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The Statistical Value of Injury Risk in Pakistan's Construction and Manufacturing Sectors

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Abstract

Although health and safety regulations are a key aspect of labor market policymaking, very few studies have examined compensating wage differentials and the statistical value of injury in Pakistan's context. This study looks at injury risk against occupation and industry, using data from the Labor Force Survey for 2013/14. We target five blue-collar occupations in two industries (construction and manufacturing), which tend to account for the highest number of injuries. However, we find that the statistical value of injury in these occupations is too small to reflect the wage premium that workers should be paid for risky jobs.

Keywords: value of injury, industry, labor market conditions, public policy, Pakistan.

JEL classification: O14.

1. Introduction

With a population of approximately 182.1 million (United Nations Population Fund, 2013), Pakistan's total workforce comprises 59.74 million, of which 45.98 million are male and 13.76 million are female (Labor Force Survey for 2012/13). The country ranks 146th out of 187 countries on the 2014 Human Development Index: most of its indicators are below those of other South Asian countries and it has failed to meet several targets under the Millennium Development Goals. In 2013, public spending on education was 2.1 percent of GDP, indicating that education remains a low priority. Similarly, public health expenditure was merely 1 percent of GDP in 2013, making Pakistan one of the world's lowest spenders under this head (World Bank, 2014).

The literature on labor economics uses three different approaches to estimate the statistical value of injury (SVI) or life. The first, developed by Viscusi and Aldy (2003), suggests that workers be compensated for risky

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jobs in the form of wages. The second approach, put forward by Blomquist (2004), entails observing the behavior of workers prepared to undertake risk and measuring its cost. The third is the willingness-to-pay approach, according to which workers are asked how much they are willing to pay to reduce the fatal or nonfatal risk associated with their jobs. This study uses the first approach to estimate a wage-risk premium for workers in Pakistan's manufacturing and construction sectors.

2. Literature Review

Insufficient wage and labor data for developing countries has meant that the literature in this area is scant. The theory of compensating wage differentials itself goes back to Adam Smith, who observed that workers required compensation in the form of higher wages to accept any fatal or nonfatal risk associated with a job. Thaler and Rosen (1976) develop a hedonic wage function that measures the wage-risk tradeoff or wage differential associated with fatal and nonfatal job risk. Schelling (1968) gauges the extent to which workers are willing to accept risk in the process of labor market bargaining over the composition and acceptance or prevention of such risk.

Among more recent studies, Viscusi and Aldy (2003) estimate the value of life by constructing a fatality risk variable based on data for a range of occupations and industries. Using a hedonic wage equation, they find that the value of life is US$4.7 million across the sample, and is US$7.0 million and US$8.5 million for blue-collar male and female workers, respectively. Kluve and Schaffner (2007) examine the impact of compensation for injury risk on the gender pay gap. Finding that male workers are far more likely to be exposed to riskier jobs than female workers, they calculate the observed gender pay gap resulting from job segregation into those that are more dangerous or less so.

Hammitt and Ibarrarán (2006) use compensating wage differentials to estimate the tradeoff between occupational injury risk and income in Mexico City. Their survey provides data on fatal and nonfatal occupational injury risk for a sample of 600 workers, in addition to which they rely on government statistics for actuarial risk data. While the results obtained from the variables that represent workers' subjective perception of risk (based on the survey) may be less reliable, the estimates obtained using the actuarial risk variables are more accurate, given their insensitivity to the omitted variable problem. The values estimated for injury risk are smaller than those for developed countries such as the US, but closer to higher-income countries such as Taiwan and Korea. The results of such studies can be used in cost–benefit analyses to mitigate health and environmental risks in the workplace.

The literature includes a number of studies on compensating wage differentials in labor markets: see, for example, Atkinson and Halvorsen (1990); Shanmugam (2000) and Madheswaran (2004) for India; Liu and Hammitt (1999) for Taiwan; Parada-Contzen, Riquelme-Won and Vasquez-Lavin (2013) for Chile; Polat (2013) for Turkey; and Rafiq and Shah (2010) and Hyder and Behrman (2011) for Pakistan (Table A1 in the Appendix summarizes the literature review). This paper contributes to the literature from a developing country perspective by looking at two different types of risk: the occupational injury risk rate and the industrial injury risk rate. Using both measures provides a broader comparative picture of the SVI in Pakistan's labor market.

3. Data and Summary Statistics

We use data from the Labor Force Survey for 2012/13, drawing on a sample of 6,421 individuals. It is worth noting that the survey has certain limitations: (i) its categorization of occupations and industries restricts the study to 2-digit industries; and (ii) it does not provide any information on the nature of injuries or the number of fatalities, which means that we cannot estimate the cost associated with a particular kind of injury. As a result, the study is restricted to nonfatal risk for which one would expect labor market compensation. Thus, for our purposes, any worker who reported an injury that was followed by a medical consultation is considered a workplace injury.

The hedonic wage equation we estimate takes the log of the hourly wage as a dependent variable. The independent variables include injury risk or nonfatal injury per 100 workers (both industrial and occupational risk), job training, the type of job (permanent or temporary), a regional dummy (urban, rural), provincial dummies, a sector dummy (private, public), human capital variables (age, age-squared and level of education) and two industrial and broad occupational categories. Table 1 presents the study's summary statistics.

The sample includes people of working age, that is, 14–65 years, where age is a proxy for labor market experience is expected to have a positive effect on wages. Age-squared is expected to have a negative sign because it shows how the impact of experience changes over time. While some studies use the Mincer proxy (a school-going age of six years), this does not apply in Pakistan's case where there is no fixed school-going age. Moreover, the high unemployment rate means that not every individual is guaranteed employment after leaving school.

Table 1: Summary statistics

Variable	Percentage
Gender	
Male	93
Female	7
Training	
Trained	26
Not trained	74
Education	
No formal schooling	55
Primary to middle	32
Matriculation	8
Higher	5
Province	
Punjab	19
Sindh	47
KP	26
Balochistan	8
Region	
Rural	56
Urban	44
Industry	
Manufacturing	34
Construction	66
Job status	
Permanent	14
Contractual	61
Without contract	25
Occupation	
Services and market sales	5
Craft and related trades	37
Plant and machine operation	7
Assembly (elementary occupations)	51

Source: Authors' calculations based on data from the Labor Force Survey for 2012/13.

The education variable is divided into five categories: (i) no formal education, (ii) primary schooling but below middle school, (iii) middle schooling but below matriculation, (iv) schooling up to and including matriculation and (v) education beyond matriculation. Technical training is expected to have a positive sign because it is associated with higher wages (75 percent of the workers in our sample had no formal job training). The province variable gauges the wage differential for each of the four provinces. Of the total sample of workers, 19 percent are from Punjab, 48 percent from Sindh, 26 percent from Khyber Pakhtunkhwa (KP) and 8 percent from Balochistan. In addition, the model includes job-related characteristics such as employment sector and the type of job held.

To enable a more detailed analysis, we include the occupational and industrial injury rates and associated demographics. As Table 2 shows, the occupational injury variable has a very high standard deviation because the severity of risk varies widely by occupation: those such as firefighting, kiln work and mining, for example, carry a higher risk than others. However, there may be less variation in the injury rate because a given industry will comprise numerous occupations, thus lowering the deviation of risk.

Table 2: Occupational injury rate, by industry

Variable	Mean	Standard deviation
Injury rate in industry	6.00	2.34
Injury rate in occupation	5.93	5.90

Note: Per 100 workers.
Source: Authors' calculations based on data from the Labor Force Survey for 2012/13.

Table 3 shows that men are exposed to greater risk of injury in the labor market than women, who tend to be more risk-averse and less likely to opt for high-risk, physically demanding occupations.

Table 3: Average industrial injury rate, by gender

Gender	Injury rate by industry	Injury rate by occupation
Male	6.21	6.08
Female	2.64	3.80

Note: Per 100 workers.
Source: Authors' calculations based on data from the Labor Force Survey for 2012/13.

4. Construction of Injury Rate Variables

The hedonic wage equation includes an industrial injury risk variable that is calculated using the formula adopted by the US Bureau of Labor Statistics:

$$\textit{Industrial injury rate} = N/H \times 200{,}000$$

where N is the total number of injuries to have occurred in a given industry[1] and H is the total number of hours worked by all employees in that industry in a year. The figure 200,000 is a combined base scaling the total number of hours worked by 100 workers in a year – a technique also used by Hersch (1998). Table A2 in the Appendix lists the 2-digit industries covered by the study.

The same method is used to calculate the occupational injury rate:

$$\textit{Occupational injury rate} = N/H \times 200{,}000$$

where N is the total number of injuries to have occurred in a given occupation and H is the total number of hours worked by all employees in that occupation in a year. Again, 200,000 is a combined base scaling the total number of hours worked by 100 workers in a year. Table A3 in the Appendix lists the blue-collar occupations covered by the study.

5. Theoretical Model

Under the hedonic wage model, the demand for labor is a decreasing function of the cost of employing labor, i.e., as the cost of employing a worker rises, the demand for his or her labor falls. This cost includes salary and compensation as well as the cost of providing medical care, training and a safe working environment. For a given level of profit, firms will pay their workers less as these costs increase. Thus, workers will choose a wage-risk combination that yields the highest wage.

The hedonic wage function we employ is adapted from the models developed by Viscusi (2003) and Elia, Carrieri and Di Porto (2009). We assume that risk has a price in the form of a wage premium, such that workers are willing to reduce the probability of injury or death by forgoing part of this wage premium. Thus, firms and workers set a wage-risk combination (w, r) in the implicit labor market.

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[1] The survey asks respondents if, in the last 12 months, they have suffered any occupational injury or disease that led them to take time off work and/or consult a doctor.

We also assume that a worker's decision to work in a certain occupation or industry depends solely on the associated risk and wage rate. Let $U(w)$ denote the utility function of a healthy worker and $V(w)$ the utility function of a nonhealthy or injured worker at wage w. Assuming that a worker would rather be healthy than injured, $U(w) > V(w)$. In both cases, the marginal utility of the wage rate is positive: $U'(w) > 0$, $V'(w) > 0$.

If f is the likelihood of an accident (nonfatal), then the expected utility function of a worker will be:

$$Q = (1 - f)U(w) + fV(w) \quad (1)$$

Differentiating equation (1) with respect to f and w, we obtain the wage-risk tradeoff:

$$\frac{dw}{df} = -\frac{Q_f}{Q_w} = \frac{U(w) - V(w)}{(1-f)U'(w) + fV'(w)} > 0 \quad (2)$$

Equation (2) shows that, as the level of risk increases, so does the wage rate – this is the compensating wage differential. The wage-risk tradeoff is, therefore, obtained by differentiating both utilities with respect to the marginal utility of wages.

6. Empirical Model

To calculate the SVI, we estimate the hedonic wage equation by regressing the log of the hourly wage on the model's independent variables – province, region, age, education, experience, industrial and occupational dummies and injury risk – using a semi-log linear model:

lnwage = *f* (*human capital variables and individual characteristics*, *residential characteristics*, *job characteristics*, *injury rate*) (3)

Equation (3) is estimated twice,[2] first using the occupational injury rate and then the industrial injury rate. The log of hourly wages is constructed by dividing the weekly wage of the *i*th worker by the total number of hours he/she has worked that week.[3] The SVI is then calculated as follows:

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[2] While computing this specification without the log of hourly wages yields similar results, the F-test statistics clearly support the use of *lnwage*. It also normalizes the distribution.

[3] In using this model, one concern is that workers do not select jobs at random and their preferences are unobserved. The literature on the statistical value of life or injury does not address this problem of self-selection per se. The most common method used is the Heckman two-stage procedure, which involves a discrete choice variable. Some studies employ union membership as the discrete choice variable at the

$$SVI = \beta * \overline{\omega} * 2{,}000 * 100 \quad (4)$$

where β is the coefficient of the injury risk variable and $\overline{\omega}$ is the mean wage of all workers multiplied by 2,000 (as the total number of hours worked in a year to annualize the value) and then multiplied by 100 as the scale of the variable (per 100 workers).[4]

7. Results and Discussion

Table 4 gives the estimates obtained from the two hedonic wage equations specified earlier. In the first model, the injury risk variable is based on the 2-digit industry injury rate. The second model includes the 2-digit occupation injury rate besides other control variables. Both sets of results exhibit a parabolic age-earning profile. Male workers receive higher wages than their female counterparts. The training variable is significant and negative and shows that workers without job training are paid 12 percent less than trained workers.[5] The education category estimates are in line with human capital theory.

Table 4: Regression results for two hedonic wage equations

	Dependent variable = log of hourly wages		
Independent variables	**Model 1**	**Model 2**	**Model 3**
Industrial injury rate	0.006	–	
	(0.005)		
Occupational injury rate	–	0.023***	-0.043
		(0.006)	(0.038)
Occupational injury rate squared			0.006**
			(0.0028)
Controls			
Age	0.190***	0.190***	0.0180***
	(0.004)	(0.004)	(0.0039)
Age squared	-0.0002**	-0.0002**	-0.0002***
	(0.00005)	(0.00005)	(0.00005)
Gender (ref. = male)			
Female	-0.326***	-0.310***	-0.303***
	(0.039)	(0.038)	(0.037)
Training (ref. = trained)			

first stage – see, for example, Marin and Psacharopoulos (1982) – but we are restricted to very limited choice variables as the Labor Force Survey does not provide any data on union membership.

[4] 2,000 is the annual average number of hours worked, used globally (see Viscusi, 2003).

[5] All the dummy coefficients are calculated by the following formula $100(e^{coefficient} - 1)$ (see Halvorsen & Palmquist, 1980).

Independent variables	Model 1	Model 2	Model 3
Untrained	-0.115***	-0.120***	-0.131***
	(0.022)	(0.022)	(0.021)
Education (ref. = no schooling)			
Primary to middle	0.062***	0.064***	-0.016
	(0.016)	(0.016)	(0.017)
Matriculation	0.053**	0.052**	0.216***
	(0.026)	(0.027)	(0.027)
Above matriculation	0.059*	0.058*	0.054**
	(0.032)	(0.032)	(0.021)
Province (ref. = Punjab)			
Sindh	-0.153***	-0.155***	-0.150***
	(0.017)	(0.017)	(0.016)
KP	-0.362***	-0.362***	-0.356***
	(0.023)	(0.024)	(0.023)
Balochistan	0.274***	0.276***	0.270***
	(0.037)	(0.037)	(0.034)
Region (ref. = rural)			
Urban	0.091***	0.080***	0.080***
	(0.015)	(0.015)	(0.014)
Job status (ref. = permanent)			
Contractual	0.194**	0.196***	0.215**
	(0.086)	(0.084)	(0.083)
Without contract	0.070	0.081	0.081
	(0.064)	(0.064)	(0.064)
Industry (ref. = manufacturing)			
Construction	0.377**	0.318***	0.312***
	(0.025)	(0.029)	(0.030)
Occupation (ref. = services and sales)			
Craft and related trades	-0.197	-0.318*	-0.116
	(0.132)	(0.133)	(0.149)
Plant and machine operation and assembly	-0.175	-0.291*	-0.080
	(0.141)	(0.141)	(0.161)
Elementary occupations	-0.514***	-0.591***	-0.326**
	(0.133)	(0.131)	(0.168)
Constant	3.601***	3.631***	3.570
	(0.168)	(0.164)	(0.160)
F-statistic	127.60	135.80	128.88
Adjusted R^2	0.220	0.222	0.222

Note: Robust standard errors given in parentheses. * = significant at 10% level, ** = significant at 5% level, *** = significant at 1% level

Source: Authors' calculations based on data from the Labor Force Survey for 2012/13.

The province dummies are included in the regression to capture the wage differential between each province relative to Punjab. Both the province and urban/rural dummies are significant, showing that workers' place of residence has a significant effect on their wages. With respect to the job characteristic variables, the estimates show that contractual jobs pay a significantly higher wage than permanent jobs. The 1-digit industry dummy is used to measure the effect of working in a particular industry and its coefficient shows that workers in construction earn 30–40 percent more than their counterparts in manufacturing.

The injury risk variable is the focus of this study. Its estimated coefficient in model 1 is positive but not statistically different from 0, while the occupational injury risk variable in model 2 is positive and statistically significant at the 1 percent level. The estimated beta of occupational injury risk in model 2 demonstrates that workers are compensated very poorly for the risk they assume at the workplace. The coefficient of occupational injury risk is 0.023, indicating that a 1 percent increase in injury risk raises the wage level by 2.3 percent.

The difference between the occupational and industrial injury rates is interesting. While an industry comprises a range of occupations (for instance, manufacturing includes assembly and operation, craft and related trades, services and marketing), which lowers the average risk rate, an occupation consists of a specific task associated with a specific injury rate. This is an important finding because it implies that the occupational injury rate is a better measure of exposure to risk.

The SVI per 100 workers is calculated as follows:

$$SVI = \beta * \bar{\omega} * 2{,}000 * 100 \tag{4}$$

SVI_1 is based on the industrial injury rate and has an insignificant coefficient.

SVI_1 = 0.006*43*2,000*100

= PKR 51,600/100 workers/year

= PKR 43/ worker/month[6]

[6] At the lower and upper confidence interval levels, the value of SVI_1 for the industrial injury rate is 42.34 and 44.94, respectively.

SVI_2 is based on the occupational injury rate and has a significant coefficient.

SVI_2 = 0.023*43*2,000*100

= PKR 197,800/100 workers/year

= PKR 165/worker/month[7]

Given that the result for occupational injury risk is significant, we also estimate the impact of the occupational injury rate squared to assess the nonlinear relationship between injury risk and the wage rate. Applying the results of model 3 to an occupational injury rate ranging from 0 to 11.5, the labor market begins to pay a premium after the occupational injury rate crosses 3.5, on average. Our final calculation, SVI_3, represents the nonlinear relationship between the occupational injury rate and the wage premium.

In the linear model 2, the wage depended on β*(injury rate) so that dw/d(injury rate) = β in the SVI_2 formula. However, in the nonlinear model 3, the wage depends on β_1*(injury rate) + β_2*(injury rate squared), such that dw/d(injury rate) = $\beta_1 + 2\beta_2$*(injury rate) is the new β. Since this β is no longer constant, we evaluate it at the average occupational injury rate and then apply the SVI formula to determine SVI_3:

SVI_3 = [– (0.043) + 2(0.006)*(average injury rate)]*43*2,000*100

= [– (0.043) + 2(0.006)*(5.93)] *43*2,000*100

= 0.0281*43*2,000*100

= PKR 242,176/100 workers/year

= PKR 201/ worker/month[8]

These figures show that blue-collar workers in Pakistan are paid a relatively small compensating wage differential. High unemployment and the abundance of labor, which gives workers a weaker bargaining position, is a likely contributor to this small differential. Our results are consistent with Elia et al. (2009), where unemployment, job scarcity and

[7] At the lower and upper confidence interval levels, the value of SVI_2 for the occupational injury rate is 161.30 and 172.27, respectively.

[8] At the lower and upper confidence interval levels, the value of SVI_3 for the occupational injury rate is 195.0 and 206.9, respectively.

labor abundance explain the absence of an adequate wage premium for risky jobs.

Our results highlight the inadequacies of labor market institutions and the weak bargaining position of workers in Pakistan, which, when combined with the large supply of labor, open up further opportunities for labor exploitation. Another important implication of these estimates is that the occupational injury rate is a more meaningful indicator of risk than the industrial injury rate.

8. Conclusion

This study draws on a sample of blue-collar workers in construction and manufacturing to estimate the SVI for Pakistan's labor market. The industries and occupations selected account for the highest number of injuries in a one-year period relative to other occupations and industries, implying that workers in these sectors are exposed to greater risk of injury. Workers in construction earn more than their counterparts in manufacturing.

The estimates we obtain do not validate the theory of compensating wage differentials to a satisfactory degree: these differentials are negligible and insufficient to cover the cost of damaged health among workers. One possible explanation is that, given Pakistan's high unemployment rate (above 6 percent), people are more willing to accept riskier jobs even if they are not compensated fully for the risk they assume. These results indicate that the area needs further research.

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Appendix

Table A1: Summary of literature review

Study	Country	Data source	Methodology	Outcome
Krueger and Summers (1988)	US	US Census Bureau 1974 and 1979, population survey for 1984	Standard deviations	The industry wage structure is remarkably stable across regions and time, but a detailed micro-analysis shows slight wage differentials based on the characteristics of the work performed.
Viscusi (2003)	US	Bureau of Labor Statistics 1992–97	Hedonic wage equation, OLS	Blue-collar women have higher compensating wage differentials than blue-collar men.
Viscusi and Aldy (2003)	US	Bureau of Labor Statistics	Hedonic wage equation, OLS	Nonunion members have lower risk premiums. VSL decreases with age.
Kluve and Schaffner (2007)	Germany and the US	German Socioeconomic Panel, Panel Study of Income Dynamics	Hedonic wage equation, OLS	Men are exposed to riskier, more dangerous work than women.
Polat (2013)	Turkey	Ministry of Labor and Social Security, Household Labor Force Survey 2010–11	Hedonic wage model, OLS	The injury risk premium is pertinent in all sectors. In the case of fatal risk, it is limited to manufacturing.
Nakata et al. (2006)	Japan	Survey	Multivariable logistic regression	There is an expected increase in the risk of occupational injury among current and former male smokers and a risk factor for nonsmokers through passive smoking.
Hersch (1998)	US	Bureau of Labor Statistics	Hedonic wage equation, OLS	Adjusting for the number of women in employment, they are 71 percent as likely as men to get injured.

Study	Country	Data source	Methodology	Outcome
Elia, Carrieri and Di Porto (2009)	Italy	Survey of Household Income and Wealth	Hedonic wage equation, OLS	Small firms pay their workers a flat wage risk premium. The wage-risk tradeoff does not always emerge as hedonic wage theory would predict.
Marin and Psacharopoulos (1982)	UK	Office of Population Censuses and Surveys	Hedonic wage model, OLS, semi-log linear model	Workers are compensated for risk even if they are not union members.
Shanmugam (2000)	India	Survey 1990	Hedonic wage equation, OLS	Minor compensating wage differentials exist.
Madheswaran (2004)	India	Survey and interviews	Hedonic wage equation, OLS	The labor market pays INR240 as an annual wage premium for risky jobs.
Hammitt and Ibarrarán (2006)	Mexico	Survey	Hedonic wage regression, OLS	The SVI is smaller than in the US, but almost the same when compared to Taiwan and South Korea.
Liu and Hammitt (1999)	Taiwan	Survey and interviews, Chilean Safety Association	Hedonic wage function, OLS	Petrochemical workers receive a significant compensating wage differential for risky jobs.
Parada-Contzen, Riquelme-Won and Vasquez-Lavin (2013)	Chile	Chilean Safety Association	Hedonic wage model, OLS, probit model	A wage premium exists. The results are consistent with other developing countries.
Rafiq and Shah (2010)	Pakistan	Punjab Employees Social Security Institute (only for Lahore	Hedonic wage model, OLS	Workers are compensated for risk in selected private sector firms in Lahore.

Table A2: Classification of 2-digit level industries

Code	Industry
	Manufacturing
10	Manufacture of food products
11	Manufacture of beverages
12	Manufacture of tobacco products
13	Manufacture of textiles
14	Manufacture of wearing apparel
15	Manufacture of leather and related
16	Manufacture of wood and its products and cork manufacture of articles of straw and plaiting materials
17	Manufacture of paper and paper products
18	Printing and reproduction of recorded media
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
22	Manufacture of rubber and plastics
23	Manufacture of other nonmetallic mineral products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment
31	Manufacture of furniture
32	Other manufacturing
33	Repair and installation of machinery
	Construction
41	Construction of buildings
42	Civil engineering
43	Specialized construction activities

Source: Pakistan Standard Industrial Classification (all economic activities) Rev. 4 (2010).

Table A3: Classification of blue-collar occupations

Occupation	Sub-occupation
Services shop and market sales	Personal and protective services
	Models, sales and demonstrations
	Extraction and building trades
Craft and related trades	Metal, machinery and related trades
	Precision, handicraft, printing and related trades
	Other craft and related trades
Plant and machinery operation and assembly	Stationary plant and related operation
	Machinery operation and assembly
	Driving and mobile plant operation
Elementary occupations	Sales and services elementary occupations
	Labor in mining