1981, 2.12), (1982, 2.09), (1983, 2.06), (1984, 2.04), (1985, 2.01), (1986, 1.98), (1987, 1.95), (1988, 1.92), (1989, 1.90), (1990, 1.87), (1991, 1.85), (1992, 1.82), (1993, 1.79), (1994, 1.77), (1995, 1.74), (1996, 1.72), (1997, 1.70), (1998, 1.67), (1999, 1.65), (2000, 1.63), (2001, 1.60), (2002, 1.58), (2003, 1.56), (2004, 1.54), (2005, 1.52), (2006, 1.50), (2007, 1.47), (2008, 1.45), (2009, 1.43), (2010, 1.41), (2011, 1.39), (2012, 1.38), (2013, 1.36), (2014, 1.34), (2015, 1.32), (2016, 1.30), (2017, 1.28), (2018, 1.26), (2019, 1.25), (2020, 1.23)
survival rate firms = .5 UNITS: unitless
worksites ratio mature firms = 1.50 UNITS: sites/firm
worksites ratio startup firms = 1.01 UNITS: sites/firm
worksites ratio young firms = 1.04 UNITS: sites/firm