Online Appendix to "Hedging Labor Income Risk"

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In this appendix we provide further information about the theoretical background for our empirical tests (Section A), the elimination of unusual data (Section B), the definition of variables (Section C), and some additional robustness tests (Section D).

A Theoretical background: a stylized model

We introduce a stylized model to motivate the predicted relationships between wages and portfolio decisions. Our model is a simplified version of the model in Parlour and Walden (2010), although similar results also arise elsewhere in the literature. Parlour and Walden (2010) introduce a multi-sector model in which firms in different sectors have different labor productivity and where there is moral hazard between firms and workers, which leads to risky compensation. For our purposes, it is sufficient to introduce a two-sector model and we have no need to model the moral hazard between workers and firms.

Time is discrete, $t = 0, 1$. There are two units of agents with CARA utility, one unit of which have a risk aversion coefficient γ_L and the other unit γ_H, where $\gamma_L < \gamma_H$. Then the risk-aversion coefficient of the representative agent is $\overline{\gamma} = \frac{1}{\frac{1}{\gamma_H}+\frac{1}{\gamma_L}}$.

There are two firms ℓ and h, both generating total revenues of $R + \xi$ at $t = 1$ where $R > 1$ is a constant and $\xi \sim N(0, \sigma^2)$ is a normally distributed random variable. The volatility $\sigma > 0$ is constant as well. The total risk in the economy is therefore 2ξ, and in a full risk sharing equilibrium each agent should take on $\frac{\overline{\gamma}}{\gamma_i}\xi$, $i \in \{L, H\}$.

Each firm $j \in \{\ell, h\}$ employs one unit of workers and pays a risky wage of $s_j + w_j\xi$. Here we assume $s_j > 0$ and $0 \leq w_j < 1$. We also assume that $w_\ell < w_h$, so that the wages of firm h are riskier than those of firm ℓ. For a micro foundation for why firms differ in the riskiness of their wage contracts, see Parlour and Walden (2010). There is one share of each firm traded in the stock market. The remaining cash-flows, net wages, $D_j = R - s_j + (1 - w_j)\xi$, are paid out as a liquidating dividend at $t = 1$ to shareholders. There is also a risk-free asset in elastic supply, with returns normalized to zero.

It follows from a standard Walrasian equilibrium argument (similar to that made in Parlour and Walden (2010) that the price of one unit of ξ risk in equilibrium is $-\overline{\gamma}\sigma^2$, that the market clearing price of firm $j \in \{\ell, h\}$ is $P_j = R - s_j - \overline{\gamma}\sigma^2(1 - w_j)$, and that the value of wages are $s_j - w_j\overline{\gamma}\sigma^2$. Now, given that labor markets are competitive and that the same human capital skills are needed for all jobs, it further follows that $s_j = W + w_j\overline{\gamma}\sigma^2$ for some constant W representing the market price of a worker's human capital (see Parlour and Walden (2010)).

Since there is only one risk-factor in the stock market, each agent can reach his optimal allocation by trading in the stock market portfolio, together with the risk-free asset. We therefore treat the total stock market payout of $\overline{D} = 2(R - W + \xi) - (w_\ell + w_h)(\xi + \overline{\gamma}\sigma^2)$ as that of a representative firm in the market with a supply of one share and a price of $\overline{P} = 2(R - W - \overline{\gamma}\sigma^2)$.

We now have all the ingredients to compare the portfolio holdings of the two types of agents. Let q_j^i denote the stock portfolio of agent $i \in \{L, H\}$, who works in firm $j \in \{\ell, h\}$. Using a standard hedging argument, we can show that

$$q_j^i = \kappa \frac{\overline{\gamma} - \gamma_i w_j}{\gamma_i}, \qquad \text{where } \kappa = \frac{1}{2 - w_\ell - w_h}, \tag{A-1}$$

and further that

$$q_\ell^i > q_h^i, \qquad i \in \{L, H\}. \tag{A-2}$$

Eq. (A-2) is the key relation that we would like to test. It relates wage risk (w_j) to the agents' portfolio decisions (q_j^i). Specifically, it says that any agent who works in the high wage risk firm h, i.e. who has a high wage volatility, will choose to have a lower share of his wealth invested in the stock market portfolio than if he works in the low wage risk firm. In other words, any agent who switches jobs from a high wage volatility firm to a low wage volatility firm (i.e. whether or not he has high or low risk aversion) will rebalance his stock market portfolio upward, and vice-versa.

Now, given that a fraction $\alpha \in [0, 1]$ of L-agents work in the ℓ-firm, it follows that the average portfolio of agents working in ℓ-firms is

$$\bar{q}_\ell = \kappa\overline{\gamma}\left(\frac{\alpha}{\gamma_L} + \frac{1 - \alpha}{\gamma_H}\right) - \kappa w_\ell, \tag{A-3}$$

and similarly the average portfolio of agents working in h-firms is

$$\bar{q}_h = \kappa\bar{\gamma}\left(\frac{\alpha}{\gamma_H} + \frac{1-\alpha}{\gamma_L}\right) - \kappa w_h. \tag{A-4}$$

It follows that

$$\bar{q}_l \geq \bar{q}_h \qquad \Leftrightarrow \qquad w_h - w_\ell \geq \left(\frac{\gamma_H - \gamma_L}{\gamma_H + \gamma_L}\right)(1-2\alpha). \tag{A-5}$$

Thus, as long as $\alpha \geq 1/2$, i.e., as long as at least half of the agents with low risk aversion work in the low labor-risk firm, the average investment portfolio of an agent in the low labor-risk firm will have higher market exposure than that of an agent working in the high labor-risk firm, i.e. $\bar{q}_l > \bar{q}_h$. When $\alpha < 1/2$, however, agents who work in high-risk firms may have *higher* risk exposure in the market than agents who work in low-risk firms. Therefore, in a statistical test of the relationship between wage risk and investment portfolios the outcome may be that of "anti-hedging." In other words, the endogeneity introduced by heterogeneous risk preferences makes such a test inconclusive, especially since one may expect that agents with high risk aversion naturally choose to work in low labor risk industries (i.e. the case where $\alpha < 1/2$). On the other hand, a test based on (A-2) where we study agents who switch jobs largely mitigates these issues of endogeneity. Our tests in the paper will therefore be based on (A-2).

We summarize the two hypotheses on the relationship between wage volatility and portfolio holdings, again emphasizing that the first hypothesis is vulnerable to heterogeneity in risk preferences:

H1: The higher a worker's wage volatility, the lower his/her exposure to the market through financial assets.

H2: A worker who switches to a sector with higher wage volatility decreases his/her exposure to the market through financial assets.

B Excluded data

In this section we provide more information on the various filters we impose to eliminate unusual data. LINDA (Longitudinal INdividual DAta for Sweden) is an annual cross-sectional sample of around 300,000 individuals. There are 230,000 households that exist in the data for the entire 1999-2002 period and that do not undergo any major change in their civil status.

Then, there are many individuals who do not have an industry code but still generate positive disposable income. This could occur if they receive welfare transfers from the government and are not employed. As we describe below, including these households can bias our measure of wage volatility. So we only retain the 137,000 households where individuals report a positive disposable income and have a SNI code.

We also impose minimum financial requirements. Households whose financial wealth, net wealth or disposable income is extremely low or negative - less than SEK 3000, SEK 1000, and SEK 1000 respectively, as well as those with negative net holdings of risky assets, are eliminated.[1] This involves approximately 60,000 households. We exclude households in which the largest income goes to someone younger than 18 years or older than 65 years, as well as observations in which information on the wage volatility is missing (about 14 SNI codes). Finally, we trim outliers: we exclude households whose family income or house-to-wealth ratio ranges in the top 0.1% of the remaining sample in 1999 and 2002 and households for which the change in wage volatility between 1999 and 2002 is in the bottom or top 0.1% of the remaining sample. We end up with a sample of 73,346 households.

C Additional definitions of variables

In this section we provide additional details on how we define variables from the LINDA dataset for the empirical analysis.

Table 1: Reported variables include the age of the household head (age), the number of children who are minors in the household (no. children), household disposable income (family income), in thousands of SEK, and household financial wealth (fin. wealth) and net worth (net worth) in thousands of SEK (see below for exact definitions). We also report the following dummy variables which are 1 if at least one adult satisfies the criterion: unemployed (if he/she is receiving unemployment insurance), Nordic (born in either Sweden, Norway, Denmark, Finland, or Iceland), college degree, post-high school business degree, married, single, student, lives in a high population density area (Stockholm, Gothenburg or Malmo/Lund/Trelleborg), medium population density (not a high density area but with more than 27,000 inhabitants, less than 90,000 inhabitants within 30km of the municipality center, and more than 300,000 inhabitants within 100 km of the municipality center), low population density (not a high or medium density area), retired, homeowner (of any real

[1] See the Appendix for the definition of these variables.

estate).

Financial wealth is the sum of cash (checking and savings accounts, money-market funds), bond-only mutual funds, stocks, and risky mutual funds, and capital insurance and other products. Other products include lottery bonds, subscription rights, right offerings, and options. The highest share is invested in lottery bonds. Capital insurance products, which are another form of investment subjected to a special tax treatment, may also include risky assets. They exist in two forms: the traditional products which guarantee a minimum fixed return and are essentially risk-free, and the "unit link" savings, which are invested in mutual funds. Data on the exact composition of these products is very difficult to get but given the importance of the traditional products in the early 2000s and the special tax incentives for the elderly, it seems that these products were primarily risk-free during 1999-2002. For robustness, we created two additional measures: one where we exclude capital insurance and other products from financial wealth and another one where the share of risky assets includes half the value of capital insurance and other products. Our empirical results are robust to these two alternative specifications.

Net wealth is the sum of financial wealth and all housing wealth minus the sum of all debt. It does not include the value of other real assets such as yachts etc. unless the household is subject to wealth tax. Further, net wealth does not include any retirement – tax-deductible – assets, human capital, and the values of private businesses and bank accounts for which less than SEK 100 is earned annually.

Tables 5 and 6: In addition to the variables described in Table 1, "age^2" is the squared value of age (scaled by 1000) and "has emigrated" is a dummy variable that is 1 at least one adult who used to be part of the household has emigrated from Sweden. "house / networth" is the ratio of housing wealth over net worth (in 1999), and "debt-to-income" corresponds to the ratio of debts to household disposable income. Both family income and net worth (in 1999) are in log terms. "wage vol" is defined as the average volatility of annual returns to real disposable income across all individuals within a 3-digit SNI code who have stayed in the same 5-digit SNI code for at least 5 consecutive years between 1993 and 2003 (see below for details). "wage vol. same ind." is an interaction variable that is equal to wage volatility if the two adults in the household work in the same 1-digit SNI code. "public" ("private") is a dummy variable that is 1 if all the working individuals within the household work in the public (private) sector.

For our computation of "wage vol," we restrict the individuals to have the same five-digit SNI code to make sure they do not switch jobs. We also exclude individuals who are receiving student aid and new job training (if they are unemployed), in order to exclude part-time jobs. Finally, we exclude individuals who are either self-employed or who are owners (or who are a close relative to an owner) of a closely held company, e.g. "3:12" firms, because these individuals are more likely to report their income in a non-conventional way. We choose a period of five consecutive years to maximize the sample size but results are robust to different specifications. We work with disposable income because it is more reliable than pre-taxed income. One weakness of using disposable income is that we may be picking up tax effects that are not related to the individuals' labor income situation. On the other hand, it allows us to capture all the tax effects that are related to their labor income situation. Disposable income is available at the individual-level because in Sweden individuals do not file their taxes jointly.

Tables 8 and 9: Explanatory variables are changes to family disposable income in logs (family income), changes to house-to-net wealth-ratio (house / networth), changes in the debt-to-income ratio (debt / income), changes to net worth in logs, and changes in wage volatility (Δ wage vol.). We also interact Δ wage vol. with dummies on whether the switchers are up- or down- switchers. "Δ sign(wage vol) $\cdot$ (wage vol)^2" is a variable whose absolute value is squared. "toPrivate" and "toPublic" are both dummy variables on whether the high-income generating individual switches to the private and public sectors respectively in 2002 (see below for details). Furthermore, we include dummy variables that equal 1 if at least one in the household satisfies the criteria: moved from a low population density to a high one (low to high), stopped receiving student aid between 1999 and 2002 (has graduated), retired between 1999 and 2002 (has retired), unemployed in 1999 but not in 2002 (found job), employed in 1999 but not in 2002 (lost job), owned no real estate in 1999 but owned real estate in 2002 (bought house), and owned real estate in 1999 but owned no real estate in 2002 (sold house).

For our computation of "toPrivate" and "toPublic," our objective is to focus purely on the switch between the public and private sectors, so we restrict the switcher individuals to work at all times between 1999 and 2002. In other words, they cannot enter or quit the workforce during that time period. Switchers also do not have to change three-digit SNI codes as long as they switch between the public and private sectors. Finally, because we have a smaller sample of switcher households, we do not restrict switchers to switch between the public and private sectors only between 2000 and 2001. They can switch anytime between 1999 and 2002 as long as they only switch once.

D Additional robustness tests

D.1 Endogeneity Taste Shocks

In Section 4.4 of the paper, we address the potential endogeneity issue that a job switch may be part of a major life change – a "taste shock"which jointly affects households' job switching and portfolio rebalancing decisions. In this section we explain in more details the first three robustness tests that we run to compare the characteristics of switchers and the other households.

In Table D.1, we compare statistics on wage volatility for three categories of households: the up-switchers, the down-switchers, and the non-switchers. With the wage volatility measure, there are 1,739 down-switchers, 45,615 non-switchers, and 2,076 up-switchers. The average wage volatility in 1999 is highest for the down-switchers and lowest for the up-switchers. This result is to be expected given the finite number of industries. By definition, a worker who switches out of the safest industry must switch to a riskier industry and vice-versa. Finally, both up- and down- switchers are more likely than the non-switchers to be in the private sector in 1999. This is not surprising given the lower job turnover in the public sector. Thus, these systematic differences between switchers and non-switchers are most likely purely mechanical.

In terms of industries, we study the distribution of industries in 1999 for the switchers and check whether they worked in different types of industries compared with non switchers. In Fig. D.1 we plot histograms of the 3-digit SNI codes in 1999 for switchers and non switchers. The histograms are remarkably similar. The only main difference is the lower fraction of switchers households that have SNI code in the 850s, which correspond to industries in the public sector, such as healthcare or education. This result is consistent with the high share of switchers in the private sector from Table D.1. Thus, Fig. D.1 provides no evidence for systematic differences between switchers and non switchers.

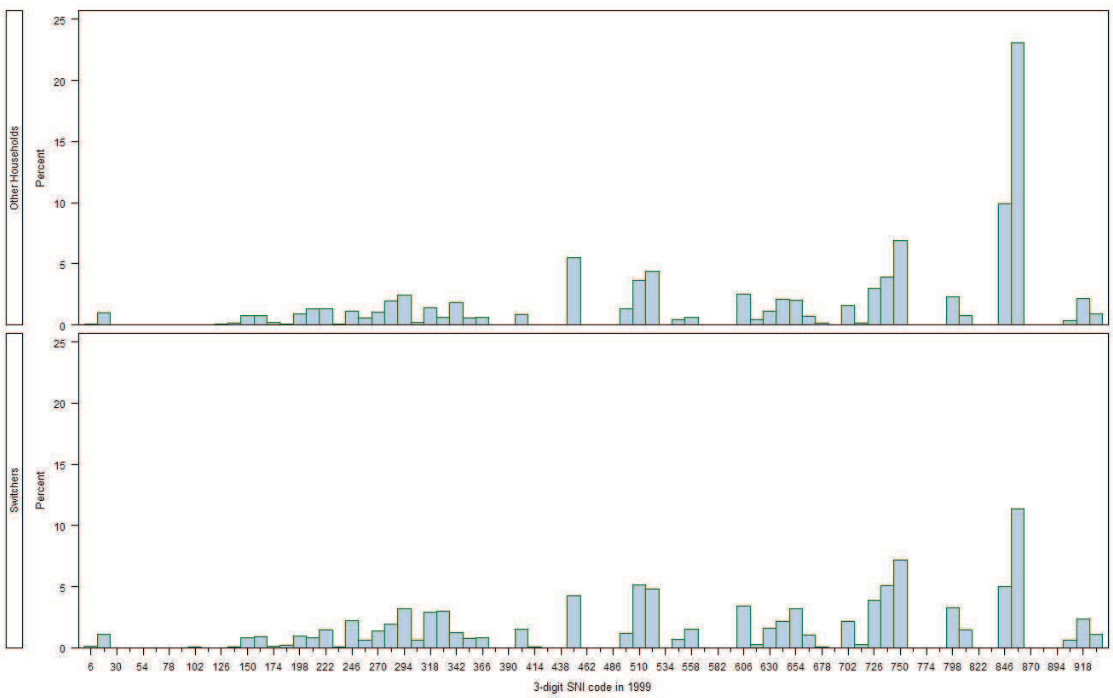
Finally, we examine whether individuals who have already switched jobs are more likely to switch jobs again in the future. Once again, we use the entire data from 1993 to 2003 at the individual-level and compare individuals who have already switched to all the other

Table D.1: Summary statistics of wage volatility for switchers

	Down switchers				Non-switchers				Up-switchers			
Variable	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Wage Volatility												
Vol 99	.16	.03	.1	.28	.14	.02	.08	.3	.13	.02	.08	.23
Private 99 (%)	.81	.39	0	1	.59	.49	0	1	.67	.47	0	1
Δ Vol 99-02	-.02	.02	-.12	0	0	0	0	0	.03	.02	0	.12
N	1,739				45,615				2,076			

Wage volatility is defined as the average volatility of annual returns to real disposable income across all individuals within a 3-digit SNI code who have stayed in the same 5-digit SNI code for at least 5 consecutive years between 1993 and 2003. It is assigned to each individual based on their 3-digit SNI code and then aggregated at the household level. "Private 99" is a dummy on whether the high-income individual worked in the private sector in 1999. Switchers are defined as households where at least one adult switched to a new industry between 1999 and 2002 (see Section 4.1 in the paper for details). The up-switchers (down-switchers) are defined as switchers that experience an increase (decrease) in wage volatility. Non-switchers are defined as households neither individual switched industries between 1999 and 2002.

Figure D.1: Histograms of industries for switchers and other households in 1999



Industries are represented as 3-digit SNI codes. The bottom histogram represents switchers and the top histogram all the other households.

individuals. There are differences, but they are small. If we consider the individuals who have existed in LINDA during the entire sample (the vast majority of individuals), the switching frequency for our switchers is 24.5%, which is slightly higher than for the other households (22.6%). Again, this has to do with the fact that switchers are more likely to come from industries with higher turnover. If we exclude the individuals who worked in the public sector, there is less of a difference between the switching frequency of switchers (22.6%) and the other individuals (21.3%).

D.2 Basis Functions

In our analysis of switchers in Section 5.2, we begin by modeling the change in the risky share between 1999 and 2002 as a function of the households' initial risky share in 1999. In our baseline model we use three cubic splines to get a smooth approximation and filter out noise. The advantage of using splines is that they are local functions and therefore capture local variations well.

To make sure that our results are not driven by our specification of this basis function, we also run our estimations with different types of basis functions. The results of the empirical analysis are remarkably similar. In Table D.2, we show the results with three other basis functions: a simple linear regression, a quadratic regression, and another cubic spline with 6 degrees of freedom this time. In Panel A., we report the average predicted difference in the active change of the risky share between down-switchers and up-switchers. The estimates for each method are almost identical to the ones we just reported above. In Panel B., we report the estimates of Eq. (5) in the paper and we find once again that the results are not sensitive to the way we model the basis function, which suggests that our results are not biased by our first-stage estimation.

Table D.2: Robustness checks with different basis functions

	(cubic spline 3df)		(cubic spline 6df)		(linear reg)		(quad reg)	
A. Average predicted difference in the active change of the risky share between down- and up-switchers								
Variable	Est.	t-stat	Est.	t-stat	Est.	t-stat	Est.	t-stat
high → low wage vol.	1.57%		1.54%		1.17%		1.48%	
private → public	2.6%		2.6%		2.77%		2.56%	
B. Estimates of Eq. (5)								
Intercept	.005	1.09	.005	.1.09	.003	.62	.005	1
Δ wage vol	-.323	-2.34	-.323	-2.34	-.26	-1.83	-.325	-.236
Δ no. children	.023	2.48	.022	2.24	.021	2.06	.023	2.2
has retired	-.035	-1.75	-.035	-1.85	-.031	-1.61	-.034	-1.81
Δ family income	-.074	-4.03	-.073	-4.03	-.08	-4.26	-.076	-4.13
Δ debt / income	-.007	-1.83	-.007	-1.83	-.01	-2.24	-.008	-1.92
sold house	-.147	-3.66	-.147	-3.66	-.152	-4.03	-.145	-3.6
Δ house / networth	.022	2.27	.022	2.27	.022	2.31	.023	2.39
Δ net worth	-.02	-3	-.02	-2.6	-.024	-3.07	-.021	-3.16
No. Obs	2,565		2,565		2,565		2,565	
F	7.95		7.95		8.63		8.35	
Adj R-sq	.021		.021		.023		.022	

In Panel A, we report the average *predicted difference* in the 99-02 active change of the risky share between down-switchers and up-switchers. For each population (switcher, non-switcher...), the average is taken from the predicted values of their active changes of the risky share between 99-02 given their initial risky shares in 1999. We report the results using four different interpolation methods: our main one ("cubic spline 3df"), another cubic spline with 6 degrees of freedom ("cubic spline 6df"), a linear regression ("linear reg"), and a quadratic regression ("quad reg"). Values in the first row are computed from our main definition of switchers (w.r.t. wage vol.) and values in the second row are computed from our second definition (w.r.t. public or private sector).

In Panel B, we report estimates of changes in portfolio holdings as a percentage of financial assets between 1999 and 2002. The dependent variable is the difference between the observed active change in the risky share for switchers and the predicted active change in the risky share for non-switchers (between 1999 and 2002) given the same initial risky share in 1999. See Fig. 3 in the paper for a visualization of the construction. We repeat the estimations from Table 9 in the paper given the four different interpolation methods for the predicted active change in the risky share for the non-switchers. Column 1 is equivalent to column 2 of Table 9. The sample is restricted to households with positive holdings in 1999. We report the t-statistics for the heteroskedasticity-robust standard errors. All the goodness-of-fit F tests are statistically significant at the 1% level. Other explanatory variables are described in Section C.