An aging dynamo: demographic change and the decline of entrepreneurial activity in the United States

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Abstract

The rate of new business startups has fallen drastically over the last thirty-five years, a trend that accelerated after the year 2000. Other measures of business dynamism, such as the job reallocation rate, are consistent with this trend. This has raised serious concern, given the effect that young, high-growth firms have been shown to have on employment, and may also have on innovation and growth. The timing of this decline coincides with the start of a steady increase in both the life expectancy and average age of the workforce. I document that an individual's propensity to select into entrepreneurship follows a 'hump shape' as they age. To account for both individual behavior and aggregate trends, I construct a life cycle model of entrepreneurial choice, studying a number of channels that link demographic forces to entrepreneurial selection. I find that demographic channels can account for a large portion of the recent decline in startup activity. This model predicts that entrepreneurial activity will continue to decline as the pool of potential entrepreneurs continue to age. I conclude with a discussion of the potential policy tools that will affect individual's life cycle risk attitudes and the predicted effects that such measures will have on the rate of new business startups.

1 Introduction

By every measure business dynamism has declined sharply over the last thirty-five years. The driving force behind this decline is the nearly one-third decline in the rate of new business starts over that period. To what degree can this decline be explained by the aging of the United States population? I document the hump-shaped relationship of entrepreneurship and age, and show that the age-structure of a country's labor force is a significant predictor of level of entrepreneurial activity taking place in its economy. Motivated by these empirical facts, I construct a life cycle model of entrepreneurial choice in which I am able to replicate the observed age specific selection into entrepreneurial activity. Studying this model I describe a number channels through which aging can affect the rate of startups in such an economy, finding that these can account for a large share of the documented decline in new business creation in the United States since the 1980s as well as a relatively large portion of the cross-sectional variation in entrepreneurship observed across countries. I find that these results are not significantly effected by alternative specifications of the model, and conclude with a discussion of the potential policy options that may be available to affect the age specific decisions of would be entrepreneurs.

In their recent summary of the literature on business dynamism in the United States, Decker et al. (2016b) find that various measures of entrepreneurial activity have been in secular decline since the early 1980s. This can be seen through a falling share of young (less than five years old) firms in: the distribution of firms, job creation, and employment. This is troubling given that young firms have been shown to be an important source of job creation and employment (Haltiwanger et al., 2013). In addition, recent work by Pugsley and Sahin (2015), finds that young firms are linked to an economy's responsiveness to downturns, and suggest that the decline in young firms may lead to slower growth rates following recessions and 'jobless' recoveries. Decker et al. (2016c) document that since 2000 this decline in entrepreneurship has been increasingly concentrated in high growth entrepreneurs, finding that the gap between the 90th and 50th percentile in the growth rates has shrunk significantly over the period. Their work suggests that the recent decline may additionally have important implications on employment rates and growth. Their most recent work on the source of these declines, Decker et al. (2016a), rules out a number of plausible candidate theories as to why this slowdown has occurred. For one, there is little evidence of change in the distribution of productivity to shocks firms in a way that would cause a slowdown in the rate of new startups. Although this is difficult to observe empirically they find that productivity has remained flat, or slightly risen over this period for industries in which such data is available. This suggests, if anything, that we should expect and increase in the amount of startup activity. This and other suggestive evidence points them to the idea that firms have likely become less sensitive to the productivity shocks they receive over time. The authors put forward, but find little evidence supporting, three potential mechanisms for startup decline: globalization and exposure to foreign trade, shifting margins of adjustment from labor to capital, and a mechanism proposed by Byrne (2015) in which there is a transition from "general-purpose" to "special-purpose" manufacturing. Another candidate for altering the rate at which firms enter in the market in the face of promising opportunities is changing regulatory schemes. However, Goldschlag and Tabarrok (2014) find that there is little evidence that government regulation has had an effect on business startup behavior over this period. I propose a novel solution to this puzzle: that long run demographic change has driven the observed decline in United States startup activity.

The primary difference between the mechanism put forward in this work and that of earlier studies, is to study the entrepreneurial decision making process from the individual, rather than firm level perspective. While aggregate changes to productivity and firm structure may well be crucial in determining business dynamism, it is important, and often overlooked, that behind nearly all startup activity is an individual incurring a great deal of personal risk to get the project off the ground. Taking this approach, I show that the secular decline in entrepreneurial activity can arise as a result of an aging pool of potential entrepreneurs, whose willingness to take on risk evolves over their life cycle. Studying the impact of demographic change on entrepreneurial investment behavior fits into a growing body of work that seeks to understand the way that slow moving demographic variables may effect important macroeconomic aggregates. A large field has recently sprung up linking demographic forces to long run secular stagnation and interest rates. The important underlying mechanism in the majority of these papers is a life cycle component to household investment decisions. Backus et al. (2014) find that changing life expectancies and age distributions are important determinants for international capital flows. More recently many have looked to demographic channels as an explanation for secular stagnation. In Gagnon et al. (2016), demographic variables account for a 1.25 percentage point fall in the long run real interest rate. They decompose this result into half a percentage point coming from falling fertility and the evolution of the employment/population ratio, and the final quarter from lower mortality rates.

To understand how individuals may approach the decision to undertake a risky entrepreneurial investment I construct a heterogeneous agent model in the class of Aiyagari (1994) where finitely lived individuals receive idiosyncratic opportunities to begin a new business venture. I show that individuals with identical preference parameters react differently to these shocks at different stages of their life, opening a channel through which the age structure of an economy can have profound impacts on the rate of business creation. Although unexplored in the context of new business creation, the mechanisms working in this model have been long underston in finance. Studies of life cycle portfolio composition such as that of Cocco et al. (2005) and Bodie et al. (1992a), show that individuals rebalance from risky to safe assets as they age. Further there is evidence that the life cycle risk patters implied by such models are born out by the life cycle portfolio choices of households. This is evidenced by the work of Fagereng et al. (2015) who find that individuals wind down their equity positions as they approach retirement and Spaenjers and Spira (2015) who show that the risk tolerance of individuals is significantly positively related to their current life expectancy. Further, work by Moskowitz and Vissing-Jørgensen (2002) shows that entrepreneurs hold undiversified, and highly risky portfolios. This fact would imply and even more exaggerated life cycle effect than that found with publicly traded equity.

There is a great deal of empirical precedent to suggest that age is an important determinant of selection into entrepreneurship. Most studies of selection into entrepreneurship suggest a hump shaped relationship with age. Data from the Global Entrepreneurial Monitor show that most entrepreneurs are between the age of twenty-five and forty-five. The peak age for individuals engaged in new startups occurs earlier, peaking in the late twenties to early thirties (Reynolds et al., 2002). In a survey of the literature Parker (2009) suggests that descriptive studies tend to agree with this characterization, with entrepreneurship peaking in the late thirties. Due to limitations in data availability and in the definition of what constitutes an entrepreneur, it is difficult to compare estimates across studies directly. However, the ubiquity and statistical strength of this life cycle 'hump shape' across empirical work suggests that the relationship is of some importance.

The idea that risk is evaluated differently across life is supported by the work of Pålsson (1996) who estimates coefficients of relative risk aversion across individual characteristics, finding a strong positive relationship with age. In fact, age is the only demographic characteristic tested that has a significant effect on risk aversion. Polkovnichenko (2003) calibrates a static model that studies the riskiness of entrepreneurial ventures for individuals by considering both the risk of new business ventures, and the value of that individual's lifetime human capital as a non-entrepreneur. He finds that there is a 40% increase in the risk premium required for a 45 year old to undertake a new startup relative to the same venture presented to a 40 year old individual. This mechanism, which in my model I will refer to as "life-cycle" risk, will be a primary driver of my results. My approach does no begin with an ad hoc relationship linking age to risk preferences, which I hold constant over the life cycle, but rather has the observationally equivalent implication that individuals will have a higher threshold for willingness to engage in risky enterprise due to the shrinking value of lifetime earnings potential in the labor force as well as a need to finance consumption in retirement. This is methodologically similar to the model of Bodie et al. (1992a) and Cocco et al. (2005) who find that individuals move towards safer financial assets as they age and the value of their relatively less risky future labor income falls. I am agnostic with respect to how the entrepreneurial ability of individuals may evolve as they age although there has been some evidence that it may decline over time. Such an assumption in this model would strengthen my results.

Heterogeneous agent general equilibrium models have become ubiquitous in the macroeconomic literature. Stemming from the incomplete markets model of Bewley (1977), these models introduce idiosyncratic risk to agents who cannot self insure against all possible states of the world. In particular, my model is in the spirit of Aiyagari (1994), and Huggett (1993) who generate precautionary savings of a single risk free asset as a means of partial insurance against risk to labor income. Perhaps due to the widely cited work of Bernanke et al. (1999), it has been common for research to incorporate an entrepreneurial sector into this class of models. For most purposes these agents are treated as a separate, and exogenous, pool of individuals whose motives and preferences are distinct from those of 'normal' consumers. Evans and Jovanovic (1989) provide a model that allows for selection into entrepreneurship. Their static framework provides key insight into important mechanisms at work in this selection process, especially with regard to the role of financial constraints. Much of the research that models selection into entrepreneurship has used the need for individuals to build large savings (to overcome risk and barriers to entry) as a means of generating plausible wage and wealth distributions. This is the goal of a number of studies such as Cagetti and De Nardi (2006) and Quadrini (2000), who find that the introduction of entrepreneurs to this class of models allows them to account for the high degree of wealth inequality that is observed in the data. A secondary, but potentially important contribution of my work is to more precisely understand the degree to which such models can generate plausible rates of entrepreneurial activity and the effect that may have on savings distributions, which has not to my knowledge has not been studied in this literature.

My life cycle model has its roots in the overlapping generations model of Samuelson (1958). Specifically I build on a class of life cycle models such as Huggett (1996) and Ríos-Rull (1996), who both incorporate heterogeneous agents, into such a framework. Gourinchas and Parker (2002) and Storesletten et al. (2004a) use this setup to show that the idiosyncratic risks faced by differently aged individuals can account for a significant amount of the consumption inequality in the United States. In the finance literature, life cycle models have been used to study the variation of portfolio choice at different stages of life. The aforementioned work of Bodie et al. (1992b), show that individuals adjust their portfolios to account for the declining share of future potential labor income as they age, offsetting the decline of this relatively low risk labor asset by shifting their financial portfolio from risky assets towards safer ones. Cocco et al. (2005) support this result and find that the utility costs of failing to balance portfolio to account for declining human capital assets is potentially quite large. In related work Benzoni et al. (2007) find that when stocks dividends are cointegrated with the labor market this portfolio shifting rather takes a hump shape over the life cycle as human capital acts 'stock-like' for young investors and 'bond-like' for those nearer retirement. In many ways my work contributes to this literature, treating entrepreneurial ability and opportunity as an investment opportunity.

To my knowledge the only two other papers that model entrepreneurship and demographics together are: Levesque and Minniti (2006) and Liang et al. (2014). In particular the underlying mechanisms driving decisions in my model will be similar to that of Levesque and Minniti (2006). However, both of these partial equilibrium frameworks cannot produce the quantitative predictions concerning the way in which these decisions drive aggregate results that I wish to study. Bringing these questions to a general equilibrium model yields a number of benefits: adding clarity to the channels through which these effects take place, generating predictions for future paths given changing demographics, and allowing for the study of policy experiments in the model environment. My model is equipped to forecast the path of future entrepreneurial activity as well as provide a laboratory in which policy experiments can be studied.

Section 2 provides empirical motivation for the study of the life cycle entrepreneurial decision making. Section 3 describes a heterogeneous agent life cycle model of entrepreneurial choice and section 4 lays out the calibration of the model. Section 5 summarizes the key results and gives a description of the mechanisms that drive them and Section 6 concludes.

2 Empirical aspects of life cycle entrepreneurship

In this section I will demonstrate that the relationship between aging and entrepreneurship is an important factor for individual selection into new business ventures and argue that aging can have important effects on the rate of new business creation within a country. Later my model will provide a framework for understanding the determinants of these individual choices and the way that they aggregate to yield differential effects in economies of different age structures. I will do so using data from the Global Entrepreneurial Monitor (GEM) from 1998-2010. This dataset contains population surveys conducted by the GEM on an annual basis identifying individuals as entrepreneurs and, if so, the nature of their new business ventures. For cross country analysis I aggregate their data to the age-country-year level and merge it with census data as well as some financial data from the world bank. I conclude this section with some analysis of some characteristics of young startups from the Panel Study of Entrepreneurial Dynamics, which follows a group of Nascent entrepreneurs over six years. This will yield some implications on the nature of nascent funding and the characteristics of nascent entrepreneurs that will further motivate some of the mechanisms that will operate in my theoretical framework.

2.1 Selection into entrepreneurship and the life cycle

To begin, it is important to carefully understand the individual level relationship between entrepreneurial choice and age. Figure 1 presents a stylized picture of the rate of selection into entrepreneurship conditional on age. I plot the rate of total-early stage entrepreneurship across five year age cohorts for a sample of individuals in the United States surveyed by the Global Entrepreneurship Monitor (GEM) from 1998-2010. This hump shaped relationship is well supported by the literature on entrepreneurial selection in which age is nearly always included in empirical models as a second order polynomial, with both a negative and positive component.

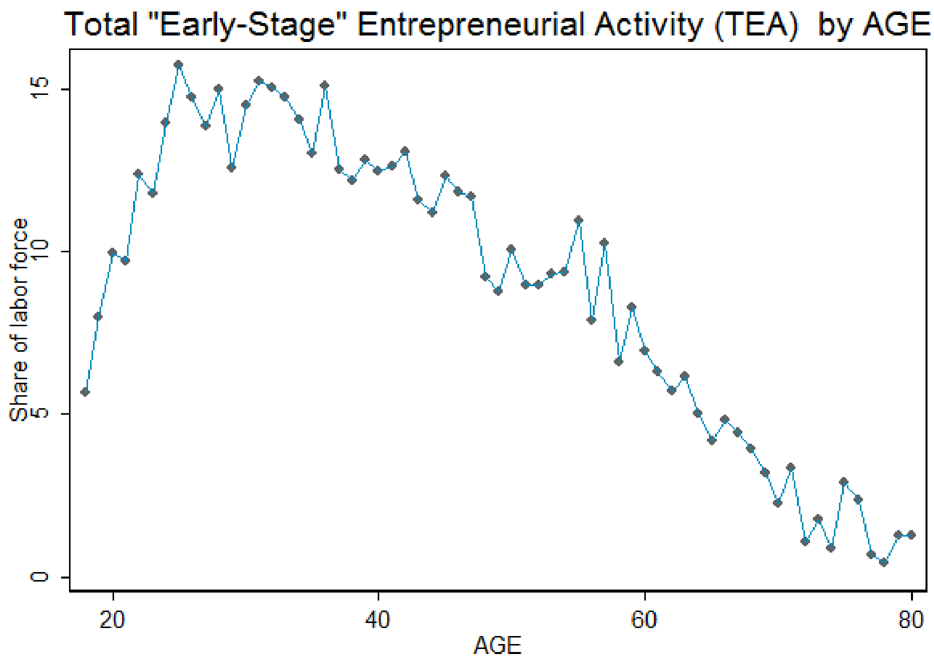

Figure 1: US total early stage entrepreneurial activity

To test this relationship I estimate selection into entrepreneurship using logistic regressions on this repeated cross section. Table 1 shows results from logistic regressions of selection into 'early-stage entrepreneurship' against age, gender, and opportunity. [1] I find that the conditional likelihood of becoming an early stage entrepreneur is maximized at age 28 at which point it is 14.075 percent. This probability falls to 10.56 percent at age 50 (fifteen years before retirement) and to 7.34 by age 60. A thirty-six year old individual who is the average age of individuals in the United States would be 15.94% more likely to

[1]Opportunity is a self reported measure of whether the individual perceives that there are profitable business ventures in their area. It is a variable that is largely used to remove necessity entrepreneurs who may become self employed due to lack of jobs, rather than profit motives.

engage in early stage entrepreneurial behavior than an individual who is the 46 (the average age in Japan). Running similar estimations for other countries yield similar results. For example using only pooled data for Japan yield similar results although their peak age is somewhat later at 35, and the level of entrepreneurial activity is lower at every age than in the United States[2].

Table 1: Regression estimates of annual US GEM data

VARIABLES	(1) TEA	(2) TEA	(3) TEA
age	0.0923***	0.0262***	0.0250***
	(0.00577)	(0.00726)	(0.00730)
age_sq/100	-0.1319***	-0.047***	-0.0471***
	(0.0064)	(0.008)	(0.0082)
Covariates		X	X
YEAR FE			X
Constant	-3.456***	-3.475***	-3.754***
	(0.123)	(0.169)	(0.179)
Pseudo-R^2	0.05	0.18	0.19
Observations	54,875	35,374	35,374

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Few studies have directly attempted to study the role that age plays in individual selection. One difficulty that is common across the entire literature on selection is that it is hard to define an entrepreneur. While I try to understand selection into entrepreneurship (new business creation) many empirical studies have relied only on individual classification as 'self employed' in order to take advantage of large public use microdata. One such study, Rees and Shah (1986), reports a similar, if less pronounced, hump shape to that which I plot above. Evans and Leighton (1989) are able to show that entry does not increase

[2] This is consistent with the work of Liang et al. (2014) who find that entrepreneurship for older economies is lower for every age group. I will show that this is consistent with my proposed model.

in later years[3], though they do not take a stand on whether or not it is decreasing with age. Blanchflower et al. (2001) find that although self employment appears to increase with age, the propensity of individuals to *prefer* self employment falls rapidly with age. While there is still no consensus in the empirical linterature on the causal link between age and entrepreneurship, there is a wealth of suggestive evidence that conflicting forces create strong non-linearities between these variables. I do not claim in this empirical section to causally identify this age-entrepreneur relation, but rather wish to emphasize the preponderance of evidence that such a correlation exists. Further my model will give motivation for the potential age related variables that may drive such a correlation.

A key difficulty in empirically linking age and entrepreneurship is that age likely captures many underlying and often unobserved characteristics that are likely important in determining entrepreneurial status. As suggested by Wagner and Sternberg (2004) and Evans and Leighton (1989) age is highly correlated with wealth, which is a potentially important factor for access to financing new ventures. Further, old individuals will likely have a shorter time to realize the long run gains of new business starts as well as a shorter time to recover from potentially large short run losses. My suggestive work in this section does not seek to provide a definitive answer these questions, about which further empirical work must be done. However, these forces are at the heart of the significant age-entrepreneur relationship displayed in Table 1 and suggest an important relationship that a quantitative model can help us understand.

2.2 Demographics and the rate of new startups

Life cycle dynamics are important insomuch as they are a channel that can drive the rate of new startups in an economy. Countries that are very old (or very young) will have a smaller share of their workforce in peak entrepreneurial ages, which may result in fewer total startups due to what I will refer to as a *composition effect*. In addition, changing life

[3] Dispelling a previously hypothesized notion that individuals use entrepreneurship as a means of postponing retirement (Fuchs, 1980).

expectancies and general equilibrium effects can alter the shape of the age-entrepreneur relationship itself.

Figure 4 shows a 'stylized' presentation of the cross country relationship with the share of the working population engaged in new startups on the vertical axis and the countries median age on the horizontal as a crude metric for demographic structure. The measure of entrepreneurship used is the same 'total early stage entrepreneurship' that includes young firms and firms still in early stages of creation. It also includes only individuals who claim to have started their new venture due to perceived opportunity, to avoid considering 'necessity' entrepreneurs who, though common in many poorer countries, are not making the kind of risk-reward trade-offs in their decision that I wish to study in this paper.

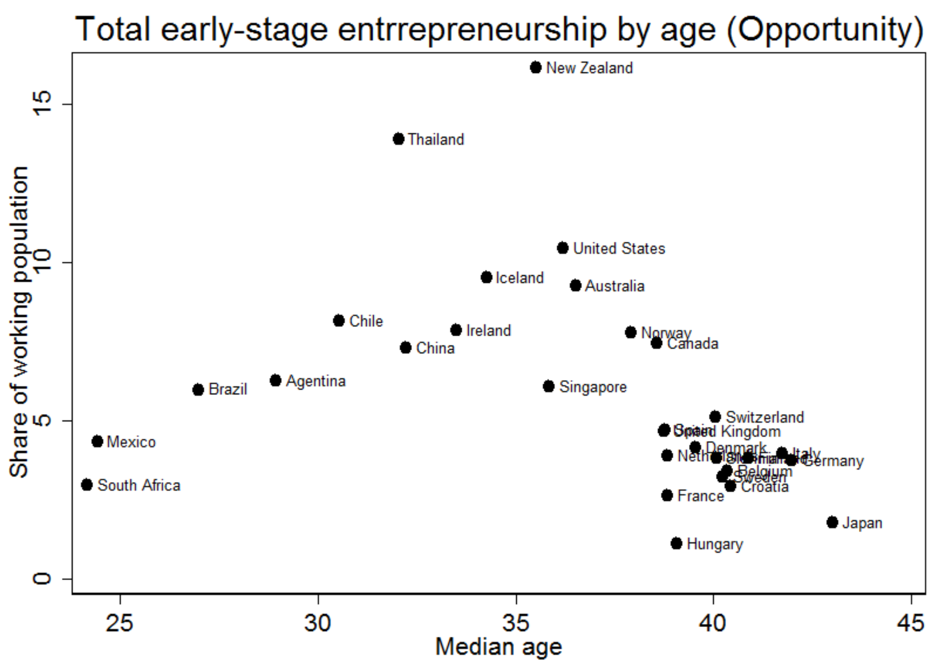

Figure 2: Source: GEM adult population survey (national statistics)

Table 2 studies this empirical relationship in a cross country dataset. For each country-year-age, I regress the rate of early stage entrepreneurship on a linear and quadratic

VARIABLES	(1) TEA	(2) TEA	(3) TEA	(4) TEA
age	0.188***	0.127***	0.128***	0.162***
	(0.0421)	(0.0416)	(0.0423)	(0.0394)
$\frac{age^2}{100}$	-0.295***	-0.207***	-0.209***	-0.248***
	(0.0415)	(0.0434)	(0.0442)	(0.0443)
Covariates		X	X	X
Year FE			X	X
Country FE				X
Observations	12,305	11,273	11,273	11,273
R-squared	0.143	0.194	0.202	0.321

*** p<0.01, ** p<0.05, * p<0.1

Table 2

age term. In columns two-four I include covariates for the share of the population in each age group who express feeling that there is entrepreneurial opportunity, sex ratio, a dummy for the financial crisis, and the share of domestic credit available to the private sector as a fraction of GDP. [4] The final two columns include fixed effects for countries and years. All standard errors are clustered at the country level. The added covariates include averages of a number of characteristic variables such dummies for the share in various education groups, sex ratio, the share reporting entrepreneurial opportunity, and the share belonging to three income groups. It also includes some country-year specific variables such as gdp per capita and the share of private domestic investment available as a percentage of gdp. My hope is that the latter will proxy the availability of financial capital for startup projects which of course differs greatly across countries. The results across all specifications suggest peak entrepreneurial age between 32-33. The signs on these variables is generally as expected: more education, income, and domestic credit availability increase the rate of entrepreneurial activity. The various levels of education and income within country-year-ages are each jointly significant and perceived entrepreneurial opportunity is the only other variable that is strongly significant across specifications on

[4] These variables, which are country-year specific I hope will act as a proxy for the overall availability of financing in a given country-year.

its own, it is strongly positive. The addition of year and country fixed affects increased the R-squared significantly without having a meaningful impact on the point estimates of age variables. Using the specification in column four, this would imply a 9.4% reduction in entrepreneurial activity for aged 45 cohort relative to age 35. These results show that age can not only be an important determinant in individual selection into entrepreneurship but that this effect, when coupled with shifting demographics, can significantly affect the overall rate of entrepreneurial activity taking place within an economy.

These results mirror recent work conducted by Liang et al. (2014) who to my knowledge are the only other work to directly study this effect. Also using the GEM dataset they run country-year-age regressions similar to the one above regressing age and the share of the population above that age against various measures of entrepreneurial activity. I replicate their work finding similar results, but report age and age squared regressions here to clarify the hump-shape that I will try to replicate in my theoretical section. The mechanisms they propose, though different than mine, are not mutually exclusive and indeed may be complimentary. They suggest that being in an age cohort with relatively fewer old individuals allows for faster advancement in traditional work, demographic change gives less opportunity for individuals to get this experience. Working against this is an ad hoc assumption that individuals have more entrepreneurial zeal at young ages. While such assumptions would strengthen my results, they are not necessary to achieve a significant demographic effect on the rate of startups. In the following section I describe this model.

3 A Life Cycle Model of Entrepreneurial Choice

I study a parsimonious model that is able to capture these empirical facts about entrepreneurship. The properties that such a model must have to answer these questions are: incomplete markets, risky entrepreneurial opportunity, and finite lifespans. An appealing aspect to this approach is that it does not require ad hoc assumptions about the way in which entrepreneurial skills or risk preferences evolve as individuals age, both of which remain constant with respect to age for individuals in my model.

The life cycle attributes of my model are crucial to studying the age specific responses to risk that will open the channel between demographics and the rate of new business creation. In addition, for there to be individual risk I must allow for heterogeneous agents. I therefore begin by building on a class of models such as Storesletten et al. (2004b), which takes heterogeneous agents from an Aiyagari (1994) model and places them into a finite life cycle framework. Individuals are ex-ante homogeneous and their life spans, though finite, are uncertain. These agents may work for wages as well as invest in entrepreneurial activities that allow them to produce and sell a homogeneous good. These entrepreneurial opportunities randomly manifest through an 'entrepreneurial idea' shock, that require a fixed upfront capital investment that forces potential entrepreneurs to risk their own savings (to an extent) before knowing the if the project will be successful. To hedge their idiosyncratic wage and production risk, as well as to build retirement savings, these agents will trade in a risk free bond. The incompleteness of markets, necessary in any Bewley (1977) model, will limit the degree that they can hedge their risk. In addition, and consistent with data on early-stage entrepreneurs, individuals are limited in their borrowing to finance entrepreneurial projects by the size of their personal wealth.

The inability to borrow limitlessly will make raising the requisite capital needed to start a new business harder for young individuals who have not had time to build their wealth. On the other side of the life span, the need to have saved to finance retirement will limit the amount of risk older workers are willing to take for fear of the large potential downside of entrepreneurial failure.

3.1 Households

The household sector is populated by ex-ante identical individuals. Households face finite and uncertain lifespans living for a maximum of N periods, with conditional mortality risk s_i having reached age i. These probabilities are generated using the methodology proposed by Henriksen (2015) who generates annual survival probabilities that are approximated based on the life expectancy of an individual at birth. If life expectancy falls this will appear in the conditional mortality and individuals will more heavily discount the future retirement due to the lowered expectations that they will survive to enjoy consumption in later periods.

Although it is possible to endogenize the retirement age in such a model, many efforts to do so require an ad hoc choice of modeling age specific labor disutility, since such assumptions already presuppose a preference to retire at a narrow band of ages I presently model retirement, at age = R, as being fixed. Similar life cycle models have been widely used to study consumption and income inequality (Storesletten et al., 2004a) (Krueger and Perri, 2006), as well as aggregate savings fluctuations (Ríos-Rull, 1996), and capital flows (Backus et al., 2014).

Households maximize lifetime utility that is derived from consumption and disutility from labor effort with a standard constant relative risk aversion utility function:

$$\max \left\{ \mathbb{E}_0 \sum_{i=0}^{N} s_i \beta^i u(c_i, h_i) \right\} \ ; \text{with } u(c_i, h_i) = \frac{c_i^{1-\sigma}}{1-\sigma} + \xi \left(\frac{1-h_i}{1-\gamma} \right)^{1-\gamma}$$

The household has two potential sources of income, their labor earnings and earnings

derived from individual production in the entrepreneurial sector. Age specific labor ability consists of an ae fixed effect as well as a random and persistent AR(1) process:

$$\epsilon_i = \rho_\epsilon z_{i-1} + n_i + \varepsilon_i^\epsilon \varepsilon_i^\epsilon \ ; \ \varepsilon_i^\epsilon \sim N(0, \sigma_\epsilon^2)$$

Entrepreneurial production occurs through an allocation of hired labor and capital towards a project that is specific to the individual. Following the entrepreneurial sector of Quadrini

(2000): at the end of each period every household receives an idea, $\kappa \in \mathcal{K} = \{k_0, k_1, ..., k_\kappa\}$ with probability $\mathcal{P}_k(\kappa)$. These ideas map one-to-one into the capital required to implement the project and individuals must decide in the current period whether they will enter the next period as producers (by investing in capital to use) or to work as wage earners. Once a household has a project they keep that project until they decide to abandon it either for a better idea or to halt production. They also receive a technology shock, η, at the beginning of the period before production takes place, and contains at least some realizations that would induce an individual to shut down current production. This technology shock is persistent, following an AR(1) process.

$$\eta_i = \rho_\eta \eta_{i-1} + \varepsilon_i^\eta \ ; \ \varepsilon_i^\eta \sim N(0, \sigma_\eta^2)$$

The individual entrepreneurial profit function is given by:

$$\pi_i(\eta_i, \ell_i, k_i) = \max_{\ell_i} \left\{ \eta_i^\alpha k_i^\alpha \ell_i^{1-\alpha} - w\ell_i - (1+r)k_i \right\}$$

Since capital is fixed in the current period the entrepreneurial profit function reduces to a simple one variable optimization. The entrepreneur will either choose to produce at $\ell = \ell^*$, or $\ell = 0$, depending on the realization of the productivity shock. An entrepreneur that chooses to shut down loses their current project and will only be able to produce in the following period if they receive a new idea shock in which to invest. There always exists an η_{min} realization of the productivity shock that is sufficiently bad (and persistent) that an individual will choose to shut down.

Production: Production takes place in two sectors, a corporate sector and an entrepreneurial sector. Corporate production is characterized by a representative agent that combines capital and labor in a competitive market using a Cobb-Douglas technology, $Y_c = F(K_c, N_c) = K_c^{\theta} N_c^{1-\theta}$, and factor prices are determined in the corporate sector such that:

$$w_t = F_{\ell}^{c}(k, \ell)$$

$$r_t = F_{k}^{c}(k, \ell)$$

The entrepreneurial sector is made up of households who have access to a Cobb-Douglas production function and heterogeneous production efficiency η_i as described in the above section. The contribution of entrepreneurial production is simply the sum of all individual production projects given by:

$$Y_e = \sum_{i=1}^{I} y_i = \sum_{i=1}^{I} \eta_i^{\alpha} k_i^{\alpha} \ell_i^{1-\alpha}$$

The total supply of the homogeneous final good is given by the sum of production in these sectors, which must equal the demand of consumption by households in equilibrium.

Financial Intermediaries: Individuals can borrow and save using one period risk free bonds that trade competitively and return (1+r) units of consumption after one period. As is standard in this literature households use these bonds to insure against idiosyncratic risk. The borrowing constraints that I employ follow Moll (2014), among others, and I allow individuals to borrow up to λ times their current level of asset holdings to finance a project.

$$k \leq a\lambda$$

This is equivalent to a limited liability contract where an individual can 'steal' $\frac{1}{\lambda}$ of their current capital stock, and lose their assets and the intermediary sets the constraint so that they will not choose to do so. As such this simple linear requirement can be easily mapped into micro foundations.

Timing: A crucial feature of the model economy is the timing with which individuals make their decisions. Capital investment in the entrepreneurial project takes place in the prior period, before uncertainty is resolved (but after current production has taken place). It is useful to think of each period is split into two parts:

1. Entrepreneurs observe realizations of productivity and make decisions regarding hiring and production.

2. Households receive entrepreneurial idea, choose whether or not to invest, and make consumption and savings decisions.

In this second sub-period an individual is choosing whether they enter then next period as an entrepreneur or as merely a wage worker. The benefit of taking advantage of an entrepreneurial idea not only yields potential profit in the next period, but allows the individual access to the technology in subsequent periods until a sufficiently bad productivity shock forces shutdown.

3.2 The households's problem and equilibrium:

An individual enters each period with five state variables and five choice variables. Let $\varsigma_i = (\eta_i, \kappa_i, \epsilon_i, a_i, k_i)$ denote the vector of an individual's state variables which respectively are: the entrepreneurial productivity shock, entrepreneurial idea shock, labor productivity, current asset holdings, and working capital. In addition there are five choice variables: savings (a'), capital investment (k'), firm hiring (ℓ), work effort (h), and consumption (c).

In each period the individuals must choose if they will enter the following period as an entrepreneur. The Bellman equation that characterizes the problem of an individual who begins age i as an entrepreneur is characterized by:

$$
\begin{aligned}
V_i^e\left(\varsigma_i\right) = & \max_{h,a',k' \in \{k,\kappa\}} \left\{u_i(c,h) + \beta s_i \mathbb{E}_i\left[\max\left\{V_{i+1}^e\left(\varsigma_i'\right), V_{i+1}^w\left(\varsigma_i'\right)\right\}\right]\right\} \\
c = & a(1+r) + \pi_i(a,k,\eta) + we^{\epsilon}h - a' \\
\pi_i(\eta_i,\ell,k) = & \max_{\ell}\left\{\eta_i^{\alpha}k^{\alpha}\ell^{1-\alpha} - w\ell - (1+r)k\right\} \\
\lambda a' \geq & k'
\end{aligned}
$$

Recalling that individual choice of consumption, savings, and future investment in any entrepreneurial projects takes place after an individual's current period wage and productivity uncertainty has been resolved. Since an entrepreneur can always continue their current project, but has the option to instead take on a project associated with a new idea, $V_{i+1}^e(\varsigma')$, is actually given by $\max\left\{V_{i+1}^e(\eta_i', \kappa_i', \epsilon_i', a_i', k_i), V_{i+1}^e(\eta_i', \kappa_i', \epsilon_i', a_i', \kappa_i)\right\}$, in the event that they have received a new (and different) idea shock. This is not the case for a wage worker who wishes to become and entrepreneur, but who only has one potential project at any given time. The value function of a wage worker at age i is given by:

$$
\begin{aligned}
V_i^w\left(\varsigma_i\right) = & \max_{h,a',k' \in \{k,\kappa\}} \left\{u_i(c,h) + \beta s_i \mathbb{E}_i\left[\max\left\{V_{i+1}^e\left(\varsigma_i'\right), V_{i+1}^w\left(\varsigma_i'\right)\right\}\right]\right\} \\
c = & a(1+r) + we^{\epsilon}h - a' \\
\lambda a' \geq & k'
\end{aligned}
$$

Finally after reaching age = R agents no longer participate in the workforce and do not carry out entrepreneurial projects. As a result they finance their consumption solely out of accumulated savings. Their value function is given by:

$$V_i^R(\varsigma_i) = \max_{h,a',k' \in \{k,\kappa\}} \left\{ u_i(c,h) + \beta s_i \mathbb{E}_i \left[V_{i+1}^R \right] \right\}$$

$$c = a(1+r) - a'$$

As a result in the year before retirement no agent will invest in a new project or the continuation of an existing one. Further, it is this need to save as a means of smoothing consumption in post-retirement years that causes individuals to treat similarly risky projects differently as they approach this time.

Equilibrium requires that individuals optimize their Bellman equation in addition to the market clearing conditions. Finding an equilibrium for this model requires:

1. Taking as given factor prices and demographics, households choose optimal consumption, savings, and work effort, as well as entrepreneurial investment and hiring.

2. Corporate firms produce

3. Markets clear given the following conditions

I define the number of individuals in period t, age i as $\chi_{t,i}$, and the measure of individuals aged i with a particular realization of shocks as: $\mu_i(\epsilon, \eta, a, k)$. Then the following conditions define equilibrium for this economy:

- Factor markets clear:

$$\sum_{i,\kappa,\epsilon,\eta} \left\{ \chi_{t,i} \int_a k_i \mu_i(\epsilon, \eta, a, k) da \right\} + K^c = \sum_{i,\kappa,\epsilon,z} \chi_{t,i} a_i(\epsilon, \eta, k)$$

$$\sum_{i,\kappa,\epsilon} \left\{ \chi_{t,i} \int_a \ell_i \mu_i(\varepsilon, \eta, a, k) da \right\} + L^c = \sum_{i,\kappa,\epsilon,\eta} \chi_{t,i}(i) h_i(\epsilon, \eta, a, k)$$

- Factor prices as determined in the corporate sector

$$w_t = F^c_\ell(k,\ell)$$

$$r_t = F^c_k(k,\ell)$$

- Feasibility of the allocation

$$\sum_i \left(a'(\epsilon,\eta,\kappa,a,k) + c(\epsilon,\eta,\kappa,a,k)\right)\chi_{t,i} = \sum_{i,\kappa,\epsilon,\eta} \chi_{t,i} \int_a y_i \mu_i(\epsilon,\eta,a,k) da + Y^c$$

If market clearing conditions are not met, factor prices update and the process is repeated until a solution is found.

Numerical Solution: Due to the nature of this problem analytical solutions are not readily available. However, it is relatively straightforward to solve the life cycle path of individuals by making assumptions about asset holdings in the final period of life (I set these to zero) and solving backwards for each period. To do this I define a grid of potential state and choice variables. Since in the final period the future asset choice is set to zero the path of choices, conditional on realizations of shocks, and initial asset holdings is easily solved through grid search. To solve equilibrium I use a piecewise linear spline method of numerical optimization. I outline this solution method in more detail in Appendix A.

4 Calibration

I parameterize this model to match data in the United States. Most preference parameters are taken to from a similarly calibrated life cycle model by Kitao (2014). Exogenous retirement age is set at the current average age in the US at 65. Age specific conditional mortality rates, s_i, are calculated using the method suggested by Henriksen (2015), who uses life expectancy at birth to construct annual mortality rates from the five year rates provided by the World Health Organization.

To calibrate the riskiness of entrepreneurial projects I use data from the University of Michigan Panel Study of Entrepreneurial Dynamics. I match my productivity shock of entrepreneurs to the conditional survival rate of firms in their dataset. [flesh out the AR(1) process]

In addition to entrepreneurial risk, agents are heterogeneous with respect to their labor market earnings. In order to match the age profile of earnings observed in the data, labor consists of an age specific fixed effect as well as being subject to persistent shocks. To calibrate this I estimate the following equation using panel data from the PSID:

$$log\epsilon = z_i + n_i$$

Where n_i is the average age-profile of earnings and z_i is a first order auto regressive process following:

$$z_i = \rho_z z_{i-1} + \varepsilon_i^z \,;\, \varepsilon_i^z \sim N(0, \sigma_z^2)$$

To calibrate the i.i.d. arrival rate of new entrepreneurial projects I use data from the GEM as well as the PSED. For my baseline calibration the probability of receiving an opportunity for a new business for those not currently engaged in an entrepreneurial project, $\mathcal{P}_{(}\kappa_0)$ is set to equal the average rate of individuals who report belief that there exists an entrepreneurial opportunity as well as belief that they have the ability to undertake such a project and who are either in the very early startup stage or are not currently engaged in any entrepreneurial activity. This is approximately 15% for the United States over this period. For the probability of moving to a higher project I estimate from the PSED the probability that currently existing projects expands its scale [describe process in detail, possibly in appendix]. There are a number of ways I have estimated this with fairly little consequence for my results with respect to business creation. This choice does have potentially large impacts on the ability of this model to match the wealth distribution, which is the target of many similar papers using models of entrepreneurial choice in this context.

Name	Parameter	Value	Source
Discount rate	β	0.98	
Relative risk aversion	σ	2.5	
Labor utility coeff.	γ	4	Kitao (2013)
Labor utility "share"	ξ	0.5	Kitao (2013)
Annual Conditional mortality	s		Henriksen (2015)
Life exp. at birth		78.5	US Average
Retirement age	N_R	65	US Current
Borrowing constraint	λ	2	Moll (2012)
Capital share	α	0.34	US Average
mean productivity	η	2	PSED II
Productivity shocks	$\mathcal{P}_z$	$\begin{bmatrix} 0.82 & 0.14 & 0.036 \\ 0.22 & 0.70 & 0.08 \\ 0.15 & 0.13 & 0.72 \end{bmatrix}$	PSED II
Labor shocks	$\rho_\epsilon, \sigma_\epsilon$	0.9,0.25	
Probability of idea	$\mathcal{P}_{k_1}(k_0), \mathcal{P}_{k_2}(k_1)$	0.15, 0.02	GEM/PSED
Capital values	κ	$\{0, 10\}$	CEX/Quadrini (2000)

This specification of the model aims to be a simple, first look at the dynamics that can be captured in such an environment. A more detailed specification of the entrepreneurial shock process may draw from Haltiwanger et al. (2015), who studies the life cycle of firms. As the model is currently constructed I must make the coefficient of relative risk aversion quite high, 6, to avoid a situation where all individuals choose to pursue a project any time the opportunity arises. However, the entrepreneurial process here is actually quite safe relative to the likelihood of failure in the literature, especially in early years, so perhaps a more detailed calibration can allow for this parameter to be reduced.

5 Results

Figures 3 and 4 show the results of this parameterization for the average rate of new starts across ages defined as the share of individuals in an age group who choose to start a new project, as well as the rates of entrepreneurship defined as the share of individuals engaged in production at a given age. The present calibration does a reasonably good job matching the qualitative life cycle dynamics of selection into entrepreneurship. While the rate of new startups matches quite closely, there are some differences in the share of each age cohort engaged in entrepreneurship. Part of his is due to the exogenous retirement cutoff at 70. Individuals actively managing an entrepreneurial project tend to put off retirement due to their high return relative to wage workers. Incorporating an endogenous retirement age, such as that used in Kitao (2014), would allow for the slower selection out of entrepreneurship without necessarily increasing the rate of startups for that age.

In Figure 3 (new starts), the share of individuals involved in startups jumps quickly as soon as individuals can overcome the borrowing constraint, after which it falls gradually over the life cycle. The rate of entry is slightly lower in the model than the data, but a few alternative specifications suggest that this can be easily scaled up or down by adjusting entrepreneurial risk. However doing so creates too many entrepreneurs in Figure 4 (business owners). A more complicated specification of entrepreneurial shocks would likely resolve this. My PSED dataset as well as a great deal of research shows that the rate of failure is very high in the first years of business and significantly lower thereafter. Matching on these two characteristics should create a mechanism by which these two curves can be brought closer together as it will end more ventures without having a large effect on the expected lifetime value of surviving firms. This would, however, require tracking one additional state variable, firm age. This is work that I indent to complete in future drafts of this paper.

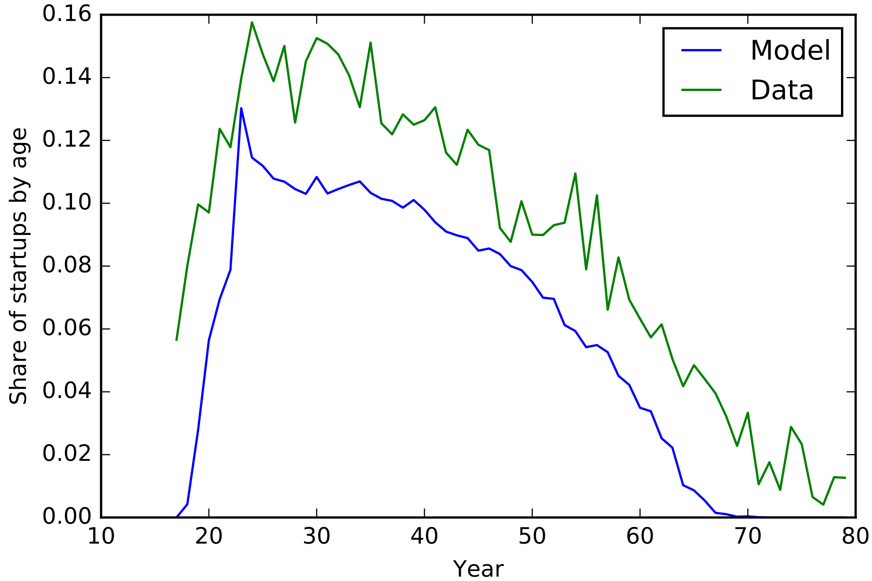

Figure 3

Given averages across ages and the size of age cohorts the rate of new startups for this economy would be 5.52% slightly under-predicting for every age and falling short of the 6.79% percent average rate of starts in the economy. The share of individuals owning/managing a business is 14.19% in these model results, again shy of the 16.13% found in the data.

5.1 Declining Business Dynamism

Figure 5 shows the model results under the demographic structure of the United States from 1982 until 2010. These are plotted along with the equivalent measure found by Decker et al. (2014) who plot the share of firms aged five years or less in the UC Census Bureau's Business Dynamics Statistics database, which tracks the universe of US firms in the private, nonagricultural sector with one or more employee. The model captures the trend in the data quite well, missing only what appears to be cyclical variation. Such close matching of this key statistic in the literature on declining business dynamism suggests that this previously ignored demographic channel may be of crucial importance in determining the rate of new businesses created in the United States. This is useful knowledge for

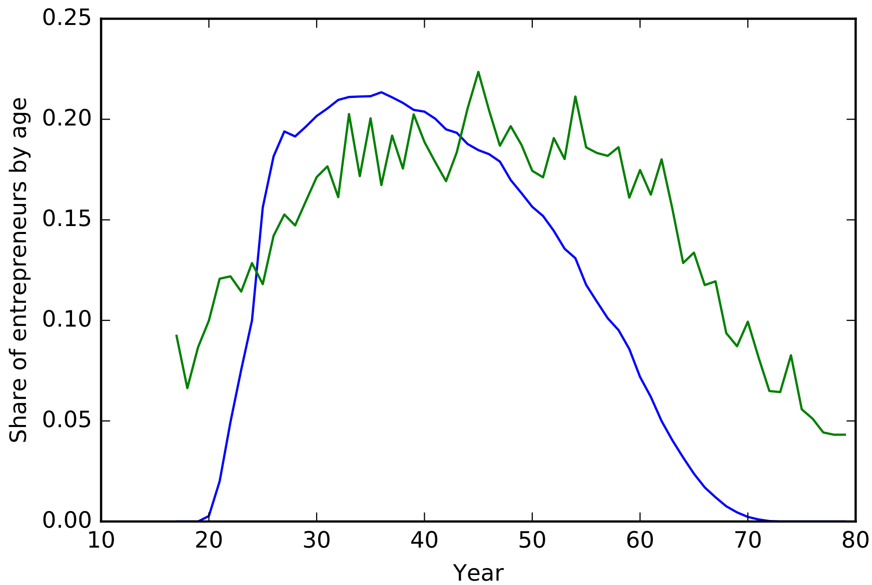

Figure 4

a number of reasons. First, traditional policy advice arguing to ease restrictions would have little impact in such a framework. Although this model does not have a channel for such a policy intervention often looked at policies such as loosening credit constraints would largely only effect younger individuals, who are declining in their importance in this model. Second, understanding that an aging population is causing the average agent to take on less risk opens the door for policy options, such as altering retirement age and social security as means of potentially altering the age specific risk profile of an individual. I will discuss these in more depth at the end of this section.

5.2 Aging economies and aggregate rates of entrepreneurship:

Knowing that this model can account for the current decline in US business dynamism I now project startup rates going into the future. Since the United States is just beginning its slow transition towards a population characterized by low employment population ratios and large concentrations of individuals near the retirement age, I wish to understand what this model predicts for the United States in 2060 when the median age is projected to peak. Of course there are two forces at work here, one is the retirement of a cohort that

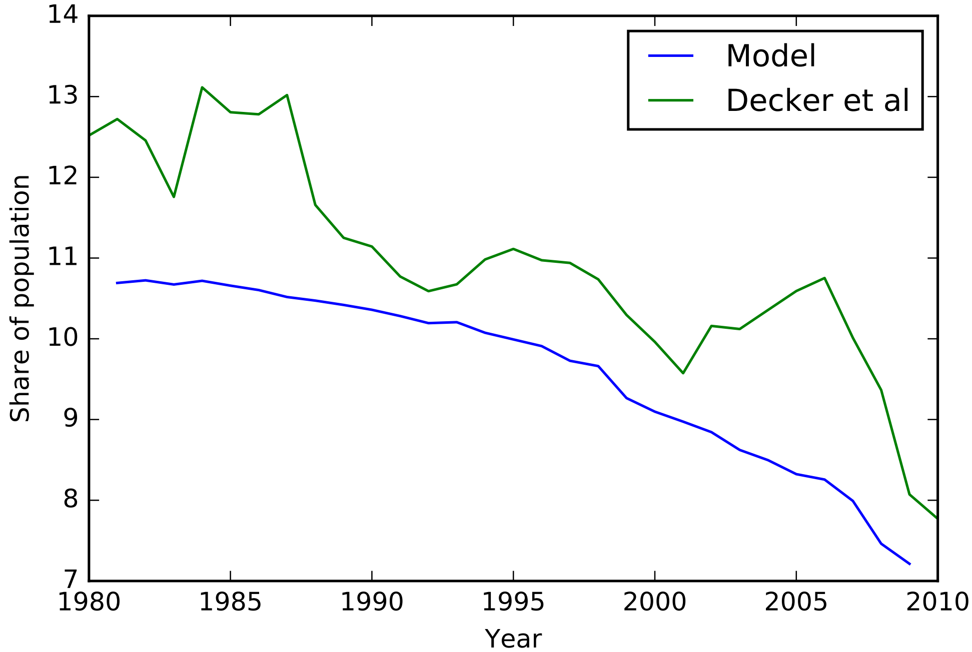

Figure 5: Declining share of young firms

is relatively large (the baby boomers) and another is life expectancies that will continue to rise over time. I study the changes that take place to the aggregate rate of entrepreneurship over this period. I also compare these projections to Japan in 2015, who's current demographic structure is quite similar to that of the United States in 2060. Although this exercise only changes the demographic variables in the calibration, so that other cross country differences are ignored, this does give a sense of the model's ability to account for cross country differences in startup rates and the degree to which the demographic channel can account for these differences. The model prediction column gives the results, with the United States serving as my base line parameterization and matching the facts from Figure 5.

Table 3

Country	US 2015	Japan 2015	US 2060 (Forecast)
Life expectancy	79	84	85
Business Ownership			
GEM Data	16.13%	9.68%	-
Model prediction	14.19%	-	11.6%
New Starts			
GEM Data	6.79%	2.72%	-
Model prediction	5.52%	-%	3.96%

The model predicts a significant drop-off in the rate of entrepreneurial activity and while it does not fall quite as far as the rates seen in Japan today a large fraction of the difference can perhaps be explained by differences in demography. Calibrating this model to more closely resemble the Japanese economy could perhaps further explore this comparison. Figure 6 shows the annual forecast of the rate of startups in the United States as demographic variables are moved forward to their projections until the year 2050. As the baby boomer cohorts fully enter retirement the decline begins to level of for some time before again falling as increasing life expectancies continue to balloon the share of the population that are near or in retirement.

6 Model mechanisms:

I will now discuss some of the mechanisms that drive dynamics observed in these results. With a need to finance consumption in retirement individuals are be more willing to take on risk at young ages where bad outcomes can be made up for through adjusting labor later in life. As such, the flexibility of labor supply will play an important role in determining the dynamics of individual decisions over their life-cycle. Near retirement there is less time to accumulate assets and the effective cost of failure rises as a bad outcome represents a larger fraction of their remaining lifetime earnings potential, and is therefore more difficult to hedge against. Running the model without entrepreneurs produces some very low precautionary savings early in life, followed by a large increase

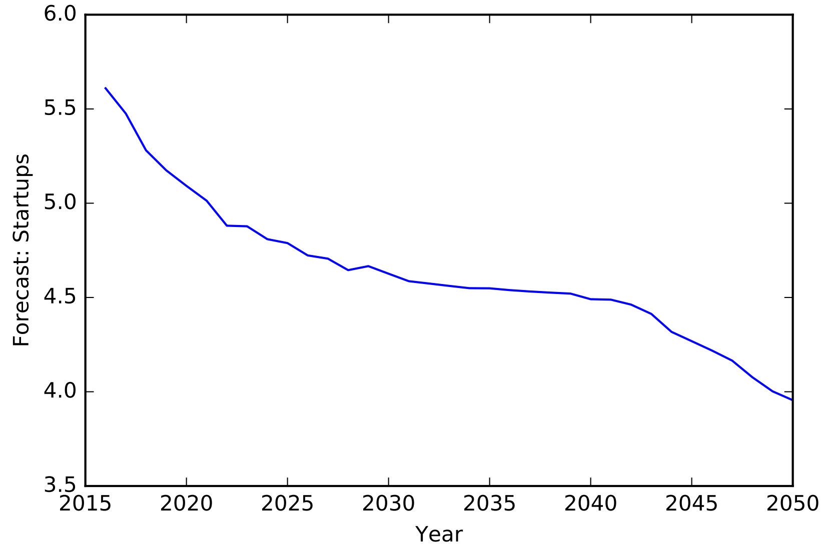

Figure 6

in savings near retirement. The addition of entrepreneurs increases these savings, an indication that individuals are trying to compensate for this additional risk, but due to the incompleteness of markets they will be unable to do so fully.

It is again important to note that agents risk preferences do not change as they age, but rather that their evaluation of a risky asset, given a set of risk preferences, will change as they age. A young and old agent with identical CRRA parameters react differently towards identical risks. This puts downward pressure on the rate of entry later in life. My parsimonious specification of this model is able to capture the phenomenon reasonably well, although a more sophisticated model with more complex decision processes could likely improve the fit in Figures 3 and 4. In addition a more sophisticated process for risk of failure (larger in early years of production and falling over time) will make the appeal of projects fall as the potential length of lifetime that can be expected producing shortens with age. There are three ways that demographics operate in this model

6.1 Demographic risk channels

6.1.1 Life Cycle Risk:

The following table presents the share of the of risky entrepreneurial capital investment for each age group relative to the average value of those individual's total financial wealth. Total financial wealth here includes the value of entrepreneurial projects, but not non-fungible human capital.

Age	Proportion of wealth
21-30	19.9%
31-40	14.3%
41-50	7.6%
51-60	2.8%

Table 4: Proportion of wealth invested in risky entrepreneurial capital

Despite having constant coefficients of relative risk aversion, this life cycle risk channel makes individuals effectively more risk averse. As a result individuals will wish to rebalanced their portfolio's so that they are exposed to smaller relative amounts of risky entrepreneurial wealth as they approach retirement.

This is the same mechanism that operates in Bodie et al. (1992a). Individuals with CRRA preferences and identical opportunities should have portfolios with the same composition of assets. Although not all agents are exposed to an entrepreneurial opportunity at any given time, the arrival of the shock is not conditional on age and therefore the average agent has the same opportunity across the life cycle. As in their work, I find that otherwise identical individuals rebalance toward safe assets as they age. This is due to the gradual shrinking of their relatively safe human capital, which acts as a safe hedge when agents are younger, but makes up a relatively small part of the individual's portfolio as they near retirement.

This mechanism is crucial in generating the channel through which demographic change affects the startup rate. The contour graph below shows the choice to begin a new entrepreneurial venture (1 or zero) averaged across all state variables and plotted by age and financial wealth. The wealth axis has been rescaled so that only individuals who have enough wealth to overcome the borrowing constraint for the smallest entrepreneurial project are included. There are two interesting features here. First as people get closer to retirement, moving left to right, they become less likely to select into entrepreneurship conditional on a given level of wealth. Second individuals who have lower levels of wealth, but enough to invest, are more likely to invest in an entrepreneurial project. There are two forces driving this second and seemingly puzzling result. The first is that entrepreneurs in this environment have some skin in the game where a share of their wealth is tied to the success and failure of the project. Therefore the relative downside of failure is slightly higher for those investors with more to lose. The second is that there is an optimal buffer stock that agents in life cycle economies which to achieve to insure against bad shocks and save for retirement. Once they have achieved that level they are less willing to gamble their savings to the highly risky startup opportunity.

This effect should not be confused with the choice that individuals who are running an already profitable business will make. Nearly all individuals will continue to run an existing business until they get a negative productivity shock. This means they've already had a positive productivity shock, and as a surviving firm, are significantly more likely to remain profitable in the future than a startup would be.

Continuing firms that receive a negative productivity shock, making them unprofitable, see similar dynamics to the startup firms where younger individuals who can afford to do so are significantly more likely to continue operating so that they may keep the project and hope to see positive productivity improvements in the future. This is a highly risky proposition as productivity shocks are first order autocorrelated and unprofitable firms are significantly more likely to remain that way than they are to improve. Figure 8 shows

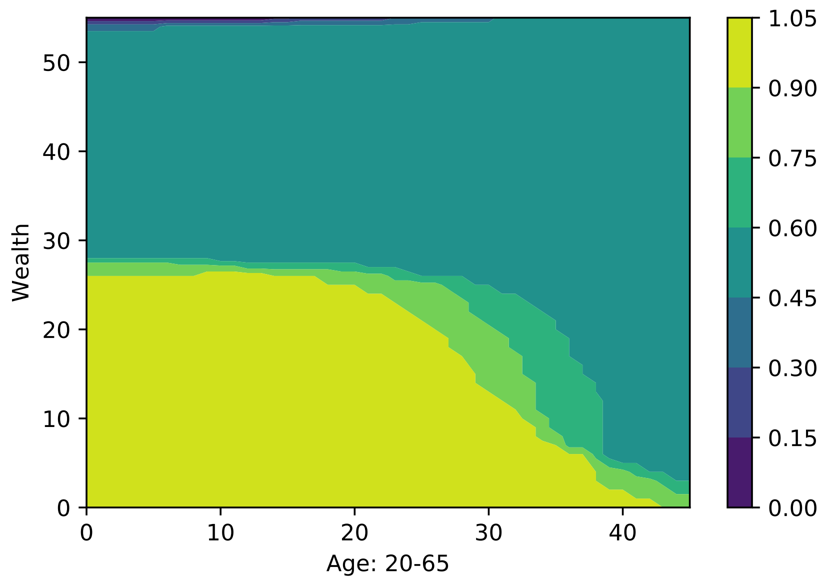

Figure 7: Choice to invest in new startup by age and asset holdings, averaged across all realizations of shocks

that this decision is highly related to age with younger individuals and those with lower levels of wealth are more likely to gamble for reclamation on their entrepreneurial project rather than cut their losses and return to wage work. Most however shut down in this situation. The model is calibrated such that there is always some negative shock that is large enough to force individuals to shut down. This graph shows those who have received a bad shock that is not sufficiently large so as to force a shutdown.

6.1.2 Mortality risk and buffer stock savings

High probability of survival implies longer lifespan and therefore a more expensive retirement that individuals in this model must self finance. Secular increases in conditional survival probabilities, s_i, cause individuals to discount the future *less* as life expectancy improves. This relates closely to the above channel as a potential entrepreneur looks at both the expected profits of the entrepreneurial project as well as the share of risky assets in his portfolio. Individuals wish to attain an optimal buffer stock not only to insure against adverse shocks, but also to consume out of during retirement. Increases in life

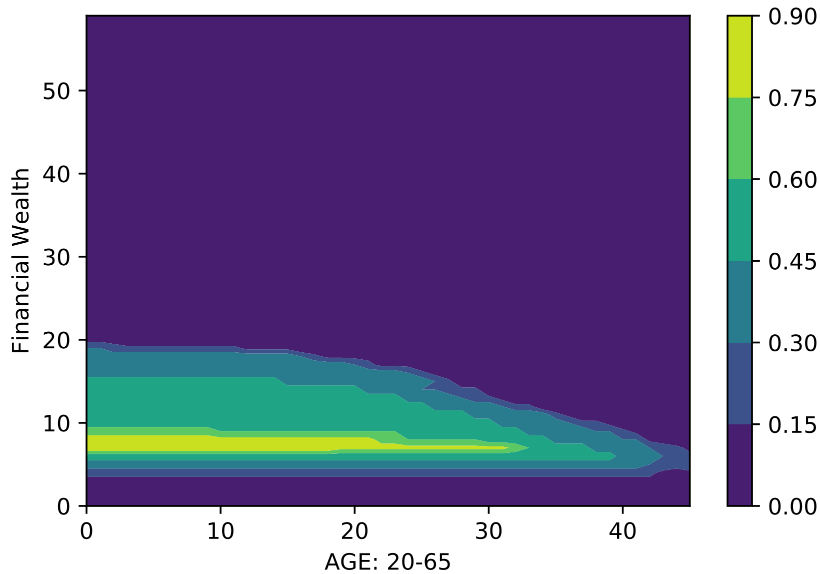

Figure 8: Choice to invest in new startup by age and asset holdings, averaged after receiving a negative productivity shock

Figure 9

expectancy, and therefore retirement length, increases the need for this buffer stock and as a result also makes larger the range in which individuals near the end of their lives will weigh the downside risk of an entrepreneurial project as too great given their need to achieve a certain, now higher, level of wealth before reaching retirement age. As a result new generations that expect to live for longer periods of time will be less likely, all things equal, to become entrepreneurs late in life than those who's life expectancy is low.

6.1.3 Composition effects

Perhaps the most intuitive demographic force at work in this model are cohort composition effects. As demographics change the composition of the labor force shifts from consisting primarily of young/middle aged workers to those who are near retirement. If the age-entrepreneur relationships depicted in figure two were constant over time this would shift population mass away from highly entrepreneurial ages toward low entrepreneurial ones. Having a larger share of the work force unlikly to become entrepreneurs would mechanically in this way lower the rate of startups. This would be true holding constant the mortality effects from above. In general, these composition effects are not the most important factor in driving the decline in startups, mainly because the change in cohort size happens at such a slow rate as to make the year on year effect quite small.

6.2 Borrowing constraints:

In any Bewley model some natural borrowing constraint must arise from the Inada and no ponzi scheme conditions. My constraints are slightly more restrictive and represent the need for potential entrepreneurs to have some degree of skin in the game, that is, they must either self finance or put up a fraction of their wealth as collateral for, a fraction of any potential venture. This is consistent with empirical evidence on early stage startups as well on contract structures of venture capital funding. Although these constraints do not depart from those standard in the literature without entrepreneurship, they are well motivated by Cassar (2004) who finds that personal savings are the most important source of financing for start-ups suggesting that financing does not allow individuals with little collateral to borrow for new business projects. Indeed one of the most prominent findings in the PSED is that nearly all entrepreneurs in the very early stages must self finance a large amount of funds.

These constraints have an important impact on the right half of the hump shaped selection of very young individuals in Figures 3 & 4. These constraints act as filters that keep the very young, and the very unlucky, who have not accumulated enough assets to invest in potential projects as they arrive. As a result the rise in selection at the start of working life is not immediate but takes some time. Because my calibration makes these constraints quite weak the effect is not particularly strong, but there is not particularly strong evidence that such need for self financing keeps a great deal of young potential entrepreneurs from beginning startups in the data so this is not too problematic. In robustness checks where I raise the fraction of asset needed to be held as assets for individuals to invest the peak of the hump shifts to later years with a more gradual increase as it takes longer for most individuals to reach the level of assets required to participate in startup activity.

6.3 General Equilibrium Effects:

In addition to the *cohort effect* there is a general equilibrium effect that arises due to changing factor prices. The profitability of entrepreneurial work depends strongly on the wage and rental rate in the economy. As economies age, that is when older cohorts become a larger share of the population, a smaller workforce will be available to produce. Further the clustering of individuals around retirement increases savings, and thus the supply of capital. As a model economy ages the relative scarceness of labor both has a cost effect of rising hiring costs for the entrepreneurial firm, but also increases the outside option of entering the workforce relative to producing independently. Since I allow my entrepreneurs to continue to earn labor income, this second effect does not operate, but restricting them would greatly exaggerate the results. Figure 8 shows how changes to the age specific risk structure (determined by life expectancy at birth), will alter the shape of the age-entrepreneur relationship. As previously suggested it is likely that for plausible parameter values this will reinforce the *cohort effect* in determining aggregate rates of entrepreneurship.

Figure 8 separates out the model effects estimated in Figure 7 with those that would be obtained by a pure cohort change and in absence of general equilibrium effects. It's important to note that the green line in this figure is not 'model free', in order to estimate these results I need to specify some kind of age-entrepreneur relationship (the hump-shape). To do this I take the partial equilibrium effects that arise from a fixed demographic structure in the first year of estimation and then use that age-entrepreneur selection relationship to estimate the rates as I move the demographic structure forward. There are a few things that are important here. The model results are initially below the estimates that arise from cohort effects and the gap between them appears to grow for most of the period estimated. This is because the difference between them represents both of the second two model mechanisms described above. In the first period these estimates should be the same, with the exception of general equilibrium effects. For the periods that follow, there is not only a general equilibrium difference, but also the effect of changing life cycle mortality that reinforces this gap by increasing the expected lifespan of agents and exaggerating the effective riskiness of business failure late in life as described above.

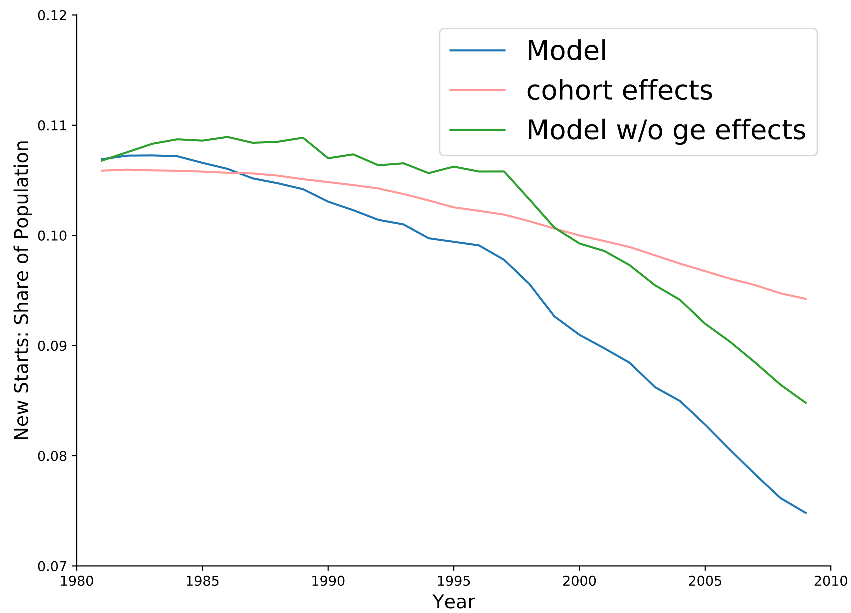

Figure 10

7 Equity and Aggregate Risk

In the baseline specification of the model there are no markets for equity and owners have no option to sell their business. While it would be possible to partially model the latter without the formal, to do so in a sensible way requires the inclusion of these equity markets and as a result aggregate risk. While this adds sufficient computational difficulty to be excluded from the baseline specification, it is something that could potential play an important role in entrepreneurial selection. From a practical perspective the process of running a startup until it is viable enough to be bought out by a larger entity is becoming a common practice, especially in the tech world where Google, Amazon, and other large companies have made a cottage industry out of buying smaller firms. From the perspective of the model, there is concern that this may alter the key mechanisms of selection. If individuals are able to sell entrepreneurial projects after investing in them, then perhaps the choice to select into entrepreneurship will change. A startup carries less risk if the entrepreneur must only operate the project to the point where it is valuable enough to sell and then offload the risk onto equity markets. Working in the opposite direction, if agents may invest in equity markets and receive a higher return then they may be less inclined to take on the still more risky prospect of investing in their own equity markets.

Previously agents needed only know the sequence of wages and risk free capital returns pinned down by the corporate sector. Allowing for individuals to trade risky equity of entrepreneurs essentially requires them to forecast aggregate entrepreneurial capital stock. This can be achieved using the method of Krusell and Smith (1998), who suggest that this infinite-dimensional state space can be approximated with a small set of moments of the aggregate (entrepreneurial) capital stock as well as current realizations of aggregate shocks.

8 Conclusions

I identify an important channel through which demographic change can affect the level of entrepreneurship in an economy. My parsimonious general equilibrium model provides key insights into the mechanisms that can play a role in determining rates of new startups through this channel. The model outlined above is capable of producing the shape of life cycle selection into entrepreneurship as well as the decline in aggregate business creation observed in the United States over time and the cross sectional variation observed in countries. This environment has the potential to serve as an excellent testing ground for a number of government policies that may operate through the demographics channel on levels of entrepreneurship. In particular reforms to social security through: financing, changes in retirement age, and altering the benefit structure; could alter the way in which individuals approach retirement savings and view risk in late stages of their lives. Such experiments are crucially important given the wide range of policy actions that governments undertake in the pursuit of increasing new entrants into entrepreneurial ventures. Though this present work leaves perhaps more questions than answers, it provides a flexible framework through which the dynamics of entrepreneurship, and our ability to affect individual selection into it, can be more carefully understood. While it is important to understand the potentially changing business environment that may be altering the rate of entrepreneurship in the United States, this work suggests that additional attention should be spent on understanding the decision of individuals who are actively involved in the creation of such firms and the factors, such as aging, that can alter their decision making.

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A Solution Algorithm

1. Households solve optimization problem

    - Solve for optimal choices (a', k', h, c),through grid search of all possible states $(age, a, k, \epsilon, \kappa)$, taking as given prices r, w.

    - Simulate economy for 10000 individuals who receive different realizations of (ϵ, z, κ).

2. Solve firm optimization:

    - Supply: given household choices of h and a

    - Demand: given entrepreneurial and corporate factor demand for ℓ, k given prices w, r.

3. Market clearing conditions.

    - Check market equilibrium conditions. If not met update (w, r) using a linear spline method and go to the first step, repeating until conditions are met within degree of tolerance.