# Obsolescence Rents: Teamsters, Truckers, and Impending Innovations *

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**Abstract**

We consider large, permanent shocks to individual occupations whose arrival date is uncertain. We are motivated by the advent of self-driving trucks, which will reduce demand for truck drivers dramatically. Using a bare-bones overlapping generations model, we examine an occupation facing a risk of obsolescence. We show that workers must be compensated to enter the occupation - receiving what we dub *obsolescence rents* - while employment in the occupation falls and becomes older. We investigate the market for teamsters at the dawn of the automotive truck as an à propos parallel to truckers, themselves, as self-driving trucks crest the horizon. We find that as widespread adoption of trucks drew nearer, the number of teamsters fell, the occupation became 'grayer', and teamster wages rose, as predicted by the model.

PRELIMINARY AND INCOMPLETE

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# 1 Introduction

Self-driving trucks now seem (nearly) inevitable. They are expected to dramatically reduce demand for truck drivers but their exact arrival date is uncertain. This motivates us to study the behaviour of labor markets when a demand shock is anticipated but hasn't quite arrived. We show how the anticipation of a large, negative shock to an occupation impacts the labor market. We think of this as an analog to investigating the aftermath of negative labor demand shocks, which is well-studied in seminal work such as Dorn et al. (2009) and Autor et al. (2016).

We model a labor market in which occupational choices are hard to reverse. We show that during the *anticipatory dread* stage when young workers expect that the occupation's demand may decline dramatically in their lifetime, those entering the occupation receive an *obsolescence rent.* Wages are lowest directly after the shock. Employment is reduced by the anticipation of the shock, and then reduced further at the shock's arrival. The workforce in the occupation is older during the anticipatory stage than either before the announcement of the shock or after the dust settles, although unsurprisingly, the age distribution may be oldest right after the shock hits. Drawing informally on Cavounidis and Lang (2020), we anticipate that once the shock hits, older affected workers will shift to closely related jobs that are less adversely affected by the shock, while younger ones will 'retrain' for the new jobs.

As an informal test of the model, we study the market for teamsters around the time that motor trucks were developed. Teamsters drove teams of horses that pulled wagons and were the antecedents to today's truck drivers.

The rise of motor trucks became increasingly likely starting between roughly 1895 and 1910, but the shock did not really hit until after World War I. Subject to inevitable data limitations, the results are largely consistent with our expectations. Teamsters' wages rose and then plummeted. Employment fell even while wages rose, and then collapsed further when wages crashed. The proportion of new teamsters who were young fell, while the proportion of exiting teamsters who were young rose. Former teamsters were much more likely to take up motor truck driving if they were young.

Like teamsters, dressmakers and milliners were displaced by technological change.

In their case, this was the arrival of department stores and ready-made dresses, which shifted garment-making from small independent shops or work in stores to factory work. In the decades before 1900, employment of dressmakers and milliners outside factories grew rapidly but levelled off between 1900 and 1910 before collapsing during the next decade. Unfortunately, we have no wage data, but we observe a similar aging process in terms of who enters and who leaves the occupation.

Our model and results are related to macroeconomic models of labor supply decisions with forward-looking agents in the context of structural change. Like us, Hobijn et al. (2019) studies the effect of retraining frictions. We also use idiosyncratic preferences (or skills) for occupations like Lagakos and Waugh (2013), and our agents pick jobs taking into account current and future wages as is Bárány and Siegel (2018).

## 2 A Model of an Occupation Passing Into Obsolescence

We begin with a simple overlapping generations (OLG) model in which each individual lives and works for two periods. Initially, we assume that workers choose their occupation and cannot move after a shock. Later we allow for limited occupational mobility. We use a two-period OLG model because it allows us to distinguish young and old workers straightforwardly while remaining tractable. However, tractability comes with costs. The stark assumption that large groups of workers are born and die on the same days makes it so that convergence to steady-state employment and wages is not monotonic. For this reason, most of our statements focus on the steady-state within a *stage* ('no shock', 'dread', or 'aftermath'), although in some cases, we discuss what happens immediately following a shift from one stage's steady-state to a new stage.

### 2.1 Wages and Employment with No Mobility

We first solve a model where individuals pick a job for their lifetime. A unit measure of workers is born each period, and each worker lives for two periods. Workers choose an occupation when born, which they keep for both periods they are alive. We focus on a single occupation which we dub 'widgeting'.

We take as a primitive the inverse demand function for the occupation, simply called the *wage function*. We denote the wage function before the shock arrives, including in the dread stage, by $w_h(\cdot)$ and after it arrives by $w_l(\cdot)$. Young and old widgeters are equally-productive perfect substitutes. Therefore, the widgeting wage is a function of the total number of widgeters. The shock is a negative one, so wages are lower after the shock: $w_l(x) < w_h(x)$ for all $x$. We assume that widgeting wages are differentiable and also downwards-sloping so that $w_h' < 0$ and $w_l' < 0$. For convenience, we assume that $w_h(0) \leq 1$ and that $w_l(2) \geq 0$ so that the wage always lies between 0 and 1.

To ensure that the model behaves smoothly, we endow workers with 'preferences' for widgeting. Formally, when workers are born, they receive a random draw, $\vartheta$, of the *per-period disutility from widgeting*. Without loss of generality, we set utility from the outside option to 0. Thus, a worker born at $t$ with a draw $\vartheta$ chooses to be a widgeter if

$$(w_t - \vartheta) + \delta(E[w_{t+1}] - \vartheta) > 0$$

where the widgeting wage today is $w_t$, $\delta \in (0, 1)$ is the common discount factor, and the expected widgeting wage tomorrow is $E[w_{t+1}]$.

We assume that *lifetime* widgeting disutility $(1 + \delta)\vartheta$ follows CDF $F$ which is continuous and strictly increasing on $[0, 1 + \delta]$. Effectively, $F$ maps the expected net present value of wages from widgeting to the fraction of young workers who become widgeters or, equivalently, the number of young widgeters. In other words, when the widgeting wage today is $w_t$ and the expected widgeting wage tomorrow is $E[w_{t+1}]$, the number of young widgeters today ought to be $F(w_t + \delta E[w_{t+1}])$.

We investigate three stages; the 'no-shock' (N) stage, in which workers believe the wage function will remain $w_h$ forever; the 'anticipatory dread' (D) stage in which workers believe the wage function will transition from $w_h$ to $w_l$ at a constant hazard $\lambda$; and the 'aftermath' (A) stage in which workers believe the wage function will be $w_l$ forever. These correspond to the three phases of obsolescence: before obsolescence is perceived as a risk, once it is on the horizon but arrives at an uncertain time, and after its arrival.

To summarize, our model posits that more young workers choose to become widgeters when they expect higher lifetime wages, that widgeter wages, in turn, decrease in the total number of widgeters, and that the arrival of the shock transitions the market to a lower demand function.

### 2.1.1 From old workers' numbers to young workers' earnings

We view a solution to the model as a triple of continuous functions $(V_N, V_D, V_A)$, one for each stage, mapping the number of old widgeters today to the expected lifetime discounted earnings of a young widgeter. For instance, in the no-shock stage when there are $o$ old widgeters, a young widgeter expects to earn $V_N(o)$. Thus the proportion (number) of young workers who become widgeters is $F(V_N(o))$. The next period, there will be $F(V_N(o))$ old and $F(V_N(F(V_N(o)))) = (F \circ V_N)^2(o)$ young widgeters; the new generation enters widgeting based on their expected discounted earnings given the number of old widgeters, who had in turn become young widgeters based on the previous generation of old widgeters, and so on.

Thus, recalling that wages depend on the sum of young and old widgeters, a solution must satisfy that for each $o \in [0, 1]$

$$V_N(o) = \underbrace{w_h(o + F(V_N(o)))}_{\text{wage today}} + \delta \underbrace{w_h(F(V_N(o)) + (F \circ V_N)^2(o))}_{\text{wage tomorrow}} \tag{1}$$

$$V_A(o) = \underbrace{w_l(o + F(V_A(o)))}_{\text{wage today}} + \delta \underbrace{w_l(F(V_A(o)) + (F \circ V_A)^2(o))}_{\text{wage tomorrow}} \tag{2}$$

$$\begin{aligned} V_D(o) = {} & \underbrace{w_h(o + F(V_D(o)))}_{\text{wage today}} + \delta[\lambda \underbrace{w_l(F(V_D(o)) + (F \circ V_A \circ F \circ V_D)(o))}_{\text{shocked wage tomorrow}} \\ & + (1 - \lambda) \underbrace{w_h(F(V_D(o)) + (F \circ V_D)^2(o))}_{\text{not-shocked wage tomorrow}}] \end{aligned} \tag{3}$$

Rather than derive necessary and sufficient conditions on primitives for the existence of a solution, we directly assume one exists. This assumption has quite a bit of content: we can immediately derive a few results from existence.

#### 2.1.2 Properties of the steady-states

We now turn to steady-states of the number old widgeters $\{o_N^*, o_A^*, o_D^*\}$ in the no shock, aftermath, and dread stages, respectively. As a solution is continuous, the existence of steady-states of $F \circ V_s$ for each $s \in \{N, D, A\}$ follows from Brouwer. Steady-states must satisfy

$$F(V_N(o_N^*)) = \quad F((1+\delta)w_h(2o_N^*)) = \quad o_N^* \tag{4}$$
$$F(V_A(o_A^*)) = \quad F((1+\delta)w_l(2o_A^*)) = \quad o_A^* \tag{5}$$
$$F(V_D(o_D^*)) = \quad F((1+\delta(1-\lambda))w_h(2o_D^*) + \lambda\delta w_l(o_D^* + F(V_A(o_D^*)))) = \quad o_D^* \tag{6}$$

Uniqueness of $o_N^*$ and $o_A^*$ is immediate from the fact $w$ is strictly decreasing, while $F$ is strictly increasing. Showing that $o_D^*$ is also unique takes a bit more work.

**Proposition 1.** *$F(V_D(\cdot))$ has a unique steady-state $o_D^*$.*

*Proof.* This and other proofs are to be found in Appendix A. □

The uniqueness of steady-states allows us to compare wages and employment in the three stages. In fact, we proceed to rank the wages and employment levels in the three steady-states. The next proposition encompasses two facts. First, that widgeter employment is highest in the no-shock steady state, followed by the anticipatory dread steady-state, which in turn features more widgeters than the aftermath steady-state. Second, that wages in the anticipatory dread steady-state are higher than wages in the no-shock steady state, which are in turn higher than wages in the aftermath steady-state.

**Proposition 2.** *The steady-state numbers of old workers satisfy $o_N^* > o_D^* > o_A^*$ and $w_h(2o_D^*) > w_h(2o_N^*) > w_l(2o_A^*)$.*

In addition, when the shock arrives in the anticipatory dread steady-state, wages in the short run drop to below the aftermath steady-state wage.

**Proposition 3.** *$w_h(2o_D^*) > w_l(o_D^* + F(V_A(o_D^*)))$.*

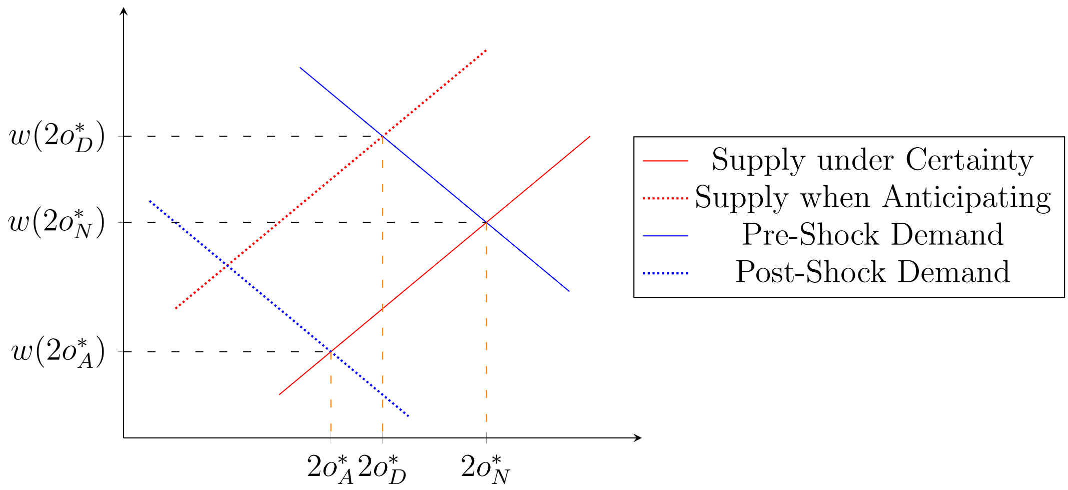


Figure 1: An example of the no-shock, anticipatory dread, and aftermath steady-states of the market for widgeters.

Less formally, when workers learn of the impending shock, they become more reluctant to enter widgeting. Therefore, as in Figure 1 the supply curve shifts to the left, and the wage rises while employment falls. When the shock arrives, demand shifts sharply to the left, causing the wage to fall, while the supply curve shifts back to its original location. Steady-state is restored with fewer workers and lower wages as the new marginal worker is less averse to working as a teamster than the previous marginal workers were.

## 2.2 Worker mobility

We now augment the model to allow us to explain changes in worker age profiles. We do this by introducing a probability $\pi$ that a given worker can change jobs when they turn old. This opportunity arises *after* the arrival or not of widgeting's obsolescence - the potential transition from the anticipatory dread stage to the aftermath stage - is observed.

If $\pi = 0$, no worker can move, and things are as above. If $\pi = 1$, every living worker can choose a new job in every period, and thus the steady-states in the no-shock and aftermath stages are reached immediately. There is no risk of getting 'stuck' as a widgeter. Therefore, the anticipatory dread steady state coincides with the no-shock steady-state. In both of these cases, in each steady state the numbers of young and old widgeters are equal. This also applies in the no-shock and aftermath steady-states when $\pi \in (0,1)$, as the wage is constant and there is no uncertainty.

However, when $\pi \in (0,1)$, in the anticipatory dread steady state, the number of young widgeters is less than the number of old widgeters. To see this, note that when the present widgeting wage is $w_t$ and the next period's widgeting wage $w_{t+1}$ is stochastic, a worker with per-period widgeting disutility $\vartheta$ becomes a widgeter if

$$\underbrace{w_t - \vartheta}_{\text{today}} + \delta[\underbrace{(1-\pi)E[w_{t+1} - \vartheta]}_{\text{tomorrow w/o mobility}} + \underbrace{\pi E \max\{0, w_{t+1} - \vartheta\}}_{\text{tomorrow w/ mobility}}] \geq \underbrace{0}_{\text{today}} + \delta \underbrace{\pi E \max\{0, w_{t+1} - \vartheta\}}_{\text{tomorrow w/ mobility}} \tag{7}$$

or simply

$$\vartheta \leq \frac{w_t + \delta(1-\pi)E[w_{t+1}]}{1 + \delta(1-\pi)}. \tag{8}$$

Thus, the number of young widgeters is

$$y_t = F\left((1+\delta)\frac{w_t + \delta(1-\pi)E[w_{t+1}]}{1+\delta(1-\pi)}\right). \tag{9}$$

Correspondingly, mobile old workers choose to be widgeters when

$$\vartheta + w_t \leq 0, \tag{10}$$

so that a fraction

$$F((1+\delta)w_t) \tag{11}$$

widgets. Thus the total number of old widgeters is

$$(1-\pi)y_{t-1} + \pi F((1+\delta w_t)). \tag{12}$$

Suppose, then, that $o^*_{D,\pi}$ and $y^*_{D,\pi}$ are the number of old and young widgeters in the anticipatory dread steady-state and that the corresponding wage is $w^*_{D,\pi}$.

The number of young widgeters must satisfy

$$y^*_{D,\pi} = F\left((1+\delta)\frac{w^*_{D,\pi} + \delta(1-\pi)E[w_{t+1}]}{1+\delta(1-\pi)}\right). \tag{13}$$

while the number of old widgeters is

$$o^*_{D,\pi} = (1-\pi)y^*_{D,\pi} + \pi F((1+\delta)w^*_{D,\pi}). \tag{14}$$

Given that $F$ is increasing, and that $E[w_{t+1}] < w^*_{D,\pi}$ by an analogue of Proposition 3,

$$y^*_{D,\pi} = F\left((1+\delta)\frac{w^*_{D,\pi} + \delta(1-\pi)E[w_{t+1}]}{1+\delta(1-\pi)}\right) < F((1+\delta)w^*_{D,\pi}) \tag{15}$$

and hence $o^*_{D,\pi} > y^*_{D,\pi}$.

# 3 Teamsters

## 3.1 Historical Context

The arrival of motor trucks was heralded long before they became widely available and used. In 1895 Thomas Edison declared that it was "... only a question of time when the carriages and trucks in every larger city will be run with motors." (quoted in Montville (1971), p. 378) In fact, the first commercial truck was purchased in 1897 (ibid p. 382), but it was not until much later that the use of motor trucks became widespread. The issue was not whether motor trucks could be built, which had certainly been demonstrated by the end of the 19th century, but if and when they would become commercially viable for local freight hauling. Moreover, it remained to be determined whether motor trucks would be driven by steam, electricity, or gasoline. Steam lost out early, but competition between electricity and gasoline continued well into the 20th century (Mom and Kirsch (2001)).

The use of both cars and motor trucks (hereafter, trucks) in the United States grew rapidly in the first three decades of the 20th century, but, as shown in Figure 2, the rise of cars preceded (gasoline and electric) trucks. In 1910 there were almost 460,000 registered cars but only about 10,000 registered trucks. By 1920, there were over eight million cars but just over one million trucks. In 1929, on the eve of the Great Depression, there were 23 million cars and about 3.5 million trucks. By way of comparison, in 1995, the ratio of registered cars to trucks was about 1.8.

Of course, there was no single year in which transportation of people and freight in the U.S. moved from horse-drawn vehicles to motor trucks. Still, in 1916, just before the U.S. entry into World War I, there were only 250,000 trucks. But the war was demonstrating their value. France and Britain purchased large quantities of trucks from American manufacturers, and the United States followed a crash course in designing standardized trucks for military use (Utz (1919)). Industry produced thousands of trucks. The experience showed using trucks was feasible (Smiley (2004)). The end of the war meant that significant production capacity created to meet the demands of the military was no longer needed for military purposes. Moreover, many military trucks were sold for civilian use and glutted the market until 1921 (Mom and Kirsch (2001)). Between 1918 and 1919, registrations increased by almost 300,000, a gain that would not be matched again until 1924.

By 1920, the rise of automotive trucks had not yet dramatically decreased demand for teamsters. By our calculation, the 1910 Census includes 480,135 teamsters compared with 383,787 in the 1920 Census. This contrasts markedly with occupations affected by the rise of passenger vehicles. Over the same period, the number of people employed as hostlers and stablehands fell from 63,000 to 19,000, and carriage and hack drivers fell from 35,000 to 10,000. In contrast, chauffeurs increased from 46,000 to 285,000.

However, by 1930, helped by the development of pneumatic truck tires, the rise of trucks had dramatically reduced the number of workers employed as teamsters. The number of teamsters collapsed to 123,180, about 32% of the number in 1920.

We searched *Scientific American* for articles with 'truck' in their title and 'motor' in the body or title. From 1901 through 1910, this produced 11 articles, of which we judge only 6 to be about what we would recognize as trucks. Five are very brief, mostly a single paragraph. The exception is a 1909 article (Rogers (1909)) that argued that motor trucks were superior to horse-drawn trucks in New York City because they could cover more territory. Still, the article also warned, "Two weeks at the factory is not sufficient to change a stable hand into a competent driver," and stressed the importance of proper maintenance, the risks of overloading, and issues related to roads. Only an adventurous businessman would come away from reading the article with a feeling that it was time to purchase a fleet of motor trucks.

Between 1911 and 1920, 96 articles met our criteria, almost all of which appear to be about vehicles recognizable as motor trucks. A 1913 article comparing the cost of horses, electric trucks, and gasoline trucks (Ritchie (1913)) generally favored electric trucks. Still, it stressed that "It is practically impossible to pre-determine what will be the total annual cost of operating a truck at given rating without knowing what will be the requirements of the service, the nature of the road and the general method of handling and repairing for the cars." Horses pulling 1/2 ton and 2 tons could go further on $1 of expense than the same size gasoline truck, although not as far as the equivalent electric truck. Helford (1914) argued that, since they might have difficulty raising the requisite funds to purchase a motor truck, businessmen might want to purchase on an installment plan.

A 1918 article in *Scientific American* (the Washington Correspondent of the Scientific American (1918)) captures our view. "Prior to the war the motor truck was making steady progress towards ultimate complete employment. ... But the war accelerated its adoption, perhaps by twenty years." The article further argued that American roads were woefully inadequate for truck traffic.

Our interpretation is that between 1910 and 1919, it became increasingly clear that automotive trucks were "on their way." The experience of World War I, including the direct observations of returning soldiers, and the injection of trucks into the civilian market should have made it apparent that trucks would supplant horse-drawn vehicles in local freight markets. By 1930, they had largely done so. However, the timing was uncertain since trucks required higher quality roads, which depended on local governments' willingness to undertake the expense. Ultimately, trucks would displace trains in the intercity market, but that transition occurred later. In 1929, intercity trucking accounted for somewhat more than one percent of the ton-miles of freight hauled, but it was growing at 18 percent per year (Smiley (2004)).

## 3.2 Employment: Identifying Anticipatory Dread and the Aftermath

Based on the previous account, we view the no-shock period as ending sometime around 1910. The shock arrived shortly after World War I, roughly in 1919. The anticipatory dread period fell in between. In contrast, with our formal model, the arrival probability of motor trucks was not constant but rose rapidly between 1910 and 1919, and, of course, the new technology was not adopted instantaneously. Unfortunately, we cannot date the collapse of teamster employment precisely. As we will see, teamster employment fell modestly between 1910 and 1920, consistent with what we anticipate in the anticipatory dread period and then collapsed between 1920 and 1930 after the arrival of the shock.

We focus on the male labor force for all the analysis for teamsters as almost all teamsters were males during this period. We use the IPUMS 1880 (10%), 1900 (5%), 1910 (1%), 1920 (1%), and 1930 (5%) census samples, rather than the full-count census, to estimate teamster employment. Unfortunately, the readily available full-count census data provide only a single occupation code (*occ1950*) which does not record teamsters consistently over this period. In 1880 and 1900, teamsters are all classified as "Truck and Tractor Drivers." The coding treats teamsters as equivalent to truck drivers in 1950. Starting in 1910, *occ1950* codes teamsters in agriculture, forestry, mining, baking, and laundry as 'laborers' or 'deliverymen', which reduces the number of teamsters compared to the previous years.[1]

The census samples have two additional but imperfect variables, *occstr* and *occ*, that allow us to identify teamsters more accurately. The latter is year-specific. Previous census reports have used it to infer occupations (Edwards, 1943). However, in some years it includes hackmen (who correspond more nearly to taxi drivers than truckers) and it excludes teamsters in some industries. *occstr* reports the respondent's original (unedited) response, which is sometimes not immediately recognizable as describing work as a teamster.

We combine these variables to obtain a more accurate count of teamsters than we would from any single variable. We first include anyone coded as a teamster using either *occ1950* or *occ*. Then we exclude workers who were coded as hackmen, taxicab drivers, or chauffeurs in *occstr* or *occ* and exclude teamsters who have the keyword "truck" in *occstr*. Next, in order to ensure consistency across year, we exclude all teamsters in the industries either *occ1950* or *occ* excludes since *occstr* fails to identify all teamsters in these industries. Finally, *occ1950* and *occ* include "deliverymen in stores" in teamsters before 1910 and exclude them starting in 1910.

[1] See https://usa.ipums.org/usa/volii/88occtc.shtml and https://usa.ipums.org/usa/volii/occ1920.shtml for details.

We are unable to exclude them in the early censuses. Therefore, for 1910-1930 we include workers with the keyword "team" in *occstr*.

Table 1 shows the teamster employment by decade in absolute numbers and as fractions of employed males. Column 2 shows the employment of 'male draymen, teamsters, and carriage drivers' copied directly from the census report (Edwards, 1943), while the rest of the columns show our estimates of the employment using the census samples. Our estimates are largely consistent with official reports although our estimates are somewhat higher, consistent with our including "deliverymen in stores" as teamsters. The census report documents 361,308 draymen, teamsters, and carriage drivers in 1900 and 443,735 in 1910, while our inferred teamster employment is 409,904 in 1900 and 480,135 in 1910. The census report and our calculation show similar patterns of teamster employment over time. Teamsters increased from 1880-1900 when the economy experienced radical industrial expansion and population growth. Teamster employment remained stable from 1900 to 1910 as the number of teamsters increased, while the fraction decreased slightly. Absolute teamster employment then decreased from 1910 to 1920 and collapsed from 1920 to 1930.

These employment changes are consistent with the distribution of trucks. According to the motor vehicle registration records shown in Figure 2, before 1910, very few trucks were available, and the number of teamsters grew between 1900 and 1910 although it fell as a proportion of the labor force. In the late 1910s, the number of trucks began to increase. Some teamsters felt the threat and changed their occupation, but most stayed. From 1920 to 1930, trucks increased dramatically, and it became clear that teamsters would be replaced by truckers. Correspondingly, employment collapsed.

These figures complement our discussion of the historical setting. The anticipatory dread began around 1910. The dread grew along with the actual shock over the following decade, with the predicted decline in employment, but the shock hit in a major way at the end of the decade causing employment to collapse in the 1920s.

## 3.3 The Aging of Teamsters

As our model predicts, the age distribution of workers in the occupation shifted to the right, as being stuck in an occupation with low demand is more costly for young workers. Importantly, again as predicted, this shift began *before* employment collapsed because younger workers bear both a higher risk that the shock will arrive while they are still working and will have more work years remaining if it does.

Figure 3 shows how the age composition of individuals employed as teamsters changed in anticipation of the shock and after the shock. The age compositions of teamsters are measured by the teamster share of employed males by age. Each panel shows teamsters by age as a proportion of the male workforce in each of two adjacent census years.

Between 1880 and 1900 the proportion of workers who were teamsters almost doubled. This change breaks down more or less evenly across cohorts, although the growth in employment was somewhat higher in younger age groups. Teamsters tended to be relatively young during this period. The proportion of workers employed as teamsters peaked between 25 and 40 in 1880 and two to three years earlier in 1900.

We observe some aging of the occupation between 1900 and 1910 when we also observe the first indications that motor trucks are on the horizon. Thus, the occupation began to age even though competition from motor trucks was negligible, with only 10,000 trucks registered in the entire country.

By 1920, the aging of the occupation even relative to 1910 was self-evident. In 1910, teamsters accounted for 1.85% of the 25-year-old employed males, while in 1920, they represented only 1.22%. On the other hand, the change in older workers was smaller; the teamster fraction of employed males aged 55 and over decreased from 1.14% to .98%. Again, this shift occurred largely in anticipation of the coming collapse. Teamsters still accounted for 1.58% of employment, and almost as many men were employed as teamsters in 1920 as in 1910.

From 1920 to 1930, as the number of trucks dramatically increased, employment decreased sharply in both absolute and relative terms, with young workers decreasing more dramatically than older workers. Despite the heavy physical demands, driving a team of horses had become an old man's job. Note that we had to change the range of the y-axis for this panel.

Our model further implies that after the shock has been in place for a sufficiently long time, the shocked occupation should approach a new steady-state. In the formal model, with productivity and tastes independent of age, the proportion of workers in the occupation should be independent of age in the new steady-state. While we do not wish to read too much into the age distribution of the small population of teamsters, we note that this prediction is quite accurate for teamsters in 1960 (see Figure 4).

## 3.4 Entrants Got Older, Leavers Younger

To determine the age distribution of workers entering and leaving work as a teamster, we require the full-count censuses since they are the only ones for which linked data are readily available. Therefore, despite its limitations, we have to rely on *occ1950* to identify teamsters. Implicitly, we assume that movements of teamsters from or to industries in which *occ1950* does not code them as teamsters would not offset our findings. Since the coding is consistent for 1910-30, this is less problematic for comparing movement between 1910-20 and 1920-30 but could be an issue for comparing these movements with those in previous decades.

Figure 5 shows the age distribution of workers entering and leaving work as a teamster between each pair of proximate censuses. The left panel shows the age composition for entrants, measured by the number of workers of a given age who moved from other occupations to teamsters divided by workers in other occupations who were ten years younger in the earlier census (presented as a percentage). The right panel shows the age composition for teamsters who exited, measured by workers of a given age who moved from teamsters to other occupations divided by the number of teamsters ten years younger in the earlier census. The horizontal axis shows the age in the later census. We do not include the movements between the 1880 and 1900 censuses because it covers a twenty-year period and, thus, is not comparable to the other three panels.

The age compositions of workers entering and leaving work as a teamster further confirm the model's predictions for age composition changes. Between 1900 and 1910, teamster employment remained stable, and the age compositions of movers mainly reflected mobility differences across different ages. For both figures, the age compositions are as expected. Young workers have higher mobility than older workers, so the lines are downward slopping for both workers entering and leaving work as a teamster. Between 1910 and 1920, teamsters' prospects changed. Our model predicts that, while workers of all ages should have become less likely to start as teamsters, young workers should have decreased entry more sharply, as being stuck in a sunset industry is more costly for younger workers. This prediction is confirmed by the left panel. From period 1900-1910 to period 1910-1920, the entry of young workers decreased significantly, while the entry of older workers decreased less both in percentage points and in percent. From 1920 to 1930, teamster employment collapsed, and the entry of workers of all ages further decreased with young workers decreasing more than older workers.

For the right panel, between each pair of periods, the proportion of teamsters exiting the occupation at different ages declines by roughly the same number of percentage points, except for very old workers for 1910-1920 relative to 1900-1910. However, the percentage decline is much higher for younger workers. Thus, figure 3 reflects that, relative to older workers, as they foresaw the possible arrival of motor trucks, young workers became both less likely to enter and more likely to exit work as a teamster.

### 3.5 Moving to Opportunity or Moving to What's Left?

Cavounidis and Lang (2020) analyze the reaction of individual workers to a shock that lowers the value of one skill and raises that of another. Older workers employed in occupations that are intensive in the negatively shocked skill move away from that skill relatively slowly. Young workers move towards the positively shocked occupations relatively rapidly. That model is distinct from the one in this paper. Nevertheless, we draw on the intuition from that model to explore patterns of mobility into and, especially, out of employment as a teamster. In our context, the negatively shocked occupation is self-evidently teamster. The positively shocked occupation is driver of a motor truck.

Unfortunately, *occ1950* is somewhat imperfect for measuring movement to the latter. Tractor and truck drivers were grouped together, and in 1910 truck drivers did not necessarily drive motor trucks. Between 1900 and 1910, over 9,000 workers in our sample switched from teamster to truck or tractor driver. This number is simply too high to reflect only workers who became drivers of motor trucks.

Workers who entered employment as a teamster from another occupation came primarily from employment as laborers (not elsewhere classified), farm laborers/wage workers, and farmers (owners and tenants). These are the top three source occupations for all age groups (26-35, 36-45, 46-55, 56-65) and all periods (1900-10, 1910-20, 1920-30) except that in the two earliest periods, the oldest age group was somewhat more likely to enter from managers, proprietors and officials (not elsewhere classified) than from working as a farm laborer. In each age/year, these three occupations account for between 55% and 70% of workers entering teamster employment from another occupation.

Workers who leave employment as a teamster for other employment exit primarily to laborer (not elsewhere classified), farmers (owners and tenants), truck and tractor drivers, managers, proprietors and officials (not elsewhere classified) (see Table 2). These four occupations account for 41% to 63% of these transitions, with higher proportions at older ages, and are the four most common exit occupations in all cases except for the two youngest age groups in 1910-20 when the managerial group slips to fifth place.

As predicted by Cavounidis and Lang (2020), we observe a strong negative age gradient in the proportion of exiting teamsters who enter the new occupation. Recall that this gradient is on top of the higher rate of exit by young teamsters. In 1910-20, 10% of the youngest group but only 6% of the oldest who exited became truck or tractor drivers. In the last decade, the youngest group was more than twice as likely as the oldest to exit in this way. Some movement to truck and tractor driver is probably measurement error in which teamsters who drove horse-drawn trucks were misclassified as truck drivers. We suspect, but cannot prove, that a much greater proportion of younger than older truck and tractor drivers drove motor trucks. Consequently, the results in Table 2 probably underestimate the extent to which younger workers were more likely than older workers to move to the positively shocked occupation.

It is also striking that the age gradient for moving to a declining occupation, farmer, increased. Between 1910 and 1920, among exiters, movement to farming shows a slight hump-shape with respect to age. Between 1920 and 1930, there is a clear upward slope. Although the shift is modest, it becomes more noticeable if we add in farm laborers (not shown). Recall that farm laborer was a common source occupation for teamsters but not a leading exit occupation. During 1900-10, there is no noticeable relation between age and becoming a farm laborer among exiters; 4.6% of 26-35 year old exiters enter farm labor compared with 4.9% of 56-65 year old exiters. The gap between the youngest and oldest group grows to 1.3 percentage points in 1910-20 and 1.9 percentage points in 1920-30.

## 3.6 Wages Rose and then Fell

The wage data for teamsters and other occupations are taken from the bulletins of the Bureau of Labor Statistics.[2] These bulletins report the union scale of wages annually in selected trades and selected cities. Neither the set of trades nor the cities covered are consistent over years. We focus on the hourly wage of teamsters from 1913-1931 in Boston, Chicago, New York, St. Louis, and San Francisco, for each of which we have a complete time-series for two-horse teamsters.[3] Unfortunately, the BLS did not collect wage data for teamsters between 1901 and 1912 and the data prior to 1901 are not comparable to the later data. Similarly, we have no wage data for 1931-1939, and the later data are not comparable to those we use.

We use "all trades" and close trades to compare the wages of teamster and other workers. All trades, which is the average of all the selected trades and cities covered in each BLS bulletin has the advantage of being more stable and reflecting an aggregate trend covering more cities and occupations. On the other hand, as complete teamster wage data are only available for the five cities, wages of all trades include additional cities, and the wages in some included trades are not directly comparable to those of teamsters. Also, the sets of trades and cities are

[2]The Bulletin of the United States Bureau of Labor Statistics Nos. 143, 171, 194, 214, 245, 259, 274, 286, 302, 325, 354, 388, 404, 431, 457, 482, 515, 540, and 566.

[3]Cincinnati, Ohio and Philadelphia, PA also have complete time-series. Cincinnati was too small a city, while data on Philadelphia consists of two types of two-horse teamsters (general teamsters before 1921 and lumber drivers since 1921), so its data is not comparable over time and is thus excluded.

inconsistent over time for "all trades".

For close trades, we used occupations with wages close to teamster wages in 1896-1900 that had data for at least four of our five cities for the entire period. We define 'close' as a daily rate below $3 in 1896-1900. The highest daily rate for teamsters in that period was $2.74 in New York in 1898. Teamsters earned close to the lowest wages among those for whom we have wage data; so this restriction only eliminates higher-pay occupations. The resulting occupations are building trades laborers, carpenters, hod carriers, inside wiremen, painters in the building trades, and platen and cylinder press feeders.[4]

Figure 6 shows the city average wage levels for two-horse teamsters relative to close trades in Boston, Chicago, New York, St. Louis, and San Francisco, when reported by the BLS and all trades in the full set of cities surveyed by the BLS, again subject to the caveat that the trades and cities are not consistent from year to year.[5]

The results for most occupations are consistent with our expectations. In the period leading up to the take-off of motor trucking, teamster wages rose relative to workers in most occupations except for building trades laborers. This increase in wages reflects the obsolescence rents discussed in the model. Faced with the prospect of the arrival of the shock, the massive entry of trucks, teamsters required a premium to stay in the occupation . Then, as the use of trucks increased dramatically, their relative wages fell before beginning to rise again.

Figure 7 further confirms the patterns in Figure 6 using the average wages of the close trades. Compared to close trades, the teamster wage began to increase in 1916, peaked around 1918-1919, collapsed after 1919, and then slightly recovered

[4]Based on descriptions from the Bureau of Labor Statistics, building trades laborers are those who perform tasks involving physical labor in building trades; carpenters are those who construct, erect, install, or repair structures and fixtures made of wood and comparable materials; hod carriers are those who carry supplies to masons or bricklayers; inside wiremen are those who install, maintain, and repair electrical wiring, equipment, and fixtures indoors; painters (building trades) are those who apply paint, stain, and coatings to walls and ceilings, buildings, large machinery and equipment, and bridges and other structures; press feeders, cylinder are those who loads paper into the feeding tray of a printing press using cylinder press; press feeders, platen are those who loads paper into the feeding tray of a printing press using platen press.

[5]New York has no data on hod carriers, San Francisco has no data on inside wiremen in 1921, St. Louis has no data on press feeders (platen) in 1918-1919, and Boston has no data on press feeders (platen).

after 1927. Teamsters' wages relative to all trades have a similar pattern but peaked in 1920. The relative wage in 1931 was slightly lower than in 1913 for close trades while being essentially equal for all trades. We do not, however, claim that the only reason for relative wage changes between 1929 and 1931 was the long-run response to the arrival of motor trucks. Apart from economy-wide events, the changes in teamsters' age composition could also have played a role.

To examine the statistical significance of the changes, we estimate the equation below:

$$\begin{aligned}\ln hourlywage_{ict} = \Sigma_{y=1917}^{1921}\beta_y Teamster \times \mathbb{1}\left\{Year = y_t\right\} + \\ \beta_{1922-26} Teamster \times \mathbb{1}\left\{1922 \leq Year_t \leq 1926\right\} + \\ \beta_{1927-31} Teamster \times \mathbb{1}\left\{1927 \leq Year_t \leq 1931\right\} + \\ \mu_{ct} + \gamma_{ic} + \eta_{ict}\end{aligned} \tag{16}$$

where $lnhourlywage_{ict}$ is the log hourly wage for occupation $i$ in city $c$ in year $t$, $\mu_{ct}$ are city-year fixed effects, and $\gamma_{ci}$ are city-occupation fixed effects. $\beta$s are the coefficients of interest. Period 1913-1916 is taken as the reference period. $\beta_y$ ($y$ = 1917, ..., 1921) measures the deviation of the teamster wage in year $y$ from the aggregate wage trend, which can be attributed to some time-variant idiosyncratic shocks faced only by teamsters. $\beta_{1922-1926}$ and $\beta_{1927-1931}$ reflect the wage deviations in a similar sense for the period 1922-1926 and 1927-1931.

Figure 8 shows the estimation results. Consistent with the previous figures, teamsters' relative wage increased since 1917. In 1919, the wage increase is significantly positive compared to 1913-1916. Since 1920, teamster wages were lower than the reference period and show no obvious recovery in the later periods.

Of course, it would be foolish to suggest that the wage increases in 1917-1919 can be explained only by teamsters' fear of obsolescence. For example, the run-up to the U.S. entry into World War I and the return of military equipment after the war might have increased demand for teamsters to haul military-related goods and equipment. To address this concern, we examine "revenue-tons of railroad freight." In essence this counts the total tons of freight shipped by rail but does not double-count freight transferred from one train to another. The amount shipped was essentially flat from 1916 through 1920 except for a dip in 1919 (U.S. Bureau of the Census, 1960) (p. 431). It is hard to reconcile the run-up of wages from 1916 to 1919 and the collapse in 1920 with the pattern for freight shipment.

# 4 Dressmakers and Milliners

While we have less data about dressmakers and milliners, they represent an important supplementary occupation for our analysis because, unlike teamsters, most dressmakers and milliners were women. Due to data limitations, our focus is on occupational mobility. We have no consistent data on earnings. In this section, we focus on the female labor force as almost all dressmakers and milliners were females during the period of interest.

## 4.1 Historical Context

Dressmakers and milliners were major occupations for female workers. In 1900, almost 10% of the female labor force was engaged in one of them. Before the rise of ready-to-wear women's clothing, frequently sold in department stores, women's dresses and hats were custom-made in dress shops that were run and managed primarily by women who also primarily employed women. Since workers appear to switch between dressmakers and milliners frequently, we combine the two occupations in the following analysis.

According to Gamber (1997), on which this subsection is based almost entirely, employment of women as dressmakers and milliners grew rapidly in the latter part of the 19th century. By 1870, dressmakers were the fourth largest female occupation, behind domestic servants, agricultural laborers, and seamstresses. In 1876, of 650 female proprietors in Boston, 191 were dressmakers and 80 were milliners. In the later part of the century, women owned 95% of the dressmaking and millinery shops. By 1900 dressmakers were the third largest female occupation and milliners ranked fourteenth. Significantly, dressmakers and milliners were skilled workers, unlike domestic servants, agricultural laborers, and seamstresses, who primarily sewed together pre-cut cloth for ready-to-wear men's clothing. The labor market valued highly the ability to cut the fabric to fit the individual woman who would wear the dress or hat. In 1913, expert milliners made $10-12/week, trimmers made \$15-25/week, and designers \$40-75/week. At the same time, two-horse male teamsters, as low-skilled workers, made \$10-17/week. Milliners earn slightly lower wages while trimmers and designers earn much higher wages than male teamsters. Milliners tended to have somewhat higher wages than dressmakers, which may have reflected the greater seasonality of their work.

Throughout the second half of the 19th century, numerous inventors developed 'scientific' methods designed to remove much of the skill needed for cutting dresses. These methods typically allowed individuals to cut material and sew dresses based on simplified patterns. By 1900, these developments had increased home production, but dressmaking shops remained dominant. Perhaps more significantly, they appear to have paved the way towards a shift to ready-to-wear women's clothing. The rise of department stores after 1890 further contributed to this shift. Anecdotal evidence from the period suggests that the ready-made industry for women's clothing began to expand noticeably in the early 1900s and went on to supersede the custom dressmaking industry (Picken, 1917).

As discussed with reference to teamsters, the occupation variable in the readily available full-count census is occ1950, which defines dressmakers and milliners inconsistently across censuses.[6] Therefore, we use the census samples to identify dressmakers and milliners more accurately. Unfortunately, seamstresses are not coded separately from dressmakers. Therefore, we are forced to include them when estimating employment.

Table 3 shows dressmakers and milliners' employment in the early 20th century. Between 1860 and 1870, their employment decreased slightly in absolute numbers and more noticeably as a proportion of female employment, which grew significantly during that period. Between 1870 and 1880, dressmakers and milliners expanded in both absolute terms and as a proportion of the female workforce.

[6] Using occ, we find that *occ1950* includes apprentices in 1860 and 1870 but not in the other years. From 1910-1930 but not in other years, *occ1950* includes millinery dealers. and some factory workers. On the other hand, most workers coded as dressmakers and milliners in *occ* are also coded as dressmakers and milliners in *occ1950*. Therefore, *occ* appears to be more consistent and accurate. Previous census reports also use *occ* rather than *occ1950* (Edwards, 1943). Unfortunately, as *occ* is only available for the census samples in IPUMS (except for 1860 and 1870), we use the census samples instead of the full-count data for most of the analysis. For 1860 and 1870, we use the full-count census data as *occ* is available in the full-count census data in these two years. The 1890 census is not available.

Employment increased dramatically in numbers between 1880 and 1900, while remaining stable as a proportion of female employment. Between 1900 and 1910, absolute employment held steady but declined as a proportion of the growing female labor force. After 1910, employment declined precipitously.

Based on this evidence we view 1900-10 as the anticipatory dread period. We place the arrival of the shock between 1910 and 1920.

## 4.2 Movements in and Out of Dressmaking & Millinery

In each panel, Figure 9 shows the ratio of dressmakers and milliners to employed females at each age for one census (the solid line) and the subsequent available census (the dashed line) from 1880-1930. Relative to the female workforce, the age distribution remained stable between 1880 and 1900 as employment boomed. Notably, although absolute employment grew between 1900 and 1910, the anticipatory dread period, the occupation began to age relative to the female workforce and continued aging through at least 1930. Dressmakers and milliners made up 11.52% of employed 25-year-old women in 1900 but just 6.46% in 1910, a decrease of roughly 44%. In comparison, the percentage of employed women over 55 who were dressmakers and milliners dropped from 9.96% to 8.99% or less than one-tenth. The aging of the occupation strengthened from 1910 to 1920 and 1920 to 1930. Dressmaking and millinery had become old women's jobs.

To track workers' movements between dressmakers and milliners and other occupations, we use the linked census data between 1900 and 1930, linking individual records between pairs of adjacent census years and relying on *occ1950*, as we did for teamsters. In what follows, 'workers' always refers to 'female workers'.

The shock and its anticipation both increased the age of new entrants and reduced the age of departing workers. The age distribution of employees beginning and ending their careers as dressmakers or milliners between each pair of proximate censuses is depicted in Figure 10. The left panel shows the age composition for entrants, measured by the number of workers at that age who became dressmakers and milliners (as a proportion of employed workers who were in other occupations and ten years younger in the previous census). The right panel shows the number of workers of a given age who exited work as dressmakers or milliners relative to the number of dressmakers and milliners who were ten years younger in the previous census. The horizontal axis displays age in the latter year: e.g. for 1900-1910, the x-axis shows ages in 1910. We do not include the movements between the 1880 and 1900 censuses because they cover a twenty-year period and thus are not comparable to the other three panels.

Our expectations regarding the age distribution of workers entering and leaving the dressmaker and milliner industries are supported by Figure 10. Our model predicts that because being stuck in a sunset industry is particularly costly for younger workers, their entry into the occupation should be curtailed, while entry by older workers should decline less or even increase. The left panel confirms this hypothesis. Long-term prospects for milliners and dressmakers shifted between 1900 and 1910. However, the impacts of the ready-made garment on custom-tailored clothing might not be fully anticipated, and many workers entered the occupation. Younger workers are more mobile than older workers, a fact reflected in the downward-sloping entry curve. Between 1910 and 1920, young employees entered the workforce at a much lower rate than between 1900 and 1910, while the entry of old workers decreased but to a much lesser extent. In later census years, the entry of young workers continued to decrease more than old workers. In the right panel, exit increased at all ages although the decline between 1900-10 and 1920-30 is less pronounced among older workers.

# 5 Discussion: Current Truckers and Broader Lessons

We find very mixed evidence regarding the current state of trucking employment. Different sources suggest different conclusions about whether we have entered the anticipatory dread period, but the clear aging of entry into the occupation suggests to us that we may have.

The American Trucking Associations (2021) trade group reports a current truck driver shortage of 'historic' proportions, along with both significant increases in driver pay and a high average age of current drivers. Our model can explain these movements within the framework of the anticipated arrival of a future shock to demand, which we associate with self-driving trucks. From this perspective we appear to be in the anticipatory dread stage of our model.

Figure 11 shows the interest over time for the keyword "self-driving" taken from Google Trends. The time series suggests that self-driving was not a keyword of interest until around 2012. We note that just as motor cars arrived before motor trucks, interest in self-driving cars may have preceded interest in self-driving trucks. We conclude simply that the anticipatory dread period is unlikely to have started before 2012, not that it has started.

When commercially viable self-driving trucks will truly be readily available is highly uncertain. It seems to us that they have been "five years away" for a decade. Truck drivers seem to think that their arrival is sufficiently distant that self-driving trucks may be irrelevant for all but the youngest drivers (Shoag et al. (2022)). Of course, while not in our model, implicitly the workers who enter an occupation during the anticipatory dread state should be those who view the arrival probability, $\lambda$, as low. Therefore, the views of current drivers may be misleading.

Whether truckers wages are currently unusually high and their employment low depends on whom we include in the occupation, with whom we compare truckers, and which data source we rely on. If we rely on the Current Population Surveys (CPS), our preferred source because we can track movement in and out of the occupation, we see weak evidence consistent with recent entry into the anticipatory dread stage.

Figure 12 uses the CPS data to show the employment and real weekly earnings for male truckers compared to the male labor force in close occupations, where close occupations are the occupations that truckers move from or to most frequently.[7] The sample only includes private employees and excludes the self-employed because they lack weekly earnings data. It suggests that trucker's relative employment began to decrease around January 2021 while their relative weekly earnings began to increase at the same time. However, their relative wages at the end of our period were still slightly below their peak over the entire period. We can certainly read the recent data as suggesting the onset of anticipatory dread, the ongoing effects

[7] Close occupations are 1) Laborers and Freight, Stock, and Material Movers, Hand, 2) Construction Laborers 3) Retail Salespersons, and 4) First-Line Supervisors of Sales Workers. These occupations are among the top six occupations that truckers move from or to. We exclude Couriers and Messengers because it is a sufficiently small occupation that trucker flows might significantly affect earnings. We also exclude Managers (not elsewhere classified) because the average wage is much higher than trucker wages, making it not "close" to truckers.

of the pandemic, or a blip.

Moreover, different choices lead to different results. For example, if we restrict truckers to those working in the trucking industry, their employment remains stable in recent years with a small peak around 2020. If we use Current Employment Statistics data and compare truckers with all workers in non-farm private employment, relative employment of truckers appears stable except for a peak in 2020 during the pandemic. If we use data from the American Community Surveys, we can show increasing trucker employment.

Returning to the CPS, in Figure 13, we compare the age distributions of truckers in 2006 and 2021. We choose the former as it clearly precedes widespread expectations of the arrival of self-driving trucks and avoids any effects from the financial crisis and great recession. The figure visually confirms the industry report that the occupation has aged.

More notably, we use the linked CPS to examine entry to and exit from truck driving[8]. We compare truckers entering the occupation in 2006 with entrants in 2021. The left panel of Figure 14 suggests a clear aging of new entrants. The average age of entrants increased by roughly 2.6 years between the two periods. The difference is significant at any conventinal level. As with our historical studies, it is less clear that departing workers are younger recently than they were in 2006, but the right panel suggests a modest shift in this direction. While it would be premature to conclude definitively that we have entered a period of anticipatory dread, the aging of entry into the occupation adds credibility to this conclusion.

In sum, our model shows promise for understanding employment and earnings when technological change is on the horizon, a state which seems to be increasingly significant. Foresighted workers avoid entering occupations at risk of obsolescence, or will only enter if they receive a sufficient wage premium. Therefore, wages rise and employment falls while the age distribution shifts up in anticipation of the shock. These predictions are largely consistent with the available data for teamsters at the dawn of the motor truck and for dressmakers and milliners at the

[8]Our measures of age composition for workers who entered and exited truck driving are generated in a similar way as for teamsters, dressmakers and milliners. The main difference is that here, we use adjacent surveyed months. For example, if a worker is observed to have a non-trucker occupation in January 2005, and is next observed in March 2006 and reported to be a trucker, the worker will be coded as an entrant in 2006.

advent of ready-made clothing.

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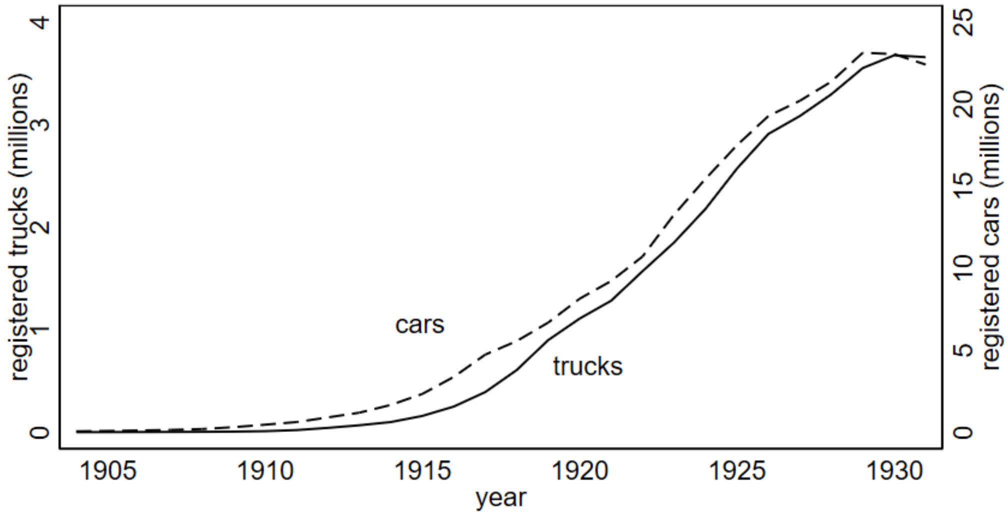
Figure 2: Registrations of Automobiles and Trucks: 1904-1931

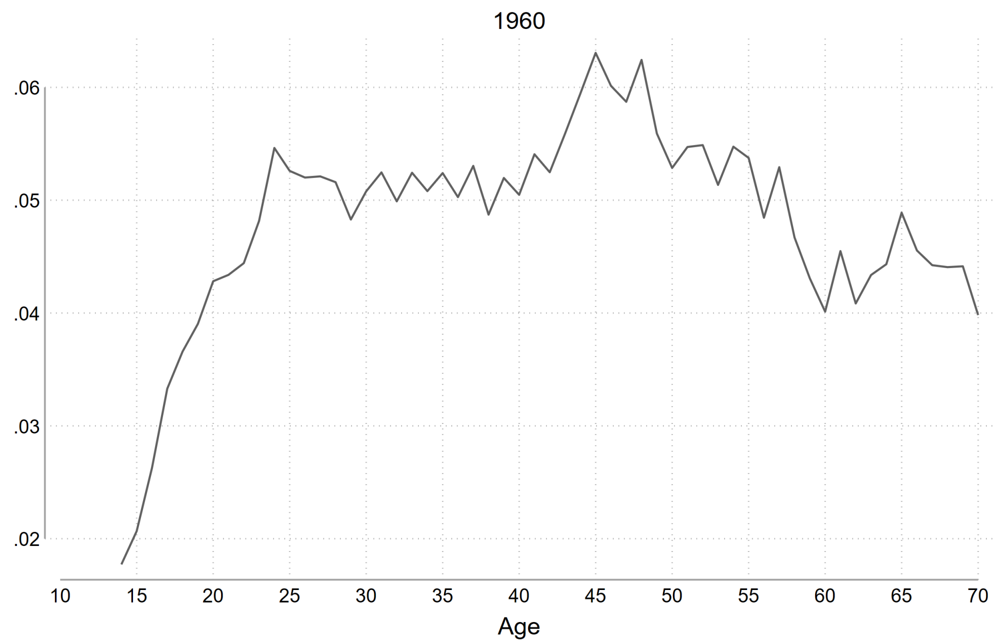



Source: Federal Highways Administration, State Motor Vehicle Registrations, by Years, 1900 - 1995
https//www.fhwa.dot.gov/ohim/summary95/mv201.pdf, accessed 8/21/2022

Figure 3: Teamster Age Composition: 1880-1930

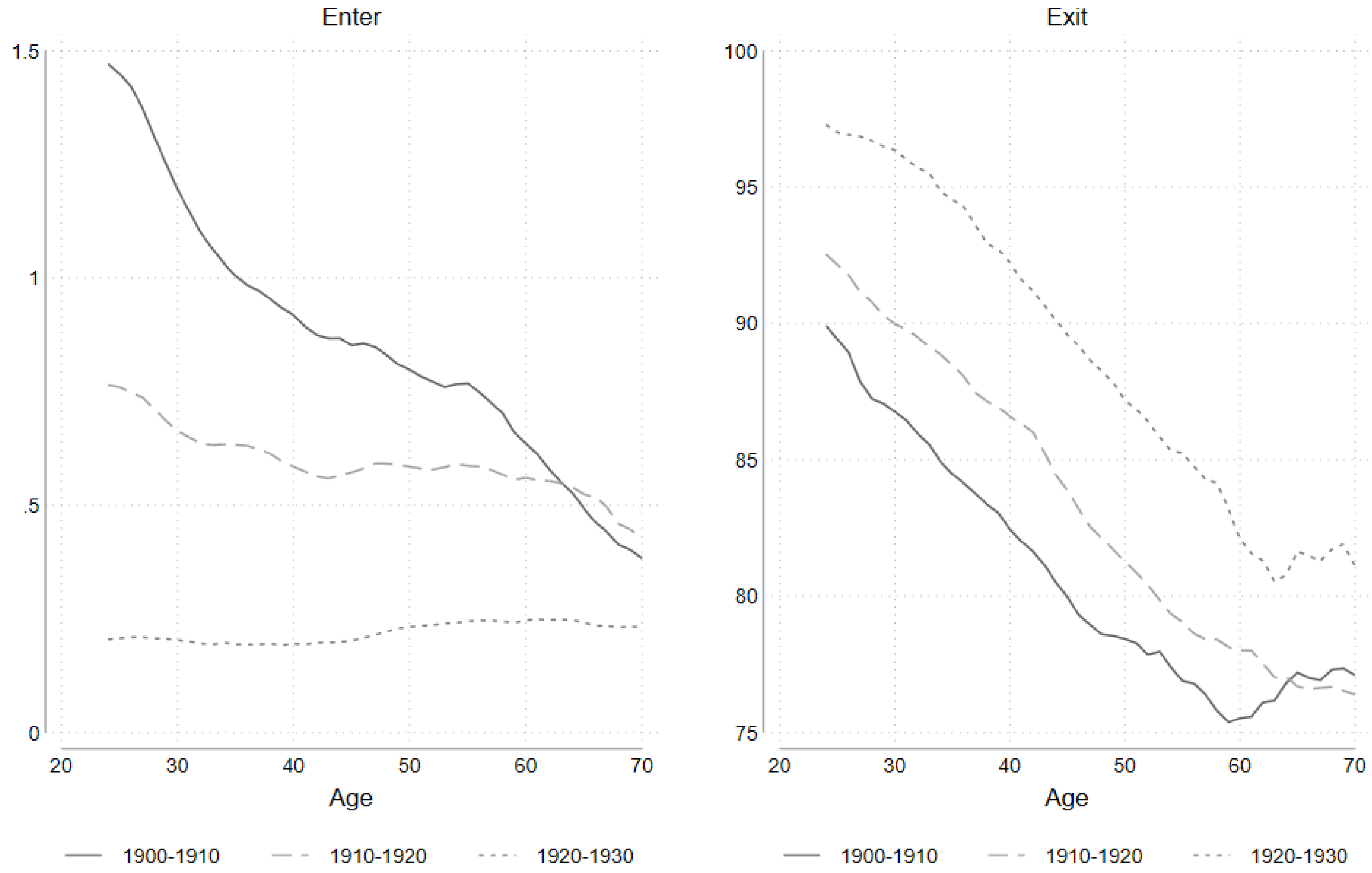

*Notes*: The figure shows the teamster share in employed males by age. Sample includes teamsters and employed males of age 14-70. The lines are smoothed using 5-year moving averages.

Figure 4: Teamster Age Composition: 1960



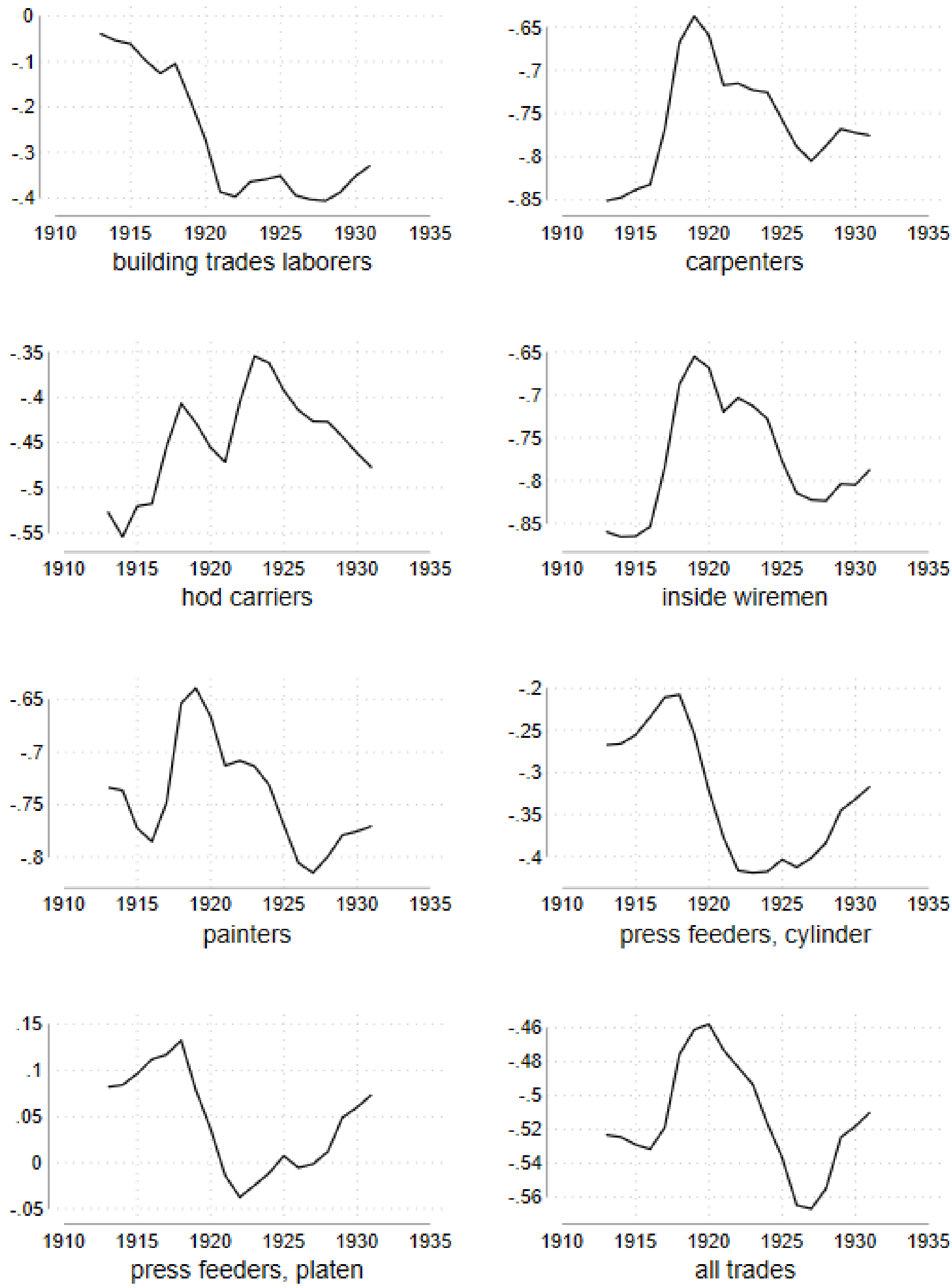

*Notes*: The figure shows the teamster share in employed males by age generated using the IPUMS census sample 1960 (5%). Sample includes teamsters and employed males of age 14-70. The lines are smoothed using 5-year moving averages.

Figure 5: Entering and Exiting Teamster Age Composition: 1900-1930




*Notes*: The figure shows the teamster age composition for workers who entered and exited the teamster occupation over the adjacent census years. The figure is generated using the IPUMS linked full-count censuses. The left panel shows the age composition for entrants measured by the number of workers of a certain age who moved from other occupations to teamsters divided by workers of that age who could enter, i.e. who had other occupations in the former year. The right panel shows the age composition for teamsters who exited measured by workers of a certain age who moved from teamsters to other occupations divided by workers of that age who could exit, i.e. workers who were teamsters in the former year. The sample is restricted to workers with age 14-60 in the former year (age 24-70 in the later year). The X-axis shows the age in the later year: e.g. for 1900-1910, x-axis shows age in 1910. We do not include the movements between the 1880 and 1900 censuses because it covers a twenty-year period and thus is not comparable to the other three panels. The lines are smoothed using 5-year moving averages.

Figure 6: $\ln w_{\text{teamster}} - \ln w_{\text{other}}$

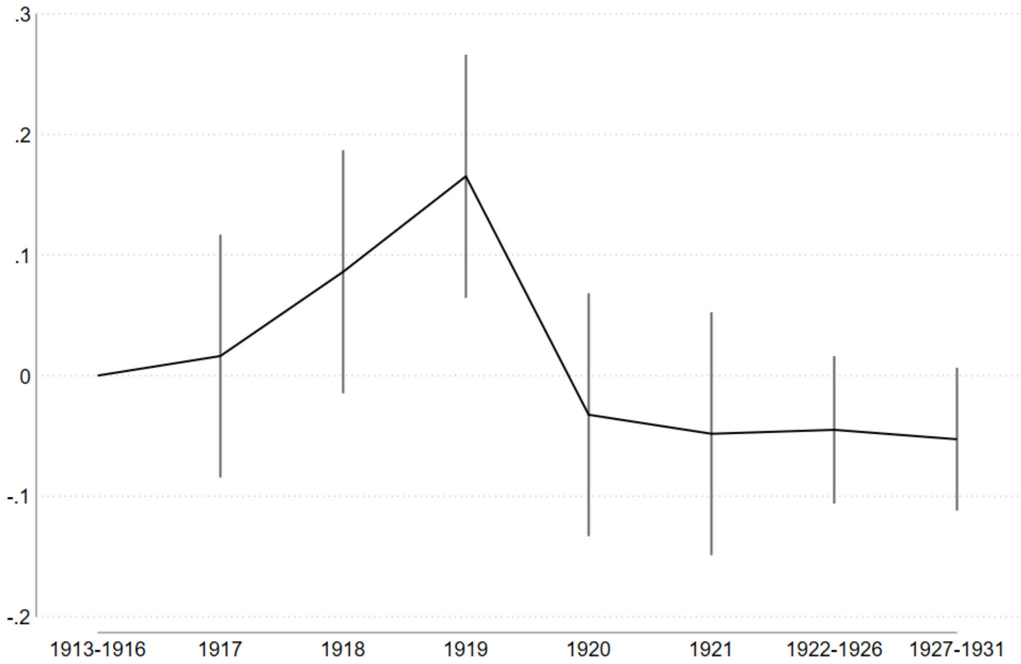



*Notes*: The figures show differences in wages between teamsters and other occupations. Wage differences are city averages weighted by cities male labor force. Lines are smoothed using 3-year moving averages. Aside from all trades, other occupations are "close trades" for which 1) wages are close to teamsters in 1896-1900, 2) have data for at least 4 cities of interest, and 3) have available data in 1913-1931. New York has no data on hod carriers, and Boston has no data on press feeders, platen. The lines are smoothed using 3-year moving averages.

Figure 7: Wage differences between teamsters and other occupations (averages)

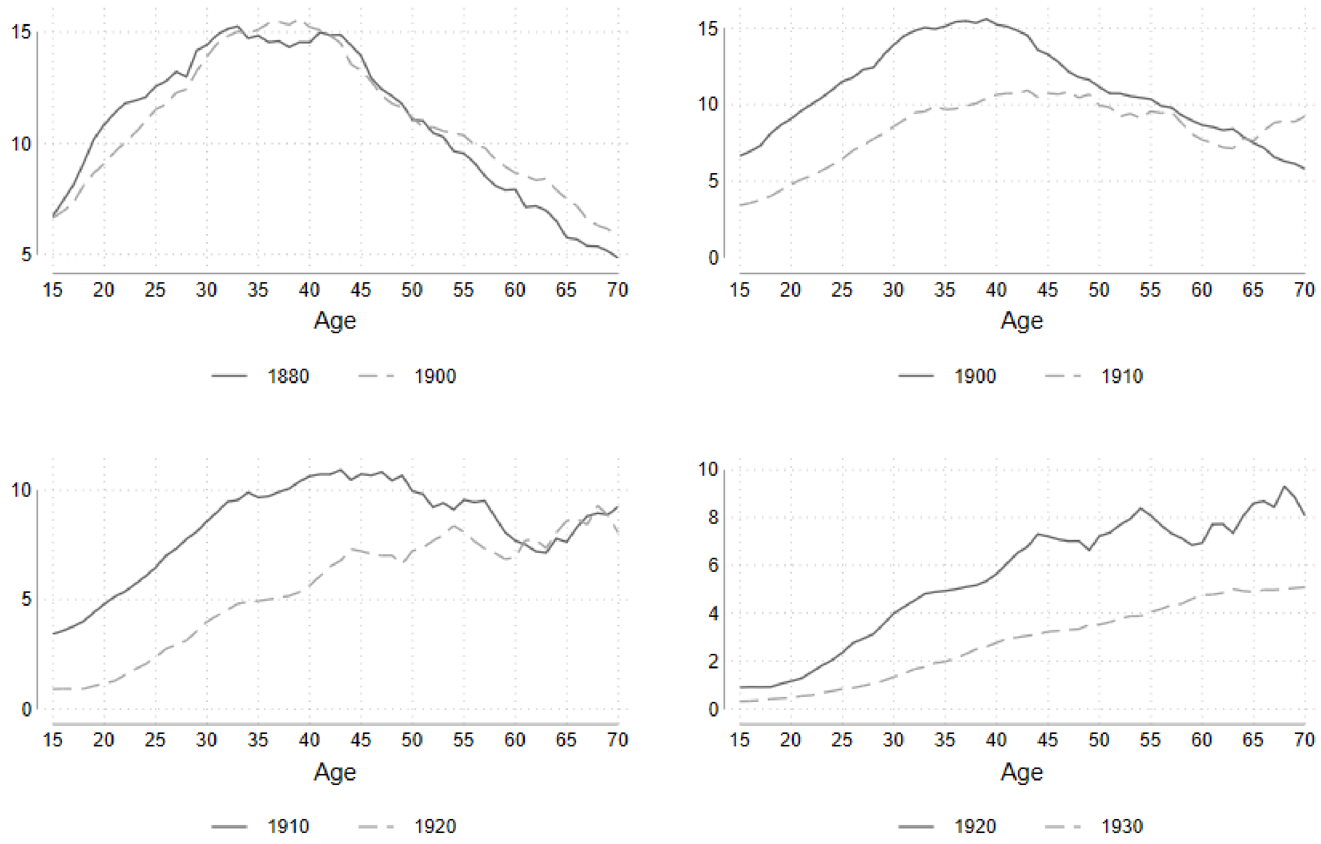

*Notes*: Wage differences are measured by subtracting the log hourly wage of close trades or all trades from the log hourly wage of teamsters. “Close trades” is the simple average of the log wage of all the close trades: building trade laborers, carpenters, hod carriers, inside wiremen, painters in building trades, and the two types of press feeders. The lines are smoothed using 3-year moving averages.

Figure 8: Wage differences between teamsters and other occupations



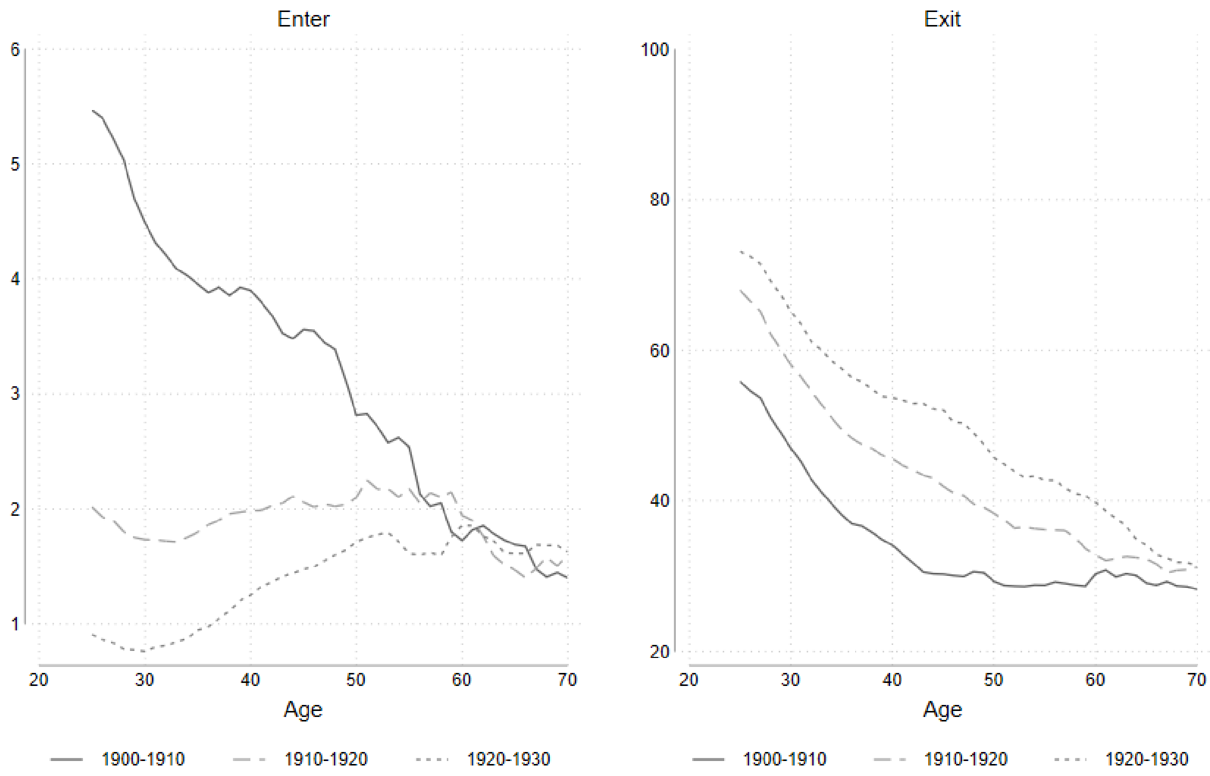

*Notes*: The Figure shows the estimation results using Equation (1). Bars reflect 95% confidence intervals.

Figure 9: Dressmakers, Seamstresses, and Milliners Age Composition: 1880-1930



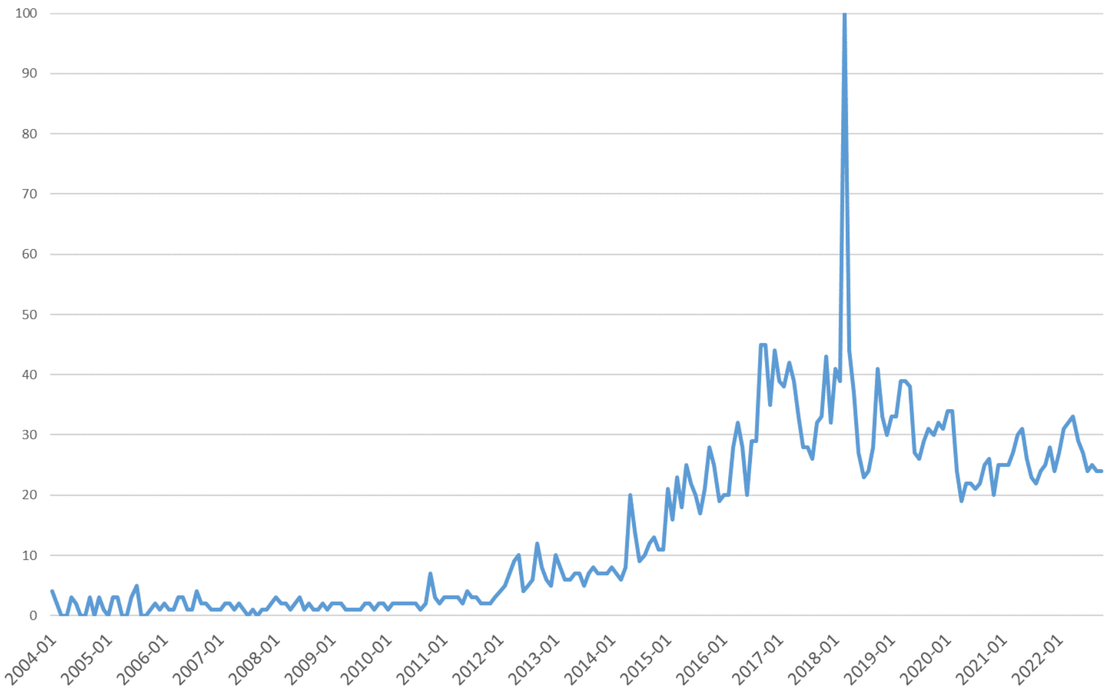

*Notes*: The figure shows the dressmakers, seamstresses, and milliners share in employed females by age. Sample includes employed females of age 15-70. The lines are smoothed using 5-year moving averages. Note that, due to data limitation, seamstresses are included for all the years because dressmakers and seamstresses are always coded as one occupation in the census data. Comparable census data in 1890 is not available.

Figure 10: Entering and Exiting Dressmakers, Seamstresses, and Milliners Age Composition: 1900-1930



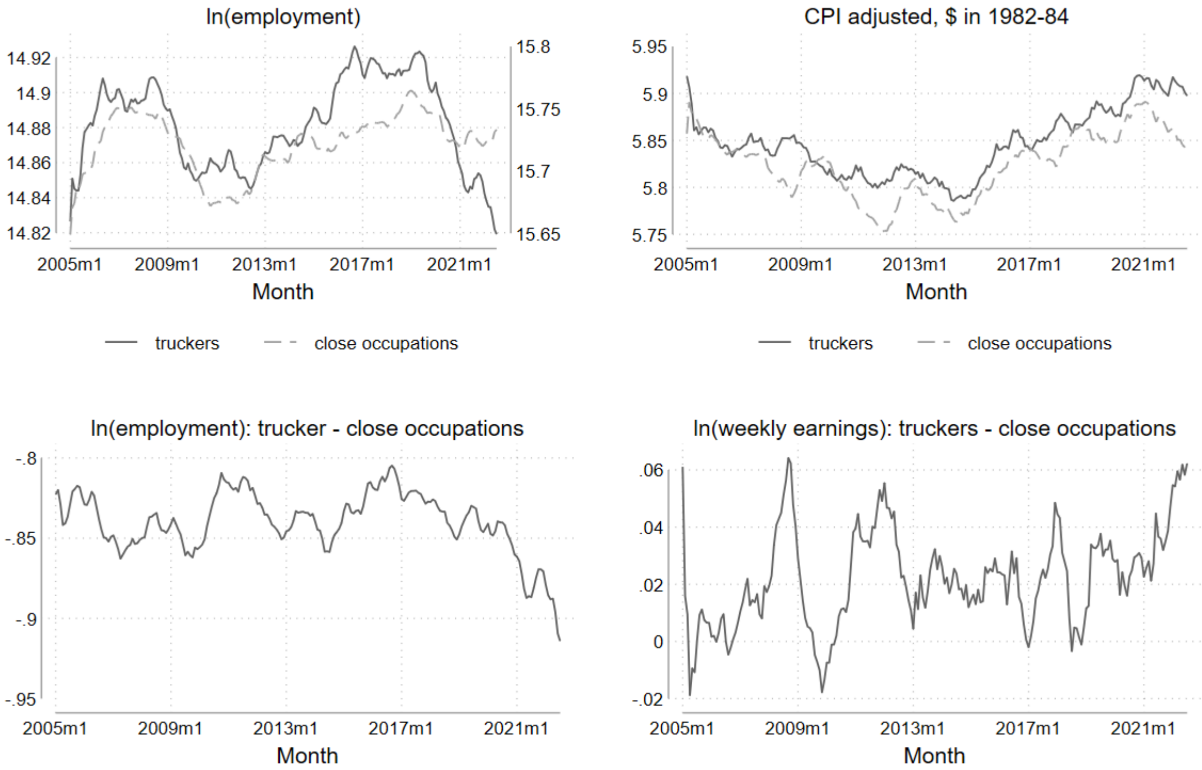

*Notes*: The figure shows the dressmakers, seamstresses, and milliners age composition for workers who entered and exited the occupations over the adjacent census years. The left panel shows the age composition for entrants measured by the number of workers of a certain age who moved from other occupations to dressmakers, seamstresses, or milliners divided by workers of that age who could enter, i.e. who had other occupations in the former year. The right panel shows the age composition for dressmakers, seamstresses, and milliners who exited measured by workers of a certain age who moved from dressmakers, seamstresses, or milliners to other occupations divided by workers of that age who could exit, i.e. workers who were dressmakers, seamstresses, or milliners in the former year. The sample is restricted to workers with age 15-60 in the former year (age 25-70 in the later year). The X-axis shows the age in the later year: e.g. for 1900-1910, x-axis shows age in 1910. We do not include the movements between the 1880 and 1900 censuses because it covers a twenty-year period and thus is not comparable to the other three panels. The lines are smoothed using 5-year moving averages. Note that, due to data limitation, seamstresses are included for all the years because dressmakers and seamstresses are always coded as one occupation in the census data.

Figure 11: Interest over time for the keyword “self-driving”



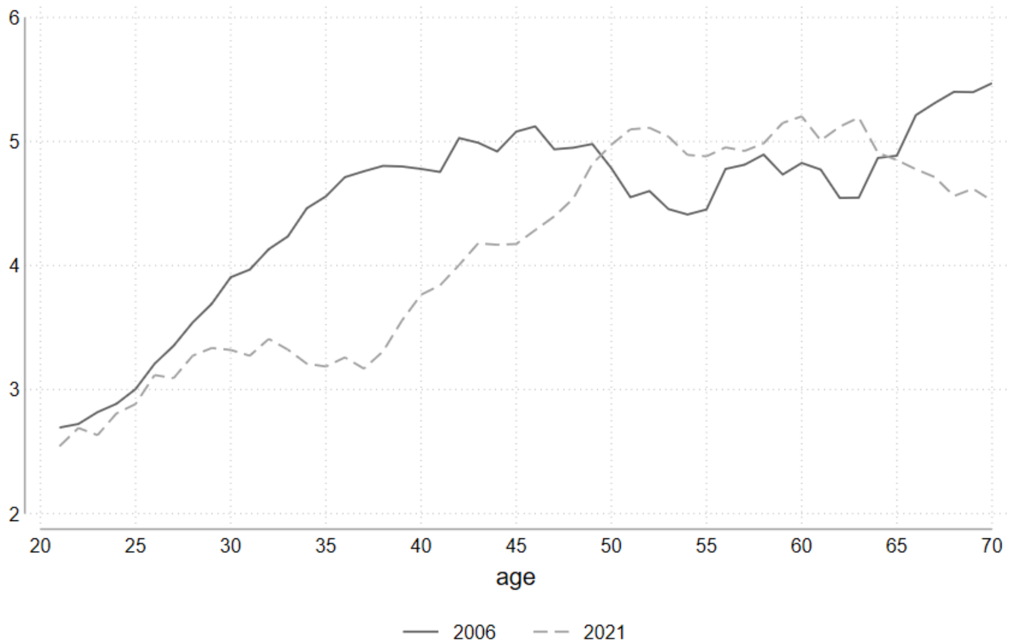

*Notes*: The figure shows the interest over time for keyword “self driving”. “Interest” is measured by the search interest relative to the highest point on the chart for the given region and time. A value of 100 is the peak popularity for the term. A value of 50 means that the term is half as popular. A score of 0 means there was not enough data for this term.
*Source*: Google Trends

Figure 12: Employment and Real Weekly Earnings for Current Truckers: Jan 2005 – Jul 2022



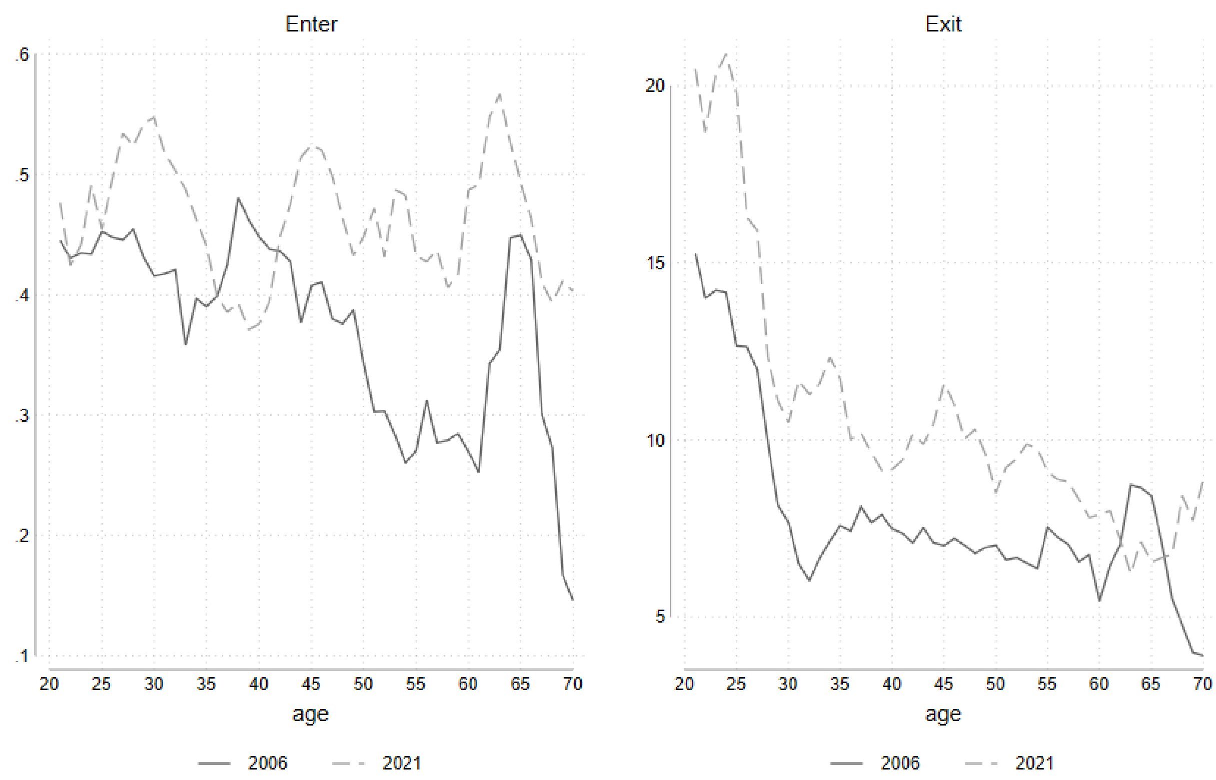

*Notes*: The figure shows the employment and real weekly earnings for truckers from Jan2005-Jul2022. Sample includes male truckers in all industries (not restricted to the trucking industry) and male labor force in close occupations age 16 and above. The lines are smoothed using 12-month moving averages. Labor force are restricted to employees in non-government, non-unpaid family business. The self-employed workers are excluded because the weekly earning data is only available for employees.
*Source*: CPS

Figure 13: Current Trucker Age Composition: 2006 and 2021




*Notes*: The figure shows the trucker share in male labor force by age. Sample includes truckers and male labor force of age 21-70. The lines are smoothed using 5-year moving averages.
*Source*: CPS

Figure 14: Entering and Exiting Trucker Age Composition: 2006 and 2021




*Notes*: The figure shows the trucker age composition for male labor force who entered and exited the trucker occupation over the adjacent surveyed month. The figure is generated using the CPS data. The left panel shows the age composition for entrants measured by the number of workers of a certain age who moved from other occupations to truckers divided by workers of that age who could enter, i.e. who had other occupations in the former surveyed month. The right panel shows the age composition for truckers who exited measured by workers of a certain age who moved from truckers to other occupations divided by workers of that age who could exit, i.e. workers who were truckers in the former surveyed month. The sample is restricted to male labor force with age 21-70 in the current surveyed month. The X-axis shows the age in the current surveyed month. The lines are smoothed using 5-year moving averages.

Table 1: Teamster Employment: 1880-1930

| Year | Male draymen, teamsters, and carriage drivers | Male teamsters | Employed males | Fraction (%) |
|---|---|---|---|---|
| 1880 | 119,131 | 134,274 | 15,163,724 | 0.89 |
| 1890 | 246,095 | | | |
| 1900 | 361,308 | 409,904 | 23,860,604 | 1.72 |
| 1910 | 443,735 | 480,135 | 30,347,136 | 1.58 |
| 1920 | 419,450 | 383,787 | 33,139,452 | 1.16 |
| 1930 | 111,178 | 123,180 | 38,181,932 | 0.32 |

*Notes*: All the numbers are for males 10 years old and over. Column 'Male draymen, teamsters, and carriage drivers' are copied from Edwards (1943). Other columns are from authors' calculations based on census samples.
*Source*: US Census

Table 2: Primary Destination Occupations of Workers Leaving Employment as Teamsters

| | Laborer (nec) | Farmers owners & tenants | Truck/Tractor Drivers | Mangers, Officials Proprietors (nec) | Total | N |
|---|---|---|---|---|---|---|
| 1910-1920 | | | | | | |
| 26-35 | 13.75 | 11.81 | 10.28 | 5.44 | 41.28 | 17,535 |
| 36-45 | 17.34 | 16.44 | 9.74 | 6.44 | 49.96 | 23,883 |
| 46-55 | 22.69 | 15.64 | 8.34 | 6.76 | 53.43 | 18,713 |
| 56-65 | 28.22 | 14.91 | 6.15 | 6.33 | 55.61 | 10,741 |
| 1920-1930 | | | | | | |
| 26-35 | 18.57 | 9.59 | 17.36 | 5.43 | 50.95 | 12,362 |
| 36-45 | 22.07 | 14.01 | 14.80 | 7.45 | 58.33 | 18,957 |
| 46-55 | 27.28 | 14.52 | 11.73 | 8.15 | 61.68 | 16,060 |
| 56-65 | 31.87 | 14.57 | 8.55 | 8.11 | 63.10 | 10,240 |

*Notes*: nec = not elsewhere classified.

*Source*: Authors' calculations based on pairwise matched Census data.

Table 3: Dressmakers, Seamstresses, and Milliners Employement: 1860-1960

| Year | Female dressmakers seamstresses and milliners | Employed females | Fraction (%) |
|---|---|---|---|
| 1860 | 110,983 | 1,007,045 | 11.02 |
| 1870 | 108,231 | 1,660,975 | 6.52 |
| 1880 | 272,404 | 2,550,740 | 10.68 |
| 1900 | 538,294 | 5,027,530 | 10.71 |
| 1910 | 542,587 | 7,688,783 | 7.06 |
| 1920 | 301,745 | 8,289,871 | 3.64 |
| 1930 | 195,753 | 11,058,602 | 1.77 |
| 1940 | 163,909 | 12,373,975 | 1.32 |
| 1950 | 159,376 | 16,833,230 | 0.95 |
| 1960 | 196,080 | 35,313,560 | 0.56 |

*Notes*: Table includes employed females who were 15 years old and over. Due to data limitation, seamstresses are always included because dressmakers and seamstresses are coded as one occupation in the census data. Comparable census data in 1890 is not available.
*Source*: US Census

# A Appendix: Theory

First we show that $o_N^*$ and $o_A^*$ are global attractors of $F \circ V_N$ and $F \circ V_A$ respectively.

**Lemma 1.** *For* $s \in \{N, A\}$, $o \underset{(>)}{<} o_s^* \implies (F \circ V_s)^2(o) \underset{(<)}{>} o$

*Proof.* We show that $o{<}o_s^* \implies (F \circ V_s)^2(o){>}o$; the other case is proven symmetrically. Define $z : [0,1] \to [0,1]$ via $z(o) = (F \circ V)^2(o) - o$ and claim for contradiction that there is an $o' < o^*$ such that $z(o') < 0$. Because the range of g is $[0,1]$, $z(0) \geq 0$. Thus from continuity of $z$ and the intermediate value theorem there must be some $x \in [0, o']$ such that $z(x) = 0$. Which would mean that $(F \circ V)^2(x) = x$. But then for any $n > 0$, $w((F \circ V)^n(x) + (F \circ V)^{n-1}(x))) = w(F(V(x)) + x)$ so that the wage is constant. As the wage is constant, so is the number of entrants $F(V(x))$, and hence $x$ is a steady state. But since $x < o' < o^*$ and since $o^*$ is the unique steady state, we have a contradiction. □

**Lemma 2.** *For* $s \in \{N, A\}$, $o \underset{(>)}{<} o_s^* \implies (F \circ V_s)^2(o) \underset{(>)}{<} o_s^*$

*Proof.* We show that $o < o_s^* \implies (F \circ V_s)^2(o) < o_s^*$; the other case is proven symmetrically. We proceed by contradiction again, via two sub-cases. **(Case A.)** Suppose $o < o^*$, $F(V(o)) < o^*$ and $(F \circ V)^2(o) > o^*$. From $o^*$ being the steady state, we have that $V(o^*) = (1 + \delta)w(2o^*)$. From $F$ strictly increasing and $F(V(o)) < o^*$, we have

$$w(o + F(V(o))) + \delta w(F(V(o)) + (F \circ V)^2(o)) < (1 + \delta)w(2o^*). \tag{17}$$

From $F$ strictly increasing and $(F \circ V)^2(o) > o^*$, we have

$$w((F \circ V)^2(o) + F(V(o))) + \delta w((F \circ V)^3(o) + (F \circ V)^2(o)) > (1 + \delta)w(2o^*). \tag{18}$$

From Lemma 1 and $F(V(o)) < o^*$ we have that $(F \circ V)^3(o) > F(V(o))$. From this and the strictly decreasing nature of $w$, we have

$$w((F \circ V)^3(o)) + (F \circ V)^2(o)) < w(F(V(o)) + (F \circ V)^2(o)). \tag{19}$$

Combining this with (18), we obtain

$$w(F(V(o)) + (F \circ V)^2(o)) > w(2o^*). \tag{20}$$

Now, we can use this and (17) to derive

$$w(o + F(V(o))) < w(2o^*). \tag{21}$$

However, ex hypothesi both $o < o^*$ and $F(V(o)) < o^*$, so that given that $w$ is strictly decreasing, we have a contradiction.

**(Case B.)** Suppose $o < o^*$, $F(V(o)) > o^*$ and $(F \circ V)^2(o) > o^*$. From $F(V(o)) > o^*$, the strictly increasing nature of $F$, and $V(o^*) = (1+\delta)w(2o^*)$, we have

$$w(o + F(V(o))) + \delta w(F(V(o)) + (F \circ V)^2(o)) > (1+\delta)w(2o^*). \tag{22}$$

From $(F \circ V)^2(o) > o^*$ and similar reasoning, we have

$$w(F(V(o)) + (F \circ V)^2(o)) + \delta w((F \circ V)^2(o) + (F \circ V)^3(o)) > (1+\delta)w(2o^*). \tag{23}$$

As ex hypothesi $F(V(o)) > o^*$ and $(F \circ V)^2(o)) > o^*$, and $w$ is a strictly decreasing function, 23 implies that $(F \circ V)^3(o)) < o^*$. In other words, from the fact that $F$ is strictly increasing,

$$w((F \circ V)^2(o) + (F \circ V)^3(o)) + \delta w((F \circ V)^3(o) + (F \circ V)^4(o)) < (1+\delta)w(2o^*). \tag{24}$$

Now, we use Lemma 1 and $F(V(o)) > o^*$ to obtain

$$(F \circ V)^3(o) < F(V(o)) \tag{25}$$

and similarly Lemma 1 and $(F \circ V)^2(o) > o^*$ to obtain

$$(F \circ V)^4(o) < (F \circ V)^2(o). \tag{26}$$

Thus from the fact that $w$ is strictly decreasing,

$$w((F \circ V)^3(o) + (F \circ V)^4(o)) > w(F(V(o)) + (F \circ V)^2(o)). \tag{27}$$

Now, from combining (23), (24), and (27), we have

$$(1 - \delta)w((F \circ V)^2(o) + (F \circ V)^3(o)) < (1 - \delta)w(F(V(o)) + (F \circ V)^2(o)) \tag{28}$$

which, from the fact that $w$ is strictly decreasing implies $(F \circ V)^3(o) > F(V(o))$, contradicting (25). $\square$

Lemmata 1 and 2 along with continuity make $o_N^*, o_A^*$ global attractors. Moreover, it is easy to see that $F(V_N(\cdot))$ and $F(V_A(\cdot))$ are injective. As a consequence, $F(V_N(\cdot))$ and $F(V_A(\cdot))$ are strictly decreasing and so are $V_N$ and $V_A$.

**Lemma 3.** *For $s \in \{N, A\}$, $o \underset{(>)}{<} o_s^* \implies F(V_s(o)) \underset{(<)}{>} o_s^*$*

*Proof.* Again, we show that $o<o_s^* \implies F(V_s(o))>o_s^*$ and leave the case with the reversed inequalities to the reader. Suppose $o < o^*$ and $F(V(o)) < o^*$ for contradiction. From Lemma 2, we have $(F \circ V)^2(o) < o^*$. Therefore, from $w$ decreasing, we have

$$V(o) = w(o + F(V(o)) + \delta w(F(V(o) + (F \circ V)^2(o)) > (1 + \delta)w(2o^*) = V(o^*) \tag{29}$$

and therefore, from $F$ increasing, $F(V(o)) > F(V(o^*)) = o^*$, a contradiction. $\square$

**Lemma 4.** *In the no-shock and aftermath cases, wages are decreasing as a function of old workers: $w_s(o + F(V_s(o)))$ decreases in $o$.*

*Proof.* I think my reliance on proofs by contradiction indicates some deeper behavioral problem. Suppose $o_1 > o_2$ and $w(o_1 + F(V(o_1))) > w(o_2 + F(V(o_2)))$. Then, from the fact $F \circ V$ is strictly decreasing, $(F \circ V)^n(o_1) < (>)(F \circ V)^n(o_2)$ for $n$ odd (even). From $w(o_1 + F(V(o_1))) > w(o_2 + F(V(o_2)))$ and $F(V(o_1)) < F(V(o_2))$, which implies

$$\begin{aligned} &w(o_1 + F(V(o_1))) + \delta w(F(V(o_1)) + (F \circ V)^2(o_1)) \\ &< w(o_2 + F(V(o_2))) + \delta w(F(V(o_2)) + (F \circ V)^2(o_2)). \end{aligned} \tag{30}$$

Via rearrangement, we have

$$\begin{aligned} & w(o_1 + F(V(o_1))) - w(o_2 + F(V(o_2))) \\ & < \delta[w(F(V(o_2))) + (F \circ V)^2(o_2))) - w(F(V(o_1) + (F \circ V)^2(o_1)))] \end{aligned} \tag{31}$$

which generalizes via an inductive argument to

$$\begin{aligned} & 0 < w(o_1 + F(V(o_1))) - w(o_2 + F(V(o_2))) \\ & < \delta^n[w((F \circ V)^n(o_2) + (F \circ V)^{n+1}(o_2)) - w((F \circ V)^n(o_1) + (F \circ V)^{n+1}(o_1))] \end{aligned} \tag{32}$$

for all $n$ odd, which (eventually) contradicts not only attraction but also the bounded range of $w$. □

We can now prove Proposition 1:

**Proposition 1.** *$F(V_D(\cdot))$ has a unique steady-state $o_D^*$.*

*Proof.* As $F(V_A(\cdot))$ is decreasing, and from Lemma 4 so are aftermath wages $w_l(o+F(V_A(o)))$ as a function of $o$, the steady-state equation for $F(V_D)$,

$$F(V_D(o)) = F((1 + \delta(1 - \lambda))w_h(2o) + \lambda\delta w_l(o + F(V_A(o)))) = o, \tag{33}$$

has a LHS decreasing in $o$ and a RHS increasing in $o$. Thus, by continuity, it has a unique solution $o_D^*$. □

**Lemma 5.** *There are more workers in the anticipatory dread steady-state than in the aftermath steady-state: $o_D^* > o_A^*$. Furthermore, the steady-state wage is higher in the anticipatory dread steady state: $w_h(2o_D^*) > w_l(2o_A^*)$.*

*Proof.* For the first part, suppose for contradiction $o_A^* > o_D^*$. From (5), (6), and $F$ increasing, this implies

$$(1 + \delta(1 - \lambda))w_h(2o_D^*) + \lambda\delta w_l(o_D^* + F(V_A(o_D^*))) < (1 + \delta)w_l(2o_A^*). \tag{34}$$

From $o_A^* > o_D^*$ and Lemma 4,

$$w_l(2o_A^*) < w_l(o_D^* + F(V_A(o_D^*))). \tag{35}$$

From $o_A^* > o_D^*$ and Lemma 3 we have that

$$F(V_A(o_D^*)) > o_A^* > o_D^*, \tag{36}$$

so that from $w_l$ decreasing we have

$$w_l(F(V_A(o_D^*)) + o_D^*) < w_l(2o_D^*). \tag{37}$$

From $w_h > w_l$ and (35), we have $w_l(2o_A^*) < w_l(2o_D^*) < w_h(2o_D^*)$. Combining this with (35) we arrive at a contradiction to (34).

For the second part of the statement, notice that $o_D^* > o_A^*$ implies $F(V_D(o_D^*)) > F(V_A(o_A^*))$. This and the monotonicity of $F$ in turn give us

$$(1 + (1 - \lambda)\delta)w_h(o_D^*) + \lambda\delta w_l(o_D^* + F(V_A(o_D^*))) > (1 + \delta)w_l(2o_A^*). \tag{38}$$

From $o_D^* > o_A^*$ and Lemma 4, $w_l(o_D^* + F(V_D(o^*))) < w_l(2o_A^*)$. From this and (38), we have that $w_h^*(2o_D^*) > w_l(2o_A^*)$. $\square$

We are now in a position to prove Proposition 3:

**Proposition 3.** $w_h(2o_D^*) > w_l(o_D^* + F(V_A(o_D^*)))$.

*Proof.* From Lemma 5 $o_D^* > o_A^*$; from Lemma 4 and this, $w_l(o_D^* + F(V_A(o_D^*))) < w(2o_A^*)$. From the second part of Lemma 5, $w_h^*(2o_D^*) > w_l(2o_A^*)$, and thus $w_h(2o_D^*) > w_l(o_D^* + F(V_A(o_D^*)))$. $\square$

We can now use Proposition 3 to prove Proposition 2:

**Proposition 2.** *The steady-state numbers of old workers satisfy* $o_N^* > o_D^* > o_A^*$ *and* $w_h(2o_D^*) > w_h(2o_N^*) > w_l(2o_A^*)$.

*Proof.* We begin with wages, and proceed separately for each of the two inequalities. First, from $F$ increasing, $w_h > w_l$, $w_h$ and $w_l$ strictly decreasing, we have that $w_l(2o_A^*) < w_h(2o_N^*)$. Now suppose for contradiction that $w_h(2o_D^*) \leq w_h(2o_N^*)$. Then, $o_D^* \geq o_N^*$ from the fact that $w_h$ is strictly decreasing. Using (4) and (6), as well as the fact $F$ is strictly increasing, we deduce

$$(1+\delta)w_h(2o_N^*) \leq (1+\delta(1-\lambda)w_h(2o_D^*)+\lambda\delta w_l(o_D^*+F(V_D(o_D^*))) < (1+\delta)w_h(2o_D^*), \tag{39}$$

where the last bit follows from Proposition 3's implication that $w_h(2o_D^*) > w_l(o_D^* + F(V_D(o_D^*)))$, yielding a contradiction. Thus $w_h(2o_D^*) > w_h(2o_N^*) > w_l(2o_A^*)$.

To show that $o_N^* > o_D^* > o_A^*$, we have but to use the monotonicity of $w_h$ and $w_h(2o_D^*) > w_h(2o_N^*)$ for the first inequality, and Lemma 5 for the second one. $\square$