Hazardous Agrochemicals, Smoking, and Farmers' Differences in Wage-Risk Tradeoffs

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This paper utilizes the theory of compensating differentials for job risks from the labor economics literature to evaluate farmers' differences in wage-risk tradeoffs. In the context of job risks, the theory predicts that farmers who place a lower value on health status are willing to work for lower compensation on a risky job. The aim of the paper is to evaluate how the observed wage-risk tradeoff is affected by individual heterogeneity in risk preferences, by acknowledging variations in farmers' revealed attitudes toward risk, both in job-related and non-job activities. The job risk measure employed is self-reported job risk of low back pain, the most recurring health risk faced by farmers. The job-related risky activity is the application of hazardous agrochemicals. The non-job activity is smoking. The primary finding of the study is that individual heterogeneity in risk attitudes is an important determinant of the risk premium workers receive, i.e., individual differences in other health-related activities are influential determinants of the observed wage-risk tradeoff.

Keywords: agrochemicals, smoking, farming job risk, compensating differentials, risk preferences, health impairment

I. Introduction

The theory of compensating differentials for job risks postulates that there is a link between the wage rate a worker receives and risky attributes of a job. Labor economists have long noted that workers who are more willing to bear risk are attracted to more hazardous jobs and correspondingly are compensated with a higher wage. A compensating wage differential, or equalizing difference, is the amount of additional income necessary to motivate an individual worker to undertake a riskier job relative to other jobs the worker would take (Rosen, 1986). An extensive literature has paid attention to the role of industry-wide job risk on wage rates (Viscusi, 1993), however less attention has been given the role of individual heterogeneity in risk preferences in estimating average wage-risk tradeoffs.

In practice, however, there are likely to be substantial differences in individual worker risk preferences. Hersch and Viscusi (1990) were the first to use information on individual cigarette smoking and seat belt behavior as proxies for the individual risk parameter. Hersch and Pickton (1995), using a richer US dataset, found similar findings: that nonsmokers and seat belt wearers receive a higher compensating differential per unit of job risk than do workers who engage in either one of the risky behaviors. A number of studies have also explored the interactions between job risks and personal characteristics such as age and education (Thaler and Rosen, 1976, Moore and Viscusi, 1988b, Moore and Viscusi, 1988a, Viscusi and Moore, 1987, Viscusi, 1979). However, no study has focused on the wage-risk tradeoff on farming and the role of farmers' individual heterogeneity in risk preferences.

Farming is an occupation in which workers necessarily bear a significant amount of risk (Hardaker, 2004, Harwood et al., 1999, Arcury and Quandt, 1998). Farmers in the U.S. have one of the highest fatality rates among occupations, 35.8 deaths per 100,000 workers, approximately ten times the average of 3.3 per 100,000 for all US workers. But, there is also substantial variability on risk levels faced by individual farmers. Farmers can choose to undertake or not in risky activities by choosing from the set of actions available to them. Therefore, farmers can control the level of risk they actually face.

Farmers' risk preferences, however, cannot always be observed directly. But, these preferences are likely to be revealed through other risk taking behavior. We employ two measures as proxies for these risk attitudes, an on-farm risk-taking activity and an off-farm risk-taking activity. The measures that we use are use of protective gear when applying agrochemicals, a professional risk-taking activity, and smoking, a personal risk-taking activity.

This paper is the first to employ the hedonic wage literature from labor economics in investigating farmers' wage-risk tradeoff. Our analysis of differences in risk-taking behavior is an attempt to integrate into a labor market analysis the types of factors that have been stressed by researchers in the health economics literature as important determinants of investments in human capital (Grossman, 1972, Fuchs, 1986). Fuchs documented the expected effect of time preference and schooling on investments in health, including smoking (Hersch and Viscusi, 1990). The approach of this paper is to use smoking and the use of protective gear during the application of agrochemicals as proxies for one's investment in health, which are then related to preferences towards job risks.

Our findings demonstrate that workers who by their on-job and off-job behavior indicate a high value of safety – nonsmokers who use all recommended protective gear – receive a higher compensating differential per unit of job risk than do workers who engage in either one of the risky behaviors. Overall, there appear to be substantial differences in either tastes or productivity in producing safety that influence observed wage-risk tradeoffs.

The paper proceeds by presenting the theory of compensating differentials, followed by the empirical framework in Section III and the data description in Section IV. Section V presents the empirical results. We conclude in Section VI.

II. Theory of Compensating Differentials

The theory of compensating differentials or of equalizing differences for job risks has long been employed in labor economics (Thaler and Rosen, 1976, Rosen, 1986, Viscusi, 1993). According to the theory, a competitive market in long-run equilibrium will produce a market clearing wage-offer curve on which farmers will locate according to their preferences about job risk and their costs of producing job safety. The usual assumption is that producing safety has a positive and increasing marginal cost. Hence, the market offer curve increases with risk at a decreasing rate, and farmers at lower levels of job risk face a higher wage-risk tradeoff than farmers at higher risk levels. What is observed empirically is the equilibrium locus of tangencies between wage offer curves and farmer utility functions. For the market to be in equilibrium, the risk levels on high wage-risk tradeoff jobs must be lower than for the lower wage-risk tradeoff jobs. That is, individuals who are willing to bear risks cannot earn as much total compensation for risk by taking the low risk jobs with the higher compensating differential per unit risk (Hersch and Viscusi, 1990).

The wage-risk tradeoffs using the standard hedonic wage model (Thaler and Rosen, 1976) are illustrated in Figure 1. The market opportunities curve W* represents the lower envelope of the individuals' wage-risk indifference curves. Individuals locate along this curve based on their preferences towards bearing job risk. The indifference curve AA represents an individual with greater willingness to bear risk, while BB presents and indifference curve for an individual willing to bear less risk. The actual wage-risk tradeoffs selected by individuals with indifference curves AA and BB are given by A* and B*, respectively.

In the standard hedonic wage model, the aim is not to estimate the locus of tangencies represented by A* and B*, which make up the market opportunities frontier, but to focus instead on how the observed wage-risk tradeoff is affected by variations in revealed attitudes towards risk in on-job and off-job areas (Hersch and Pickton, 1995, Hersch and Viscusi, 1990).

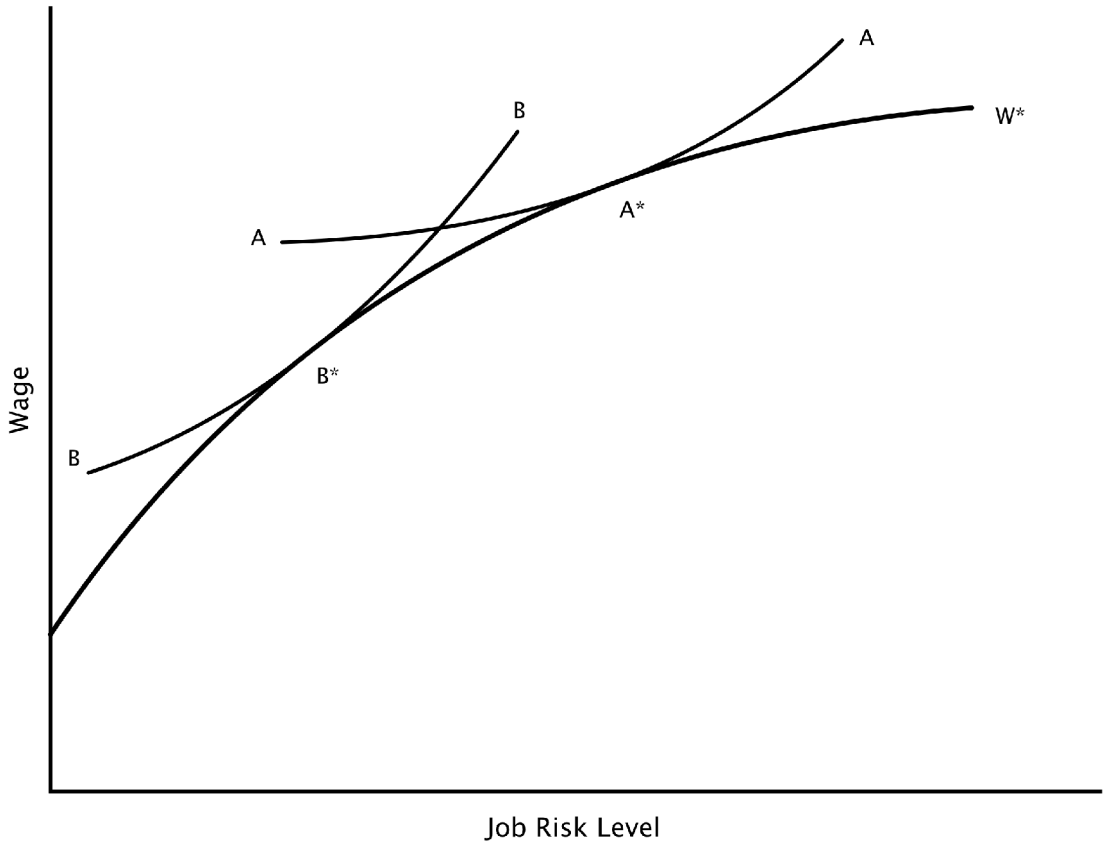

Figure 1. Job Risk Level

However, because of differences in individual characteristics such as the level of education, tenure on the job, family and farm attributes, farmers are not free to compete for all job risk levels and thus may face different wage-offer curves and wage-risk opportunities, even though all farmers belong in one industry. For example, based on their level of education and farm size, small-size uneducated farmers do not directly compete with large-size farm educated farmers. Controlling for the level of risk, the theory predicts that farmers who place a lower value on health status will be willing to work for lower pay on a risky job.

Since risk preferences cannot be fully observed, behaviors in health-related activities are used as proxies for individual risk attitudes. We are interested here in observing how the wage-risk tradeoff varies with personal risk-taking activities, namely cigarette smoking and use of protective gear during the application of agrochemicals. Protective gear users

and nonsmokers reveal by their behavior a high value of safety, suggesting that they would require a higher wage-risk tradeoff controlling for the level of risk than their counterparts who don't use protective gear and smoke. Two are the main reasons we would expect such a variation: differences in tastes and differences in farmers production of safety through their behavior on the job (Hersch and Viscusi, 1990).

III. Empirical Framework

Farming is an occupation in which workers necessarily bear a significant amount of risk (Hardaker, 2004, Harwood et al., 1999, Arcury and Quandt, 1998). Farming is considered one of the ten most dangerous occupations in the US (Bureau of Labor Statistics, 2010). In addition, farmers have the highest risk of low back pain among all professions. Interestingly, despite mechanization and other changes in production technology, the finding of the highest low back pain rates among professions is consistent for developed countries such as the US, Australia, Belgium, Germany, and Sweden, and for developing countries such as China, the Philippines, Indonesia and Nigeria (Concha-Barrientos et al., 2004). Table 1 presents relative risks of back pain by occupational groups, with managers and professionals as the reference group.

Table 1. Relative risks of low back pain for occupational groups

Occupational activity	*Relative risk (95% CI)*
Managers and professionals	1.0 (NA)
Clerical or sales workers	1.38 (0.85-2.25)
Operators	2.39 (1.09-5.25)
Service workers	2.67 (1.26-5.69)
Farmers	5.17 (1.57-17.0)

Source: Concha-Barrientos et al., 2004

But, there is also substantial variability on risk levels faced by farmers, as is apparent from the data. For low back pain, as is evident from the confidence interval, farmers may face a lower risk than clerical or sales workers, on the one hand, or face seventeen times the risk of the reference group, managers and professionals, on the other. Farmers, thus,

can choose to undertake or not risky activities such as lifting heavy weights and operating heavy machinery, more or less frequently, by choosing from the set of actions available to them, such as type of crops cultivated, machinery used, and amount of hired labor. Therefore, farmers can control the level of risk they actually face. In effect, the risk farmers face is endogenous (Ehrlich and Becker, 1972).

It is not always possible to observe farmer health risk preferences directly. But, these preferences are likely to be revealed through other risk taking behavior. Two measures are employed as proxies for these risk attitudes, the use of protective gear when applying agrochemicals and cigarette smoking.

Farmers' pesticide exposure during application has been well documented (Rola and Pingali, 1993, Antle and Pingali, 1994). The World Health Organization (WHO) and the United Nations Environment Program (UNEP) estimate that one to five million cases of pesticide poisoning occur among agricultural workers each year with about 20 000 fatalities (World Health Organization, 1990), the majority occurring in developing countries (Rosenstock et al., 1991). Nevertheless, pesticide risks are expected to be low compared to their management costs, which are typically high (Travisi et al., 2006). Lay people, including farmers, underestimate the on-farm adverse effects of pesticide usage (Goldenman, 1996). This perception is corroborated by the fact that there is no standard case definition of pesticide poisoning that can be used for epidemiological purposes, and symptoms of the pesticide poisoning are usually non-specific of the pesticide exposure. This implies that large datasets of pesticide exposed workers are not available, since epidemiological studies of the relation between occupational exposure and illness necessarily have to include comparison with a group of non-exposed workers (Partanen et al., 1991). Hence, for most farmers, not using protective gear during the application of agrochemicals is a risk that they may be willing to take, in the same process that they may choose cigarette smoking. Hence, it signals risk-taking.

Cigarette smoking poses a lifetime mortality risk of 0.18 to 0.36, a risk several orders of magnitude greater than almost any other personal risk (Viscusi, 1992). Hence, one would

expect smokers to signal risk-takers. Furthermore, controlling for other observable characteristics, smokers overall earn less than nonsmokers (Levine et al., 1996).

To identify the influence of individual risk preferences in determining the wage-risk tradeoff, we estimate a standard wage equation of the form:

$$\ln(WAGE_i) = \beta_o + \beta_1 RISK_i + \beta_2 RISK_i \times SMOKE_i + \beta_3 RISK_i \times PROTECT_i + \sum_{j=1} \gamma_j X_{ij} + \varepsilon_i$$

where the variable *SMOKE* is a dummy variable capturing the smoking of the respondent, *PROTECT* is a dummy variable capturing the use of protective gear during the application of agrochemicals, *RISK* is a measure of the level of job risk faced by the individual worker, *X* is a vector of explanatory variables such as education, tenure, family and farm attributes, the β_i and γ_i are parameters to be estimated, and ε is a random error term.

The standard theory of compensating differentials implies that β_1 is positive, reflecting a positive wage-risk tradeoff. Since smokers are hypothesized to have a lower wage-risk tradeoff, and users of protective equipment to have a higher wage-risk tradeoff, we expect the coefficient on β_2 to be negative and on β_3 to be positive. However, even in the case of smokers who do not use protective gear, we expect a positive wage-risk tradeoff; that is, the magnitude of β_1 should be greater than β_2.

We will assume, following Hersch and Viscusi (1990), for both smokers and users of protective gear that the risk activity variable captures individual sorting based on risk differences in the production of safety. Other factors may also enter, of course, such as one's taste for nicotine and the discomfort of wearing protective gear. For the empirical analysis to be meaningful, on balance, smoking and use of protective gear should have the expected correlations with omitted variables that affect one's willingness to bear health risks. Thus, our analysis also represents an exploration of whether there are important differences in risk preferences that are correlated with wage-risk tradeoffs.

IV. Data description

The data employed in the analysis were collected through a survey from a sample of one hundred farmers from the region of Western Macedonia, Greece, in the spring of 2010. More specifically, it is a randomized sample from two agricultural regions, Edessa and Ptolemaida. The dataset is unique in providing information on agrochemical use, farmers' risk of low back pain, health status, as well as farm and socio-demographic data. Table 2 presents descriptive statistics for the variables employed in the analysis. Column 1 provides statistics for the entire sample, columns 2 and 3 present statistics stratified by smoking status, while columns 4 and 5 present statistics stratified by use of protective gear during the application of agrochemicals. Smoking behavior is measured by a dummy variable (SMOKE) that equals one if the respondent is a current smoker. Use of protective measures during the application of agrochemicals (PROTECT) is a dummy variable equaling one if the respondent reported that he or she uses protective equipment during the application of agrochemicals. More specifically, the protective equipment question comprised of five sub-questions: i) use of mask, ii) use of protective goggles, iii) use of gloves, iv) use of appropriate spraying unit, and v) use of correct dosage. The dummy variable PROTECT takes the value of 1 if the respondent answered positively to all five sub-questions and takes the value of zero otherwise.

The wage rate variable (WAGE) is estimated from the results of the questionnaire. Since farmers are self-employed their wage rate expresses their reservation wages. More specifically, it is calculated from their reported income, whether they are full-time or part-time farmers, and from their reported average daily hours of on farm work.

The job risk (RISK) measure used in the study is estimated from respondents' objective and subjective responses regarding job risk. It is a modification of the linear risk scale that was employed in Viscusi and O'Connor (1984). More specifically, it is a weighted average of the response to three questions, the farmers' perception of their job as risky or not, the level of heavy lifting and the level of heavy machinery they use in day-to-day

farm work. An index was then constructed ranging in values from 1 to 10, increasing with the level of risk of low back pain. This measure was designed to capture both the severity and frequency of risk. This measure thus varies by individual and captures potentially important variations in job risk, including individual differences in the production of job safety.

Table 2. Descriptive statistics

	All Farmers		Smokers		Nonsmokers		Protective Gear		No Protective Gear	
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Personal Background and Human Capital Characteristics										
age	47.3	8.54	46.87	8.59	47.8	8.57	47.24	7.54	47.35	9.40
female	0.38	0.48	0.39	0.49	0.37	0.49	0.46	0.50	0.31	0.47
married	0.72	0.45	0.74	0.44	0.7	0.47	0.85	0.36	0.61	0.49
education	11	3.23	11.15	3.21	10.83	3.3	10.91	2.88	11.07	3.54
hhdsize	4.16	1.76	3.98	1.3	4.37	2.18	4.15	0.92	4.17	2.25
tenure (years)	19.89	7.55	20.37	8.08	19.33	6.93	20.59	7.27	19.30	7.80
Job Characteristics										
wage	26.58	20.85	27.5	24.84	25.51	15.09	24.33	15.70	28.50	24.39
risk	4.2	2.07	4.45	2.09	3.9	2.03	3.83	1.81	4.52	2.23
farmsizeown (ha)	4.29	2.44	46.52	25.6	38.85	22.5	44.04	21.08	42.09	27.08
fulltime	0.47	0.5	0.5	0.5	0.43	0.5	0.41	0.50	0.52	0.50
Personal Risk Factors										
smoke	0.54	0.5	1	0	0	0	0.57	0.50	0.52	0.50
protect	0.46	0.5	0.48	0.5	0.43	0.5	1	0	0.00	0.00
Sample size	100		54		46		46		54	

As is evident from the descriptive statistics presented in Table 1, fifty four percent of the sample are current smokers. This is higher than the percentage of smokers in the Greek adult population, estimated at approximately forty two percent (Eurobarometer, 2010). Forty six percent of the sample uses all recommended protective equipment during the

application of agrochemicals. Moreover, the average respondent in the sample is 47 years old, with 11 years of education, 20 years of job tenure, receives an hourly wage of 26 Euros, has a farm size of 6 ha, of which 4.3 are owned. Thirty eight percent of the respondents were female, seventy two percent are married and less than half (47%) are full-time farmers.

V. Empirical Results

Job risk, smoking, and use of protective equipment are correlated with other characteristics such as education, tenure, and farm size, which also affect wages. Therefore, we look into the wage regression analyses to identify whether differences in individual preferences affect wage-risk tradeoffs. Table 3 presents the estimates of the wage equations. Column 1 shows the results of the standard wage regression including job risk for all farmers. Columns 2 and 3 present the wage equation results for smokers and nonsmokers, respectively. Columns 4 and 5 present the wage equation results for nonusers and users of protective gear. Finally, column 6 pools the sample and interacts risk with smoking and use of protective gear.

The results of the wage equation are consistent with the literature. Wages rise with years of education and tenure at a decreasing rate. Female farmers earn less than male farmers. Of greatest interest are the results measuring the wage return to job risk, mediated by individual risk behavior. For all farmers, riskier jobs pay significantly higher wages. The results stratified by smoking status, reported in columns 2 and 3, indicate that nonsmokers receive about twice the return to bearing risk than smokers, a result consistent with Hersch and Pickton (1995). Furthermore, the results stratified by use of protective gear, reported in columns 4 and 5, indicate that users of protective gear receive approximately five times the return to bearing risk than nonusers. Finally, column 6, which interacts risk with both smoking status and protective gear use, demonstrates that the wage-risk tradeoff is affected by use of protective gear, but not by smoking behavior. As expected, protective gear users receive a higher tradeoff per risk unit.

Table 3. Parameter estimates for ln(WAGE) regressions

Independent variables	All	Smokers	Non smokers	No Protection	Protection	All farmers
RISK	0.104	0.075	0.140			0.086
	(0.035)	(0.061)	(0.046)	0.052 (0.050)	0.272 (0.071)	(0.039)
RISK x SMOKE						0.006 (0.028)
RISK x PROTECT						0.075 (0.031)
AGE	0.061	0.086	0.223			0.041
	(0.156)	(0.338)	(0.204)	0.188 (0.201)	-0.371 (0.428)	(0.156)
AGE SQUARED	-0.0008	-0.001	-0.002			-0.0008
	(0.001)	(0.003)	(0.002)	-0.002 (0.002)	0.004 (0.004)	(0.001)
FEMALE	-0.730	-0.822	-0.724			-0.692
	(0.157)	(0.259)	(0.223)	-0.900 (0.243)	-0.653 (0.216)	(0.155)
EDUCATION	0.036	0.064	-0.038			0.043
	(0.032)	(0.052)	(0.051)	0.062 (0.049)	0.006 (0.053)	(0.032)
MARRIED	0.328	0.406	0.055			0.422
	(0.243)	(0.401)	(0.400)	0.371 (0.376)	0.021 (0.410)	(0.245)
FAMILY SIZE	-0.010	-0.111	-0.006			0.00001
	(0.0002)	(0.121)	(0.003)	0.061 (0.073)	0.009 (0.165)	(0.054)
FARM SIZE (OWN)	-0.010	-0.011	-0.006			-0.009
	(0.002)	(0.004)	(0.003)	-0.007 (0.003)	-0.001 (0.006)	(0.002)
TENURE	0.111	0.113	0.091			0.127
	(0.072)	(0.164)	(0.080)	0.100 (0.090)	0.150 (0.195)	(0.071)
TENURE SQUARED	-0.001	-0.001	-0.001			-0.001
	(0.001)	(0.003)	(0.001)	-0.0006 (0.002)	-0.004 (0.004)	(0.001)
FULL TIME	0.402	0.370	0.640			0.273
	(0.158)	(0.252)	(0.220)	0.228 (0.255)	0.203 (0.284)	(0.165)
INTERCEPT	1.076	0.314	-1.523			1.509
	(3.31)	(6.775)	(4.266)	-2.224 (4.488)	10.784 (7.741)	(3.306)
R^2	0.43	0.47	0.49	0.51	0.61	0.46
Sample size	100	54	46	54	46	100

Standard errors are in parentheses.

Table 4 presents estimates of alternative specifications. To investigate whether the estimated risk effects are spurious and due to correlation with omitted risk interactions, we estimated the equations including interactions of risk and education, and risk and full time farm employment. More educated farmers are less likely to smoke and more likely to use protective gear, and omitting the interaction of education with risk from the equation may bias the estimated effects of individual risk behaviors. While full time farm employment is not necessarily correlated with smoking and protective gear use; full time farmers may be less willing to take on-farm job risks.

For ease of comparison, columns 1 and 2 of Table 4 reproduce the results on risk compensation reported in columns 1 and 6 of Table 3. Columns 3 and 4 present the estimated results including *RISK* x *EDUCATION.* As a comparison of columns 2 and 4 indicates, inclusion of the interaction *RISK* x *EDUCATION* does not substantially alter the estimated coefficients of *RISK* x *SMOKE* and *RISK* x *PROTECT*. This provides evidence that the estimated effect on wage-risk tradeoffs of heterogeneity in risk behavior as measured by smoking and use of protective gear is not spurious.

Note that the estimated effect on wages of *RISK* x *EDUCATION* is negative, which is consistent with the literature. Education can have two main effects on determining an individual's job risk level (Hersch and Pickton, 1995). First, more educated farmers sort themselves into safer occupations within an industry. Second, more educated farmers may be more efficient in producing job safety. If more educated farmers reduce their own risk exposure, either by their own precautions or by sorting into safer tasks, the risk that they actually face is below the industry average. They will receive a lower compensating differential for risk than their industry counterparts with less education who are employed in jobs that are riskier.

Table 4. Parameter estimates for ln(WAGE) regressions

Independent Variables	Coefficients					
	1	2	3	4	5	6
RISK	0.104	0.086	0.107	0.201	0.193	0.151
	(0.035)	(0.039)	(0.151)	(0.155)	(0.058)	(0.065)
RISK x SMOKE		0.006		0.005		0.003
		(0.28)		(0.028)		(0.028)
RISK x PROTECT		0.075		0.082		0.062
		(0.031)		(0.032)		(0.032)
RISK x EDUCATION			-0.0002	-0.009		
			(0.012)	(0.012)		
RISK x FULLTIME					-0.146	-0.100
					(0.076)	(0.079)
R^2	0.43	0.46	0.43	0.47	0.45	0.47

Standard errors are in parentheses. Each equation also includes the variables AGE, AGE SQUARED, FEMALE, EDUCATION, MARRIED FAMILY SIZE, FARM SIZE (OWN), TENURE, TENURE SQUARED, and FULL TIME. Columns (1) and (2) are repeated from Table 3.

The results with respect to full time employment are presented in columns 5 and 6 of Table 4. Again, inclusion of the interaction *RISK* x *FULLTIME* does not substantially alter the estimated coefficients of *RISK* x *SMOKE* and *RISK* x *PROTECT.* We find a negative effect of full time farm employment on the wage-risk tradeoff, indicating that full time farmers have lower risk premiums than part time farmers, suggesting that off-farm employment is important to part time farmers and they thus exhibit lower willingness to accept risk, as expected.

VI. Conclusions

The aim of this paper was to analyze the effects of farmers' individual risk-taking behavior on estimated wage-risk tradeoffs. The primary finding is that, consistent with the labor economics literature (Hersch and Pickton, 1995, Hersch and Viscusi, 1990), individual heterogeneity in risk attitudes is an important determinant of the risk premium farmers receive. We employed individual differences in smoking use, following the

literature, and, for the first time, we also employed use of protective gear during application of agrochemicals, as proxies for differences in risk attitudes.

Regarding the users of protective gear during the application of agrochemicals, our findings demonstrate that these farmers receive a higher compensating differential per unit of job risk than do farmers who don't use protective gear. Similarly, nonsmokers also receive a higher compensating differential per unit of job risk than do smokers.

The risk measures used in this study are of independent research interest with respect to the more traditional issues in the compensating differential literature. The risk measure of the use of protective gear during the application of agrochemicals is unusual since it measures individual farmers' subjective perceptions regarding the riskiness of their job. Thus the estimates provide a more refined perspective on the compensating differential mechanism in the farming sector.

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