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Analysis of Turkey's Base Metal Ore Exports by Herfindahl Hirschman Concentration Index

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ABSTRACT

Turkey produces underground resources through mining activities and brings them into the economy. Some of the produced minerals are exported. One of the most important of these minerals is base metal ores. Base metal ores are mainly exported to China, and its demand for raw materials is constantly increasing. These ores are also sent for re-import after processing to Belgium, which hosts the important smelters of Europe. However, the weight of these countries in the export markets has greatly increased. Therefore they are negatively affecting the market diversity of exports and increasing the risk of market concentration. The Herfindahl Hirschman concentration index was used to investigate and determine the extent of these risks and their impact on metallurgical raw material exports. The results showed that Turkey's base metal exports are moderately and highly concentrated and vulnerable to the risk of monopoly. In addition, it has been determined that increasing concentration levels increase the volume of raw material trade.

Türkiye Baz Metal Cevheri İhracatının Herfindahl Hirschman Yoğunlaşma Endeksi ile İncelenmesi

ÖZ

Türkiye yeraltı kaynaklarını madencilik faaliyetleri ile üreterek ekonomiye kazandırmaktadır. Üretilen bazı madenler ihraç edilmektedir. Bu madenlerden en önemlilerinden birisi de baz metal cevherleridir. Baz metal cevherleri sürekli büyüyen ve talebi artan Çin'e ve Avrupa'nın önemli izabe tesislerini barındıran Belçika'ya işlendikten sonra geri ithalat için gönderilmektedir. Ancak ihracat pazarlarında bu ülkelerin ağırlıklarının fazla olması ihracatın Pazar çeşitliliğine negatif yönde etki ederek pazar yoğunlaşması riskini artırmıştır. Bu risklerin boyutunu ve metalurjik hammadde ihracatı üzerindeki etkisini araştırmak ve belirlemek için Herfindahl Hirschman yoğunlaşma endeksi kullanılmıştır. Sonuçlar Türkiye baz metal ihracatının orta ve ileri düzeyde yoğunlaşma gösterdiğini, monopson riski taşıdığını göstermiştir. Ayrıca artan yoğunlaşma seviyelerinin hammadde ticareti seviyesini de artırdığı tespit edilmiştir.

Keywords: Base metals, mineral export, concentration index, HHI

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Anahtar Kelimeler: Baz metaller, maden ihracatı, yoğunlaşma endeksi, HHI

1. Introduction

Mineral reserves were accumulated, formed, and allocated through certain geological developments such as comet impacts, tectonic movements, and sedimentation. By the nature of this mechanism, material accumulation is not related or bounded with modern geography. Therefore “mineral reserves” were unevenly distributed on the land and under the sea [1]. Thus every modern country has different levels of abundance of minerals. While some countries are rich in case of certain minerals, some are not. However, this unequal dispersion does not affect modern society. Society is interconnected by the material flow that from abundant to scarce or from sufficient to insufficient.

Modern Turkey is located on the Anatolian peninsula and a small part of Thracian. There are 4 tectonic plates i.e. Anatolian plate, Eurasian Plate, Arabian Plate, and African Plate, under the modern Turkey. Therefore, the geology of Turkey is quite active and complex [2], [3]. This complexity has given Turkey important mineral reserves such as; boron (73% of world reserves), carbonated rocks (33% world reserves), graphite (28% of world reserves), barite (9% worlds reserves), antimony (6.7% of world reserves), gold (3% of world reserves) [4]–[9]. As a result of this wealth, Turkey exports 59 different mineral titles to 181 sovereign countries all over the world [10]. In 2021, Turkey made 5930M\$ from exported minerals. Thus minerals count for Turkey 2,63% of total exports [11], [12].

Exporting metallic raw materials and other minerals gives exporter countries a considerable amount of income regarding the unit value and amount of the material. There is another important parameter affecting income is the market itself namely market structure [13]. A concentrated market would pose danger for both exporters and importers. From the exporters’ aspect, the dependence on one or a small number of countries threatens prices and income respectively. Likewise; from importers’ point of view, the dependence jeopardizes material supply security in the mid-long term [1], [14], [15]. Therefore a diversified market structure is desired and aimed for both sides. The diversity of the markets is measured and determined with concentration (diversity) indexes. The most widely used indexes are Herfindahl-Hirschman, Concentration Ratio, and Shannon Wiener Entropy.

This paper deals with Turkey’s base metal ore exports i.e. aluminum, copper, lead, zinc, and nickel ores. The market concentrations of these metallurgic raw materials were determined individually for each mineral title. Thus, the impact of the market structure on mineral exports was investigated.

2. Material And Investigation Methodology

Base metals are common metals. After steel (iron), they are the most produced metals. When exposed to air or moisture, they oxidize relatively quickly. They are mostly listed as Al, Cu, Ni, Pb, Zn, and Sn. But in this study, Sn was excluded since there is no tin reserve in Turkey. In this research, as stated before, base metals were selected to observe the effect of market structure on export. Their reserves, production rates, and Turkey’s share were given respectively. Following this step, market shares were calculated by values were taken from Trademap. By using calculated market shares and concentration indexes (HHI) market diversities were determined.

2.1. Base Metals

Base metals are common metals. After steel (iron), they are the most produced metals. When exposed to air or moisture, they oxidize relatively quickly. They are mostly listed as Al, Cu, Ni, Pb, Zn, and Sn. But in this study, Sn was excluded since there is no tin reserve in Turkey.

2.1.1. Aluminum ore

World recoverable aluminum reserves (Al content) are approximately 30000Mtons. However, Turkey has only a very small portion of it. In the case of ore production, Turkey’s share is proportional to its reserve (Table 1).

Table 1. World and Turkey Aluminum Reserves and Production [16, 17]

	Reserves (Mton)		Production (Mton)	
	Amount	Share (%)	Amount	Share (%)
Turkey	63	0.21	1.00	0.27
Others	29937	99.79	369	99.73
Total	30000	100	370	100.00

2.1.2. Copper ore

While world recoverable copper reserves (Cu content) are approximately 870Mtons, Turkey's share is 3.79Mtons. Turkey's production is parallel to the share of its reserve (Table 2).

Table 2. World and Turkey Copper Reserves and Production [18,19]

	Reserves (Mton)		Production (Mton)	
	Amount	Share (%)	Amount	Share (%)
Turkey	3.79	0.44	0.10	0.49
Others	866.21	99.56	369.90	99.51
Total	870.00	100	370.00	100.00

2.1.3. Lead ore

World lead reserves contain 88Mtons of metallic Pb. Turkey holds 0.86Mtons of world reserves. However, Turkey's share in ore production is twice its reserve share (Table 3).

Table 3. World and Turkey Copper Reserves and Production [20, 21]

	Reserves (Mton)		Production (Kton)	
	Amount	Share (%)	Amount	Share (%)
Turkey	0.90	0.98	72	1.64
Others	87.10	99.02	4328	98.36
Total	88.00	100.00	4400	100.00

2.1.4. Nickel ore

World recoverable nickel reserves (Ni content) are approximately 95Mtons. Turkey bears 1.20Mtons of global reserves. Turkey's production is 10Ktons while world production is 2040Ktons (Table 4).

Table 4. World and Turkey Nickel Reserves and Production [22, 23]

	Reserves (Mton)		Production (Kton)	
	Amount	Share (%)	Amount	Share (%)
Turkey	1.20	1.28	10.20	0.50
Others	93.80	98.72	2029.80	99.50
Total	95.00	100.00	2040.00	100.00

2.1.5. Zinc ore

World recoverable zinc reserves (Zn content) are approximately 250Mtons. Turkey accounts for 2.2Mtons of total reserves (Table 5).

Table 5. World and Turkey Zinc Reserves and Production [20, 24]

	Reserves (Mton)		Production (Mton)	
	Amount	Share (%)	Amount	Share (%)
Turkey	22.00	0.88	0.22	1.83
Others	228.00	99.12	11.78	98.17
Total	250.00	100.00	12.00	100.00

2.2. Herfindahl Hirschman Concentration Index

Concentration (diversity) indexes have been used by scientists, economists, engineers, and biologists

for several decades. The versatility and adaptability of these indexes give them a wide range of usage areas.

The Herfindahl Hirschman Index was individually developed by two separate economists. While Hirschman used the index to examine the foreign trade of the US, Herfindahl incorporated the index to measure the competitiveness of US steel production. [25]. The formula of the index is given below (Eq.1) [26].

$$HHI = \sum_{i=1}^n S_i^2 \quad (1)$$

Where;

HHI: Herfindahl –Hirschman Concentration Value

n: Number of exported countries

S_i: Share of exported countries (%)

Since this index used the 2nd power of shares, it gives higher importance to larger shares. The interpretation of HHI index intervals were given below in Table 6.

Table 6. HHI Intervals [27]

HHI	Concentration Level
HHI<100	Highly Diversified Market
100≤HHI<1500	Diversified Market
1500≤HHI<2500	Moderately Diversified Market
2500≤HHI<10000	Highly Concentrated Market
HHI=10000	Monopoly / Monopsony

2.3. Base Metal Ore Export

The export values were collected from Trademap. The time interval was selected as 2001-2020 due to data quality and availability. Since the data is accessible online, only 2020 values and related HHI values were given. The data belonging to the year 2020 were given for each base metal ore that was listed alphabetically. Aluminum ore was given in Table 7, copper ore in Table 8, lead ore in Table 9, nickel ore in Table 10, and finally zinc ore in Table 11.

Table 7. Turkey Aluminum Ore Export

Al Ore Export (M\$)	Year ₂₀₂₀	Share (%)	HHI ₂₀₂₀
China	12.75	34.07	1161
Canada	5.11	13.64	186
France	2.88	7.70	59
Greece	2.39	6.38	41
Spain	2.33	6.23	39
USA	2.15	5.75	33
Croatia	1.62	4.32	19
Holland	1.39	3.72	14
Israel	1.37	3.67	13
Kuwait	1.01	2.70	7
Others	0.00	0.00	
Total	37.43	100.00	1592

Table 8. Turkey Lead Ore Export

Pb Ore Export (M\$)	Year ₂₀₂₀	Share (%)	HHI ₂₀₂₀
China	153.18	88.85	7894
S.Korea	8.88	5.15	27
Germany	2.92	1.69	3
Bulgaria	1.74	1.01	1
India	1.72	1.00	1
Iran	1.61	0.94	1
Greece	1.15	0.66	0
Peru	0.58	0.33	0
Indonesia	0.39	0.22	0
Colombia	0.15	0.09	0
Othes	0.09	0.05	
Total	172.41	100.00	7927

Table 9. Turkey Nickel Ore Export

Ni Ore Export (M\$)	Year ₂₀₂₀	Share (%)	HHI ₂₀₂₀
China	16.77	99.93	9986
Others	0,02	0,07	
Total	16.79	100	9986

Table 10. Turkey Zinc Ore Export

Zn Ore Export (M\$)	Year ₂₀₂₀	Share (%)	HHI ₂₀₂₀
Belgium	169.02	58.26	3394
Iran	42.07	14.50	210
Spain	35.15	12.12	147
China	10.14	3.50	12
S. Korea	8.24	2.84	8
Finland	7.27	2.51	6
Mexico	5.76	1.99	4
Peru	5.18	1.78	3
Japan	4.30	1.48	2
Bulgaria	2.99	1.03	1
Others	0.00	0.00	
Total	290.11	100.00	3788

Results of the HHI Analysis were given in the following Results section. Evaluation and discussion of the results were given in the Discussion section.

3. Results

The market concentration analyses results were given as metal ore-wise for the years between 2001 and 2020.

3.1. Aluminum Ore HHI Values

Aluminum ore export market concentration values were given in Figure 1 for years between 2001-2020. While the index values were high in the early 2000s, later on market diversity has increased. Since 2010, aluminum ore export is moderately concentrated.

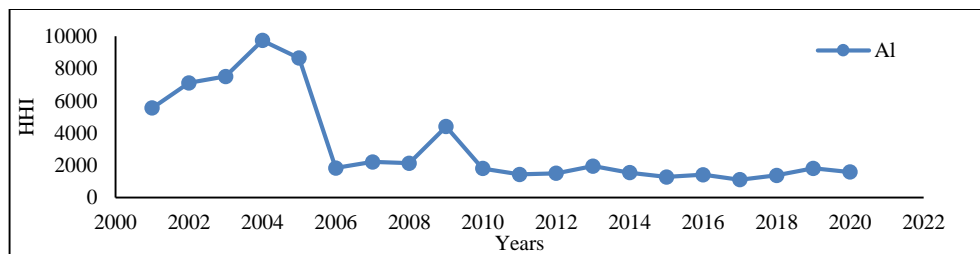


Figure 1. Aluminum ore export market concentration values

3.2. Copper Ore HHI Values

Concentration values of the copper ore export market were given in Figure 2. While the index values were low and the market was moderately concentrated after 2007 market diversity has been drastically dropped. In the last ten years, copper ore export is highly concentrated. Bulgaria is the largest importer of copper ore.

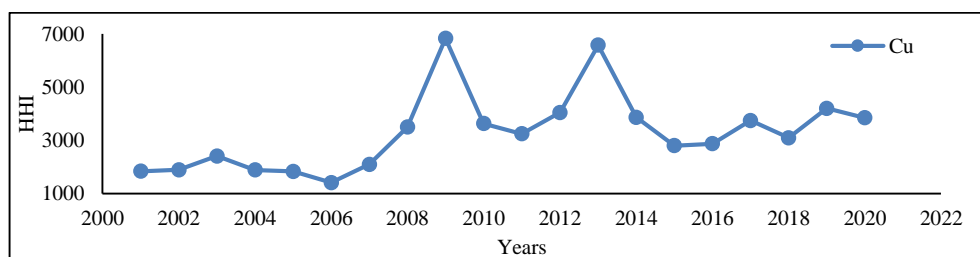


Figure 2. Copper ore export market concentration values

3.3. Lead Ore HHI Values

The lead ore export market has been poorly diversified for 20 years. Index values were given in Figure 3. China is the largest importer of lead ore.

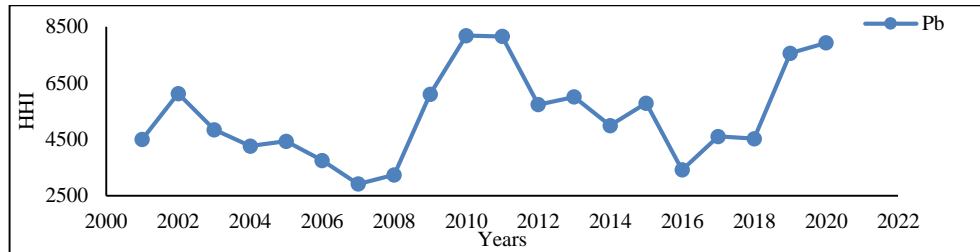


Figure 3. Lead ore export market concentration values

3.4. Nickel Ore HHI Values

Turkey has started exporting nickel ore in 2003. Since 2003 the market structure is almost monopsony (Figure 4). China is the largest (sometimes the sole) importer of Turkish nickel ore.

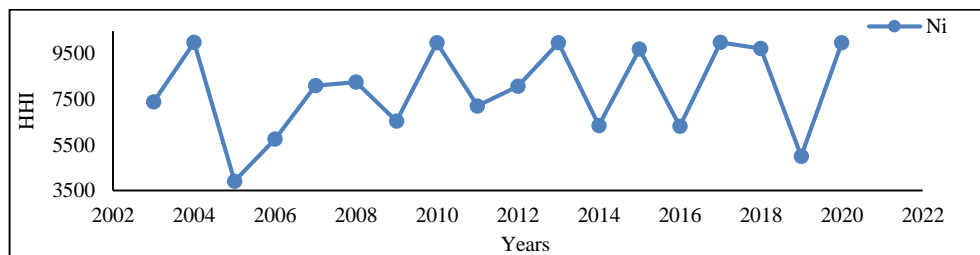


Figure 1. Nickel ore export market concentration values

3.4. Zinc Ore HHI Values

The diversity of the zinc ore export market has been decreased for 20 years. Market concentration has changed from moderately to high. Index values were given in Figure 5. Belgium is the largest importer of zinc ore

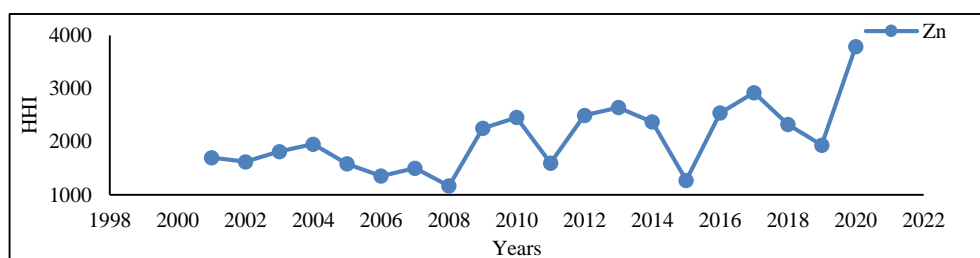


Figure 2. Zinc ore export market concentration values

The result of the market diversity analysis has shown that Turkey's base metal ore export exhibits "country dependence". In other words, while aluminum, lead, and nickel ore exports are dependent on China, copper, and zinc ore exports are dependent on Belgium. Aluminum ore export is the less concentrated market and stable for 10 years. Copper, lead, nickel, and zinc exports have more volatility. The effects of the market concentration on exports were discussed in the following section.

4. Discussion

In the previous section, Turkey's base metal exports were investigated. The results have shown that excluding the aluminum ore, mineral exports are highly concentrated. However, effect of the

concentration is unclear besides the potential monopsony risks. Therefore the relationships between HHI values and export volumes were presented.

Aluminum ore export volume shows no relationship with market diversity. The market concentration has no significant impact on the export level (Figure 6a). Among the five metals, aluminum has the most diverse market. Unlike the aluminum, copper has a concentrated market and the copper ore export tends to increase along with the market concentration (Figure 6b)

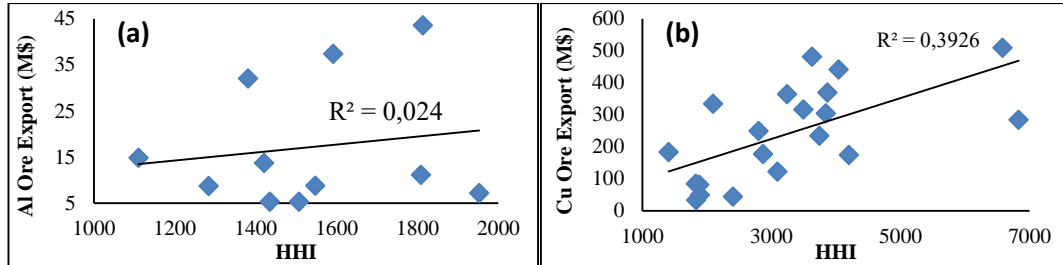


Figure 6. Market concentration – export volume relationship of Al (a) and Cu (b)

Lead ore export has a small tendency to increase with the market concentration (Figure 7a). Likewise, the nickel ore export increases with concentration level (Figure 7b). The nickel has the least diverse market among the other base metals.

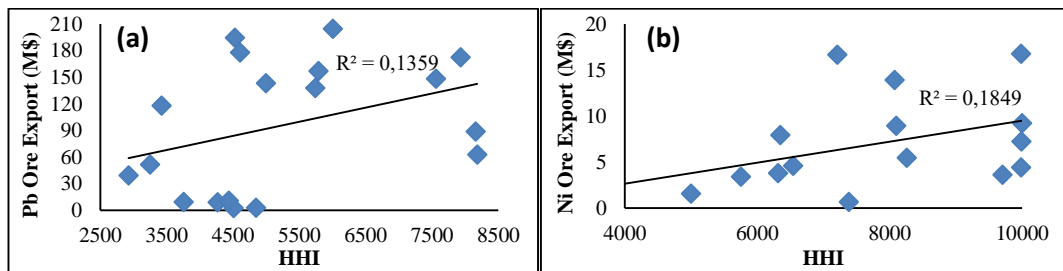


Figure 7. Market concentration – export volume relationship of Pb (a) and Ni (b)

Zinc ore export increases along with the market concentration. This mutual relationship can be distinguished from Figure 8. The zinc export market is the second most diversified market among the base metals.

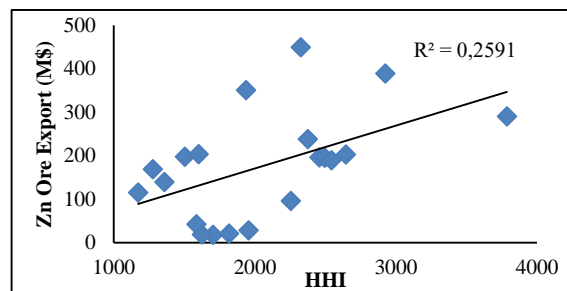


Figure 8. Market concentration – export volume relationship of Zn

5. Conclusion and Recommendations

In this study; Turkey's base metal ore export was investigated from the market concentration aspect. Moreover, the effect of the market diversity on export volume was examined for further inspection. The findings were summarized as below:

- Base metal ore export of Turkey is vulnerable to adverse outcomes of the market concentration.
- Two countries are responsible for the majority of the mineral imports, i.e. China and Belgium. However, the dynamics behind the imports are different. While Belgium imports metallurgical raw materials to smelt and export as a value-added material, China imports for both industrial purposes

and domestic demand.

- Aluminum ore export is not under the market concentration, unlike other minerals. But its trade volume is the 2nd smallest after nickel ore.
- Copper ore is mainly exported to Belgium. Metallic copper is reimported to Turkey after the smelting process. The market concentration positively affects the trade volume.
- The Major buyer of the lead ore is China. Therefore, solely focusing on China increases exports while increasing monopsony risk.
- Nickel ore export is monopsony, the sole buyer is China. This market structure poses a great danger in the long term for Turkey. Fortunately, the trade volume is minuscule.
- Zinc ore is the other mineral that Belgium imports most. Like copper ore, it is reimported after the smelting process.

As the exports are under the pressure of market stability due to excessive market concentration, there are several precautions are to take in long term:

- First of all domestic smelter facilities should be employed. In order to encourage entrepreneurs and corporates should be supported subsidies, incentives, and tax exemption. Because having smelter facilities means more domestic production and industrial material security.
- The mineral wealth should not be mined or exported without considering sustainability and future generations. Because they are nonrenewable resources.
- Market diversity should be provided at the macro level too. That means the export should not be concentrated on a specific country. It should be distributed to minimize demand/price shocks.

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Conflict Of Interest Statement

The authors declare that there is no conflict of interest with other parts/groups/affiliations.

Symbols And Abbreviations

Metals	Others
Al: Aluminium	Mton: Million tons
Cu: Copper	Kton: Kilo tons
Ni: Nickel	M\$: Million US dollars
Pb: Lead	R ² : Determination coefficient
Zn: Zinc	

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