UNDERSTANDING THE SCARRING EFFECT OF RECESSIONS

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Abstract. This paper documents that the earnings cost of job loss is concentrated among workers who find reemployment in lower-skill occupations, and that the cost and incidence of such occupation displacement is higher for workers who lose their job during a recession. I propose a model where hiring is endogenously more selective during recessions, leading some unemployed workers to optimally search for reemployment in lower-skill jobs. The model accounts for existing estimates of the size and cyclicality of the present value cost of job loss, and the cost of entering the labor market during a recession.
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It is well known from the labor literature that the earnings cost of job loss is large, persistent, and countercyclical. In this paper, I establish that the earnings cost of job loss is not dispersed uniformly, but instead falls primarily upon workers who find reemployment in a lower-paying occupation relative to that of their prior job. Thus, occupation displacement explains

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the majority of the earnings cost of job loss. To understand these findings, I propose a model where hiring is endogenously more selective during a recession, leading some unemployed workers to optimally search for lower-skill jobs than they previously held. In explaining the paper's new findings, the model is able to account for the size and cyclicality of the earnings cost of job loss, quantities which have eluded existing models of cyclical unemployment (Davis and von Wachter, 2011). The model also accounts for the cost of entering the labor market during a recession.

The paper first presents a set of stylized facts from the CPS Displaced Worker Supplement and the PSID to document that the size and cyclicality of the earnings cost of job displacement is almost entirely concentrated among workers who switch occupation subsequent to job loss: The initial earnings losses of workers who lose their job and subsequently switch occupation are more than double those of workers who find reemployment in the same occupation. The cost and incidence of such occupation displacement is higher among workers who lose their job during a recession. While occupation switchers continue to face markedly lower earnings a full decade after job loss, the wage and earnings losses of occupation stayers recover within four years. Together, these facts offer *prime facie* evidence of occupation displacement as the proximate source for the size and cyclicality of the earnings cost of job loss.

To understand these facts, I propose a simple and novel theoretical framework where selective hiring may prevent an unemployed worker from finding reemployment in a job that utilizes previously accumulated specific human capital. To recoup the fixed costs of finding a worker, firms posting vacancies for higher-paying, "skill-sensitive" jobs hire selectively, only directing vacancies towards workers with skill above an endogenously determined threshold. Other workers are left to search for lower-paying "skill-insensitive" jobs that do not utilize skill. A worker who is displaced from a job that uses skill and reemployed in a job that does not suffers larger and more persistent earnings losses. During a recession, an equilibrium skill threshold describing the search behavior of workers in unemployment endogenously tightens, as firms hire more selectively and workers who would otherwise search for skill-sensitive jobs now optimally redirect their search towards skill-insensitive jobs; and thus, the incidence and earnings loss of displacement from skill-sensitive to skill-insensitive jobs increases.

The calibrated model successfully accounts for the size and cyclicality of the earnings cost of job loss. In particular, I show that the non-linear earnings dynamics associated with occupation displacement in the model are crucial for generating a cyclical cost of job loss. The model is also able to speak to separate empirical findings that workers who enter the labor market during a recession have persistently lower earnings. This paper is the first to connect the cyclical cost of job loss with the cost of entering the labor market during a recession— two distinct but related dimensions of the scarring effect of recessions. The central economic mechanism of the model – countercyclical hiring standards within skilled occupations – is new to the literature and finds direct support in empirical studies of firm-level vacancy postings, including Hershbein and Kahn (2018) and Modestino et al. (2020).

The paper is the first in the literature to account for both the size and cyclicality of the cost of job loss. Davis and von Wachter (2011) estimate large present value costs of job loss in the U.S. that increase by nearly 70% from expansions to recessions; but also document that leading macroeconomic models are unable to speak to either the size or cyclicality of the present value cost of job loss. A subsequent macroeconomic literature has emerged to account for the size of the average cost of job loss, but not its cyclicality; e.g. Krolikowski (2017), Jung and Kuhn (2018), Burdett et al. (2020), and Jarosch (2021).

The theory offered here further contributes to the existing literature in that it confronts both the size and cyclicality of the cost of job loss in a manner consistent with the stark difference in the cost of job loss across occupation switchers and stayers. Indeed, the new empirical findings from the paper establish a tight link between these two features of costly displacements: the same group of workers who are shown to generate the large cost of job loss during normal times — workers who downgrade to a lower-paying occupation subsequent to job loss — also serve as the margin by which the average cost of job loss across all workers is amplified during recessions.

Although there has been little progress in understanding the cyclical cost of job loss, the subject remains important for research programs within labor economics and macroeconomics. Lucas (2003) concludes that the welfare gains of eliminating business cycles are small, and hence, stabilization policies in the United States are unwarranted as they may serve as an impediment to long-run growth. The subsequent literature has stressed, however, that the welfare cost of business cycles increases with the cyclical component of uninsurable idiosyncratic persistent income risk, e.g. Krusell et al. (2009). Along these lines, Krebs (2007) shows that calculations of the welfare cost of business cycles that explicitly account for the dominant role of job loss in explaining earnings losses produce higher estimates of the cost of business cycles, as job loss is experienced by a small subset of the population and welfare costs are increasing in the concentration of income risk.

The empirical findings here show that the earnings cost of job loss is not uniformly distributed within the subset of job-losers, and hence may be even more important for welfare than previously thought. In providing a model for understanding these features of the data, the paper contributes to a growing empirical literature on non-linear earnings processes (Arellano et al., 2017) and the cyclical distribution of income risk (Guvenen et al., 2014).

Both the empirical and theoretical parts of the paper relate the cyclical cost of job loss to the cost of entering the labor market during a recession (Kahn, 2010). Insofar as displaced workers and new labor market entrants are exposed to the same aggregate conditions while searching for a job during a recession, researchers have speculated on whether their employment outcomes are driven by similar forces, e.g. Rogerson (2011). The empirical literature has found that the cost of entering the labor market during a recession is larger for lower-skill workers (Oreopoulos et al., 2012), and that much of the cost can be explained by initial employment in a lower paying occupation (Altonji et al., 2016). The cost of entering the labor market during a recession computed from the model here is close to that estimated by Schwandt and von Wachter (2019) and von Wachter (2020).

Of the stylized facts documented in the paper, several are novel to the literature, including that (*i*) the earnings losses associated with job displacement are predominantly explained by reemployment in lower-paying occupations, and that (*ii*) such outcomes are more common (and more costly) for workers who lose their job during a recession. These findings are of independent interest and serve as further evidence of vertical sorting across occupations under absolute advantage, as in Groes et al. (2015).

In the following section, I show that the earnings cost of job loss is largely concentrated among workers who switch occupations, and that the cost and incidence of such occupation displacement is greater during a recession. In Section 2, I develop a model that is capable of addressing these empirical findings. Calibration and estimation of the model is discussed in Section 3. In section 4, I show that the model is quantitatively consistent with the empirical facts documented by the paper, while also accounting for the cyclical cost of job loss and the cost of entering the labor market during a recession.

1. The cost and incidence of occupation displacement: evidence

I use data from the Current Population Study Displaced Worker Supplement and the Panel Study of Income Dynamics to document that the earnings cost of job displacement is most severe for workers who find reemployment in a different occupation to that of their prior job, i.e. workers who suffer *occupation displacement*. I document the following stylized facts: *A)* Immediate earnings losses of displaced workers who switch occupation upon reemployment are up to three times those of occupation stayers; *B)* Workers displaced during a recession are more likely to switch occupation upon reemployment; *C)* The earnings losses and countercyclical incidence of occupation displacement is almost entirely accounted for by workers who switch to lower-paying occupations upon reemployment; *D)* While workers may find reemployment in a lower-paying occupation as a stop-gap, transitory measure, countercyclical occupation displacement represents a persistent phenomenon. Among workers for whom occupation displacement is a persistent phenomenon, earnings losses are strongly countercyclical with respect to aggregate conditions at the time of job displacement; and finally, *E)* Long-run earnings, hours, and wage recoveries are far slower for workers who switch occupation upon reemployment.[1] Collectively, the empirical findings suggest occupation displacement as a proximate source for the size and cyclicality of the earnings cost of job loss estimated by Davis and von Wachter (2011).

The first four facts are documented using the Displaced Worker Supplement (DWS), a supplement to the Current Population Survey (CPS) that has been administered in the January or February of every even year since 1984. The DWS identifies workers who have been separated from their jobs for reasons of slack work, plant closings, and abolished jobs— reasons which have been taken by the literature to capture "exogenous" layoffs. The DWS also records retrospective information on earnings and occupation of the displacement job. The fifth set of findings concerns longer-term outcomes subsequent to job loss, and hence are established using the Panel Study of Income Dynamics (PSID) from 1968 to 1997. Additional details are presented below and in the Online Appendix.

1.1. **Immediate earnings losses are higher for occupation switchers.** I first use the DWS re-establish that workers who are involuntarily displaced from a job and reemployed into a different occupation suffer larger immediate earnings losses than other workers.[2] I construct a sample of workers who were involuntarily displaced from a full-time job within the previous three

[1]Findings A and E have been established elsewhere in the literature, i.e. Jacobson et al. (1993), Stevens (1997), Kambourov and Manovskii (2009), Couch and Placzek (2010), and Raposo et al. (2019). The other findings are novel to this paper.
[2]Similar findings has been established by Jacobson et al. (1993), Stevens (1997), Kambourov and Manovskii (2009), Couch and Placzek (2010), and Raposo et al. (2019).

Table 1. Immediate earnings losses are higher for occupation switchers

Dependent variable: log difference of pre-displacement and current real weekly earnings

	(1)	(2)	(3)	(4)	(5)	(6)
Switcher	-0.057^{***}	-0.069^{***}	-0.064^{***}	-0.065^{***}	-0.077^{***}	-0.072^{***}
	(0.0064)	(0.0055)	(0.0057)	(0.0063)	(0.0052)	(0.0053)
Recession	-0.055^{***}	-0.055^{***}	-0.055^{***}	-0.058^{***}	-0.058^{***}	-0.058^{***}
	(0.0115)	(0.0115)	(0.0116)	(0.0099)	(0.0101)	(0.0100)
Constant	-0.056^{***}	-0.036^{***}	-0.040^{***}	-0.063^{***}	-0.042^{***}	-0.047^{***}
	(0.0073)	(0.0076)	(0.0073)	(0.0110)	(0.0108)	(0.0106)
N	24,920	24,920	24,920	24,920	24,920	24,920
Occ. def.	CPS/Broad	CPS/Fine	AD	CPS/Broad	CPS/Fine	AD
Controls?	No	No	No	Yes	Yes	Yes
Predicted loss: Switcher/Stayer	2.02	2.93	2.58	2.04	2.83	2.53

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include years since displacement, potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

years and are reemployed in a full-time job at the time of their interview.[3] Other selection criteria are similar to Farber (2015) and are discussed in greater detail in the appendix. I employ three different definitions of occupation to identify occupation switchers: "CPS/Fine", the fully disaggregated three-digit occupation code available from the CPS, with over 300 values depending on the survey year; "CPS/Broad", the more coarsely aggregated two-digit occupation code provided by the CPS with between eleven and fifteen possible values depending on the survey year; and "AD", the time-consistent occupation code developed in Autor and Dorn (2013), with over 300 possible values. I regress the log differential in weekly earnings in the job at the time of observation and the displacement job on a constant and a dummy variable indicating whether the individual changed occupations

[3]I focus workers employed full-time on the previous and current job to isolate the wage channel of earnings losses. This is consistent with recent work emphasizing the importance of wages for explaining earnings losses of displaced workers, e.g. Lachowska et al. (2020).

across jobs. I include an additional dummy variable indicating whether the individual lost his or her job during a recession.[4] Separate specifications are estimated with and without controls for each definition of occupation switcher, all with robust standard errors clustered by year of job loss. Where additional controls are introduced, the baseline group is composed of white male college graduates displaced during an expansion. Controls for experience and the linear time trend are normalized so that the coefficient on the constant can be directly interpreted as the average earnings loss among workers in the baseline group. Observations are weighted using CPS final weights. Results are given in Table 1.

The results show significantly higher earnings losses for occupation switchers, by factors between 2.02 and 2.93. Across all occupation codings, between 45% and 67% of all workers in the sample are observed to switch occupation.[5,6] The immediate cost of job loss for occupation switchers exceeds the cost for occupation stayers.

1.2. **Occupation switching is countercyclical for displaced workers.** Next, I document a new result to the literature: workers displaced during a recession are more likely to switch occupation upon reemployment. Using the sample of the previous section, I estimate a linear probability model for the event that a displaced worker is observed to be working in a different occupation from their pre-displacement job, with robust standard errors clustered by displacement year. The first regression specification includes only a constant and a dummy variable for recession. The coefficient on the constant represents the average fraction of occupation switchers among workers who are displaced during an expansion, while the coefficient on the recession dummy indicates additional switching among workers who lose

[4]A recession year is defined as a year with more than one quarter in recession according to the NBER classification. Similar results are obtained with a variable measuring the fraction of the year the economy is in recession. See Online Appendix A.

[5]An important paper by Fujita and Moscarini (2017) documents that a substantial portion of separated workers return to their previous employers as "recalls." To my knowledge, this issue has not yet received much attention within the literature on displaced workers, and the data from the CPS leave me poorly equipped to tackle this issue. However, an earlier version of that paper, Fujita and Moscarini (2013), shows that occupation switching is far less prominent among recalls (pg. 1). Hence, the indicator for occupation switchers isolates workers who are recalled at a lower frequency, and thus the more extensive earnings losses of displaced workers who switch occupation upon reemployment are less likely to reflect phenomena associated with recall reemployment.

[6]These results are similar to Fujita and Moscarini (2013), who find from the SIPP that over 50% of unemployed workers switch occupation from unemployment.

Table 2. Occupation switching is countercyclical for displaced workers

Dependent variable: indicator for occupation switcher

	(1)	(2)	(3)	(4)	(5)	(6)
Recession	0.040***	0.029***	0.030**	0.030***	0.021***	0.022***
	(0.0125)	(0.0111)	(0.0120)	(0.0051)	(0.0069)	(0.0062)
Constant	0.461***	0.670***	0.654***	0.333***	0.547***	0.519***
	(0.0048)	(0.0043)	(0.0044)	(0.0146)	(0.0149)	(0.0144)
N	24,920	24,920	24,920	24,920	24,920	24,920
Occ. def.	CPS/Broad	CPS/Fine	AD	CPS/Broad	CPS/Fine	AD
Controls?	No	No	No	Yes	Yes	Yes

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include years since displacement, potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

their job during a recession. The second regression specification includes additional controls, as in the previous section. Results are given in Table 2.

The estimates show that workers who lose a job during a recession are more likely to find reemployment in a different occupation compared to workers who lose their job during an expansion. Such findings of countercyclical occupation switching are consistent with vertical sorting across occupations under absolute advantage à la Groes et al. (2015); and countercyclical hiring standards, à la Hershbein and Kahn (2018). For example, consider a framework where occupations differ primarily in the rate of return to a general skill that is distributed non-uniformly across the population of workers. If firms require greater skill of an applicant during a recession, a worker that is randomly displaced to unemployment during a recession is more likely to switch to an occupation characterized by a lower return to skill.

1.3. **Occupation displacement is vertical.** The previous findings of (i) greater earnings losses among displaced workers who switch occupation, and (ii) countercyclical occupation displacement can be rationalized in terms of a model of vertically ranked occupations. Here I show that such an interpretation is supported by the data: the evidence for countercyclical occupation switching and greater immediate earnings losses for occupation

Table 3. The verticality of countercyclical occupation displacement

Dependent variable: indicator for occupation switcher

	(1)	(2)	(3)	(4)	(5)	(6)
Recession	0.030***	−0.008	0.019***	0.009	0.015**	−0.001
	(0.0090)	(0.0070)	(0.0054)	(0.0054)	(0.0068)	(0.0064)
Constant	0.270***	0.250***	0.110***	0.081***	0.090***	0.068***
	(0.0117)	(0.0111)	(0.0070)	(0.0074)	(0.0074)	(0.0073)
N	24,920	24,920	24,920	24,920	24,920	24,920
Occ. def.	AD↓	AD↑	AD6↓	AD6↑	JS3↓	JS3↑

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include years since displacement, potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

switchers is entirely accounted for by the ranking of occupation by average wage.

To establish these findings, I consider the longitudinally consistent occupation classification of Autor and Dorn (2013) at three different levels of aggregation: I first use the fully disaggregated occupation classification, henceforth referred to as "AD." Then, I consider the broader, six-category occupation classification considered by Autor and Dorn (2013), henceforth "AD6." Finally, I consider occupation transitions according the classification used by Jaimovich and Siu (2012), henceforth "JS3."

First, I estimate a linear probability model to establish that the higher incidence of occupation switching among workers who lose their job during a recession is entirely due to downwards switchers. Results are given in Table 3. Columns one and two offer estimates from downwards (AD↓) and upwards (AD↑) switchers using the fully disaggregated AD classification. While workers are observed to make both downward and upward occupation changes, a recessionary increase in occupation switching is only observed for downwards switchers.[7] The results hold for greater levels of aggregation, as shown in columns three and four for the AD6 classification, and in columns five and six for the JS3 classification. In percentage terms, recessionary

[7]The relation of this finding to the distinct but complementary work of Robinson (2018) is discussed in Online Appendix Section A.2.

Table 4. Vertical displacement and re-employment earnings losses

	Dependent variable: log difference of pre-displacement and current real weekly earnings		
	(1)	(2)	(3)
Switch ↑	0.010	0.017^{*}	0.038^{***}
	(0.0069)	(0.0094)	(0.0111)
Switch ↓	-0.140^{***}	-0.119^{***}	-0.135^{***}
	(0.0067)	(0.0082)	(0.0087)
Recession	-0.056^{***}	-0.058^{***}	-0.058^{***}
	(0.0099)	(0.0099)	(0.0098)
Constant	-0.049^{***}	-0.073^{***}	-0.075^{***}
	(0.0103)	(0.0105)	(0.0107)
N	24,920	24,920	24,920
Occ. def.	AD	AD6	JS3
Predicted loss: Switcher/Stayer	3.84	2.63	2.79

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include years since displacement, potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

increases in downward occupation switching are greater for higher levels of aggregation.[8]

Next, I show that earnings losses are only higher for the subset of occupation switchers who make downward shifts in occupation. I estimate a similar specification to that of Table 1, but I allow separate intercepts for downward and upward occupation switchers. Separate regressions are estimated for each of the three different occupation rankings. Results are given in Table 4. The coefficient estimates reveal a striking non-linearity for upward and downward occupation switchers. While reemployment in a lower-paying

[8]The finding of countercyclical displacement for JS↓ workers is consistent with the Jaimovich and Siu (2012) observation that recessions are accompanied by an acceleration in the trend reallocation of employment towards service occupations. Indeed, the results are robust to a more restrictive definition of JS↓ that only includes transitions to service occupations.

occupation is associated with substantially larger earnings losses relative to non-switchers, reemployment in a higher-paying occupation is associated with mildly lower earnings reduction compared to non-switchers. Hence, the results imply a distinct role for displacement to a lower-paying occupation in understanding the earnings losses of displaced workers.

Across Tables 3 and 4, the results indicate that the earnings cost and cyclical incidence of occupation displacement can both be attributed to workers moving to lower-skill occupations. These results are consistent with the aforementioned empirical literature emphasizing the importance of the vertical ranking of occupations for explaining occupation flows. But moreover, they bear commonality to findings from the empirical literature on workers who enter the labor market during a recession, e.g. Altonji et al. (2016), who show that nearly half of the initial relative wage losses of such workers can be attributed to employment in a lower paying occupation.

1.4. **Displacement to a lower-paying occupation is a persistent source of earnings losses.** The results of the previous section show that the immediate earnings cost of job loss is concentrated upon workers displaced to a lower-paying occupation upon reemployment; and that the incidence of such displacement is higher for workers who lose their job during a recession. However, such patterns of occupation displacement may be associated with temporary, stop-gap employment that resolves upon successful employment in a stable job of the worker's previous occupation. Here, I establish that occupation displacement represents a large and persistent component of the earnings cost of job loss.

In particular, occupation displacement is only slightly less prevalent among workers surveyed more than two years subsequent to job loss (referred to here as the medium-run) as it is among workers surveyed within zero to two years subsequent to job loss (the short-run); and the incidence of occupation displacement displays greater counter-cyclicality with respect to the state of the economy at job loss in the medium run. Estimates from these workers reveal that the cyclical cost of job loss for workers displaced from their prior occupation doubles from expansions to recessions.

To document the persistence of occupation displacement, I estimate a variant of the linear probability model of the previous sections, with an indicator for AD$\downarrow$ as the dependent variable indicating whether a worker has moved to a lower-paying occupation. I consider two separate samples: workers displaced within two years of the survey date (the short-run) and workers more than two years subsequent to the survey date (the medium-run). I estimate separate coefficients for the entirety of both samples, but also for sub-samples of workers that are employed at their first job since job

Table 5. Vertical occupation displacement in the short- and medium-run

Dependent variable: indicator for AD↓ occupation switcher

	Displaced within two years of survey		Displaced more than two years prior to survey	
	(1)	(2)	(3)	(4)
Recession	0.022**	0.020*	0.044***	0.049***
	(0.0101)	(0.0112)	(0.0156)	(0.0160)
Constant	0.286***	0.279***	0.305***	0.285***
	(0.0095)	(0.0106)	(0.0138)	(0.0118)
N	17,101	11,052	7,819	4,273
First jobs only?	No	Yes	No	Yes

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

loss. Results are given in Table 5. As can be seen from the coefficient on the constant term, the incidence of occupation displacement is similar for both the short-run and medium-run samples. The magnitude of the recessionary increase in occupation displacement, however, is greater in the medium run. These results reveal reemployment to a lower-paying occupation is not merely a stop-gap phenomenon, but a persistent one.

Next, I show that in the medium-run, the earnings losses of occupation-displaced workers are more persistent and more cyclical than those of workers that are not occupation-displaced. To do so, I introduce an interaction term for AD↓ and the variable identifying displacements occurring during a recession year. Columns one and two give results from the full and "first jobs" short-run sample. The results appear similar to those from column one of Table 4: the earnings losses of the occupation-displaced are considerably higher than those of other workers. Notably, the interaction term is small in magnitude and positive, but not statistically significant.

Findings from the medium-run sample show even more severe earnings losses for workers undergoing occupation displacement. Here, the constant term, representing the average reduction in earnings conditional on

Table 6. Short- and medium-run earnings losses of vertical occupation displacement

Dependent variable: log difference of pre-displacement and current real weekly earnings

	Displaced within two years of survey		Displaced more than two years prior to survey	
	(1)	(2)	(3)	(4)
Switch↓	-0.151^{***}	-0.139^{***}	-0.127^{***}	-0.119^{***}
	(0.0080)	(0.0077)	(0.0142)	(0.0184)
Switch↓ × Recession	0.037^{*}	0.007	-0.071^{***}	-0.076^{***}
	(0.0197)	(0.0286)	(0.0226)	(0.0209)
Recession	-0.059^{***}	-0.043^{***}	-0.045^{***}	-0.067^{***}
	(0.0082)	(0.0099)	(0.0150)	(0.0144)
Constant	-0.050^{***}	-0.029^{**}	-0.028	0.009
	(0.0182)	(0.0131)	(0.0170)	(0.0178)
N	17,101	11,052	7,819	4,273
First jobs only?	No	Yes	No	Yes
Recessionary increase in predicted earnings losses, occ. switchers component	-18.5%	2.1%	78.4%	92.1%

*** significant at 0.01, ** at 0.05, * at 0.10.

Note: Controls include potential experience, potential experience squared, a linear time trend, indicator for female, indicator for non-white, and four indicator variables for education. Potential experience, potential experience squared, and the linear time trend are normalized to mean zero. "AD" occupation coding adopted from "occ1990dd" codes from Autor and Dorn (2013). Robust standard errors clustered by year of job loss in parentheses. Data from CPS DWS, 1984-2018.

no occupation-displacement, is smaller in magnitude and not significantly different from zero, indicating a recovery of previous earnings for non-occupation-displaced workers who lose their job during an expansion. However, estimates of coefficients for downward occupation-switchers reveal highly cyclical persistent earnings losses. Indeed, there is a near doubling in the component describing the contribution of occupation displacement to the recessionary increase in the earnings cost of job loss.[9] Hence, the cost of

[9]In Online Appendix A.4, I define the earnings cost of job loss (in terms of pre-displacement earnings) using the estimated parameters from Tables 5 and 6. The cost of

job loss for workers displaced from their most recent occupation is large, persistent, and highly cyclical.

The columns of Table 6 showing the estimates for the "medium-run" sample demonstrate that the cost of job loss is mild for occupation stayers, as indicated by the coefficient on the constant term not being signficantly different from zero; and far more cyclical for occupation switchers, as indicated by the coefficient on the interaction term. Accordingly, if one were to run a similar regression that does not control for whether a worker switches occupation, the estimated coefficient for the constant term woud be larger and magnitude and negative; and the estimated coefficient on the indicator variable for recessions would be larger in magnitude as well. Thus, looking at earnings outcomes separately for the occupation displaced is important for understanding the true nature of earnings loss for workers who are able to find employment in a job of their previous occupation; as well as understanding the sources of the cyclicality of the earnings cost of job loss.

1.5. **Long-run costs of job loss in earnings, wages, and hours are higher and more persistent for occupation switchers.** The findings of the previous section reveal that the size and cyclicality in the cost of job loss can be attributed to workers displaced to a lower-paying occupation. However, these results are established using a dataset that follows workers over a relatively short time frame, and hence do not rule out the possibility that the earnings recoveries of occupation stayers and switchers appear more similar in the long term. In this section, I use the Panel Study of Income Dynamics from 1968 to 1997 to re-establish that the long-term cost of job loss in earnings, wages, and hours is higher for occupation switchers.[10] Meanwhile, occupation stayers display relatively quick recoveries in earnings, wages, and hours subsequent to job loss.

To assess the cost of job loss of occupation switchers and stayers, I compare their outcomes to those of workers who have not been dismissed from their job within the past ten years. I employ a regression similar to that of the existing literature, e.g. Jacobson et al. (1993) and Stevens (1997). The

job loss can then be expressed as a convex combination of a common component and a component that is specific to workers who switch occupation upon reemployment.

[10]Similar results establishing that the long-run effects of job displacement are concentrated on occupation-switchers are given by Stevens (1997) and Raposo et al. (2019). While the analysis of this section focuses on occupation switchers and stayers rather than expansions and recessions, the analysis can be expanded to document findings similar to that of the previous sections. See Birinci (2021).

FIGURE 1. Earnings and wage losses are more persistent for occupation switchers

Note: Estimates come from PSID. Dashed lines represent 95% confidence intervals around estimates.

regression equation is

$$y_{it} = x_{it}'\beta + \sum_{k\geq -2}^{10} \delta_{ns}^{k} D_{it}^{ns,k} + \varphi_{ns} F_{it}^{ns} + \sum_{k\geq -2}^{10} \delta_{sw}^{k} D_{it}^{sw,k} + \varphi_{sw} F_{it}^{sw} + \alpha_i + \gamma_t + \varepsilon_{it}, \quad (1)$$

The outcome variables including log annual earnings, log hourly wages, and log annual hours. The variable x_{it} is a vector of time-varying individual characteristics, including experience and schooling; α_i is a time invariant unobserved error component associated with person i; and γ_t is an error component common to all individuals in the sample at year t. The indicator variables $D_{it}^{j,k}$ are used to identify displaced workers in the k^{th} year after job displacement, where $j = ns$ indicates that the worker does not switch occupation upon reemployment, and $j = sw$ indicates that the worker does switch occupation upon reemployment. As in Stevens (1997), I focus on the first displacement recorded for each individual in the sample. Then, the indicator variable F_{it}^{j} is equal to one for zero to ten years following the most recent job loss. Accordingly, $\delta_j^k + \varphi_j$ represents the effect of job displacement for post-displacement occupation stayers and switchers in years $k \in [0, 10]$

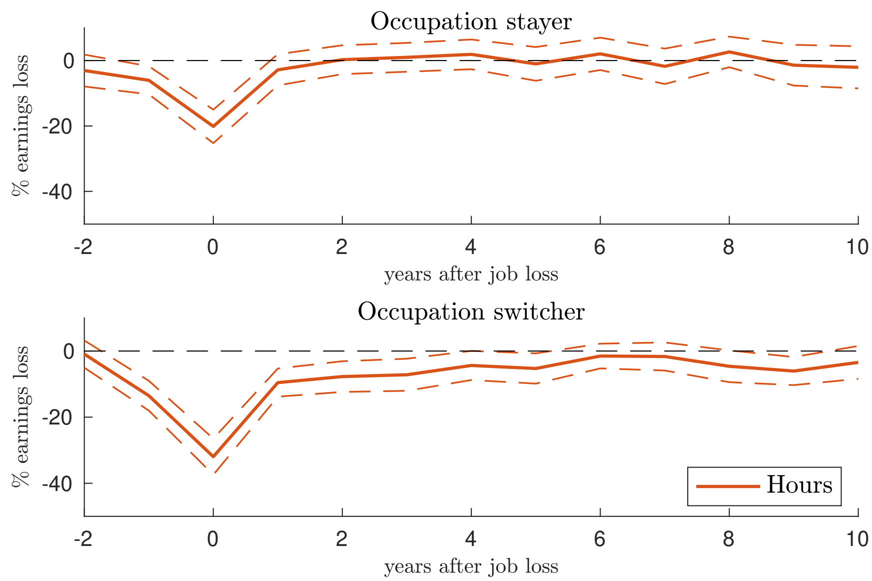

FIGURE 2. Longer hours recoveries for occupation switchers

Note: Estimates come from PSID. Dashed lines represent 95% confidence intervals around estimates.

after job loss, relative to workers who have not been dismissed from their job in the previous ten years. The regressions are estimated with fixed effects and robust standard errors clustered by individual.

Figure 1 shows the earnings and wage losses for occupation switchers and stayers relative to counterfactual outcomes under no displacement, with dashed lines indicating 95% confidence intervals around the estimates. Workers who switch occupations subsequent to job displacement experience a 42% percent drop in earnings, twice as large as the 21% drop in earnings for workers who remain in the same occupation. The subsequent earnings recovery of occupation stayers is estimated to be complete within several years: relative earnings losses recover to 6.4% one year after displacement, and thereafter are not significantly different from zero. Meanwhile, for occupation switchers, there is a slow and incomplete recovery in annual earnings, with relative losses remaining around 10% ten years after job displacement. A similar pattern is observed for the recovery of hourly wages. Workers who remain in the same occupation experience relative wage losses of around 7% in their first year after job loss, with subsequent relative wage losses that rapidly approach zero. In contrast, occupation switchers experience relative wage losses of 18.1% in the year after displacement, with an incomplete recovery that leaves wages around 10% below those of comparable workers who did not lose their job.

Figure 2 shows the recovery in hours worked per year. Occupation stayers experience a 20% reduction in hours the year of displacement, and a full recovery thereafter. In contrast, occupation switchers experience a 33% reduction in hours the year of displacement, with losses that persist more than three years subsequent to displacement. Thus, while hours losses are still revealed to recover fairly quickly — as previously documented by Stevens (1997), Altonji et al. (2013), Lachowska et al. (2020), and Schmieder et al. (2020), among others — we still see a slightly more important role for hours losses among occupation switchers.

In the following section, I propose a new model where the size and cyclicality of the earnings cost of job loss depends on whether a worker is able to find reemployment in her previous employment, consistent with the findings presented above. As in the data, the cost of job loss in the model is higher and more cyclical for workers displaced from their prior occupation; and the earnings cost and incidence of such displacements is higher for workers who lose their job during a recession.

2. A model of unemployment, skill, and selective hiring

To understand the facts documented in the previous section, I develop a new model of unemployment, skill, and selective hiring. The model combines elements of a Diamond-Mortensen-Pissarides search and matching model with the Ljungqvist and Sargent (1998) model of human capital accumulation and depreciation. The framework also borrows insights from Acemoglu (1999), as the qualitative composition of jobs changes endogenously with the skill-composition of the labor force.

There are two types of jobs in the model, each associated with a large measure of occupations: "skill-sensitive" and "skill-insensitive". Jobs in skill-sensitive occupations are characterized by a production technology that requires a human capital input. Jobs in skill-insensitive occupations are characterized by a production technology that does not require a human capital input. This novel feature of the model allows it to match the heterogeneity and cyclicality in the cost of job loss documented in the previous section of the paper: Displaced workers from skill-sensitive jobs who find reemployment in lower-paying skill-insensitive jobs suffer larger and more persistent earnings losses. The greater occurrence (and earnings losses) of such occupation displacement during recessions lends cyclicality to the cost of job loss.

The stochastic process for human capital accumulation is standard to the literature, e.g. Ljungqvist and Sargent (1998), except that workers in unemployment are subject to the risk that their skills become obsolete, wherein they draw a new value of human capital from the initial distribution. This feature of the model captures the increasing income disaster risk over the lifecycle documented by Guvenen, Karahan, Ozkan and Song (2015), but also lends a broader interpretation of the mapping of occupation in the model to occupation in the data. A worker may be displaced from a job as a machinist (skill-sensitive employment); discover during her time in unemployment that her skills are no longer relevant to new vintages of technology (obsolescence shock); subsequently find employment as a salesperson (skill-insensitive employment); and then work her way up to a job as a manager (skill-sensitive employment).

A full description of the environment is given in Sections 2.1 through 2.6. The problems of workers and firms are given in Sections 2.7 and 2.8. The wage bargaining protocol is described in Section 2.9, and the free entry condition that determines equilibrium market tightness is discussed in 2.10. After defining the equilibrium in Section 2.11, I explain how the model generates a large and cyclical cost of job loss among workers switching to lower-skill occupations.

2.1. **Setting.** The model is set in discrete time with an infinite horizon. There is a unit measure of workers and a large measure of firms. Workers have linear preferences over the consumption good, suffer no disutility of labor, and discount the future by a factor $\beta < 1$. Workers are either unemployed, employed in a skill-insensitive job, or employed in a skill-sensitive job. Jobs are subject to an exogenous destruction probability δ. Workers are endowed with h units of human capital (skill). A cumulative distribution function λ gives the measure of workers over human capital and employment. Workers have geometric lifespans: each period a measure ν of workers die and a measure ν are born into unemployment. There are two aggregate state variables: productivity Z and the distribution of workers across human capital and employment states, λ. Z takes on finite values and evolves according to a first-order Markov chain.

As will be established, the only relevant individual-level state variable is the worker's level of human capital h; and the equilibrium is block recursive à la Menzio and Shi (2010, 2011). Hence, I include only h and Z as arguments to value functions and labor market quantities going forward.

2.2. **Production.** Production occurs within single worker firms. In firms operating the skill-insensitive technology, output y_L varies with aggregate productivity Z but not the worker's skill h. Skill-sensitive firms operate a production technology that is linear in the worker's human capital input h and aggregate productivity Z to produce y_H:

$$y_L(h, Z) = Z, \quad y_H(h, Z) = Zh. \tag{2}$$

Once a firm and worker are matched, the job type is fixed: a skill-insensitive job cannot be converted into a skill-sensitive job, and vice versa.

2.3. **Human capital dynamics.** Human capital lies in an equispaced grid $\mathcal{H}$ with lower bound h_{lb} and upper bound h_{ub}. New entrants draw an initial value of human capital from a distribution function F with support over the entire grid $\mathcal{H}$.

Workers in skill-sensitive and skill-insensitive jobs stochastically accumulate human capital. Each period, the human capital endowment of a worker in a skill-sensitive (skill-insensitive) job increases by amount $\Delta_{\mathcal{H}}$ with probability π_H (π_L).[11] Hence, for a worker with human capital h employed in a job of type i, human capital evolves as follows:

$$h' = \begin{cases} h + \Delta_{\mathcal{H}} & \text{with probability } \pi_i \\ h & \text{with probability } 1 - \pi_i \end{cases} \qquad i = L,\ H. \tag{3}$$

Workers in unemployment face two sources of human capital risk: obsolescence and gradual depreciation. With probability ξ, an unemployed worker entering the period with human capital h finds her skills rendered obsolete and must draw a new value of human capital h_{obs} from the conditional distribution $F_{obs}(\cdot; h)$. The conditional distribution is constructed from the initial distribution F with lower bound of the support h_{lb}, upper bound of the support h, and normalized to integrate to one.

Immediately after the realization of the obsolescence shock (and within the same period), the worker faces a probability π_U of losing a quantity $\Delta_{\mathcal{H}}$ of human capital. Hence, the human capital of a workers in unemployment who enters the period with human capital h evolves according to the following:

$$h' = \begin{cases} h_{obs} & \text{with probability } \xi(1 - \pi_U) \\ h_{obs} - \Delta_{\mathcal{H}} & \text{with probability } \xi\pi_U \\ h & \text{with probability } (1 - \xi)(1 - \pi_U) \\ h - \Delta_{\mathcal{H}} & \text{with probability } (1 - \xi)\pi_U \end{cases}. \tag{4}$$

[11]In the calibrated model, the estimated value of π_H is higher than π_L.

2.4. **Search and matching.** Workers must be matched with firms in order to produce. Firms post vacancies at submarkets specific to a single level of human capital, i.e. search is segmented in h. Given the vacancy posting decision of firms, workers of a particular h choose whether to search for either skill-insensitive or skill-sensitive employment.

Given aggregate productivity Z, the number of vacancies for a worker of skill h in the skill-insensitive and skill-sensitive submarkets are $\upsilon_L(h, Z)$ and $\upsilon_H(h, Z)$. Searchers $s_L(h, Z)$ for skill-insensitive jobs consist only of workers searching from unemployment, whereas searchers $s_H(h, Z)$ for skill-sensitive vacancies comprise both unemployed workers and workers in skill-insensitive jobs. Workers in skill-insensitive jobs search with the same efficiency as unemployed workers and hence never quit to unemployment to improve search outcomes.

The total number of matches generated within a particular submarket $m_i(h, Z)$, $i = L, H$, is determined by a Cobb-Douglas matching function:

$$m_i(h, Z) = \phi_i s_i(h, Z)^{\sigma} \upsilon_i(h, Z)^{1-\sigma},\ \ i = L, H. \tag{5}$$

The job-finding probability $p_i(h, Z)$ for a worker with human capital h searching for a job of type i when aggregate productivity is Z (and the corresponding vacancy filling probability $q_i(h, Z)$) are given as follows:

$$p_i(h, Z) = \frac{m_i(h, Z)}{s_i(h, Z)}, \quad q_i(h, Z) = \frac{m_i(h, Z)}{\upsilon_i(h, Z)}, \quad i = L, H. \tag{6}$$

Job-finding and vacancy-filling probabilities can be expressed as functions of the ratio of vacancies to unemployment within each submarket, i.e. the market tightness ratios $\theta_i(h, Z)$, $i = L, H$.

2.5. **Occupation switching.** For each type of job, there is a continuum of occupations. If a worker from unemployment finds a job using the production function of their previous job, the worker's occupation changes with probability χ upon reemployment to their new job. If the worker finds a job using a different type of production technology, the worker's occupation changes with probability one. Thus, if a fraction x of workers switch occupations across job-types across occupation spells, total occupation switching is recorded as $x + (1 - x)\chi$.

Clearly, the only type of occupation change that is relevant for computing future values are occupation switches across types of jobs, skill-sensitive to skill-insensitive or vice versa. But although occupation switching within job-types is irrelevant for outcomes in the model, such transitions will be important for bringing the model to the data. As will be shown, this feature of the model allows for acyclical, non-costly occupation switches to coexist alongside countercyclical occupation displacement, as documented in Section 1.3.

2.6. **Timing.** A single period is divided into three sub-periods. In the first sub-period, a measure ν of workers die and are replaced by new entrants, and new values of productivity Z and human capital of h are realized. Search and matching occurs in the second sub-period. In the third and final sub-period, matches produce and wages are paid to workers.

2.7. **Worker value functions.** The value functions of workers and firms are written in terms of the value in the third sub-period, after search and matching has taken place. The decision of a worker in unemployment is whether to search for a skill-sensitive or skill-insensitive job. Let $W_H(h, Z)$ and $W_L(h, Z)$ be the value of a worker with skill h in a skill-sensitive and skill-insensitive job when aggregate productivity is Z. Then, let $U_j(h, Z)$ be the value of a worker in unemployment with skill h when aggregate productivity is Z, and whose previous match operated using the skill-sensitive production function $j = H$, or the skill-insensitive production function $j = L$. The value of such a worker in unemployment satisfies

$$\begin{aligned} U_j(h, Z) = u_j^b(h) + (1-\nu)\beta\mathbb{E}_{h,Z} \max\Big\{ & p_H(h', Z')W_H(h', Z') \\ & + (1 - p_H(h', Z'))\, U_j(h', Z'),\ p_L(h', Z')W_L(h', Z') \\ & + (1 - p_L(h', Z'))\, U_j(h', Z')\Big\} \end{aligned} \tag{7}$$

subject to the laws of motion for h and Z, where $u_j^b(h)$ represents the period value of leisure for an unemployed worker with skill h and previous job of type $j = L, H$.

Note that the continuation value of a worker reflects the optimal search decision in the subsequent period: a worker searches for a skill-sensitive job from unemployment if and only if $p_H\,(W_H - U_j) \geq p_L\,(W_L - U_j)$, and the worker searches for a skill-insensitive job from unemployment otherwise.

The value of a worker employed in a skill-sensitive job, $W_H(h, Z)$, satisfies

$$W_H(h, Z) = w_H(h, Z) + (1-\nu)\beta\mathbb{E}_{h,Z}\left[(1-\delta)W_H(h', Z') + \delta U_H(h', Z')\right] \tag{8}$$

subject to the laws of motion for h and Z, where $w_H(h, Z)$ is the period wage. The continuation value reflects values associated with both continued employment and possible job loss.

The value of a worker employed in a skill-insensitive job, $W_L(h,Z)$, satisfies

$$W_L(h,Z) = w_L(h,Z) + (1-\nu)\beta\mathbb{E}_{h,Z}\Big[p_{H_+}(h',Z')(1-\delta)W_H(h',Z') \\ + \Big(1-p_{H_+}(h',Z')\Big)(1-\delta)W_L(h',Z') + \delta U(h',Z')\Big] \tag{9}$$

subject to the laws of motion for h and Z, where $w_L(h,Z)$ is the period wage. Here, the continuation value reflects not only the possibility of future unemployment, but also the possibility that the worker optimally moves to a skill-sensitive job via on-the-job search:

$$p_{H_+}(h,Z) = \mathbb{I}\left\{W_H(h,Z) > W_L(h,Z)\right\} \cdot p_H(h,Z).$$

As will be shown for the calibrated model, the probability of successful on-the-job search increases with h and Z, implying a corresponding increase in the worker's value.

2.8. **Firm value functions.** Let $J_H(h,Z)$ denote the value of a skill-sensitive firm employing a worker of type h when aggregate productivity is Z,

$$J_H(h,Z) = Zh - w_H(h,Z) + (1-\nu)\beta\mathbb{E}_{h,Z}\Big[(1-\delta)J_H(h',Z')\Big] \tag{10}$$

subject to the laws of motion for h and Z. As will be shown, the value of a skill-sensitive job to a firm is increasing in human capital h, implying correspondingly increasing job-finding probabilities. The value $J_L(h,Z)$ of a skill-sensitive firm employing a worker of type h when aggregate productivity is Z satisfies

$$J_L(h,Z) = Z - w_L(h,Z) \\ + (1-\nu)\beta\mathbb{E}_{h,Z}\Big[\Big(1-p_{H_+}(h',Z')\Big)(1-\delta)J_L(h',Z')\Big] \tag{11}$$

subject to the laws of motion for h and Z.

Note, the continuation values of both the worker and a firm in a skill-insensitive match depend on the probability of successful on-the-job search, p_{H_+}. But within a skill-insensitive match, a higher probability of successful on-the-job search p_{H_+} yields higher expected payoffs to the worker and lower expected payoffs to the firm. Hence, while output in such a match does not depend on the worker's endowment of human capital h, the discount rate applied by the firm depends on p_{H_+}. As will be shown, this will mean that fewer vacancies will be posted for certain high-h skill-insensitive jobs due to retention concerns on the part of the firm.

2.9. **Wage bargaining.** The earnings cost of job loss depends on wages. But to the extent that wages are the outcome of a bargaining protocol that is responsive to the outside values of negotiating parties, the dependence goes both ways: wages depend on the earnings cost of job loss. To parameterize the extent to which wages depend on outside values of negotiating parties, I apply a bargaining protocol à la Binmore et al. (1986) and Hall and Milgrom (2008), but with the novel feature that the dependence of wages on outside values can be exactly characterized. As in Hall and Milgrom (2008), workers and firms alternate each period in offering a wage offer. Should a wage offer be rejected by either party, firms incur a delay cost $d_i(h, Z)$ and workers receive a benefit $u_i^d(h, Z)$, where i denotes whether the match is skill-sensitive or skill-insensitive. Also as in Hall and Milgrom, if an offer is rejected, the match dissolves with probability ς, where ς may differ from separation probability δ when an offer is accepted.

The novel feature of the bargaining protocol introduced here is that the influence of outside values on wages can be exactly parameterized by the difference in match destruction probability under agreement and disagreement, $\varsigma - \delta$. This follows from a slight change in timing compared to Hall and Milgrom (2008). Here, if a wage offer is rejected and the match dissolves, a worker can only search again in the subsequent period rather than immediately. This subtle change in bargaining affords considerable analytic tractability, as established in the following proposition.

Proposition 1 (Wage equations)**.** *Take the proposed bargaining mechansim, and assume that the outside option for workers or firms never binds during bargaining. Then, the exposure of wages $w_H(h, Z)$ and $w_L(h, Z)$ to outside values is linear in the difference of the separation rates under disagreement and agreement, $\varsigma - \delta$. Indeed, when $\varsigma = \delta$, the outcome of bargaining is independent of outside values, and the wage equations simplify further:*

$$w_H(h, Z) = u_H^d(h) + (1-\nu)\beta\mathbb{E}_{h,Z}\Big[(1-\delta)\left(Z'h' + d_H(h') - w_H(h', Z')\right)\Big]$$

$$\begin{aligned} w_L(h, Z) &= u_L^d(h) \\ &\quad + (1-\nu)\beta\mathbb{E}_{h,Z}\Big[\Big(1 - p_{H_+}(h', Z')\Big)(1-\delta)\left(Z' + d_L(h') - w_L(h', Z')\right)\Big] \end{aligned}$$

Proof. See Online Appendix B. □

The proposition offers a sharp characterization of the sensitivity of wages to outside values. Such a precise characterization is necessary under the fully quantitative model, where discontinuities in the value of searching for skill-sensitive or skill-insensitive jobs generate non-convexities in worker outside values, substantially complicating the computation of equilibrium quantities. Note, even under parameterizations where wages are completely independent of outside values, wages still reflect forward-looking properties associated within a given match: for example, the wage of a worker employed in a skill-insensitive job is declining in the probability of successful on-the-job search.

2.10. **Vacancy posting and free entry.** Firms pay a period cost κ_H (κ_L) to post a vacancy in a skill-sensitive (skill-insensitive) submarket. In equilibrium, free entry drives the value of posting a vacancy in any market to zero, with complementary slackness:

$$q_i(h,Z)J_i(h,Z) \leq \kappa_i, \ \theta_i(h,Z) \geq 0, \ i = L,H. \tag{12}$$

Thus, the expected value associated with posting a vacancy for a job of type i, $q_i(h,Z)J_i(h,Z)$, is equal to the vacancy posting cost κ_i across active submarkets in the equilibrium of the model. In inactive submarkets, I assume $\theta_i(h,Z) = 0$, following Menzio and Shi (2010). Note that search is fully segmented, and the value associated with filling a vacancy is independent of the distribution of workers across unemployment and jobs. Thus, the equilibrium of the model inherits a "block recursive structure" as defined in Menzio and Shi (2010, 2011).

2.11. **Equilibrium.** An equilibrium consists of schedules of market tightness in skill-sensitive and skill-insensitive labor markets and an optimal search policy for workers; such that market tightness is consistent with the free entry condition (12), and the search policies solve the problems of an unemployed worker (7) and a worker searching on-the-job from a skill-insensitive job (9).

2.12. **Countercyclical occupation displacement in the model environment.** Occupation displacement in the model occurs when workers displaced from skill-sensitive jobs find reemployment in skill-insensitive jobs. As in the data, the model generates a large and cyclical cost of job loss through such displacements. To convey how such displacements in the model capture the most salient features of occupation displacement documented from the data, it is useful to first characterize a threshold property emerging from the calibrated model that summarizes the search policies of workers and the vacancy posting policies of firms. This property is formalized below as the *equilibrium skill-threshold*.

Definition 1 (Equilibrium skill-threshold)**.** *An equilibrium admits an equilibrium skill-threshold for aggregate productivity Z if there exists a value $h^*(Z)$ such that a worker from unemployment searches for a skill-sensitive*

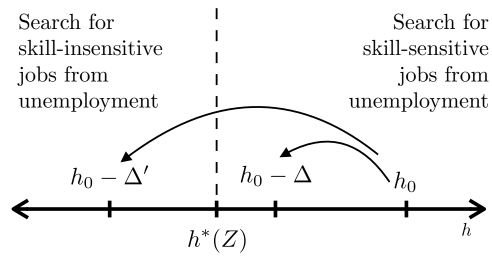

FIGURE 3. Search behavior is described by an equilibrium skill threshold h^*

Note: The *equilibrium skill threshold* h^* characterizes the search behavior of workers. Workers with $h \geq h^*(Z)$ search for skill-sensitive jobs, whereas workers with $h < h^*(Z)$ search for skill-insensitive jobs. A worker who enters unemployment from a skill-sensitive job with skill h_0 searches for another skill-sensitive job if shocks to skill are sufficiently small, e.g. of size Δ. For sufficiently larger shocks, e.g. of size Δ', the worker switches their search to skill-insensitive jobs.

job if and only if $h \geq h^*(Z)$; and otherwise, the worker searches for a skill-insensitive job.

To understand the existence of an equilibrium skill threshold, first suppose that $\kappa_H > \kappa_L$, as will be the case for the fully calibrated model. We can then guess-and-verify that the value to the firm from a skill-sensitive job $J_H(h, Z)$ is increasing in h through flow profits.[12] Then, by the free entry condition (12), we can confirm that $\theta_H(h, Z)$ and $p_H(h, Z)$ are also increasing in h. Similarly, we can verify that the value to the firm from a skill-insensitive job $J_L(h, Z)$ is decreasing in $p_H(h, Z)$ (and thus also in h) through diminishing retention probabilities to a firm in a skill-insensitive match, $1 - p_H(h, Z)$. Thus, the free entry condition (12) implies that $\theta_L(h, Z)$ and $p_L(h, Z)$ are decreasing in h.

Next, we can establish the existence of a single interval where both skill-sensitive and skill-insensitive vacancies are posted. Given fixed vacancy posting costs κ_H, a firm earns strictly negative profits of posting vacancies $\upsilon_H(h, Z)$ from a skill-sensitive job for $h < \underline{h}(Z)$ for some $\underline{h}(Z)$. Similarly, a firm will earn strictly negative profits of posting vacancies $\upsilon_L(h, Z)$ from a

[12]Note, the properties of the calibrated model discussed in this section are not imposed in the solution, but rather emerge as a property of the equilibrium. In a previous version of the paper, I show how these properties can be established analytically from a special case of the model wages are determined according to an flow-surplus splitting rule, as in Elsby and Gottfries (2021), and where h and Z are taken as fixed.

skill-insensitive job for $h > \overline{h}(Z)$ for some $\underline{h}(Z)$.[13] We then guess-and-verify that the value of searching for a skill-sensitive job minus the value of searching for a skill-insensitive job is strictly increasing in h. Then, from verifying that the value of searching for a skill-sensitive over a skill-insensitive job is increasing in h, we can establish that the equilibrium skill-threshold $h^*(Z)$ lives in the interval $\left[\underline{h}(Z), \overline{h}(Z)\right]$.

The equilibrium skill threshold h^* is decreasing in aggregate productivity Z. The intuition for this property can be understood most simply if we focus on a case where $\underline{h}(Z) = \overline{h}(Z)$ for all Z. Such a case would arise from an optimal search policy where a worker searches for a skill-sensitive job from unemployment whenever possible, i.e. $h^*(Z) = \underline{h}(Z)$.[14] Then, it is enough to analyze the behavior of $\underline{h}(Z)$, the minimum h for which a firm can recoup non-negative returns from posting a vacancy for a skill-sensitive job. When Z falls, we can verify that the value to the firm from a skill-sensitive job $J_H(h, Z)$ drops. Thus, the firm requires a higher productive input from the worker to recoup vacancy posting costs, so $\underline{h}(Z)$ and $h^*(Z)$ both increase.

Having characterized the properties of the equilibrium skill threshold $h^*(Z)$ and job-finding probabilities $\{p_L(h, Z),\ p_H(h, Z)\}$, we are well-placed to understand how the model generates a large and cyclical cost of job loss through occupation displacement:

Recall from the empirics that the highest earnings cost of job loss in the data is for workers who find reemployment in a lower-skill occupation. In the model, this corresponds to the case of a worker with skill $h > h^*(Z)$ moving from a skill-sensitive job to unemployment; and then losing sufficient skill to eventually search and find employment in skill-insensitive job, but from some diminished skill endowment $h' < h^*(Z)$. Such a case is illustrated in Figure 3. For a given loss in skill, workers switching from skill-sensitive to skill-insensitive employment realize greater losses in earnings, as their earnings reductions incorporate additional costs from reallocation.

Workers are more likely to switch from skill-sensitive to skill-insensitive employment (and thus undergo occupation displacement) if they lose their job during a recession, i.e. when Z is low. Recall, if Z falls, $h^*(Z)$ rises. Thus, small shocks that would not have otherwise induced an unemployed worker previously employed in a skill-sensitive job to search for a skill-insensitive job might now do so, as in Figure 4. Moreover, unemployed workers of higher h who were previously employed skill-sensitive jobs are

[13]The condition $\kappa_H > \kappa_L$ guarantees that $\underline{h}(Z) \leq \overline{h}(Z)$; and thus, there is no h where $p_H(h, Z) = p_L(h, Z) = 0$.

[14]Note, such a condition is not necessary to establish h^* as countercyclical, as will be demonstrated in the quantitative section of the paper.

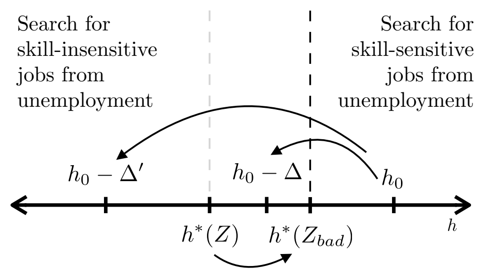

FIGURE 4. The equilibrium skill threshold h^* increases during recessions

Note: The equilibrium skill threshold is countercyclical, i.e. declining in Z. In the figure above, productivity falls from Z to Z_{bad} and the equilibrium skill threshold increases from $h^*(Z)$ to $h^*(Z_{bad})$. As in the previous figure, a worker who enters unemployment from a skill-sensitive job with skill h_0 searches for another skill-sensitive job in the absence of skill depreciation. However, small shocks that would have previously left the worker's search behavior unaltered — such as a reduction in skill from h_0 to $(h_0 - \Delta)$ — now induce the worker to search for a skill-insensitive job, generating occupation displacement.

more likely to be reallocated to skill-insensitive jobs if they lose their job during a recession. Recall, higher-h workers earn commensurately higher wages in skill-sensitive jobs, but not in skill-insensitive jobs. Thus, in the model, the heightened exposure of such high-h workers to reallocation risk during a recession increases the average earnings cost of occupation displacement, mirroring similar findings from the data documented in Section 1.4.

Thus, displacement of workers from skill-sensitive to skill-insensitive employment captures the essential qualitative features of job displacement in the data.

In the next section, I discuss the calibration of the model. Then, I show that the model is able to quantitatively capture the features of occupation displacement documented from the data; and in doing so, generate a large and cyclical cost of job loss.

3. Calibrating the model

I calibrate the model to assess its ability to match the size and cyclicality of the present value earnings cost of job loss. The model is fitted to match a combination of aggregate and micro moments, many of which depend on the endogenous distribution of workers across human capital and employment states. As such, only a subset of the model parameters are directly assigned and the rest are estimated by simulated method of moments. I leave

Table 7. Assigned parameters

Parameter	Description	Value/Source
β	discount factor (quarterly)	0.9992
b	value of leisure	0.71 (Hall and Milgrom, 2008)
δ	match survival prob.	0.0060, weekly EU rate
σ	matching function elasticity	0.5 (Pissarides and Petrongolo, 2001)
ν	death probability	4.8×10^{-4}, 40 year career
h_{ub}	human capital upper bound	10.0, see text
h_{lb}	human capital lower bound	0.5, see text
$\Delta_{\mathcal{H}}$	human capital increment	0.0638

moments describing the cyclicality and persistence of the earnings losses of displaced workers untargeted, preserving these as outcomes by which the model can be evaluated.

I consider two parameterizations of the model. The baseline parameterization allows for all of the novel mechanisms of the full model to be operative. Then, under a separate "single-technology" parameterization, all jobs are restricted to use the skill-sensitive production function. Thus, the single-technology parameterization does not allow for occupation displacement, instead offering the more traditional mechanisms of the canonical Ljungqvist and Sargent (1998) model of skill loss.[15] Hence, a comparison of the two parameterizations can be used to assess the quantitative contribution of occupation displacement for the size and cyclicality of the earnings cost of job loss.

The model is calibrated to a weekly frequency. The assigned parameters are common across the three parameterizations of the model and are given in Table 7. Most assigned values are standard to the literature. Following Ljungqvist and Sargent (1998), workers have an expected 40-year working career, implying $\nu = 4.8 \times 10^{-4}$. The maximum and minimum values of human capital h_{ub} and h_{lb} are set so that significant masses in the ergodic distribution do not accumulate at the endpoints of the human capital distribution. I use a grid with 150 equispaced points, implying $\Delta_{\mathcal{H}} = 0.0638$.

The flow values of unemployment are set such that higher skill workers coming from skill-sensitive jobs enjoy a greater value of leisure. Workers who last matched with a firm posting a vacancy for a skill-sensitive job (i.e., $j = H$) receive flow utility $u^b h$; whereas workers who last matched with a

[15]For both parameterizations, $\varsigma = \delta$, so outside values have no influence on wages. In the Online Appendix, I show results of an additional parameterization where $\varsigma > \delta$, and thus outside values matter for wages. There, I also provide additional moments for all three parameterizations as Table C.5.

TABLE 8. Targeted moments

Moment	Target	Simulated moments: Baseline model	Simulated moments: Single technology
Mean wage change following displacement	0.0700	0.0696	0.0793
10th percentile wage loss following displacement	0.0345	0.0122	0.0108
Average wage loss occupation switchers/stayers	1.3000	1.2955	—
Fraction of occupation switchers	0.6580	0.6666	—
Persistence of measured labor productivity	0.7654	0.7609	0.7268
Standard dev. of measured labor productivity	0.0132	0.0143	0.0141
Relative volatility of unemployment	11.1500	11.2422	10.9809
Weekly UE rate	0.0966	0.0966	0.1000
Average wage growth	0.0117	0.0090	0.0106
Experience premium, ≥ 5 years experience	1.3501	1.4600	1.5423
P90/P10 log wage residuals, < 5 years experience	0.9628	0.7720	0.7078
Wage distribution, p90/p50	2.1333	1.9619	1.9754
Wage distribution, p50/p25	1.4563	1.4851	1.2783

Note: Moments describing "Mean wage change following displacement" up through "Fraction of occupation switchers" are taken from the CPS DWS, 1984-2018. "Persistence . . . ," "Standard dev. of measured labor productivity," and "Relative volatility of unemployment" is taken from Hagedorn and Manovskii (2008). "Weekly UE rate" is taken from Menzio and Shi (2010). All other moments are calculated from the 2000 Census.

firm posting a vacancy for a skill-insensitive job (i.e., $j = L$) receive a flow utility u^b. I set u^b equal to match Hall and Milgrom's (2008) estimate of the ratio of the flow value of unemployment to output, 0.71. Following Hall and Milgrom (2008) and Christiano et al. (2016), I assume that a worker's flow value of delay u^d is equal to their flow value of leisure.

The remaining thirteen parameters are estimated by simulated method of moments, with targeted moments that describe labor productivity, employment flows, individual-level wage growth, and the wage distribution. There are as many parameters as there are targeted moments. The list of targeted moments and model generated counterparts are given in Table 8. The associated parameter values are given in Table 9. While the model parameters are jointly estimated, certain moments are more informative about some parameters than others. I discuss identification of model parameters using this correspondence below. Additional descriptive moments to be discussed in the text are given in Table C.5. Unless otherwise stated, the discussion below focuses on moments and parameter estimates from the baseline model.

Table 9. Estimated parameters

Parameter	Description	Baseline model	Single technology
Labor productivity:			
ρ_Z	Persistence of labor productivity	0.9821	0.9728
σ_Z	Standard dev. of labor productivity	0.0040	0.0035
Labor market:			
γ	Firm cost of delay	0.2592	0.2680
κ_H	Vacancy posting cost (skill-sensitive)	3.9382	0.9238
ϕ_H	Matching efficiency (skill-sensitive)	0.2581	0.2410
ϕ_L	Matching efficiency (skill-insensitive)	0.0743	—
χ	Task-common occupation switching	0.6343	—
Human capital:			
μ_{nb}	Human capital initial distribution mean	0.2495	−1.0434
σ_{nb}	Human capital initial distribution, standard deviation	0.0001	0.0001
π_H	Probability of human capital increase (skill-sensitive)	0.0315	0.0220
π_L	Probability of human capital increase (skill-insensitive)	0.0011	—
π_U	Probability of human capital decrease (unemployment)	0.1121	0.1296
ξ	Obsolescence probability	0.0364	0.0645

To facilitate comparison to Davis and von Wachter (2011) and the literature following Shimer (2005), labor productivity is taken to be the driving force for business cycles. Note, the dynamics of measured labor productivity here depend on the dynamics of the distribution of workers, and thus the parameters governing the driving force for labor productivity must be estimated. Estimates of the persistence and standard deviation of measured labor productivity from Hagedorn and Manovskii (2008) are included as targeted moments, where the process for labor productivity is discretized as a three-state Markov chain using the Rouwenhorst method (Kopecky and Suen, 2010). Following Hall and Milgrom (2008), the volatility of unemployment is included as a targeted moment. The firm value of delay is they key parameter for matching this target. The delay cost for a firm employing a worker of human capital h in a skill-sensitive match is taken to be γh, whereas the delay cost associated with a skill-insensitive match is simply γ. The estimated value for γ under the baseline calibration is 0.2592.

Three parameters are particularly important for determining human capital loss and reallocation across job types: the probability of gradual skill loss π_U, the obsolescence probability ξ, and the vacancy posting cost in the skill-sensitive market κ_H. While the role of π_U and ξ in determining human capital dynamics is clear, the role of κ_H may be less so. A higher value of κ_H represents a direct increase in the fixed cost of job creation for skill-sensitive jobs and will thus increase the equilibrium skill threshold, directing more job creation towards skill-insensitive jobs. Hence, a higher κ_H will increase the probability that a worker is reallocated from the skill-sensitive to skill-insensitive sector upon separation. Three moments are important for determining these parameters: the average wage loss of displaced workers, the 10th percentile wage change of displaced workers, and the average wage loss of displaced workers who switch occupations. The estimated weekly probability of gradual skill loss in unemployment is 0.1121, corresponding to an average 3.79% loss in human capital over a full quarter of unemployment. The estimated obsolescence probability ξ is 0.0364, and the estimated vacancy posting cost κ_H is 3.94.

The calibration of the model accounts for the novel empirical findings that only a subset of occupation switchers incur higher earnings losses upon reemployment (compared to non-switchers). As discussed in section 2.5, the parameter χ dictates the extent to which occupation switches are costly and thus describes the extent occupation displacement. The parameter is identified from the fraction of displaced workers who switch occupation upon reemployment and the associated average wage losses.

The monthly transition rate from unemployment to employment (from Menzio and Shi 2011) and the p90/p50 wage ratio calculated from the 2000 U.S. Census help identify the matching efficiency parameters for the skill-insensitive and skill-sensitive labor markets, ϕ_L and ϕ_H.[16] Wage dispersion in the upper ends of the wage distribution is generated through continuous human capital accumulation of workers within skill-sensitive jobs. Intuitively, if the model matches the average job-finding probability but job-finding rates for skill-sensitive jobs are too low, longer spells of unemployment for workers separated from skill-sensitive jobs will dampen the rate at which such workers find new jobs and resume skill accumulation, decreasing the p90/p50 wage ratio.

[16]I set $\kappa_L = 0.05$ and estimate ϕ_L, as these parameters only determine quantities through the ratio κ_L/ϕ_L. This identification strategy fails if κ_L is sufficiently high that there is a range of human capital where it is unprofitable for firms to post any type of job. In practice, such an outcome requires an implausibly high value of κ_L, and hence is not of particular interest.

While the model is forced to match moments describing the range of negative outcomes associated with job displacement, the calibration strategy still preserves a role for human capital in translating accumulated labor market experiences into higher wages, as shown in Table 8. The parameter estimates for π_H and π_L suggest that skill accumulation is much slower in skill-insensitive employments: the average worker in a skill-sensitive job expects a 0.99% increase in human capital over a quarter of continuous employment, versus a 0.08% increase for the average worker in a skill-insensitive jobs. Workers have a stochastic lifecycle, and the distribution of the initial skill draw for new entrants is parameterized as a discretized log-normal.[17] Entrants enter the economy in unemployment, where their skill is subject to depreciation until they find a job: the average human capital of a newly employed entrant is 1.28, compared to 2.30 for all employed workers under the baseline parameterization. As should be expected, workers in skill-sensitive jobs have on average higher human capital than workers in skill-insensitive jobs: 2.64 versus 1.13.

Note, while both versions of the model do well at matching the targeted moments, estimated parameters differ in important ways across the two parameterizations. Most strikingly, the parameters dictating the rate of human capital depreciation π_u and ξ are substantially larger under the single-technology parameterization, implying less durability of accumulated skill. The reason is clear: A given earnings loss in the single-technology parameterization requires a proportionate reduction in human capital; whereas earnings losses under the baseline parameterization can occur through reallocation across jobs of different production technologies, obviating the need for such large and arguably unrealistic human capital losses to match the data.

4. The scarring effect of recessions: model implications

In this section, I demonstrate the ability of the quantitative model to match the size and cyclicality of the cost of job loss. I show that the model is able to do so through its ability to match the persistent earnings losses and countercyclical incidence of occupation displacement. Finally, I show how related forces within the model allow it to match the persistent earnings loss of workers who enter the labor market during a recession.[18]

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[17]Note, the parameters defining the entrant distribution under the "single-technology" parameterization includes points below the minimum value of human capital, h_{lb}. When a newborn draws such a value of human capital, it is replaced with h_{lb}.

[18]Going forward, we require a measure of recessions in the model that is similar to that in the data. I generate a mapping of aggregate productivity and the distribution of workers

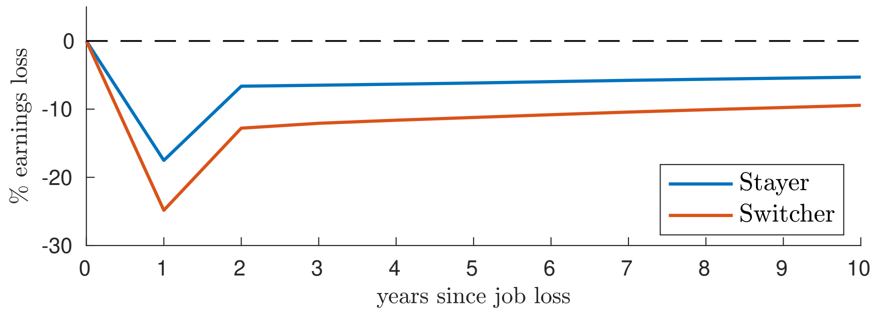

FIGURE 5. Earnings losses, stayers and switchers: model

Note: Earnings losses relative to counterfactual for occupation stayers and switchers under benchmark parameterization. See text for details.

Figure 5 shows the simulated time series of relative earnings losses for occupation stayers and switchers in the model. As in the data, occupation switchers in the model suffer higher and more persistent earnings losses than occupation stayers. Although the immediate drop in earnings for displaced workers and the relative immediate earnings drop of occupation switchers are included as a calibration targets, no moments related to the persistence of earnings losses or the divergent earnings recovery from job displacement for occupation switchers and stayers are targeted. Hence, the persistence of earnings losses for displaced workers who switch occupation upon reemployment speaks to the quantitative success of the model. The model is also successful in matching the higher incidence of occupation displacement among workers who lose their job during a recession relative to an expansion: there is a 4.4 percentage point increase in the model, close to the estimated 3.0 percentage point increase recorded in the data.[19]. So while the estimation only includes average measured occupation switching as a targeted moment, the model well accounts for the cyclicality of occupation displacement.

The estimated model matches the essential features of occupation displacement discussed in empirical section, including moments that are not targeted in the estimation. I now use the model to consider two separate but related aspects of the scarring effect of recessions: the cyclical cost of job loss (Davis and von Wachter, 2011), and the cost of entering the labor

across human capital and employment into a binary expansion/recession state variable. Details of all mapping and simulation procedures are given in Online Appendix C.

[19]See Table 2, Column 3

market during a recession (Kahn, 2010; Oreopoulos et al., 2012; Altonji et al., 2016; von Wachter, 2020).

4.1. **The cyclical cost of job loss.** I now consider the model implications for the size and cyclicality of the present value cost of job loss for each of the three model parameterizations. In doing so, I establish the importance of occupation displacement for generating a large cyclical cost of job loss.

I compute the cost of job loss using simulated data from the model using the regression equation and sample restrictions as in Davis and von Wachter (2011). The simulated data are organized by displacement year, y. For each displacement year y, I construct a sample of workers who have been continuously employed at the same job for six years as of y. Workers who separate from their job to unemployment at either year y, $y+1$, or $y+2$ constitute the subsample of displaced workers for displacement year y. Workers who do not separate from their job at years y, $y+1$, or $y+2$ constitute the subsample of displaced workers for sample y. From these simulated data, I estimate the regression equation

$$e^y_{it} = \alpha^y_i + \gamma^y_t + \bar{e}^y_i \lambda^y_t + \beta^y_t + \beta^y X_{it} + \sum_{k=-6}^{20} \delta^y_k D^k_{it} + u^y_{it} \tag{13}$$

where e^y_{it} represents real annual earnings of an individual i at time t for displacement year sample y, α^y_i is an individual fixed effect, γ^y_t is a year fixed effect, $\bar{e}^y_i$ represents average earnings from years $y-5$ to $y-1$, X_{it} is a quartic polynomial in age, and D^k_{it} equals one at year k subsequent to displacement and zero otherwise, where $k = 0$ represents a displaced worker's final year in the displacement job.[20] The coefficients δ^y_k are identified from earnings differentials between displaced and non-displaced workers and represent the reduction in earnings due to displacement k years prior. The earnings cost of job loss for displacement year y is computed using these and the other coefficient estimates from equation (13).

Figure 6 shows the earnings losses of displaced workers relative to non-displaced workers at various horizons from the baseline model, with separate plots for workers displaced during for recessions and expansions.[21] The empirical measures of expansion and recession come from the NBER Business Cycle Dating Committee, with roughly 12% of the years in the data falling

[20]Note, the dating convention is shifted in Figure 6, where "year zero" is the displacement year.

[21]Note that Figure 5 reveals milder earnings losses than Figure 6. This is because the latter figure conditions on a sample of high-tenure workers, as in Davis and von Wachter (2011).

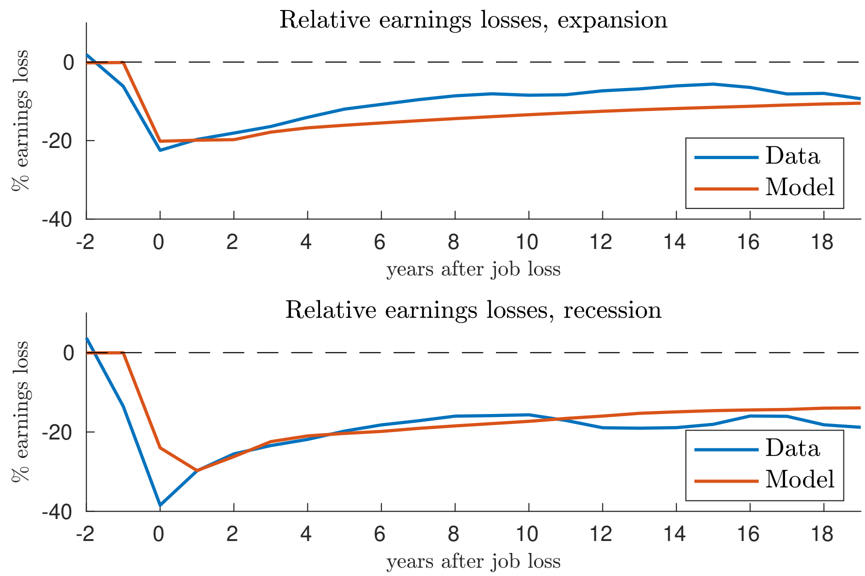

FIGURE 6. Comparison of model and empirical earnings loss profiles

Note: Earnings losses relative to counterfactual under the benchmark parameterization, as computed according to equation (13). Data from Davis and von Wachter (2011).

during recessions. For comparability, I adopt an ad hoc rule for model-simulated data where a year is identified to fall in a recession if the annual unemployment rate is in the upper 12% of the annual unemployment rate distribution. While there are some discrepancies between the empirical estimates and the simulated data from the model — for example, earnings recover quicker during expansions in the data than in the model — the overall fit of the model to the data is good.

The regression estimates from equation (13) can be used to construct an estimate of the present value of annual earnings losses from job displacement as a fraction of the present value of the earnings the worker would have received absent displacement. As in Davis and von Wachter (2011), I compute the present value losses over a twenty year horizon with a discount rate of 5%. I assess the ability of the model to generate a cyclical cost of job loss using two measures provided in Davis and von Wachter (2011): *1)* the present value cost of job loss according to whether a job is lost during a recession year or expansion year and *2)* the average present value cost of job

Table 10. Present value cost of job loss, data and model

		by NBER recession			by unemployment rate		
	All	Exp.	Rec.	Δ/Avg.	u_{low}	u_{high}	Δ/Avg.
1) Data	11.9	11.0	18.6	63.9	9.9	15.9	50.4
2) Baseline	13.7	13.6	17.5	28.4	11.7	16.7	35.9
3) Single technology	15.9	15.9	17.6	10.7	14.9	16.9	12.7
% of sample	100	88	12	—	23	29	—

Note: Data from Davis and von Wachter (2011). Davis and von Wachter report the average cost of job loss across years in the lower 23rd and upper 29th percentiles of annual unemployment rates, denoted above as u_{low} and u_{high}. Moments from the model are calculated similarly. Construction of "recessions" and "expansions" in the model-simulated data is described in the text. The "single technology" parameterization assumes an economy where all jobs utilize the skill-sensitive production technology, shutting down occupation displacement as a mechanism to generate a large and cyclical cost of job loss.

loss across years in the lower 23$^{\text{rd}}$ and upper 29$^{\text{th}}$ percentiles of the annual unemployment rate distribution.

The first column of Table 10 reports the average cost of job loss in the data and across the three parameterizations of the model. The second and third columns of Table 10 report the cost of job loss during expansions and recessions. Relative to the existing literature, both parameterizations of the model generate a large and cyclical cost of job loss.[22] A closer look, however, reveals that the baseline parameterization that allows a role for occupation displacement does far better at matching the data than the single-technology parameterization. The single-technology model suffers from two problems: First, it generates far too large of an average present value cost of job loss compared to the data. But most strikingly, the single-technology model fails to generate a cyclical cost of job loss, capturing just 16.7% of the percentage increase in the cost of job loss from recessions to expansions. By comparison, the baseline model that allows for occupation displacement generates 44.4% of the cyclical increase in the present value cost of job loss.

Next, I compute the average present value cost of job loss for workers who lose their job in a year when the average unemployment rate is high; and for workers who lose their job in a year when the average unemployment rate

[22]By way of comparison, the best-performing models considered by Davis and von Wachter (2011) generate a present value cost of job loss of 2.44% when the aggregate state is "good" and 2.71% when the aggregate state is "bad."

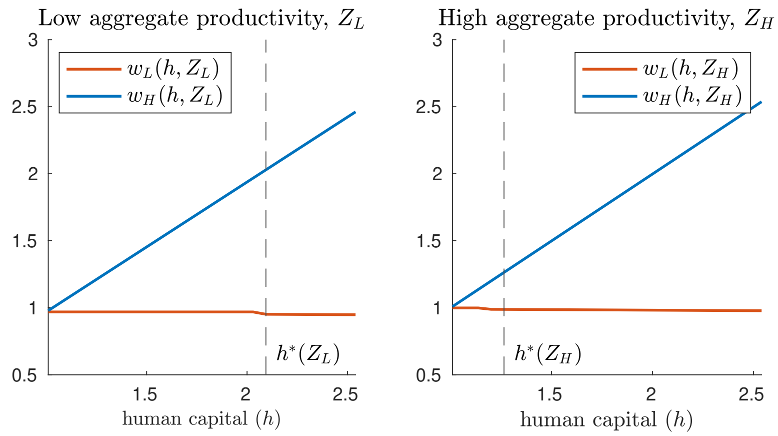

FIGURE 7. Wages, benchmark model

Note: The equilibrium skill thresholds for aggregate productivity Z_i given by $h^*(Z_i)$, $i = L, H$. Workers with human capital to the left of the equilibrium skill threshold $h^*(Z_i)$ search for skill-insensitive jobs from unemployment when aggregate productivity is Z_i; whereas unemployed workers with human capital to the right of the equilibrium skill threshold $h^*(Z_i)$ search for skill-sensitive jobs.

is low.[23] Results are given in the fifth through seventh columns of Table 10. Here, the quantitative importance of occupation displacement for generating a cyclical cost of job loss becomes even more apparent. Whereas the baseline model captures 71.2% of the percentage increase in the average cost of job loss from low-unemployment years to high-unemployment years, the single-technology parameterization that excludes occupation displacement captures just 25.2% of the cyclical increase.

Thus, the quantitative model confirms the key insight from the empirical analysis: occupation displacement is the key force behind the large and cyclical cost of job loss. To better understand the role of occupation displacement in generating the quantitative properties of the baseline model, it is useful to study how wages, job-finding probabilities, and vacancy-filling probabilities vary as a function of job-types and human capital over the business cycle.

[23]Periods when the unemployment rate is "high" correspond to periods when the annual unemployment rate falls into the upper 29$^{\text{th}}$ percentile of the annual unemployment rate distributions. Periods when the unemployment rate is "low" correspond to periods when the average unemployment rate falls into the lower 23$^{\text{th}}$ percentile of the annual unemployment distribution. The percentiles are chosen to correspond to Table 1 of Davis and von Wachter (2011).

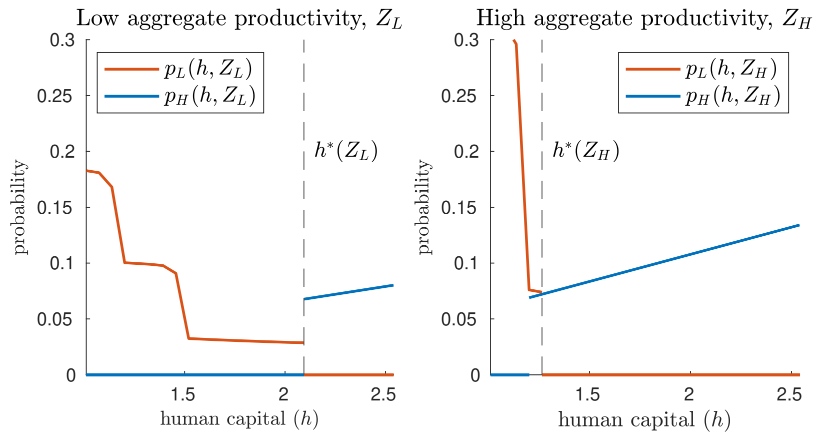

FIGURE 8. Job-finding probabilities, benchmark model

Note: The equilibrium skill thresholds for aggregate productivity Z_i given by $h^*(Z_i)$, $i = L, H$. Workers with human capital to the left of the equilibrium skill threshold $h^*(Z_i)$ search for skill-insensitive jobs from unemployment when aggregate productivity is Z_i; whereas unemployed workers with human capital to the right of the equilibrium skill threshold $h^*(Z_i)$ search for skill-sensitive jobs.

Figure 7 plots wages within skill-sensitive and skill-insensitive jobs, w_L and w_H, for low and high aggregate productivity, Z_L and Z_H. Wage schedules for a given job-type show relatively little cyclicality with respect to the aggregate state. Note, however, that the placement of the equilibrium skill threshold is countercyclical, indicating that hiring standards tighten during recessions. This implies larger wages losses from occupation displacement during a recession: Consider a worker with skill $h = h^*(Z)$ employed in a skill-sensitive job when aggregate productivity is Z. If the worker loses their job and any amount of human capital, the worker will optimally search for employment in a skill insensitive job. The wage losses from job loss for such a worker can be computed from the difference of the wage of the skill-sensitive job, $w_H(h, Z)$, and the skill-insensitive job, $w_L(h, Z)$, around the region of the equilibrium skill threshold, $h^*(Z)$. Figure 7 shows that such wage losses are considerably higher when aggregate productivity is low ($Z = Z_L$) compared to when aggregate productivity is high ($Z = Z_H$).

Figure 8 gives the schedule of job-finding probabilities for skill-sensitive and skill-insensitive jobs. The figure is particularly useful for studying the forces within the model that generate persistent earnings losses. Under the given process for skill depreciation in unemployment, a worker with a longer unemployment spell is more likely to switch from searching for skill-sensitive to skill-insensitive jobs. Then, observe from the figure that job-finding probabilities for skill-sensitive matches are strictly increasing decreasing in h, whereas job-finding probabilities for skill-insensitive matches are strictly increasing in h.[24] Hence, as an unemployed worker's level of human capital approaches the equilibrium skill threshold $h^*(Z)$ from above due to skill loss, expected unemployment durations become longer; and thus, the possibility of further unemployment-related skill loss becomes greater.

Hence, skill depreciation and the properties of the equilibrium job-finding probabilities work together as a human capital rip current: As an unemployed worker's level of human capital approaches the equilibrium skill threshold from above, expected skill losses increase due to longer expected unemployment durations, and it thus becomes increasingly likely that the worker's skill will be further eroded. Only when a worker's human capital falls below $h^*(Z)$ — and the worker accordingly redirects her search from skill-sensitive to skill-insensitive employment — can the worker expect job-finding probabilities to improve with further skill loss. This interplay of skill depreciation and unemployment dynamics in the neighborhood of the equilibrium skill threshold generates persistent skill losses (and hence persistent earnings losses) from occupation displacement.

We can further see from Figure 8 how these forces are amplified during a recession. As is typical for a Diamond-Mortensen-Pissarides model, a lower value of aggregate productivity is shown to be associated with lower job-finding probabilities. But here, low aggregate productivity Z_L is also attendant to a higher equilibrium skill threshold $h^*(Z_L)$. Hence, some workers displaced from skill-sensitive jobs who would otherwise optimally search for another skill-sensitive job instead must optimally search for skill-insensitive jobs; and unemployed workers whose skill endowment h still places them above the equilibrium skill threshold $h^*(Z_L)$ face a greater risk of losing sufficient human capital to drop below the equilibrium skill threshold through longer expected unemployment durations.

Finally, unemployed workers with human capital just below the equilibrium skill threshold $h^*(Z_L)$ face especially low job-finding probabilities for skill-insensitive jobs during a recession. When productivity is low, i.e. $Z = Z_L$, firms posting vacancies for skill-insensitive jobs in the region $[h^*(Z_H), h^*(Z_L))$ anticipate that workers they meet will immediately search on-the-job for skill-sensitive employment when aggregate productivity recovers. Firms respond accordingly by posting fewer vacancies, implying even lower job-finding probabilities for workers whose human capital places

[24]The underpinnings for this feature of the model are discussed in detail in Section 2.12.

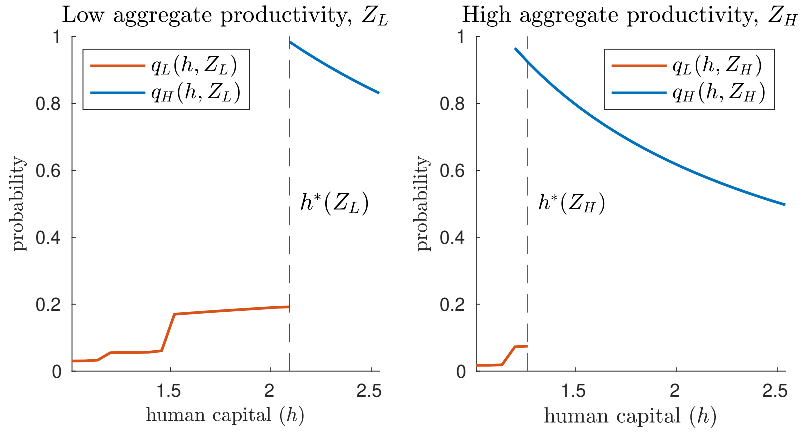

FIGURE 9. Vacancy-filling probabilities, benchmark model

Note: The equilibrium skill thresholds for aggregate productivity Z_i given by $h^*(Z_i)$, $i = L, H$. Workers with human capital to the left of the equilibrium skill threshold $h^*(Z_i)$ search for skill-insensitive jobs from unemployment when aggregate productivity is Z_i; whereas unemployed workers with human capital to the right of the equilibrium skill threshold $h^*(Z_i)$ search for skill-sensitive jobs.

them in this region. These workers are thus placed at even greater risk of persistent human capital loss during a recession.

Figure 9 gives the schedule of vacancy filling probabilities for skill-sensitive and skill-insensitive jobs. The figure is useful for understanding the existence of the equilibrium skill threshold. Recall that the value to a firm J_H of a skill-sensitive job is increasing in h, due to increasing flow profits; whereas the value to a firm J_L of a skill-insensitive job is decreasing in h, due to lower retention probabilities. The free entry condition (12) dictates that the expected value from posting a vacancy — equal to the vacancy filling probability times the job value — is only enough to recoup vacancy posting costs. Thus, fewer vacancies are posted for lower-value jobs, implying higher vacancy filling probabilities. Put more simply, firms are compensated for lower job values with higher vacancy-filling probabilities.

Even with a vacancy-filling probability equal to unity, however, not all job will still not be created. Note from Figure 9 that the vacancy-filling probability for a skill-sensitive job $q_H(h, Z)$ approaches unity as h falls; but then ceases to exist, by complementary slackness of the free entry condition.[25] We can understand this phenomenon by first verifying that the

[25]Recall that $q_H(h, Z)$ is computed on a grid. The maximum value of the computed vacancy filling probability $q_H(h, Z)$ comes arbitrarily close to one as the number of gridpoints goes to infinity.

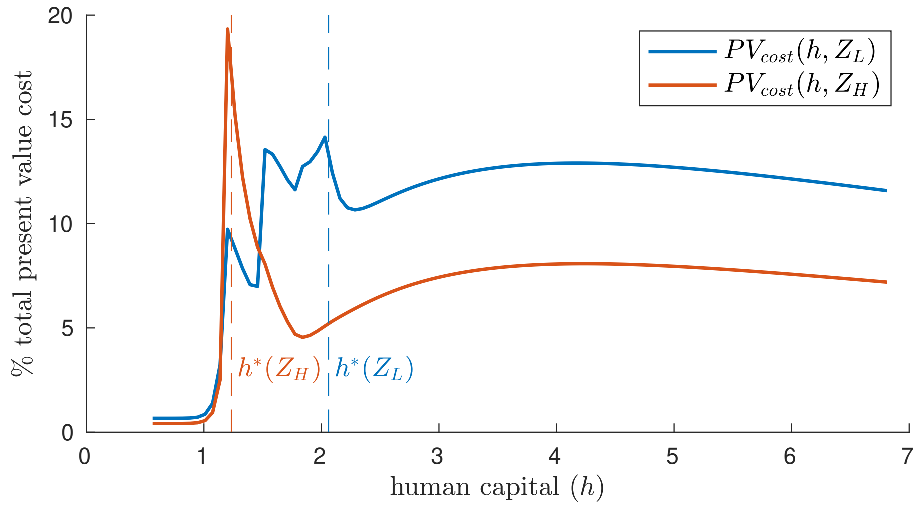

FIGURE 10. Total present value cost of job loss, benchmark model

Note: The total present value cost of job loss is calculated from the lifetime earnings loss associated with job displacement relative to the counterfactual path of earnings absent job displacement. Note, the total cost for a given Z achieves global maxima at the equilibrium skill-threshold, indicating the importance of occupation-displacement in generating a persistent cost of job loss, as well establishing the link between future earnings losses and the aggregate state at the time of job-displacement.

firm's value $J_H(h, Z)$ is continuously increasing in h. Hence, there exists an $\underline{h}(Z) \leq h^*(Z)$ such that $J_H(\underline{h}(Z), Z) = \kappa_H$ and $J_H(h, Z) < \kappa_H$ for h below $\underline{h}(Z)$. Therefore, when $h < \underline{h}(Z)$, the present discounted value of the match to the firm is less than cost of posting a vacancy. Given a vacancy-filling probability bounded above by one, the value of posting a vacancy in such markets is strictly negative, and so market tightness and job-finding probabilities $\theta_H(h, Z)$ and $p_H(h, Z)$ both equal zero. As discussed in Section 2.12, such an $\underline{h}(Z)$ is decreasing in Z, as a lower value of aggregate productivity requires a higher minimal human capital input $\underline{h}$ if the firm's job value is to recover vacancy posting costs. From this, we obtain an equilibrium skill threshold $h^*(Z)$ that decreases in Z; and accordingly, a greater cost and incidence of occupation displacement during recessions.

Thus far, we have studied schedules of wages, job-finding probabilities, and vacancy-filling probabilities to analyze the channels by which occupation displacement in the model generates a large and cyclical cost of job loss. Next, I show that the total present value of earnings losses reaches maxima in the neighborhood of the equilibrium skill thresholds. To produce the necessary quantities, I first calculate the values of employment and unemployment absent the flow utility of non-employment via value function iteration. Then, I use these quantities to calculate the lifetime present value cost of job loss for workers in skill-sensitive and skill-insensitive jobs. Finally, I calculate the total cost of job loss for a given h and Z using the simulated distribution of workers across skill-sensitive and skill-sensitive jobs for a given (h, Z) pair.

The schedule of the total cost of job loss is given in Figure 10. Notably, for a given Z, the total cost of job loss achieves a maximum in the neighborhood of the equilibrium skill threshold. Moreover, the cost of job loss when $Z = Z_L$ shows local maxima around the equilibrium skill thresholds for Z_M and Z_H; should the aggregate state change to one of these values, such workers will be more exposed to the risk of occupation displacement.[26] Figure 10 thus reveals that total present value cost of job loss is highest not for workers with the most human capital to lose, but rather for workers whose continued employment in skill-sensitive jobs is most tenuous.

Having established the importance of occupation displacement and the equilibrium skill threshold for generating a large and cyclical cost of job loss under the model environment, I explore the implications of the model for the cost of entering the labor market during a recession.

4.2. **The cost of entering the labor market during a recession.** Starting with Kahn (2010), an empirical literature has established that labor market entrants fare worse during recessions. Oreopoulos et al. (2012) study Canadian administrative data and find that the median college graduate entering the labor market during a recession year receives an earnings stream with a 10-year present discounted value that is 6% lower than that associated with entry during an average year. Lower-skill workers are predicted to experience larger present value earnings losses. Recovery of earnings after entry is facilitated in part by mobility from the job and industry of initial employment. Altonji et al. (2016) find that nearly half of the initial wage losses associated with entering the labor market during a recession can be explained by employment in lower-paying occupations. They find that high-skill workers fare better in part because they are more likely to find employment in an occupation typical to their field of study during a recession. For a broader sample of young workers, Schwandt and von Wachter

[26]Note, the total present value cost of job loss integrated over the worker distribution is lower than the present value cost of job loss calculated by Davis and von Wachter (2011). This is due in part because of the longer horizon and the lack of a minimum tenure restriction.

(2019) and von Wachter (2020) estimate the 10-year present value cost of entering the labor market during a recession to be 9% of the present value earnings the entrant would have received otherwise.

As labor market entrants and displaced workers must search for employment in the same aggregate environment, one might suspect that their subsequent earnings profiles are shaped by related forces. Outcomes of the model closely correspond to the empirical findings discussed above. As in Oreopoulos et al. (2012) and Altonji et al. (2016), workers of lower skill in the model fare worse both in the short and long-term. In the model, workers who enter the labor market during a recession face longer initial unemployment durations and more stringent hiring standards, and hence are more likely to find initial employment in a skill-insensitive job, similar to the findings of Altonji et al. (2016). Among entrants who find skill-sensitive employment during an expansion, the probability that a given worker also finds a skill-sensitive job during a recession is increasing in skill h. Hence, entrants at the top of the skill distribution are less likely to be forced to search for employment in a skill-insensitive job during a recession. This is consistent with Altonji et al.'s finding that high-skill workers are largely insulated from the cost of entering the labor market during a recession by the fact that they are more likely to find employment in a typical occupation.

To evaluate the cost of entering the labor market during a recession, I simulate outcomes for two cohorts of new entrants: the first cohort enters the labor market during an expansion, the second during a recession. Both cohorts are assumed to enter the labor market searching, i.e. through unemployment. Figure 11 plots the distribution of human capital of new entrants at the time of their first job, illustrating the impact of aggregate conditions on the labor market experiences of new entrants. Given that the initial distribution of human capital for labor market entrants is invariant to the aggregate state, the differences in the two distributions entirely reflect variation in job-finding probabilities and the equilibrium skill thresholds across recessions and expansions. For both expansions and recessions, there are irregularities in the distribution corresponding to workers who are hired exactly at the equilibrium skill threshold.

During recessions, a significant mass of the distribution lies to the left of the hiring standard. This is due to the depressed job-finding probabilities during recessions for workers with human capital just below the equilibrium skill threshold, as illustrated in Figure 8. During expansions, only 19.6% of workers start in skill-insensitive jobs in the baseline and outside value parameterizations. This increases to 74.5% during recessions. The present value cost of entering the labor market in the baseline parameterization

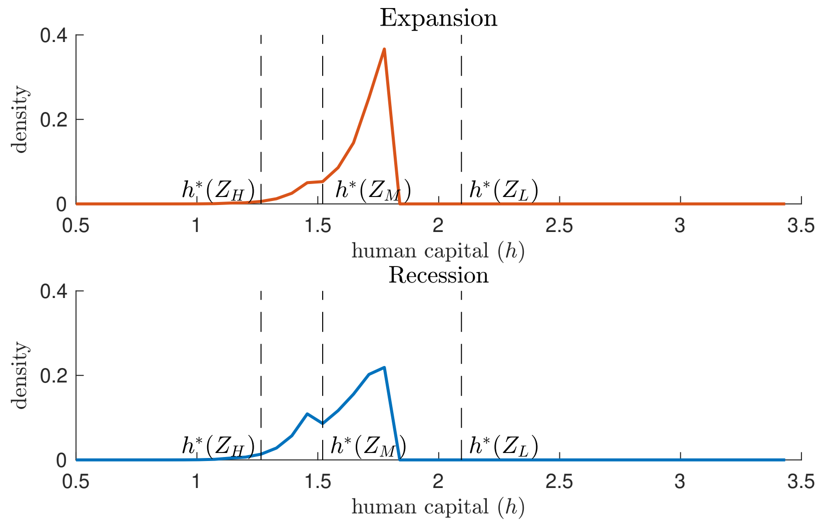

FIGURE 11. Human capital distribution of new entrants at initial employment

Note: The figure shows the distribution of human capital upon initial employment for workers entering the labor market during a recession and an expansion. The distribution of human capital during a recession is worse due lower job-finding probabilities, but also the higher equilibrium skill threshold associated with lower values of aggregate productivity.

of the model is 12.2%, close to the estimate of 9% of Schwandt and von Wachter (2019) and von Wachter (2020). Meanwhile, the single technology parameterization of the model predicts a ten-year present value cost of only 1.49%.

5. Conclusion

This paper has documented that the large and persistent earnings losses of involuntary job displacement are concentrated among workers who switch occupation after job displacement. The incidence and earnings cost of such occupation displacement increases during recessions. I propose a model of unemployment where hiring is endogenously more selective during recessions, and thus a greater fraction of unemployed workers – both displaced workers and labor market entrants – are left to search for employment in worse jobs. In accounting for the new empirical findings of the paper, the calibrated model accounts for the size and cyclicality of the earnings cost of job loss, and the earnings cost of entering the labor market during a recession.

The paper leaves open important avenues for future research. Several of the paper's findings suggest a non-negligible role for transitions to the low-skill service sector in the explaining earnings cost of job loss. Thus, the paper offers further evidence of an acceleration in the reallocation of workers to lower-skill occupations during recessions, as documented by Jaimovich and Siu (2012). The model offered in the paper could be enriched to allow a full quantitative analysis of such countercyclical employment polarization.

The paper also has implications for computing the welfare cost of business cycles à la Lucas (2003). Lacking an appropriate framework, the welfare cost of business cycles is computed from models that do not sufficiently account for the large and cyclical cost of job loss. This paper offers an appropriate framework. In identifying occupation displacement as a primary factor in accounting for the size and cyclicality of the earnings losses from job loss, the paper offers a starting point for the formulation of optimal policy to reduce the earnings cost of job loss.

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