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Evaluating of Safety and Economic Challenges in Dimensional Stone Quarries of Western-Azerbaijan Province Using FMEA Method

R. Mikaeil *[1], B. Soltani [2], A. Alipour [3], A. Jafarpour [4]

Abstract

Nowadays, many of Iran's dimensional stone quarries are affected by safety hazards, economic risks (such as: market demand decline, reducing of the production quality, increasing of production costs and raising of the final price of the product). This has led to a decline in production capacity or the abandonment of dimensional stone mines. So study these problems and safety hazards is very necessary to improve the status of mines and increase exports rates. The current study is a new approach to introducing economic problems alongside safety hazards for dimensional stone mines of West-Azerbaijan province. It also offers solutions to these problems. In this study, the safety and economic hazards were first identified. Then, the risk severity, probability of occurrence and probability of risk in 10 dimensional stone mines of West-Azerbaijan province were assessed by completing a questionnaire. The risk scores of each risk were determined using the FMEA risk assessment method. The results showed that volatility in mining activities laws, mineral prices, housing market, fixed capital, working capital, financing, renting of extractive products to processing plants and the impact of policy on mining economy including the risk is over 80 (high risk area). Of course, by formulating and implementing the right policies we can guide the construction stone industry to a safe margin from an economic point of view. Among safety hazards, cutting wire had the highest critical risk (about 72% of mines). After that, falling of rock was in second rank. The lowest risk is related to the rupture of the compressed air hose and the dislocation of the jack in the cranes, respectively.

***Key words**: Dimensional stone quarries, diamond-wire cutting method, economic risk, safety hazards, FMEA.*

1. Associate Professor, Department of Mining Engineering, Faculty of Environment, Urmia University of Technology, Urmia, Iran. reza.mikaeil@gmail.com
2. MSc student, Department of Mining Engineering, Faculty of Environment, Urmia University of Technology, Urmia, Iran
3. Assisstant Professor, Department of Mining Engineering, Faculty of Environment, Urmia University of Technology, Urmia, Iran.
4. PhD student in Department of Mining and Metallurgical Engineering, Yazd University, Yazd, Iran.

*** Corresponding Author**

Extended Abstract:

1. Introduction

The mining industry is one of the most important and influential economic sectors in many countries due to the production of raw materials required by other large-scale industries. This industry is faced with many uncontrollable factors during operation and this has caused mining to become one of the most dangerous and accident-prone manufacturing industries. Extraction of dimensional rocks is one of the dangerous branches in mining activities; In such a way that the mines of these rocks (next to coal mines) have the highest rate of accidents compared to other mines. In all stages of extraction of these rocks, including: cutting of bedrock, transportation, loading and unloading, there are risks and serious mining events (Yenchek & Sammarco, 2010).

Nowadays, many of Iran's dimensional stone quarries are affected by safety hazards, economic risks (such as: market demand decline, reducing of the production quality, increasing of production costs and raising of the final price of the product). This has led to a decline in production capacity or the abandonment of dimensional stone mines. So study these problems and safety hazards is very necessary to improve the status of mines and increase exports rates. The current study is a new approach to introducing economic problems alongside safety hazards for dimensional stone mines of Western-Azerbaijan province. It also offers solutions to these problems. In this study, the safety and economic hazards were first identified.

Table 1. Studied quarries list

Mine ID	Mine	Mine ID	Mine
A_1	Qara qeshlaq (Marble)	A_7	Dash Aghul (Marble)
A_2	Dash Aghul 3 (Marble)	A_8	Gonbad Tekab (Travertine)
A_3	Kamaneh Urmia (Marble)	A_9	Berenjeh Tekab (Travertine)
A_4	Poldasht (Travertine)	A_{10}	Dash Aghul 2 (Marble)
A_5	Nari (Marble)	A_{11}	Dizaj doul (Marble)
A_6	Hosseinzadeh (Marble)		

In current study, using Failure Modes and Effects Analysis (FMEA) method, the safety and economic risks of construction stone mines are evaluated. For this purpose, after a brief introduction of the method and the introduction of stone mines located in Western-Azerbaijan province in the form of a case study, the risks have been identified. Then, the potential hazards and challenges of construction stone mines are ranked and finally, solutions to reduce the potential risks and challenges are presented.

2. Materials and methods

One of the common and efficient methods for identifying, classifying, analyzing and evaluating the challenges and risks is FMEA. Using this method, in addition to identifying hazards and errors, various accidents can be prevented. The FMEA method was first used to analyze various issues related to errors and their different states in industries such as the automotive industry, and after proving its various capabilities and functions for researchers, it was also used in the software industry.

The implementation steps of the FMEA method include: gathering information about the process, determining potential hazards, examining the effects of each hazard, determining the causes of the hazard, checking the control processes, determining the deterioration rate, probability of occurrence (probability of occurrence is measured on a scale of 1 to 10); The probability rate of risk detection and, finally, the calculation of the risk priority number. Table (2) is used to determine the severity of the hazard and the probability of an accident. Table (3) also shows the probability of risk detection.

Table 2. Table for determining intensity of impact and the probability of an accident (Ersoy, 2013)

			Intensity of impact				
			Hazardous	High	Moderate	Low	Negligible
			10	5	3	1	0.5
Probability of occurrence	Frequently	10	100	50	30	10	5
	Occasionally	5	50	25	15	5	2.5
	Accidentally	2	20	10	6	2	1
	Rarely	1	10	5	3	1	0.5
	Unlikely	0.5	5	2.5	1.5	0.5	0.25

Table 3. Risk detection probability rate (Ersoy, 2013)

Discovery probability rate	**Description**	**considerations**
4	Dindiscoverable	It is not detectable by scientific methods and occurs suddenly
3	Moderate	It cannot be identified by scientific methods, but it does not occur suddenly.
2	High	It can be identified by scientific methods and occurs suddenly.
1	Very high	It can be identified by scientific methods and does not occur suddenly.

The risk priority number is the product of three risk deterioration numbers, the probability of occurrence and the probability of risk detection. The obtained risk numbers will be ranked according to Table (4), which is related to the classification of risk numbers.

Table 4. FMEA Risk Number Classification

20	**40**	**120**	**200**	**400**
10	**20**	**75**	**100**	**200**
4	**8**	**24**	**40**	**80**
2	**4**	**12**	**20**	**40**
0.25	**2**	**6**	**10**	**20**

In Table (4), red cell numbers indicate critical risk numbers, orange cells indicate high-risk hazards, yellow cells indicate moderate-risk hazards, and green cells indicate low-risk hazards.

3. Results and discussion

By sending questionnaires to experts and activists in the field of extraction, processing and sale of building stones, the intensity, probability and probability of risk detection for safety and economic hazards were categorized and the risk number of each of these challenges was obtained. Tables (5) and (6) present the risk number values for the classified safety and economic hazards for the mines of Western-Azerbaijan province.

Table 5. Classified safety challenges for mines in West Azerbaijan province

Title of incident	Code	Description
Tear the cutting wire and deal with it	1	Occurs due to wire abrasion and dealing with it is always accompanied by death and severe injuries.
Workers falls from the edge of the stairs to lower levels	2	The carelessness of people in the mine during mining operations due to various factors such as economic concerns or unsuitable work environment due to factors such as wet soil, etc. can lead to many accidents and cause a lot of damage to operators and personnel.
Deal with moving and stationary objects	3	
Slipping and falling on the ground floor	4	
Machinery falls from the edge of the stairs to lower levels	5	
Falling and throwing pieces of rock	6	Rock fall along discontinuities in mines
Overturning machines during loading	7	Failure to comply with issues regarding the bearing capacity of the machines and loss of control
Machine fire	8	Technical defects, car fuel leaks and collisions with objects to the operator and employees
Unexpected overturning of coupes and blocks due to lack of balance	9	Unexpected release of the coupe in the direction of layering in the stairwell
Electric shock due to erosion of cable wear	10	Cable rupture and exposure to conductive materials
Impacts from the impact of a perforator and a hammer on a mineral	11	Leads to upper body muscle damage and heart problems
Jack dislocation in cranes	12	Sliding crane jacks when lifting minerals
Rupture of tow wire in cranes	13	Crane tow wire rupture during loading and unloading
escape of rock	14	Rock dislocation under the tires of vehicles
Inhalation of dust and chemicals	15	Dust from rock extraction, especially silica dispersion
Excessive noise exposure	16	Noise to the activity of cutting and transporting tools
Transportation of heavy tools and equipment by operators	17	Movement of tools and equipment by operators and manual transport
Rupture of the tow wire of the peak device	18	Rupture of the tow wire of the peak device during the transportation and movement of the peaks
Slate the block	19	Slate block cutting operation
Compressed air hose rupture	20	2, 3 or 4 inch compressed air hose ruptures and inability to restrain it

Table 6. Classified economic risks for mines of West Azerbaijan

Title of incident	Code	Description
Housing market	1	Reducing the supply and demand of processed stone directly affects the reduction of mine production
Repair and maintenance	2	Damage to extraction machinery and annual maintenance costs
Suppliers	3	Delays in the supply of spare parts, mechanical parts and equipment for mining machinery due to factors such as sanctions, etc.
Mining design issues	4	Opening the mine, determining the direction of extraction and determining the appropriate method for extraction

Energy carriers	5	Increasing the cost of energy carriers as well as reducing the quota of mines from fossil fuels
Providing fixed and working capital	6	Lack of fixed and annual working capital and their non-supply
climate conditions	7	Increased holidays in the mine due to bad climate conditions and reduced production
The cost price of the mineral	8	Increase in the cost of purchasing devices and running costs
Access to the sales market	9	Lagging behind the top countries in the production and cutting of building stones
Instability in laws and regulations	10	Instability in mining laws and regulations in recent years due to changing governments
Distance of mines from stone cutting factories	11	Avoiding stone processing plants to mines and imposing transportation costs
Lack of cooperation of government agencies	12	Lack of cooperation of bodies such as electricity, water, oil company and natural resources
financing	13	Check expenses, banking system, bank interest
The impact of politics on the mining economy	14	Foreign and domestic policy, government
Machinery efficiency	15	Renovation of equipment and machinery and second-hand equipment purchased
Impact of security on mine production	16	Indigenous security, border security and economic security
Production efficiency of parts and tools	17	Low quality diamond cutting wire, coupe series, core wire, Foley rubber, loader rubber etc.
Low quality of inside fuel	18	Reduction of diesel quality and rapid erosion of related parts
Counterfeit oils on the market	19	Low quality of oils on the market
Not using modern technologies	20	No use of cranes and up-to-date equipment such as waterjets, air conditioners and complementary industries in mines
No use of surveying equipment and design engineers in mines	21	Failure to use surveying equipment in mines to determine the location of pits, etc., which leads to unprincipled extraction and financial losses.
Lack of unit prices in mines	22	This multiplies the selling price of the mineral and reduces prices.
Freight cost	23	Transportation of stone and coupe to the processing plant in the city

After calculating the risk priority number, for high risk numbers, in order to reduce this number, a working group should be formed through corrective action. At this stage, in order to moderate the unacceptable risks, corrective and remedial measures commensurate with the level of risk obtained were put on the agenda. For this purpose, in consultation with the officials of the studied mines, corrective strategies were developed to mitigate safety hazards, the results of which are presented below for safety and economic risks. In this section, solutions to mitigate safety and economic risks in the studied mines will be presented.

Cutting wire rupture is one of the high risk hazards in the studied mines. In order to mitigate and reduce the risk of this risk, solutions such as regular checking of diamond grains of wire cutting and wire connections by the operator, increasing the quality of cut wire of domestically produced diamonds, timely replacement of new wires instead of old ones by operators, not using wires of different brands in A cut, checking the cutting path and preventing the cutting path from being blocked, using skilled operators for cutting (increasing and decreasing the cutting speed by an amateur operator is very dangerous), using a suitable wire suitable for the stone material, preventing the wire from freezing, from Avoid standing behind the cutting wire. Finally, regular use of the wire guard and its control can be done by the safety officer or technical manager.

In Table (7), it is clear that in the studied mines, more than 70% of the accidents occurred due to tearing of the cutting wire and this was introduced as a critical hazard. Compression of the compressed air hose was also rated as the least dangerous accident among the considered hazards. Among the studied mines, case number 5, which is related to Poldasht travertine mine, most of the risks were considered as critical, which indicates the importance of all challenges for the employers of this mine. Risks such as rupture of peak tow ropes, rupture of tow ropes in cranes, collisions with moving and stationary objects and slipping and falling on the ground floor were also considered as high risk hazards in about 30% of the mines studied. The maximum mean risk for the studied hazards in the mines related to cutting wire rupture among the studied mines, Poldasht travertine mine has the highest average risk and Qara-qeshlaq marble mine also has the lowest average risk for the studied hazards.

Table 7. Table of average risk of safety hazards in the mines of West Azerbaijan province

Title of incident	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	Average risk of incident
Tear the cutting wire and deal with it	126	200	28	100	200	200	10	20	150	100	100	**112.18**
Falling and throwing pieces of rock	8	10	100	96	80	50	5	40	100	100	100	**62.64**
Inhalation of dust and chemicals	6	10	18	80	300	2	30	5	120	25	0.5	**59.60**
Workers falls from the edge of the stairs to lower levels	20	40	3	5	120	30	80	40	60	40	6	**40.36**
Rupture of the tow wire of the peak device	1	12	24	60	240	80	30	40	40	40	5	**52.00**
Excessive noise exposure	4	10	2	70	256	1	50	50	400	30	30	**82.91**
Electric shock due to erosion of cable wear	108	10	12	5	180	20	10	20	20	50	10	**40.45**
Transportation of heavy tools and equipment by operators	4	5	1	16	168	25	50	100	6	6	1	**34.73**
Slate the block	9	4	40	50	240	200	3	10	10	1	15	**52.91**
Escape of rock	1	25	12	20	180	6	30	100	12	20	15	**38.27**
Overturning machines during loading	0.5	5	3	6	84	1	10	4	300	20	6	**43.90**
Rupture of tow wire in cranes	9	12	50	64	75	12	10	40	200	20	24	**46.91**
Deal with moving and stationary objects	8	5	1	36	64	40	200	2	10	10	5	**34.64**
Slipping and falling on the ground floor	8	1	6	72	50	4	60	100	10	10	10	**30.09**
Machinery falls from the edge of the stairs to lower levels	20	5	50	40	240	30	30	12	30	20	10	**44.27**
Unexpected overturning of blocks due to lack of balance	1	30	1	4	240	2	10	20	50	50	10	**38.00**
Impacts from the impact of a perforator on a mineral	4	5	25	40	100	0.25	50	0.5	0.5	6	3	**29.13**
Machine fire	3	40	2	0.25	80	4	10	2	60	20	1	**22.20**
Jack dislocation in cranes	4	5	0.25	0.75	75	20	10	4	150	20	3	**32.33**
Compressed air hose rupture	4	3	12	32	27	2	6	5	40	12	60	**18.45**
Average risk for the studied mines	**18.32**	**21.85**	**20.53**	**44.22**	**149.9**	**38.84**	**34.70**	**32.32**	**93.05**	**30.00**	**21.75**	

On the other hand, risks, risks and economic accidents are important and influential factors in the process of production and extraction of building stones. It is possible that one of the collected economic events alone will have an impact on the process of extraction and processing of building stones in the short and long term, above all safety risks. Therefore, the risk numbers related to each of these memories and also the critical risk percentage for each hazard according to the studied mines are calculated and presented in Table (8). Among the economic risks and risks, according to the experts in the field of building stone extraction, respectively, mining laws and regulations, mineral selling price, housing market, providing fixed and working capital, financing, transportation of mining products to processing plants And the impact of policy on the mining economy was identified as the challenges with the highest risk.

Table 8. Average risk of economic risks for mines in Western-Azerbaijan province

Title of incident	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	Average risk of incident
Providing fixed and working capital	90	100	8	270	144	200	35	100	100	100	50	**107.91**
financing	98	50	100	120	128	70	25	100	200	20	100	**91.91**
Freight cost	128	100	100	48	242	100	24	50	100	10	100	**91.18**
Unit prices of mineral	128	100	32	200	200	280	40	200	100	20	25	**138.64**
The impact of politics on the mining economics	112	100	100	8	98	100	60	100	100	12	3	**72.09**
Housing market	200	100	20	400	100	50	100	50	50	100	45	**110.45**
Instability in laws and regulations	160	100	240	6	400	400	50	50	100	50	3	**141.73**
Lack of cooperation of government with mining companies	49	100	100	20	400	100	100	100	25	20	5	**92.64**
Counterfeit oils on the market	32	100	100	60	162	100	8	100	100	1	25	**71.64**
Energy carriers	96	100	100	6	147	140	18	100	150	20	50	**84.27**
Access to the sales market	112	50	10	72	400	100	5	100	100	50	50	**95.36**
Low quality of inside-producted fuel	48	10	100	4	162	100	8	100	100	40	6	**61.64**
Machinery efficiency in production year	144	100	50	30	75	100	10	50	100	25	50	**66.73**
Repair and maintenance	49	100	50	30	64	50	10	150	300	40	30	**79.36**
Suppliers	60	50	30	50	49	100	60	400	100	10	25	**84.91**
Impact of security on mine production	128	50	10	20	162	100	40	50	6	30	50	**58.73**
Production efficiency of parts and tools	72	30	15	64	128	100	5	100	15	6	50	**53.18**
Mining design issues	160	25	50	9	300	3	6	100	40	10	25	**66.18**
Distance of mines from stone cutting factories	24	50	50	6	324	70	10	100	50	6	30	**65.45**
The cost price of the mineral	60	10	30	35	400	50	8	100	50	40	15	**72.55**
Not using modern technologies	25	50	20	36	400	30	6	100	50	20	50	**71.55**
No use of surveying equipment and designers in mines	18	3	20	12	400	15	1	3	6	100	9	**53.36**
climate conditions	63	25	70	90	50	20	2	50	20	20	15	**38.64**
Road accidents	12	18	12	40	18	10	4	10	12	10	6	**13.82**
Average risk for the studied mines	**86.17**	**63.38**	**59.04**	**68.17**	**210.5**	**99.50**	**26.04**	**102.6**	**82.25**	**31.67**	**34.04**	

According to Table (9), it is clear that all risks with high risk have been adjusted and the risk is no longer in the critical part. Of course, reducing the risk for the same hazards in different mines is not the same due to different characteristics and quality of management, the impact of the presence or absence of different facilities and working conditions. Control of hazards such as: diamond cut wire rupture, electric shock due to worn cables and hazards of this type, are highly dependent on the facilities of the mine and mines with high facilities are more successful in controlling these hazards. On the other hand, the control of hazards that are formed by the negligence and inaccuracy of personnel and employees are related to management issues and warnings of mine officials and require the attention of mine managers.

The modification of some safety hazards, such as rock erosion and block slate, also depends, of course, on issues related to the bracket and the extracted mineral itself. After adjusting the risks, the highest average risk was related to the rupture of tow towers in cranes. Before adjusting the risk, the title had reached the diamond cutting wire, which after adjusting the risk, the average risk of rupture of the cutting wire decreased to approximately 24, which is an acceptable amount. Average risk All risks were in the balanced risk area after adjustment.

Table 9. Average adjusted risk for safety hazards for mines in West Azerbaijan province

Title of incident	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	Average risk of incident
Tear the cutting wire and deal with it	24	20	28	20	20	40	10	20	30	20	30	**23.82**
Workers falls from the edge of the stairs to lower levels	20	40	3	5	10	30	20	40	60	40	6	**24.91**
Deal with moving and stationary objects	8	5	1	36	64	40	24	2	10	10	5	**18.64**
Slipping and falling on the ground floor	8	1	6	72	50	4	60	24	10	10	10	**23.18**
Machinery falls from the edge of the stairs to lower levels	20	5	50	40	40	30	30	12	30	20	10	**26.09**
Falling and throwing pieces of rock	8	10	28	40	10	50	5	40	20	30	25	**24.18**
Overturning machines during loading	0.5	5	3	6	12	1	10	4	45	20	6	**11.20**
Machine fire	3	40	2	0.25	30	4	10	2	60	20	1	**17.20**
Unexpected overturning of blocks due to lack of balance	1	30	1	4	45	2	10	20	50	50	10	**20.27**
Electric shock due to erosion of cable wear	10	10	12	5	30	20	10	20	20	50	10	**17.91**
Impacts from the impact of a perforator on a mineral	4	5	25	40	12	0.25	50	0.5	0.5	6	3	**18.13**
Jack dislocation in cranes	4	5	0.25	0.75	75	20	10	4	30	20	3	**19.00**
Rupture of tow wire in cranes	9	12	50	64	75	12	10	40	40	20	24	**32.36**
Compressed air hose rupture	4	3	12	32	27	2	6	5	40	12	60	**18.45**
Inhalation of dust and chemicals	6	10	18	25	30	2	30	5	36	25	0.5	**18.70**
Excessive noise exposure	4	10	2	70	40	10	50	50	40	30	30	**30.55**
Transportation of heavy tools and equipment by operators	4	5	1	16	36	25	50	24	6	6	1	**15.82**
Rupture of the tow wire of the peak device	1	12	24	60	45	20	30	40	40	40	5	**28.82**
Slating the block	9	4	40	50	18	40	3	10	10	1	15	**18.18**
escape of rock	1	25	12	20	20	6	30	24	12	20	15	**16.82**
Average risk for the studied mines	**7.79**	**12.85**	**16.74**	**33.61**	**34.45**	**18.84**	**22.90**	**20.32**	**31.00**	**22.50**	**14.16**	

Table 10. Average adjusted risk for economic risks for mines in West Azerbaijan province

Title of incident	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	Average risk of incident
Housing market	50	24	20	40	25	50	20	50	50	10	45	34.91
Repair and maintenance	49	25	50	30	64	50	10	27	30	50	30	37.73
Suppliers	60	50	30	50	49	25	60	40	20	20	25	39.00
Mining design issues	40	25	50	9	30	3	6	25	40	10	25	23.91
Energy carriers	24	15	24	6	45	24	18	25	30	20	50	25.55
Providing fixed and working capital	18	25	8	15	40	30	25	25	30	10	50	25.09
Climate conditions	63	25	70	18	50	20	2	50	20	25	15	32.55
Unit prices of mineral	40	25	32	20	30	32	40	30	30	25	25	29.91
Access to the sales market	30	50	10	72	40	10	5	25	30	50	50	33.82
Instability in laws and regulations	40	25	60	6	40	40	50	50	30	50	3	35.82
Distance of mines from stone cutting factories	24	50	50	6	20	70	10	25	50	50	30	35.00
Lack of cooperation of government with mining companies	49	25	20	20	40	25	24	25	25	20	5	25.27
Financing	18	50	24	20	20	70	25	10	60	10	10	28.82
The impact of politics on the mining economics'	40	25	30	8	12	25	60	25	18	50	3	26.91
Machinery efficiency in production year	36	25	50	30	75	15	10	50	24	50	50	37.73
Impact of security on mine production	30	50	10	20	30	10	40	10	6	50	50	27.82
Production efficiency of parts and tools	72	30	15	64	20	25	5	15	15	50	50	32.82
Low quality of inside-producted fuel	48	10	24	4	30	10	8	20	25	20	6	18.64
Counterfeit oils on the market	32	15	24	60	30	25	8	25	40	25	25	28.09
Not using modern technologies	25	50	20	36	40	30	6	10	50	10	50	29.73
No use of surveying equipment and designers in mines	18	3	20	12	40	15	1	3	6	50	9	16.09
Lack of uniqe price of mineral	60	10	30	35	20	50	8	10	50	50	15	30.73
Freight cost	30	25	30	48	30	10	24	50	30	30	30	30.64
Road accidents	12	18	12	40	18	10	4	10	12	24	6	15.06
Average risk for the studied mines	37.83	28.13	29.71	27.88	34.92	28.08	19.54	26.46	30.04	31.63	27.38	

According to Table (10), it is clear that after adjusting for economic risks, all economic risks whose risk level was critical were reduced and no other risks have critical risk. Regarding economic risks, it is necessary to state that the process of controlling these risks is broader and is not only related to the management issues inside the mine and personnel. The control of these risks starts from the management infrastructure of the mine itself and extends for most of the risks to the infrastructure and management issues and provincial and national officials. For risks such as the impact of policy on the mining economy and issues related to machinery imports and stone exports, attention and reform should begin from mining organizations and organizations influencing the process. Of course, controlling risks such as purchase and sale prices, maintenance, securing fixed and working capital and financial issues related to the mine, depends on the care and attention of mine officials.

The highest average risk was related to economic risks related to instability in mining laws and regulations, which decreased after adjusting the risk, which is in the balanced risk area. After adjustment, the highest average risk among risks reached the suppliers of spare parts and tools. For economic risks, the risks obtained after adjustment were in the balanced risk area.

4. Conclusion

In the present study, after reviewing and identifying safety and economic hazards in 10 mines of building stone mines in West Azerbaijan province using the FMEA method, the risk of these hazards before and after mitigation measures was discussed. The results of this study showed that:

- Among safety hazards, cutting wire had the highest critical risk (about 72% of mines). After that, falling and throwing a piece of rock was in second place. The lowest risk was related to rupture of compressed air hose and dislocation of jack in cranes, respectively.
- Among the economic risks and risks in the field of mining in West Azerbaijan province, respectively, instability in mining laws and regulations, selling price of minerals, housing market, providing fixed and working capital, financing, transportation of mining products to processing plants And the impact of policy on the mining economy were identified as the risks with the highest risk (risks with risk numbers above 80).
- The highest average risk for safety hazards in the studied mines was related to rupture of the cutting wire and then, exposure to high noise. Among the studied mines, Poldasht travertine mine had the highest average risk.
- Among the studied economic risks, instability in mining laws and regulations with the highest average risk was recorded and measured for mines A5 and A6. After that, the selling price of the mineral was recorded as the second economic risk with the highest average risk for A5 and A8 mines, and finally, the risk of recession in the housing market with the highest average risk for A4 mine was introduced as the third economic risk. In general, after the studies, A5 mine was selected as the most risky mine among the building stone mines of West Azerbaijan province in terms of economic risks.

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