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ESTIMATING THE RELATIONSHIP BETWEEN RESOURCE INTENSITY AND OCCUPATIONAL HEALTH AND SAFETY IN KAZAKHSTAN

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Estimating the Relationship Between Resource Intensity and Occupational Health and Safety in Kazakhstan

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Abstract:
This paper evaluates the impact of resource intensity on occupational health in Kazakhstan, exploiting official statistical data on injury rates, mining production and employment, income and inequality measurements across 16 regions for period from 2001 to 2014. The injury and the fatality rates in the panel are estimated using fixed effects and random effects model respectively. The results indicate positive correlation between engagement in the resource sector and the injury rate. The paper also finds other significant determinants of occupational accident rates in Kazakhstan – inequality, income, and unemployment.

JEL: J28, J24, I15, J80
Keywords: occupational health and safety, Kazakhstan, mining, resource sector, occupational accidents

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1 INTRODUCTION

Mining, without a doubt, is a dangerous activity not only to environment, but also to the health of workers employed in the resource extraction. According to the International Labour Organisation, mining is listed among "the world's most hazardous industries". Occupational medicine researcher A.M. Donoghue (2004) described different causes of traumatic injuries in mining, causing temporary or permanent disability, or in some cases fatal outcomes. The nature of mining activity itself implies dangerous working environment, where workers are exposed to different risks, including "*rock falls, explosions, mobile equipment accidents, falls from height, entrapment and electrocution*" (Donoghue, 2004, p. 283). Noise, generated by drilling and rock crushing, heat and humidity in tropical places, solar ultraviolet irradiation in open pit mines, and barometric pressure at high altitude mines also contribute to the health hazard and occupation-specific diseases.

The key research question of this paper is whether or not the resource extraction intensity has any effect on occupational accident rates in modern Kazakhstan. Due to favourable geographical position in the middle of Eurasia, the country's land has a very specific and rich geological composition. Kazakhstan possesses over 90 kinds of mineral resources, including substantial stock of oil and gas, coal, aluminium, uranium, iron, copper, zinc, lead, and the variety of other ore and non-ore minerals. Resource sector has great significance for Kazakhstani economy and constitutes more than 40% of GDP.[1]

However, even with higher income per capita, the country remains developing in many aspects. According to the data from the Statistical Committee of Kazakhstan, over the period from 2001 to 2014, over 41,900 workers sustained injuries and nearly 4,400 people died due to occupational accidents. Work related accidents affect the labour force and human capital directly by harming the workers' health. While the existing literature assesses impact of mining on occupational health and safety in different countries, such research has not yet been done in the context of post-Soviet Kazakhstan. Filling this gap is valuable for two reasons. Firstly, it is important to understand how mining industry affects the workers' health and what pattern it exhibits as far as occupational accidents are concerned. Secondly, the results of this study may be generalized to other resource-rich post-Soviet countries, as most of them would have historically similar regulative and industrial background.

[1] Section 3 discusses Kazakhstan's context in more details.

To estimate the effect of resource intensity on occupational health and safety, this paper exploits panel dataset, which was constructed using officially published data from the Statistical Committee of Kazakhstan. Fixed effects model was used to analyse data on the workplace injuries and fatalities at the regional level, across 16 regions over 14 years' period. Share of people employed in mining in each region reflected the resource intensity of a region, while controlling for unemployment, income and poverty level supposedly captured other possible determinants of dynamics in occupational accident rates.

Estimating both injury and fatality rates distinguishes the current paper from other academic research in the area. Existing literature normally evaluates either injury or fatality rates, but not both. As both affect the workers' health, investigating the two of them is believed to capture the effect of resource intensity on occupational health and safety more precisely. Focusing on the whole resource extractive industry rather than one or two specific minerals is another distinct feature of this paper.

The analysis finds the engagement in mining activities has a small positive effect on increasing injury rates, along with the engagement in manufacturing and construction sectors. However, the unemployment rate and real income have greater impact on dynamics of injury rates. These findings reflect the correlation of injury rates with business cycles, and the theory of compensating wage differentials finds support in the specific context of Kazakhstan. The analysis of fatality rates at the workplace shows explicit positive correlation between level of inequality in a region with the number of workers died at work.

This paper is organised in 8 main sections, including introduction. The remainder of the paper is structured as follows. Section 2 reviews existing academic literature devoted to the economic theory of occupational health and safety, the determinants of variation in occupational accident rates, and the empirical evidence supporting or refuting the theoretical inferences. Section 3 defines the specific context of Kazakhstan and discusses the statistics of occupational health and safety in different industries in the country's economy. Section 4 describes the data used, the variables featured in the empirical model, and the potential pitfalls of the data. Section 5 outlines the empirical methodology of the fixed effects model, used for estimation. The results and implications of the empirical analysis are examined in Section 6. Section 7 presents discussion and policy implications of this study, while Section 8 provides concluding remarks and explores potential questions for future research.

2 LITERATURE REVIEW

Occupational accidents in mining are dangerous and negatively affect the labour force involved. Therefore, the issue of occupational health and safety is acutely relevant for extractive industries. The academic literature available on economics of occupational health and safety, highlights the complicated interdisciplinary nature of the research topic. It involves different aspects of health and labour economics, business management, and occupational health medicine. This literature review section contains three parts. The first part is the theoretical framework, this presents two main theories – the neoclassical theory of compensating wage differentials and the theory of the government mandate to enforce safe working environments. It also presents the empirical evidence on labour force dynamics related to workplace injuries. The second part looks at the strain of literature explaining the variation in injury and fatality rates over time. The final part discusses more specific literature on occupational health hazards in the mining industry in order to understand how the issue was tackled in the past.

2.1 THEORETICAL FRAMEWORK OF OCCUPATIONAL HEALTH AND SAFETY ECONOMICS

The father of modern economics, Adam Smith (1776), first expressed the theoretical foundation of modern occupational health science in his book "*An Inquiry into the Nature and Causes of the Wealth of Nations*". He suggested that capitalism by nature creates simple routine jobs, which in turn make workers "stupid and ignorant". Smith advocated for a government to take measures to maintain proper mental and physical state of workers. The idea of government intervention is reflected in the government mandate theory that is examined more closely later in this section. Another of Smith's contributions to occupational health economics was the introduction of the theory of compensating wage differentials. Current analysis is testing the proposition that the wages have effect on injury and fatality rates. Therefore, the theory of compensating wage differentials is examined here, as it provides the theoretical background to the correlation between occupational accident rates and the level of a worker's income.

2.1.1 COMPENSATING WAGE DIFFERENTIALS THEORY

To illustrate the compensating wage differentials, Ehrenberg and Smith used the hedonic wage model,[2] which has primary value in understanding job matching process and the trade-off between risk injury and wage rate (Ehrenberg & Smith, 2015). The theory assumes that firms aim to maximize their profit, while employees seek to maximize their utility. The labour market is competitive – firms do not have monopsony power and have to compete for workers offering wage. Workers are marginally mobile and aware about hazards in the workplace. Assuming there are two firms *A* and *B* in the market offering a job, it is easier to graph the model as reflected in Figure 1. In the graph, both the firms and the employees face the trade-off between the risk of injury and different levels of the wage rate along the axes. Firm *A* has cheaper safety costs, therefore, can offer higher wage at lower levels of risk than firm B. Graphically it is shown along the zero-profit curves OC_A and OC_B to the left from point *R*. However, at higher risk levels firm *B* can offer higher wages. Even though firm *B* has to invest more in risk reduction, it still saves by operating in a more dangerous industry. Hence, firm *B* will pay relatively higher wage rates at higher risk levels to attract employees. This implies that people who are less risk averse will prefer to work for firm *B* along the curve OC_B beyond *R*.

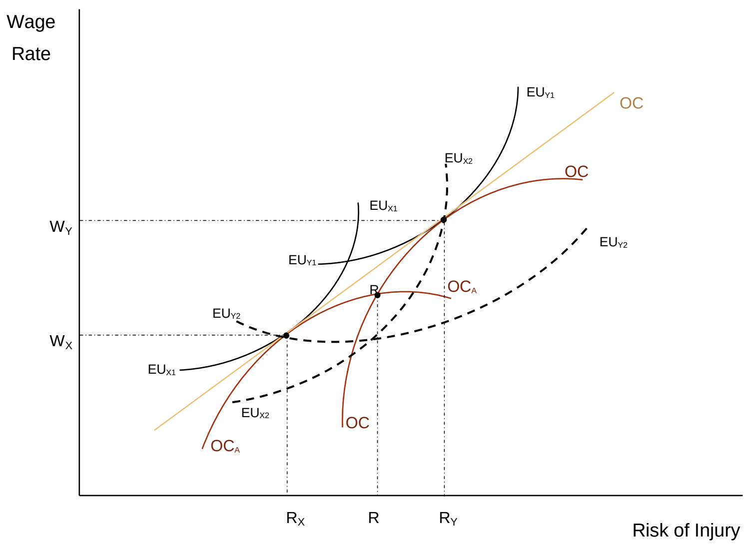
From the perspective of employees, the model considers indifference curves of two workers *X* and *Y* are represented by EU_X and EU_Y. Employee *X* is more risk averse and maximizes utility, working for firm *A* at wage rate W_X and risk level R_X. In turn, employee *Y* is willing to accept higher risk and therefore, his maximum utility is at the point where his indifference curve EU_{Y1} is tangent to the zero-profit curve of firm *B* (OC_B). The combination of the wage and risk of injury rates for him is W_Y and R_Y respectively. If we consider utility of worker *X* working for company *B*, then his expected utility would be represented by the curve EU_{X2}, he would receive higher wage W_Y, but overall utility would be lower than at W_X. Similar analysis applies to worker *Y*, whose utility is higher along EU_{Y1} at W_Y and R_Y rather than if he decided to work for firm A. In that case his utility curve would be represented by EU_{Y2}.

There are two major implications of the hedonic wage model for the labour market. Firstly, the wage is positively correlated with risk of injury, i.e. everything else equal, higher risk jobs are better paid, Expanding the logic of the two firms setup to the overall job matching

[2] Hedonism as a philosophical school argues that the primary goal for an individual is maximizing his or her pleasure (Moore, 2013)

process, it would be reflected by generalized offer curve of all the firms in the market *OC*, capturing the relationship between higher risk levels and higher wages.

Figure 1. Determining compensating wage differentials in labour market



Source: Ehrenberg & Smith, 2015

Secondly, more risk averse workers will tend to accept lower paid jobs in firms where safety costs are cheaper; and workers who are more prone to accept the risk will more likely to take jobs in firms where investment in safety is more expensive. The latter means, that job matching in the market is strongly based on the preferences of both workers and employers.

Thomason and Burton (1993) examine a "pure" neoclassical model, and demonstrate that the employers with dangerous jobs can only attract employees by offering a higher wage to workers. Using the OLS model and the data from a stratified random sample of 977 New York compensation claims, the researchers found that insurer's claim adjustment efforts increase settlement probability, but the discount rate of about 25% is required to equate lump sum settlements with the benefit stream paid by a compensation award. From the perspective of the employer, the findings imply that the risk of accidents provides the incentives to invest in safety in order to reduce costs related to the risk premium. The firm will make safety investments until the marginal cost of safety is equal to the marginal reduction in the risk premium. Oi (1974) states that since there is a rising marginal cost to investments in safety, equilibrium will occur with a positive value for the risk premium, which means that there will be some workplace injuries in equilibrium.

Over the years a large number of studies have attempted to test the compensating wage differential theory and in particular the hedonic labour market model in practice. Kip Viscusi and Michael Moore (1987) tested the compensating wage differentials theory, by including dummy variable for hazardous working conditions into the wage equation. In order to conduct comprehensive analysis of the workers' income, the researchers also took workers' compensation system into account and the interaction between the compensation and risk. The results exhibited positive correlation between the wage and the risk levels, however, the workers' compensation lowers the wage rates even for riskier occupations. Nevertheless, if the compensation would go to zero, the wage rates would have to increase to cover the risk imposed on workers. Hence, the evidence provided is still consistent with the theory.

The review by Viscusi and his co-author Aldy (2003) presented critical analysis of more than 100 papers, estimating injury and fatality risk premiums. They found that a substantial number of studies confirmed the theory of compensating wage differentials for occupational hazards. The authors conducted a meta-analysis based on four previous studies of value of statistical life, replicating econometric specification from earlier papers on a new dataset. Estimates of the value of statistical life conditional on income, controlling for unionisation of workers, unemployment, industry and occupation, and different types of risk level yield the result that with some variation, the income elasticity to the value of statistical life ranges from 0.5 to 0.6.

On the other hand, the critical studies did not find evidence for the compensating wage differentials theory to hold. Leigh (1995) noted that there are more factors affecting compensating wage differentials than simply risks of injury or fatality at work. Some industry-specific working conditions may not be directly hazardous, but incur higher wages for being less pleasant. For example, working in mining or construction sector often implies night working shifts and unpleasant working environments, e.g. dust, noise, or outdoor work. Estimating the wage equation, Leigh included industry specific dummies and the results did not support the theory of increasing wages as the riskiness of a job rises. According to his findings, manufacturing has lower death rates and higher wage rates, while mining with higher fatality rates is paid lower. He argued that the evidence, consistent with the compensating wage differentials theory, was flawed due to unreliable data on fatality rates and the effect of inter-industry differentials.

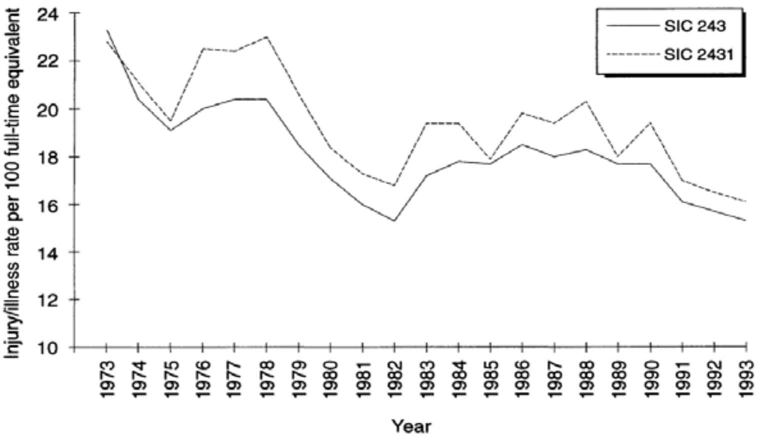
Leigh's results were confirmed by Purse (2004), who claimed that the assumptions of perfect competition in neoclassical theory did not reflect the state of the real labour market, arguing that "*the power relations that are integral to the employment relationship are ignored and conflict over workplace health and safety between employers and workers is abstracted out of existence*." From the perspective of finding the empirical evidence, Purse criticized previous studies, pointing out the measurement error and omitted variables problem make econometric testing of compensating wage differentials flawed. In addition, the empirical studies used inter-industry wage and risk data, which makes it difficult to spot industry specific wage-risk effects.

2.1.2 GOVERNMENT MANDATE THEORY

The government mandate theory is based on a belief that the government should require companies to maintain a certain level of health and safety standards, and enforce the standards by inspections and fines for non-compliance. Although, it is rather a legal theory, its application in economic theory is related to evaluation of effectiveness of existing health and safety policies, such as American Occupational Safety and Health Act (OSHA) of 1970, which originally addressed workers' protection from hazardous jobs. (U.S. Department of Labor, 2009)

David Weil (1996) assessed effectiveness of OSHA using sample panel data from Integrated Management Information System on OSHA enforcement activities in the woodworking industry. Weil's model predicts level of compliance with OSHA standards for each particular plant, based on number and duration of inspections received by a plant, amount of penalties incurred, company size, and dummy variable capturing union status of a firm. The main finding of the paper is the increasing compliance effect with OSHA standards with each subsequent inspection and accumulation of penalties. The probability of a firm being compliant rises from 0.35 during the first inspection up to 0.83 after the sixth inspection. Weil examines the general dynamic of injury rates, as can be seen in Figure 2, representing total injury and illness rates over 30 years for two industries SIC 243 (millwork, veneer, plywood, and structural wood) and SIC 2431 (millwork). Comparing it with the empirical results, he concludes that OSHA enforcement system has been effective and therefore, infers that compliance with OSHA standards is the reason for the significant decline in occupational injury rates since 1974, when the standards were legally enforced.

Figure 2. Total Injury and Illness rates, USA 1973-1993



Source: Weil, 1996

Other studies were less enthusiastic about the effectiveness of OSHA in reducing the number of occupational injuries. Viscusi and Gayer (2002) criticized the American safety regulation system for low economic efficiency, claiming that the cost-effectiveness of the compliance monitoring agencies is inadequate, while the cost of enforcement per saved life is excessively high. In the paper "*Regulation of Health, Safety, and Environmental Risks*" the author conducted cost-benefit test of different regulations, based on average value of statistical life equal to $7 million (Viscusi, 2007). According to his findings, a number of regulations cost more than $140 million per statistical life saved. Although, from behavioural point of view OSHA has played significant role in decreasing accident rates at work, the extremely high costs of enforcing it might imply that it is not the most efficient way to address labour market failures, given it imposes additional burden on taxpayers.

2.2 RESEARCH ON VARIABILITY OF OCCUPATIONAL ACCIDENTS

Empirical evidence on occupational injuries highlighted correlation of workplace accidents with other factors. Fabiano et al. (2004) defined four main aspects affecting industrial accident rates:

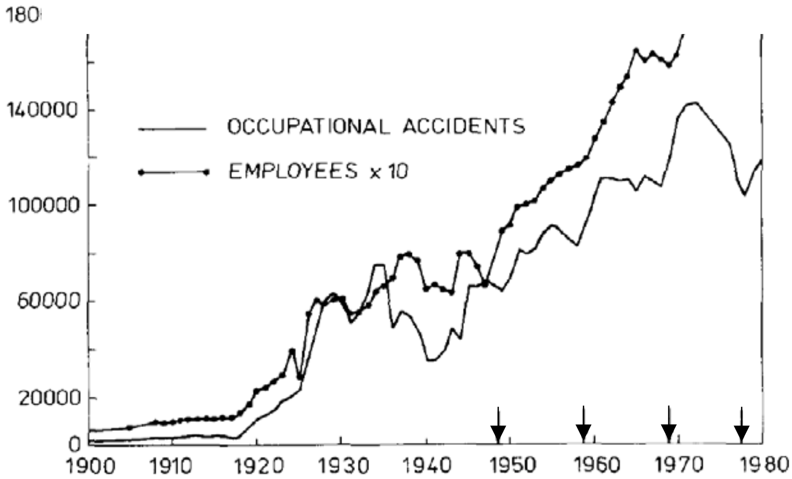
- **Economic factors –** business cycles, unemployment rate, legal regulation of labour market, and cost-effectiveness of the safety regulation
- **Technology used in production** – automation level, operating cycles, level of modernization of machinery used, and effectiveness protection measures
- **Working environment and job design –** a number of accidents may be avoided by providing more efficient work space and processes

- **Human factors** relate to workers' experience and education, motivation, and their innate physical and mental abilities.

Each of the factors affects productivity and hence rates of occupational accidents, but economic factors, by nature, play the most important role among them. Simply put, economic factors are connected with economic fluctuations, technological progress, trends in labour market, and organizational and job design issues. In this review, two implications of economic factors for occupational safety are taken into account – business cycles and industry-specific research on occupational accidents.

Saari (1982) examined general trends of occupational accidents in Finland, comparing them with changes in technological progress and economic cycles from 1900 to 1979. He noticed that times of high or low rates of occupational accidents correlated with the employment rate and economic cycles.

Figure 3. Occupational accidents dynamic, Finland 1900-1979



Source: Saari, 1982

Figure 3 depicts the dynamic of accidental rate in Finland for 80 years; black arrows point out periods of economic depression during period from 1950 to 1980. As shown in the graph, the decrease in accidental rates is observed during economic downturns in Finland, while at times of economic upswings there is sharp increase in the number of industrial accidents.

Revising the evidence found in Saari's paper, Fabiano et al. (1995) investigated the long-term trends of occupational accidents in Italy. Based on the data from the State Organization for the Labour Accident Insurance (Istituto Nazionale per I'Assicurazione centre gli Infortuni sul

Lavoro), they computed accident frequency indices for nearly 100 years and compared it with dynamics in the index of industrial development in the country. According to their results, a period of Italian economic boom in 1960s is associated with the highest frequency rates of occupational accidents, while lower rates of accidents correspond to economic downturns. Thus, the cyclical nature of accident rates is upheld by the evidence from Italian industrial development history.

The economic narrative behind the relationship between accidental injuries and business cycles is summarized by Asfaw et al. (2011). Human and physical capital composition is subject to change due to economic fluctuations. When the economy expands, less trained workers are able to get employed, and this can lead to increase in injury rates. Lower unemployment rates might cut underreporting accidents at workplaces, because workers might be more willing to report them. During economic downturns, unemployment increases and less skilled workers lose their jobs. Hence, the remaining labour force is better trained and less likely to get injured due to inexperience or negligence. In addition, workers might underreport injuries in the face of the unemployment threat. This explains the decrease in injury rates during recessions and the increase during economic booms. Economic boom puts pressure on firms willing to increase output, meaning longer hour shifts for workers and less time for breaks and rest, which can negatively affect the workers' health. In addition, compliance with safety rules and regulation is weaker during expansions due to higher production pace. For the same reason, intensive use of machinery and lack of maintenance and repair along with the use of old equipment might contribute to higher injury rates during economic upswings. On the other hand, when GDP is decreasing, the economy is working below its full capacity, hence, work hours are shorter and there is more time for equipment maintenance and checks.

However, other Finnish researchers Saloniemi and Oksanen (1998) found the opposite result of correlation between business cycles and occupational accident and fatality rates. The researchers used a linear regression model to predict the effect of economic activity indicators on the fatality rates in construction and manufacturing, controlling for number of workers, number of working hours, unemployment rates and industry specific variables, e.g. cubic metres under construction. Their results differ by the industry: in manufacturing, there is no meaningful correlation between accident and fatality rates and economic cycles; but in construction decreasing production volume was associated with the decline in fatal accidents.

Finding the difference between the two industries gave insight into the different effects of industry specific characteristics on the nature and outcome of occupational accidents.

Among others, higher inequality and poverty negatively affect the risk of occupational accidents. The evidence, discussed in the paper “Health Issues of Migrant and Seasonal Farmworkers” by Hansen and Donohoe (2003), shows that poverty and occupational health hazards are interrelated. The migrant and seasonal workers are mainly from a poor segment of population, which make them take up more hazardous jobs, dealing with pesticides, fertilizers, waste, heavy machinery and equipment, etc. In another study, Loewenson (2001) demonstrated the case of Zimbabwe, where working women face more occupational health hazards, because they constitute vulnerable and impaired social group in the first place and experience less or no protection from occupational accidents. However, the direction of causality between occupational accidents and poverty and inequality is not very clear in the literature and has to be elaborated.

Given different nature of production process in different industries, it is logical there is a strand of research devoted to investigating dynamics and causal relationship in particular industries. Reilly et al. (1995) looked at the nature of employer-worker relationship to assess the risk of workplace injuries in the sample of manufacturing companies in the UK. Using data from Workplace Industrial Relations Survey 1990, the researchers examined determinants of injuries at company level, focusing specifically on presence of labour unions in the company and its effect on the injury rates. According to the results of the paper, the unions’ safety committees have a positive effect on reduction of the workplace injury rates. Thus, labour unions and safety committees play a significant role in promoting and monitoring successful implementation of safety regulations in the UK manufacturing industry.

Asfaw et al. (2011) underlined lack of industry specific research on injury rates by industry and examined occupational accidents in agriculture, mining, manufacturing, and construction. The authors used industrial production index as a measure of business activity in the sectors of interest, and fluctuations of GDP and unemployment rate to identify the national pattern of economic cycles. They reported three sectors to be the most sensitive to economic fluctuations: the number of injuries increased during economic expansion and reduced during the downturns in manufacturing, construction and mining. Moreover, they pointed out that the correlation of injury rates and business cycles has different patterns in different industries. For example, in construction, training of workers plays the most important role along with thorough planning of work shifts to avoid employees' fatigue. In manufacturing, both good training of workers and proper maintenance of machinery should be ensured to reduce the number of injuries. Mining industry is more capital intensive (van der Ploeg, 2011), hence, the nature of injuries is more often related to the use of machinery and equipment. Therefore, any machinery brought to the production process during economic boom should be maintained and monitored thoroughly, and the workers should be well trained in terms of safety and security measures.

Papers discussing accidents specifically in mining are concentrated on promoting safety regulation and monitoring measures, but only few of them conduct proper economic analysis of the issue. The study by Coleman and Kerkering (2007) discusses the probability of injury in underground coal, metal and non-metal mining industries. They used the workdays lost due to injury to measure the severity and intensity of the accidents. They reported the that the probability of having injury resulted in 10 or more lost workdays is almost 1.5 times higher in underground coal mining versus metal or non-metal mining. The authors stressed the need for reinforcement of safety measures in mining industry and the role of government health and safety regulation in managing the risks.

Another study by Leigh et al. (1990) describes the pattern of non-fatal injuries in coal mining industry in Australia. Using cross-sectional data, they analysed the worktime losses associated with accidents, and studied the distribution of injuries by age of workers, their experience and occupation, causes and types of the injury, difference in working time, compensations paid to the worker, and types of equipment involved in production. According to the findings of the paper, work experience has a crucial role in coal mining, and workers under 40 years old are more accident prone. In the data used around half of the accidents equipment and machinery were reported as a cause of the injury.

In turn, the problems with statistics on occupational accidents are discussed by Blank et al. (1995). Examining cross-sectional data on occupational injuries from Swedish mining industry, the researchers found out the counter intuitive rapidly decreasing pattern of accident rates in mining. The findings of the paper indicated that decrease in the injury rates in mining happened due to massive involvement of contractor workers in the industry. Hence, accidents happening in the industry are not necessarily reported by mining companies, if contractor workers are involved in the accidents. Therefore, under regular classification, without including contractors, the statistics do not reflect the real dynamics of the injury rates in mining. According to the study, it is important to depict and eliminate flaws of statistical system, and to include contractor workers in mining to obtain more realistic picture of safety issues in mining industry.

Summarising this comprehensive literature review, it is clear the existing academic literature on occupational health and safety is a complex multifaceted issue, which require thorough interdisciplinary research to tackle different aspects of the topic. From economic perspective, occupational accidents directly affect labour force and human capital, therefore, it is an important topic of interest for labour economists. The theoretical models take compensating wage differentials and government regulation as determinants of injury rates in the economy, while empirical evidence captures the correlation of injury rates with business cycles and unemployment, technology and equipment used, along with workers' experience, job design and organisation of work (Ehrenberg & Smith, 2015). The empirical testing of the compensating wage differentials theory displayed mixed results. Many studies found positive correlation between riskiness of a job and wage rates, thus, confirming that employers have to offer higher wages to attract workers to dangerous jobs (Viscusi & Moore, 1987). However, criticists of the theory claimed that the empirical research suffered from the measurement error and omitted variables problems (Purse, 2004). Indeed, some studies confirm that statistical data on injury rates is often difficult to collect, given that only severe injuries get reported, and sometimes workers hide the fact of injury facing the threat of unemployment (Asfaw, et al., 2011). Presence of labour unions proved to be a significant factor of improvement in workplace accident rates, emphasizing the importance of inclusive job organization (Reilly, et al., 1995).

Industry specific research identified mining as one of the most hazardous occupations along with manufacturing and construction, where high injury and fatality rates are determined by industrial accidents (Asfaw, et al., 2011). However, there are pitfalls related to mining specific studies. First of all, measurement error in the statistical data imposes downward bias, while the use of specific type of the resource (e.g. coal or iron) makes it hard to generalize the results for the whole resource sector (Leigh, et al., 1990). Secondly, the use of cross-sectional data does not take into account time invariant factors like natural environment and geographical location, while current paper enjoys the benefits of using panel data. Thirdly, most of the studies use either injury or fatality rates, but in this study, both are used to have more precise picture of the effect the mining activity has on occupational health and safety. Finally, there are few studies tackling the issue of occupational accidents in mining with a robust econometric approach. In this paper a linear fixed effects model is used to analyse panel data set and more detailed specification of the model is provided in the empirical strategy section. For these reasons the current study is believed to be valuable contribution to the research area.

3 CONTEXT OF KAZAKHSTAN

The Republic of Kazakhstan is an upper-middle-income country[3] located in Central Asia. It is the largest landlocked and the ninth largest country in the world with the territory of 2,724,900 square kilometres or 1,049,150 square miles. The country has common borders with China, Russia, Kyrgyzstan, Uzbekistan, and Turkmenistan. The population of Kazakstan as of December 2015 was 17,670,579 people and around 56% of total population live in the cities (Committee of Statistics of the Republic of Kazakhstan, 2016). Administrative division of the country represents 14 regions and 2 cities of republican significance[4]:

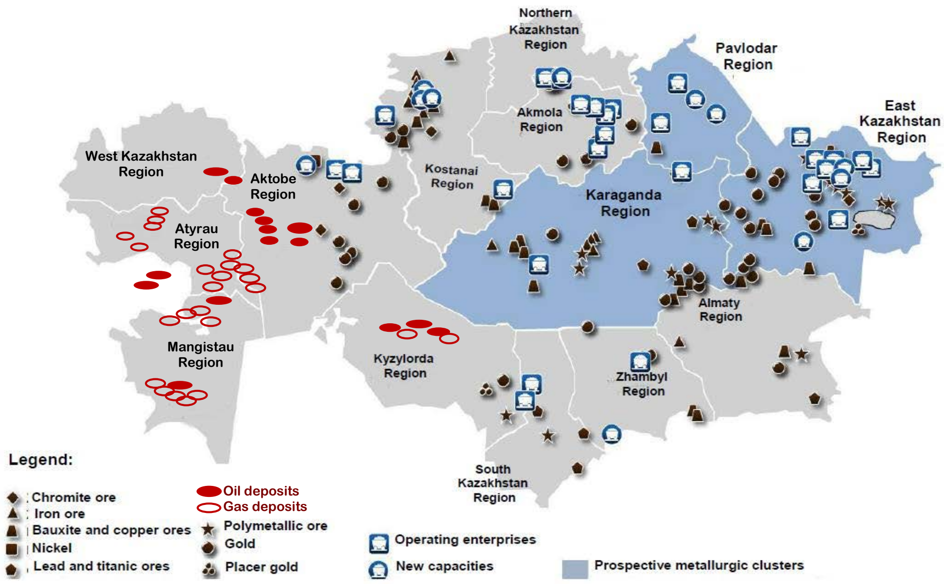
- *Astana – the city of republican significance – the capital of Kazakhstan*
- *Almaty – the city of republican significance – former capital*
- *Akmola region*
- *Aktobe region*
- *Almaty region*
- *Atyrau region*
- *East Kazakhstan region*
- *Zhambyl region*
- *West Kazakhstan region*
- *Karagandy region*
- *Kostanay region*
- *Kyzylorda region*
- *Mangystau region*
- *Pavlodar region*
- *North Kazakhstan region*
- *South Kazakhstan region*

The country is massively endowed with natural resources, including fuel resources, metallic and non-metallic minerals. Kazakhstan possesses over 90 kinds of mineral resources and is listed among the largest resource exporters in the world. Proved reserves of the country add up to 30 billion barrels of oil and 89 trillion cubic feet of natural gas (Resource Governance Index, 2013). Export of mineral resources contributed 74.3% of total export of the country

[3] According to the World Bank classification
[4] (The Law of the Republic of Kazakhstan , 1993)

(Committee of Statistics of the Republic of Kazakhstan, 2016). Natural resources rents constituted 42.3% of GDP in 2011, and declined to 27.5% in 2014.[5] As shown in Figure 4, the mineral resources are spread across the country, oil and gas reserves are mainly concentrated in Western Kazakhstan; coal, copper and manganese – in central region; aluminium in Northern Kazakhstan. Polymetallic ore and uranium mining sites are located in Eastern and Southern Kazakhstan respectively.

Figure 4. Mineral Resources map of Kazakhstan

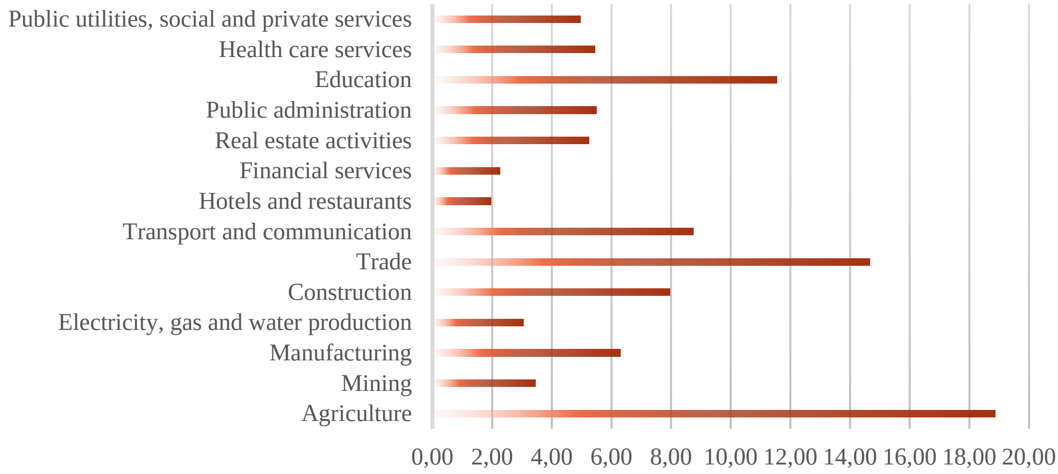


Source: Extractive Industries Transparency Initiative

According to the Statistical Committee of Kazakhstan, despite the significant output produced, mining industry employs only 3.46% of totally employed labour force in Kazakhstan. Nearly 19% are employed in agriculture and about 15% are in trade. Manufacturing and construction sectors provided jobs for 6.30% and 8% of labour force respectively in 2014. Figure 5 shows distribution of employed labour force across the industries in 2014. Small share of people employed in mining sector can be explained by relatively low labour and high capital intensity of the sector (van der Ploeg, 2011), while agriculture still requires significant labour forces involved.

[5] This fact is related to the commodity price crisis (The World Bank Database, 2014)

Figure 5. Employment by industry in Kazakhstan in 2014, %



Source: Committee of Statistics of the Republic of Kazakhstan

However, even with low employment levels mining appears to be hazardous for the workers' health and safety. In 2014 there were 2,578 workplace accidents which caused injuries, out of which 357 happened during mining related activities (about 14%).

Table 1 summarizes the distribution of injury and fatality rates across different industries for 15 years. Over the years 2001-2014 mining industry exhibited the highest average rate of 30.74 injuries per 10,000 of employed people. Manufacturing takes the second place with 17.76 injuries per 10,000 of workers, and construction follows with 9.45 injuries per 10,000 workers.

Table 1. Summary of injury and fatality rates by industry in 2001-2014, per 10,000 of employed people

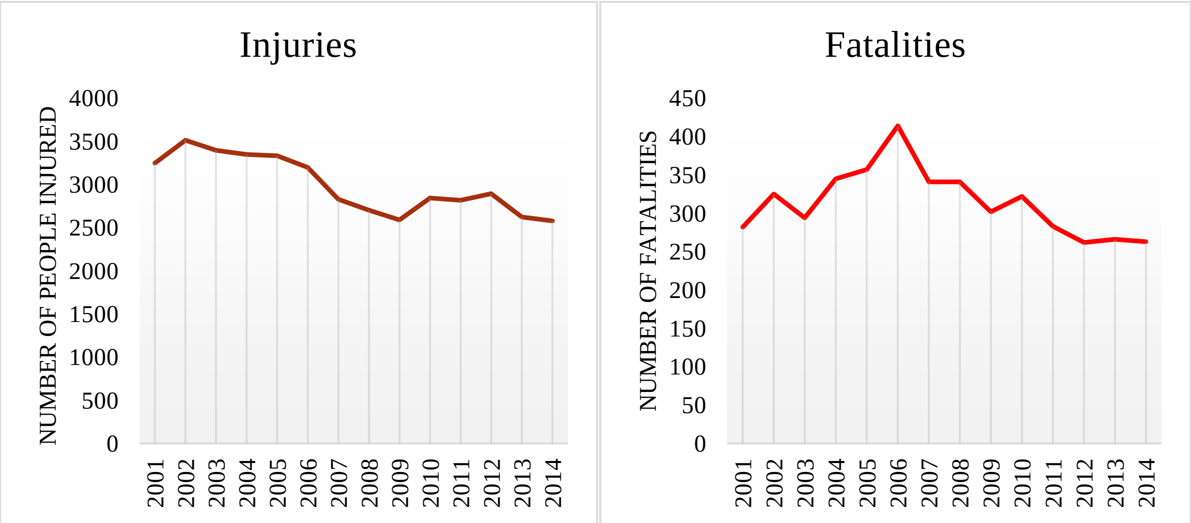
Industry	Injury rate	Fatality rate
Agriculture	0.74	0.10
Construction	9.45	1.62
Education	0.86	0.06
Financial services	1.13	0.14
Health care services	3.93	0.13
Hotels and restaurants	1.80	0.06
Manufacturing	17.76	1.23
Mining	**30.74**	**2.34**
Public administration	2.43	0.35
Real estate activities	2.96	0.36
Trade	0.68	0.13
Transport and communication	3.61	0.43
Electricity, gas and water production	9.73	1.23
Public utilities, social and private services	1.46	0.70
Total	6.24	0.60

Source: Committee of Statistics of the Republic of Kazakhstan

Fatality rate per 10,000 workers over the same period also exhibits its highest mean value of 2.34 in mining sector. Construction has second highest value of 1.62 fatalities per 10,000 of employed, while in manufacturing and electricity production, on average 1.23 workers die at the workplace. General statistics and high average values of injury and fatality rates support the assumption that mining is one of the most hazardous occupations in the economy of Kazakhstan.

Nevertheless, over 14 years from 2001 to 2014 there is observed declining trend in number of both injuries and fatalities as shown in Figure 6. It can possibly be explained by the country's efforts to improve health and safety standards in the workplace. According to the International Labour Organisation, Kazakhstan made significant improvement in the area of occupational health and safety by enforcing new Labour Code in 2007[6], which was later amended in 2015. The Labour Code sets the legal framework and protection of workers in case of occupational accident. The Code prioritizes life and health of employees, regulates health and safety activities at the workplace and enforces liability of employers for non-compliance (Labour Code of the Republic of Kazakhstan, 2015). From the perspective of practical implementation, Kazakhstan features lack of industrial culture and awareness of the risks, high level of negligence from both employers and employees, the compliance with OHS standards are often overlooked at the workplace.

Figure 6. Dynamics of injury and fatality rates over time



Source: Committee of Statistics of the Republic of Kazakhstan

[6] (International Labour Organisation, 2008)

4 DATA

In order to answer the research question whether mining intensity affects occupational injury and fatality rates, this study exploits the data on occupational injuries and fatalities from the Statistical Committee of Kazakhstan for years 2001-2014. The data represents total number of people injured and dead due to the accidents at the workplace distributed across 14 regions and 2 largest cities – Almaty and Astana.

The Statistical Committee of Kazakhstan uses several units of measurement for occupational accidents:

- the number of employees suffered from an accident with one or more workdays lost due to the injury,
- the number of fatalities if the occupational accident caused death of the worker at the workplace,
- the total number of working days lost due to the accident,
- and the amount compensated to the workers in case of occupational accident.

The number of workers sustained an injury at the workplace and the number of workers died at the workplace are used to measure occupational injury and fatality rates in this study. The two units are chosen for simplicity of computing the injury and fatality rates per total number of people employed in each region and for each year. Although some papers used the number of workdays lost to measure injuries (Coleman & Kerkering, 2007), it is less suitable here, as the severity of accidents is not the primary focus of this study. The amount paid as compensation to the worker would be more relevant to analyse the wage equation rather than the occupational accidents themselves (Viscusi & Moore, 1987).

The panel dataset was constructed using injury and fatality rates in region *i* and year *t.* Total numbers of occupational injuries and fatalities were standardized dividing by the total number of people employed in each region and year. The result represented the variable of interest in current analysis – the injury and the fatality rates. The rates are taken per 10,000 of people employed in region *i* and year *t* in order to magnify the variability of workplace injuries and fatalities, as they are rather rare events. Table 2 summarizes dependent and explanatory variables used in the analysis.

Table 2. Variables description

Dependent variables	
injrate	Total number of workers who sustained a workplace injury divided by 10,000 of employed people in region *i* in year *t*
fatalrate	Total number of deaths related to work activities divided by 10,000 of employed people in region *i* in year *t*
Explanatory variables	
eminshare	Share of workers employed in mining in total employment, expressed as percentage of total employment in region *i* in year *t*
emfrshare	Share of workers employed in manufacturing in total employment, expressed as percentage of total employment in region *i* in year *t*
ecstrshare	Share of workers employed in construction in total employment, expressed as percentage of total employment in region *i* in year *t*
unemplrate	Rate of unemployment in region *i* in year *t*
gini	Gini coefficient in region *i* in year *t*
ly	Log of real income, corrected for inflation

Source: Author

Mining intensity is used as explanatory variable, defined by the share of people employed in mining in total employment in region *i*, in year *t*, expressed as percentage. However, the share of employment in mining in total employment is small, as shown before. Manufacturing, and construction industries along with the mining exhibit highest average values of occupational injury and fatality rates at the national level. Therefore, the shares of employment in manufacturing and construction in total employment are also controlled for each region and year at the later stage of the analysis.

Other control variables are unemployment rate, log of real income per capita, and Gini coefficient – all taken at the regional level for each year in the dataset. Unemployment rate is assumed to reflect the business cycles[7], and income level and Gini coefficient – to capture relative poverty in the regions. Log of real income is derived from nominal income in tenge[8] corrected for inflation and logged:

$$\ln(Y_{it}) = \ln(\frac{nominal\ income_{it}}{CPI_{it}})$$

[7] Following the literature on correlation between economic cycles and occupational accidents – Fabiano et al. (1995), Asfaw et al. (2011)

[8] Tenge is the national currency in Kazakhstan, approximately 1 US dollar is equal to 340 tenge

where CPI is consumer price index in region *i* in year *t*.

Gini coefficient is the measure of inequality of the income distribution among the population degree. It determines the variance of log income distribution of numerically equal population groups from the equal distribution line.[9]

Every legal entity in Kazakhstan is obliged to register and report all accidents at the workplace if they result in deterioration of a worker's health, and consequent temporary or permanent loss of his working capacity, or consequent death. Number of fatal outcomes must be registered and reported to the Statistical Committee. However, the evidence showed that the employers do not always report accidents if the latter did not cause any material cost (International Labour Organisation, 2008). The workers also tend to report only severe injuries, or hide the fact of injury in the face of potential unemployment (Asfaw, et al., 2011).

For these reasons and given the "*lack of industrial culture*", there might be the problem of the measurement error in the data exploited. Underreporting of injuries might cause downward bias in the estimation of the models[10]. However, it is rather difficult to hide the information if a worker missed one or more working days, as exploited for the current study. Fatal cases occurred at the workplaces are even harder to conceal. Therefore, the measurement error is assumed to be less of a problem in this study.

Small share of people employed in mining sector can cause underestimating of the effect of engagement in mining on the rates of occupational accidents. Since larger shares of workers are employed in the construction and manufacturing sectors, in order to account for these disproportionate labour distribution, they are used as controls in the regression. Including the share of employment in manufacturing and construction helps to control for the low labour intensity of the mining sector by reducing the base employment group in the regression.

Table 3 shows the summary of descriptive statistics of both dependent and explanatory variables of the model. The dataset contains 224 observations (16 regions over 14 years), therefore, it is a strongly balanced panel. Over the examined period 2001 to 2014 the injury rates varied from 0.37 to 14.61 injuries per 10,000 of workers, the average value is 3.95 injuries per 10,000 of total employment. The average fatality rate is 0.44 fatal outcomes per 10,000 of total number of employees, with its minimum of 0.09 and maximum of 1.62 deaths per 10,000 of workers.

[9] (Statistical Committee of Kazakhstan, 2015)
[10] (Tengrinews.kz, 2011)

Table 3. Summary of descriptive statistics

VARIABLES	Obs.	Mean	Std. Dev.	Min	Max
Injury rate	224	3.950	2.964	0.368	14.61
Fatality rate	224	0.443	0.273	0.0919	1.624
Unemployment rate	224	7.263	1.967	4.800	13.90
Gini coefficient	224	0.269	0.0367	0.159	0.360
Log real income	224	5.459	0.817	3.534	7.116
Share of workers employed in mining	224	3.257	3.388	0	22.44
Share of workers employed in manufacturing	224	6.757	3.875	2.184	19.61
Share of workers employed in construction	224	6.977	4.173	1.307	22.66

Source: Author

The unemployment rate is on average 7.26%, but varied from 4.8% to 13.9% over the period considered. Gini coefficient varies from 0.16 to 0.36. On average the coefficient equals to 0.27 and represents moderate inequality across the regions and time. Average log of real income is 5.46, but varies from 3.53 to 7.11 and also exhibits slightly uneven distribution of income across the regions and over time. On average in the dataset 3.26% of workers are employed in mining, but varies greatly from 0% to 22.44%. Therefore, it presumably captures the mining intensity in the regions. Share of people employed in manufacturing ranges from 2.18% to 19.61% of total employment, and its average is 6.76%. Employment in construction sector exhibits large variation from 1.31% to 22.66% of total number of workers in the economy, but on average 6.98% of all workers are employed in construction.

5 EMPIRICAL STRATEGY

The main research question to answer is whether or not mining intensive regions have higher rates of occupational accidents in Kazakhstan. Exploiting the panel dataset allows to control for unobservable time-invariant region-specific omitted variables by using linear fixed or random effects model to estimate the effect of mining activity on occupational injury and fatality rates. Time dummy variables are used to control for common shocks in the whole economy, affecting all regions in the sample in a particular year. For example, the improved Labour Code was enforced in 2007 and could have strengthened monitoring of health and safety standards. That, in turn, would reduce the number of occupational accidents across the country.

There are two main specifications of the model:

$$(1)\ injrate_{it} = \alpha_i + \beta_1 gini_{it} + \beta_2 unemplrate_{it} + \beta_3 ly_{it} + \beta_4 eminshare_{it} + \beta_5 emfrshare_{it} + \beta_6 ecstrshare_{it} + u_{it}$$

$$(2)\ fatalrate_{it} = \alpha_i + \beta_1 gini_{it} + \beta_2 unemplrate_{it} + \beta_3 ly_{it} + \beta_4 eminshare_{it} + \beta_5 emfrshare_{it} + \beta_6 ecstrshare_{it} + u_{it}$$

where α_i is time invariant regional effects for each region, *i*= 1, 2,…., 16;

u_{it} is the homoscedastic and uncorrelated over time error term in region *i* in year *t*, where *t*= 2001, 2002,…, 2014;

$\beta_1 - \beta_6$ coefficients reflect the effect of explanatory variable on the injury rate in equation (1) and the fatality rate in equation (2).

Table 2 in previous section presents detailed description of dependent and explanatory variables for the model.

To choose between the random and the fixed effects models, the Hausman test was used. The test helps to understand whether the omitted heterogeneity in the model is fixed and correlated with the explanatory variables, or it is random and not correlated with the independent variables. The null hypothesis under the Hausman test is the random effects estimators are consistent and efficient. The alternative hypothesis states the null hypothesis is not true, and hence, the fixed effects estimators are consistent and more favourable to use (Reilly, 2016).

The test of fixed effects against random effects featuring *injrate* as dependent variable, yielded very high value of $\chi^2_{19} = 101.89$. Hence, the null hypothesis is decisively rejected, as the random effects estimators are inconsistent. Therefore, the fixed effects specification is more preferable in this case to reduce the risk of omitted variable bias in the model.

The Hausman test for the model, specified in equation (2), with *fatalrate* as dependent variable, showed that the difference between the fixed effects and random effects estimators is not significant and with the test value of $\chi^2_{19} = 4.05$ the null hypothesis cannot be rejected. Hence, for the estimation of the fatality rates, the random effects model produces consistent and efficient estimators. The full details of the test results can be found in Tables 8-9 in Appendix.

5.1 Fixed Effects Model

In order to estimate the effect of engagement in mining sector on the injury rates, the fixed effects model is used in this study. The fixed effects model was chosen over random effects because of the restrictive assumption of the random effects model. Although the random effects model produces more efficient estimators, it is unlikely to have time invariant omitted variables that would not be correlated with the dependent variable and the explanatory variables. For example, time invariant effects like initial resource endowment, geographical location, climate conditions[11] are highly correlated with the number of people employed in the mining industry and the working conditions and environment in the sites.

The model is estimated first, including only share of mining workers. Then, the shares of employees in manufacturing and construction are included in the regressions. This allows to check if the assumption of disproportionate distribution of workers employed in different industries is correct and might understate the effect of the mining on the workplace accidents.

5.2 Random Effects Model

Estimation of the correlation between mining intensity in a region and the occupational fatality rate was done using the random effects model. The random effects estimators are not only consistent, but also efficient, as now the assumption is that omitted unobservable time-invariant effects are random for every region and not correlated with other explanatory variables. Term α_i in the equation (2) captures the random effects for region i.

[11] Climate conditions vary across different regions due to the large territory of Kazakhstan.

According to the results of the Hausman test, both fixed effects and random effects models can be used to estimate the determinants of occupational fatality rates. However, occupational fatalities are rare and less systematic than injuries. They are likely to be affected by the incidence of overlooked safety and health standards at the workplace and negligence. These factors are random across the regions and more likely to be independent from the explanatory variables. Therefore, the random effects model is believed to provide more precise estimators for the given specification.

As in the fixed effects regression, the estimation was done in two stages – including only share of mining workers, and then with the added proportions of the employment in manufacturing and construction.

5.3 TESTING THE MODEL FOR HETEROSCEDASTICITY AND AUTOCORRELATION

Modified Wald test for groupwise heteroscedasticity and Wooldridge test for autocorrelation in panel data were used to check efficiency of the fixed effects model (Drukker, 2003). The modified Wald test exhibited that the model, specified for injury rate, was heteroscedastic, hence, the error variance is not constant across observations in the sample. The reason for that may lie in the improved statistical data collection by the Statistical Committee, or improvement in health and safety standards.

According to the Wooldridge test, the equation (1) specification is serially correlated, while the model specified by the equation (2) is not autocorrelated. Due to heteroscedasticity and serial correlation the model generates biased standard errors, and while the estimators are still unbiased, the results of estimation are less efficient. There is no need to correct for serial correlation in the random effects estimation.

Correction of heteroscedasticity and autocorrelation in panel data models often implies clustering standard errors. However, it is most efficient when the number of clusters is greater than 50. As there are only 16 groups (regions) in the current dataset, Least Squares Dummy Variable approach with robust standard errors was used. The corrected model is specified in equations (3).

$$(3)\ injrate_{it} = \beta_0 + \beta_1 gini_{it} + \beta_2 unemplrate_{it} + \beta_3 ly_{it} + \beta_4 eminshare_{it} + \beta_5 emfrshare_{it} + \beta_6 ecstrshare_{it} + \delta_{2002}T_{2002} + \cdots + \delta_{2014}T_{2014} + \gamma_1 R_1 + \cdots + \gamma_{16}R_{16} + u_{it}$$

where β_0 is constant term;

δ_t is the coefficient for binary time variable;

T_t is time as dummy variable;

γ_i is the coefficient for binary regional variable;

R_i is regional dummy variable.

By including time and region dummy variables and robust check for the standard errors, the corrected model generates unbiased and consistent, and efficient estimators. The estimation procedure is repeated again with and without shares of employees in manufacturing and construction.

5.4 POTENTIAL LIMITATIONS OF THE MODELS

The main potential problem is created by limited data availability. The Statistical Committee does not provide official data on the share of employed by industry by region, which imposes the risk of over- and underestimation. Real regional effect of mining activity is potentially underestimated in resource intensive regions, while it might be overestimated in the regions with low resource extracting activity.

The problem of omitted variable bias in the empirical testing is supposed to be solved by including unemployment rate, log of real income, and Gini coefficient as control variables, while including regional fixed and random effects captures unobservable time-invariant differences across the regions. Another potential issue is the probability of reverse causality occurring in the model. High injury and fatality rates in the mining sector might intimidate workers. Given the unpleasant and potentially hazardous working environment, high risk of accident might discourage the workers from engaging in the industry at all. However, the fact is that the jobs in mining industry is listed among the most highly paid in Kazakhstan according to the Statistical Committee of Kazakhstan. Although, in a more developed country, that might not be a strong argument, given that Kazakhstan is still a developing country and the income level in most of the regions is relatively low, it is likely that the employees would still be willing to take up the jobs in mining. Figure 7 in the Appendix displays the average income per capita across the regions. Therefore, for the time being the issue of reverse causality is assumed to be minor in the current study.

6 EMPIRICAL RESULTS

Table 4 displays the results of estimating the effect of the mining intensity on injury rates, and Table 5 represents the estimation of the effect of mining on fatality rates at the workplace. As explained in Section 5, the first regression includes only share of mining employees, the second regression has shares of employment in construction and manufacturing added to the model.

Results of regression (1) in Table 4 exhibit long linear downward time trend from the second to final year. On average, by year 2014 there are approximately 9.7 injuries less per 10,000 employees. Regional trend is less homogeneous and represents different riskiness levels in different regions. On average and holding other variables constant, in Atyrau region injury rate decreased over time by 2.43 injuries per 10,000 workers, while in Karaganda region the number of injuries per 10,000 employees increased by 8.52 over time. Full transcript of the region codes is presented in Table 6 in the Appendix.

The main variable of interest is the percentage of people employed in mining sector. According to the results of estimation in column (1), the coefficient is positive, but not significant. That supports the assumption of disproportionate difference in the shares of labour force employed in different industries. Although the average national level of the injury rates in mining is very high, and one would expect to see the positive effect of mining on injury rates, the base group is very diffuse with all the different levels in it. Considering low percentage of mining workers in total labour force, the large base group might distort the result in estimation (1).

Inequality represented by Gini coefficient in the model, does not have any significant effect on injury rates in the sample. This result shows that on average and ceteris paribus poorer regions are not necessarily riskier than richer ones as far as occupations are concerned. From the other hand, less poverty in a region does not imply safer jobs for people. Log of real income, however, exhibits positive and significant at 1% level effect on occupational injury rate. On average, other things equal, 10% increase in income is associated with 0.3 more injuries per 10,000 employees. The result is consistent with the compensating wage differentials theory and supports the assumption that riskier jobs are better paid. Unemployment rate has negative effect on injury rates, implying that 1% increase in the regional unemployment rate reduces injury rate by 0.29 injuries per 10,000 workers. The result is significant at 5% level and consistent with the assumption of business cycles determining injury rates. As the unemployment rate is a proxy for economic fluctuations in the model, the sample used in current study exhibits countercyclical trend in occupational injury rates. In other words, there are more injuries at the workplace, when the economy operates at full capacity, and fewer injuries, when there is a decline in output.

The results of estimating the regression with two other industries as controls are presented in column (2) of Table 4. The time trend in amended regression still shows steady decline in injury rates, although controlling for more explanatory variables shows smaller value of reduction by 7.11 injuries per 10,000 in year 2014 compared to 2001. Region fixed effects also capture the same pattern across different regions, some having decline in injury rate down to 2.76 per 10,000 of employees (Atyrau region), while in Karaganda, the region mostly focused on coal mining, the number of injuries increased by 6 per 10,000 of workers.

The model again displays that inequality does not affect injury rates at a regional level. After adding two more controls to the regression, the estimated effect of income became smaller, but it is still positive and significant at 5% level. Now 10% of rise in income in a region implies that on average and ceteris paribus, there are 0.19 injuries more per 10,000 employees. Unemployment rate has negative but slightly smaller effect on injury rates here. Holding everything else constant, 1% increase in unemployment rate is associated with the average decrease of 0.23 injuries per 10,000 workers.

The crucial variable of interest – the share of workers employed in mining – shows positive significant effect on injury rates. Increase in the share of employment in mining sector by 10 percentage points would mean that on average, there are two injuries more per 10,000 employees in a region, other things equal. Engagement in both manufacturing and construction also increases risk of injuries. 10 percentage points increase in share of manufacturing employees raises the injury rate by 2.4 injuries per 10,000 workers in a region, on average and ceteris paribus. Similarly, rise in number of construction workers by 10 percentage points increase the injury rate by 0.9 injuries per 10,000 people working in a region. According to the results, on average engagement in manufacturing sector is more dangerous than in mining sector, while being employed in construction is less risky than working for a construction or mining company.

Table 4. Fixed effects estimation, dependent variable: *injury rate*

VARIABLES	(1) injrate	(2) injrate
gini	5.042	4.006
	(4.824)	(4.777)
unemplrate	-0.287**	-0.228*
	(0.140)	(0.137)
ly	3.054***	1.884**
	(0.903)	(0.890)
eminshare	0.0599	0.200***
	(0.0707)	(0.0646)
ecstrshare	-	0.0919**
		(0.0382)
emfrshare	-	0.240***
		(0.0636)
2002.year	-0.560	-0.304
	(0.583)	(0.577)
2003.year	-1.347*	-0.974
	(0.686)	(0.665)
2004.year	-2.360***	-1.731**
	(0.809)	(0.796)
2005.year	-3.196***	-2.425***
	(0.927)	(0.915)
2006.year	-4.012***	-3.086***
	(1.096)	(1.071)
2007.year	-5.600***	-4.411***
	(1.297)	(1.273)
2008.year	-6.775***	-5.240***
	(1.554)	(1.510)
2009.year	-7.098***	-5.422***
	(1.646)	(1.595)
2010.year	-7.484***	-5.557***
	(1.820)	(1.799)
2011.year	-8.251***	-6.057***
	(1.922)	(1.881)
2012.year	-8.664***	-6.318***
	(2.046)	(2.004)
2013.year	-9.215***	-6.815***
	(2.098)	(2.056)
2014.year	-9.564***	-7.112***
	(2.186)	(2.146)
2.regioncode	0.0463	-0.290
	(0.428)	(0.388)
3.regioncode	-1.074***	-0.646*
	(0.307)	(0.345)
4.regioncode	-2.436**	-2.761***
	(1.053)	(0.971)
5.regioncode	3.850***	3.172***
	(0.393)	(0.400)
6.regioncode	0.967**	1.031**
	(0.418)	(0.403)

Table 4 continued

VARIABLES	(1) injrate	(2) injrate
7.regioncode	0.133	0.685*
	(0.372)	(0.385)
8.regioncode	8.521***	6.030***
	(0.478)	(0.782)
9.regioncode	0.406	0.375
	(0.353)	(0.353)
10.regioncode	-0.142	-0.231
	(0.382)	(0.388)
11.regioncode	-0.331	-2.527*
	(1.439)	(1.394)
12.regioncode	1.867***	0.306
	(0.470)	(0.644)
13.regioncode	0.367	1.363***
	(0.333)	(0.387)
14.regioncode	0.0263	0.229
	(0.463)	(0.472)
15.regioncode	1.034	1.867**
	(0.823)	(0.856)
16.regioncode	-0.989	-0.742
	(0.907)	(0.835)
Constant	-7.666*	-5.207
	(3.953)	(3.901)
Observations	224	224
R-squared	0.908	0.915

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author

Table 5 presents the results of estimation featuring the fatality rate as dependent variable. The time trend shows there is not much variation in the fatality rates over time. The results in column (3) show insignificant negative effect of the unemployment rate, and the effect of engagement in the mining is close to zero. There is a very small positive, but significant at 1% level effect of income, inferring that holding other factors constant, on average 1% rise in real income increases the fatality rate by 0.21 fatal outcomes in case of occupational accidents per 10,000 employees. Another factor that appears to be significant at 1% level is Gini coefficient, which is positively correlated with the fatality rate. The result implies that on average and ceteris paribus, every additional point of Gini coefficient increases the deadly dangerous accident rate by 2.29 fatal cases per 10,000 employees.

The estimation of the regression with the added shares of employment in manufacturing and construction yields slightly higher and significant result for the Gini. The increase in Gini coefficient by 1 point is associated now with the fatality rate rising by 2.53 fatalities per 10,000 workers. The inference here is that greater inequality in income distribution across the region's population might encourage poorer people to accept higher risk jobs (Hansen & Donohoe, 2003). Additionally, poorer people might underestimate potential risk, or not have complete information about the risks taken.

The income effect in the specification in column 3 is not significant, but the coefficient becomes negative. It is worth noting, that some of the explanatory variables in the model might have more than one interpretation. Here, for example, the effect of income is not straightforward, because from one hand, with income increasing, demand for safety rises, and therefore, richer people would choose less risky jobs. Hence, higher income would mean fewer injuries at the workplace. From the other hand, there is some compensating wage differential, which infers that a worker is willing to accept higher risk for higher wage.

Column (4) also indicates small positive effect of engagement in construction and manufacturing on fatality rates. The result appears significant, meaning that on average and ceteris paribus, 10% increase in employment in both construction and manufacturing sector is correlated with 0.24 fatalities more per 10,000 of workers. The estimated coefficients on the share of mining in total employment do not exhibit any significant result in the model.

Table 5. Random effects estimation, dependent variable: *fatality rate*

VARIABLES	(3) fatalrate	(4) fatalrate
gini	2.287***	2.526***
	(0.630)	(0.642)
unemplrate	-0.0227	-0.0176
	(0.0192)	(0.0184)
ly	0.208**	-0.0380
	(0.0862)	(0.0963)
eminshare	0.000575	0.00873
	(0.00762)	(0.00707)
ecstrshare	-	0.0244***
		(0.00798)
emfrshare	-	0.0238***
		(0.00708)
2002.year	-0.0180	0.0322
	(0.0679)	(0.0677)
2003.year	-0.0799	-0.00425
	(0.0774)	(0.0775)
2005.year	-0.110	0.0341
	(0.0982)	(0.0989)
2006.year	-0.126	0.0456
	(0.108)	(0.108)
2007.year	-0.289**	-0.0691
	(0.128)	(0.129)
2008.year	-0.329**	-0.0348
	(0.155)	(0.159)
2009.year	-0.325*	0.0110
	(0.171)	(0.177)
2010.year	-0.382**	-0.0117
	(0.183)	(0.191)
2011.year	-0.520***	-0.107
	(0.196)	(0.205)
2012.year	-0.550***	-0.102
	(0.208)	(0.218)
2013.year	-0.559***	-0.0877
	(0.214)	(0.226)
2014.year	-0.578***	-0.0857
	(0.220)	(0.234)
Constant	-0.862**	-0.238
	(0.440)	(0.411)
Observations	224	224
Number of regioncode	16	16

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author

Interestingly, mining industry demonstrates the highest fatality rate at the national level, as shown in Table 1 in Data section, construction has second and manufacturing has third highest fatality rates. However, the estimation of the sample at the regional level do not display the evidence of the national statistics. There may be several reasons for this inconsistent result. First, fatalities at the workplace are very rare events, even if employers do not want to massively invest in safety, they still try to avoid fatal accidents as it negatively affects their reputation and apart from the lost labour force, cause costly compensations to the workers' families. Second, being rare at the national level, dispersion across the regions makes it even harder to capture significant correlation between trends in fatalities and employment in different industries. Thirdly, the variation in fatality rates over the examined time period is smaller than in injury rates. Therefore, to capture the effect of mining on occupational fatality rates, one would probably need to expand the time period to have greater variation.

7 DISCUSSION AND POLICY IMPLICATIONS

After thorough analysis of injury and fatality rates in modern Kazakhstan, the key findings demonstrate that mining intensity of a region has a small, yet significant, positive effect on occupational injury rates. The effect is smaller than one would expect to see given the high injury rates in mining at the national level. Second and third most hazardous occupations in Kazakhstan, manufacturing and construction, also exhibit positive effect on injury rates at the regional level. However, the engagement in a hazardous industry is not the only determinant of the trend in occupational injuries. Income level has greater impact on the accident frequency at work, which allows to presume that the rationality of compensating wage differentials for higher risk jobs is correct for Kazakhstan's case. The correlation of the accidents with the unemployment supports the evidence of interaction between the injury rates and economic fluctuations.

The examination of the fatality rates gives the insights into the difference between the determinants of occupational injuries, causing temporary or permanent disability, and fatalities. The inequality of income distribution and, hence, poverty has significantly larger effect on the fatal occupational accidents. However, employment in mining does not have any visible effect on the fatality rates. This might be the case that the mining companies invest in health and safety standards to at least avoid fatal accidents, as loss of the labour force is costly for the employers (Blumenstein, et al., 2011). These results provide the empirical evidence for the negative effect of poverty on occupational health and safety, as was suggested by the previous research on the issue (Loewenson, 2001). Given the developing status of the country in focus, greater inequality supposedly induces poorer people to take up riskier jobs where health and safety standards are not properly maintained.

This paper introduces the robust econometric approach to estimate the correlation between resource intensity and occupational health and safety in Kazakhstan. The use of the panel data helps to tackle the omitted heterogeneity across the regions, while the use of two different models accounts for the nature of the injuries and fatalities. Hausman test was used to differentiate between fixed and random effects model, allowing to make the estimation of the two dependent variables as precise as possible. The problem of reverse causality might potentially lead to a biased estimation due to the endogeneity issue in the model. However, this issue was assumed to have minimal effect in this study. Correction for heteroscedasticity and serial correlation makes the efficient estimators available in the model.

The policy implications of this paper are closely related to further development of health and safety standards and regulation in Kazakhstan. It is essential for policy makers to understand what are the determinants of occupational accident rates, and how they differ depending on the outcomes of the accidents. Once the policy makers are aware of the driving forces in the area, they can address specific issues in regulations and work contracts to protect workers from being injured at the workplace. For the employers, current study might imply the necessity of continuous investment in reducing occupational hazards for the workers and paying greater attention to proper training on the health and safety measures in mining, construction and manufacturing industries.

8 CONCLUSION

This paper addresses the issue of high injury rates in mining in Kazakhstan. The main research question imposed in the introduction was whether there is any relationship between occupational accident rates and resource intensity. The scrupulous review of the literature provided comprehensive analysis of different possible factors affecting the accident rates at the workplace, theoretical framework and historical background of the research. While the international empirical evidence demonstrated contradictory results, the findings of this paper appear to support the initial theoretical assumptions of correlation between occupational accidents and wages, economic cycles, poverty, and engagement in hazardous industries like mining, manufacturing, and construction.

This fact is probably related to the different development stages of different countries. Noted, that the research made about 20-30 years ago for the developed economies (UK, Finland, Italy) came up with similar inferences as the results of the current study. Whilst Kazakhstan is referred to as an upper-middle-income country, it is not demonstrating best practices as far as the occupational health and safety are concerned.

Official data on occupational accidents from the Statistical Committee of Kazakhstan was used to construct the panel for 16 regional units over 14 years period. Estimation of the fixed and random effects models completed the analysis and revealed the correlation between the two. However, the engagement in mining is not the only and not even the largest determinant of higher injury rates. Manufacturing and construction are also correlated with the injury rates. But more importantly, income, unemployment rate, and inequality have significant effects on injury and fatality occurrence at the workplace. Nevertheless, there is a steady decline in injury rates over the years, which may imply the improvement in the regulations and monitoring of compliance with health and safety standards at the workplace.

These findings have several implications for the policy making process in Kazakhstan. First, there is a potential for improvement in occupational health and safety at the mine sites. Compliance with the regulations is important, as even if it induces additional investment in safety, it saves the cost of workers' compensations for the employer. The possible measures to be taken include better training of new workers and keeping existing employees vigilant about the risks, safer and properly maintained equipment and machinery used in production, and introducing more balanced working shifts. For the policy makers concerned with the health hazard from the employees' perspective, the results of this paper imply the necessity of enforcing protection mechanism in labour regulations. For example, ensuring that poor people have the opportunity to work in safe and healthy locations and have minimal income to avoid taking up high risk jobs out of desperation.

This paper presents the first attempt of solid economic research on the occupational health and safety in mining sector of Kazakhstan. The value of this research lies in its potential to be less prone to different sorts of bias due to the use of the panel data and the case study of one country. The findings and the theoretical layout are possibly applicable to other post-Soviet resource abundant countries, like Kyrgyzstan, Uzbekistan, and Russia, which makes an important contribution to the research pool on occupational health and safety in the resource sector. There is a large room for future research. Testing the results of this study for other countries in the region is one option. For Kazakhstan, there is a need to have a closer look at the way the health and safety standards are implemented and monitored in mining companies and the presence and strength of labour unions in the industry. That would help to address the ambiguous direction of causality in the estimated models.

To conclude, there is only one thing left to mention. Kazakhstan aims to reach the level of the world's most advanced economies, but to do so it needs to address health issues in the first place. Therefore, being a huge country with the scarce population, Kazakhstan must pay greater attention to the health and safety of its labour force.

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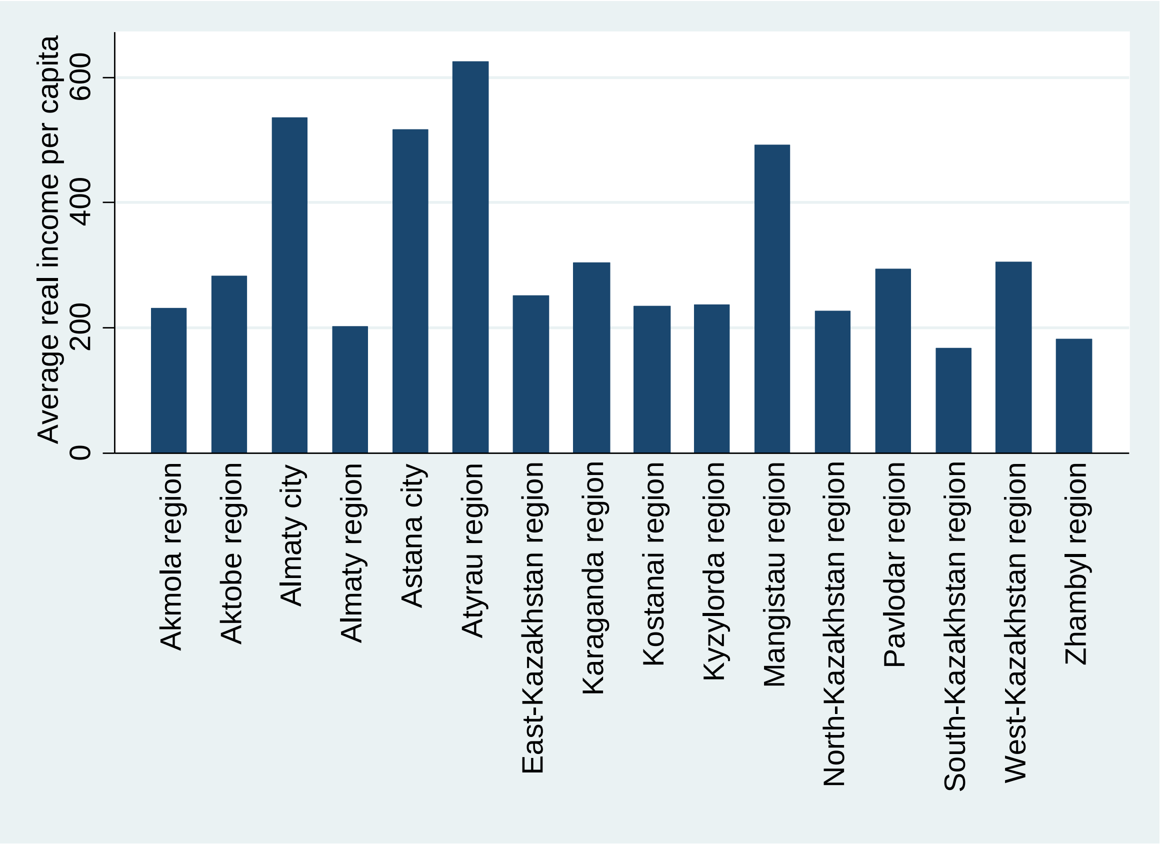
10 APPENDICES

Table 6. Region codes description

Regioncode	***Region***
1	Akmola region
2	Aktobe region
3	Almaty region
4	Atyrau region
5	East-Kazakhstan region
6	Zhambyl region
7	West-Kazakhstan region
8	Karaganda region
9	Kostanai region
10	Kyzylorda region
11	Mangistau region
12	Pavlodar region
13	North-Kazakhstan region
14	South-Kazakhstan region
15	Astana city
16	Almaty city

Source: Author

Figure 7. Distribution of average income per capita across the regions, Kazakh tenge



Source: Author

Table 7. The Hausman test results for *injrate* as dependent variable

	Fixed Effects *injrate*	Random Effects *injrate*	(FE – RE) *Difference*	Sqrt (diag (V_FE-V_RE)) *S.E.*
gini	4.006	5.615	-1.609	0.480
unemplrate	-0.228**	-0.325**	0.097	0.034
ly	1.884*	0.895	0 .989	0.639
2002.year	-0.304	-0.228	-0.076	0.040
2003.year	-0.974**	-0.775	-0.198	0.151
2004.year	-1.731***	-1.365**	-0.366	0.265
2005.year	-2.425***	-1.896**	-0.529	0.377
2006.year	-3.086***	-2.421***	-0.665	0.483
2007.year	-4.411***	-3.544***	-0.867	0.627
2008.year	-5.240***	-4.143***	-1.096	0.782
2009.year	-5.422***	-4.167***	-1.254	0.874
2010.year	-5.557***	-4.244**	-1.313	0.927
2011.year	-6.057***	-4.621**	-1.437	1.017
2012.year	-6.318**	-4.734**	-1.584	1.113
2013.year	-6.815***	-5.164**	-1.651	1.162
2014.year	-7.112***	-5.384**	-1.728	1.220
eminshare	0.200***	0.194***	0.006	0.037
ecstrshare	0.0919	0.0716	0.020	0.008
emfrshare	0.240***	0.294***	-0.054	0.037
_cons	-4.716	-0.161	-1.609	0.480

Test: Ho: difference in coefficients not systematic

chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 101.89

Prob>chi2 = 0.0000

Source: Author

Table 8. The Hausman test results for *fatalrate* as dependent variable

	Fixed Effects *fatalrate*	Random Effects *fatalrate*	(FE – RE) *Difference*	Sqrt (diag(V_FE-V_RE) *S.E.*
gini	2.377***	2.526***	-0.149	0.299
unemplrate	-0.019	-0.018	-0.002	0.010
ly	-0.075	-0.038	-0.037	0.154
eminshare	0.004	0.009	-0.005	0.009
ecstrshare	0.0238	0.024**	-0.001	0.004
emfrshare	0.017	0.024***	-0.007	0.010
2002.year	0.037	0.032	0.005	0.024
2003.year	0.004	-0.004	0.008	0.044
2004.year	0.056	0.044	0.012	0.070
2005.year	0.053	0.034	0.019	0.096
2006.year	0.075	0.046	0.029	0.121
2007.year	-0.031	-0.069	0.038	0.156
2008.year	0.007	-0.035	0.042	0.195
2009.year	0.053	0.011	0.042	0.217
2010.year	0.033	-0.012	0.045	0.232
2011.year	-0.056	-0.107	0.051	0.254
2012.year	-0.047	-0.102	0.056	0.277
2013.year	-0.029	-0.088	0.059	0.288
2014.year	-0.021	-0.086	0.064	0.302

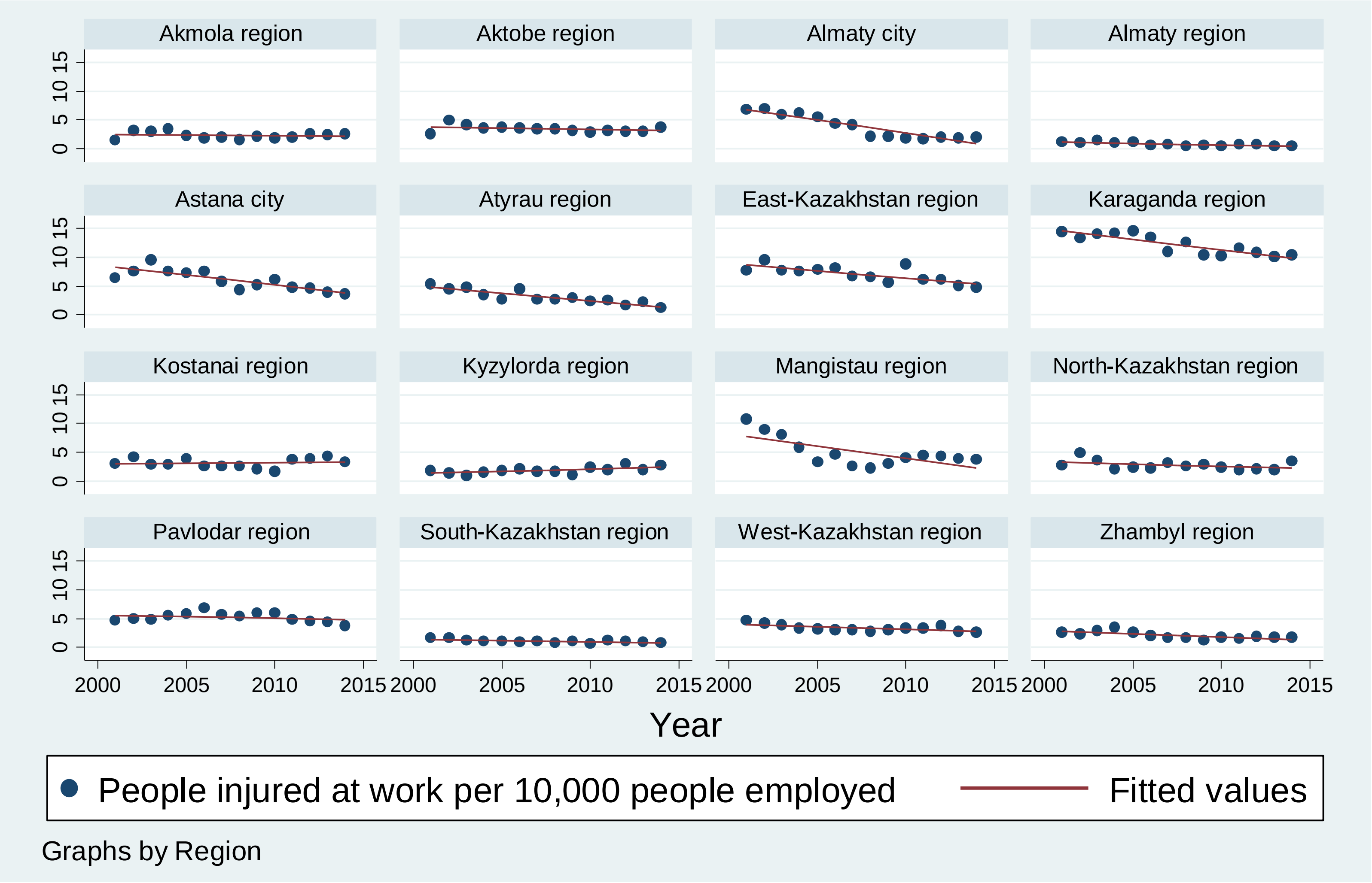
Test: Ho: difference in coefficients not systematic

chi2(19) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 4.05

Prob>chi2 = 0.9999

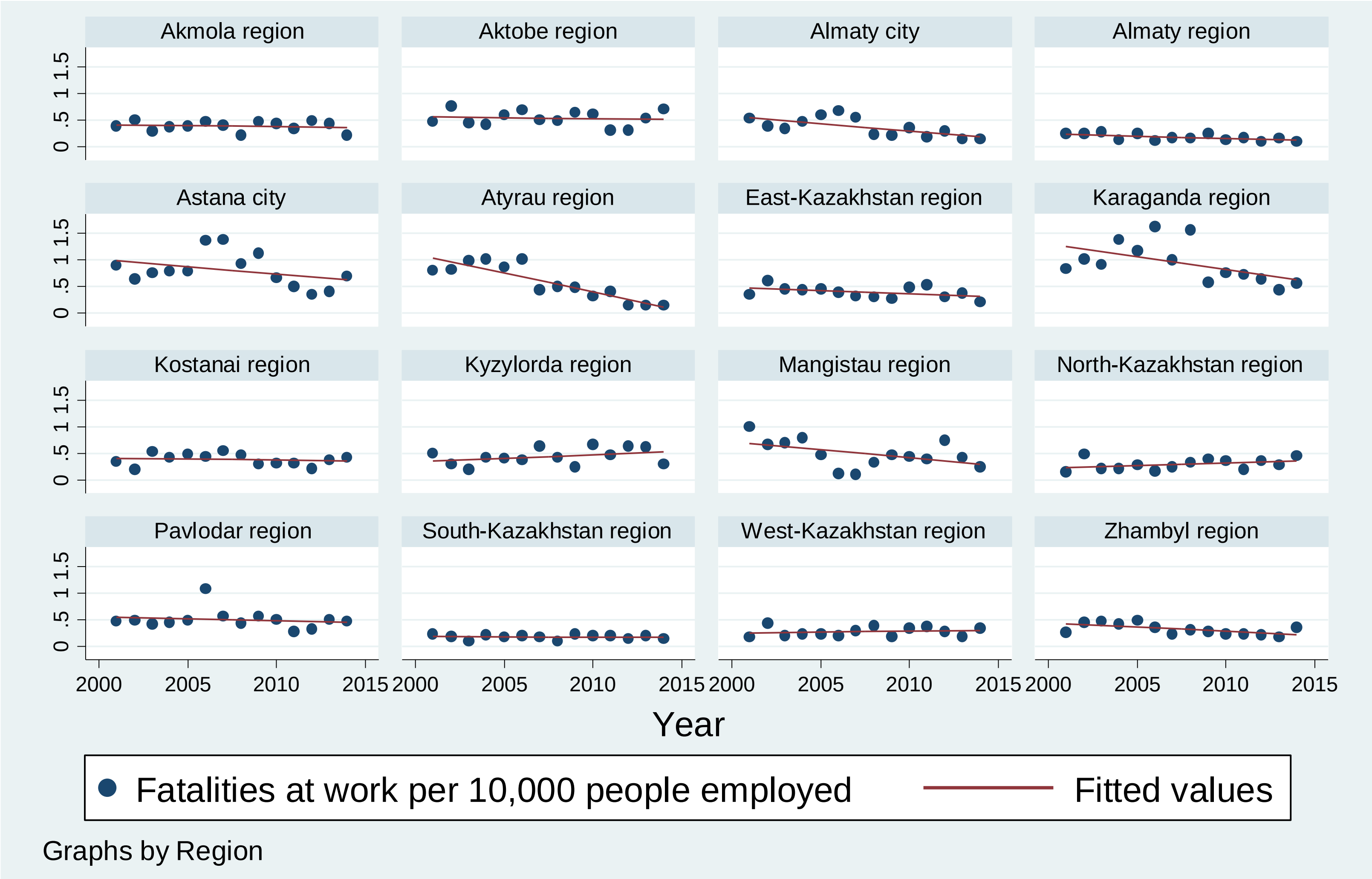
Source: Author

Figure 8. Injury rates dynamics across the regions



Source: Author

Figure 9. Fatality rates dynamics across the regions



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