Dynamic Inefficiencies in an Employment-Based Health-Insurance System: Theory and Evidence

Hanming Fang and Alessandro Gavazza

ONLINE APPENDICES

A First-stage Regressions

Panel A in Table A1 reports the results of a regression of the endogenous variable Log (Job Tenure) on the exogenous instruments on the sample of workers in the MEPS data set. The signs of the coefficients of the instruments are largely as expected. In particular, on average, a larger value of the instruments—i.e., more plant closures and more workers losing jobs due to plant closures—reduces job tenure, and the effect is stronger for older workers and males. Moreover, the instruments are jointly significant: The F-test on the exogenous instruments has a value above 23 in the specification of Panel A. Similarly, Panel B in Table A1 reports the first-stage regression of retirees' past tenure on the instruments using HRS data. It shows that the signs of the coefficients of the instruments are largely as expected. In particular, on average, a larger value of the instruments—i.e., a larger rate of plant closures and a larger rate of workers losing jobs due to plant closures—reduces job tenure, and the effect is stronger for less-educated workers and males. The instruments are again jointly significant: The F-test on the exogenous instruments has a value above 18 in the specification of Panel B.

B Mismeasurement of Workers' Job Tenure

An important robustness check is to verify the results of Section 5.1 on workers' medical expenditures in light of potential mismeasurement of workers' job tenure. The concern over potential mismeasurement arises because our analysis employs *current* job tenure, whereas the exact empirical equivalent of the variable used in the comparative statics of our theoretical analysis is *completed* job tenure. In Section 5.1, we made the implicit assumption that current job tenure and completed job tenure are related. Indeed, the two variables are identical if the probability of separation is independent of previous job tenure.[1] We address this potential concern by performing a robustness check using the Arellano-Bond specification. Specifically, we calculate retention/separation probabilities of cohort j in year t as the difference between (the log of) job tenure of cohort j in year t and the (log of) job tenure of the same cohort j in year $t-1$—i.e., $\textsc{log}(\textsc{Job Tenure}_{jt})$-$\textsc{log}(\textsc{Job Tenure}_{jt-1})$. The idea is that the higher (lower) is the retention (separation) probability, the higher $\textsc{log}(\textsc{Job Tenure}_{jt})$-$\textsc{log}(\textsc{Job Tenure}_{jt-1})$ is. Because of sampling error, this newly-constructed variable sometimes is negative and sometimes larger than the theoretical maximum of $\textsc{log}(1+\frac{1}{\textsc{Job Tenure}_{jt-1}})$. Hence, the instruments are particularly useful to correct the bias derived from this sampling error,

[1]For evidence that the probability of separation is independent of job tenure, see, among others, Van den Berg and Ridder (1998).

Table A1: The Relationship Between Workers' Job Tenure and the Instruments in MEPS (Panel A) and HRS (Panel B)

Panel A: MEPS: Log (Job Tenure)			Panel B: HRS: Log (Past Tenure)		
	Coefficient	Std. Error		Coefficient	Std. Error
Establishment Deaths_t	-4.27e-6***	(1.47e-7)	Rate of Workers Lost Job_{1990}	-40.976***	(8.203)
Rate of Establishment Deaths_t	0.676	(0.526)	Rate of Establishment Deaths_{1990}	18.064***	(6.170)
Workers Lost Job_t	7.80e-7***	(8.93e-8)	Rate of Workers Lost Job_{1990}*Education	3.091***	(0.611)
Rate of Workers Lost Job_t	-1.397***	(0.542)	Rate of Establishment Deaths_{1990}*Education	-1.447***	(0.457)
Establishment Deaths_t*Male	-1.75e-6***	(7.07e-7)	Rate of Establishment Deaths_{1990}*Female	-6.186	(4.190)
Establishment Deaths_t*Age	-7.74e-8***	(2.93e-8)	Rate of Workers Lost Job_{1990}*Female	10.722***	(2.852)
Age	0.163***	(0.017)	Age	-0.406	(0.311)
Age Squared	-0.002***	(0.0004)	Age Squared	0.051	(0.004)
Education	-0.015***	(0.002)	Education	0.030	(0.026)
Income/10,000	0.272***	(0.015)	Total Assets/1,000,000	0.088***	(0.011)
Male	0.072**	(0.021)	Male	1.324***	(0.144)
Married	0.156***	(0.014)	Married	-0.017***	(0.014)
Family Size	0.024***	(0.004)	Household Size	-0.018***	(0.006)
Union	0.579***	(0.015)			
# Obs	91,287			17,530	
Individuals				7,055	

Notes: (I) Panel A reports the first-stage regression of workers' (log of) job tenure on the instruments using MEPS data. Panel B reports the first-stage regression of the retirees' (log of) past job tenure on the instruments using HRS data. (II) The specification in Panel A also contains Age Cubed, Income Squared, Firm Size, Race and year fixed effects (not reported). (III) The specification in Panel B also contains Age Cubed, Total Assets Squared, Race and year fixed effects (not reported). (IV) *, **, *** denote significance at ten, five and one percent, respectively.

as well.

Table B2 reports the results, using the specification of equation (12) that explicitly takes into account serial correlation in the unobservables ϵ_{jt}.[2] Column (1) reports the results for the (log of) medical expenditures, and column (2) reports the results for the fraction of people in the cohort who report that they *did not* visit a doctor in the last year—i.e., they had zero doctor visits. In both cases, the qualitative results are identical to those reported in Table 2, and the quantitative magnitudes are also similar, reinforcing the idea that job attachment is an important determinant of workers' medical expenditures, as our theoretical framework implies.

C Specific Capital

This Appendix has two goals: 1) to extend the model of Section 3 to allow for endogenous turnover; and 2) to present the results of an additional empirical strategy that closely follows the extension of the model. This empirical strategy differs substantially from the analysis in Sections 5.1 and 5.2. Nonetheless, the qualitative and quantitative results are remarkably similar.

C.1 An Extended Model

In the model of Section 3, the turnover probability q was exogenously fixed. Obviously, in many cases, employees decide to voluntarily leave employers and, thus, turnover is endogenous. We now consider a simple extension of the model that delivers endogenous turnover. The main new mechanism is firm-specific human capital. This extension is also particularly useful because in the next section, C.2, we use a measure of industry-specific human capital provided by the Department of Labor as an exogenous proxy for job turnover.[3] We assume that there is a continuum of jobs/industries, indexed by i, and that jobs/industries differ in the importance of specific capital. In job i, the production function of a worker is

$$y_i = f(h, s_i),$$

[2] The number of observations is lower than in the corresponding regressions of Table 2 because the variable $\log$(Job Tenure$_{jt}$)-$\log$(Job Tenure$_{jt-1}$) requires first-differencing and, thus, some observations are lost.

[3] Related models in which specific capital and turnover rates are endogenously modeled can be found in Chang and Wang (1995, 1996). They focus on the role of asymmetric information where current employers are assumed to know more than potential employers about workers' productivity.

Table B2: The Relationship Between Workers' Job Tenure and Medical Expenditures (Panel A) and Doctor Visits (Panel B)—Alternative Measure of Job Turnover

	Panel A: Log Medical Expenditures	Panel B: Fraction Not Visiting Doctors
	(1)	(2)
ΔLog (Job Tenure)	0.679***	-0.090**
	(0.233)	(0.045)
Age	-0.622**	0.037
	(0.305)	(0.038)
Age Squared	0.014*	-0.0005
	(0.007)	(0.0004)
Education	0.178***	-0.022***
	(0.024)	(0.003)
Income/10,000	0.009	0.001
	(0.070)	(0.012)
Male	-1.099***	0.203***
	(0.060)	(0.009)
Married (Fraction)	0.204	-0.029
	(0.156)	(0.024)
Family Size	-0.199***	0.020***
	(0.044)	(0.007)
Union (Fraction)	0.349**	0.010
	(0.191)	(0.031)
ρ	0.257***	0.099***
	(0.031)	(0.033)
# Obs	3322	3322
Panels	552	552

Notes: (I) Columns 1 and 2 report Arellano-Bond IV regressions assuming AR(1) errors. (II) All regressions also contain Age Cubed, Income Squared, Firm Size, Race and year fixed effects (not reported). (III) Standard errors in parentheses are calculated by applying the finite sample correction proposed by Windmeijer (2005) and are robust to autocorrelation and heteroskedasticity of unknown form. (IV) *, **, *** denote significance at ten, five and one percent, respectively.

where s_i are skills specific to job i. More precisely, a worker moving to a different job can transfer only a fraction $(1-i)$ of his skills s_i, so that a higher-indexed job i has more-specific skills. For simplicity, assume that the employee acquires the level of skills s_i during the first period with the employer via a learning mechanism, as in Jovanovic (1979), and that the level s_i is equal across all jobs.[4] To obtain endogenous turnover in the model, we assume that, in the second period, the worker can approach another firm at no cost. The new firm and the worker draw a match-specific productivity shock ϵ from the distribution $G(\epsilon)$. The worker's productivity in the new firm y_2^n is equal to

$$y_2^n = f(h_2, (1-i)\, s_i) + \epsilon.$$

In the new firm, the worker and the employer divide the surplus according to the Nash bargaining solution, so that, at the new firm, the worker gets a wage equal to:

$$w_2^n(y_2^n, y_2^o) = (1-\beta)\, w_2^o(y_2^o, y_2^n) + \beta y_2^n, \tag{C1}$$

where $w_2^o(y_2^o, y_2^n)$ and $y_2^o = f(h_2, s_i)$ are the wage and the production in the old firm, respectively. Similarly, at the old firm, the worker gets a wage equal to:

$$w_2^o(y_2^o, y_2^n) = (1-\beta)\, w_2^n(y_2^n, y_2^o) + \beta y_2^o. \tag{C2}$$

Solving the system of equations (C1) and (C2), we obtain

$$w_2^n(y_2^n, y_2^o) = \frac{(1-\beta)\, y_2^o + y_2^n}{2-\beta} \text{ and } w_2^o(y_2^o, y_2^n) = \frac{(1-\beta)\, y_2^n + y_2^o}{2-\beta}.$$

The worker leaves his old firm whenever the new firm offers him a higher salary. Thus, the probability that the worker leaves the old firm in the second period is equal to:

$$\Pr\left(w_2^n(y_2^n, y_2^o) \geq w_2^o(y_2^o, y_2^n)\right) = \Pr\left(y_2^n \geq y_2^o\right) = 1 - G\left(f(h_2, s_i) - f(h_2, (1-i)\, s_i)\right),$$

which is decreasing in i. Thus, the introduction of firm-specific human capital makes turnover endogenous. We state this result as a modified version of Proposition 1:

Proposition 1 *Workers in jobs with more-specific skills (higher i) have a lower turnover rate and, thus, higher health investment.*

[4] We can allow specific skills s_i to be endogenously accumulated at some cost. All results go through, at the cost of additional assumptions and calculations. Details are available from the authors upon request.

C.2 An Alternative Empirical Strategy

In this section, we report results from an empirical strategy that differs from the strategy of Sections 5.1 and 5.2. More precisely, we construct a proxy of current (for employed individuals) and past (for retirees) job attachment at the three-digit industry level using data from the 1991 Dictionary of Occupational Titles (DOT). We then match this proxy to MEPS and HRS data. We present the results of this alternative empirical strategy that more closely follow the results of Sections 5.1 and 5.2. In Fang and Gavazza (2007), we provide several additional tests, looking at whether firms offer health plans to their workers and what the characteristics of the offered health plans are. The results of these additional tests are all consistent with the results reported here.

Dictionary of Occupational Titles (DOT) and Average Specific Vocational Preparation (ASVP). The *Dictionary of Occupation Titles* compiled by the U.S. Department of Labor (1991) provides information about the training specificity required in various *occupations*. The variable, known as "Specific Vocational Preparation" (SVP), is defined as "the amount of time required to learn the techniques, acquire information, and develop the facility needed for average performance in a specific job-worker situation." It is based on nine numerical categories of vocational preparation, ranging from "Short demonstrations only" (category 1) to "Over 10 years" (category 9) [see U.S. Department of Labor (1991) for more details]. The Employee Retirement Income Security Act of 1974 (ERISA) requires employers to provide the same menu of health-care benefits to all workers in order for these benefits to be tax-exempt. Thus, firms presumably use the average job attachment of all workers in the firm as the relevant measure of job attachment when deciding what health benefits to offer to workers. Unfortunately, the data do not provide us with detailed information on the entire workforce of each individual firm. Thus, we focus on differences across *industries* in our analysis. More precisely, following the procedure described in Crocker and Moran (2003), we construct an Average Specific Vocational Preparation (ASVP) index for all the three-digit industry codes. Specifically, for each industry, we construct an ASVP by taking the weighted average of the SVPs of workers' occupations, where the weights are given by the five-percent sample from the 1990 Census. The industries with the three lowest values of ASVP are "Services to dwellings" (industry code 722), "Services to private households" (industry code 761) and "Taxicab service" (industry code 402)—all industries in which intuition suggests that specific human capital is not important. Industries with the highest values of ASVP are "Legal services" (industry code 841), "Engineering, architectural, and surveying services" (industry code 882) and "Miscellaneous professional and related services" (industry code 892).

Table C3: Means and Standard Deviations of the ASVP Variable

MEPS (1998)		HRS (2002)		BHPS (1997)	
Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
5.19	0.83	5.23	0.82	5.33	0.68

Intuition suggests that a higher ASVP value would be associated with a higher importance of industry-specific human capital, and, indeed, Crocker and Moran (2003) show that a higher industry ASVP value is a strong predictor of longer job tenure at the *firm* level. We match the constructed industry ASVP variable with individual-level data from MEPS (1998), HRS (2002) and BHPS (1997) in our analysis below. Table C3 shows the average ASVP for individuals' current industry in MEPS (1998) and BHPS (1997) and individuals' pre-retirement industry with longest job tenure in HRS (2002).

Empirical Specification. We match the ASVP index to the three-digit industry of each worker in the MEPS to investigate how current job attachment affects workers' current medical expenditures. We also match each individual's three-digit industry of the longest reported job in the HRS to investigate how past job attachment affects retirees' medical expenditures. The basic analysis is based on the following regression:

$$y_i = \alpha \text{ASVP}_i + \beta \mathbf{X}_i + \epsilon_i, \tag{C3}$$

where y_i is one of the several outcomes considered for individual i, such as total health expenditures, doctor visits, health status, etc.; $\mathbf{X}_i$ is a large set of control variables, including individual $i's$ age (also squared and cubed), education, gender, etc.. The coefficient of ASVP_i, α, measures the average effect of our proxy for job attachment on the outcome y_i, after controlling for a large number of factors included in the vector X_i.

C.2.1 Medical Expenditures of Workers

Table C4 presents the results of several regressions that investigate employees' medical expenditures (Panel A) and doctor visits (Panel B). Columns (1) and (2) report the coefficients of Tobit regressions in which the dependent variables are the level and the log of an individual's (annual) total medical expenditures, respectively. We employ Tobit regressions since the dependent variables are right-censored at zero expenditures. Columns (3) and (4) report the coefficients of negative binomial regressions in which the dependent variable is the number of office-based visits and the number of physician visits, respectively.[5]

Columns (1) and (2) show that individuals working in high-ASVP industries—i.e., industries with low turnover rates—have higher medical expenditures. The marginal effect calculated from the Tobit regression coefficient on the ASVP reported in Column 1 implies that a unit increase in ASVP increases annual medical expenditures by around $113 dollars, or about six percent of the average medical expenditure, a rather large effect. The coefficient of the ASVP reported in Column 2 is much bigger: It implies that a unit increase in ASVP increases annual medical expenditures by about 15 percent.[6]

Columns (3) and (4) show that workers in high-ASVP industries visit medical providers more frequently. The magnitudes of the coefficients imply that a unit increase in ASVP is associated with an increase in the annual number of medical providers' visits and physician visits of about five percent, a rather large effect.

Overall, the results of Table C4 are consistent with Proposition 1 (and its extension, Proposition 1) of our model.

C.2.2 Medical Expenditures of Retirees

We now, using HRS data, investigate how past job attachment affects retirees' medical expenditures and health status. More precisely, the HRS reports individuals' longest job, along with its three-digit industry code. Thus, we match our ASVP proxy to the industry in which the individual had his longest job.

Column (1) in Table C5 presents the results of a Tobit regression that investigates how past ASVP affects retirees' current medical expenditures. Column (2) presents the results of an ordered Probit regression that investigates how past ASVP affects retirees' current health status. The dependent variable is a categorical indicator of self-reported health status, with 1 indicating "Excellent," 2 "Very Good," 3 "Good," 4 "Fair," and 5 "Poor."

Column (1) shows that medical expenditures are lower for individuals who worked in high-ASVP industries prior to retirement. The marginal effect from the estimated Tobit coefficients

[5] The number of office visits is the sum of visits to physicians and nonphysicians. MEPS classifies the following categories as nonphysicians: chiropractors, midwives, nurses and nurse practitioners, optometrists, podiatrists, physician's assistants, physical therapists, occupational therapists, psychologists, social workers, technicians, and receptionists/clerks/secretaries.

[6] The difference between the two coefficients suggests that individuals in low-turnover industries have higher average medical expenditures and a lower variance of medical expenditures. This is an implication of Jensen's inequality due to the log transformation of the dependent variable. See, also, Santos Silva and Tenreyro (2006).

Table C4: Relationship Between Industry ASVP and Total Medical Expenditures (Panel A) and Doctor Visits (Panel B)

	Panel A: Total Medical Expenditures		Panel B: Doctor Visits	
	Level	Log	Office-Based Visits	Physician Visits
Variables	(1)	(2)	(3)	(4)
ASVP	199.8**	0.22***	0.046*	0.053**
	(92.2)	(0.06)	(0.026)	(0.022)
Age	-135.5*	-0.24***	-0.005	-0.028*
	(72.6)	(0.05)	(0.023)	(0.016)
Age Squared	3.8**	0.006***	0.001	0.001***
	(1.7)	(0.001)	(0.000)	(0.000)
Education	74.5***	0.13***	0.039***	0.026***
	(27.9)	(0.02)	(0.008)	(0.009)
Male	-1257.7***	-1.63***	-0.593***	-0.622***
	148.4)	(0.11)	(0.043)	(0.038)
Income/10,000	-38.3*	-0.04***	-0.011	-0.019***
	(21.4)	(0.01)	(0.008)	(0.006)
Family Size	-239.4***	-0.19***	-0.071***	-0.043***
	(36.9)	(0.02)	(0.020)	(0.016)
Union	512.0***	0.43***	0.244***	0.231***
	(178.6)	(0.11)	(0.077)	(0.053)
Obs.	13,459	13,459	13,459	13,459

Notes: (I) Panel A reports the coefficient estimates from Tobit regressions with the total medical expenditures (level) or Log (1+Total Medical Expenditures) as the dependent variable. Panel B reports the coefficient estimates from negative binomial regressions where the dependent variables are "Number of Office Based Visits" and "Number of Visits to Physicians," respectively. (II) All regressions include a constant and additional controls for Firm Size, Race, Census Region and MSA dummies, as well as Age Cubed. Their coefficient estimates are not shown. (III) Robust standard errors clustered at the industry level are in parentheses. (IV) *, **, *** denote significance at ten, five and one percent, respectively.

Table C5: Relationship Between Retirees' Total Medical Expenditures and Perceived Health Status and the ASVP of their Pre-retirement Industries

Variables	Total Medical Expenditures		Perceived Health Status	
	(1)		(2)	
ASVP	-1,012.5*	(537.3)	-0.045**	(0.020)
Age	19,889	(23,447)	-0.046	(0.515)
Age Squared	-268.3	(307.4)	-0.001	(0.007)
Age Cubed	1.22	(1.34)	0.000	(0.000)
Education	132.1	(125.9)	-0.069***	(0.006)
Male	1766.0***	(730.6)	0.072***	(0.029)
Assets/100,000	-56.2***	(21.7)	-0.013***	(0.004)
Family Size	-100.3	(350.9)	0.034**	(0.014)
Married	-839.9	(791.3)	-0.178***	(0.037)
No. of Obs.	5,583		6,730	

Notes: (I) Column (1) reports the estimates from a Tobit regression with the total medical expenditures as the dependent variable. Column (2) reports the estimates from an ordered Probit regression with "Perceived health status 1: Excellent; 2: Very Good; 3: Good; 4: Fair; 5: Poor" as the dependent variable. (II) Both regressions include Race, Census Region and MSA dummies and their coefficient estimates are not shown. (III) Robust standard errors clustered at the industry level are in parentheses. (IV) *, **, *** denote significance at ten, five and one percent, respectively.

on ASVP shows that a one-unit increase in pre-retirement industry ASVP is associated with a decrease of $\$1,037$ in annual medical expenditures, a substantial effect. Column (2) of Table C5 shows that the coefficient of ASVP is negative and statistically significant, indicating that individuals who worked in high-ASVP industries prior to retirement have better self-reported health in retirement. This is particularly interesting since Column (1) shows that these same individuals have lower medical expenditures. Overall, these findings are consistent with Proposition 2 of our model.

C.2.3 Assessing the Magnitude of Life-Cycle Inefficiency

We now combine the estimates of the previous two sections to try to calculate the magnitude of the externality implied by our new set of regressions, in a parallel way to our calculations of Section 5.3.

Suppose that both individuals A and B work for 45 years and then retire for 15 years before dying. Individual A works in an industry in which the ASVP is low (i.e., turnover is high), while individual B works in an industry in which the ASVP is high (i.e., turnover is low). More precisely, individual A's ASVP is one unit lower than individual B's. The coefficient of the ASVP in the regressions of Table C4 on MEPS data implies that individual A's expenditures are lower than B's by \$113 per year. Instead, the coefficient of the ASVP in the regressions of Table C5 on HRS data implies that individual A has higher medical expenditures than individual B by \$1,037 per year.

Thus, if individuals A and B work for 45 years and then retire for 15 years, non-discounting their expenditures, we have that individual A has approximately \$5,000 less in medical expenditures per year than individual B when working, but approximately \$15,000 *more* in medical expenditures when retired. This calculation suggests that one additional dollar of medical expenditures during the working years may lead to about three dollars of savings during retirement. Again, we wish to emphasize that this calculation is very rough, as we already noted in Section 5.3. Nonetheless, it describes in a very simple way the externality we have in mind and its magnitude in the data. Moreover, it is quite interesting to note that the magnitude of the externality is close to the one that we calculated in Section 5.3, obtained with a different empirical methodology.[7]

C.2.4 Falsification Test: U.K. Workers

We now present the results of a falsification test that uses data from the U.K. BHPS, similar to the test we performed in Section 6.2. Specifically, we use the 1997 wave of British Household Panel Survey (BHPS) to investigate the relationship between ASVP and doctor visits for U.K. workers.

Column (1) in Table C6 reports the results from a negative binomial regression in which the dependent variable is the number of annual doctor visits. The estimated coefficient is almost zero, and is not statistically significant. This shows that our proxy for job attachment, ASVP, does not significantly affect the frequency of doctor visits, in sharp contrast to the evidence for the U.S., reported in Panel B of Table C4. Column (2) further reports the results of an ordered Probit regression that investigates the relationship between ASVP and a five-categorical indicator of self-reported health. Column (2) shows that the coefficient of the ASVP does not statistically differ from zero. This provides additional evidence in favor of

[7] The levels of the expenditures do not correspond to the levels reported in Section 5.3 because one unit of ASVP does not translate into one standard deviation of the log of job tenure.

Table C6: Falsification Test: Relationship Between Industry ASVP and Doctor Visits and Perceived Health Status for U.K. Workers.

Variables	Doctor Visits	Perceived Health Status
	(1)	(2)
ASVP	-0.007	-0.035
	(0.031)	(0.028)
Age	-0.031***	-0.006
	(0.008)	(0.008)
Age^2	0.0004***	0.000
	(0.0001)	(0.000)
Education	-0.001	-0.030**
	(0.008)	(0.009)
Male	-0.502***	-0.129***
	(0.032)	(0.035)
Income/10,000	-0.026***	-0.043**
	(0.008)	(0.011)
Family Size	-0.006	0.013
	(0.013)	(0.016)
Union	0.110**	0.052
	(0.044)	(0.047)
No. of Obs.	4,926	4,928

Notes: (I) Column (1) reports the coefficient estimates from a negative binomial regression where the dependent variables is the "Number of Annual Doctor Visits"; column (2) reports the coefficient estimates from an ordered Probit regression with "Perceived health status 1: Excellent; 2: Very Good; 3: Good; 4: Fair; 5: Poor" as the dependent variable. (II) Robust standard errors clustered at the industry level are in parentheses. (III) *, **, *** denote significance at ten, five and one percent, respectively.

the mechanism identified by our model.

D Quantitative Assessment of a Dynamic Search Model

In this Appendix, we show that an infinite-horizon extension of our model quantitatively matches the data well. Consider the following extension of our model. This extension closely follows the model in the Appendix of Acemoglu and Pischke (1998), but we allow the employer-employee pair to bargain over the level of investment in health, as in the model of Section 3.

Each worker is matched with a firm. The productivity of a worker with health h is equal to $f(h)$ in every period. For simplicity, suppose that investment in health is possible only in the first period. Both the firm and the worker are risk-neutral and discount the future at rate r. All worker-firm matches end at the exogenous rate q. A worker, once unemployed, finds a new firm at rate u_w, which is independent of her health, and a firm finds a new employer at rate u_f.

Suppose that all workers have health h^*, and consider a worker with health $h = k(h_0, m)$ where h_0 is the worker's initial health and m is the health investment to be determined in equilibrium, and $k(\cdot, \cdot)$ is the health production function. The value $J^E(h)$ of being employed satisfies

$$rJ^E(h) = w(h) + q\left[J^U(h) - J^E(h)\right], \tag{D4}$$

where $J^U(h)$ is the value of being unemployed. Equation (D4) has the usual interpretation of an asset-pricing equation. The worker receives a flow utility equal to her wage $w(h)$. At any date, at most, one possible event might happen to her: At rate q, she loses her current job, resulting in a capital loss equal to $J^U(h) - J^E(h)$. Similarly, the value of unemployment $J^U(h)$ satisfies:

$$rJ^U(h) = u_w\left[J^E(h) - J^U(h)\right]. \tag{D5}$$

For the firm, the value of employing a worker with health h, denoted by $J^F(h)$, satisfies

$$rJ^F(h) = f(h) - w(h) + q\left[J^V - J^F(h)\right], \tag{D6}$$

where J^V is the value of an unfilled vacancy, which itself satisfies:

$$rJ^V = u_f\left[J^F(h^*) - J^V\right]. \tag{D7}$$

Nash Bargaining between the employer and the employee over wage $w(h)$ and medical expenditures (i.e., health investment) m solves:

$$\max_{\{w,m\}} \left[J^E(h) - J^U(h)\right]^{\beta} \left[J^F(h) - J^V\right]^{1-\beta} - pm, \tag{D8}$$

where p is the price of medical expenditures and $h = k(h_0, m)$. Standard calculations following the first-order condition with respect to w yields the following wage function:

$$w(h) = \frac{(u_w + r + q)\left[\beta f(h) - \beta r J^V\right]}{r + q + \beta u_w}.$$

The first-order condition with respect to medical expenditures m is given by:

$$\left\{ \begin{array}{c} \beta\left[J^E(h) - J^U(h)\right]^{\beta-1}\left[J^F(h) - J^V\right]^{1-\beta}\left[J^{E\prime}(h) - J^{U\prime}(h)\right] \\ +(1-\beta)\left[J^E(h) - J^U(h)\right]^{\beta}\left[J^F(h) - J^V\right]^{-\beta} J^{F\prime}(h) \end{array} \right\} \frac{\partial k}{\partial m} = p. \tag{D9}$$

Using equations (D4)-(D7), we can simplify equation (D9) as:

$$\left[\beta^2\left(\frac{1-\beta}{\beta}\right)^{1-\beta} + (1-\beta)^2\left(\frac{\beta}{1-\beta}\right)^{\beta}\right]\frac{f'(h)}{q + r + \beta u_w}\frac{\partial k}{\partial m} = p. \tag{D10}$$

Suppose that we adopt the following functional form for $f(\cdot)$ and $k(\cdot,\cdot)$:

- $f(h) = zh$ where $z > 0$ is a constant;[8]
- $h = k(h_0, m) = h_0 m^{\alpha}$ where we assume $0 < \alpha < 1$ to guarantee an interior solution.

With these functional forms, the equilibrium condition (D10) becomes:

$$\left[\beta^2\left(\frac{1-\beta}{\beta}\right)^{1-\beta} + (1-\beta)^2\left(\frac{\beta}{1-\beta}\right)^{\beta}\right]\frac{z\alpha h_0 m^{\alpha-1}}{q + r + \beta u_w} = p. \tag{D11}$$

From (D11), we have:

$$m = \left\{\frac{(r + q + \beta u_w)\, p}{\left[\beta^2\left(\frac{1-\beta}{\beta}\right)^{1-\beta} + (1-\beta)^2\left(\frac{\beta}{1-\beta}\right)^{\beta}\right] z\alpha h_0}\right\}^{\frac{1}{\alpha-1}}.$$

Taking logs on both sides of the above equation, we obtain:

$$\begin{aligned} \ln m &= \frac{1}{\alpha-1}\ln(r + q + \beta u_w) + \frac{1}{\alpha-1}\ln p \\ &\quad -\frac{1}{\alpha-1}\ln\left\{\left[\beta^2\left(\frac{1-\beta}{\beta}\right)^{1-\beta} + (1-\beta)^2\left(\frac{\beta}{1-\beta}\right)^{\beta}\right] z\alpha h_0\right\}. \end{aligned}$$

[8] This is for simplicity only. The functional form for $f(\cdot)$ linking health to productivity is not relevant for the calculation of $\frac{\partial m}{\partial q}\frac{q}{m}$, as can be easily seen from Eq. (D10). This is because once we take logs on both sides, the function form for $f(\cdot)$ does not matter in our calculation of $\frac{\partial m}{\partial q}\frac{q}{m} \equiv \partial \ln m / \partial \ln q$.

Thus, the elasticity of medical expenditures m with respect to separation probability q is given by:

$$\frac{\partial m}{\partial q}\frac{q}{m} = \frac{q}{(\alpha - 1)(q + r + u_w \beta)}, \tag{D12}$$

and the elasticity of medical expenditures with respect to price is given by:

$$\frac{\partial m}{\partial p}\frac{p}{m} = \frac{1}{\alpha - 1}. \tag{D13}$$

Now, in our data, the mean job tenure is 6.7 years, as shown in Table 1. Thus, we have $q \approx 1/6.7$. Kowalski (2009) estimates that $\frac{\partial m}{\partial p}\frac{p}{m} \approx -2.3$. Hence, equation (D13) implies that $\alpha \approx 1 - 1/2.3 = \frac{13}{23}$. Furthermore, assuming that unemployment duration is six months, then $u_w = 2$. (Note that u_w and q imply an unemployment rate of $q/(q + u_w) = 0.074$, which matches the average unemployment rate reasonably well). Finally, Cahuc, Postel-Vinay and Robin (2008) estimate that the average bargaining parameter β is approximately .15. Taking an interest rate $r = .04$, we obtain from (D12) that

$$\frac{\partial m}{\partial q}\frac{q}{m} = \frac{1/6.7}{(13/23 - 1)(1/6.7 + .04 + 2 \times .15)} = -0.70.$$

Columns (3) and (4) of Table 2 reports our estimated elasticity of medical expenditures with respect to job tenure to be equal to 0.801 or 0.535, respectively. Because the elasticity of medical expenditures with respect to job tenure is equal to the negative of the elasticity with respect to separation probability q, our estimates straddle the calibrated elasticity above. Note that in this model, equation (D5) implies that $J^U(h) = u_w J^E(h)/(r + u_w)$. Given the values we assigned, $r = 0.04$, and $u_w = 2.0$, $J^U(h) = 0.98 J^E(h)$. Thus, the major reason for the sensitivity of equilibrium medical expenditures to turnover rate q in this model is the difference between $J^F(h)$ and J^V, which can be seen from equations (D6) and (D7).

Additional References

[1] Cahuc, Pierre., Fabien Postel-Vinay and Jean-Marc Robin (2006). "Wage Bargaining with On-the-job Search: Theory and Evidence." *Econometrica*, 74(2), 323-64.

[2] Chang, Chun and Yijiang Wang (1995). "A Framework for Understanding Differences in Labor Turnover and Human Capital Investment." *Journal of Economic Behavior and Organization*, Vol. 28, 91-105.

[3] Chang, Chun and Yijiang Wang (1996). "Human Capital Investment Under Asymmetric Information: The Pigovian Conjecture Revisited." *Journal of Labor Economics*, Vol. 14, No. 3, 505-520.

[4] Fang, Hanming and Alessandro Gavazza (2007). “Dynamic Inefficiencies in an Employment-Based Health Insurance System: Theory and Evidence.” NBER Working Paper No. 13371.

[5] Jovanovic, Boyan (1979). “Job Matching and the Theory of Turnover.” *Journal of Political Economy*, Vol. 87, No. 5, 972-990.

[6] Kowalski, Amanda (2009). “Censored Quantile Instrumental Variable Estimates of the Price Elasticity of Expenditure on Medical Care.” NBER Working Paper 15085.

[7] Santos Silva, Joao and Silvana Tenreyro (2006). “The Log of Gravity.” *Review of Economics and Statistics*, Vol. 88, No. 4, 641-658.

[8] van den Berg, Gerard. and Geert Ridder (1998). “An Empirical Equilibrium Search Model of the Labor Market.” *Econometrica*, Vol. 66, No. 5, 1183-1223.

[9] Windmeijer, Frank (2005). “A Finite sample correction for the variance of linear efficient two-step GMM estimators.” *Journal of Econometrics*, Vol. 126, Issue 1, pp. 25-51.