Declining Labor Turnover and the Importance of Intensive Margin Adjustment*

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Abstract

The contribution of intensive margin adjustments to the cyclical fluctuations in total hours worked has increased in the US since the 1980s. I document that the job tenure length has increased during this period and labor hours adjustments in recessions are more prominent in economies with higher job tenure lengths. I build a search-and-matching model with part-time workers and job-specific human capital accumulation. With the model, I claim that the improvement in initial match quality can account for the increased use of intensive margin adjustments along the business cycle.

Keywords: Intensive margin adjustments, endogenous separation, human capital, business cycle

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1 Introduction

The total hours worked show cyclical movements along the business cycle. However, it has been increasingly the hours per worker that contribute more to the cyclicality of total hours in the last four decades. For workers and firms, there are two different ways to decrease their labor input for production when the aggregate productivity is low. One is by firing workers, which is the extensive margin of labor adjustments. The other is by reducing the hours per worker, which is the intensive margin adjustments. Since the 1980s, there has been a steady decline in unemployment inflow rates. (Fujita (2018) and Crump et al. (2019)). Between 1976 and 2000, the monthly unemployment inflow rates were on average 2.1 percent, which has decreased to 1.6 percent in the post-2000 period. On the other hand, the labor market flows between full-time (FT) to part-time (PT) workers are steady at 4 percent across the same period. It implies that intensive margin adjustments have become relatively more important for reducing labor usage than firing workers.

One of the significant differences between extensive and intensive margin adjustments is their implications on job-specific human capital. Once a job match is dissolved, the worker has to find another employer making the job-specific human capital for the previous position obsolete. In contrast, reducing the hours worked allows workers and firms to preserve their job-specific human capital by adjusting the labor input with hours worked without ending their relationship. After the aggregate productivity goes back up to the normal level, workers with reduced hours can again work for their original hours with their preserved human capital.

There are two empirical and two theoretical findings in this paper. Empirically, I first find that the relative importance of intensive margin adjustments in recessions has increased for the last four decades. I start my analysis by decomposing the change in total hours worked into changes in employment and hours per worker from the NBER peak before NBER-dated recessions. Using the aggregate data from Labor Productivity and Costs (LPC), I find that a larger share of the decrease in total hours worked has been coming from reductions in the working hours of incumbent workers rather than dissolving their match in more recent recessions. Among OECD countries, the United States is known to be less reliant on intensive margin adjustments compared to other countries (Ohanian and Raffo (2012)). However, little has been explored about how the importance of intensive margin adjustments has changed over time. In recessions before 2000, only a 10 percent of total hours decrease was due to intensive margin adjustments. In the post-2000 period, the number went up to 25 percent in the Great Recession.

Secondly, I find that the right shift in job tenure is related to the increased importance of intensive margin adjustments. The job separation rates have decreased in the last four decades and have been associated with a rightward shift in job tenure distribution. Hyatt and Spletzer (2016) record that the fraction of workers who stayed in their jobs for less than a year has constantly been decreasing for the last four decades. Considering that workers are more likely to possess more job-specific human capital when they stay in their jobs for longer, workers and firms would be increasingly less willing to forgo the current match in economic downturns. Using within-state variations in job tenure distribution, I find that economies with high job tenure are more likely to use intensive margin than extensive margin adjustments in recessions.

The first theoretical finding is that the improvement in initial match productivities simultaneously replicates the secular decline in job separation rates and the increased importance of intensive margin adjustments. I added three main features to the standard search-and-matching model. There are part-time workers, on-the-job search, and job-specific human capital to incorporate the different consequences in human capital between extensive margin and intensive margin adjustments. After calibrating the model to the data in the 1980-2000 period, I estimate the size of the change in initial match productivities needed to replicate the decline in labor turnover in the post-2000 economy. 12% increase in the initial match productivities can replicate the decline in job separation rates from 2.1% in the pre-2000 period to 1.6% in the post-2000 period. For a sequence of shocks that replicates the Great Recession, the change in hours per worker contributes only 17% to the total hours change for the pre-2000 economy, while the number is 43% for the post-2000 economy.

In this paper, I consider the improved initial match quality as a driving force behind the decline in labor turnover. Mercan (2017) and Pries and Rogerson (2022) both consider the improvement in initial signal about the quality of job matches as a source of reduced labor market fluidity. The era of personal computers arrived in 1980 and the ICT revolution gained its traction. Since then, employers and employees have been using better technologies to form better matches than before as Mercan (2017) pointed out. For example, employers now actively use employee referrals, advertise internships, and post vacancies on online job platforms with detailed job descriptions to find candidates with a good fit. Employees also use professional networking platforms, insider reviews, and recruiter services to find firms with a good match. In the labor market models of Mercan (2017) and Pries and Rogerson (2022), the quality of initial matches improves as firms and workers become more selective in forming matches when the noise in the signal is exogenously reduced. I directly shift the initial match productivity distribution instead of modeling the signaling process to keep the model tractable.

The second theoretical finding is that the short-time compensation (STC) policy is more effective at reducing unemployment volatility in the low-labor turnover (post-2000) economy than in the high-labor turnover (pre-2000) economy. The short-time compensation is a labor subsidy scheme that is designed to incentivize firms and workers to reduce hours worked temporarily instead of firing them. The government subsidizes the reduced wage due to hours reduction. For the cost equivalent STC policy, unemployment volatility goes down only 2.7% in the pre-2000 economy while it goes down 14% in the post-2000 economy. The implementation of STC decreases average unemployment rates in both economies but diminishes the volatility of unemployment only for the post-2000 calibration.

In the US, California was the very first state where STC was introduced in 1978. Now, 27 states have implemented the policy, but the take-up rates have been steadily low. The amount of STC paid out is less than 1 percent of Unemployment Insurance (Krolikowski and Weixel (2020)). Even though STC policy utilization momentarily increased during the COVID-19 pandemic, the share of Unemployment Insurance (UI) initial claims that were STC has still been tiny at 1 percent at its highest. In contrast, European countries such as Germany and France have successfully managed to reduce unemployment fluctuations using STC along the business cycle (Tilly and Niedermayer (2017), and Giupponi and Landais (2022)). Therefore, it is worthwhile to examine how successfully promoting STC in the US can stabilize the labor market in recessions and if it is still valuable in the current low labor turnover economy.

2 Related Literature

There are three different strands of literature that are closely related to this paper. First, this paper contributes to the literature on declining labor turnover. Several papers have uncovered the reason behind the diminishing fluidity in the US labor market. For example, Fujita (2018) explores the increasing risk of skill loss during unemployment as a reason behind the reduced turnover. On the other hand, Mercan (2017) and Pries and Rogerson (2022) emphasize the improved signal on new matches as the driving force behind the lessened fluidity. The main difference between these two is that the former investigates job-to-job transitions and the latter examines job destruction rates. I contribute to this literature by analyzing the effects of improvements in initial match quality on the use of intensive margin adjustments where the improvement is calibrated to replicate the decline in job separation rates.

The second strand of literature that this paper is related to is measuring the importance of intensive margin adjustments. Ohanian and Raffo (2012) and Cacciatore et al. (2020) have confirmed that hours per worker accounts for one-third of the unconditional volatility of aggregate hours in the United States, which is in line with the previous research, including Cho and Cooley (1994)). However, little has been explored about how the importance of intensive margin adjustments has changed over time in the United States. I contribute to the literature by finding that the cyclical fluctuations in total hours worked have increasingly consisted of hours per worker fluctuations in recessions.

Some of the recent literature on intensive margin adjustments has focused on fluctuations in part-time workers when analyzing the change in hours per worker. Borowczyk-Martins and Lalé (2019) find that cyclical variation in hours per worker is primarily driven by fluctuations in the share of part-time workers, especially in recessions. Gomis-Porqueras and Griffy (2020) develop a random search model that incorporates part-time workers by introducing different acyclical match maintenance costs to full and part-time matches. I adopt their assumption of different acyclical overhead costs between full- and part-time positions. Warren (2017) and Lariau (2018) are other papers that also calibrate a search and matching model with US data. I add on-the-job search and job-specific human capital accumulation to fully incorporate the virtue of preserving human capital in intensive margin adjustments. The random search model is tractable because I assume Bertrand competition between poaching and incumbent firms following Lise and Robin (2017).

Lastly, this paper is related to Short-time compensation (STC) literature. Most of the papers in this literature have mainly analyzed STC in European countries (Tilly and Niedermayer (2017) and Giupponi and Landais (2022)). It is because Germany has been one of the most successful countries in introducing the STC policy called Kurzarbeit. Other European countries also extensively use STC to reduce unemployment fluctuations in recessions. In contrast, STC policy has gained little traction in the US even though it exists (Krolikowski and Weixel (2020)). Therefore, I examine the effects of STC policy once the policy is successfully promoted and widely used. Specifically, I compare its effectiveness in reducing unemployment volatility in low and high labor turnover economies.

3 Empirical Analysis

3.1 Labor Turnover and Intensive Margin Adjustments

To compare how total hours adjustments during recessions changed over time during recessions, I use hours per worker and quarterly employment data from Labor Productivity and Costs (LPC). In the following analysis, I decompose the total hours change into hours per worker change and employment change from the onset of the recession to the trough.

$$\Delta \log(\text{Total Hours}) = \Delta \log(\#\text{ of Employees}) + \Delta \log(\text{Hours per Worker})$$

Figure 1 records the change in total hours from the quarter before the NBER dated recessions to the trough in four different recession periods that happened after 1980. Both total hours and hours per worker decreased during the recession periods. In terms of the total hours decreased during recessions, the 1980s Twin Recessions and the 2007 Great Recession are similar in size at 7%. Compared to these two recessions, the 1990 and 2001 recessions were milder at 1.7% and 3.1%. As shown in table 1, the post-2000 recessions show a higher contribution of hours per worker decrease in the total hour adjustment. Among the 7.24% decrease in the total hours, the decrease in hours per worker contributed only 11.68% of the decrease in the Twin Recessions in the 1980s. In the 2007 Great Recession the total hours decreased by 7.39%, which is similar in size to that of the Twin Recessions. However, the share of hours per worker is much higher at 25.08% in the Great Recession. It more than doubled in its contribution to the peak-to-trough decline in total hours worked. For table 1, I logged all the time-series data and hp-filtered with parameter 1600. The trend of the increasing importance of hours per worker is consistent across using different filtering parameters and methods[1].

	Total Hours	Hours per worker	Hour share (HP)	Hour share (BK)
1980	7.24%	0.85%	11.68%	8.88%
1990	1.70%	0.20%	11.53%	14.34%
2001	3.11%	0.64%	20.46%	19.94%
2007	7.39%	1.83%	25.08%	26.36%

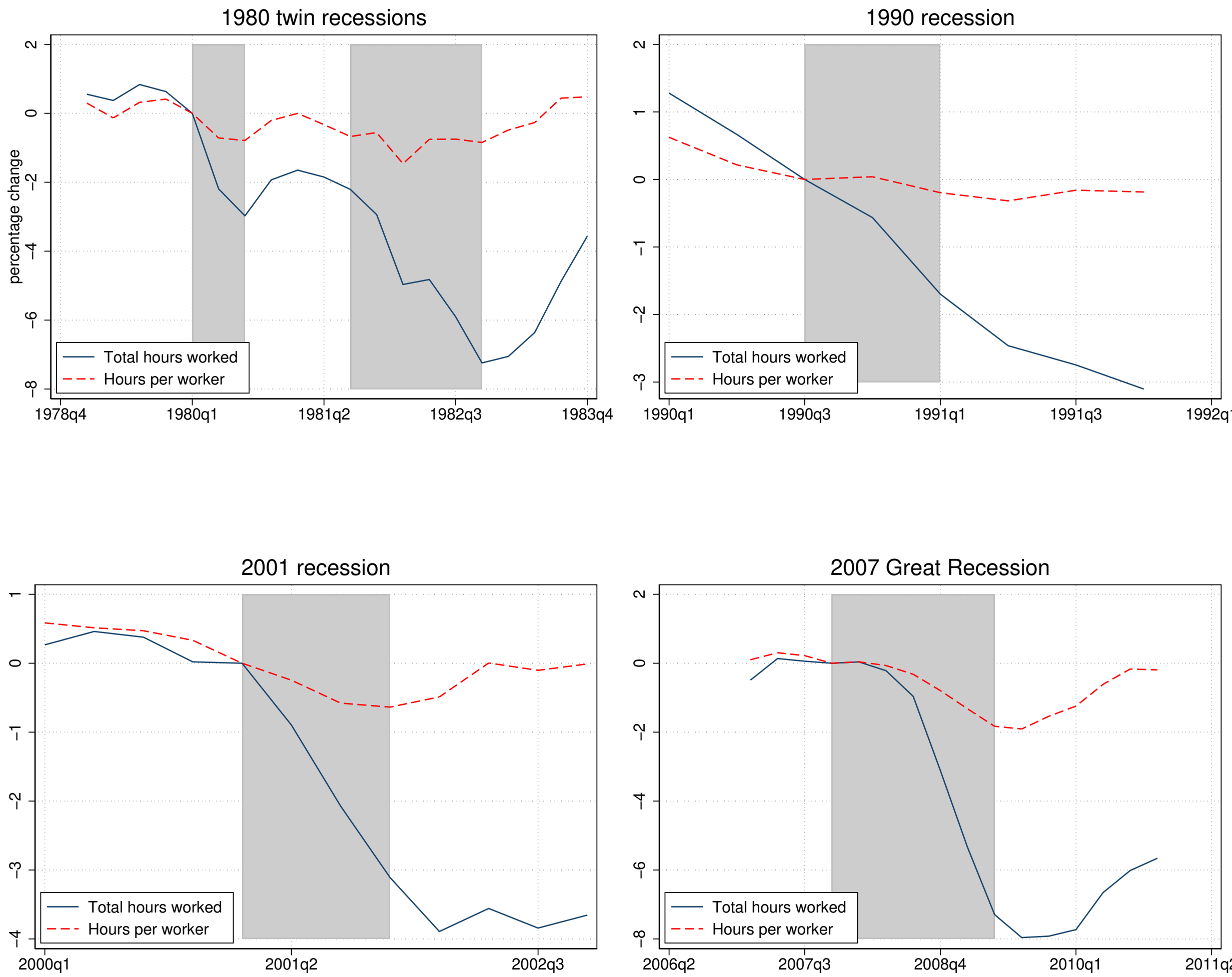
Peak-to-trough changes are HP-filtered log deviations from NBER peak quarter to trough quarter for each recession. Total hours and hours per worker series are logged and calculated after HP-filtering the data with a smoothing parameter of 1600. Total hours are defined as an employment level multiplied by the average weekly hours worked per worker.

Table 1: Peak-to-trough changes in hours

3.2 Job Tenure and Full-Time/Part-Time Transitions

Using the Current Population Survey (CPS) monthly survey, I measure monthly unemployment inflow rates utilizing its rotating panel structure. It repeats the findings from previous research of Fujita (2018) and Molloy et al. (2016) that the unemployment inflow rates and job

[1]The filtering methods include Hodrick-Prescott, Baxter-King, and Hamilton filters

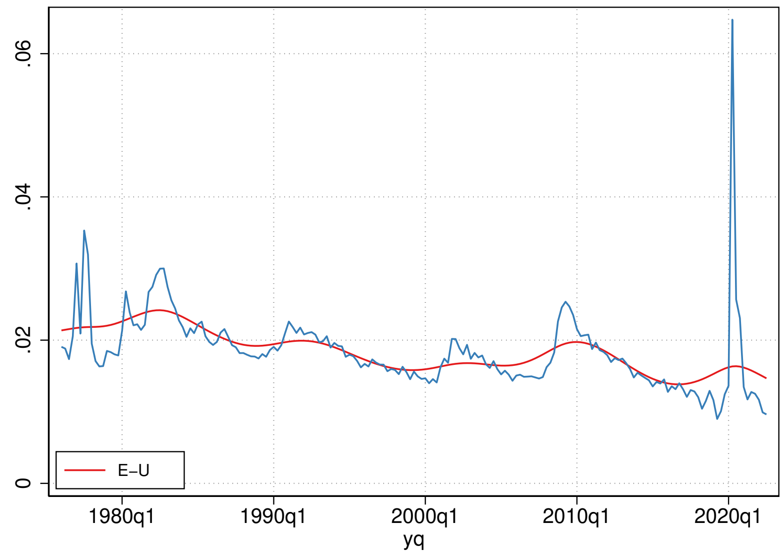


Peak-to-trough changes are HP-filtered log deviations from NBER peak quarter to trough quarter for each recession. The log deviation is normalized to 0 at the onset of each recession. All series are in percentage change relative to the peak quarter before the recession.

Figure 1: Peak-to-trough changes in hours

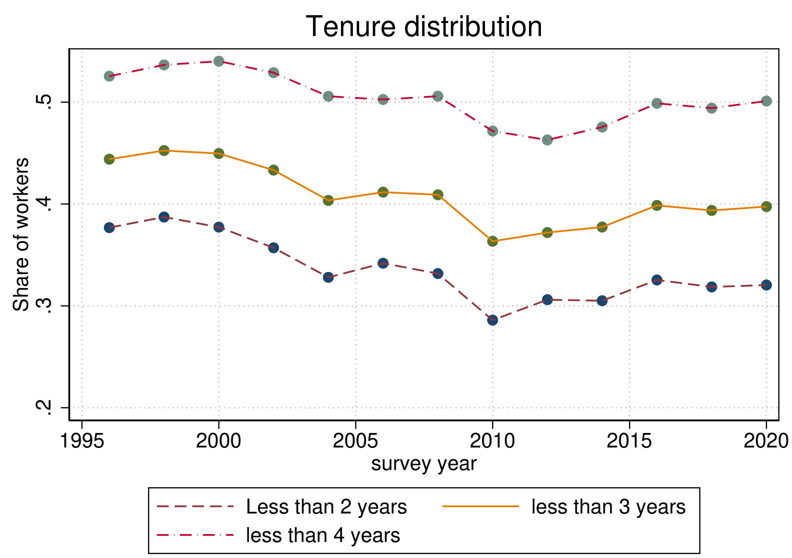
destruction rates have been on a secular decline since the 1980s. Before 2000, the monthly unemployment inflow rates have been on average 2.1% but it decreased to 1.6% after 2000.

Another dimension of the secular change in the labor market is the decline in the short-duration job. Naturally, workers would stay in their jobs longer if they were less likely to be separated from them. Therefore, the right shift in job tenure distribution is a mirror image of declining job separation rates. Figure 2 shows that unemployment inflow rates have been steadily declining. The decline in unemployment inflow rates has been concentrated in low-tenure workers (Pries and Rogerson (2022)). Figure 3 confirms this trend suggesting that the job tenure distribution has been on a secular right shift. Moreover, the decline in the



The monthly labor market flows are aggregated into the quarterly levels. The sample includes workers in age 16-64 working for private-sector employers. The trend is calculated using an HP filter with parameter 1600.

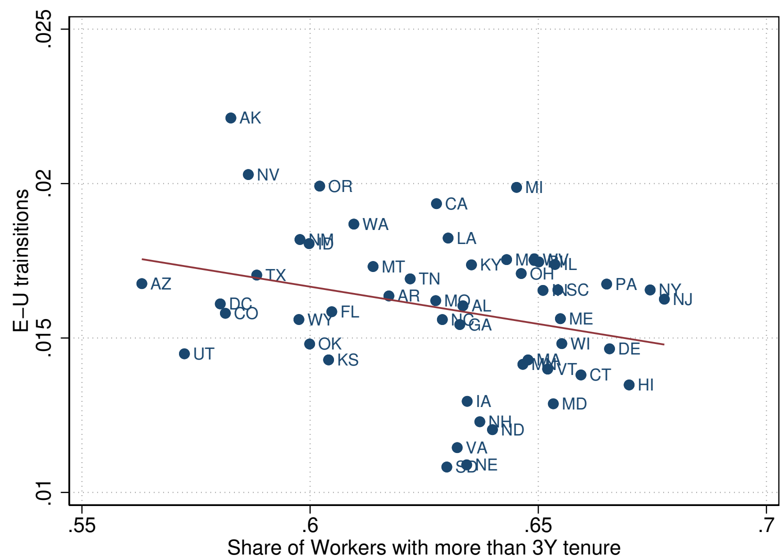
Figure 2: Employment to unemployment flow rates



The sample includes workers in age 16-64 working for private sector employers in the CPS Job Tenure Supplement.

Figure 3: Job tenure distribution

share of workers with less than two years of job tenure has driven this trend. Over the years, the labor market has been filled with workers with more job-specific human capital.



E-U rates are averaged for years when Job Tenure Supplement data is available.

Figure 4: State-level E-U rates and share of workers with more than 3 years

State-level data also repeat the pattern of the decrease in job separation rates and the right shift in tenure distribution across time. Figure 4 shows the negative relationship between average unemployment inflow rates in each state and its share of workers with more than two years of job tenure. In states with higher labor turnover, fewer workers stay in the same job for a given period[2].

One caveat with the CPS Job Tenure Supplement is that it started in 1996, which does not give the complete picture of the change in job tenure distribution in the 1980s. [3] Alternatively, I exploit within-state variations in job tenure distribution to measure the relationship between job tenure and labor adjustments. Here, I run the following regression.

$$\begin{aligned} \log y_{it} = {} & \beta_1 \log U_{it} \cdot \log T_{it} + \beta_2 \log U_{it} + \beta_3 \log T_{it} \\ & + \beta_4 X_{it} + \lambda_i + \lambda_t + \varepsilon_{it} \end{aligned}$$

where y_{it} is the yearly average of monthly transition probabilities of each state for years when the job tenure data is available [4]. State-level unemployment rates are denoted as U_{it}, and the share of workers with more than two years of tenure within the state is denoted as

[2]This relationship holds with alternative measures of job tenure such as the share of workers with more than three years of job tenure or the average length of tenure

[3]1983 and 1987 job tenure supplement exist, but it was fielded as part of ob Tenure/Occupation Mobility and Training Supplement and under a different sample universe.

[4]Job tenure data is available biannually starting from 1996. CPS Job Tenure Supplement survey was conducted in February until 2000 and January starting from 2002

T_{it}. The main coefficient of interest is β_1 which measures how differently the business cycle (U_{it}) affects labor market flows y_{it} depending on the state-level job tenure distribution (T_{it}). I control for state and year-fixed effects. I also include control (X_{it}) for average age, the share of female workers, and years of education.

I consider two dependent variables: full-time to part-time (F-P) and employment to unemployment transitions (E-U). The former represents intensive margin adjustments while the latter represents extensive margin adjustments[5]. β_2 measures the elasticity of labor flows with respect to state unemployment rates U_{it}. This elasticity is positive for both F-P and E-U flows, which means that they go up in recessions. The estimated signs of the main coefficient β_1 are the opposite between the dependent variable F-P and E-U transitions meaning the job tenure distribution has contrasting effects to the above-mentioned elasticities. In table 2, the positive β_1 for columns (1) and (2) implies that a 1 percent increase in the share of high-tenure workers within states is associated with a 0.47 percent increased elasticity of F-P flows with respect to unemployment rates. Conversely, a 1 percent increase in the share of high-tenure workers is associated with a 0.7 percent decreased elasticity of E-U flows with respect to unemployment rates according to column (3) and 0.3 percent according to column (4)[6]. This state-level evidence shows that the increase in job tenure is related to increased use of the FT to PT transitions in recessions. Conversely, the increase in job tenure is related to the decreased use of job separation rates.

To solve a concern that the labor market fluctuation might move the job tenure distribution in the short term and bias the estimates, I additionally report the result with an instrument variable in table 3[7]. I use the sum of the number of births at the state 20-30 years earlier and use that as an instrument variable for the share of high-tenure workers. The identifying assumption here is that the lagged birth rate is not affected by the current labor market conditions. Compared to the OLS estimates, the change of elasticities with regard to the increased share of high-tenure workers is steeper for both the FT-to-PT and employment-to-unemployment flows.

[5] Borowczyk-Martins and Lalé (2019) have shown that change in the number of part-time workers accounts for a large part of hours per worker change. More than half of the change comes from transitions between full-time and part-time positions. Also, over 90 percent of these transitions happen within the same employer

[6] Using job destruction rates from Quarterly Workforce Indicator (QWI) instead of job separation rates also similarly show negative β_1 coeffcients

[7] Engbom (2023) uses the lagged birth rate variable as an instrument variable for the local labor market age composition while I use it for the tenure length composition.

	(1) F-P	(2) F-P	(3) E-U	(4) E-U
Unem. x more than 2y	0.465**	0.437*	-0.701	-0.252
	(0.174)	(0.186)	(0.366)	(0.286)
Unem.	0.402***	0.3387***	0.571***	0.597***
	(0.0568)	(0.0644)	(0.124)	(0.106)
more than 2y	1.317*	1.427*	-3.697**	-0.987
	(0.554)	(0.599)	(1.114)	(0.860)
Controls	Y	Y	Y	Y
State FE	Y	Y	Y	Y
Time FE	N	Y	N	Y
N	663	663	663	663
adj. R^2	0.487	0.523	0.659	0.866

Standard errors in parentheses

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

Labor market flow of each state is aggregated into annual frequency. The measure of job tenure is the share of workers in each state with greater than or equal to 2 years of job tenure. I cluster standard errors at the state level.

Table 2: Job tenure and labor market flows across states

	(1) F-P	(2) F-P	(3) E-U	(4) E-U
Unem. x more than 2y	2.610**	3.685**	-2.915	-0.394
	(1.217)	(1.686)	(1.820)	(1.076)
Unem.	1.001**	1.378**	-0.118	0.538
	(0.400)	(0.574)	(0.607)	(0.362)
more than 2y	9.898***	13.90***	-10.82**	-1.230
	(3.801)	(5.203)	(5.459)	(3.648)
N	612	612	612	612
F-stat	199.16	234.78	199.16	234.78

Standard errors in parentheses

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

I report F-statistics for first-stage regressions with the interaction term as a dependent variable. Labor market flow of each state is aggregated into annual frequency. The measure of job tenure is the share of workers in each state with greater than or equal to 2 years of job tenure. I cluster standard errors at the state level.

Table 3: Job tenure and labor market flows across states with an instrument variable

4 Search and Matching Model with Part-Time Workers

I have shown two empirical facts. Firstly, I found that the hours per worker decrease contributed more to the total hours decrease in post-2000 recessions than in recessions before 2000 from the aggregate data. One of the most pronounced changes in the labor market in the last four decades was the steady decline in unemployment inflow rates. Because of this, there has been an increase in job-specific human capital, which is observed as a right shift in job tenure distribution. Using the within-state variation, I found that this right shift is related to the increased use of intensive margin adjustments in recessions.

In this section, I quantitatively examine the hypothesis that the improvement in initial match productivities led to the increased use of intensive margin adjustments in recessions[8]. I built a search and matching model with part-time workers to add intensive margin adjustments to the standard Diamond-Mortensen-Pissarides (DMP) model (Mortensen and Pissarides (1994)). Moreover, I add job-specific human capital accumulation and on-the-job search to consider that intensive margin adjustments preserve job-specific human capital, unlike extensive margin adjustments. Then, I calibrate the model in the pre-2000 economy and estimate the size of the initial match productivity improvements to replicate the decline in job separation rates in the data. After that, I compare the response of the pre-2000 and post-2000 economies to aggregate productivity shocks.

4.1 Environment

I build a random search model with counter-cyclical part-time rates where workers accumulate job-specific human capital and on-the-job search. Time is discrete in monthly frequency. Workers either have low or high human capital ($h^h > 1$ or $h^l = 1$). Every match starts from a low human capital level and can exogenously attain high human capital with a fixed monthly probability (ϵ). High human capital workers lose their job-specific human capital once they lose their job or move to another job.

Each worker draws match-specific productivity (x_t) that follows an AR(1) process from its stationary distribution. As Gomis-Porqueras and Griffy (2020), there is a constant overhead cost for each match, and full-time positions pay a higher amount compared to part-time positions ($T_p < T_f$). Figure A.2 suggests that such cost exists. However, the yearly frequency of observation does not allow for investigating the overhead cost change related to hours

[8] Even though it is hard to measure the individual-level productivity, the initial wage of new employees has been in an increasing trend starting from 1996. I show this result in table A.1

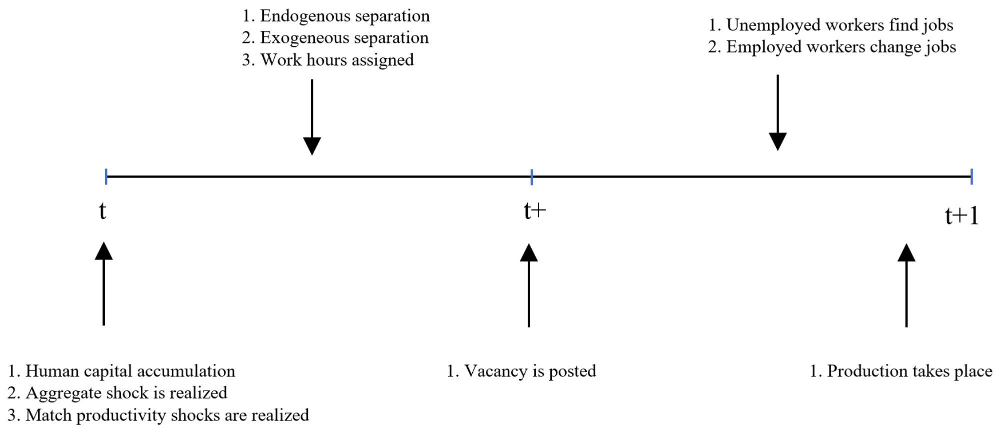


Figure 5: Timing of events

worked the change. At the same time, part-time workers produce less amount of goods than their full-time counterparts ($H^{pt} < H^{ft}$). It leads to sorting low-match productivity workers into part-time positions. Workers get an opportunity to draw the match-specific productivity again once they contact a poaching firm and move if their expected surplus is higher than their current one. Workers can be separated either exogenously or endogenously. The endogenous separation thresholds move counter-cyclically, and the aggregate productivity (z_t) also follows an AR(1) process as standard in endogenous separation literature (Mueller (2017) and Moscarini and Postel-Vinay (2018)).

There are a few assumptions that make this model tractable. Firstly, match formation and destruction are efficient. Workers leave their match once they find a match that gives them a higher surplus. Also, firms are assumed to make state contingent and counter offers to workers. Lastly, the incumbent and the poaching firm engage in Bertrand competition following Lise and Robin (2017) to ensure tractability.

At the start of the period, human capital accumulates exogenously. Then, the aggregate Z_t and match-specific productivities X_t are realized. After that, exogenous separations happen with probability δ, and the remaining workers are subject to endogenous separations depending on their realized productivity. Among those who survived the separations, workers below the part-time threshold work only part-time. After observing the allocation of workers of that period, firms post their vacancies, and matching occurs. Finally, they produce after unemployed and employed workers find new jobs.

4.2 Value Functions

4.2.1 Unemployed Value Function

$$
\begin{aligned}
U_t &= b + \beta\mathbb{E}\big[[\underbrace{(1-\lambda_{t+1})}_{\text{Fail job search}} U_{t+1} + \lambda_{t+1}\int max\{U_{t+1}, \quad \underbrace{W_{t+1}(x_{t+1})}_{\text{Offer to the unemployed}} \quad \}d\Gamma(x)\big|z_t\big] \\
&= b + \beta\mathbb{E}\big[U_{t+1}\big|z_t\big]
\end{aligned}
$$

The flow value of unemployment is b and time-invariant. The probability of an unemployed worker finding a vacancy at period $t+1$ is denoted as λ_{t+1}. Conditional on finding a job offer, an unemployed worker takes the job if it gives higher value than staying unemployed. Let $W_{t+1}(x_{t+1})$ be the value offered to the unemployed worker by a match of productivity x_{t+1}. $U_{t+1} = W_{t+1}(x_{t+1})$ holds because it is assumed that firms have all the bargaining power. Firms extract all the rent from unemployed workers, making them indifferent between employment and unemployment. $\Gamma(x)$ is a stationary distribution of x_t.

4.2.2 Joint Value Function

$$
\begin{aligned}
J_t^j(x_t) &= \max\{J_t^{ft,j}(x_t), J_t^{pt,j}(x_t)\} \\
&\quad \text{where } \eta \in \{\underbrace{ft}_{\text{Full-time}}, \underbrace{pt}_{\text{Part-time}}\} \text{ and } j \in \{\underbrace{l}_{\text{Low-type}}, \underbrace{h}_{\text{High-type}}\}
\end{aligned}
$$

The joint value function is a sum of the job's value for the worker and the firm. Therefore, the wage does not appear in the equation. The joint value function takes the maximum value between the match's value in a full-time and part-time position. The value depends on the aggregate productivity z_t, match specific productivity x_t, and human capital $j \in \{l, h\}$.

$$
\begin{aligned}
J_t^{\eta,j}(x_t) &= z_t \cdot H^\eta \cdot x_t \cdot h^j - T^\eta \\
&\quad + \beta \sum_{j'=l,h} p^{jj'} \cdot \mathbb{E}\Big[\underbrace{(1-(1-\delta)\mathbf{1}\{J_{t+1}^{j'}(x') \geq U_{t+1}\})}_{\text{Exo. and endo. sep.}} \cdot U_{t+1} \\
&\quad + (1-\delta)\mathbf{1}\{J_{t+1}^{j'}(x') \geq U_{t+1}\}\Big(\underbrace{(1-s\lambda_{t+1})}_{\text{fail OJS}} J_{t+1}^{j'}(x') \\
&\quad + s\lambda_{t+1}\int max\{J_{t+1}^{j'}(x'), \quad \underbrace{W_{t+1}(x',y)}_{\text{Offer from firm with prod. } y} \quad \}d\Gamma(y)\Big)\Big|z_t, x_t\Big]
\end{aligned}
$$

Each match produces a product of aggregate productivity z_t, hours worked H^η, match productivity x_t, and human capital h^j minus match maintenance cost T_η at period t. In the next period, the match either 1. dissolves due to an exogenous or endogenous separation, 2. fails to find a new employer, 3. or succeeds on-the-job search.

For workers who succeed in on-the-job search, if $J^l_{t+1}(y) >= J^{j'}_{t+1}(x')$, because of the Bertrand competition assumption, the poaching firm does not offer higher value than the incumbent firm. Thus, $W_{t+1}(x', y) = J^{j'}_{t+1}(x')$ holds and worker moves to firm with productivity y. If $J^l_{t+1}(y) < J^{j'}_{t+1}(x')$, the worker does not move and keep the current value $J^{j'}_{t+1}(x')$. So, $max\{J^{j'}_{t+1}(x'), W_{t+1}(x', y)\} = J^{j'}_{t+1}(x')$ for all y holds. Therefore, it is simplified as below.

$$
\begin{aligned}
J^j_t(x_t) = {} & z_t \cdot H^\eta \cdot x_t \cdot h^j - T^\eta \\
& + \beta \sum_{j'=l,h} p^{jj'} \cdot \mathbb{E}\Big[(1 - (1-\delta)\mathbf{1}\{J^{j'}_{t+1}(x') \geq U_{t+1}\}) \cdot U_{t+1} \\
& + (1-\delta)\mathbf{1}\{J^{j'}_{t+1}(x') \geq U_{t+1}\} J^{j'}_{t+1}(x') \Big| z_t, x_t \Big]
\end{aligned}
$$

The human capital accumulation $p^{jj'}$ follows the process below. Each period, an employed worker with low human capital h^l becomes a worker with high human capital h^h with exogenous probability ϵ conditional on staying at the same employer. Once the human capital is gained, the employee does not lose the human capital, and it only disappears once the worker moves to another employer or loses the job.

$$
p^{jj'} = \begin{cases} \epsilon & \text{if } j = l \text{ and } j' = h \\ 1-\epsilon & \text{if } j = l \text{ and } j' = l \\ 1 & \text{if } j = h \text{ and } j' = h \\ 0 & \text{if } j = h \text{ and } j' = l \end{cases}
$$

4.2.3 Surplus Function

The surplus function is a joint value subtracted by the unemployed value, which characterizes worker-firm matches' mobility and hours worked decisions. After some algebra, the surplus functions are simplified as below.

$$
\begin{aligned}
S_t^{\eta,l}(x_t) &= z_t \cdot H^\eta \cdot x_t \cdot h^l - T^\eta - b \\
&\quad + \beta(1-\epsilon)(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^l(x'), 0\} | z_t, x_t\big] \\
&\quad + \beta\epsilon(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x'), 0\} | z_t, x_t\big] \\
S_t^{\eta,h}(x_t) &= z_t \cdot H^\eta \cdot x_t \cdot h^h - T^\eta - b \\
&\quad + \beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x'), 0\} | z_t, x_t\big]
\end{aligned}
$$

Then, endogenous separation and part-time thresholds are given by

$$
\begin{aligned}
S_t^{ft,l}(\hat{\hat{x}}^l) &= S_t^{pt,l}(\hat{\hat{x}}^l) \\
S_t^{pt,l}(\hat{x}^l) &= 0 \\
S_t^{ft,h}(\hat{\hat{x}}^h) &= S_t^{pt,h}(\hat{\hat{x}}^h) \\
S_t^{pt,h}(\hat{x}^h) &= 0
\end{aligned}
$$

The surplus from a match at time t depends on time only through the TFP z_t and match-specific productivities x_t. It does not depend on the distributions of human capital, unemployed workers, or employed workers. For low productivity matches under threshold $\hat{\hat{x}}^l$ ($\hat{\hat{x}}^l$ for high human capital workers), it is more beneficial to work part-time and save overhead costs than to work full-time and pay high overhead costs. This is because the range of productivity that gives higher value in part-time positions is wider when the aggregate productivity is low.

4.2.4 Vacancy Posting

$$
\begin{aligned}
V_t = -\kappa + q_t \Bigg[& P(u_{t+}) \int \max\{ \underbrace{S_t^l(x_t)}_{\text{Surplus of hiring unemployed worker with prod. } x_t}, 0\} d\Gamma(x_t) \\
& + P(e_{t+}) \sum_{j=l,h} \int \int_{\hat{x}^j} \max\{ \underbrace{S_t^l(y) - S_t^j(x_t)}_{\text{Surplus of hiring prod. } y \text{ worker from prod. } x_t \text{ position}}, 0\} L_{t+}(x,j) dx d\Gamma(y) \Bigg| z_t \Bigg]
\end{aligned}
$$

Vacant firms pay vacancy post κ. The vacancy is filled with probability q_t. New matches always possess low human capital, including those who job-to-job transitioned to new positions. $\Gamma(\cdot)$ is stationary distribution of match-specific productivity, $L_t(x, j)$ is share of workers with productivity x and human capital j at period t. Period $t+$ denotes a time in period t after endogenous job separations and FT-PT transitions happened and before search and matching take place.

$$
\begin{aligned}
P(u_{t+}) &= \frac{u_{t+}}{s} \\
P(e_{t+}) &= \frac{s \cdot \sum_{j=l,h} \int_{\hat{x}} L_{t+}(x,j)dx}{s}
\end{aligned}
$$

$P(u_{t+})$ denotes a probability that the vacancy is filled with an unemployed job searcher, and $P(e_{t+})$ denotes a probability that the vacancy is filled with an employed job searcher.

$$
\begin{aligned}
u_{t+} = u_t + \sum_{j=l,h} \int \left[\mathbf{1}\left\{ S_t^j(x) < 0 \right\} + \delta \mathbf{1}\left\{ S_t^j(x) \geq 0 \right\} \right] L_t(x,j)dx \\
L_{t+}(x,l) = (1-\delta)\mathbf{1}\left\{ S_t(x) \geq 0 \right\} L_t(x,l) \\
L_{t+}(x,h) = (1-\delta)\mathbf{1}\left\{ S_t(x) \geq 0 \right\} L_t(x,h)
\end{aligned}
$$

The unemployed search pool (u_{t+}) consists of unemployed workers at the start of the period t and workers who are newly separated at the start of period t. The employed search pool ($L_{t+}(x,l)$ and $L_{t+}(x,h)$) consists of employed workers who survived exogenous and endogenous job separations at period t. Here, I assume a free-entry condition. Therefore, the expected value of posting vacancy is the same as κ.

4.2.5 Matching Function

While unemployed workers' relative contact probability with a poaching firm is normalized to 1, part-time and full-time workers meet a poaching firm with a probability of $s < 1$. Market tightness is defined as

$$
\theta_t \equiv \frac{v_t}{s_t}
$$

where

$$
s_t = u_{t+} + s \sum_{j=l,h} \int_{\hat{x}} L_{t+}(x,j)
$$

Then, I assume a standard matching function with match efficiency normalized to 1 and can define job-finding rates and vacancy-filling rates as

$$
\begin{aligned}
M_t &= s_t^{\nu} v_t^{(1-\nu)} \\
\lambda_t &= \frac{M_t}{s_t} \\
q_t &= \frac{M_t}{v_t}
\end{aligned}
$$

4.2.6 Law of Motion

$$
\begin{aligned}
u_{t+1} &= u_{t+} \left[1 - \int \lambda_t \mathbf{1}\{S_t^l(x) \geq 0\} d\Gamma(x) \right] \\
L_{t+1}(x', l) &= \pi(x'|x) \int \left[(1-\epsilon) L_{t+}(x, l) \left[1 - s \int \lambda_t \mathbf{1}\{S_t^l(y) > S_t^l(x)\} d\Gamma(y) \right] \right. \\
&\quad \left. + \sum_{j=l,h} \int s \lambda_t \mathbf{1}\{S_t^l(x) > S_t^j(y)\} L_{t+}(y, j) dy \right] dx \\
&\quad + u_{t+} \lambda_t \Gamma(x) \\
L_{t+1}(x', h) &= \pi(x'|x) \int \left[L_{t+}(x, h) \left[1 - s \int \lambda_t \mathbf{1}\{S_t^l(y) > S_t^h(x)\} d\Gamma(y) \right] \right. \\
&\quad \left. + \epsilon L_{t+}(x, l) \left[1 - s \int \lambda_t \mathbf{1}\{S_t^l(y) > S_t^h(x)\} d\Gamma(y) \right] \right] dx \\
p_{t+1} &= \sum_{j=l,h} \int_{\hat{x}}^{\hat{\hat{x}}} L_{t+1}(x, j) dx \\
f_{t+1} &= \sum_{j=l,h} \int_{\hat{\hat{x}}} L_{t+1}(x, j) dx
\end{aligned}
$$

When unemployed searchers fail their job search, they start as unemployed workers in the next period. If they succeed search, they start as a low human capital worker. When a low human capital worker stays in the same job, they accumulate human capital with exogenous probability ϵ. When workers succeed in on-the-job searches, they start again as low human capital workers.

4.2.7 Stochastic Equilibrium

1. For given $\{b, \beta, \delta, h^l, h^h, \epsilon, H^{pt}, H^{ft}, T^{pt}, T^{ft}\}$ and stochastic process of $\{z_t, x_t\}$, the surplus function $S^{\eta,j}(x)$ is sufficient to determine all decisions regarding worker mobility and work hours

2. For a given distribution $\Gamma(x)$ where match-specific productivity x is drawn from, vacancy cost κ, and meeting technology $M(s, V)$; and for any given initial share of unemployed workers u_o and match productivity distribution $L_0(x, j)$, a sequence of market tightness, unemployed workers, and worker-firm matches $\{\theta_t, u_{t+1}, L_{t+1}\}_{t=0}^{T}$ can be calculated by using the surplus function, given sequence of $\{z_t\}_{t=0}^{T}$ and match-specific process for each match

4.2.8 Calibration Procedure

For Aggregate productivity and match productivity grids, I picked 101 values with each maximum and minimum grid set at 4 standard deviations apart from 1. Then, I approximated the AR(1) process with the Tauchen process. As shown in table 4, I externally calibrate the flow value of unemployment b as 0.7 following Mortensen and Éva Nagypál (2007). The model is estimated in monthly frequency, and the matching elasticity ν is set at 0.5, which is from micro studies. The TFP process is AR(1) in log, and the persistence of the process ρ_z and the standard deviation of the shock ϵ_z follow Hagedorn and Manovskii (2008). The probability of exogenous separation δ is fixed at 2%. The hours worked by part-time workers H^{pt} is normalized at 1, and that of full-time workers H^{ft} is estimated using CPS actual weekly hours worked. The human capital accumulation takes on average 2 years, conditional on staying in the same employer. The relative productivity of high human capital workers h^h are from the estimated return to 2 years of job tenure estimated by Buchinsky et al. (2010) where the low-type productivity h^l is normalized as 1.

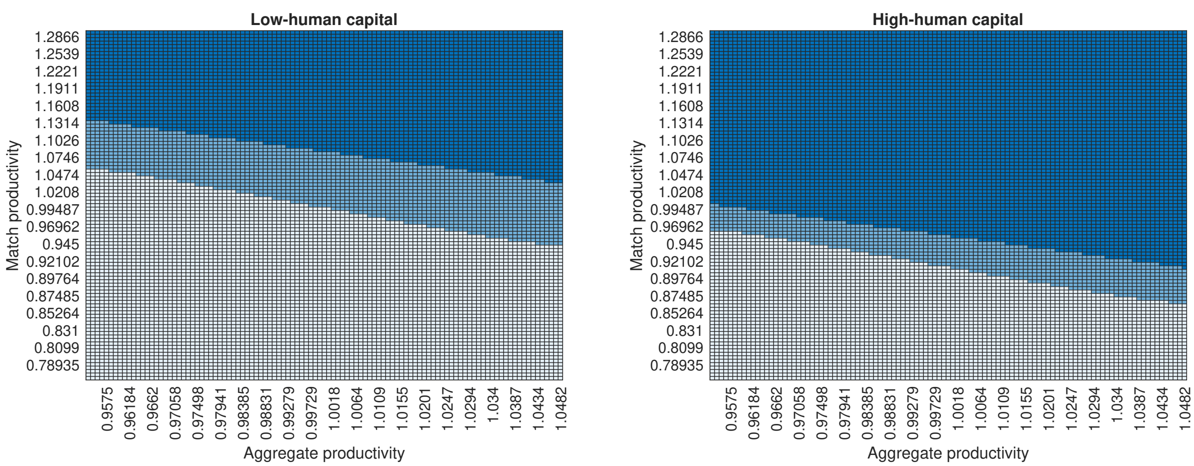
Then, I have 6 different parameters left to estimate and use 6 first moments from data to pin them down. I structurally estimate the model using the simulated method of moments (SMM) that matches labor market stocks and flows from the CPS. The internal calibration is conducted in two different levels of loops. Since the number of parameters and target moments are the same, parameters are just identified. The estimation result is shown in table 5.

1. For each iteration, on-the-job search intensity s and vacancy posting cost κ are estimated to match job-to-job transition rates and job-finding rates. It is possible to separate this step because the surplus function is solved without these two parameters.

	External calibration	
Parameter	Value (and source)	Description
b	0.7 (Mortensen and Éva Nagypál (2007))	Flow value of unem.
β	0.9966 (Monthly frequency)	Discount factor
ν	0.5	Matching elasticity
ρ_z	0.94 (Hagedorn and Manovskii (2008))	TFP persistence
ε_z	0.0034 (Hagedorn and Manovskii (2008))	TFP S.D.
δ	0.02	Exo. sep.
H^{ft}	2.067 (Current Population Survey)	Full-time hours
H^{pt}	1 (Normalized)	Part-time hours
ϵ	$\frac{1}{24}$ (2 years to accumulate human capital)	Upgrade prob.
h^h	1.134 (Buchinsky et al. (2010))	High-type productivity
h^l	1 (Normalized)	Low-type productivity

Table 4: External calibration

2. Then, overhead costs (T_f and T_p) and match productivity process parameters (ρ_x and ϵ_x) are jointly estimated to match average part-time rates, job separation rates, full-time to part-time transition rates, and part-time to full-time transition rates in the 1980-2000 period



When the combination of aggregate productivity and match productivity lies in the bottom area, workers are endogenously separated. When in the middle, employees work part-time hours.

Figure 6: Policy functions for low- and high-type workers

The resulting policy functions are shown in figure 6. For each human capital type, there are two match productivity thresholds for a given aggregate productivity. Low-type workers face higher intensive- and extensive- margin thresholds than high-type workers. If the match productivity lies in the lower area, the match is endogenously separated. If the match productivity lies in the middle area, the worker works for part-time hours. When the

	Internal calibration	
Parameter	Value	Description
T_f	1.67	Full-time overhead cost
T_p	0.51	Part-time overhead cost
ρ_x	0.974	Match productivity persistence
ε_x	0.029	Match productivity S.D.
s	0.375	OJS intensity
κ	0.5273	Vacancy cost
	Model moments	Data moments
mean(PR)	0.174	0.170
mean(E-U)	0.0212	0.0213
mean(P-F)	0.2128	0.2204
mean(F-P)	0.0407	0.0430
mean(J-J)	0.0263	0.028
mean(U-E)	0.3705	0.3698

Table 5: Internal calibration

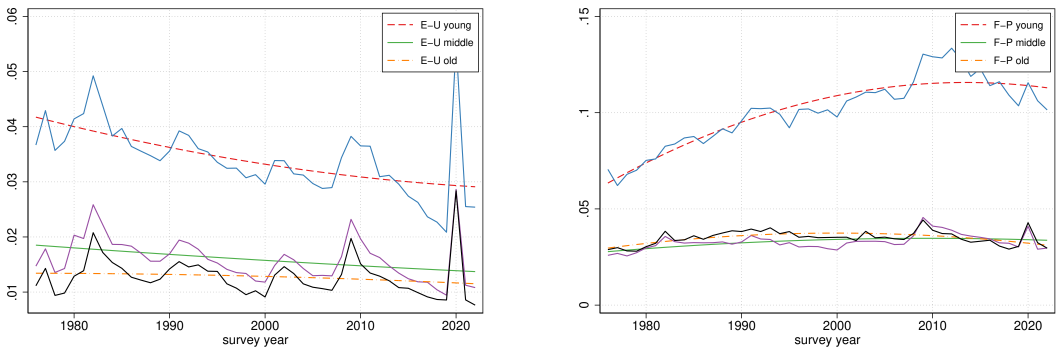
match productivity lies in the upper area, the worker works for full-time hours. Comparing low- and high-human capital thresholds, high-human capital thresholds are lower for both separation thresholds and part-time transition thresholds. It implies that once human capital is accumulated, workers are likely to work full-time hours even when the aggregate and match productivities are low, thanks to their high human capital. Moreover, for a set of productivities where the low-type workers would have been separated, high-type workers stay in the match as part-time workers.

4.3 Improvments in Initial Match Productivities

When it comes to the size of the decrease in unemployment inflow rates, young workers show the steepest decline over the years compared to prime-aged and old workers (-17% vs. -12% vs. -5%) as shown in figure 7. In contrast, young workers' full-time to part-time rates have increased the most (30% vs. 12% vs. 1%). This trend implies that young workers new to the labor market are more likely to find matches with a better fit than in the past. In the following section, I estimate the size of the shift in initial match productivity distribution that replicates the extent of the decline in job separation rates in the data.

4.3.1 Estimating the Change in Initial Match Productivities

The baseline model is calibrated to the pre-2000 data moments. Before 2000, monthly job separations were on average 2.1%. In this section, I estimate the size of the improvement in



Young: 16-24, Middle: 25-54, Old: 55-64

Aggregated into annual frequency from CPS monthly data

Figure 7: Trends in labor turnover by age group

	Internal calibration	
Parameter	Value	Description
μ	12	Improvement in initial match prod. (%)
T_p	0.4886	Part-time overhead cost
s	0.25	OJS intensity
κ	2.8906	Vacancy cost
	Model moments	Data moments
mean(PR)	0.1707	0.170
mean(E-U)	0.0169	0.0167
mean(J-J)	0.0271	0.028
mean(U-E)	0.3637	0.3698

Table 6: Calibration to the post-2000 economy

initial match productivities needed to replicate the decline in job separation rates to 1.6%. For the baseline model, the initial match productivity distribution $\Gamma(x)$ was the stationary distribution of the match productivity process. I shift the distribution μ% to the right without changing the variance of the distribution. Since any change in $\Gamma(x)$ does not affect the policy function, the right shift results in fewer part-time workers. Because the part-time rates have been stable across the periods, I recalibrate the overhead cost T_p to keep the part-time rates at 17% as in the data[9].

The estimation result in table 6 shows that a 12% increase in initial match productivities can replicate the decrease in job separation rates. Since the improvement in initial match productivities makes posting vacancies more attractive, vacancy posting cost increased to

[9]Without recalibrating the part-time overhead cost, the part-time rate goes down to below 10%. The main finding that the relative importance of intensive margin adjustments has increased still holds without recalibrating T_p

Parameter	Q1 Sep.	Q2 Sep.	Q3+ Sep.
Initial Productivities (Δ)	0.76%p	0.29%p	-0.01%p
Exogenous Separations (Δ)	0.04%p	0.08%p	0.14%p
Return to Tenure (Δ)	0.27%p	0.12%p	0.03%p
Data (Δ)	0.48%p	0.25%p	0.13%p

The change in job separation rate of each tenure group is defined as the change in the average monthly unemployment inflow rate of 3000 months of simulated periods.

Table 7: Decline in monthly job separation rates by tenure group

σ	Pre-2000	Post-2000
Model	0.861	0.973
Data	0.493	0.643

Each series of data is logged and HP-filtered with parameter 1600. For the model, data is logged without any filter because the model data is stationary. Using filters for model-generated data does not change the result significantly.

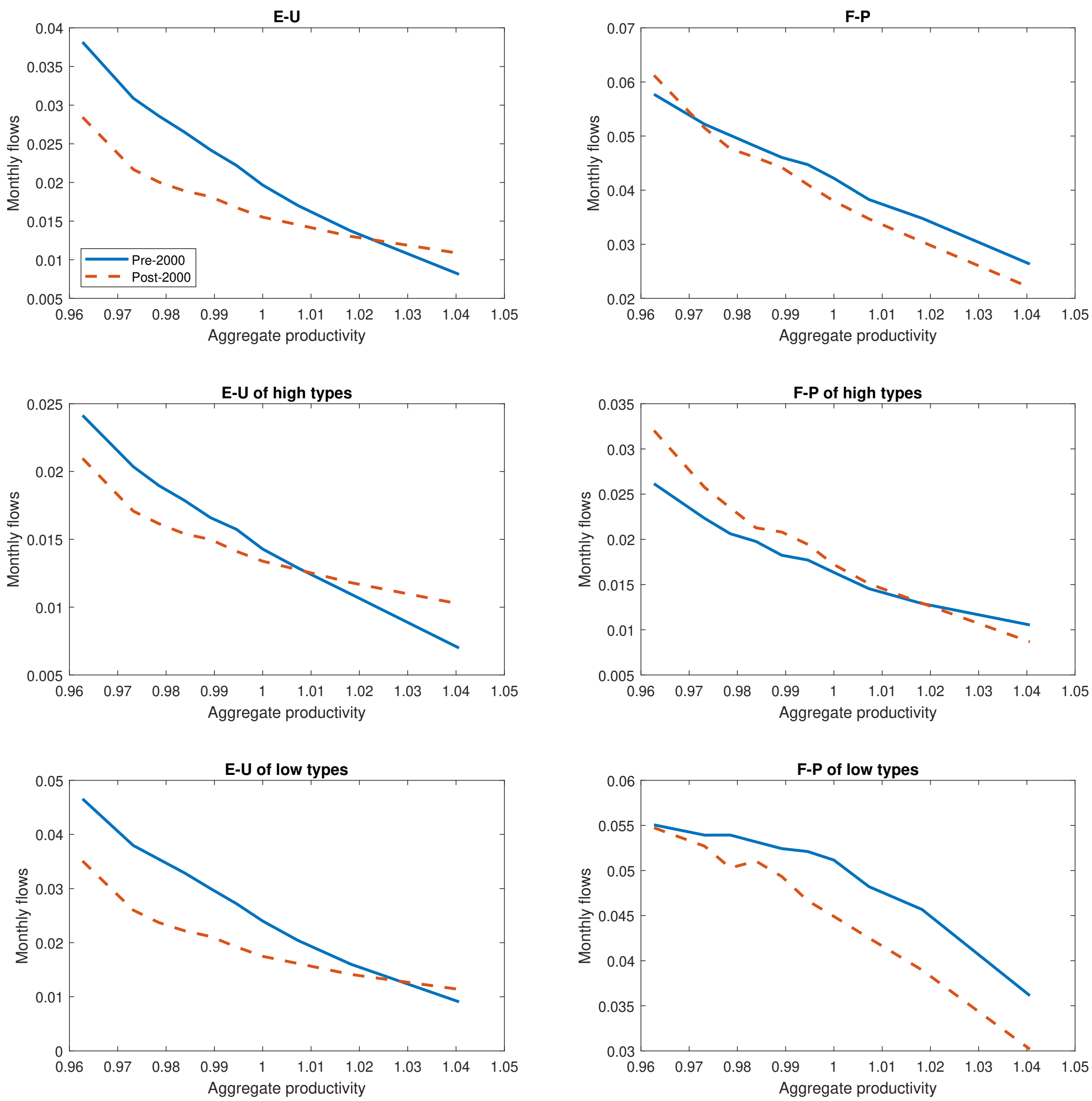
Table 8: Correlation between total hours and hours per worker

hold the hiring rates at a steady level at 36%. Because of the improved match productivity, job seekers and employers are more likely to form a match once they meet each other. The increased vacancy posting costs can be interpreted as the increased cost for recruiting firms to find better-quality job seekers. On the other hand, the estimated on-the-job search intensity decreased to keep the job-to-job transition rates at a 2.7% level since new jobs are now more attractive to incumbent workers. Similarly, this lower intensity of employed workers' job search activity can be interpreted as the worker-side cost of finding better-quality vacancies.

Table 7 report the change in job separation rates for each job tenure group of workers. The first column shows the change in the tenure profile of job separation rates with the improved initial match productivity. The second and third rows each show the change from the decline in exogenous separation rates and improvement in the return to tenure. Since the job-separation rates of short-tenure workers decreased the most in the data as shown in the fourth row, the hypothesis of the improved initial match productivities seems plausible. This corroborates the result of Pries and Rogerson (2022) where they showed that about half of the job separation decrease came from lower job separation of workers with less than a quarter of tenure.

Across the simulated periods, the correlation between logged hours per worker and total hours variables is higher in the model calibrated to the post-2000 economy than that to the pre-2000 economy as shown in table 8. In logged and then HP-filtered aggregate data, the correlation went up by 15%p. In the model counterpart, it went up by 12%p.

4.3.2 Cyclical Properties of the Pre-2000 and Post-2000 Economies



X-axis denotes 10 deciles of realized aggregate productivities along the simulation. The y-axis denotes the realized average monthly labor market flows in the given aggregate productivity decile.

Figure 8: Cyclicality of E-U and F-P transitions

In figure 8, I show the labor market flows in 10 deciles of realized aggregate productivities for two different calibrations. The slope of job separation rates is steeper for the pre-2000 calibration regarding aggregate productivity, which means that the counter-cyclicality of job separation rates is higher. It confirms that job separation is more cyclical in the pre-2000 (low job separation) economy compared to the post-2000 (high job separation) economy. For the full-time to part-time transition rates reported in the second column of figure 8, however, the post-2000 calibration shows higher counter-cyclicality. For the post-2000 economy, FT to PT transitions play a more significant role in recessions. Another noticeable difference is that the F-P transition rates in recessions are higher in the post-2000 economy compared to the pre-2000 economy only for high-type workers. Therefore, the increased use of intensive margin adjustments is pronounced for high-type workers highlighting its increased role in human capital preservation.

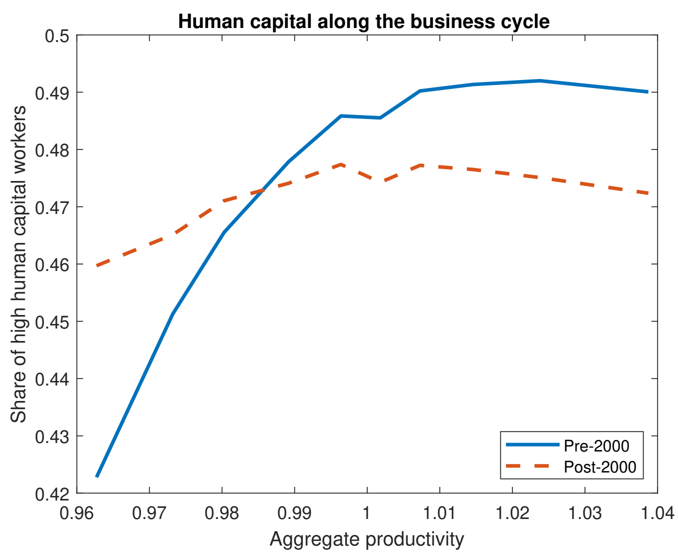


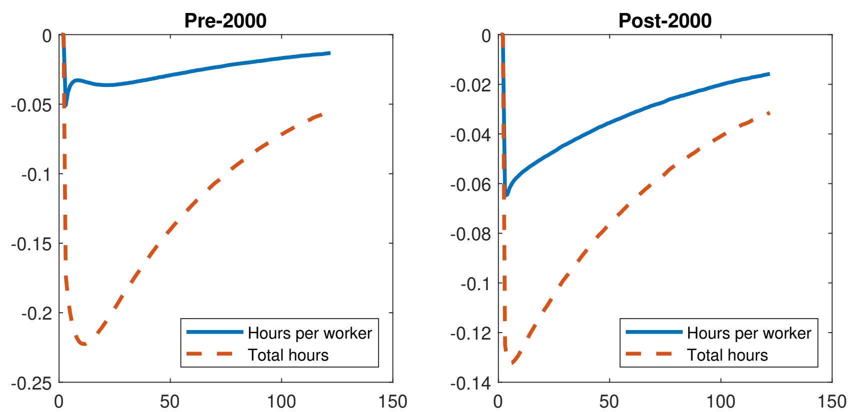
Figure 9: The Cyclicality of the aggregate human capital

X-axis denotes 10 deciles of realized aggregate productivities along the simulation. The y-axis denotes the share of high-human capital workers in the economy in the given aggregate productivity decile.

To observe how the pre-2000 and post-2000 economies perform differently in preserving and destroying human capital in recessions, I calculate the average share of high-human capital workers in the simulated economy in 10 deciles of realized aggregate productivities in figure 9. With the pre-2000 calibration, the amount of human capital fluctuates cyclically because high-type workers are more likely to be separated when aggregate productivities are low as shown in figure 8. In contrast, the cyclicality of human capital is significantly lower with the post-2000 calibration, meaning that the increased use of intensive margin adjustments serves to preserve human capital in recessions.

In figure 10, I compare the impulse response of economies with different rates of labor turnover with regards to a two standard deviation negative aggregate productivity shock[10]. Specifically, I compare the importance of intensive margin adjustments in economies with an average job separation rate of 2.1% (pre-2000) with those with 1.6% (post-2000). I compute simulation-based generalized impulse response functions (GIRF) due to the nonlinearity of the model (Koop et al. (1996))[11]. I simulate the response for 120-month periods for each economy.

In the high job separation economy, the total hours worked decreased by more than 20% with a negative productivity shock in the trough. The hours per worker decreased by about 5%. In contrast, the total hours worked decreased only 13% in the low job separation economy, but the hours per worker decreased more than 6% in response to the same size of negative productivity shock. It implies that the improvement in initial match productivity led the economy to rely more on hours-per-worker adjustments in economic downturns.



Log deviations from the stochastic steady-state with regards to a negative 2 standard-deviation aggregate productivity shock for 120 months

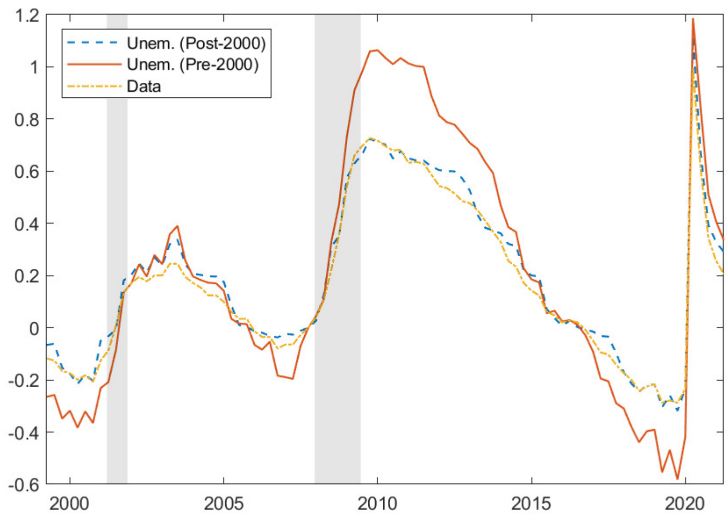
Figure 10: Impulse response function of hours per worker and total hours

Moreover, I retrieve the process of the aggregate productivity that replicates unemployment rates from the data in order to compare the labor market responses to an identical series of aggregate productivity shocks in two different economies in figure 11. I first find a series of aggregate productivities z_t that replicates the time series of unemployment rates in the post-2000 period with the post-2000 calibration. Then, using the same sequence of aggregate productivities, I simulate the unemployment rates with the pre-2000 calibration.

In Figure 11, the unemployment rates in the post-2000 economy closely follow the actual unemployment rates from the data since I targeted the data directly when retrieving the series of z_t. The solid line simulates unemployment rates with the pre-2000 calibration using

[10] The response to a positive shock is shown in appendix

[11] I document the computation of GIRFs in the appendix



Log deviations from the peak quarter before the Great Recession. The aggregate productivities are selected to match the unemployment rates from the post-2000 calibration economy to the actual data.

Figure 11: Simulated unemployment rates

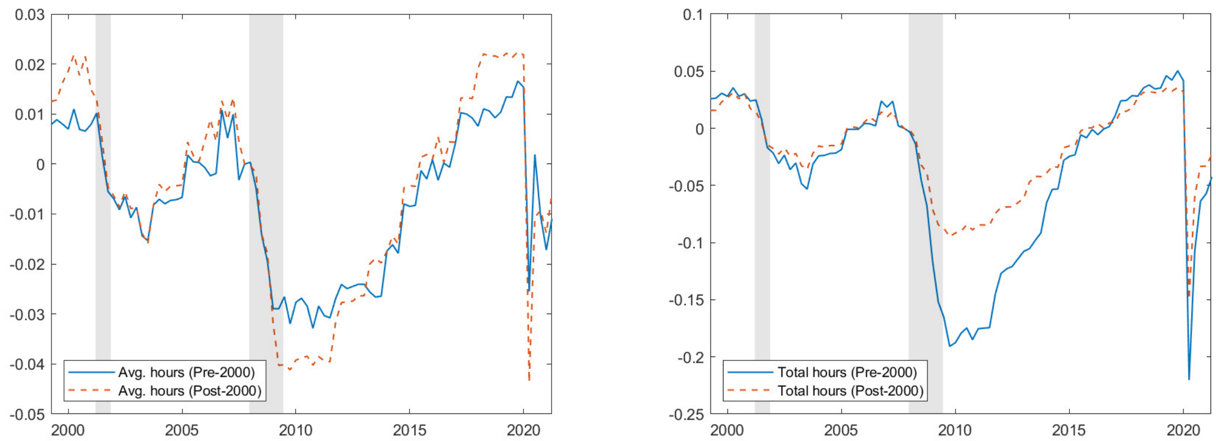
the same sequence of z_t. The significant difference is that the unemployment rates are much more volatile with the pre-2000 calibration. Even though we cannot observe how the low labor turnover economy would have behaved in the post-2000 period directly, feeding in the retrieved aggregate productivity process shows drastically different unemployment dynamics compared to the high labor turnover economy. The unemployment volatility is much higher in a low turnover economy, and unemployment rates also soar to a higher level at the trough of the Great Recession.

	Total Hours	Hours per worker	Hour share
Pre-2000	19.08%	3.20%	16.75%
Post-2000	9.48%	4.12%	43.41%
Exo. sep.	14.4%	3.39%	23.56%
Return to ten.	10.41%	2.73%	26.26%

Peak-to-trough changes are log deviations from NBER peak quarter to trough quarter for the Great Recession. Total hours and hours per worker series are logged from the simulated data. Total hours are defined as an employment level multiplied by the average weekly hours worked per worker.

Table 9: Simulated peak-to-trough changes in the Great Recession

In figure 12, I continue with the same productivity process from figure 11 but now focus on hours decomposition. In contrast to the result in unemployment rates, the responses of hours per worker were more volatile for the post-2000 economy compared to the pre-2000



Log deviations from the peak quarter before the Great Recession. The aggregate productivities are selected to match the unemployment rates from the post-2000 calibration economy to the actual data. The aggregate productivity is the same as in figure 11.

Figure 12: Simulated hours per worker and total hours change in the Great Recession

economy for the same series of the aggregate productivity process. Here, I can conduct the same decomposition as table 1 and calculate the contribution of hours per worker change to the total hours change from the peak to trough. With the pre-2000 calibration, the hours per worker decreased by 3.2% and total hours decreased by 19%, implying that the hours per worker share accounted for 16.75% of the total hour decline. For post-2000 calibration, the hours per worker decreased 4.1% and total hours decreased 9.4%, indicating that the hours per worker share was 43% as summarized in table 9.[12] The most significant difference between these two simulations of data is that the volatility of hours per worker is larger, but that of total hours is smaller with the post-2000 calibration than the pre-2000 calibration for the same sequence of aggregate productivity[13].

[12] Alternative calibrations using the change in the exogenous separation rate or the return to tenure did not generate a change as large as the one using the initial match productivities as a driving factor. These results are each shown in the 3rd and 4th rows in table 9. Additionally, I have simulated an economy without any human capital accumulation $h^h = h^l = 1$. The improvement in initial match productivity in that special case did not show as much increase in the importance of intensive margin adjustments in the simulated great recession.

[13] See figure C.4 for direct comparison of figure 12

5 Effects of Short-Time Compensation on Unemployment Volatility

Short-time compensation (STC) is a labor market policy that encourages retaining full-time workers with reduced hours instead of separating them when firms and workers want to adjust their labor input. With STC, employers reduce the hours and pay of workers. The government makes up for all or part of the lost wages due to reduced hours. Since STC helps firms hoard their existing labor, firms would apply for STC if workers are too costly to lose because they have human capital or high match productivity.

In the US, however, the STC take-up rates have been very low, and only 1% of the initial UI claims were STC benefits (Krolikowski and Weixel (2020)). Therefore, I use my model to simulate the successful promotion of the STC and evaluate how effective STC is at stabilizing unemployment volatility. When comparing cost-equivalent policies of STC in the model, STC gains its relative strength in economies where labor turnover is less prevalent. The post-2000 economy has a higher share of workers with accumulated human capital that benefits from STC in economic downturns.

With STC, there are two different part-time positions. One is part-time workers subsidized by STC, and the other is unsubsidized part-time workers. Once the worker works for a full-time schedule, the worker is eligible for STC and gets a fixed amount of subsidy once the worker is moved to part-time positions. Subsidized workers become ineligible with an exogenous probability of 1/6 each month, reflecting that the eligibility expires in 26 weeks in states with STC policy. Workers who are just hired in part-time positions and job-to-job transitioned to part-time jobs are not eligible for STC. With this design, STC subsidizes within-firm F-P transitions to preserve job-specific human capital in recessions. I assume the acyclical subsidy is financed by the government through non-distortionary taxes.[14]

$$\begin{aligned} S_t^{p,h}(x_t, 1) = {} & z_t \cdot H^{pt} \cdot x_t \cdot h^h - T^{pt} - b + Subsidy \\ & + \frac{5}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x', \underbrace{1}_{\text{STC eligible}})\}|z_t, x_t\big] \\ & + \frac{1}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x', \underbrace{0}_{\text{STC ineligible}})\}|z_t, x_t\big]^{15} \end{aligned}$$

Table 10 summarizes the change in unemployment level and volatility due to the inception

[14] Gomis-Porqueras and Griffy (2020) explore part-time subsidy schemes under the same assumption on how the subsidy is financed. The main difference between their experiment and mine is I subsidize only the transitions from full-time to part-time transitions as is the case with STC policy while they subsidize part-time positions in general.

		U		$\sigma(\log(\text{U}))$	
Pre-2000	Baseline	0.0729		0.7924	
	STC	0.0487	(-33.2%)	0.7713	(-2.7%)
Post-2000	Baseline	0.0527		0.4426	
	STC	0.0389	(-26.2%)	0.3790	(-14.4%)

The volatility of unemployment is the standard deviation of logged monthly unemployment rates from the simulated data.

Table 10: The change in level and volatility of unemployment rates due to STC

of STC. The volatility of unemployment is defined as a standard deviation of unemployment rates in log. For the pre-2000 economy, the amount of subsidy is set to raise the part-time rate to 30%. Then the amount of subsidy for the post-2000 economy is set to be cost-equivalent in both economies[16]. STC reduces the level and volatility of unemployment rates as shown in the first column for both cases. The most significant difference comes from its effects on volatility. For a low-turnover economy, STC decreases the unemployment volatility by 14% while it is only 2.7% for a high-turnover economy.

The reason why the unemployment volatility reduces more for the post-2000 economy is that the reduction in the cyclicality of hiring rates is more significant in the low labor turnover economy than the high labor turnover one. As shown in figure 9, there are more low human capital workers in recessions for the high labor turnover economy. Since the low human capital workers are a close substitute to the unemployed workers, unemployed workers face higher competition once employed workers are subsidized with the short-time compensation. This crowding out effect from implementing STC is not as significant for the low labor turnover economy, leading the cyclicality of hiring rates to go down further.[17]

However, the successful reduction in the unemployment volatility for a low labor turnover economy comes at a cost. The aggregate value added decreased with the implementation of STC in both low and high-labor turnover economies. For the pre-2000 economy, the value-added decreased by 8.3 percent while it decreased by 10.5 percent for the post-2000 economy. This is because STC reduces the efficiency by hindering labor reallocation via unemployment and the reallocation is more efficient in the post-2000 economy because of the improved initial match productivity of job searchers.

For the pre-2000 economy, I record the change in the cyclicality of E-U and F-P flows

[16]The subsidy value is 0.07 and 0.071 respectively for the pre-2000 and post-2000 calibrations. The subsidy value itself is very similar for both economies.

[17]The change in the cyclicality of unemployment rates after introducing STC could be decomposed into the change unemployment inflow rates, unemployment outflow rates, and steady-state unemployment rates following Elsby et al. (2009). The most significant difference in these changes between the pre and post-2000 periods was coming from the change in unemployment outflow rates.

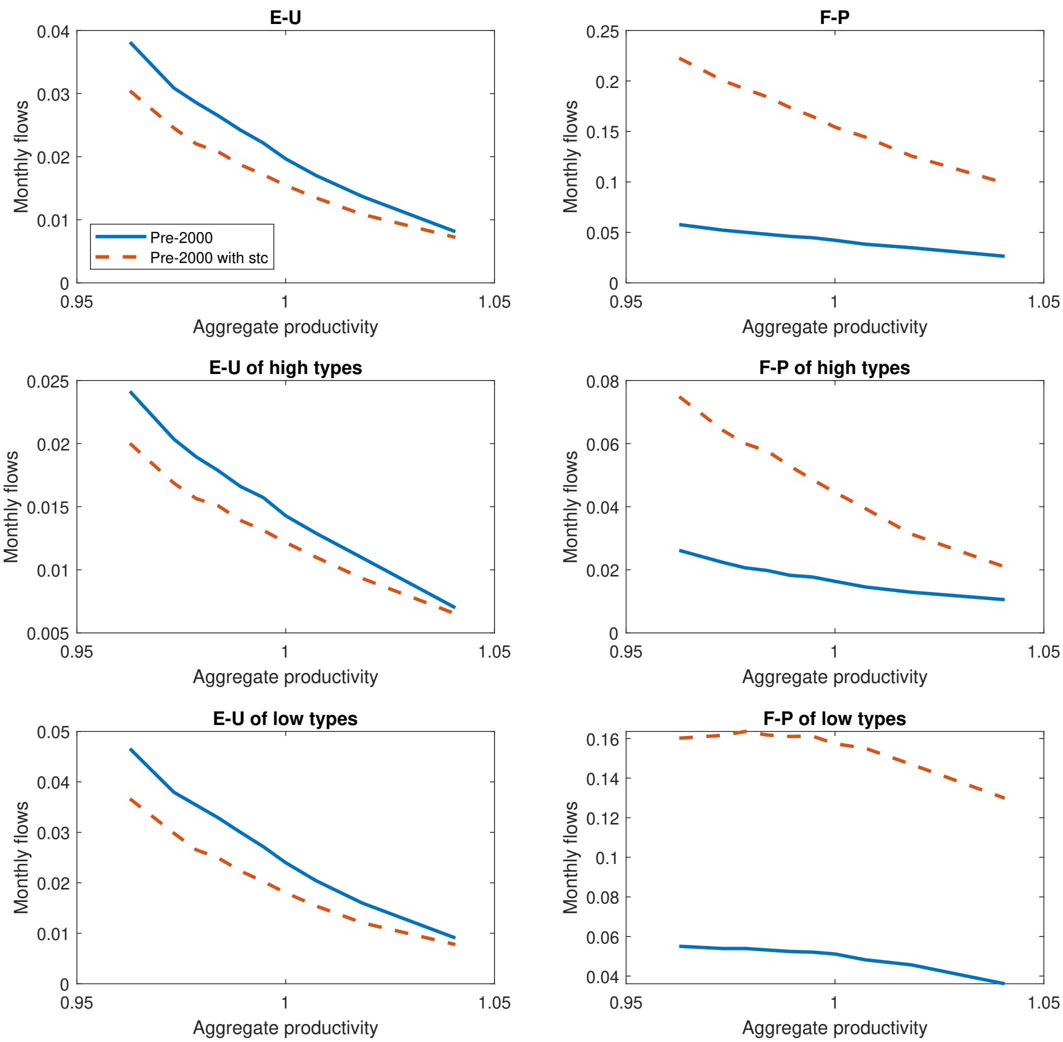


Figure 13: Monthly flows with and without STC

after introducing STC into the model in figure 13 [18]. As expected, the slope of E-U flows against aggregate productivity is gentler with STC policies. However, the slope of F-P flows is steeper with STC policies. Successful STC policy implementation would encourage using F-P transitions in recessions instead of E-U transitions.

With the sequence of aggregate productivity from figure 11, I simulate the unemployment rates. Then, starting from 1948, I simulate the log deviation of the unemployment rates. Figure 14 echoes the finding from table 10 that the inception of STC reduces unemployment volatility only for a low-turnover economy with the post-2000 calibration.

[18]For the post-2000 economy, see figure C.5

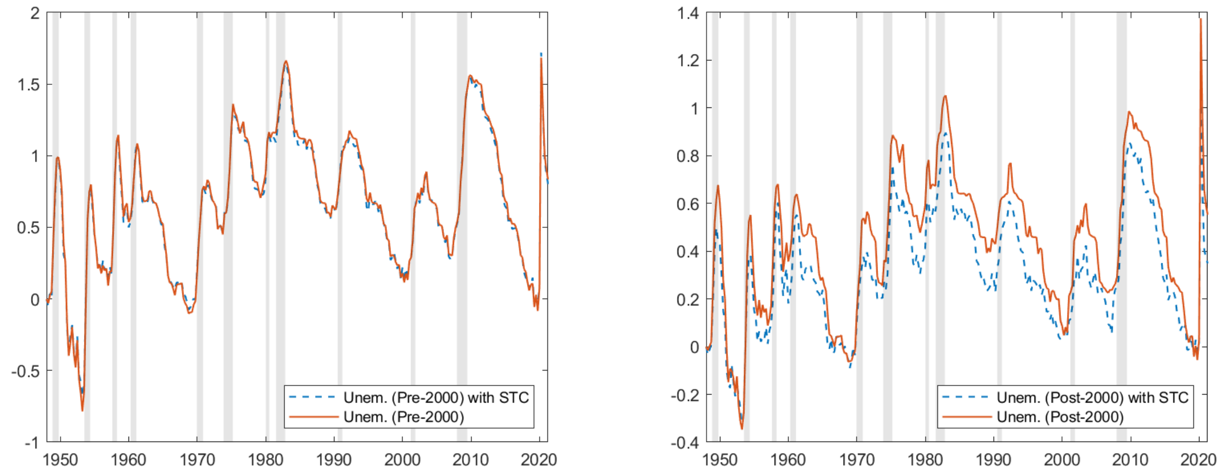


Figure 14: Simulated unemployment rates with STC

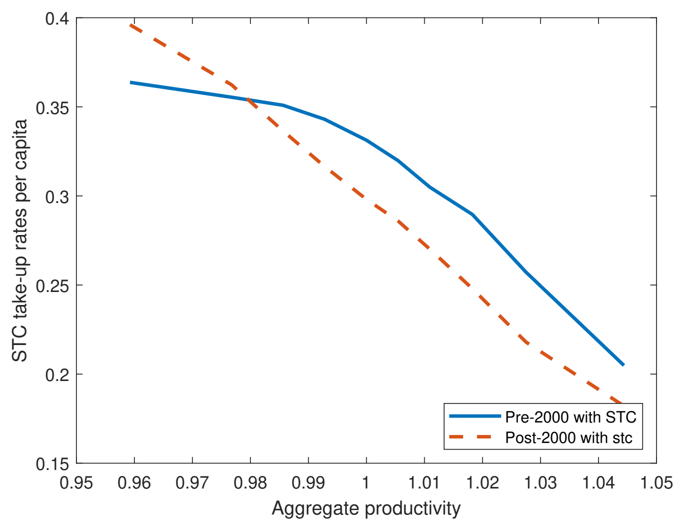


Figure 15: STC take-up rates

Figure 15 shows that the cyclicality of STC take-up rates is much steeper in the post-2000 economy. It means that the stabilization effects of STC are more substantial in the low labor turnover economy. This finding is repeated in the right figure of figure 14 that the difference in the series of unemployment rates with and without STC tends to be more prominent in recessions than in booms.

6 Conclusion

There is growing literature of research showing that the US economy is becoming less dynamic over time. In the labor market, a secular decline in job separation rates for the last four decades is one of the most prominent phenomena of reduced dynamism. A recent strand of literature focuses on the possibility that the development in information technology has led workers and firms to form better matches and caused the secular decline in unemployment inflow rates. In this paper, I have claimed that the improvement in match quality caused firms and workers to use more intensive margin adjustments in recessions. The primary mechanism behind it is that a better job match accrues job-specific human capital with its longer job tenure. In order to avoid losing human capital, firms and matches use relatively more intensive margin adjustments instead of separating workers in economic downturns. It suggests that the reduced dynamism has led intensive margin adjustments to play a more prominent role in recessions than before.

I add three model features of part-time work, on-the-job search, and human capital accumulation to the standard DMP model with match-specific productivity and endogenous separations. This model allows me to simulate the policy experiment of successfully implementing the Short-time compensation (STC) scheme in the US economy and take the human capital preserving purpose of the policy into account. The policy is more effective in reducing unemployment volatility in a high initial match productivity and low job separation economy than in a high job separation economy. It implies that STC policy stabilizes the labor market against negative productivity shocks, especially well in an economy with low labor turnover rates, and keeps its job-specific human capital.

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A Empirics

Table A.1 shows the change in the wage of new employees compared to the incumbent employees. For the dependent variable, I use the log-transformed real wage. Here, I define new workers as workers who have less than one year of job tenure. The sample here includes private sector non-self-employed workers between the ages of 16 to 64 who are in the CPS job tenure supplement from 1996 to 2020. Compared to incumbent workers, new hires tend to earn 10 percent lower wages after controlling age, sex, marital status, citizenship, industry, and occupation. However, the gap has been decreased 0.12 percent each year according to the regression.

	(1) Log wage
Year x New hire	0.00121**
	(0.000472)
New hire	-0.109***
	(0.00595)
Year	0.00510***
	(0.000220)
N	133808
adj. R^2	0.463

Standard errors in parentheses
* p¡0.10, ** p¡0.05, *** p¡0.010

Table A.1: The decrease in wage gap between new and incumbent workers

I additionally compare the incidence of FT (PT) to unemployment transitions and FT-PT transitions using individual-level job tenure data. In Table A.4, I run logit regressions using individual-level transition incidence as dependent variables and confirm that high-tenure workers are less likely to go through E-U or F-P transitions. Furthermore, the decrease in hazard rate along the tenure is much steeper for F-P flows. It implies that while high-tenure workers are less likely to either get hours reduced or separated, the relative probability of hours reduction is higher than separation compared to low-tenure workers.

Figure A.1 shows the trend in monthly probabilities of employment/unemployment and full-time/part-time transitions. Panel (a) shows that there has been a decline in unemployment inflow rates (E-U) while panel (b) shows an increase in full-time to part-time (F-P) probabilities.

	(1) F-P	(2) F-P	(3) F-P	(4) F-P	(5) F-P	(6) F-P
Unem. x more than 1y	0.539**	0.407				
	(0.240)	(0.250)				
Unem. x more than 3y			0.357**	0.327*		
			(0.163)	(0.175)		
Unem. x more than 5y					0.035	-0.016
					(0.125)	(0.126)
Unem.	0.357***	0.325***	0.400***	0.380***	0.272***	0.223**
	(0.048)	(0.052)	(0.070)	(0.078)	(0.088)	(0.094)
more than 1y	1.430*	1.212				
	(0.763)	(0.797)				
more than 3y			1.017*	1.108*		
			(0.515)	(0.556)		
more than 5y					0.046	0.071
					(0.381)	(0.382)
Time FE	N	Y	N	Y	N	Y
N	663	663	663	663	663	663
adj. R^2	0.486	0.520	0.485	0.523	0.481	0.521

Standard errors in parentheses

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

Table A.2: Cylicality of F-P rates by tenure distribution

	(1) E-U	(2) E-U	(3) E-U	(4) E-U	(5) E-U	(6) E-U
Unem. x more than 1y	-0.795*	-0.474				
	(0.440)	(0.391)				
Unem. x more than 3y			-0.836***	-0.344		
			(0.286)	(0.229)		
Unem. x more than 5y					-0.560**	-0.239
					(0.275)	(0.174)
Unem.	0.624***	0.581***	0.434***	0.536***	0.367*	0.509***
	(0.090)	(0.095)	(0.126)	(0.109)	(0.195)	(0.130)
more than 1y	-4.037***	-1.667				
	(1.315)	(1.122)				
more than 3y			-3.890***	-1.338*		
			(0.858)	(0.684)		
more than 5y					-2.524***	-0.844
					(0.880)	(0.531)
Time FE	N	Y	N	Y	N	Y
N	663	663	663	663	663	663
adj. R^2	0.647	0.867	0.661	0.868	0.649	0.867

Standard errors in parentheses

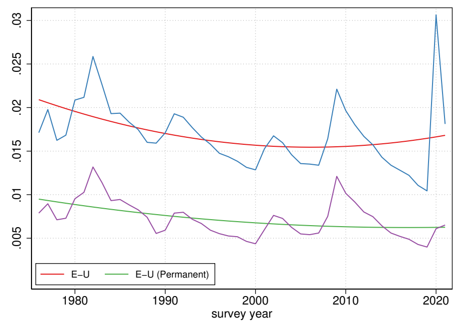
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A.3: Cylicality of E-U rates by tenure distribution

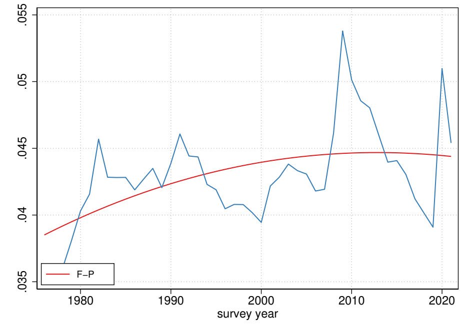
	E-U	F-P	P-F
Tenure (year)	-0.100***	-0.031***	0.015***
	(0.003)	(0.001)	(0.001)
Age	-0.049***	-0.191***	0.174***
	(0.006)	(0.004)	(0.004)
Age^2	0.001***	0.002***	-0.002***
	(0.000)	(0.000)	(0.000)
Education (year)	-0.016***	-0.014***	-0.004***
	(0.001)	(0.000)	(0.000)
Female	-0.295***	0.592***	-0.696***
	(0.026)	(0.016)	(0.018)
R-squared	0.052	0.046	0.04
N	490538	403637	86901

* p<0.05, ** p<0.01, ***p<0.001

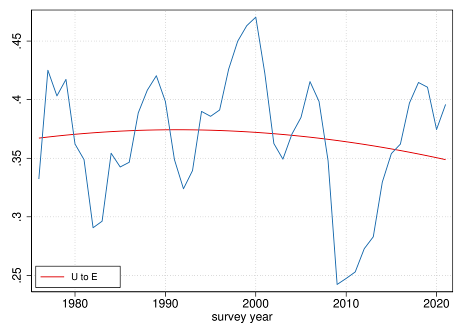
Table A.4: Job tenure and labor market flows



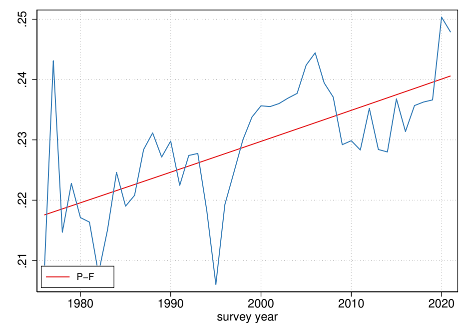
(a) Employment to unemployment



(b) Full-time to part-time



(c) Unemployment to employment



(d) Part-time to Full-time

Figure A.1: Trend in Labor Market Flows

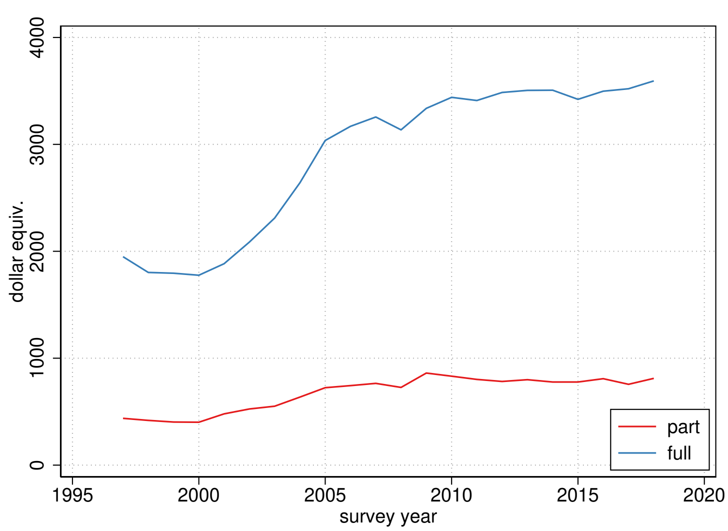


Figure A.2: Acyclical cost of match

Dollar values of employer contribution to health insurance from ASEC march supplement.

B Derivations

B.1 Surplus function

$$
\begin{aligned}
S_t^j(x) &= \max\{S_t^{ft,j}(x), S_t^{pt,j}(x)]\\
S_t^{\eta,j}(x) &= J_t^{\eta,j}(x) - U_t\\
&= z_t \cdot H^\eta \cdot x_t \cdot H^j - T^\eta - b\\
&+ \beta \sum_{j'=l,h} p^{jj'} \cdot \mathbb{E}\Big[(1-(1-\delta)\mathbf{1}\{J_{t+1}^{j'}(x') \geq U_{t+1}\}) \cdot U_{t+1}\\
&+ (1-\delta)\mathbf{1}\{J_{t+1}^{j'}(x') \geq U_{t+1}\} J_{t+1}^{j'}(x') - U_{t+1}\Big| z_t, x_t\Big]\\
&= z_t \cdot H^\eta \cdot x_t \cdot H^j - T^\eta - b\\
&+ \beta(1-\delta) \sum_{j'=l,h} p^{jj'} \cdot \mathbb{E}\Big[\mathbf{1}\{J_{t+1}^{j'}(x') \geq U_{t+1}\}(J_{t+1}^{j'}(x') - U_{t+1})\Big| z_t, x_t\Big]\\
&= z_t \cdot H^\eta \cdot x_t \cdot H^j - T^\eta - b\\
&+ \beta(1-\delta) \sum_{j'=l,h} p^{jj'} \cdot \mathbb{E}\big[\max\{S_{t+1}^{j'}(x'), 0\}\big| z_t, x_t\big]
\end{aligned}
$$

B.2 STC for low-type workers

$$
\begin{aligned}
S_t^{p,l}(x_t, 1) = z_t &\cdot H^{pt} \cdot x_t \cdot h^h - T^{pt} - b + Subsidy\\
&+ \epsilon\Big[\frac{5}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x', 1)\}|z_t, x_t\big]\\
&+ \frac{1}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^h(x', 0)\}|z_t, x_t\big]\Big]\\
&+ (1-\epsilon)\Big[\frac{5}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^l(x', 1)\}|z_t, x_t\big]\\
&+ \frac{1}{6}\beta(1-\delta) \cdot \mathbb{E}\big[\max\{S_{t+1}^l(x', 0)\}|z_t, x_t\big]\Big]
\end{aligned}
$$

C Quantitative Exercises

C.1 Generalized Impulse Response Functions

To compute the generalized impulse response functions, I follow Koop et al. (1996) as below.

1. For the first 120 months, I hold the aggregate productivity at 1 and simulate the model to make it reach the stochastic steady state for 20000 different simulations.

2. At the 121st month, a desired size of shock is realized and I simulate an additional 120-month period by letting the aggregate productivity sequence follow AR(1) process for 20000 times. I average over the simulations

3. Repeat the above process but without the shock at the 121st month and average over the simulations

4. Take the difference between the two average simulated sequences and draw the generalized impulse response functions (GIRFs).

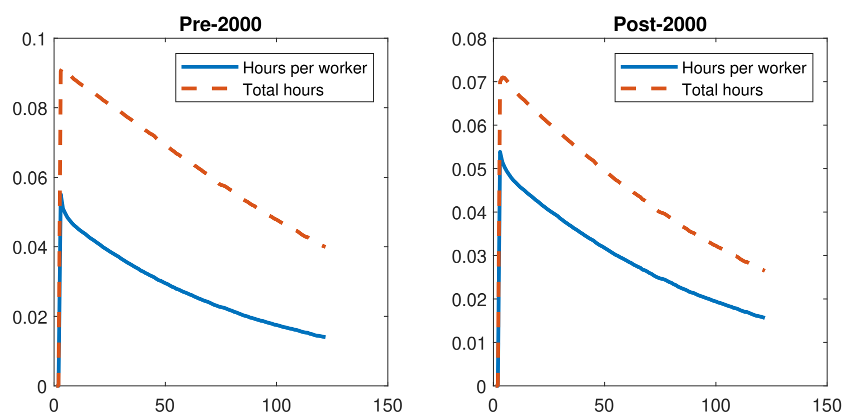
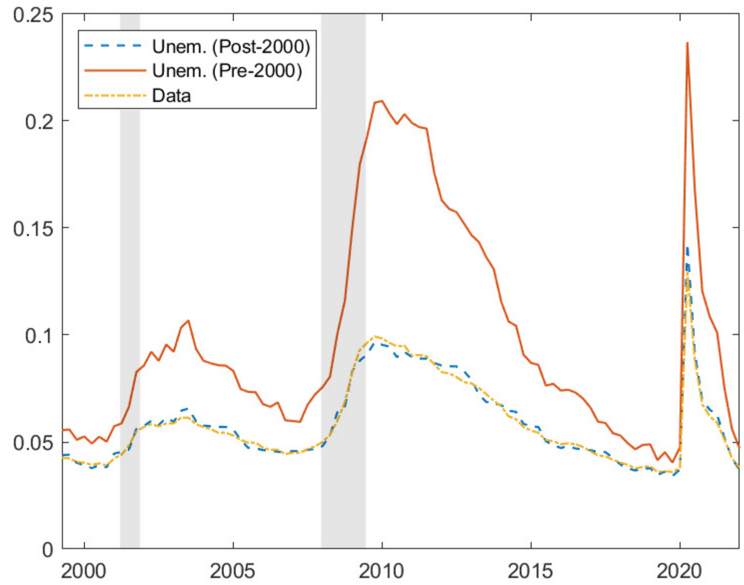


Figure C.1: Impulse response function of hours per worker and total hours to 2 S.D. positive shock

With GIRFs, the response is not symmetric between positive and negative shock. Figure C.1 reports the percentage deviation from the stochastic steady-state due to a positive aggregate productivity shock with a size of 2 standard deviations. Even though it is not symmetrical to the negative shocks, it repeats that the importance of intensive margin adjustments is increased with an improvement in initial match distribution.



Raw unemployment rates from the peak quarter before the Great Recession. The aggregate productivities are selected to match the unemployment rates from the post-2000 calibration economy to the actual data.

Figure C.2: Simulated unemployment rates

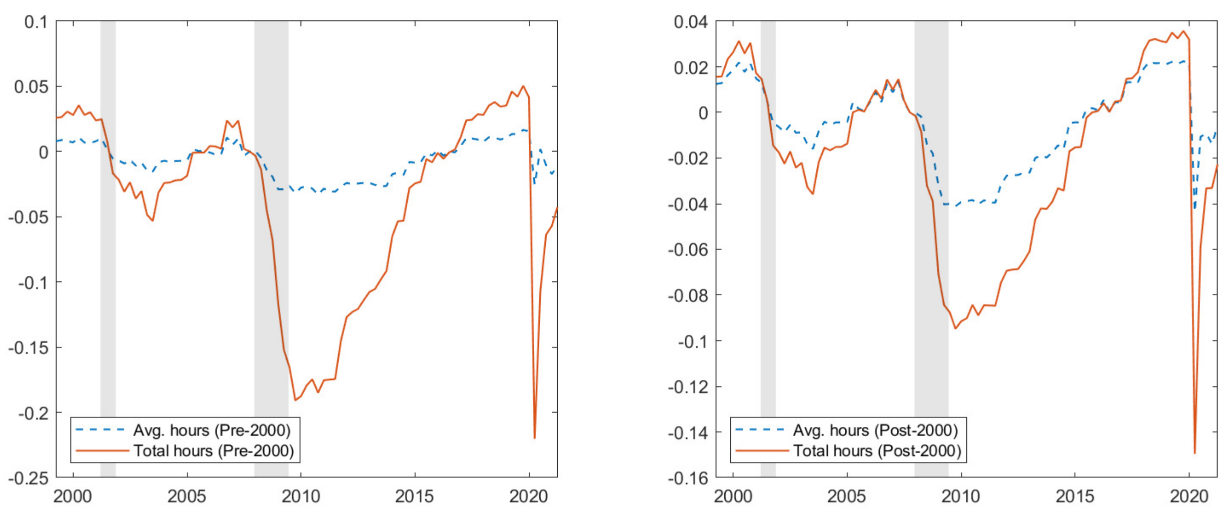


Figure C.3: Simulated hours per worker and total hours change in the Great Recession

Figure C.4: Simulation of the Great Recession for the pre-2000 and post-2000 calibrations

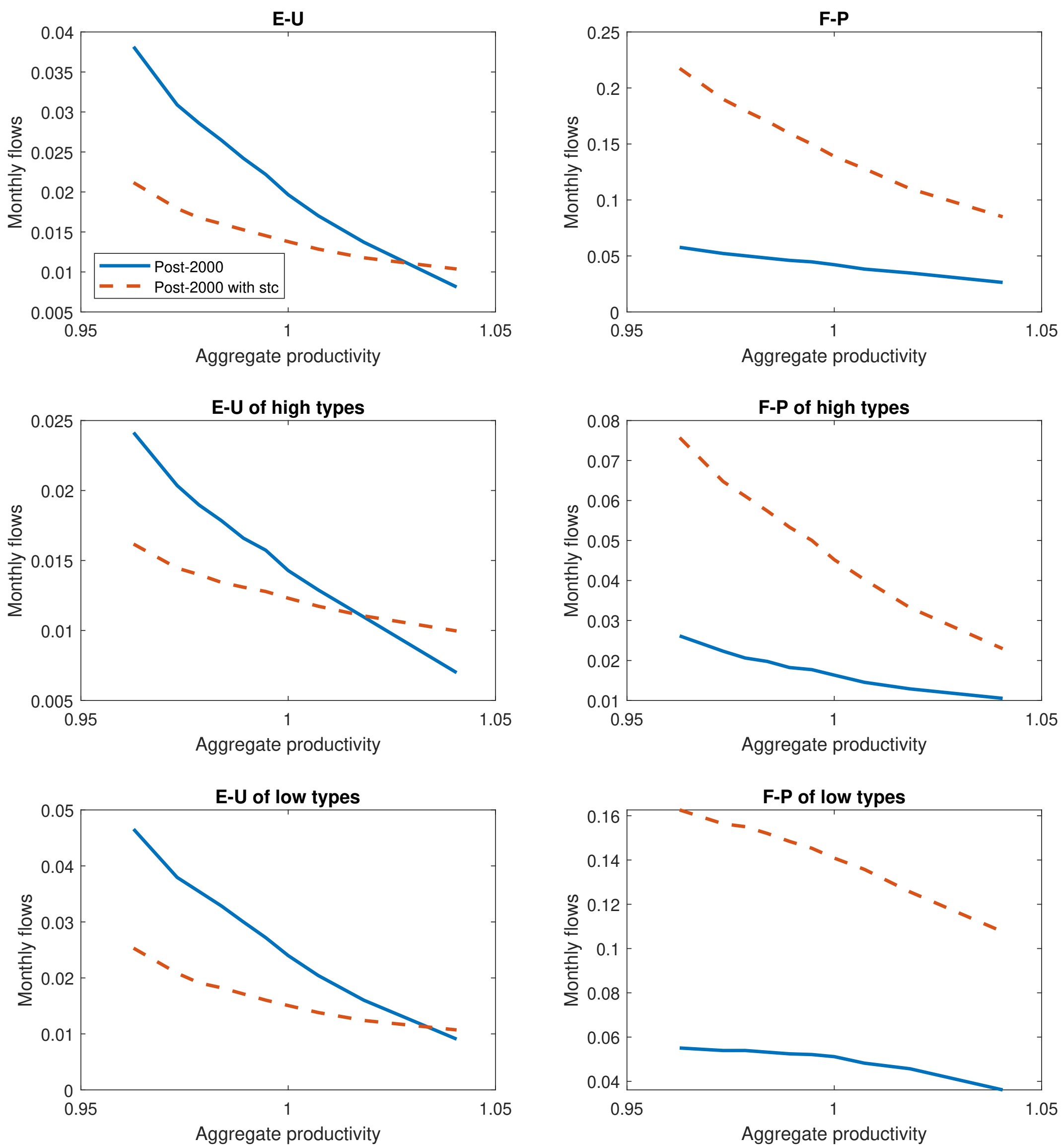


Figure C.5: Monthly flows with and without STC in the post-2000 period