Can Non-competition Agreements Explain the Decline in U.S. Job-to-job Mobility?

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Abstract

The U.S. firms can use contracts with non-competition agreements to restrict worker mobility towards their competitors. In this paper, I develop a labor search model to quantitatively investigate the impact of non-competition contracts on the U.S. labor market. The model features contracts with or without non-competition agreements, worker and firm heterogeneity, multiple sectors, on-the-job search and firm-sponsored human capital investment. I first use the model to estimate the usage of non-competition contracts over time and show that there is a sharp rise in the fraction of firms offering non-competition agreements in the recent decade. The rise in the coverage of non-competition contracts can explain around 1/2 of the aggregate job-to-job mobility and is consistent with trends of the movement in the labor share and in the within- and between- sector job-to-job mobility.

Keywords: Non-competition agreements, Worker mobility, Equilibrium labor search model

JEL Classification: J24, J41, J42, J62, K31

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1 Introduction

By offering workers contracts with non-competition clauses, the U.S. firms can prohibit workers from working in competitors or starting new businesses in competition with the previous employer, which directly affects the incidence and direction of the job switches. The rise in the non-competition contracts has thus been suspected to have an impact on shaping the secular trend of declining job-to-job mobility, as shown in Figure 1 [1]. Restricted job mobility may also affect wage growth and workers' welfare. Job mobility has long been recognized as one of the key determinants of wage growth. By switching jobs, workers move to better employers or achieve better bargaining positions (Postel-Vinay and Robin (2002), Cahuc et al. (2006)), obtain better match quality with jobs or better careers (Neal (1999)), and insure against negative shocks (Postel-Vinay and Turon (2010),Liu (2019)). Motivated by these facts, I ask the following questions in this paper: how much did the changes in the usage of non-competition agreements affect the U.S. job-to-job mobility, and what are the impact of non-competition agreements on workers' human capital accumulation, wage growth and labor share.

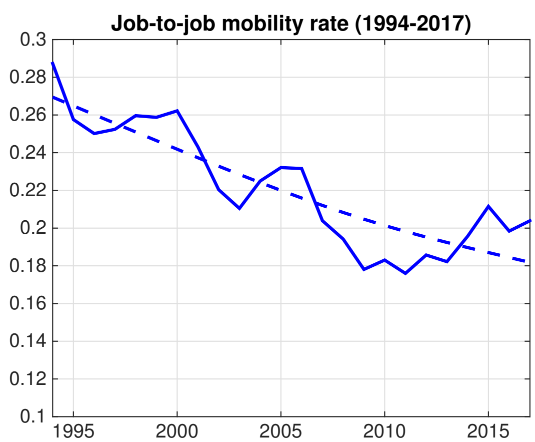


Figure 1: Decline in job mobility in the United States

In this paper, I develop an equilibrium labor search framework to investigate the economic impact of non-competition agreements. The model features contracts with or without non-competition agreements, worker and firm productivity heterogeneity, multiple sectors, on-the-job search, and firm-sponsored sector-specific human capital investment. In the model, workers search within and across sectors to climb up the job ladder. Human capital is perfectly transferable between firms within the same sector but becomes completely obsolete

[1]See for example Council of Economic Advisers Issue Brief October 2016 https://obamawhitehouse.archives.gov/sites/default/files/page/files/20161025_monopsony_labor_mrkt_cea.pdf

when workers move to firms in other sectors. Firms offering non-competition contracts can prohibit workers from switching to firms within the same sectors but cannot affect workers' decision to switch to other sectors.

In the model, non-competition contracts not only affect overall worker mobility, but also affect within- and across- sector worker mobility rates. By providing non-competition contracts, low productivity firms are able to retain workers for longer time, which impedes workers from climbing up the job ladder, especially the job ladder within same sector. This, however, benefits poachers from other sectors because the non-competition agreements are only effective as to restrict mobility to poaching "competitors" from the same sector. Workers may also act contingent on their contract type by redirecting their search to other sectors to maximize the expected gains from search. I refer to these two mechanisms as "retention effect" and "redirecting effect" respectively.

As in Acemoglu and Pischke (1999) and Lentz and Roys (2015), worker mobility affects firms' incentive to provide training since workers are risk averse, which affects the speed of skill accumulation on the job. Additionally, non-competition agreements also affect workers' opportunities to climb up the job ladder. These two effects in combination leads to an ambiguous impact of non-competition contracts on workers' wage growth.

I first utilize the model to estimate the usage of non-competition agreements over time. The identification comes from the fact that workers with different lengths of labor market history experienced different paths of meeting firms that offer non-competition contracts. The nationwide representative survey conducted by Prescott et al. (2016) shows that the younger cohorts have a higher non-competition contract coverage, I thus infer a process that exhibits a sharp increase in the usage of non-competition contracts since year 2005.

The inferred rise in non-competition contracts between 1994 to 2017 leads to around 4% decline in the aggregate job-to-job mobility in the model, while in the data, job-to-job mobility decreased by 7%. The model also generates 1/2 of the decline in the within-industry mobility and 1/3 of the rise in the across-industry mobility. Non-competition contracts affect wage growth through two channels in opposite directions. On the one hand, non-competition contracts reduces wage growth by impeding workers' from climbing up the job ladder with less outside options; on the other, firms increase training on industry-specific training as the the worker is expected to be matched with a longer duration with the non-competition agreements. I also find that the increase in the coverage of non-competition contracts negatively affect wage growth, which can account for 3/4 decline in the gross labor share of U.S. in the data. This is consistent with results in Engbom (2017) and Lentz and Roys (2015) that labor market frictions lead to lower wage growth.

Related literature. The recent empirical literature on non-competition agreements can be mainly divided into two strands. The first strand of literature mostly focuses on documenting the pervasive usage of contracts with non-competition agreements. Prescott et al. (2016) design and conduct the first nationwide representative survey on the usage of non-competition contracts in the U.S. economy to document that over 18% workers are currently working under non-competition contracts and non-competition contracts are widely used across all industries/occupations and worker skill levels; Krueger and Ashenfelter (2017) and Johnson and Lipsitz (2018) also show that non-competition contracts are pervasively used for low-skilled workers, which challenges the long-believed story that non-competition agreements only restrict the mobility of a small subset of high-skilled workers, thus have little impact on the aggregate outcomes. However, due to the lack of information on the historical usage of non-competition contracts in the whole economy, these studies are limited to cross-sectional analysis, little has known to what extent non-competition agreements affect the labor market over time. This paper fills in this gap to infer the time series of the non-competition contract usage from cross-sectional data by imposing a frictional labor market framework.

The second strand of the literature focus on various economic impacts of the non-competition agreements: Fallick et al. (2006) and Franco and Mitchell (2008) focus on the impact on industry dynamics with the application to the rise of Silicon Valley; Garmaise (2011) and Shi (2017) focus on the impact on human capital investment; Heggedal et al. (2017) focus on the impact on knowledge spillovers; Jeffers (2017) and Starr et al. (2017a) focus on the impact on spinoffs and entrepreneurship. This study is closely related to a recent series of papers by Evan Starr and several coauthors to provide reduced-form evidence on the impact of non-competition contracts by using self-conducted survey data, such as Starr et al. (2016) on impact of on the likelihood and direction of worker mobility and Starr (2015) on the impact on training and wage growth. They find no evidence that noncompetes reduce the overall level of recruiting 'attention' an employee experiences, weaken an employee's search effort, or even shrink the number of outside employment offers. They also find evidence that workers strategically redirect search effort towards non-competitors. This paper, instead, makes use of empirical evidence from their studies to estimate the macro outcomes of movements in the usage of non-competition contracts such as worker mobility within and across industries, wage growth and aggregate labor share over time.

This paper is also related to the growing literature on the impact of firm monopsony power on labor market outcomes. Several concurrent studies have documented cross-sectional and time-series patterns of concentration in employment (Benmelech et al. (2018), Rinz (2018), Macaluso and Hershbein (2018), and Berger et al. (2019)) and in vacancies (Azar et al. (2017), Azar et al. (2018)) in the United States. Berger et al. (2019) build an oligopsony model in which firm size directly affects wage markdown and estimate using U.S. Census Longitudinal Business Database (LBD) to find the welfare loss is around 5% compared with a competitive equilibrium. Jarosch et al. (2019) develop a model in which large firms have more bargaining power by eliminating its own vacancies from a worker's outside option, which depresses wages by around 10% in Austria. Both papers rely on the firm size as the source of monopsony power. This paper is complementary to this literature by investigating a specific source of monopsony power that firms can use non-competition contracts to restrict worker mobility.

Outline. The paper proceeds as follows: section 2 presents empirical findings on the impact of non-competition contracts on workers' job mobility; section 3 presents a theoretical labor search model with exogenous non-competition provision rate over time; section 4 presents the main implications and several additional properties of the theoretical model; in section 5, I utilize the model to quantify the relevance of non-competition agreements as to explain the decline in the U.S. job-to-job mobility rates; section 6 concludes.

2 Motivating empirics

In this section, I provide empirical evidence on the impact of worker mobility. I follow the literature to exploit state-level variation in non-competition agreement enforcement to examine the impact of non-competition agreements on the labor market outcomes (see, for example, Jeffers (2017) , Starr et al. (2017a)). Non-competition contracts are almost never enforced in states like California and North Dakota, while states like Florida acknowledge and enforce contracts with non-competition clauses. I take the following empirical specification

$$y_{ist} = \beta_e \text{Enforce}_{st} + \beta_x \mathbf{X}_{it} + \epsilon_{ist}$$

I use the U.S. representative national survey data from CPS (current population survey) to study the impact at the individual level. i denotes the individual worker, s denotes the state that the worker is located, t denotes the year of observation. Enforce_{st} denotes the state-level enforcement index, which increases in the likelihood of enforcing non-competition contracts.

	All workers	College	High School
Enforcement	-0.024**	0.0052	-0.031***
	(0.010)	(0.0215)	(0.012)
$\ln$ Exp	0.0081****	0.0035	0.0114***
	(0.0008)	(0.0030)	(0.0013)
Female	-0.0096**	0.0026	-0.011**
	(0.0044)	(0.0076)	(0.0054)
Year-fixed effect	Y	Y	Y
Industry-fixed effect	Y	Y	Y
Occupation-fixed effect	Y	Y	Y
Year	1976-2017	1976-2017	1976-2017
Observations	1787107	613906	1173021
R^2	0.0085	0.0066	0.0101

Table 1: Impact of on worker mobility

I adopt enforcement index from Garmaise (2011), which evaluates the state-level enforcement by compiling answers to twelve questions of the jurisdictions of non-competition contracts in each state. California and North Dakota are scored 0 and Florida is scored 9. The interested readers are referred to the original paper for the questions to construct the measure. $\mathbf{X}_{it}$ denotes a vector of individual characteristics, including wages, potential experience, age and age squared, sex, race, and marital status. I control for year-, industry- and occupation- fixed effects in all regressions.

When y denotes the incidence that worker makes a job switch this year, β_e represents the sensitivity of worker mobility with respect to the enforcement. The same idea applies for other outcome variables. The outcome variables y_{ist} I study includes the incidence of worker mobility rates and I present the main results in Table 1 and Table 2.

Table 1 report the results for job mobility. I find strong negative impact of non-competition agreement enforcement on the propensity of job mobility and I again find the impact is stronger for unskilled workers. Column (1) and (2) in Table 2 report the impact of non-competition agreement enforcement on occupational mobility and inter-industrial mobility respectively, column (3) and (4) restrict the samples to be college-educated and repeat the same regressions. Both occupational mobility and inter-industry mobility are declining in wages and potential experience, these patterns can be easily rationalized in standard models with learning or human capital accumulation. Women are less likely to switch occupations and industries. I also find strong positive impact of non-competition enforcement on worker mobility across occu-

	Occupation	Industry	Occ-College	Ind- College
Enforcement	0.0037 ***	0.0051***	0.007	0.0013
	(0.0006)	(0.0006)	(0.00147)	(0.0012)
ln Wage	-0.2516***	-0.0658***	-0.1235***	-0.0441***
	(0.00428)	(0.0020)	(0.0047)	(0.0039)
ln Exp	-0.0358***	-0.0217***	-0.0128***	0.0009
	(0.0007)	(0.0005)	(0.0032)	(0.0024)
Female	-0.0261	-0.0531**	0.0111	-0.0177***
	(0.0032)	(0.0027)	(0.0068)	(0.0054)
Year-fixed effect	Y	Y	Y	Y
Industry-fixed effect	Y	Y	Y	Y
Occupation-fixed effect	Y	Y	Y	Y
Year	1976-2017	1976-2017	1976-2017	1976-2017
Observations	2271465	2124377	517453	517453
R^2	0.0550	0.0468	0.0973	0.0551

Table 2: Impact on industrial and occupational worker mobility rates

pations and industries, and the magnitude is stronger for inter-industry mobility. However, when I restrict samples to college-educated workers, I do not find a significant impact on either mobility rate.

I follow the common treatment as in the literature when individual-level contract information is lacking. This empirical specification exploits the variation in the state-level enforcement, however, it ignores the coverage rates across states. Starr et al. (2016) also argue that firms use non-competition contracts simply to change workers' belief and the impact of non-competition contracts is actually independent of the actual enforceability of the contracts. With this in mind, I treat these empirical findings as heuristic thus will not use them as targets in the section of quantitative investigation.

Prescott et al. (2016) further document that the younger workers are covered at a higher rate than the older workers.Large literature, for example Mincer and Jovanovic (1981) and Menzio et al. (2016) document the job mobility is declining over the lifecycle. Neal (1999) further documents that workers take a two-stage search strategy to search for a good 'career' before they find a good 'job' match, which leads to a declining industry mobility and occupational mobility over lifecycle as well. The higher coverage rate at young workers implies that non-competition agreements may have large impact on the overall economy.

3 Model

In this section, I present a labor search model in which firms differ in their ability to restrict worker mobility within the same sector by offering contracts with or without a non-competition clause. The model allows for multiple sectors and workers conduct on-the-job search within and across sectors. The model also features heterogenous workers and heterogeneous firms to study the impact of labor market frictions on sorting. I also introduce firm-sponsored training and risk-averse workers to explicitly model the endogenous human capital accumulation process under the frictional labor market framework.

3.1 Environment, technology and preferences

I start by presenting the environment of the model and introduce several important notations that will be useful in the following sections.

Environment Time is continuous. Workers are hand-to-mouth consumers of wages and firms maximize the discounted present value of profits. Workers and firms have the same discount factor ρ. Workers enter the labor market as unemployed workers and have finite lives subject to Poisson death hazard d. Denote the effective discount factor as $r = \rho + d$.

Firms draw productivity p from the time-invariant distribution $\Lambda(p)$ upon entry and firm productivity is fixed until exit. Workers differ in their skills $h \in \{0, 1\}$. Workers with $h = 0$ are unexperienced and workers with $h = 1$ are experienced. Worker skills are sector-specific. Sector-specific skills, along with the stochastic arrival of job offers, are the two barriers of mobility across sectors in the model. Skilled workers can fully transfer their skills from the previous employer to a new employer in the same sector. However, all workers must start accumulating new skills whenever they switch sector and their skills accumulated in the previous sector fully depreciate [2].

Search is random and workers are faced with different job arrival rates based on the employment status and sector. I effectively only need to keep track of two sectors for each worker, which is sufficient for the human capital structure assumed. Job arrival rate is denoted as λ^0 for the unemployed. For the employed workers, job arrival rate is λ^1 from the same sector and λ^n from other sectors. In this section, I assume job arrival rates are exogenous and fixed and I will relax this assumption in the subsection 3.7.

[2] This assumption reduces the state space of the contracting problem and I do not need to keep track of sectoral employment history. Another way to deal with this issue can be found in Kennan and Walker (2011)

Denote the state space for a match as $x = (s, h, p, V)$. A match is fully characterized by firm nature s, worker skill h, firm productivity p and promised value V to worker.

Production technology Production function takes the form of a linear transformation to turn worker skills and firm productivity into the final output:

$$f_h(p) = p + ah \tag{1}$$

in which a represents the relative productivity of a skilled worker and the unskilled workers' productivity is normalized to be 0.

Preference Firms are risk neutral and they maximize the discounted present value of profit flows. There is no savings for the workers and their utility flow function is CRRA

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma} \tag{2}$$

By assuming that workers are risk-averse, I explicitly model the interaction between worker mobility restriction and the firm-sponsored training. Acemoglu and Pischke (1999) notes that by restricting worker mobility, firms have the incentive to provide more training because of the reduced hold-up concerns; Lentz and Roys (2015) claims that frictions weaken workers' bargaining position thus lead to lower training received, the result of Acemoglu and Pischke (1999) is only valid under a partial equilibrium environment. Garmaise (2011) further takes into account the payer of the training costs and shows that a higher non-competition enforcement encourages more firm-sponsored human capital investment while discourages managers ('workers' on the market of managers) from investing on their own human capital. However, it remains an empirical challenge to identify the fraction of investment made by firm or worker based on the data available, in this paper, I treat training as firm-sponsored only.

3.2 Contracts

Contracts are provided in two stages. Stage 1 determines the nature of the firm, i.e. whether the firm is a non-competition firm (C firm) or a free firm (F firm); stage 2 specifies allocation of wages, training intensity and promised values contingent on employment history.

Stage 1 Stage 1 happens before workers and firms are matched. In stage 1, firms are created with time-varying probability ϵ_t exogenously to provide contracts with a non-competition clause. Firm nature is fixed over the whole life of a worker-firm pair. Firms with non-competition clauses are denoted as C firms, firms without non-competition clauses are denoted as F firms. C firms and F firms differ in their ability to restrict worker mobility to poachers from the same sector but are faced with the same poaching rate from other sectors. Following Heggedal et al. (2017), I assume that C firms prohibit workers from being poached by firms from the same sector with probability ξ.

Stage 2 The contract determination continues to stage 2 as the worker and the firm form a match. A stage 2 contract $\mathcal{C} = \{w, \eta, H\}$ specifies wage w, training intensity η and promised value upon worker skill improves H contingent on the employment history. As in Lentz and Roys (2015), the contents of the contract realization (w, η, H) are fully determined by the state space of the match $x = (s, h, p, V)$.

In the following of section 3, I suppress the time subscript of variables and present a stationary economy version of the model in which non-competition contracts are provided at a constant rate over time. In section 5, I study the impact of non-competition agreements by introducing a sequence of non-competition provision shocks over the economy.

3.3 Bargaining and value determination

Firms compete over promised value following Bertrand competition as in Cahuc et al. (2006), Lentz and Roys (2015). The maximum value that a firm can promise is denoted as $\bar{V}(s, p, h)$, which solves

$$\Pi(s, p, h, \bar{V}(s, p, h)) = 0 \tag{3}$$

Conditional on worker's current state $x = (s, p, h, V)$, there are three possible cases when meeting with a poacher (s', p', h'), in which $h' = 1$ if and only if the poacher is from the same sector and $h = 1$.

- $V \geq \bar{V}(s', p', h')$: if the maximum value provided by the poacher is below worker's current value, this offer is not a valid threat, thus worker stays with current employer, and the value does not change;
- $\bar{V}(s, p, h) > \bar{V}(s', p', h') > V$: if the maximum value provided by the poacher is higher than worker's current value but is lower than the maximum value that the current em-

ployer provides, worker stays with current employer, and the value is increased to the poacher's maximal promised value ;

- $\bar{V}(s', p', h') > \bar{V}(s, p, h)$: if the poacher can promise a value that is higher than the maximum value that then current employer provides, the worker moves to the poacher and the value is determined at $\bar{V}(s, p, h)$.

The maximum value that entrant firms can promise determines that poaching value distribution by skilled level $F_h(V)$, which will come later into both worker's and firm's problem. For the ease of notation, I define $\hat{F}_h(V) = 1 - F_h(V)$.

3.4 Workers' value functions

Unemployed workers Following Lentz and Roys (2015) and Lise and Robin (2017), I assume unemployed workers have zero bargaining power and receive unemployment benefits b. New workers enter the labor market as unemployed unskilled workers. I also assume for simplicity that sector-specific skills that workers have accumulated from the previous employment history fully depreciate upon unemployment. All unemployed workers are thus unskilled and their value function can be simply written as

$$rU = u(b) \tag{4}$$

Employed workers Workers are risk-averse. Workers derive utility from consumption of wages. At hazard δ, the worker separates from the firm exogenously and becomes unemployed. The contracts specify training intensity η, by which rate the unskilled worker becomes skilled and the value is changed to H accordingly. Worker value is also improved via on-the-job search, which is described in the previous section. With probability $\hat{F}_h(V) = 1 - F_h(V)$, the worker changes employer and the new employer will use the maximum value that her previous employer can promise as the new starting value. If the maximum value of the poacher is between the worker's current value and the maximum value that the current employer can promise, Bertrand competition will lead to a new value which is equal to the maximum value that the poacher can promise. Note that the problems of intra- and inter- sector on-the-job search differ in both the arrival rate and the skill transferability, thus both job arrival rates λ

and value distribution $F(V)$ are different:

$$\begin{aligned}(r+\delta)V &= u(w) + \delta U + \eta(H - V)\\ &+ \lambda^1\{(1-\mathbb{1}_{\{s=C\}}\xi)\int_V^{\bar{V}_h(p)}(V'-V)dF_h(V') + \bar{V}_h(p)\hat{F}_h(V)\}\\ &+ \lambda^2\{\int_V^{\bar{V}_h(p)}(V'-V)dF_0(V') + \bar{V}_h(p)\hat{F}_0(V)\}\\ &= u(w) + \delta U_h + \eta(H - V)\\ &+ \lambda^1(1-\mathbb{1}_{\{s=C\}}\xi)\int_V^{\bar{V}(p)}\hat{F}_h(V')dV' + \lambda^2\int_V^{\bar{V}(p)}\hat{F}_0(V')dV'\end{aligned} \tag{5}$$

3.5 Firms' contracting problem

Firms optimize subject to the promise-keeping constraint and the participation constraint of workers. The firm exits the market whenever a worker separates from the firm, either exogenously or endogenously. Firms choose (η, w, H) to maximize discounted present value of profit flows and the firm's problem can be written recursively as [3]

$$\begin{aligned}(r+\delta)\Pi(s,p,h,V) = &\max_{(\eta,w,H)\in\Gamma(s,p,h,V)}\{f_h(p) - w - c_h(\eta) + \eta[\Pi(s,p,1,H) - \Pi(s,p,h,V)]\\ &+ \lambda^1(1-\mathbb{1}_{\{s=C\}}\xi)\int_V^{\bar{V}_h(p)}\Pi'_V(s,p,h,V')F_h(V')dV'\\ &+ \lambda^2\int_V^{\bar{V}_0(p)}\Pi'_V(s,p,h,V')F_h(V')dV'\}\\ s.t. \quad \Gamma(s,p,h,V) = &\{(r+\delta)V = u(w) + \delta U + \eta(H-V)\\ &+ \lambda^1(1-\mathbb{1}_{\{s=C\}}\xi)\int_V^{\bar{V}_h(p)}\hat{F}_h(V)dV' + \lambda^2\int_V^{\bar{V}_0(p)}\hat{F}_0(V)dV';\\ &U < V < \bar{V}_h(p)\}\end{aligned} \tag{6}$$

[3] I play the same trick to simplify the firm's recursive problem as that for the employed worker's value function. The original objective that the firm maximizes is

$$\max_{(\eta,w,H)\in\Gamma(s,p,h,V)}\{f_h(p) - w - c_h(\eta) + \eta[\Pi(s,p,1,H) - \Pi(s,p,h,V)]$$

$$+\lambda^1(1-\mathbb{1}_{\{s=C\}}\xi)\int_V^{\bar{V}_h(p)}[\Pi(s,p,h,V') - \Pi(s,p,h,V)]dF_h(V') + \lambda^2\int_V^{\bar{V}_0(p)}[\Pi(s,p,h,V') - \Pi(s,p,h,V)]dF_0(V')\}$$

3.6 Competitive equilibrium

Given an initial distribution of $\{\mu_0^{sh}, G_0^{sh}(V,p)\}_{s\in\{C,F\},h\in\{0,1\}}$ and a time path of non-competition provision shocks $\{\epsilon_t\}_{t=0}^{\infty}$ over time, a competitive equilibrium consists of

- Worker value function V_t;
- Firms profit function Π_t;
- Maximum value solves (3) $\forall(s,p,h)$
- Maximum value distribution for the skilled worker $F_t^0(V)$ and $F_t^1(V)$ for the unskilled workers [4];
- Optimal contracts $\mathcal{C} = \{w, \eta, H\}$;
- Worker distribution over $\{\mu_t^{sh}, G_t^{sh}(V,p)\}_{s\in\{C,F\},h\in\{0,1\}}$

such that

- Worker value function satisfies (5);
- Firm's value function and policy function solves the optimal contract problem as in (6);
- Law of motion of worker distribution holds [5];
- Distributions of maximum value are determined by individual firm's maximum value, i.e.
$$F_t^h(V) = \int_{\underline{p}}^{\bar{p}} \mathbb{1}\{\bar{V}(s,p,h) \leq V\} d\Lambda(p) \tag{7}$$
  where h denotes the skills that the poacher can utilize.

A *stationary* competitive equilibrium is similarly defined but over a constant path of $\{\epsilon_t\}_{t=0}^{\infty} = \epsilon$, which implies a stationary distribution of workers over firm type, firm productivity and worker value.

[4] Proposition 4.1 implies that maximum value distributions are independent of aggregate non-competition provision shocks, thus $\bar{V}$, Π and $F_h(V)$ $h \in \{0,1\}$ are all time-invariant

[5] See Appendix A for a complete characterization of the law of motion of the worker distribution

3.7 Endogenous job arrival rates

In the previous sections, I lay out a parsimonious random search model in which the job offers arrive exogenously. In this model, low productivity firms can retain workers for longer duration with non-competition agreements, which makes workers more easily poached by high productivity firms from other sectors. I refer to this channel as "**retention effect**".

However, the fixed search effort model may miss worker's search effort as an important channel to amplify labor market adjustments. Gomme and Lkhagvasuren (2015), Mukoyama et al. (2018), Shimer (2004) document that worker search effort can play an important role to propagate aggregate productivity shocks over business cycles. Starr et al. (2016) also empirically document that workers may be directed to search for jobs from 'non-competitors' when they are constrained by non-competition agreements. If the expected gain from intra-sector search is lower because non-competition contracts can block intra-sector transitions with positive probability, workers could possibly reoptimize their search behavior by reducing their effort on intra-sector search. I refer to this new channel as "**redirecting effect**".

I thus introduce a variable search effort choice to explore this additional "redirecting" channel. Instead of following the large Diamond-Mortensen-Pissarides model literature (see for example Mortensen and Pissarides (1994), Lise and Robin (2017), etc.) to specify a matching process which includes a free entry condition of new vacancies, I model the search effort problem as a concave job arrival function because of lacking information of vacancy creation costs over time. Another advantage of this approach is that I do not need to keep track of the worker distribution over time when computing the transition dynamics. That said, I am adopting a partial equilibrium approach to focus on the adjustment of worker side.

Job arrival rate $\lambda^i(e)$ is modeled as a concave function of workers' search effort to ensure that effort is increasing in relative expected gains in each sector. I also use $\gamma_0^i, i \in \{1, 2\}$ to capture the fact that search efficiency are different when searching for inter-sector and intra-sector jobs.

$$\lambda^i(e) = \gamma_0^i e^{\gamma_1} \quad i \in \{1, 2\}, \;\; 0 < \gamma_1 < 1 \tag{8}$$

I also assume that workers are endowed with 1 unit of total search effort per period time and the worker's value function now involves a problem of optimally allocating non-negative search effort between sectors

$$\begin{aligned}(r+\delta)V = &\max_e\{u(w)+\delta U+\eta(H-V)\\ &+(1-\mathbb{1}_{\{s=C\}}\xi)\lambda^1(e)\int_V^{\bar{V}_h(p)}\hat{F}_h(V)'dV'+\lambda^2(1-e)\int_V^{\bar{V}_0(p)}\hat{F}_0(V')dV'\}\end{aligned} \tag{9}$$

The optimal search strategy is given by

$$\frac{e}{1-e}=\{\frac{\int_V^{\bar{V}_h(p)}\hat{F}_h(V')dV'}{\int_V^{\bar{V}_0(p)}\hat{F}_0(V')dV'}\frac{\gamma_0^1}{\gamma_0^2}(1-\mathbb{1}_{\{s=C\}}\xi)\}^{\frac{1}{1-\gamma_1}} \tag{10}$$

if $\xi<1$. When $\xi=1$, it is obvious that $e=0$. The search effort for intra-sector search is increasing in worker skills and the relative search efficiency of intra-sector search and is lower if the worker is constrained by non-competition clauses.

As in Lentz (2014), firms now offer $\mathcal{C}=(w,\eta,H,e)$, which specifies search effort allocated in each sector as part of the contract as well. The firm internalizes the worker's optimal search strategy as an additional constraint to maximize the DPV of profits. The firm's problem can be written recursively as

$$\begin{aligned}(r+\delta)\Pi(s,p,h,V)=&\max_{(w,\eta,H,e)\in\Gamma(s,p,h,V)}\{f_h(p)-w+\eta(\Pi(s,p,1,H)-\Pi(s,p,h,V))\\ &+(1-\mathbb{1}_{\{s=C\}}\xi)\lambda^1(e)\int_V^{\bar{V}_h(p)}(\Pi(s,p,h,V')-\Pi(s,p,h,V))dF_h(V')\\ &+\lambda^2(1-e)\int_V^{\bar{V}_0(p)}(\Pi(s,p,h,V')-\Pi(s,p,h,V))dF_0(V')-c_h(\eta)\}\\ s.t.\quad \Gamma(s,p,h,V)=&\{\text{ PK constraint}\\ &\frac{e}{1-e}=\{\frac{\int_V^{\bar{V}_h(p)}\hat{F}_h(V')dV'}{\int_V^{\bar{V}_0(p)}\hat{F}_0(V')dV'}\frac{\gamma_0^1}{\gamma_0^2}(1-\mathbb{1}_{\{s=C\}}\xi)\}^{\frac{1}{1-\gamma_1}}\\ &U<V<\bar{V}_h(p)\}\end{aligned} \tag{11}$$

3.8 Aggregation

Given worker distribution $\{\mu_t^{sh}, G_t^{sh}(V,p)\}_{s\in\{C,F\},h\in\{0,1\}}$, the aggregate intra-sector mobility and aggregate inter-sector mobility can be expressed as

$$\text{intra}_t = \sum_{s\in\{C,F\}} \sum_{h\in\{0,1\}} \mu_t^{sh} \int\int \lambda(e(s,h,p,V))(1-\mathbb{1}_{\{s=C\}}\xi)dG_t^{sh}(V,p) \tag{12}$$

$$\text{inter}_t = \sum_{s\in\{C,F\}} \sum_{h\in\{0,1\}} \mu_t^{sh} \int\int \lambda(1-e(s,h,p,V))dG_t^{sh}(V,p) \tag{13}$$

The time-varying non-competition provision affects the aggregate mobility rates in a complex way, despite that the policy functions are invariant over time. The non-competition provision shocks affects the mobility rates directly by affecting the coverage of non-competition contracts, but also affects indirectly by affecting the value-skill distribution and sorting.

3.9 Discussion of the assumption

I acknowledge that simply treating the provision of non-competition contracts as an exogenous process may miss fundamental factors that affect firms' contract choice decisions. However, on the one hand, existing literature presents limited theoretical progresses on explaining how non-competition agreements arise between workers and firms[6] and these explanations are often limited to a certain empirical background, thus can not serve as basis of models for aggregate analysis; on the other hand, the estimates are informative as to I explicitly model the main mechanisms through which non-competition contracts affect worker mobility, namely, retention and redirecting. These two mechanism should be salient features of models with endogenous decisions of offering non-competition contracts as well.

[6] Besides the traditional stories on intellectual property (see for example Franco and Mitchell (2008),Marx et al. (2009)), Krueger and Ashenfelter (2017) find that higher new hire rate rather than education or wages leads to more likelihood of offering non-competition contracts at the sector level, Johnson and Lipsitz (2018) argues that non-competition agreements arise when employers and employees are limited in their ability to transfer utility via wage adjustment

4 Model implications

4.1 Analytical results

In this section, I present some analytical results of the model implications on worker wage growth over the lifecycle. Denote the Lagrangian Multiplier associated the promising-keeping constraint of the firms as $\gamma(s,p,h,V)$, the first order conditions are given by

$$(w) \quad -1 = u'(w)\gamma(s,p,h,V) \tag{14}$$

$$(\eta) \quad c'(\eta) = (\Pi(s,p,1,H) - \Pi(s,p,h,V)) + \gamma(s,p,h,V)(H-V) \tag{15}$$

$$(H) \quad \eta\Pi'(s,p,1,H) + \eta\gamma(s,p,h,V) = 0 \tag{16}$$

and the envelope condition is given by

$$\Pi'_V(s,p,h,V) = \gamma(s,p,h,V) \tag{17}$$

Proposition 4.1. Independence of Firm Type of Firm value: *The maximum value that a firm can promise only depend on p and h and is independent of type of the firm s.*

Proof. The proof is straightforward. The maximum value that a firm can promise to a skilled worker (when acquired) is achieved when $w = f_1(p)$ and the firm makes zero profits, i.e.

$$\bar{V}(s,p,1) = \frac{u(f_1(p)) + \delta U}{r+\delta} \quad \forall\, s \in \{C,F\}$$

The maximum value that a firm can promise to a skilled worker (when acquired) is achieved when the firm allocates profits optimally between training and worker wage to make zeros profits, i.e.

$$\bar{V}(s,p,0) = \frac{u(f_0(p) - c_h(\eta^\star)) + \delta U + \eta^\star \bar{V}(s,p,1)}{r+\delta+\eta^\star} \qquad \forall\, s \in \{C,F\}$$

$$s.t. \qquad \eta^\star = \arg\max_{\eta} \{\frac{u(f_0(p) - c_h(\eta)) + \delta U + \eta\bar{V}(s,p,1)}{r+\delta+\eta}\}$$

Both $\bar{V}(s,p,0)$ and $\bar{V}(s,p,0)$ are independent of contract status s. □

Proposition 4.1 is consistent with the economic intuition that non-competition contract status does not affect match value. It also greatly simplifies the computation of a non-stationary economy in which non-competition agreements are provided at time-varying rates, as (7) implies that only aggregate state variable that is used by firms to optimally assign contract allocation – maximum value distribution is time-invariant.

Proposition 4.2. Compensating differentials : *As long as $\xi > 0$, conditional on the same states (p, h, V), workers have a higher wage in a C firms, i.e.*

$$w(C, p, h, V) > w(F, p, h, V) \tag{18}$$

Proof. The proof for skilled worker is straightforward. Rewrite worker's value function as

$$u(w) = (r + \delta)V - \delta U_h - \lambda^1(1 - \mathbb{1}_{\{s=C\}}\xi) \int_V^{\bar{V}(p)} \hat{F}_h(V')dV' - \lambda^2 \int_V^{\bar{V}(p)} \hat{F}_0(V')dV'$$

As long as $\xi > 0$, the right hand side is higher when $s = C$. □

Proposition 4.3. On-the-job Training :

$$\eta(1, p, 0, V) > \eta(0, p, 0, V) \tag{19}$$

Intuitively, firms will compensate workers for restricting mobility with non-competition contracts. Both wage and training are strictly higher conditional on the promised value when workers are bounded by non-competition contracts. However, as in Lentz and Roys (2015), whether workers actually receive higher wages and more training are also affected by workers' bargaining position, which will be relatively worse on non-competition contracts because workers receive less job poaching.

Based on the propositions, this model predicts that workers working in a C firm have a higher initial wage but will experience lower wage growth ever after when the mobility restriction effect dominates other confounding factors, as illustrated in Figure 2. The front-loaded wage profile would affect the discounted present value of lifecycle wage income but at the same time smooth consumption across periods, thus the overall lifecycle welfare effect is ambiguous. The shift of distribution of workers under different wage growth path would also have implications for the shift of labor share in the economy. I will revisit these two questions in the quantitative section.

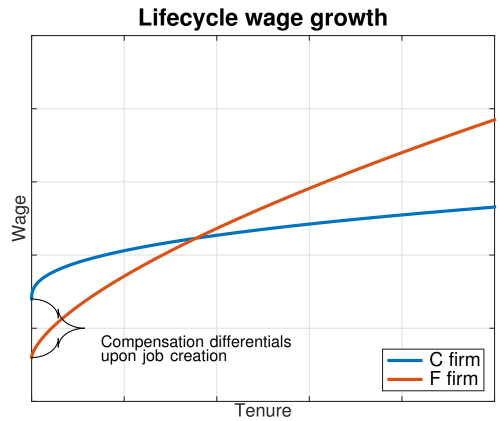


Figure 2

5 Quantitative analysis

I simulate the economy by month and aggregate to obtain yearly data. The quantitative investigation proceeds in two steps:

1. I first match the stationary model with non-competition provision rate at 0 [7] to the data of year 1994 to estimate parameters of job arrival rates (search effort parameters for the case of variable search effort model) and relative productivity of skilled workers;

2. Assuming the enforcement is constant over time, I estimate the time-varying non-competition provision shocks from 1994 to 2017 by simulating the economy and targeting the empirical cross-sectional age-correlation in 2014.

I impose the structure of the non-competition provision process to be 6 shocks, each lasting for 4 years. Apparently, with a larger amount of values and more carefully designed durations of the non-competition provision process, I can get as close to the data as possible. However, it is hard to discipline the durations and levels of actual underlying process and I use only 6 shocks to keep the arbitrariness to the minimum.

5.1 Calibration

The predetermined parameters are reported in the first block of Table 3. The parameters for the firm productivity distribution and the training costs come from Lentz and Roys (2015) and

[7] I calibrate a version of the model in which provision rate is an unknown constant before 1994 and find that the estimated rate is very close to 0

I discretize the firm productivity distribution with 11 grids. I also set $\delta = 0.24$ and $\lambda_0 = 4$ to match the layoff rate and job-finding rate out of unemployment for the U.S. workers.

I follow the literature (for example, Marx et al. (2009) and Starr et al. (2016)) to focus on the industry distinctions only because the firms are typically defined as competitors by the products they produce thus non-competition contracts are more enforceable at the industry level. This model can be easily extended to incorporate more dimensions such as occupations. Table 2 reports that a higher level of non-competition agreement enforcement also leads to statistically higher occupational mobility. However, compared with industrial mobility, occupational mobility exhibits a lower magnitude as well as smaller movements over time [8], I do not expect incorporating occupational distinctions to greatly change the estimates.

Parameter	Value	Description	Source/Targets
Predetermined			
Environment	$\rho = 0.05$	Discounting	Annual risk free rate = 5%
	$d = 0.025$	Death hazard	Average working life = 40 yrs
	$\sigma = 2$	Risk aversion	
	$\lambda^0 = 4$	Job arrival : unemployed	Lentz and Roys (2015)
	$\delta = 0.24$	Exogenous separation	Lentz and Roys (2015)
Firm Productivity	$\bar{p} = 24.6$	Pareto : Upper bound	Lentz and Roys (2015)
	$\underline{p} = 1$	Pareto : Lower bound	Lentz and Roys (2015)
	$\alpha = 0.29$	Pareto : Curvature	Lentz and Roys (2015)
Training Cost	$c_0 = 37.41$	Training cost : scaling	Lentz and Roys (2015)
	$c_1 = 0.81$	Training cost : curvature	Lentz and Roys (2015)
Calibrated			
Fixed search effort			
Job arrival	$\lambda^1 = 0.9$	OJS search efficiency : intra-industry	Intra-ind-intra-occ = 0.15
	$\lambda^2 = 0.5$	OJS search efficiency : inter-industry	Inter-ind-intra-occ = 0.05
Worker skill	$a = 7.6$	Skilled labor productivity	Gross labor share = 0.63

Table 3: Parameters

The parameters to be estimated are associated with the job arrival rates (job arrival rate function) and the relative productivity of skilled workers. I target the empirical intra-industry-intra-occupation rate of 0.15 and inter-industry-intra-occupation rate of 0.05 to pin down the job arrival rates and target the gross labor share to be 0.63 to pin down the relative productivity of the skilled workers.

[8] See Figure A2 in the Appendix.

In lack of a prior of the enforceability of non-competition agreements, I set the enforcement parameter ξ to be 1 all through the analysis. This means that the intra-industry mobility is completely prohibited when workers sign a contract with non-competition agreements. This estimates can be viewed as an upper bound of the impacts in this sense. The second block of Table 3 reports the calibrated parameters for the two versions of the model.

5.2 Stationary economy properties

With the parameters, I study three stationary economies in which non-competition contracts are created with a constant probability of 0, 5% and 20% to illustrate the forces of the model. The labor market outcomes are reported in Table 4.

Provision	$\epsilon = 0$	$\epsilon = 0.05$	$\epsilon = 0.20$
Coverage	0%	6.76%	25.41%
Utility	100	99.47	96.97
Firm productivity	12.1320	11.8953	11.3299
J2J transition rate	1.80%	1.72%	1.52%
I2I transition rate	0.42%	0.43%	0.47%
Blocked poaching	0%	0.49%	1.86%
Blocked improvement	0%	0.32%	1.23%
Blocked switching	0%	0.12%	0.47%
Skill level	0.1099	0.1120	0.1244
Training 5-years	0.0291	0.0313	0.0413
Training 10-years	0.0332	0.0353	0.0435
Training 15-years	0.0342	0.0361	0.0442
Training 20-years	0.0344	0.0366	0.0443

Table 4: Stationary economy outcomes

The converged coverage rate is strictly larger than the provision rate of new firms, which reflects that workers are increasingly covered by non-competition contracts over their lifecycle. Expected welfare is slightly lower in economies with positive non-competition provision rates when calculated with compensated variations of consumption. The firm productivity weighted by duration over lifetime is strictly decreasing in the provision rate, which reflects the fact that low productivity firms are able to retain workers for longer durations with non-competition contracts. Non-competition provision rate is positively correlated inter-industry mobility but is negatively correlated with the job-to-job mobility. Non-competition contracts help to reduce the investment holdup problem so that the firm-sponsored training as well as mean worker productivity is higher when non-competition contracts are provided at a higher rate. The workers in the high provision economy are becoming skilled at around 40% (0.413/0.291 -1)faster speed compared with workers in the economy without non-competition contracts. This model thus share the feature as Shi (2017) that wage growth is affected by non-competition contract status in opposite directions through reduced worker mobility and increased training.

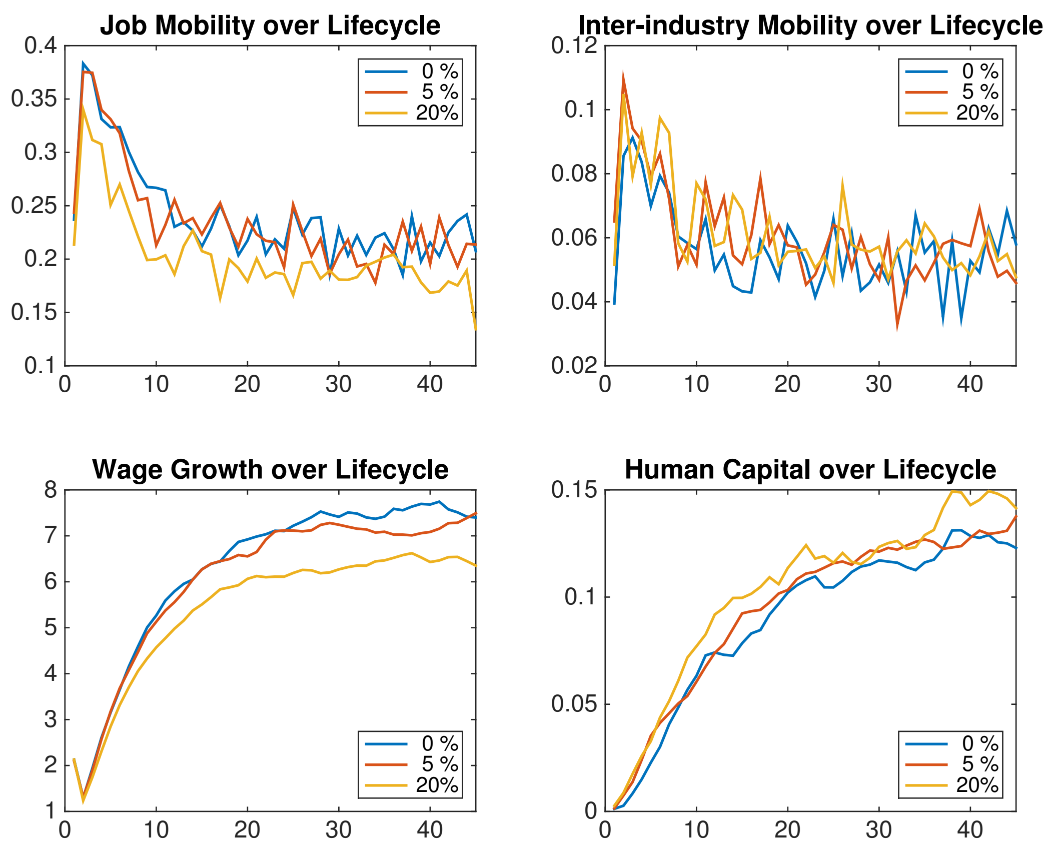


Figure 3: Lifecycle Properties in Stationary Economies

I further report the lifecycle mobility rates and wage growth across stationary economies in Figure 3. As is very clear from Figure 3, non-competition contracts make a significant impact on the economy only when the provision rate is raised to 20%, while the 5% case is indistinguishable from the benchmark economy without any non-competition contracts. The model-generated lifecycle paths of job mobility, inter-industry mobility and wage growth are in line with the empirical patterns documented by large labor literature (for example Mincer and Jovanovic (1981),Neal (1999) , and Menzio et al. (2016) etc.), I only focus on the difference across economies. In the high provision economy, job mobility rate is lower by 5% annually when entering the labor market, it continues to be lower all through the lifecycle. The inter-industry mobility rate is affected in the opposite direction, although the magnitude is less significant. Worker skills are accumulating at a higher speed, however, due to the mobility frictions, wage growth rate is lower.

5.3 Inferring the shocks over time

Identification I infer the sequence of aggregate shocks of non-competition contract provision by exploiting the fact that workers with different lengths of labor market history experience different paths of meeting firms with non-competition contracts. Appendix B provides simulations of a set of economies where non-competition contracts are offered at a constant rate and report the steady state age-coverage correlation in each economy. The fact that young cohorts have a higher non-competition contract coverage can only be consistent with an economy in which non-competition contracts are provided at an increasing rate over time. The age-correlation moments convey information on both the magnitude and the timing of the changes in the provision of non-competition contracts.

Results I thus estimate the shocks by minimizing the distance between the empirical age-coverage correlation and the corresponding model-generated correlation. The model is simulated at the monthly frequency, with 20,000 workers. I treat years before 1994 as a steady state and simulate forward with a sequence of non-competition contract provision shocks for the labor market between 1994 and 2017, which correspond to 280 model periods. As for the first step, I simulate the economy using a constant non-competition provision rate for 2500 periods to obtain a stationary distribution of the labor market, as a proxy of the economy in 1994. In the second step, I feed in a sequence of 6 non-competition provision shocks, each lasting for 48 model periods (4 years) and compute the age-coverage correlation between period 241-244, which corresponds to the first quarter of year 2014, when the survey was conducted. Table 5 reports the estimated processes of non-competition provision shocks for both models.

According to my estimation, before 2005, small fraction of new firms were provided non-competition contracts, however, there was a sharp increase in the provision of non-competition contracts at around year 2005. This sharp change in the composition of new firms give rise to

Model	ϵ_1	ϵ_2	ϵ_3	ϵ_4	ϵ_5	ϵ_6
Fixed Effort	0.1%	0.12%	1.5%	12.05%	13.65%	25.26%

Table 5: Estimated Shocks

the observed pattern in Figure 4 that workers aged 35-40 have a higher coverage rate compared with both their older and younger cohorts. They have a higher coverage rate than their older cohorts because they entered the labor market when firms started to adopt more non-competition contracts. They have a higher coverage rate than their younger cohorts because they had a longer career and most job switches happen at young ages.

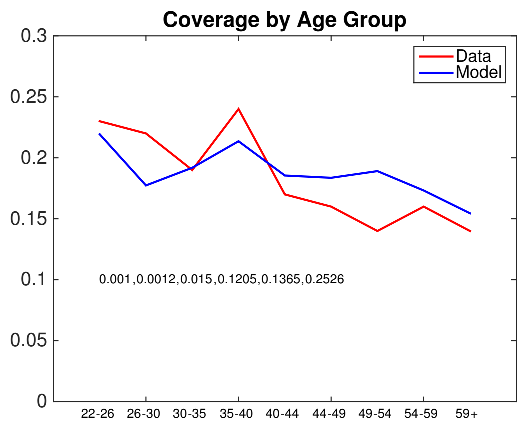
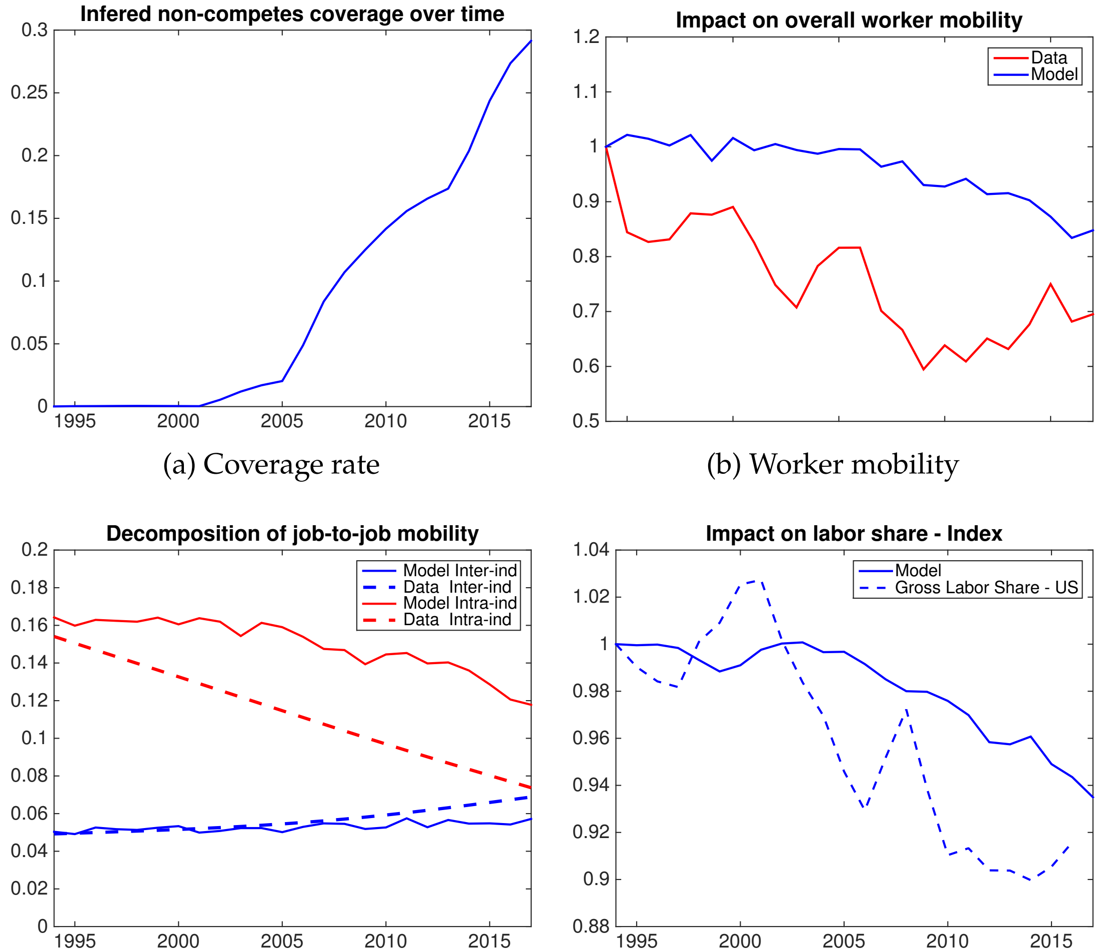


Figure 4: Model fit

5.4 Economic impact of the rise in non-competition agreements

I next use the estimated provision shocks to infer the actual usage of non-competition contracts in the economy. Not surprisingly, as can be seen in Figure 5a, the coverage rate increased only after year 2000. The increase in the coverage of non-competition contracts also lead to a decrease in the labor share in the model. Non-competition contract status have large impact over worker lifecycle growth thus the overall labor share. In Figure 6, I plot the wage growth path of workers contingent on worker contract status against tenure. However, this model does not have enough realistic features like capital to fully specify how income is distributed and thus do not attempt to establish the causality of these two phenomenon. Additionally, as reported in Figure 5d, the magnitude of the model-generated decline in labor share falls far below the actual decline.



(a) Coverage rate

(b) Worker mobility

(c) Inter- and intra- industry mobility

(d) Labor share

Figure 5: Impact on the labor market

I finally check the channels by which the non-competition agreements affect worker mobility. As can be seen is Figure 7, in the baseline calibration, the variable effort model overperforms the fixed effort model in matching the declining intra-industry mobility. However, their ability to explain the rising inter-industry mobility is indistinguishable. This might be due to the extreme assumption that non-competition contracts prohibits intra-industry mobility completely thus workers' effort choice plays little role in the model.

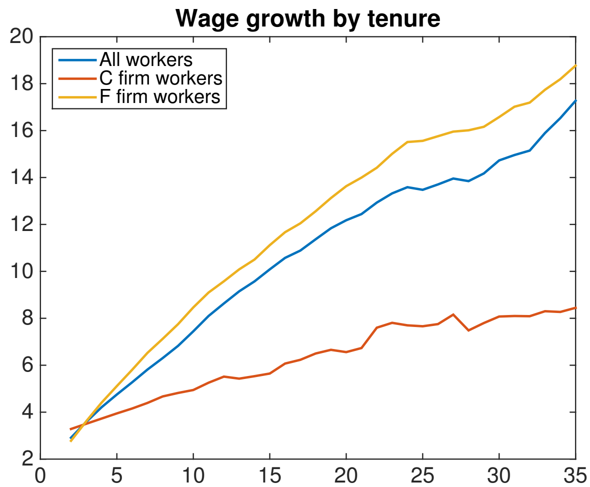


Figure 6

Parameter	Value	Description	Source/Moments
Predetermined			
Search effort	$\gamma_1 = 1/2$	Curvature	
Calibrated			
Search effort	$\gamma_0 = 0.975$	Search efficiency: intra-industry	Intra-ind-intra-occ = 0.15
	$\gamma_1 = 0.525$	Search efficiency: inter-industry	Inter-ind-intra-occ = 0.05
Worker skill	$a \ = 9.5$	Skilled labor productivity	Gross labor share =0.63

Table 6: Parameters – Variable Search Effort

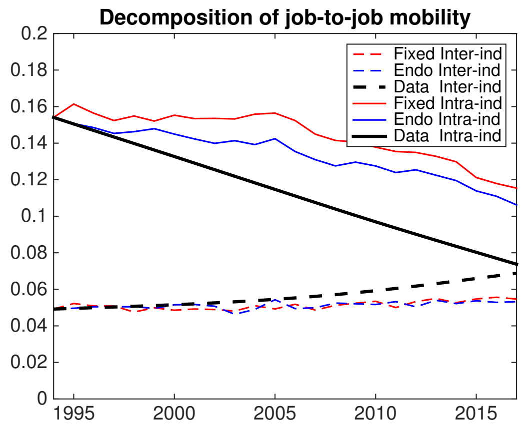


Figure 7

6 Conclusion

In this paper, I develop a tractable labor search framework to study the impact of non-competition contracts on the aggregate economy. I use the model to estimate the provision of non-competition contracts of new vacancies in the United States labor market, which exhibits a sharp increase in the recent decade. I further find that the rise in the coverage of non-competition contracts can account for around 1/2 of the aggregate job-to-job mobility and around 3/4 of the decline in gross labor share. The model also generates around 1/2 of the decline in the intra-industry mobility and 1/3 of the rise in the inter-industry mobility of that in the data.

This study establishes the fact of a rapid increase in the usage of non-competition contracts in recent years, thus can be seen as complimentary to the empirical literature on the current pervasive usage of non-competition contracts. This increase may stem from the change of legislations and regulations of the contracts. It may also be explained by macroeconomic reasons such as globalization, intellectual properties and the nature of work. The rise of non-competition contract may be closely related to the rise of product market power (De Loecker and Eeckhout (2017))and labor market power (Berger et al. (2019)) in the United States, as well as rise in firm size concentration (Benmelech et al. (2018), Rinz (2018), Macaluso and Hershbein (2018) etc.). The causality between these facts is still up to exploration.

Workers may have various ways to respond besides adjusting their search effort contingent on non-competition status. Marx (2011) provides an additional channel that inter-industry mobility rate is stimulated by non-competition contracts that technicians make 'career detours' across industries to avoid violating the contract. This channel can be incorporated when I introduce industry distinction to have a clear record of worker industry employment history.

This paper takes a partial equilibrium approach in which firms are born with certain probability of being a non-competition firm. The next step will be to investigate on the fundamental movements of the U.S. labor markets and business dynamism to endogenize the choice of providing non-competition contracts. I treat industries as homogenous, which may actually differ in the overall coverage [9] and enforceability of non-competition contracts. Firms in different industry may also provide non-competition contracts for different reasons that are related to industry-specific characteristics. Further investigation of the impact from the perspective of industry difference requires not only more data but also a unified framework to incorporate all incentives.

Another potential avenue of research is to investigate how state-level non-competition enforcement affects worker mobility in space. I leave these directions of research for future work.

[9] Starr et al. (2017b) reveal significant variations in the coverage rate across industries

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Table of contents for appendix

A Steady state distribution and model extension

A.1 Steady state distribution

In this section, I present some analytical expressions of equilibrium distribution. To facilitate the extensions in the following section, I build on the baseline model in the main text to incorporate several new features of endogenous non-competition contract provision and differential unemployment value for skilled and unskilled workers. Denote measure of unemployed workers $u_h, h \in \{0,1\}$ and the measure and distributions of employed workers $(e_{ch}, G_{ch}(V,p))_{c\in\{C,F\},h\in\{0,1\}}$.

- Law of motion for $u_0, u_1, e_{00}, e_{01}, e_{10}, e_{11}$ are given by

$$
\begin{aligned}
u_0(d+\lambda_u) &= d + \delta(e_{00}+e_{10}) \\
u_1(d+\lambda_u) &= \delta(e_{10}+e_{11}) \\
e_{00}(d+\delta+\bar{\eta}_{00}) &= \lambda^u u_0 \tilde{p}_0 + \lambda^e (1-\xi) e_{01} \int g_{10}(V',p)\hat{F}_{00}(V')dV' \\
e_{01}(d+\delta) &= \lambda^u u_1 \tilde{p}_0 + e_{00}\bar{\eta}_{00} + \lambda^e(1-\xi)e_{11} \int g_{11}(V',p)\hat{F}_{01}(V')dV' \\
e_{10}(d+\delta+\bar{\eta}_{10}) &= \lambda^u u_0 \tilde{p}_1 + \lambda^e e_{00} \int g_{00}(V',p)\hat{F}_{10}(V')dV' \\
e_{11}(d+\delta) &= \lambda^u u_1 \tilde{p}_1 + e_{10}\bar{\eta}_{10} + \lambda^e e_{11} \int g_{11}(V',p)\hat{F}_{01}(V')dV'
\end{aligned}
$$

  where

$$
\begin{aligned}
\bar{\eta}_{00} &= \int \eta(0,0,V,p)dG_{00}(V,p) \\
\bar{\eta}_{10} &= \int \eta(1,0,V,p)dG_{10}(V,p)
\end{aligned}
$$

- For $e_{00}G_{00}(V,p), e_{01}G_{01}(V,p), e_{10}G_{10}(V,p), e_{11}G_{11}(V,p)$

$$\lambda^u u_0 \int_0^p \Delta_0(p')\phi(p')dp' + \lambda^e(1-\xi)e_{10}\int_0^{\bar{p}_{10}(V)}\int_{U_0}^{\bar{V}_{10}(p')} \tilde{p}_0[F_{00}(\bar{V}_{00}(p)) - F_{00}(\bar{V}_{10}(p))]g_{10}(V',p')dV'dp'$$

$$= e_{00}\{\int_{U_0}^{V}\int_0^p g_{00}(V',p')\lambda_e\tilde{p}_1\hat{F}_{10}(V_{00}(p'))dV'dp'$$

$$+ \int_0^{\bar{p}_{00}(V)}\int_{U_0}^{\bar{V}_{00}(p')} g_{00}(V',p')[d+\delta+\eta(0,0,V',p') + \lambda_e\tilde{p}_0\hat{F}_{00}(\bar{V}_{00}(p))]dV'dp'$$

$$+ \int_{\bar{p}_{00}(V)}^{p}\int_{U_0}^{V} g_{00}(V',p')[d+\delta+\eta(0,0,V',p') + \lambda_e\tilde{p}_0\hat{F}_{00}(V)]dV'dp'\}$$

$$\lambda^u u_0 \int_0^p \Delta_1(p')\phi(p')dp' + \lambda^e(1-\xi)e_{00}\int_0^{\bar{p}_{00}(V)}\int_{U_0}^{\bar{V}_{00}(p')} \tilde{p}_1[F_{10}(\bar{V}_{10}(p)) - F_{10}(\bar{V}_{00}(p))]g_{00}(V',p')dV'dp'$$

$$= e_{10}\{\int_{U_0}^{V}\int_0^p g_{10}(V',p')\lambda_e\tilde{p}_0\hat{F}_{00}(V_{10}(p'))dV'dp'$$

$$+ \int_0^{\bar{p}_{10}(V)}\int_{U_0}^{\bar{V}_{10}(p')} g_{10}(V',p')[d+\delta+\eta(1,0,V',p') + \lambda_e\tilde{p}_1\hat{F}_{10}(\bar{V}_{10}(p))]dV'dp'$$

$$+ \int_{\bar{p}_{10}(V)}^{p}\int_{U_0}^{V} g_{10}(V',p')[d+\delta+\eta(1,0,V',p') + \lambda_e\tilde{p}_1\hat{F}_{10}(V)]dV'dp'\}$$

$$e_{00}\int_{U_1}^{V}\int_0^p g_{00}(V',p')\eta(0,0,V',p')dV'dp' \qquad \text{(use fact that M = V)}$$

$$= e_{01}\int_0^p\int_{U_0}^{\bar{V}_{01}(p)} g_{01}(V',p')[d+\delta+\lambda_e(\tilde{p}_0F_{00}(\bar{V}_{01}(p') + \tilde{p}_1F_{10}(\bar{V}_{01}(p')))]dV'dp'$$

$$e_{10}\int_{U_1}^{V}\int_0^p g_{10}(V',p')\eta(1,0,V',p')dV'dp'$$

$$= e_{11}\int_0^p\int_{U_0}^{\bar{V}_{01}(p)} g_{01}(V',p')[d+\delta+\lambda_e(\tilde{p}_0F_{00}(\bar{V}_{01}(p') + \tilde{p}_1F_{10}(\bar{V}_{01}(p')))]dV'dp'$$

B Identification

Figure A1 briefly explains the identification strategy to infer the time-varying provision shocks. I simulate the steady-state equilibrium with fixed effort in which non-competition contracts are offered at constant rates of 5%, 10%, 20%, and 30% respectively and report the age-coverage correlation for each economy. In all simulated economies, there exists a positive correlation between age and coverage rate, and young worker experience a more rapid growth rate of coverage than the older workers. Similar patterns hold in a model with variable effort as well. These patterns are in contrast with the age-coverage correlation documented by Prescott et al. (2016), which thus rejects the hypothesis that non-competition contracts are offered at a constant rate over time. By exploiting the fact that workers of different ages experience different path of non-competition contract provision shocks, the age-correlation moments convey information on both the magnitude and the timing of the changes in the provision of non-competition contracts.

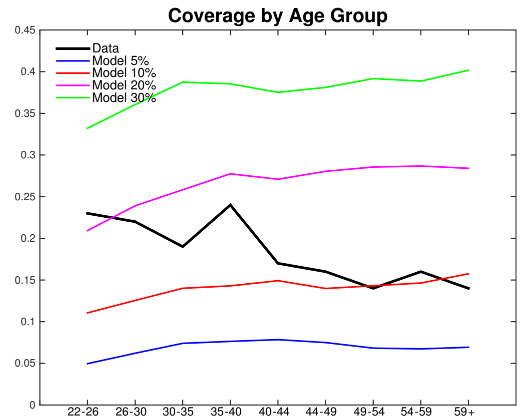

Figure A1: Graphic illustration of identification

C Data

C.1 Labor mobility

I use the Current Population Survey (CPS) to document the monthly job-to-job mobility and Annual Social and Economic Supplement of the CPS (ASEC-CPS) to document the yearly occupational mobility.

In this section, I present some new empirical findings on the movements of the U.S. job mobility rates that are qualitatively consistent with a rise in the usage of non-competition contracts. The purpose of this decomposition exercise is twofolds, on the one hand, the relative change of the components reveals some fundamental movements in the U.S. labor market, which rationalizes my investigation of non-competition agreements as the potential driver of these observations; on the other, I will test the success of the theory by examining whether the model is able to match the empirical movement of worker mobility rates.

I start by categorizing job-to-job transitions into inter-industry-inter-occupation, inter-industry-intra-occupation, intra-industry-inter-occupation and intra-industry-intra-occupation based on Census Bureau 1950 occupation code and 1950 industry code. Figure A2 reports the time series when using 10 industries and 12 occupations under 1950 Census Bureau occupational /industrial classification system.

Large literature has been studying the trend of occupational mobility over time and its implications for human capital and wage inequality(see for example, Kambourov and Manovskii (2009) and Xu (2018)). However, as can be seen from Figure A2, during the period between

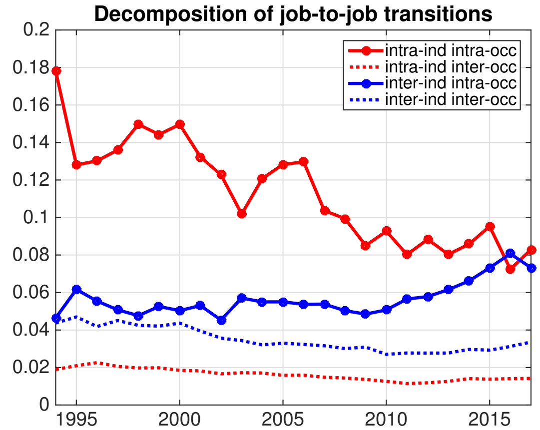

Figure A2

1994 and 2017, the inter-occupational mobility rates are relatively stable, within the same industry or across different industries. The average is 2% for the intra-industry-inter-occupation mobility rate and around 4% for the inter-industry-inter-occupation mobility rate. The relative low level and the small fluctuations of these two rates rules out the possibility that the inter-occupational mobility is the driver of the overall decline in job-to-job mobility rates.

There is a more prominent decline in the intra-industry-intra-occupation mobility. Interestingly, the inter-industry-intra-occupation mobility has a clear increasing pattern. These two observation in combination suggests that the driver of the overall decline should be some changes that have an impact from the industry perspective. A successful theory to explain the overall decline must also be able to reconcile the relative movements of each component.

The divergent patterns of inter- and intra- industry mobility is robust if I measure mobility at the 3-digit level, with the relative levels of each component adjusted to different numbers, though. However, as we can see in the model section, the way I model worker mobility is independent of the digits of industry/occupation categorization and the quantitative estimates should still be valid even if I adopt a more disaggregated code choice.

C.2 Labor share

Following Bridgman (2017), I construct gross labor share by combining corporate business income and corporate business compensation of employees from NIPA table 1.13 and corporate business depreciation from NIPA table 7.5. Bridgman (2017) also calculates measure of net labor share and net labor share less tax.

C.3 Non-competition enforcement index

In the section of empirical investigation, I use enforcement index constructed by Garmaise (2011) as a direct measure of the level of enforcement. I cite it here in Table A2. A smaller

Occupation	Codes	Industry	Codes
Professional, Technical	001-099	Agriculture, Forestry, and Fishing	105-126
Farmers	100-123	Mining	206-236
Managers, Officials & Proprietors	200-290	Construction	246
Clerical and Kindred	300-390	Manufacturing	306-499
Sales workers	400-490	Transportation, Communication & Other Utilities	506-598
Craftsmen	500-595	Wholesale and Retail Trade	606-699
Operatives	600-690	Finance, Insurance, and Real Estate	716-746
Service Workers	700-790	Business and Repair Services	806-817
Farm Laborers	810-840	Personal services	826-849
Laborers	910-970	Entertainment and Recreation Services	856-859
		Professional and Related Services	868-899
		Public Administration	906-936

Table A1 : Correspondence of occupations/industries codes (1950 Census Bureau occupational /industrial classification system), Source : IPUMS

number corresponds to a lower level of enforcement of non-competition contracts. The readers should refer to the original paper for more details procedure to construct this measure.

State	Enforcement Index	State	Enforcement index
Alabama	5	Missouri	7
Alaska	3	Montana	2
Arizona	3	Nebraska	4
Arkansas	5	Nevada	5
California	0	New Hampshire	2
Colorado	2	New Jersey	4
Connecticut	3	New Mexico	2
Delaware	6	New York	3
D.C.	7	North Carolina	4
Florida (1992-1996)	7	North Dakota	0
Florida (1997-2004)	9	Ohio	5
Georgia	5	Oklahoma	1
Hawaii	3	Oregon	6
Idaho	6	Pennsylvania	6
Illinois	5	Rhode Island	3
Indiana	5	South Carolina	5
Iowa	6	South Dakota	5
Kansas	6	Tennessee	7
Kentucky	6	Texas (1992-1994)	5
Louisiana (1992-2001,2004)	4	Texas (1995-2004)	3
Louisiana (2002-2003)	0	Utah	6
Maine	4	Vermont	5
Maryland	5	Virginia	3
Massachusetts	6	Washington	5
Michigan	5	West Virginia	2
Minnesota	5	Wisconsin	3
Mississippi	4	Wyoming	4

Table A2 : Garmaise Non-competition Enforcement index, Source: Garmaise (2011)