# From Population Growth to Firm Demographics: Implications for Concentration, Entrepreneurship and the Labor Share*

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**Abstract**

The US economy has undergone a number of puzzling changes in recent decades. Large firms now account for a greater share of economic activity, new firms are being created at a slower rate, and workers are getting paid a smaller share of GDP. This paper shows that changes in population growth provide a unified quantitative explanation for these long-term changes. The mechanism goes through firm entry rates. A decrease in population growth lowers firm entry rates, shifting the firm-age distribution towards older firms. Heterogeneity across firm age groups combined with an aging firm distribution replicates the observed trends. Micro data show that an aging firm distribution fully explains i) the concentration of employment in large firms, ii) and trends in average firm size and exit rates, key determinants of the firm entry rate. Building on empirical work that documents a negative relationship between firm size and labor share, we show that firm aging increases the market share of larger firms, leading to a decline in the aggregate labor share.

**J.E.L. Codes:** J11, E13, E20, L16, L26
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# 1 Introduction

Three long-term changes in the US economy have attracted a great deal of attention. First, economic activity is being concentrated in fewer firms. For example, the fraction of workers employed by large firms increased by 6 percentage points since 1978. Second, the entrepreneurship rate — the ratio of new firms to total firms — has nearly halved since the 1970s. Third, the share of GDP going to labor, once thought to be stable, has declined since 1975. What explains these changes?

Our analysis begins by highlighting the importance of firm demographics in driving these aggregate trends. We document that the increase in employment concentration is entirely due to changes in firm demographics: an aging firm distribution combined with heterogeneity in employment concentration by firm age. The data shows that there has been no change in employment concentration within firm-age categories. However, across age-categories, older firms have higher employment concentration. Therefore a shift in the age distribution towards older firms drives the increase in concentration. We document that changing firm demographics can also account for changes in two related variables: average firm size and the aggregate firm exit rate. Conditional on age, these variables have changed little over time. Nevertheless, because older firms are larger and exit at lower rates, an aging firm distribution leads to an increase in average firm size and a decline in the aggregate exit rate.

A simple accounting identity provides a useful starting point to analyze the decline in entrepreneurship. The firm entry rate equals the aggregate exit rate minus the growth in average firm size plus labor force growth,[1]

$$\underbrace{\lambda}_{\text{Entry Rate}} = \underbrace{\xi}_{\text{Exit Rate}} - \underbrace{\widehat{e}}_{\text{AFS Growth}} + \underbrace{\widehat{N}}_{\text{LF Growth}} . \tag{1}$$

The exit rate and average firm size are constant in stationary equilibria of standard firm dynamics models. Therefore, changes in labor force growth are a natural candidate to explain changes in the firm entry rate. Can a change in labor force growth, by itself, explain the drop in firm entry rates observed in the data? Qualitatively, yes. Quantitatively, no. US labor force growth has declined, but not by enough. Figure 1 shows US civilian labor force growth rates by decade. Since the 1970s, labor force growth has declined by 2pp, whereas the entry rate has declined by 6pp. By itself, the decline in labor force growth

[1] This identity comes from the definition of average firm size, $e \equiv N/M$, where $N$ is the number of workers and $M$ is the number of firms. It follows that the growth rate in the number of firms equals the growth rate of the labor force minus the growth rate of average firm size, $\widehat{M} = \widehat{N} - \widehat{e}$. The growth in the number of firms also depends on firm entry and exit, $\widehat{M} = \lambda - \xi$. Combining these two equations leads to accounting identity (1).

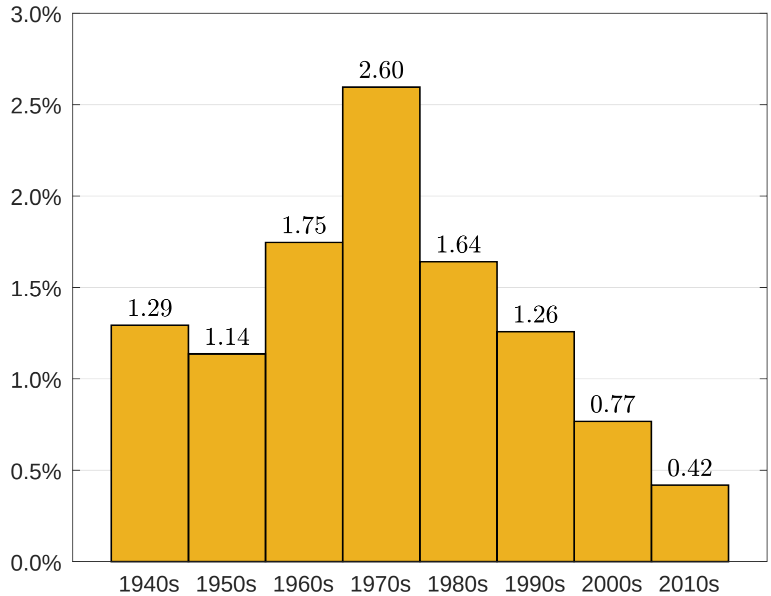



Figure 1: Civilian Labor Force Growth Rate

can only account for a third of the decline in the firm entry rate. However, if the decline in labor force growth has feedback effects which lead to changes in average firm size and aggregate exit rates, it can account for a larger extent of the decline in firm entry rates. To be consistent with the data, the feedback effects must be such that changes in average firm size and the aggregate exit rate must be solely due to changing firm demographics, i.e. an aging of the firm distribution.

We show that changes in labor force growth lead to such a change in firm demographics. Consider an increase in labor force growth. The increase in labor supply must be met by a corresponding increase in labor demand. Incumbent firms are limited by scale, so they cannot absorb the entire increase in labor supply. The residual labor demand must therefore be absorbed by new firms. The increase in firm entry shifts the firm-age distribution towards younger firms, feeding back to changes in firm demographics. While this mechanism seems intuitive in the long-run, it is not clear that it also applies to short-run changes in labor force growth. The theoretical challenge is to show that an evolving firm-age distribution along the transition path is consistent with stability of firm-level variables by age. We derive sufficient conditions for the existence of such an equilibrium in a general framework. We provide examples of standard models of perfect and imperfect competition that fall within this framework.

One important result of the paper is that the transitional dynamics of firm entry depend on the entire history of past entry. Because firm entry fills the gap between labor supply and labor demand by incumbents, it depends on the number of incumbents in each age group, which in turn is determined by past entry and survival probabilities. This leads to the *dynamic entry equation*. As the current entry changes, the age distribution of firms in the current, and therefore in future periods, is affected. This result proves useful in the quantitative exercise. It allows us to overcome the problem that we do not observe the firm-age distribution in 1977, the initial year in our dataset. We can feed historical labor force growth data into the dynamic entry equation and recover the 1977 age-distribution.

We use two approaches to explore the quantitative implications of exogenous changes in labor force growth. The first one is a structural approach, where we pick the simplest framework – perfect competition – feed the labor force sequence starting in 1940 and calibrate it to relevant targets in 1978. The second approach, an accounting approach, does not rely on a specific model specification. Instead, we obtain the initial firm distribution and firm level variables by age directly from the data using atheoretical extrapolation techniques. We then feed the labor force growth sequence starting in 1940 to obtain an endogenous evolution of the firm-age distribution. The results of both quantitative approaches are similar.

The calibrated model matches three episodes of the empirical entry rate well: it matches the majority of the decline from 1978 to 2014, the pre-1978 increase in the entry rate, and the large fluctuations in the entry rate in World War II. The model also matches well the 2pp decline in the exit rate, the 6pp increase in employment concentration, and the aging of the firm distribution. Average firm size increases in the model, as in the data, but slightly overshoots the increase. This is due to the fact that average firm size by age in the data has declined somewhat for older ages after the year 2000.

In order to better understand the mechanism, we repeat the quantitative exercise in two counterfactual economies. The first counterfactual ignores the history of past entry by assuming labor force growth was constant pre-1978, rather than increasing. This eliminates one-third of the decline in entry rates. The second counterfactual assumes away firm demographics by assuming no differences in exit rates or average firm size across age groups. This eliminates two-thirds of the decline in entry rates. The message from these counterfactual exercises is that firm demographics and history dependence interact and are both essential to understand the decline in entry rates.

Given the slow-moving nature of firm-age distributions, we can use labor force projections to make predictions about the future path of entry rates. We find that despite the continued decline in labor force growth, entry rates are predicted to bounce back by 1pp. This can be understood using identity (1). The exit rate increases because the glut of firms born in the years of high labor force growth have mostly died off and been replaced by younger firms, which have higher exit rates on average. As the economy converges to a balanced growth path, the growth in average firm size hits zero. Both these forces more than counteract the future decline of labor force growth.

We next turn to the labor share. A recent set of papers document two facts about labor shares: (i) firm-level labor shares are negatively related to firm size; (ii) almost all of the decline in the aggregate labor share is due to reallocation from high to low labor share units, rather than a decline within labor share units.[2] Because larger firms tend to be older, our mechanism generates a driving force for such a reallocation and therefore the decline of the labor share. We illustrate this by embedding into our framework the mechanism suggested by Autor, Dorn, Katz, Patterson and Van Reenen (2017), which generates the negative relationship between firm-size and labor shares by using labor-overhead ratios that decline with firm size. We compare our implied labor share to the well-known measure of the corporate labor share in Karabarbounis and Neiman (2014). The model matches the post-1975 decline in the labor share fairly well. Recent work by Koh, Santaeulalia-Llopis and Zheng (2018) extends the measurement of the corporate labor share back to 1947, and finds a hump-shaped pattern. This is exactly the pattern predicted by labor force growth, which also follows a hump shape. It is worth highlighting that we do not need to take a stand on the reason why labor shares are decreasing with firm size. For example, instead of smaller labor overhead ratios, larger firms could have lower labor shares because of larger markups or higher investment in intellectual property products. Our point is that as long as labor shares and firm size are negatively related, a decline in labor force growth will drive down the aggregate labor share.

We close by discussing the exogeneity of labor force growth and alternative measures of labor supply. We decompose labor force growth into three components: birth rates 16 years prior, the growth in participation rate, and a residual term that captures rates of migration, death and institutionalization. We find that birth rates 16 years prior account for the bulk of the changes in labor force growth. On considering alternative measures of labor supply, we find that the hump-shaped pattern is a robust feature of the data.

**Related Literature.** Our paper builds on a wealth of recent empirical evidence from seemingly disconnected strands of the literature. One strand of the literature has documented changes in entry rates and the age distribution of firms. Reedy and Strom (2012) documents declining firm entry, while Pugsley and Şahin (2018), Decker, Haltiwanger, Jarmin and Miranda (2014), Hathaway and Litan (2014a), Gourio, Messer and Siemer (2015) and Davis and Haltiwanger (2014) document the pervasiveness of this decline across geographic areas and industries. Decker, Haltiwanger, Jarmin and Miranda (2014), Hathaway and Litan (2014b) and Pugsley and Şahin (2018) document the aging of the firm distribution and link it to declining firm entry. A different strand of the literature has documented trends

[2] Hartman-Glaser, Lustig and Xiaolan (2019) documents this pattern by showing that the capital share has been increasing for the largest public firms in the US. Autor, Dorn, Katz, Patterson and Van Reenen (2017) document the same pattern using US Census Data. Kehrig and Vincent (2018) document the reallocation for manufacturing establishments.

in the aggregate labor share and the rise in concentration. Karabarbounis and Neiman (2014) find that the decline in the labor share is primarily a within-industry rather than a cross-industry phenomenon. Grullon, Larkin and Michaely (2017) document increased concentration across most U.S. industries, whereas Barkai (2017) and Autor, Dorn, Katz, Patterson and Van Reenen (2017) both document a positive correlation between industry concentration and the decline in the labor share. Our paper incorporates all of these empirical findings into one unified explanation.

We are not the first paper to propose the decline in labor force growth as an explanation for the decline in firm entry rates. Using lagged fertility rates as an instrument, Karahan, Pugsley and Şahin (2018) find that the entry rate is highly elastic to changes in labor supply across US states.[3] The authors then explore the role of labor force growth in the steady state of a Hopenhayn (1992a)-style model. There are two main differences between our papers. First, we aim to explain a broader set of facts, such as the increase in concentration and the decline of the labor share. Second, our study focuses on transitional dynamics, allowing us to uncover how the history of past entry matters for current entry and firm demographics.

To the best of our knowledge, ours is the first paper that aims to jointly explain trends of entrepreneurship, concentration, and the labor share. Alternative explanations have been proposed for a subset of these trends.[4] One related, but distinct, explanation is that of the aging of the workforce (Liang, Wang and Lazear, 2018; Kopecky, 2017; Engbom, 2017). We note that a decline in labor force growth is a different phenomenon than an aging workforce. Another explanation that has gained considerable attention is that of the rise in market power, as measured by increasing markups (Loecker and Eeckhout, 2017). Our framework features a competitive setting, and thus generates an increasing concentration without decreasing competition.[5]

The rest of the paper is organized as follows. Section 2 presents the data. Section 3 presents the theoretical results. Section 4 reports the calibration and the fit along non-targeted moments. Section 5 presents extensions and robustness. Section 6 concludes.

[3] Hathaway and Litan (2014c) also note a correlation between declining firm entry rates and population growth across geographic regions. Other explanations for the decline in entrepreneurship include the decline in corporate taxes (Neira and Singhania, 2017), the decline in interest rates, (Liu, Mian and Sufi, 2018; Chatterjee and Eyigungor, 2018), and skill-biased technical change (Salgado, 2018; Jiang and Sohail, 2017).

[4] Explanations specific to the labor share decline include an increase in firm-level volatility (Hartman-Glaser, Lustig and Xiaolan, 2019), the treatment of intangible capital (Koh, Santaeulalia-Llopis and Zheng, 2018), the decline in the relative price of capital (Karabarbounis and Neiman, 2014), capital accumulation (Piketty and Zucman, 2014), and import competition and globalization (Elsby, Hobijn and Sahin, 2013).

[5] Rossi-Hansberg, Sarte and Trachter (2018) also show that increasing concentration at the aggregate level need not be generated by a decline in competition. They present evidence that the positive trend observed in national product-market concentration becomes a negative trend when focusing on measures of local concentration.

## 2 Data

We obtain data on firms from the Business Dynamics Statistics (BDS) produced by the US Census Bureau. The BDS dataset has near universal coverage of private sector firms with paid employees in the US from 1977-2014.

We start by looking at the time series evolution of concentration, average firm size and the aggregate exit rate in US data; see top panel of Figure 2. We measure concentration as the share of employment by firms with 250+ employees. Figure 2 shows that concentration in the US has increased from about 51% to 57%.[6] Average firm size in the US has increased steadily from about 20 employees to about 24 employees. The aggregate exit rate has declined steadily from about 9.5 percentage points to about 7.5 percentage points.

What is driving the aggregate trends? The bottom panel of Figure 2 shows concentration, average firm size and exit rates broken down by firm age over time. The figure shows that, conditional on age, these variables have changed little. For example, a typical five year old firm has the same size in 1980 and 2014, with no discernible trend. The same pattern holds for concentration and exit rates: conditional on age, concentration and exit rates do not exhibit a trend over the 1977-2014 time period. It follows that the aggregate trends in concentration, average firm size and exit rates are not being driven by changes in the corresponding variables within firm-age categories.

The bottom panel of Figure 2 also shows how each variable evolves with firm age. Concentration and average firm size increase with firm age. Firm exit rates decrease with firm age. These patterns suggest that changes in the age composition of firms drive the aggregate trend in each variable. In order to investigate this formally, we regress

$$y_{ajt} = \beta_0 + \beta_y\, year + \sum_a \beta_a\, age + \sum_j \beta_j\, sector + \sum_a \sum_j \beta_{aj}(age \times sector) + \varepsilon_{ajt}$$

where $y_{ajt}$ equals the share of employment by firms with 250+ employees, log average firm size or firm exit rates. We start with a specification that features *year* with an intercept term. The coefficient on *year* captures the aggregate trend in dependent variable. We then add age controls and see how the year coefficient changes. For the average firm size and firm exit rate regressions, we add further controls for sector and age-sector interaction effects in successive specifications.[7]

[6] The increase in concentration is robust to the firm size cutoff. For size cutoffs of 5, 10, 20, 50, 100, 250, 500, 1000, 2500, 5000, and 10,000 employees, the share of employment has increased by 1.6, 3.1, 4.3, 5.4, 6.0, 5.7, 5.1, 4.6, 3.9, 3.1, and 2.4 percent, respectively.

[7] To protect the identity of firms, the Business Dynamics Statistics do not report data on share of employment by firm size, age and sector. Therefore, we cannot include controls for sector and age-sector interactions in the concentration regression.

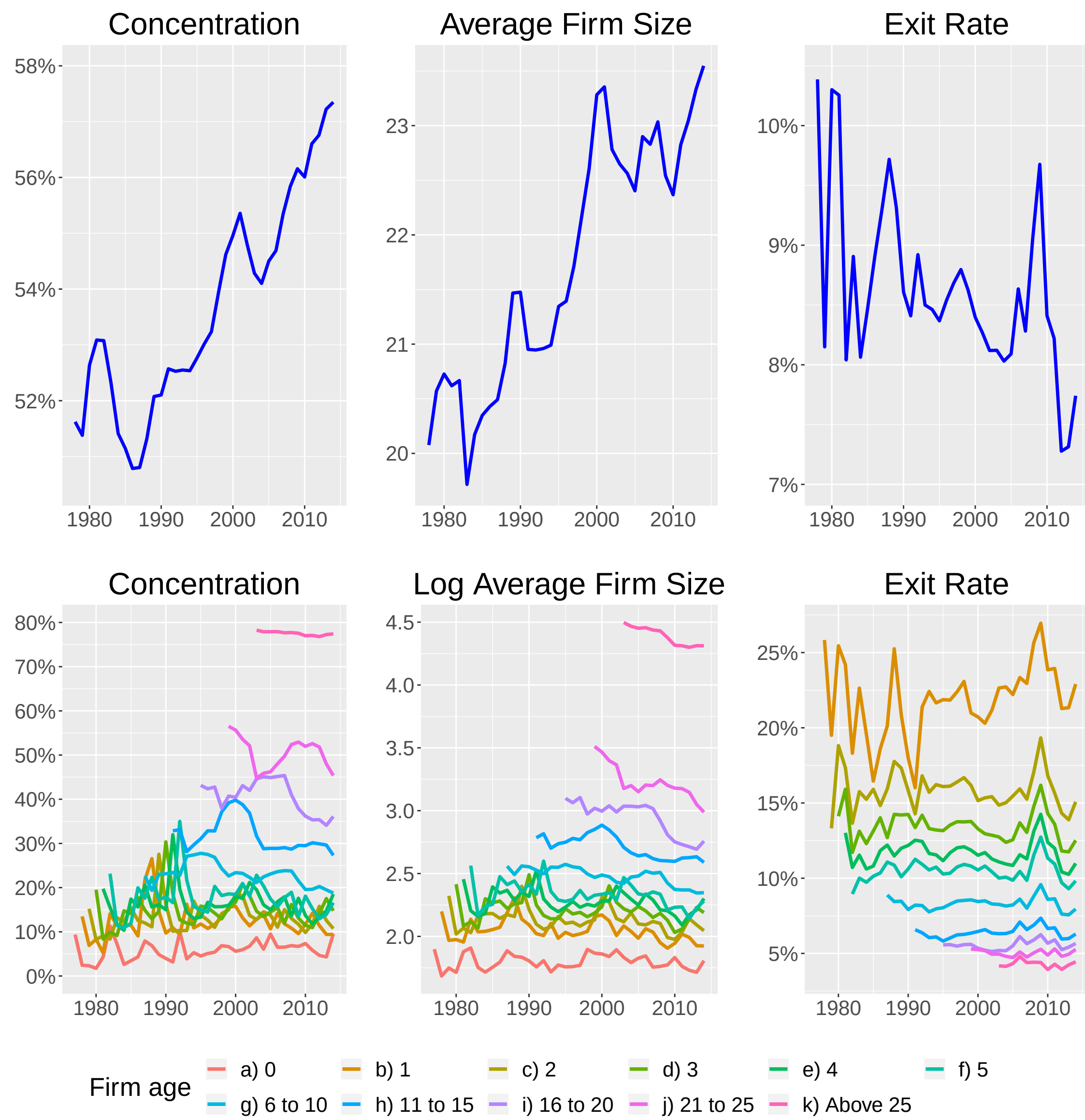



Figure 2

*Source.* US Business Dynamics Statistics.
*Notes.* Concentration is the share of employment in firms with 250+ employees. Concentration within an age category is share of employment in firms with 250+ employees within the age category divided by total employment in the age category. The *Above 25* age category includes firms labeled 26+ and Left Censored firms in the Business Dynamics Statistics. Average firm size is number of workers per firm.

The regression results confirm that changes in the age composition drive the aggregate trends.[8] Without controls, the average trend across age groups and sectors in each variable is statistically significant and non-zero. Once we control for age, the trend disappears or reverses sign. The inclusion of controls for sector and age-sector interactions has no further effect on the trend. The coefficients on the age controls exhibit the same patterns as Figure

[8]The regression tables are presented in Tables B-1 to B-3 in Appendix B.

2: they increase with age for average firm size and concentration, and decrease with age for exit rates.

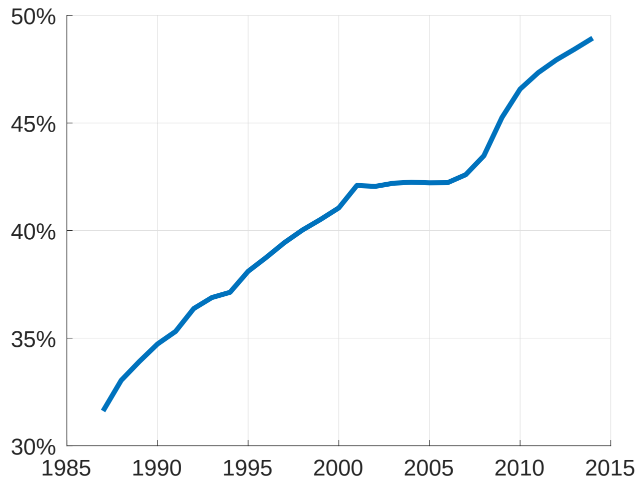



Figure 3: Share of Firms of Age 11+

Figure 3 presents direct evidence that US firms are aging. The figure shows that the share of firms aged 11+ has risen steadily from 32 percent in 1986 to 48 percent in 2014.

# 3 Theory

Firms have a common discount factor $\beta$. There is a fixed endowment of a labor $N_t$, which is inelastically supplied and also the numeraire. Firms are confronted with an aggregate state $Z$ and an idiosyncratic state $s$. The aggregate state $Z$ is determined as part of the equilibrium. The idiosyncratic state $s$ follows a Markov process with conditional distribution $F\left(s_{t+1}|s_t\right)$, which we assume is continuous and nondecreasing. Let $R(s,n,Z)$ denote the revenue function. Firms have a fixed cost of operation $c_f(s)$ denominated in units of labor, which can include an entrepreneur and other labor overhead. Firm revenue net of operating cost is $R(s,n,Z)-c_f(s)$. Assume that net revenue is increasing in all arguments, concave in $n$ and supermodular in $(s,n)$ and in $(Z,n)$, i.e. $R_{sn}>0$ and $R_{Zn}>0$ if differentiable. Let $\pi\left(s,Z\right)$ and $n\left(s,Z\right)$ denote the profit and employment functions, respectively. These functions are increasing in $s$ and $Z$.

The value of a firm is given by the Bellman equation:

$$v\left(s,\mathbf{Z}_t\right)=\max\left\{0,\pi\left(s,Z_t\right)+\beta Ev\left(s',\mathbf{Z}_{t+1}|s\right)\right\}$$

when confronted with a deterministic path of $\mathbf{Z}_t=\left\{Z_\tau\right\}_{\tau\geq t}$. The value of exit is normalized to zero, while the right hand side under the maximization is the continuation value for the firm. It is easy to show that this value is increasing in $s$ and $Z_t$ when nonzero. Let

$$s_t^* = \inf\left\{s|\pi\left(s, Z_t\right) + \beta E v\left(s', \mathbf{Z}_{t+1}|s\right) > 0\right\}. \tag{2}$$

A production unit is shut down iff $s \leq s_t^*$.

The technology for entry of a new production unit is as follows. Upon paying a cost of entry of $c_e$ units of labor, the initial productivity is drawn from distribution $G$, independently across entrants and time. Prior to entry, the expected value of an entrant net of the entry cost is

$$v^e\left(\mathbf{Z}_t\right) = \int v\left(s, \mathbf{Z}_t\right) dG\left(s\right) - c_e. \tag{3}$$

Let $\mu_t$ denote the measure of productive units operating at time $t$, where for a fixed set $A$ of firm types, $\mu_t\left(A\right)$ measures the magnitude of firms that at time $t$ have $s_{it} \in A$. Given an initial measure $\mu_0$, the exit thresholds $s_t^*$ together with entry flows $m_t$ determine uniquely the sequence of measures $\{\mu_t\}$ as follows. For any set of productivities $A$, define recursively

$$\mu_{t+1}\left(A\right) = m_{t+1}\left(\int_{s\epsilon A, s\geq s_{t+1}^*} dG\left(s\right)\right) + \int\int_{s\epsilon A, s\geq s_{t+1}^*} dF\left(s|x\right) d\mu\left(x\right) \tag{4}$$

The first term in the right hand side corresponds to entrants, excluding those that exit immediately, while the second term corresponds to incumbents after the realization of new productivities, excluding those that exit.

## 3.1 Examples

Our formulation is general and can encompass different models in the literature. As examples, we consider a class of models of perfect competition and others with imperfect competition.

**Perfect Competition.** Firms produce a homogeneous good with decreasing returns to scale production technology $f\left(s, n\right)$, where $s$ can be interpreted as a productivity shock. The model is the standard entry and exit model considered in the literature based on Hopenhayn (1992b). In this example, the revenue function $R\left(s, n, Z\right)$ is simply equal to $Zf\left(s, n\right)$, where $Z$ is the equilibrium price $p$ of the good.

**Monopolistic Competition with Constant Elasticity.** Each firm $i$ produces a differentiated good with a linear production function, $q\left(i\right) = s\left(i\right) n\left(i\right)$. The representative consumer has preferences over the intermediate goods given by the aggregator

$$U = \left( \int q(i)^{\eta} \, di \right)^{1/\eta}$$

with $0 < \eta < 1$. First order conditions for the choice of $q(i)$ are given by

$$U^{1-\eta} q(i)^{\eta-1} = \theta p(i),$$

where $\theta$ is the multiplier of the budget constraint of the consumer.[9] Letting $Z = U^{1-\eta}\theta^{-1}$, the revenue function is $R(s, n, Z) = Z(sn)^{\eta}$, which satisfies all our assumptions above.

**Imperfect Competition with Separable Utility.** Each firm $i$ produces a differentiated good with linear production function in labor, $q(i) = s(i)\, n(i)$. The representative consumer has preferences over the intermediate goods given by the aggregator:

$$U = \int u(s(i), q(i)) \, di$$

where $u(s, q)$ is strictly increasing and concave in $q$, where $s(i)$ is the type (e.g. quality) of the good produced by firm $i$.[10] First order conditions for the choice of $q(i)$ are given by:

$$u_q(s(i), q(i)) = \theta p(i).$$

Letting $Z = 1/\theta$ and substituting for $q(i)$ gives the revenue function $R(s, n, Z)$ equal to $Z u_q(s, sn)\, sn$. Under simple restrictions on the $u(s, q)$ function (for example, if $u$ does not depend directly on $s$) it is easy to verify that all our required conditions on the revenue function are satisfied. Note that this utility function admits the possibility that markups vary with the output produced by the intermediate good producer and thus with the firm's state $s(i)$. This is a class of models of imperfect competition considered by Arkolakis, Costinot, Donaldson and Rodríguez-Clare (2018).

[9] An alternative equivalent formulation is that $U$ represents a final good produced by perfectly competitive firms with the production function aggregator given above. In that case, $\theta^{-1}$ is the price of the final good.

[10] Alternatively, one can think of this utility function as a technology for producing a final good by a set of competitive producers with measure one.

## 3.2 Equilibrium

Let $M_t = \int d\mu_t(s)$ denote the total mass of firms. Denote by $m_t$ the mass of entrants at time $t$. Labor market clearing requires that:

$$\int n(s, Z_t)\, d\mu_t(s) + \int c_f(s) d\mu_t(s) + m_t c_e = N_t. \tag{5}$$

The first term is productive labor demand, the second term overhead and the third labor utilized for entry, e.g. entrepreneurs in startups. The right hand side represents total labor inelastically supplied.

An equilibrium for a given sequence $\{N_t\}$ and given initial measure $\mu_0$ is given by shutdown thresholds $\{s_t^*\}$, mass of entrants $\{m_t\}$, measures of production units $\{\mu_t\}$ and aggregate states $\mathbf{Z}_t = \{Z_t\}$ such that:

1. Exit: Shutdown thresholds are given by equation (2);
2. Entry: No rents for entrants, $v^e(\mathbf{Z}_t) \leq 0$ and $v^e(\mathbf{Z}_t)\, m_t = 0$;
3. Resource constraint (5) holds.
4. Law of motion: The sequence $\mu_t$ is generated recursively by equation (4) given the initial measure $\mu_0$.

We focus on equilibria with strictly positive entry, which is the relevant case in reality. The existence and uniqueness of such an equilibrium can be proved along the lines of Hopenhayn (1992b). Along the lines of Hopenhayn (1992a), it can be shown that a stationary equilibrium exists and is unique when labor $N_t$ grows at a constant rate. Here we generalize this result to the case where labor is growing at non-constant rates. In particular, we provide conditions for the existence and uniqueness of a *constant aggregate state equilibrium*, $Z_t = Z^*$ for all $t$. Under the above assumptions, it can be shown that $Z^*$ is unique and corresponds to the aggregate state in the stationary equilibrium in Hopenhayn (1992a). In what follows, we develop the existence argument.

For existence, we need to show that the equilibrium conditions hold in every period. Let $Z^*$ be such that the entry condition holds, $v^e(Z^*) = 0$. Let $s_t^* = s^*$ be the corresponding shutdown threshold, so that the exit condition holds. Given $\mu_0$, we construct the sequence $\mu_t$ recursively such that the law of motion holds. Let $S_a$ denote the probability that an entrant survives at least $a$ periods, i.e. that the state $s_{i\tau} \geq s^*$ for ages $\tau$ from 0 to $a$. Let $\tilde{\mu}_a$ denote the cross-sectional probability distribution of productivities for production units in the cohort of age $a$. These can be obtained recursively as follows:

1. Let $S_0 = (1 - G(s^*))$ and $\tilde{\mu}_0(ds) = G(ds)/S_0$, that is the distribution for entrants draws $G$ conditional on $s_0 \geq s^*$.

2. Let $S_a = S_{a-1} \int P(s_a \geq s^* | s_{a-1})\, d\tilde{\mu}_{a-1}(s_{a-1})$, where the term under the integral is the probability that a productive unit in cohort $a-1$ is not shutdown in the next period, and let
$$\tilde{\mu}_a(ds) = \frac{\int P(ds_a | s_{a-1})\, d\tilde{\mu}_{a-1}(s_{a-1})}{S_a / S_{a-1}}.$$

It remains to verify that the resource constraint holds. Let $\tilde{e}_a = \int (n(s, Z^*) + c_f(s)) d\tilde{\mu}_a$ denote the average employment of a productive unit in the age $n$ cohort. Let $E_{ta}$ denote total employment by that cohort at time $t$. In addition to average employment $\tilde{e}_a$, total employment $E_{ta}$ depends on the original mass of entrants in that cohort and the survival rate,
$$E_{ta} = m_{t-a} S_a \tilde{e}_a.$$

Total employment by incumbents (i.e. excluding new entrants) at time $t$ is the sum of employment by cohorts with age greater than one, $E_t^I = \sum_1^t E_{ta}$. On adding $E_t^I$ and total employment by entrants $m_t(S_0 \tilde{e}_0 + c_e)$, we recover the resource constraint:
$$N_t = m_t (S_0 \tilde{e}_0 + c_e) + E_t^I. \tag{6}$$

Given that $Z^*$ is constant, $S_a$ and $\tilde{e}_a$ are known at time $t$. Because $m_{t-a}$, and therefore $E_t^I$, are also known at time $t$, the only unknown in the above equation is $m_t$. It follows that equation (6) implicitly determines $m_t$ such that the resource constraint holds. If $m_t$ is strictly positive, all equilibrium conditions hold and the existence argument is complete. This occurs provided that $E_t^I < N_t$ in every period $t$. The following proposition provides sufficient conditions for $E_t^I < N_t$.

**Proposition 1** (Constant Aggregate State Equilibrium)**.** *Suppose that $N_t$ is a nondecreasing sequence and $S_a \tilde{e}_a$ is non-increasing. Then the aggregate state and the exit threshold are constant in the unique equilibrium, $Z_t = Z^*$ and $s_t^* = s^*$.*

The intuition is as follows. Because $N_t$ is a nondecreasing sequence, a sufficient condition for $E_t^I < N_t$, which guarantees strictly positive entry, is that $N_t - E_{t+1}^I > 0$. Note that
$$\begin{aligned} N_t &= m_t S_0 \tilde{e}_0 + m_{t-1} S_1 \tilde{e}_1 + \ldots + m_0 S_t \tilde{e}_t \, + \, m_t c_e \\ E_{t+1}^I &= m_t S_1 \tilde{e}_1 + m_{t-1} S_2 \tilde{e}_2 + \ldots + m_0 S_{t+1} \tilde{e}_{t+1}. \end{aligned}$$

Therefore $E_{t+1}^I$ is the inner product of the same vector of the mass of entrants as $N_t$, with a forward shift in the corresponding terms $S_a\tilde{e}_a$ and without the entry cost term $m_t c_e$. A sufficient condition for $N_t - E^I_{t+1} > 0$ every period is that $S_a\tilde{e}_a$ decreases with $a$. For a given cohort, this condition is equivalent to saying that the total employment of the cohort is decreasing in age. In the data, survival rates are decreasing in $a$ but average size of a cohort, when properly calibrated, is increasing. Therefore the sufficient condition holds when shutdown rates are sufficiently high to offset the growth in average size. In the model, this property is easy to verify given the stochastic process for the idiosyncratic shocks $s_{it}$ and the shutdown threshold $s^*$.[11] Note that the conditions in Proposition 1 are sufficient, but not necessary, for a constant aggregate state equilibrium. Now we discuss various properties of the equilibrium.

**Corollary 1** (Time Invariance)**.** *Exit rates by age, average firm size by age, and size distributions by age are time invariant in a constant aggregate state equilibrium.*

This Corollary follows because a constant aggregate state implies that firm exit decisions and optimal scale of operation do not change over time. The law of large numbers applies to a cohort at each age, and therefore the firm demographic variables, $S_a$ and $\tilde{e}_a$, and the size distribution by age are time invariant. It follows that the constant aggregate state equilibrium qualitatively generates the constancy by age of exit rates, average firm size and employment concentration as observed in the data. As a consequence, the Corollary implies that changes in weighted averages involving firm demographic variables $S_a$ and $\tilde{e}_a$ will be entirely due to changes in weights.

Because employment by incumbents $E^I_t$ depends on $S_a$ and $\tilde{e}_a$, the mass of entrants in equation (6) depends on firm demographics. With strictly positive entry, we can solve for $m_t$ to obtain the following result.

**Corollary 2** (Dynamic Entry Equation)**.** *The mass of entrants in equilibrium is given by*

$$m_t = \frac{N_t - \sum_{a=1}^{\infty} m_{t-a} S_a \tilde{e}_a}{S_0\tilde{e}_0 + c_e}. \tag{7}$$

Because $S_a$ and $\tilde{e}_a$ are time invariant in equilibrium, the dynamic entry equation implies that the mass of entrants $m_t$ is linear in population $N_t$. It follows that, in equilibrium, changes in $N_t$ are accommodated along the extensive margin by changes in entry. The dynamic entry equation also shows that that entry in the constant aggregate state equilibrium is history dependent: current entry $m_t$ depends on past entry $m_{t-a}$. Given $N_t$, higher entry in the past lowers current entry by increasing the mass of incumbent firms $m_{t-a}$.

[11] Models that assume permanent productivity shocks and exogenous exit trivially satisfy this condition. The same holds true for the models where productivity shocks are redrawn with some probability from the same distribution as entrants, e.g. Mortensen and Pissarides (1994).

### 3.3 The Turnover of Firms

In this section we examine the determinants of aggregate rates of entry and exit. In particular, we highlight the role of firm demographics, i.e. the age distribution of firms, in determining aggregate entry and exit rates. We show that changes in firm demographics have important feedback effects on the entry rate along transitions, when population is growing at non-constant rates.

The mass of aggregate exit at time $t$, denoted $X_t$, is the sum of exit masses of different age cohorts. Exit of firms of age $a$ equals the difference in survival rates $S_{a-1} - S_a$ multiplied by the size of the cohort at entry, $m_{t-a}$. We follow here the convention that the age at which a firm is shut down corresponds to the age at which the firm was last productive. The model allows for entrants to exit immediately without producing, so the mass of immediate exits $m_t(1 - S_0)$ are excluded from aggregate exit. It follows that aggregate exit is given by

$$X_t = \sum_{a=1}^{t} m_{t-a} \left( S_{a-1} - S_a \right).$$

The number of firms at $t - 1$ is given by

$$M_{t-1} = \sum_{a=1}^{t} m_{t-a} S_{a-1}.$$

Let $\omega_{ta} \equiv m_{t-a} S_a / M_t$ denote the share of firms of age $a$ in the total population of firms at time $t$. The hazard rate of exit for a firm of age $a - 1$ is $(S_{a-1} - S_a)/S_{a-1}$. The aggregate exit rate $\xi_t \equiv X_t / M_{t-1}$ can be expressed as the weighted average of hazard rates of exit of different cohorts

$$\xi_t = \sum_{a=1}^{t} \omega_{t-1,a-1} \left( \frac{S_{a-1} - S_a}{S_{a-1}} \right). \tag{8}$$

The hazard rates of exit are fixed by the Time Invariance Corollary. Therefore the aggregate exit rate is only a function of the age distribution of firms, which in turn is determined by past entry. This formula highlights the role of firm demographics in determining the aggregate exit rate. Because the hazard rates are different across firm ages, a change in the age distribution of firms affects the aggregate exit rate. The exception, of course, is when hazard rates are the same for all cohorts. In that case, firm demographics plays no role.

Now consider entry rates. Following the convention about exit, we define $m_t S_0$ as the measure of entry.[12] Let $e_t = N_t / M_t$ denote average employment. The rate of growth in the

[12] If we had we assumed that all entrants must produce for at least one period, then $S_0 = 1$ and $m_t$ would be measured entry.

number of firms is

$$\frac{M_t}{M_{t-1}} = \frac{N_t}{N_{t-1}} \frac{e_{t-1}}{e_t}. \tag{9}$$

Letting $\overline{S}_t$ denote the average survival rate from $t-1$ to $t$. The mass of firms $M_t$ can be decomposed into the mass of surviving incumbents plus the mass of entrants,

$$M_t = \overline{S}_t M_{t-1} + m_t S_0.$$

Solving for $M_t$ in (9) and substituting in the above equation gives the following expression for the entry rate

$$\lambda_t \equiv \frac{m_t S_0}{M_{t-1}} = \frac{N_t}{N_{t-1}} \frac{e_{t-1}}{e_t} - \overline{S}_t. \tag{10}$$

**Long-Run vs. Adjustment Path.** Suppose we are on a balanced growth path and population grows at a constant rate $g$. Average employment $e_t$ is constant along this path. The cohort entry weights $m_{t-a}$ decay as a function of age at the rate $1+g$, so that $m_{t-a} = (1+g)^{-a} m_t$. The aggregate exit rate in (8) reduces to

$$\xi_t^B = \frac{\sum_{a=1}^{\infty} (1+g)^{-a} \left(S_{a-1} - S_a\right)}{\sum_{a=0}^{\infty} (1+g)^{-a} S_a}, \tag{11}$$

which is independent of $t$. Because $e_t$ is constant and $\overline{S}_t = 1 - \xi_t$, the entry rate in (10) is also independent of $t$ along the balanced growth path.[13] We have

$$\lambda_t^B = g + \xi_t^B.$$

The entry rate equals the sum of the population growth rate and the exit rate. The intuition is simple. Entrants must replace the exiting firms. In addition, because average employment is constant, the total mass of firms needs to grow at the rate of population growth, $g$, to clear the labor market. Therefore, the entry rate must be enough to also create this extra employment.

More generally, when labor grows at non-constant rates and we are in a constant aggregate state equilibrium, changes in firm demographics will have feedback effects on entry. Aggregate exit rates depend on the age distribution of firms and thus the history of past entry. Because conditional exit rates are decreasing in age, a larger share of young firms

[13]The same holds in a model where productivity shocks are fully persistent or randomly redrawn from the same distribution as the one faced by entrants (as in Mortensen and Pissarides (1994)), average firm size is constant so the above formula applies. In particular this means that the rate of entry is independent of history and only depends on current population growth. If exit rates are not age dependent, the same will also be true for exit.

will be associated with a higher aggregate exit rate and consequently higher entry. In addition, changes in average employment will further impact the entry rate. The initial rise in entry rates will increase the share of younger productive units which tend to be smaller. This should lower average firm size and, from equation (10), further increase the rate of entry. Thus a rise in population growth will lead to increased entry rates over and above those needed to accommodate the increase in the labor force. This multiplier effect will operate similarly in the opposite direction when facing a decrease in the rate of growth in the labor force.

**Theorem 1** (Feedback Effect of Firm Demographics)**.** *Assume conditional exit rates $(S_{a-1} - S_a)/S_{a-1}$ are decreasing in age, and average firm size $\tilde{e}_a$ is increasing in age. An increase (decrease) in the rate of growth of the labor force will result in an increase (decrease) of entry rates over and beyond the rate of increase (decrease) in the labor force.*

This theorem highlights the importance firm demographic variables in determining entry along transitions. Suppose there are *No Firm Demographics*, i.e. $S_a$ and $\tilde{e}_a$ do not change with firm age. In that special case, changes in the age distribution of firms does not affect the aggregate exit rate and average employment. Therefore, the feedback effect is absent and changes in the entry rate along a transition are only due to changes in population growth.

# 4 Quantitative Analysis

We conduct the quantitative exercise using the simplest specification, the perfect competition economy of Hopenhayn (1992a). In this economy the aggregate state $Z$ is simply the output price $p$. Section 5.1 presents an alternative accounting approach.

The quantitative exercise is as follows. We assume the US economy was on a balanced growth path before 1940. This is as far back as we have reliable civilian labor force data. We then feed the time series of the civilian labor force growth rate in the data, starting in 1940, through the model economy. We calibrate the model such that the model-implied time series match the data in 1978, the first year of firm-level data in the BDS.[14] This calibration strategy allows us to capture the effects of the rise and the fall in the labor force on firm demographics, without requiring pre-1978 firm-level data.

**Functional forms.** The production function of a firm $f(s,n)$ is $sn^{\alpha}$, with $\alpha$ bounded between zero and one capturing decreasing returns to scale at the firm level. Firm productiv-

[14]BDS data starts earlier but best practice suggests dropping the first years due to suspected measurement error. See the Data Appendix for a discussion.

ity follows an AR(1) process,

$$\log(s_{t+1}) = \mu_s + \rho \log(s_t) + \varepsilon_{t+1}; \qquad \varepsilon_{t+1} \sim \mathcal{N}(0, \sigma_\varepsilon^2) \tag{12}$$

with $\rho$ as the persistence, $\mu_s$ as the drift and $\sigma_\varepsilon^2$ as the variance of shocks. The distribution of startup productivities $G$ is lognormal with mean $\mu_G$ and variance $\sigma_G^2$. We allow overhead labor to increase monotonically with firm productivity, $c_f(s) = c_{fa} + c_{fb} s^{\frac{1}{1-\alpha}}$. Because firm employment is monotonically increasing with firm productivity, this specification captures the intuitive idea that overhead labor increases with the number of production workers in the firm.

**Calibration.** The model period is set to one year. The time discount factor $\beta$ is set to 0.96. The worker's share of output $\alpha$ is set to the standard value of 0.64. The steady-state labor force growth rate $g$ is set to the standard value of one percent.

The parameters $c_e$, $c_{fa}$, $c_{fb}$, $\mu_s$, $\rho$, $\sigma_\varepsilon^2$, $\mu_G$ and $\sigma_G^2$ need to be calibrated. The entry cost parameter $c_e$ is set such that output price $p^*$ is normalized to one. As discusssed in Hopenhayn and Rogerson (1993), normalizing the equilibrium price gets around the identification problem that arises because price and the idiosyncratic shock enter the firm's objective function multiplicatively. The remaining parameters are calibrated to match the entry rate in 1978, the average size of entrants in 1978, the average firm size in 1978, the average concentration of entrants, the unconditional 5-year firm exit rates, the conditional 5-year firm growth rates, and the average dispersion of labor productivity for the years 1993 to 2001 reported in Bartelsman, Haltiwanger and Scarpetta (2013).

Some justification for the choice of moments is in order. From the dynamic entry equation, matching the average entrant size in 1978 is necessary to match the entry rate in 1978, so we target this moment. Average entrant size in the model is constant over time. It is determined primarily by $\mu_G$, the mean of the entrant productivity distribution $G$. The variance $\sigma_G^2$ determines the thickness of the right tail of $G$, and therefore targets the concentration of entrants. The variance of the productivity process $\sigma_\varepsilon^2$ affects the weight on productivity gridpoints at which firms exit, so it primarily targets the 5-year exit rate. The operating cost intercept parameter $c_{fa}$ enters into the firm size calculation and plays an important role in determining average firm size. The persistence parameter $\rho$ determines how quickly firms grow, so we use it to target the 5-year growth rate of firms. The operating cost slope parameter $c_{fb}$ plays an important role in matching labor productivity dispersion, and so we set it to match the standard deviation of log labor productivity. Table 1 summarizes the calibration targets in the model and shows that the parsimonious model does a good job of matching the targets.

Table 1

| | Assigned | | |
|---|---|---|---|
| | Value | Definition | Basis |
| $\beta$ | 0.96 | Discount factor | Standard |
| $\alpha$ | 0.64 | Worker's share of output | Standard |
| $g$ | 0.01 | Labor force growth rate (SS) | Standard |

| Jointly Calibrated | | | | | |
|---|---|---|---|---|---|
| Parameters | | | Moments | | |
| | Value | Definition | | Data | Model |
| $c_e$ | 3e−7 | Entry cost | $p^* = 1$ | — | — |
| $c_{fa}$ | 3.760 | Operating cost intercept | Avg. firm size 1978 | 20.08 | 20.08 |
| $c_{fb}$ | 0.007 | Operating cost slope | SD log-LP 1993-01 | 0.58 | 0.60 |
| $\mu_G$ | −11.189 | Mean of $G$ | Avg. entrant size 1978 | 5.40 | 5.36 |
| $\sigma_G^2$ | 3.966 | Variance of $G$ | Avg. conc. of entrants | 5.90% | 5.87% |
| $\mu_s$ | −0.025 | Drift in AR(1) | Entry rate 1978 | 14.75% | 14.33% |
| $\rho$ | 0.973 | Persistence of AR(1) | 5-year growth rate | 70.49% | 73.82% |
| $\sigma_\varepsilon^2$ | 0.073 | Variance of AR(1) shocks | 5-year exit rate | 48.42 % | 45.83% |

**Findings.** We begin by presenting the findings for the entry rate in Figure 4. We highlight three distinct episodes that the model matches very well. First, the model generates the steady decline in the entry rate observed between 1978 and 2014. The entry rate in the data declined from 14.5 to 6.2 percent, whereas the entry rate in the model declined from 14.4 to 8.1 percent. Second, the apparent increase in the entry rate pre-1978 is also generated by the model.[15] This was a time where labor force growth was steadily increasing. Third, the years around World War II were characterized by very large fluctuations in the entry rate. It turns out that the labor force growth series also exhibits very large fluctuations around the same time, corresponding to a time when large numbers of civilians left the labor force to join the war effort and returned after the war was over. Through the lens of our model, these large labor force growth fluctuations translate into similarly large fluctuations in the entry rate. The ability of the calibrated model to match both the long term trends and short term fluctuations suggests that changes in the labor force growth rate play a central role in the evolution of the entry rate.

Figure 5 compares the model versus data comparisons in the evolution of the aggregate exit rate, the average firm size and concentration. The model does an excellent job of matching the decline in the aggregate exit rate since 1978. Exit rate declines from 10.5 to

[15] Karahan, Pugsley and Şahin (2018) find that the entry rate for *establishments* was in fact increasing from 1965 to 1978.

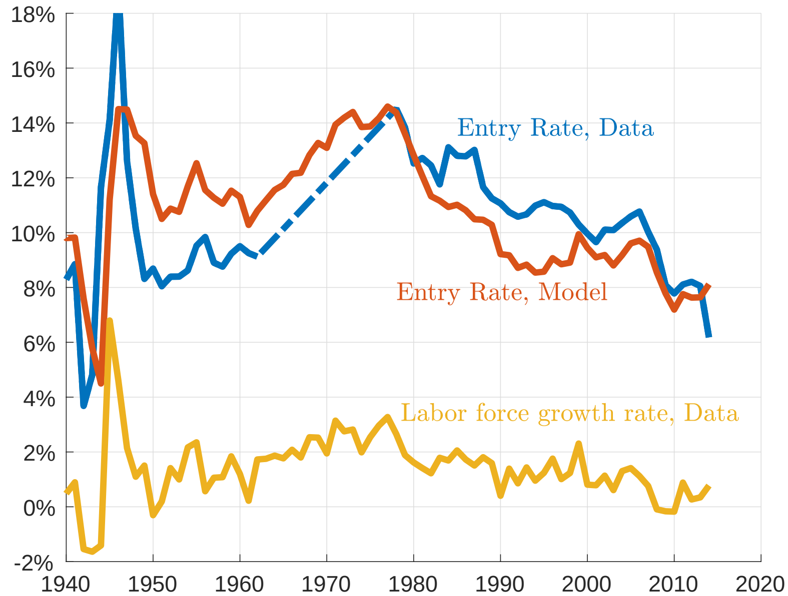


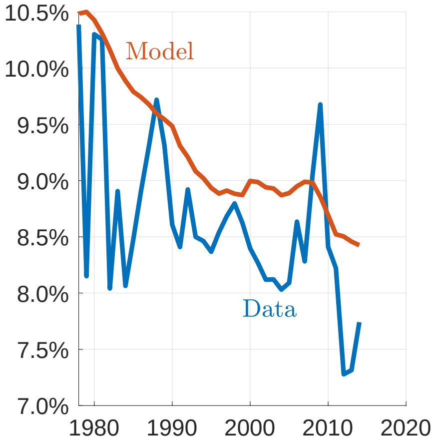

Figure 4

*Notes.* The entry rate from 1963 to 1977 is linearly interpolated.
*Sources.* Entry rate 1940-1962: Survey of Current Business. Entry rate 1978-2014: Business Dynamics Statistics. Labor force growth 1940-1946: Lebergott (1964). Labor force growth 1947-2014: Current Population Survey.

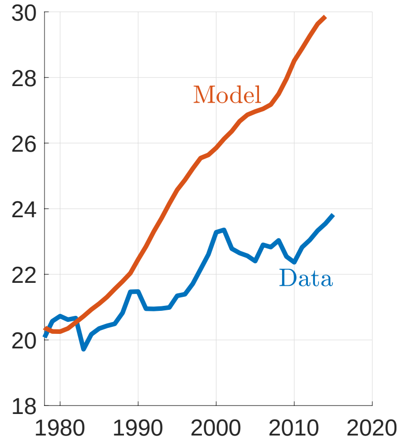
8.4 percent in the model whereas it drops from 10.4 to 7.7 percent in the data. Average firm size increases in both the model and the data. The model, however, overshoots the magnitude of the increase. This occurs because average firm size by age in the model is constant over time, whereas the average size of firms aged 11+ in fact declined somehat after 2000 in the data. The model also does an excellent job of matching the increase in concentration observed in the data since 1978. Concentration increases from 51.0 to 59.2 percent in the model vs 51.6 to 57.4 percent in the data.

Table 2 reports these same firm demographics variables across age groups. Overall the model does an excellent job matching average exit rate by firm age. This is perhaps not very surprising, given that we are calibrating to the 5-year unconditional exit rate. The model slightly undershoots average firm size for younger firms and slightly overshoots for older firms. The undershooting and overshooting is coming from a higher growth rate in the model than in the data. In the data, firm growth exhibits a discontinuity: the growth rate of 0-year old firms is almost twice that of 1-year olds, but the growth rate of 1-year olds is only slightly higher than 2-year olds. This discontinuity is absent in the model, so the model overshoots firm growth rates. Not surprisingly, the pattern for concentration by age is similar to that of average firm size: the model slightly undershoots concentration for younger firms and slightly overshoots it for older firms.

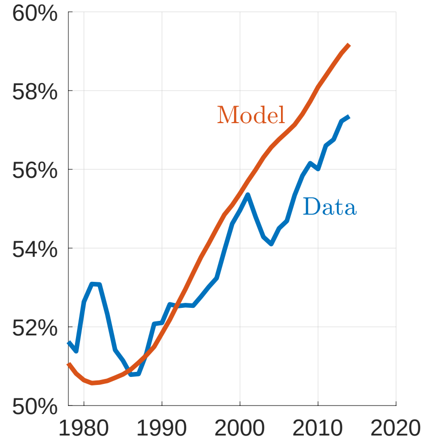
Given that the model does a good job of matching the firm demographics variables and



(a) Exit Rate



(b) Average Firm Size



(c) Concentration

Figure 5

*Notes.* Concentration is the share of employment in firms with 250+ employees.

Table 2: Firm Demographic Variables by Age

| **Age** | **Exit rate** | | **Average firm size** | | **Concentration** | |
|---|---|---|---|---|---|---|
| | Data(%) | Model(%) | Data | Model | Data(%) | Model(%) |
| 0 | – | – | 6.05 | 5.35 | 5.90 | 5.87 |
| 1 | 21.85 | 22.24 | 7.73 | 6.01 | 12.29 | 7.53 |
| 2 | 15.86 | 15.67 | 8.46 | 6.71 | 13.29 | 9.07 |
| 3 | 13.43 | 12.67 | 9.14 | 7.47 | 14.83 | 10.68 |
| 4 | 11.68 | 10.90 | 9.77 | 8.34 | 16.45 | 12.44 |
| 5 | 10.48 | 9.70 | 10.36 | 9.29 | 17.84 | 14.43 |
| 6-10 | 8.32 | 7.85 | 11.98 | 12.66 | 23.00 | 22.38 |
| 11-15 | 6.40 | 6.21 | 15.08 | 20.52 | 31.85 | 37.62 |
| 16-20 | 5.56 | 5.44 | 18.81 | 30.46 | 40.68 | 50.85 |
| 21-25 | 4.99 | 5.01 | 24.03 | 41.43 | 50.47 | 60.25 |
| Above 25 | 4.29 | 4.45 | 81.59 | 72.70 | 78.91 | 73.90 |

*Notes.* Concentration is the share of employment in firms with 250+ employees within the age category divided by total employment in the age category.

the aggregate time series, it must be the case that model matches matches firm aging well. Since 1987, the share of 11+ firms in the data increased by 17 percentage points in the data compared to 14 percentage points in the model. The model also captures the increase in the employment share of older firms. In the data, the employment share of firms age 11+ increased by 14 percentage points since 1987. In the model, the employment share increases by 11 percentage points.

## 4.1 Exploring the Mechanism: Decomposition and Counterfactuals

We run two equilibrium counterfactual experiments in order to better understand the mechanism. The first counterfactual assumes a constant labor force growth rate pre-1978. We refer to this counterfactual as the *No Rise* economy, because it ignores the pre-1978 rise in labor force growth. The second counterfactual assumes that there are no differences in exit rates and average firm size across age groups. We label this counterfactual the *No Firm Demographics* economy. We then use accounting identity (1) to decompose the decline in entry rate into a labor force growth component, an exit rate component, and an average firm size growth component in the benchmark economy and in each of the counterfactuals. Table 3 reports these decompositions.

Table 3: Counterfactuals

| | **Benchmark** | | | **No Rise** | | | **No Firm Demographics** | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1978 | 2014 | $\lvert\Delta\rvert$ | 1978 | 2014 | $\lvert\Delta\rvert$ | 1978 | 2014 | $\lvert\Delta\rvert$ |
| LF Growth, $\hat{N}$ | 2.65 | 0.77 | 1.88 | 2.65 | 0.77 | 1.88 | 2.65 | 0.77 | 1.88 |
| Exit Rate, $\xi$ | 10.48 | 8.43 | 2.05 | 10.11 | 8.53 | 1.58 | 11.65 | 11.65 | 0 |
| AFS Growth, $\hat{e}$ | −1.19 | 0.77 | 1.96 | 0 | 0.74 | 0.74 | 0 | 0 | 0 |
| Residual | 0.06 | −0.31 | 0.37 | 0 | −0.28 | 0.28 | 0.08 | −0.26 | 0.34 |
| Entry Rate, $\lambda$ | 14.38 | 8.12 | **6.26** | 12.76 | 8.28 | **4.48** | 14.38 | 12.16 | **2.22** |

*Notes.* All values are in percentage points. With entry costs denominated in units of labor, the accounting identity (1) holds approximately, $\lambda \approx \hat{N} + \xi - \hat{e}$. The residual corresponds to the growth rate of labor allocated towards the creation of entrants.

The three left columns of Table 3 present the decomposition of entry rate in the benchmark model. The entry rate declines by 6.26 percentage points between 1978 and 2014. Of this decline, 1.88 percentage points (or 30%) correspond to a decline in labor force growth, 2.05 percentage points (or 33%) correspond to a decline in exit rate, and 1.96 percentage points (or 31%) correspond to an *increase* in the growth rate of average firm size. The growth rate of average firm size increases because the average firm size time series is U-shaped and reaches a minimum in 1980. The remaining 0.37 percentage points (or 6%) residual is due to the change in labor allocated to the creation of entrants.

The middle three columns of Table 3 report the decomposition of the No Rise counterfactual. This economy starts off at a balanced growth path in 1978 corresponding to the 1978 labor force growth of 2.65 percent. All other calibrated parameter values are identical to the benchmark economy. The decline in the entry rate is 1.78 percentage points

(6.26 − 4.48) lower, or 28 percent (1.78/6.26) lower, than in the benchmark economy. This economy converges to a similar entry rate as the benchmark, but starts from a lower point. One reason for this is that average firm size is constant in the balanced growth path of 1978, while it was decreasing in the benchmark in 1978. The second reason is that the balanced growth path exit rate in 1978 is also smaller than the benchmark 1978 exit rate because the pre-1978 rise in labor force growth leads to younger firms in 1978 than in the 1978 stationary equilibrium. Because younger firms exit at a higher rate, the 1978 benchmark exit rate is higher than 1978 No Rise exit rate.

The last three columns of Table 3 report the decomposition of the No Firm Demographics economy. In this economy, firms do not grow or shrink and therefore do not exhibit differences in average firm size or exit rates across age groups.[16] The decline in the entry rate is 4.04 percentage points (6.26 − 2.22) lower, or 64 percent (4.04/6.26) lower, than the benchmark. Without firm demographics, there is no change in exit rates or average firm size over time, and therefore the decline in entry rates corresponds to the decline in the labor force growth rate.

The main message from these counterfactual exercises is that history dependence and firm demographics interact and are essential components of the decline in entry rates. Given the importance of history dependence and the slow convergence nature of age distributions, in the next section we explore what future projections of labor force growth imply for future entry rates.

## 4.2 Entry rate projections

The benchmark calibration can be used to project firm entry rates going forward. The Bureau of Labor Statistics publishes projections of labor force growth up until the year 2060. We feed the BLS projections into the benchmark model and compute firm entry rates. Figure 6 shows our findings.

The BLS projects that the labor force will slowly converge to a growth rate of about 0.25 percent by the year 2060. Through the lens of our model, these projections imply that the entry rate will bounce back from the current 8.1 percent to an entry rate of 9.1 percent. The reason for the rebound is twofold. First the exit rate increases from the current 8.4 percent to an exit rate of 8.8 percent. The reason for this is that firms are older in the transition

[16] We shut down the firm demographics by setting $\mu_s = 0$, $\rho = 1$ and $\sigma_\varepsilon = 0$. The resulting transition matrix is the identity matrix, $F = \mathbf{I}$, implying that the productivity of a firm equals its productivity drawn at birth. Without firm growth there is no endogenous exit and introducing exogenous exit rate is necessary to recover stationarity. We set the exogenous exit rate at 11.65 percent so as to match the benchmark entry rate in 1978. The mean of the startup productivity distribution $\mu_G$ is set to match the the average firm size in 1978 and $c_e$ to match $p^*$ equal to one. All other parameters equal their benchmark values. The calibrated parameter values are $\mu_G = -11.78$ and $c_e = 9e - 12$.

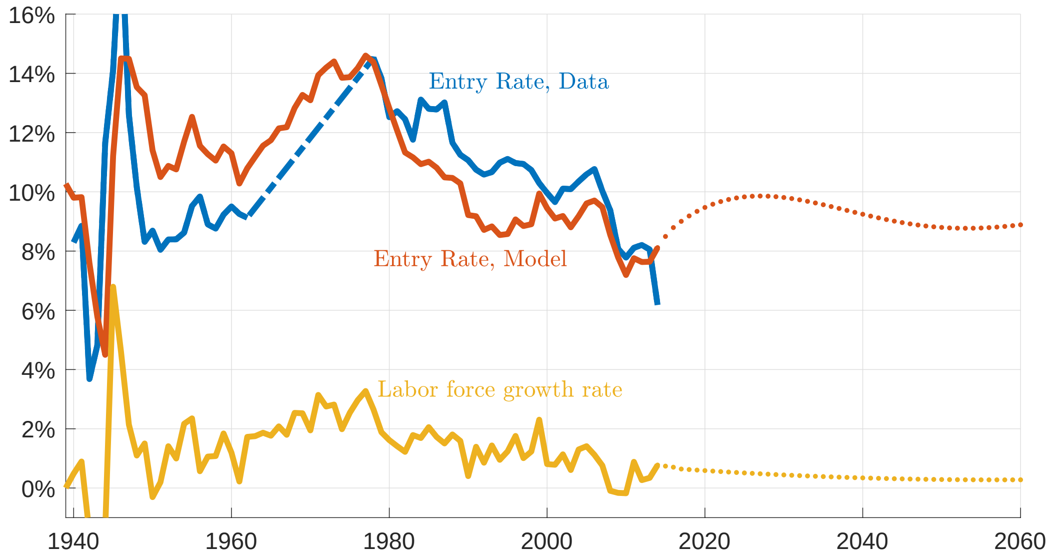


Figure 6: Projections

than in the 2060 balanced growth path, and older firms drive down the aggregate exit rate. Second, average firm size stops growing and goes back to being stable, adding an extra 0.7 percentage points to the entry rate in 2060. These two forces combined more than offset the lower labor force growth rate in 2060.

The projections also show that the convergence to the new balanced growth path is non-monotonic. The entry rate first rises above and then eventually converges to its stationary level. This cycle in entry rates is driven by the interaction of firm aging and entry rates. As firms age, they grow at slower rates and cannot absorb as much of the growth in labor supply. This creates room for new firms, raising the entry rate. As these new firms age and grow, they absorb a larger fraction of the growth in labor supply, lowering the entry rate and generating firm aging. This cycle repeats and dampens until convergence.

### 4.3 The Aggregate Labor Share

In recent work, Hartman-Glaser, Lustig and Xiaolan (2019), Kehrig and Vincent (2018) and Autor, Dorn, Katz, Patterson and Van Reenen (2017) document a negative relationship between firm size and labor share.These studies find that almost all of the decline of the aggregate labor share is due to reallocation of value-added from high to low labor share units, rather than a decline in labor share within units. Autor, Dorn, Katz, Patterson and Van Reenen (2017) propose a mechanism in which labor shares decline with firm size because of overhead labor. Because size and age are correlated, firm aging will have implications for the aggregate labor share. We explore this implication by embedding their mechanism into our benchmark model.

A firm's labor share can be broken down into the share of value added paid to production workers and to overhead labor. In equilibrium, the share paid to production workers is equal to $\alpha$ for all firms. Therefore, all differences in firm level labor shares are due to the share paid to overhead labor. We have

$$\text{Labor share} = \alpha + \frac{wc_f(s)}{py(s)} = \alpha\left(1 + \frac{c_f(s)}{n(s)}\right) \tag{13}$$

If overhead labor are identical across firms, $c_f(s) = c_{fa}$, then firm-level labor shares are decreasing in firm size. In our calibration we allow $c_f(s)$ to vary with firm size to capture the intuitive idea that larger firms have higher overhead labor. In spite of requiring higher levels of overhead labor, larger firms in the calibrated model have lower labor shares because the ratio $c_f(s)/n(s)$ declines with firm size. Firm aging reallocates market shares towards older firms, which are larger and have lower labor shares. As a result, the labor share declines. Figure 7 plots the cumulative change in the aggregate labor share in the model and the data. The aggregate labor share in the model is measured as the sum of firm-level labor shares, weighted by the value-added weight of the firm. Quantitatively, firm aging generates a large drop in the aggregate labor share.

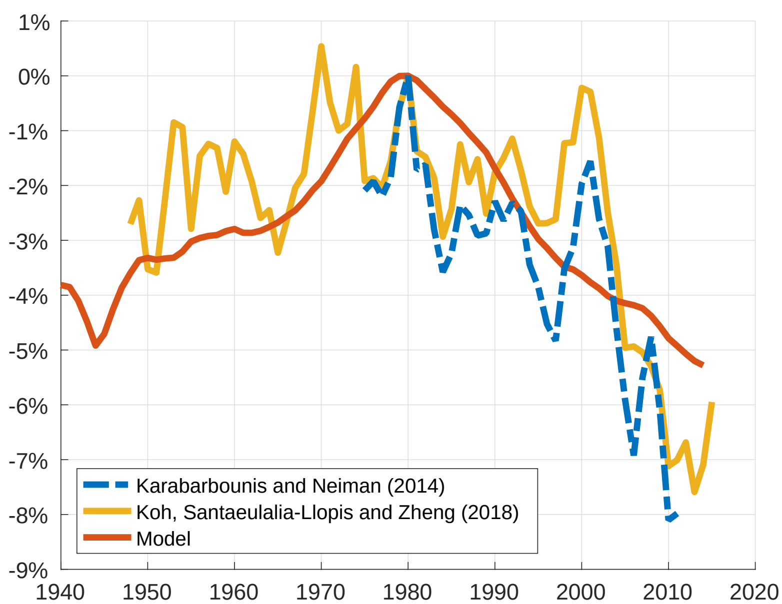



Figure 7: Corporate Labor Share (Normalized to 1980)

We compare the model generated decline to two measures of labor share in the data. First, we take the corporate labor share from 1975-2010 as measured by Karabarbounis and Neiman (2014). Second, we consider an alternative measure of the corporate labor share proposed by Koh, Santaeulalia-Llopis and Zheng (2018).[17] The model generates a decline comparable to both the series. The Koh, Santaeulalia-Llopis and Zheng (2018) series exhibit an increase in the labor share from 1947 to 1978, generating a hump-shaped aggregate labor share overall. The model matches this hump-shaped pattern quite well. The intuition for the hump-shaped pattern is as follows. From 1940-1978, the aggregate labor share increases with the entry rate because entrants are small in size, and therefore have higher labor shares. From 1978 onwards, as firms age and grow in size the share of firms with low labor shares increases, leading to a decline in the aggregate labor share.

# 5 Discussion

In this section we present a few extensions and extra checks. Specifically, Section 5.1 presents a more general quantitative exploration, Section D presents implications for job creation and destruction, Section 5.2 discuss the sources of labor force growth movements, and Section 5.3 discusses alternative measure of labor supply.

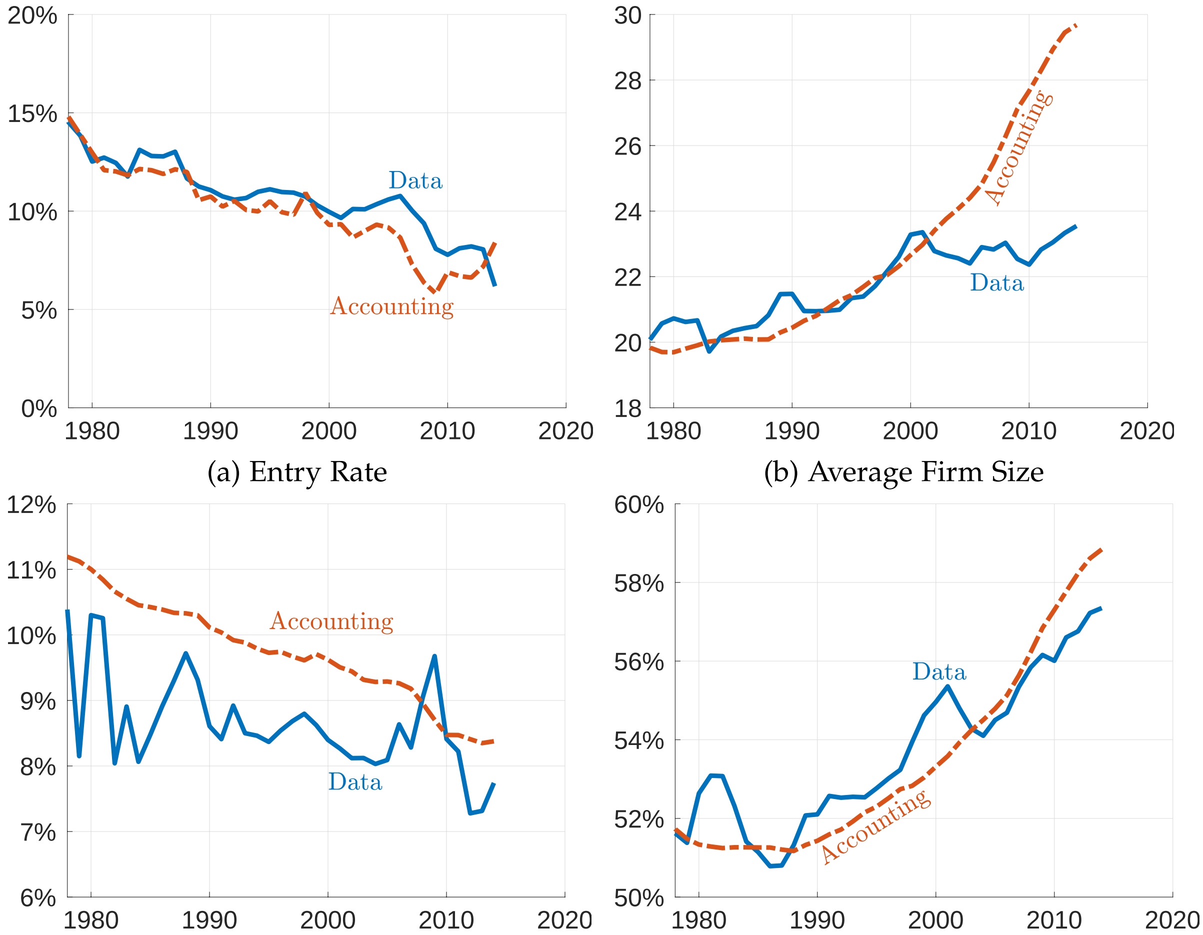
## 5.1 Accounting exercise

The calibration exercise of Section 4 was conducted in a competitive framework. However, our theoretical results hold in a variety of models, including noncompetitive settings. In this section, we present an accounting exercise that remains agnostic about the underlying model. Because it does not commit to a model, the agnostic approach requires data on firm demographic variables for all individual ages. This data does not exist for older ages.[18] Therefore, to make the agnostic approach feasible, we need to extrapolate the right tail for firm demographic variables by age. Of the many possible extrapolation strategies, we pick one that matches certain key features of the data.

The accounting exercise requires two theoretical results: the dynamic entry condition and a constant price equilibrium. The dynamic entry equation determines the mass of entrants and the constant price equilibrium generates time-invariant firm demographic

[17] This measure of the aggregate labor share is different because it accounts for changes in the way the Bureau of Economic Analysis treats intellectual property products. Prior to 1999, intellectual property was treated as a business or consumption expenditure. However, over time the BEA has started treating intellectual property as capital, affecting the measurement of the labor share. While we rely on overhead labor to generate the negative correlation between firm size and labor share, the negative relationship could just as well arise because larger firms make greater investments in intellectual property products, and therefore have lower measured labor shares.

[18] The Longitudinal Business Database can only identify the age of firms born after 1977. Therefore, firm demographics variables of those firms born before 1977 are necessarily aggregated in a single group.




(a) Entry Rate

(b) Average Firm Size

(c) Exit Rate

(d) Concentration

Figure 8

variables—exit rate, average firm size and concentration by age. If we could observe the firm demographic variables for all ages, along with the initial firm-age distribution, we could feed labor force growth into the dynamic entry equation and derive the evolution of firm entry. Because this data does not exist for older ages, we choose the initial distribution and extrapolate the firm demographics variables in order to match certain key features of the data; the details and the goodness-of-fit are in the Appendix. We also need the parameters $S_0$ and $c_e$ for the accounting exercise. The ratio of $S_0$ and $c_e$ determines the volatility of the entry rate in the dynamic entry equation, so we normalize $c_e$ to unity and set $S_0$ to match the volatility.

Figure 8 shows the results from the accounting exercise. The entry rate, average firm size, exit rate and concentration match the data well.[19]

[19]The implications for job creation and job destruction are discussed in Appendix D.

## 5.2 Sources of Labor Force Growth

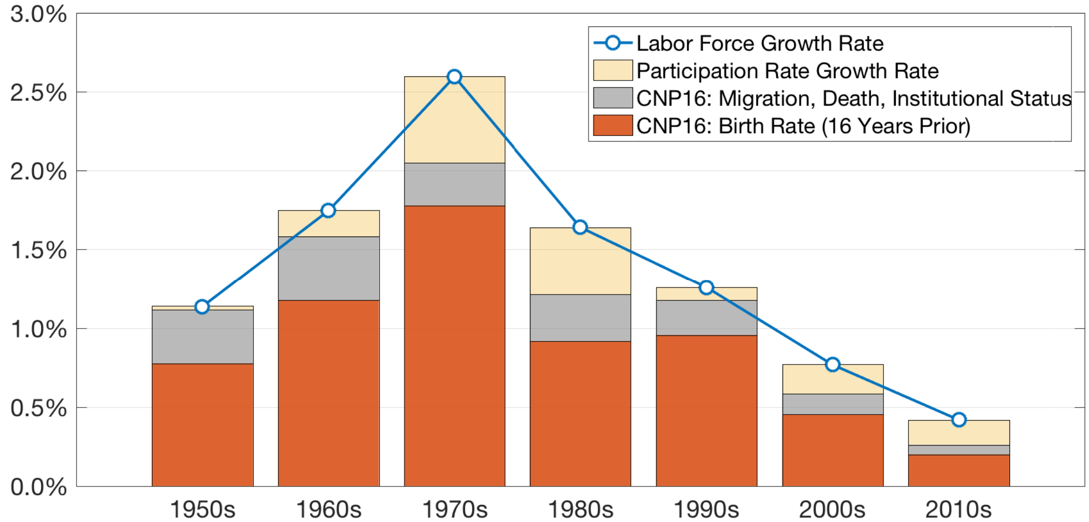



Figure 9: Decomposition of Labor Force Growth

What are the main drivers of the rise and fall of labor force growth? To answer this question, we decompose labor force growth into each of its components. We start from the BLS' definition of labor force,

$$\text{LF}_t = \text{CNP16}_t \times \text{PR}_t.$$

where $\text{LF}_t$ is the civilian labor force at time $t$, $\text{CNP16}_t$ is the civilian noninstitutional population age 16 and over at time $t$, and $\text{PR}_t$ is the participation rate at time $t$. It follows that labor force growth rate is the sum of the growth rate of each component,

$$\text{LF Growth Rate}_t = \text{CNP16 Growth Rate}_t + \text{PR Growth Rate}_t.$$

We can further decompose CNP16 growth rate at time $t$ into the birth rate at time $t-16$ and a residual term $\text{Other}_t$

$$\text{CNP16 Growth Rate}_t = \text{Birth Rate}_{t-16} + \text{Other}_t,$$

where the $\text{Other}_t$ term includes death rates, net migration rates, and rates of entry and exit into institutional status. Figure 9 plots labor force growth rate for each decade, dividing the bars into the percentage contribution of birth rates, growth rate of participation rates, and other. The decomposition shows that birth rates sixteen years prior account for the bulk of changes in labor force growth, accounting for an average of 64 percent of the labor force growth rate across decades.

The actual contribution of the birth rate to labor force growth is likely higher than

64 percent because the birth rate also has an effect on participation rates. For example, an important fraction of the decline of participation rates since the year 2000 is due to the baby boomer generation reaching the age of 55 and over, whose age group has low participation rates.

### 5.3 Alternative Measures of Labor Supply

One potential source of concern when using the civilian labor force as a measure of labor supply is that it includes the unemployed population, those employed by government, and the self-employed. Figure 10 shows that the pattern for total employment growth, which excludes unemployment, and for private sector employment growth, which excludes government and self-employment, follow a similar rise and fall pattern as labor force growth.

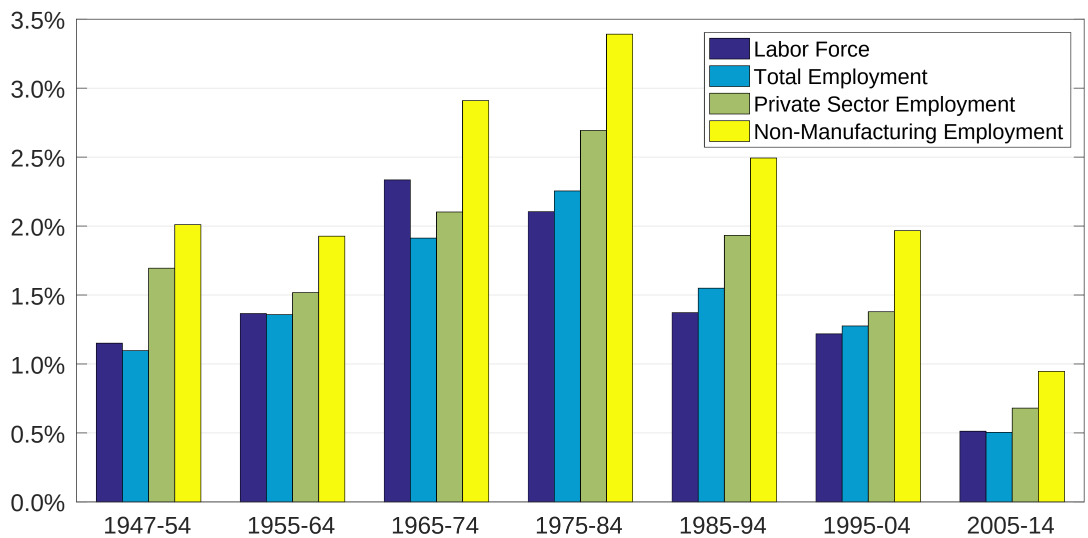



Figure 10: Growth Rates

*Sources.* Current Population Survey and Current Employment Statistics.
*Notes.* Data starts in 1947. Decade cutoffs are chosen so that full business cycles fall within the decade bin, effectively capturing the trend component in growth rates.

The manufacturing sector is another potential source of concern, as it has experienced overall negative employment growth since the 1980s (Fort, Pierce and Schott, 2018). This raises the possibility that an exodus of workers from manufacturing into non-manufacturing reverses the trend of declining employment growth in non-manufacturing sectors. Figure 10 shows that this is not the case. Non-manufacturing employment growth also follows a similar rise and fall pattern as labor force growth.

The decline of manufacturing employment does not have a large effect on nonmanufacturing employment growth partly because the flow of workers out of manufacturing is small compared to the flows of workers entering the labor force. From 1977 to 2014, manufacturing employment shrank by 6 million workers while the labor force grew by 57 million and total employment grew by 54 million workers.

# 6 Conclusion

Recent decades have witnessed a decline in firm entry and exit rates, and an increase in employment concentration and average firm size. We document that none of these changes have occurred within firm-age bins. The interplay of population growth and firm demographics can account for much of these aggregate trends, while maintaining stability within age bins. We highlight the feedback effect of firm demographics, along with the dynamic nature of entry rates, in determining these aggregate trends. When firm size and labor shares are negatively related, the mechanism also generates a decline in the aggregate labor share. Overall, our paper provides a unified quantitative explanation for a set of apparently disparate trends.

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# Appendix A Data Appendix

**Civilian Labor Force Growth Rate 1940-2014.** We obtain civilian labor force data from the Bureau of Labor Statistics (BLS) Current Population Survey for the years 1947 to 2014, and from Lebergott (1964) from 1940 to 1946. The civilian labor force definition in BLS includes population 16 years of age and over while in Lebergott the definition includes population 14 years of age and over. We can use Lebergott's series from 1947 to 1960 to compare the difference in growth rates using either definition. Figure A-1 shows that the labor force growth rates of ages 14+ and 16+ are nearly identical.

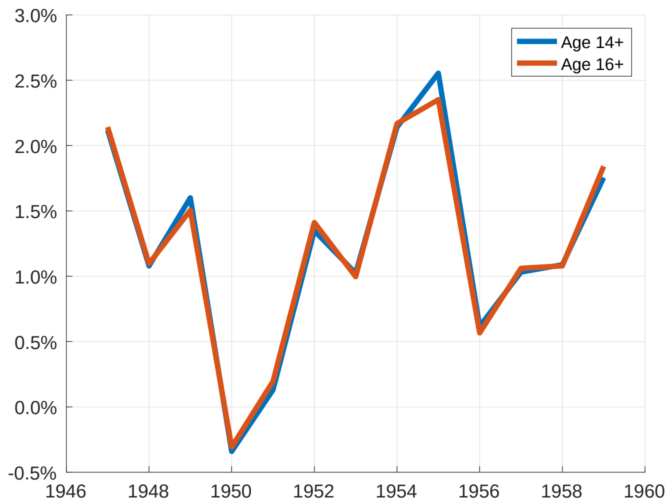



Figure A-1: US Civilian Labor Force Growth Rate

**Firm-level data 1978-2014.** Data to calculate firm-level data comes from the U.S. Census Bureau's Business Dynamics Statistics (BDS). The BDS dataset has near universal coverage of private sector firms with paid employees. BDS data starts in 1977, but best practice suggests dropping 1977 and 1978 due to suspected measurement error (e.g. Moscarini and Postel-Vinay, 2012). We drop 1977, but keep 1978, as calibrating to 1978 or 1979 does not affect our quantitative results (the model matches the startup rate in both 1978 and 1979 almost exactly).

**Firm Entry Rates 1940-1962.** The firm entry rate from 1940 to 1962 is obtained from the now-discontinued U.S. Department of Commerce's Survey of Current Business. The entry rate is 'New Businesses' divided by 'Operating Businesses'. The 1963 edition was the last one to report a 'Business Population and Turnover' section. From 1963, the Survey of Current Business reported instead 'Business Incorporations', which only include stock corporations. All nonfarm businesses are included, regardless of size.

**Birth Rates.** The 1930 to 2000 birth rate series is from the CDC National Center for Health Statistics.

**Employment 1947-2014.** Total employment corresponds to the civilian employment in the BLS Current Population Survey. Private sector employment and manufacturing employment are from the BLS Current Employment Statistics (Establishment Survey). Non-manufacturing employment is private sector employment minus manufacturing employment.

**Labor force projections.** Projections of labor force growth from are from the BLS report Toossi (2016).

# Appendix B Firm Age Regressions

Table B-1: Regression of concentration (employment share of firms sized 250+) on year

| Variable | Specification | |
|---|---|---|
| | (1) | (2) |
| Year | 0.003*** | -0.000 |
| | (0.001) | (0.000) |
| AGE: | | |
| Age 0 | | 0.065*** |
| | | (0.007) |
| Age 1 | | 0.129*** |
| | | (0.007) |
| Age 2 | | 0.139*** |
| | | (0.007) |
| Age 3 | | 0.154*** |
| | | (0.007) |
| Age 4 | | 0.171*** |
| | | (0.008) |
| Age 5 | | 0.185*** |
| | | (0.008) |
| Age 6 to 10 | | 0.237*** |
| | | (0.009) |
| Age 11 to 15 | | 0.326*** |
| | | (0.009) |
| Age 16 to 20 | | 0.415*** |
| | | (0.010) |
| Age 21 to 25 | | 0.514*** |
| | | (0.011) |
| $R^2$ | 0.026 | 0.976 |
| Observations | 351 | 301 |

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table B-2: Regression of log average firm size on year

| Variable | Specification | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year | 0.009*** | -0.005*** | -0.005*** | -0.005*** |
| | (0.001) | (0.001) | (0.000) | (0.000) |
| AGE: | | | | |
| Age 0 | | 1.844*** | 1.442*** | 1.465*** |
| | | (0.023) | (0.014) | (0.025) |
| Age 1 | | 2.089*** | 1.687*** | 1.724*** |
| | | (0.023) | (0.015) | (0.025) |
| Age 2 | | 2.179*** | 1.777*** | 1.814*** |
| | | (0.024) | (0.015) | (0.026) |
| Age 3 | | 2.256*** | 1.854*** | 1.876*** |
| | | (0.024) | (0.015) | (0.026) |
| Age 4 | | 2.327*** | 1.925*** | 1.949*** |
| | | (0.025) | (0.015) | (0.027) |
| Age 5 | | 2.386*** | 1.984*** | 2.010*** |
| | | (0.025) | (0.015) | (0.027) |
| Age 6 to 10 | | 2.534*** | 2.132*** | 2.167*** |
| | | (0.028) | (0.016) | (0.029) |
| Age 11 to 15 | | 2.756*** | 2.354*** | 2.331*** |
| | | (0.030) | (0.017) | (0.032) |
| Age 16 to 20 | | 2.985*** | 2.583*** | 2.480*** |
| | | (0.033) | (0.018) | (0.035) |
| Age 21 to 25 | | 3.258*** | 2.857*** | 2.586*** |
| | | (0.036) | (0.020) | (0.039) |
| SECTOR CONTROLS | No | No | Yes | Yes |
| SECTOR$\times$AGE CONTROLS | No | No | No | Yes |
| Observations | 3,159 | 2,709 | 2,709 | 2,709 |
| $R^2$ | 0.014 | 0.978 | 0.995 | 0.996 |

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table B-3: Regression of exit rate on year

| Variable | Specification | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Year | -0.146*** | -0.014** | -0.014*** | -0.014*** |
| | (0.011) | (0.006) | (0.005) | (0.005) |
| AGE: | | | | |
| Age 1 | | 21.967*** | 19.577*** | 19.304*** |
| | | (0.182) | (0.191) | (0.341) |
| Age 2 | | 16.227*** | 13.837*** | 12.786*** |
| | | (0.186) | (0.193) | (0.346) |
| Age 3 | | 13.758*** | 11.369*** | 10.850*** |
| | | (0.189) | (0.195) | (0.352) |
| Age 4 | | 12.115*** | 9.726*** | 9.466*** |
| | | (0.193) | (0.198) | (0.357) |
| Age 5 | | 10.842*** | 8.452*** | 8.419*** |
| | | (0.196) | (0.200) | (0.363) |
| Age 6 to 10 | | 8.743*** | 6.353*** | 6.791*** |
| | | (0.216) | (0.212) | (0.395) |
| Age 11 to 15 | | 6.814*** | 4.425*** | 5.263*** |
| | | (0.234) | (0.224) | (0.426) |
| Age 16 to 20 | | 6.010*** | 3.620*** | 4.691*** |
| | | (0.254) | (0.238) | (0.466) |
| Age 21 to 25 | | 5.531*** | 3.142*** | 4.535*** |
| | | (0.280) | (0.256) | (0.520) |
| SECTOR CONTROLS | No | No | Yes | Yes |
| SECTOR×AGE CONTROLS | No | No | No | Yes |
| Observations | 2,817 | 2,367 | 2,367 | 2,367 |
| $R^2$ | 0.061 | 0.962 | 0.975 | 0.978 |

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

# Appendix C Accounting Fit

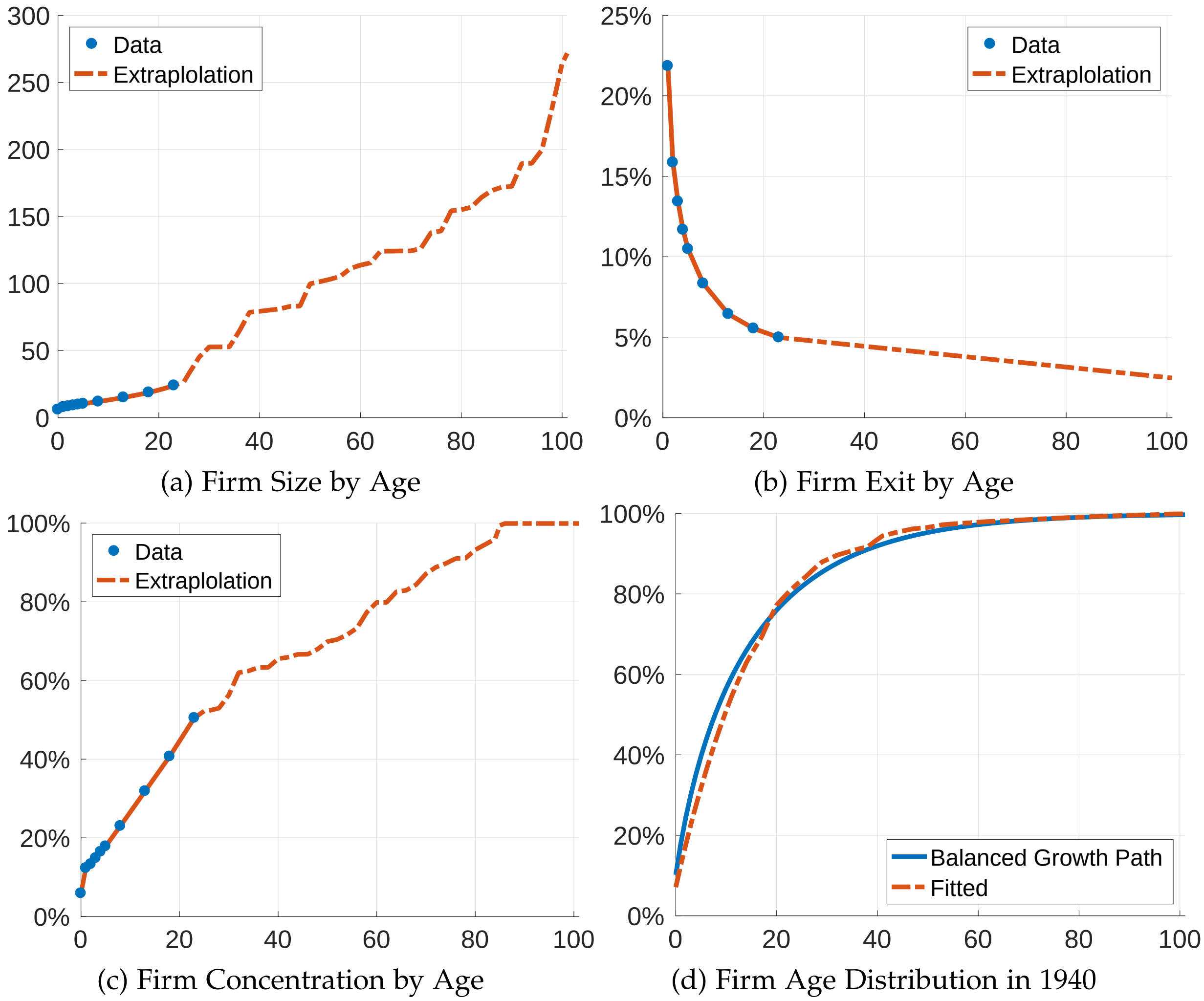
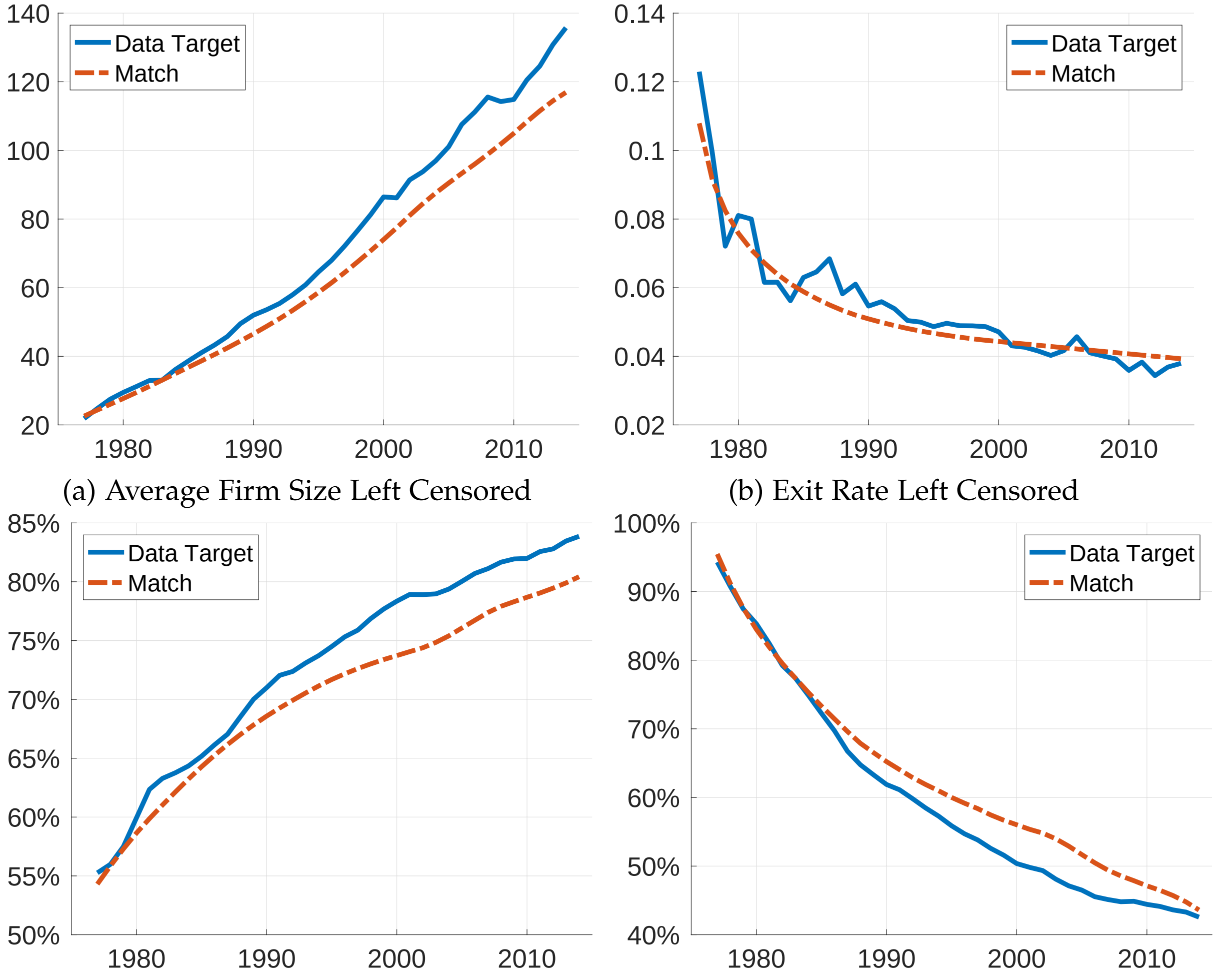



Figure C-2

*Notes.* Dots are the sample average for the age group. Value of age groups with multiple ages were assigned to the intermediate age (e.g. the mean of the 6 to 10 age group was assigned to age 8). Values in between dots are interpolated. Dashed lines are extrapolations set to match moments of the left-censored cohort in Figure C-3. Figure C-2d compares the initial distribution used in the accounting exercise (fitted) with the balanced growth path distribution in the structural calibrated model (with labor force growth of 1 percent).




(a) Average Firm Size Left Censored

(b) Exit Rate Left Censored

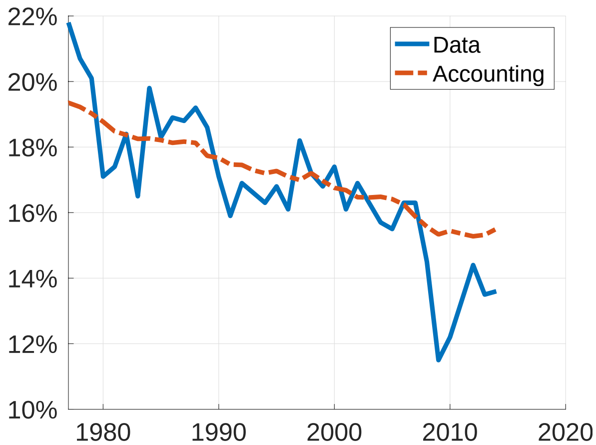
(c) Concentration Left Censored

(d) Employment Weight Left Censored

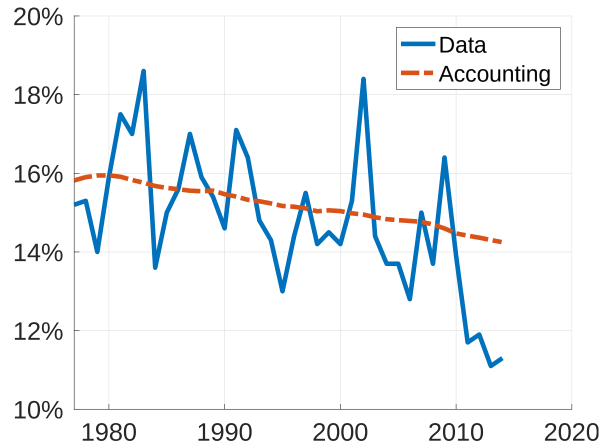
Figure C-3: Moments of the left censored cohort

*Notes.* Left censored firms are those born before 1977.

# Appendix D Job Creation and Job Destruction




(a) Job Creation Rate




(b) Job Destruction Rate

Figure D-4

In addition to firm entry rates, job creation and job destruction rates among US firms have also declined.[20] As with average firm size and exit rates, both job creation and destruction rates exhibit age effects: older firms create and destroy jobs at lower rates. Therefore an aging firm distribution qualitatively generates a decline in aggregate job creation and destruction rates. To explore the quantitative importance of firm aging, we take job creation and destruction rates by age from the data and use the firm-age distribution from the accounting exercise to calculate aggregate job creation and destruction rates. Instead of extrapolating job creation and destruction rates for older firms, we assume these rates stop declining after age 18, which imposes a lower bound on the magnitude of the effect.

Figure D-4 compares the time series of job creation and destruction rates from the accounting exercise and the data. A useful statistic that summarizes the role of firm aging is the ratio of the slope of the trendline of the accounting exercise to the slope of the trendline in the data. By this measure, aging explains a significant portion of the aggregate decline: 62.6% for the job creation rate and 48.2% for the job destruction rate.

[20]The job creation rate is the ratio of jobs created, either by entrants or continuers, to total jobs in a period. The job destruction rate is the ratio of jobs destroyed, either by exiting firms or by continuers, to total jobs.