STEEL INDUSTRY IN ITALY: WHICH TRADE-OFF?[1]

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Abstract. The steel industry is one of the most strategic economic sectors in any country and it is crucial in Italy's economy. However, it is among the most polluting industries, posing serious risks to workers and residents near industrial plants.
The paper aims to contribute to providing evidence on which to base more informed and conscious policy choices and private decisions to balance economic growth with environmental sustainability and public health connected to the steel industry, comparing economic, environmental, and health indicators for Italian provinces, depending on the presence of significant iron and steel activities.
Using official data from the Italian Institute of Statistics, we investigate economic benefits, environmental impacts, and health risks associated with the presence of steel plants in territories where they operate. The Wilcoxon (Mann-Whitney) method, a non-parametric test based on rank order, is used.
Our results suggest that while the immediate economic impact is evident, the environmental and health outcomes – found in the data but not statistically significant - may be directly correlated only in the longer term, or other factors might be influencing these results. Therefore, policy decisions should anticipate and incorporate the future effects of current actions using increasingly refined and contextualised analytical tools.

1. Introduction

The EU Court of Justice has recently established in a ruling (June 25, 2024) that steelworks in Taranto should be shut down if the plant poses a threat to human health and the environment: "In the event of serious and significant threats to the integrity of the environment and human health, the operation of the installation must be suspended", in its own words.

The ongoing debate concerning the steel industry's trade-offs—balancing workers, production, and profit against citizens, health, and the environment—is now more critical than ever. The steel sector is not only pivotal due to its direct influence on output and jobs but also for its foundational support to other industries

[1] The paper is the result of the common work of the authors. In particular, Annamaria Fiore has written Sections 1, 2 and 5; Lucia Mongelli has written Sections 3 and 4, the Discussion and conclusions are from both authors.

reliant on steel, particularly in Europe. According to Weinel et al. (2024), this sector is exceptionally strategic in Europe, with over 2,600 companies and 315,000 workers per Eurostat's 2021 data.

In the European Union, Italy ranks second among European steel producers in terms of value-added and turnover, just behind Germany and ahead of France. The latest official statistics indicate the relevance of the industry's size: more than 450 local units, nearly 40 thousand employees, 38 billion euros in turnover, more than 5 billion euros in added value (Istat data 2021), and 11,6 billion euros in exports (Coeweb data 2023).

However, the steel industry is among the most polluting and poses serious risks to workers and residents near industrial plants, as highlighted by the situation with the former ILVA plant in Puglia. For this reason, it is necessary to have updated and disaggregated statistics at the most appropriate territorial level to have a structured knowledge base for policy decisions.

In this paper, we focus on comparing Italian provinces in terms of economic, environmental, and health performance, depending on the presence of significant steel industry activities, based on the official statistical information currently available.

2. Previous literature

The literature about the steel industry in Italy is quite copious: many articles focus on the diachronic evolution of the industry in the country, often from a comparative perspective with other European states (Sáez-García, 2016; Ranieri, 2019). Until a few years ago, the focus was mainly on privatisation (Brambilla and Lavista, 2020; Mollona and Pareschi, 2020). However, in recent years, the interest has predominantly shifted to environmental issues, with particular attention to the case of Taranto.

In Lai et al. (2019a), the authors investigate the role of states in governing the sustainability trajectories and decisions of companies and their local communities. According to the authors, the Italian government made its decisions on ILVA in the name of relevant risks related to economic dimensions (unemployment, economic development, and territorial competitiveness) and silenced the environmental and health risks.

In Bellantuono et al. (2021), the authors used two different aggregate indexes (i.e., the Adjusted Mazziotta-Pareto Index and the Adjusted Differences Mean Index) to analyse data: BESdT does detect many problems affecting the examined area of Taranto, but it seems not able to frame the crisis adequately. The critical situation does not always reflect lower territorial performance, neither at the level of

single indicators nor at the level of entire domains. Such discrepancy appears to be particularly evident within the economic domain.

More recently, the World Health Organization has evaluated the health impact of the Taranto steel plan (2023). It highlights the plant's negative environmental and health consequences, including air pollution and related diseases. The WHO has updated health impact estimates, suggesting 27 annual deaths in the worst-case scenario, reduced to 5 in the best-case scenario.

The report emphasizes the need for comprehensive assessments of the plant's policies on quality of life and the environment to align with sustainable development goals.

3. Context

The steel industry is one of the main productive sectors on which the national economy is based. Steel is a material used by many other sectors of the economy as one of the most versatile and recyclable materials.

The perimeter of the steel sector can be outlined through official statistics. According to Eurostat data from 2021, there are over 2,600 steel companies in Europe with 315,000 employees.

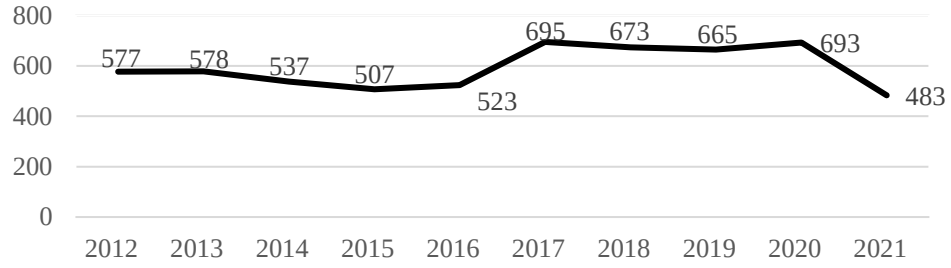
Italy maintains a key role at the European level, ranking second among European steel producers immediately after Germany and before France (Eurostat data, 2021).

In Italy, this industry also represents one of the primary sectors of national industrial production. In 2021, the international steel sector was affected by the Covid-19 pandemic, both directly in terms of production and indirectly, because the steel-using sectors experienced significant declines in activity compared to the previous year, such as the automotive sector, the production of the metal products sector, etc.

Moreover, the growth prospects for production are threatened by the rise in energy costs, the consequent increase in production costs, and the shortage of raw materials, and the consequent increase in the prices of ore, coal and iron scrap.

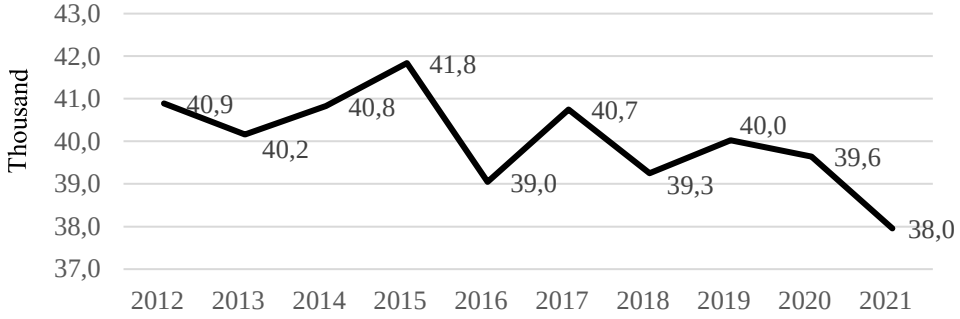
Based on Istat data as of December 31, 2021, there were 483 local units of enterprises in the steel sector in Italy (Istat ATECO 2007, NACE Rev.2, identified by code C24.1) with direct employment of about 38,000 people, with a variation over the previous year of -30.3 per cent in the number of units and -4.3 per cent in the number of employees, respectively (Figure 1 and 2).

Figure 1 - *Number of Local Units of active enterprises ATECO C24.1. Italy. Years 2012-2021. Absolute values.*



Source: Istat, ASIA UL

Figure 2 - *Number of Local Units employees of ATECO C24.1. Italy. Years 2012-2021. Average annual values.*

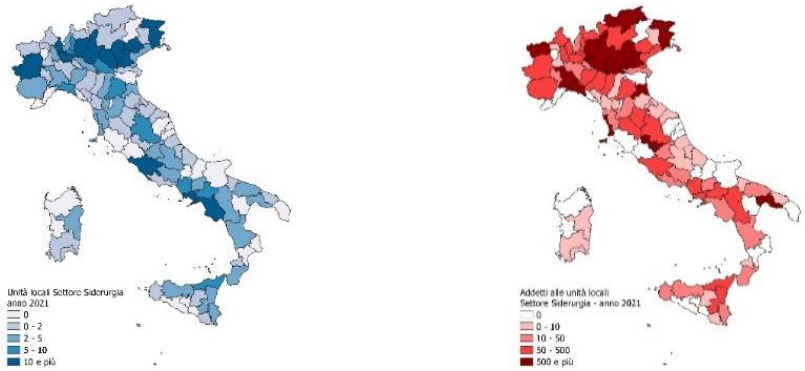


Source: Istat, ASIA UL

According to Istat, about 34% of the workforce of companies in the steel sector is concentrated in the North-West of the country, about 28% in the South and slightly more than 25% in the North-East (Figure 3); this is slightly more than 1% of the Italian manufacturing workforce.

The figures also show the industrial composition of the steel industry, which is heavily concentrated on medium-sized large firms, with 80% of workers employed in firms with over 50 employees. The bulk of the industry is made up of medium-sized steel companies.

Figure 3 - *Provincial distribution of Local Units (left panel) and of Local Units employees (right panel) of the steel industry in Italy (ATECO C24.1). Year 2021. Absolute values.*



Source: Istat, DATABASE di Indicatori Strutturali. Settore 24, https\\www.istat.it\settori-produttivi

4. Data and Method

Our analysis aimed to identify differences between territories based on a specific condition. Specifically, the differences between the territories had to concern socioeconomic, environmental aspects, and residents' health; the distinguishing characteristic between the two groups of territories was the presence or absence of large steel plants.

Considering the available data for all these dimensions, the lower territorial level at which this analysis could be conducted was the provincial level. At this point, the condition to divide the dataset into two subsamples was the number of employees in the sector: at least 250 for all the years in the considered time interval, namely from 2012 to 2021.

Out of the 109 provinces examined, they were classified into two categories: 19 provinces were identified as having a high concentration of steel industry employment (categorized as *steel-concentration*), while the rest were categorized as *no steel-concentration*.

We present the complete dataset description below (Table 1).

Table 1 – *Dataset.*

Variable	Source	Year
Employees	Istat – Archive ASIA	2012-2021
Dichotomous	1 = at least 250 employees (19 provinces)	Cumulative 2012-2021
DIMENSION: ECONOMIC		
Employment, unemployment, inactivity rate	Istat - Permanent Census of Population and Housing	2021
Low income	Our elaboration on MEF data	2021
Entrepreneurship rate	Istat - Statistical Registry of Local Units (ASIA)	2021
Specialization in high-technology sectors	Our elaboration on Istat data (ASIA)	2021
Density of local units	Istat - Statistical Registry of Local Units (ASIA)	2021
DIMENSION: ENVIRONMENTAL		
Synthetic indicator of atmospheric pollution	Istat - Environmental data in cities *(data referred to capital cities)*	2019-2020 2020-2021
DIMENSION: HEALTH		
Mortality due to malignant tumor	Istat - Survey of deaths and causes of death	2021
Mortality due to liver tumor*		2021
Mortality due to lung tumor*		2021
Mortality due to prostate tumor*		2021
Mortality due to bladder tumor*		2021

** Selected based on the study by Cazzolla Gatti and Velichevskaya (2022)*

As a first step of the analysis, we show the descriptive statistics of the variables of our dataset (Table 2).

The last decade has seen a decline in employment and local units within Italy's steel industry. The average number of employees has decreased from 397 in 2012 to 368.5 in 2021, and the number of local units has dropped from 5.6 to 4.7 per province. It is worth mentioning that the province with the highest number of employees is Taranto.

To test if there are significant differences between provinces with a high concentration of steel processing and those without, we use Wilcoxon's sum-of-ranks test (Mann-Whitney), a nonparametric test based on character rankings (Wilcoxon 1945; Mann and Whitney 1947). It tests the hypothesis that two independent samples or unmatched data are from populations with the same distribution. It is appropriate when dealing with small sample sizes or when the assumptions of the parametric tests are not met, as in our case. Results are presented in the next section.

Table 2 – *Descriptive statistics*.

Variable	Obs	Mean	Std. Dev.	Min	Max
Steel employees 2012	103	396.988	1305.267	0.000	11486.23
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Steel employees 2021	103	368.509	1126.859	0.000	9758.840
Avg. steel empl. 12-21	107	374.200	1204.800	0.000	10,794.600
Steel local units 2012	103	5.592	8.874	0.000	60.000
……					
Steel local units 2021	103	4.689	7.602	0.000	54.000
Employment rate 2019	107	45.262	5.949	33.418	58.773
Employment rate 2021	107	45.347	5.717	33.884	58.589
Unemploym. rate 2019	107	13.336	5.710	3.999	27.669
Unemploym. rate 2021	107	9.423	3.264	2.881	17.118
Inactivity rate 2019	107	47.990	3.804	38.786	55.348
Inactivity rate 2021	107	50.085	4.720	39.673	59.965
Low income 2021	107	28.513	7.100	18.971	44.379
Low work intens. 2019	107	48.875	5.258	40.057	60.619
Entrepreunership 2021	107	73.564	11.295	50.767	107.082
Density Local Units 2021	107	22.046	32.956	2.581	223.152
Hi-tech 2021	107	3.275	1.635	1.210	9.359
Air pollution 2019-20	101	23.205	20.201	0.000	66.667
Air pollution 2020 21	101	22.102	20.710	0.000	66.667
Tumor 2021	107	28.638	3.546	21.69	38.440
Liver 2021	107	1.420	.317	.740	2.340
Lung 2021	107	5.300	.931	3.280	7.100
Prostate 2021	107	1.398	.276	.840	2.110
Bladder 2021	107	1.017	.253	.500	1.660

5. Results

We tested whether there are significant differences in the data on employment, economic well-being, settled economy, air pollution, and health status of the population between the two categories of provinces: 19 provinces categorized as *steel-concentration*, while the rest as *no steel-concentration*, depending on the number of employees constantly equal to or greater than 250 throughout the examined decade.

Table 3 highlights the main results of this analysis.

In summary, we underline that:

- The results for economic indicators related to labour (employment, unemployment, inactivity) and income distribution are statistically significant ($p < 0.05$), suggesting that there is a significant difference between the two categories of provinces. In all cases, the indicators show better performance in *steel-concentration* provinces.

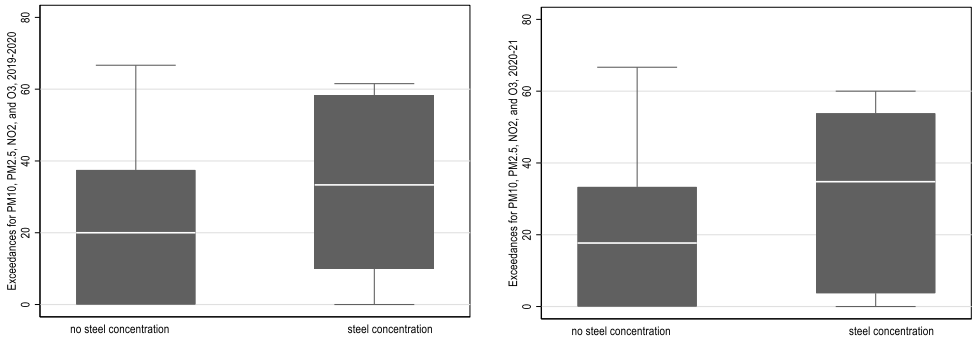
- Although the performance for settled economy (entrepreneurship rate and LU density) and innovation (specialisation in high-tech sectors) is on average higher for *steel-concentration* provinces, the differences are not statistically significant ($p > 0.05$).
- On average, environmental and health indicators present worst performance for *steel-concentration* provinces (except for bladder cancer). However, the Wilcoxon test highlights significant differences only in the case of mortality due to liver and bladder cancer.

Table 3 – *Results of the Wilcoxon rank sum test*.

Indicator	**Test value**	***p-value***
ECONOMIC INDICATORS		
Employment rate, 2021	-2.902	0.0037
Unemployment rate, 2021	3.318	0.0009
Inactivity rate, 2021	2.739	0.0062
Irpef taxpayers with total income less than 10k (incidence on total taxpayers), 2021	2.739	0.0062
Entrepreneurship rate, 2021	-1.663	0.0963
Specialization in high-tech sectors, 2021	-1.704	0.0884
Density of local units, 2021	-1.492	0.1358
ENVIRONMENTAL INDICATORS		
Summary air pollution indicator (exceedances of threshold values for PM10, PM2.5, NO2, and O3 concentrations), years 2019-2020	-1.697	0.0897
Summary indicator of air pollution (exceedances of threshold values for PM10, PM2.5, NO2, and O3 concentrations), years 2020-2021	-1.844	0.0651
HEALTH INDICATORS		
Mortality rate due to malignant cancer, 2021	-0.554	0.5794
Mortality rate due to liver cancer, 2021	-2.067	0.0388
Death rate due to lung cancer, 2021	-0.041	0.9675
Mortality rate due to prostate cancer, 2021	0.188	0.8512
Mortality rate due to bladder cancer, 2021	2.026	0.0427

Considering that environmental indicators refer to capital cities and not to the entire province, we consider it appropriate to conduct a further investigation by presenting an exploratory graphical analysis. Observing the box plots, we could conclude that in the *steel-concentration* provinces, there is a greater exceedance of threshold values for PM10, PM2.5, NO2 and O3 concentrations (Figure 4). However, this conclusion is not supported by the results of parametric tests (Table 3), possibly because official statistics provide data with a level of territorial disaggregation different from that adopted in our work.

Figure 4. *Summary indicator of environmental pollution. Years 2019-2020 and 2020-2021. Per 100 valid measurements, two-year moving averages. Values for capital cities.*



Source: Istat - Environmental data in cities

On the other hand, in the case of health indicators a comparison was made between the Italian average of health indicators with the top four steel-concentration provinces: Taranto, Brescia, Udine, Terni (Table 4).

Table 4 - *Cancer mortality rates* by selected steel-concentration provinces. Year 2021.*

Mortality rate	Italia	Taranto	Brescia	Udine	Terni
Malignant tumor	27.86	26.40	**28.10**	**32.49**	**32.35**
Liver cancer	1.36	**1.37**	**2.03**	**1.81**	**1.87**
Lung cancer	5.36	4.69	**5.49**	**5.77**	**6.57**
Prostate cancer	1.34	**1.39**	**1.45**	**1.48**	**1.83**
Bladder cancer	1.00	**1.18**	0.83	0.65	**1.19**

** Selected based on the study by Cazzolla Gatti and Velichevskaya (2022)*
Source: Istat. Survey of deaths and causes of death. https:\\dati.istat.it

Among those analysed, Terni is the only province where cancer mortality rates are higher than the national averages for all cases, while Brescia and Udine have higher mortality rates except for bladder cancer.

Taranto, on the other hand, has total cancer mortality rates lower than the Italian average and it has slightly higher mortality rates than the Italian average only for liver and prostate cancer. A larger difference is observed, however, in the case of the bladder cancer. These indicators, however, do not perfectly align with what can be inferred from the news reports, ongoing judicial investigations for the province of Taranto, or previous research (Cazzolla Gatti and Velichevskaya, 2022).

Anyway, our results are in track of what has already been expressed by Bellantuono et al. (2021), who noted, albeit with a different approach, that statistical indicators (in their case, those of the BESdT) are not sufficient to detect the overt

criticality of an area such as Taranto, and the same reasons can be cited there (data not available or not adequate or lack of historical series and/or of granularity).

6. Discussion and conclusions

In an era of growing global interconnectedness, it is crucial to simultaneously address emerging challenges related to health, environmental sustainability, and social inequalities. The decisions made by institutions and the behaviours adopted by businesses significantly impact the health of communities and the surrounding ecosystem.

Understanding phenomena in their socioeconomic-environmental dimension is essential for policymakers and stakeholders in the steel sector: public and private decisions should balance economic growth with environmental sustainability and public health, and require increasingly detailed data (Lai et al., 2019b).

In this context, the presence of steel plants, while bringing wealth to the areas where they are established, primarily by ensuring jobs and income, also raises increasingly serious questions about the destine of the populations living there. These populations continuously and inexorably suffer devastating effects on health and the environment, as exemplified by the case of the steel plant in Taranto.

This is the circumstance to delve deeper into the complex trade-off between economic growth and the deterioration of health and environmental conditions, using the available official statistical data.

Our results confirm increased employment and economic welfare for the territories hosting steel plants of some importance, at the same time risks related to the preservation of the environment and human health are non-negligible. If the economic impact is clear and immediate, environmental and health outcomes may be directly related in the long run.

To better understand and balance the costs and benefits, it is essential to have additional indicators with the same spatial granularity for environmental and sustainable development metrics or to address the lack of adequate historical data series (Bellantuono et al., 2021). To cite a few examples, we would need more detailed data on the contribution of steel plants to local economies, including job creation, investment, and technological innovation (economic aspect). Very recently, even the World Health Organization stated that important factors, such as contamination of soil, water, waste, food, the urban environment and green spaces are influenced by industrial policies in the steel industry, although these cannot be reliably quantified at present, but should be thoroughly evaluated as part of the sustainable development agenda. It is also important to consider confounding factors that might influence the results, such as socioeconomic status, access to healthcare, and other industrial activities in the areas investigated.

This research has some significant limitations. Firstly, the lack of accurate historical data prevents a full assessment of the long-term effects of steel plants. In addition, the lack of data with the spatial granularity needed to analyse local impacts limits the accuracy of conclusions. Confusing factors such as socioeconomic status and access to health care may affect outcomes, making a more advanced methodological approach necessary to isolate the specific effects of facilities. Finally, the evolution of industrial policies and technologies could alter impacts over time, requiring continuous updating of data for a more accurate and complete assessment.

In conclusion, future research directions foresee the inclusion of additional factors in the analysis to provide a more complete overview of risks, such as morbidity rates or specific production process characteristics of steel plants (e.g., continuous cycle, full cycle, and separated cycles as in Olmez et al., 2016). In the same way, it is imperative to develop methodologies capable of forecasting future scenarios; decision-makers need to anticipate and integrate the prospective impacts of current actions by employing increasingly sophisticated and context-specific analytical tools.

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