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Decarbonization in Portugal – The sectors in the ring of fire

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Abstract

Having the ambition of becoming the world's first climate-neutral continent and achieving climate neutrality by 2050, the European Union is currently preparing a set of initiatives, within the "Fit for 55" package, to accomplish those goals. As a result, high-carbon intensity sectors of activity are expected to be disproportionately affected by the urgency of decarbonization imposed to European firms by these initiatives, in particular the phase-out of free allowances of EU Emissions Trading System (ETS), once carbon leakage risk is mitigated by the Carbon Border Adjustment Mechanism.

In this work, we analyse recent trends at European level of a selection of high-carbon intensive sectors: aluminium, iron and steel, cement, fertilizers, and electricity generation. These sectors have been experiencing an increase of energy prices and ETS indirect costs, resulting in a fierce competition from abroad. Most sectors have already undergone strong efforts to reduce direct emissions, while in others the technology advances are not mature enough or cost competitive.

We also analyse the main characteristics of these sectors in Portugal, their importance for the Portuguese economy in terms of the number of firms and employment provided, and the recent trajectories of liquidity and economic and financial performance, and we find major disparities among them. These findings might justify the implementation of tailored policies and a sectoral approach, considering the different specificities of each sector in the *ring of fire* at decarbonization efforts.

JEL Classification: D24, F18, F64, Q56

Keywords: decarbonization, Portugal, sectorial analysis

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1. Introduction

The European Union (EU) has set itself the binding target of becoming the world's first climate-neutral continent and achieving climate neutrality by 2050, thus making the European Green Deal a reality. This vision requires greenhouse gas (GHG) emissions to drop significantly in the near future.

As an intermediate step, the European Commission has raised the ambition, by committing to cut the GHG emissions by at least 55% in 2030, comparing to 1990 levels. To accomplish this target, the EU is currently undergoing a revision of the legislation on climate, energy, and transport-related areas, within the **"Fit for 55" package**, presented by the European Commission on 14 July 2021.

This package of legislative proposals aims at bringing EU legislation in line with the climate goals agreed by the Council and the European Parliament and it also includes new initiatives. According to the Note of the Presidency (13977/21 of 22 November 2021), this package aims at reaching EU's climate objectives in a "fair, cost-efficient and competitive way" and **"strengthening innovation"** and **competitiveness of the EU economy**, namely the industrial sector, while **ensuring a level playing field** towards other economic players. The contribution to the post-pandemic economic recovery and the resilience of the EU and the leading position of the EU on the fight against climate change are also highlighted.

The revision of the EU Emissions Trading System (EU ETS), the Carbon Border Adjustment Mechanism (CBAM), the revision of the regulation on binding annual GHG reduction by Member States (Effort Sharing Regulation), the revision of the regulation on GHG and removals from land use, land use change and forestry (LULUCF), the revision of rules for CO_2 emission performance standards for new passenger cars and for new light commercial vehicles, and the regulation establishing a social climate fund are all initiatives under discussion within the scope of the "Fit for 55" package.

In the next two subsections of the Introduction, we focus on the legal background and regulation of EU ETS and CBAM, as our work is motivated by the disproportionate costs faced by high-carbon intensity sectors of activity due to the urgency of decarbonization imposed to European firms by the phase-off of free allowances of EU ETS, once carbon leakage risk is mitigated by the CBAM. In the final subsection of the Introduction, we shed some light on the possible economic implications of these two initiatives.

The rest of this paper is organized as follows: in section 2, we provide a brief overview of the selected sectors and recent trends at European level, using the literature and a selection of reports on this field. In section 3, we characterize these sectors in Portugal, using the information of the firm-level data from the Simplified Business Information (Informação Empresarial Simplificada - IES). In section 4, we present our conclusions. A detailed description of the indicators and ratios used to characterize sectors' evolution in section 3 is presented in a Glossary.

1.1 EU Emissions Trading System

The **EU ETS** was implemented in 2005, through the Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003. It is considered by the EU a fundamental tool to fight climate change by reducing certain GHG from the regulated sectors, in a **cost-effective and economically efficient way**.

The EU ETS works under the "**cap-and-trade" principle**. The cap limits the total amount of GHG that can be emitted by the facilities and aircraft operators covered by the system, which are responsible for around 50% of EU GHG emissions. This cap declines over time, so that the total number of emissions from the installations covered by the EU ETS falls. These firms constitute a market, where they can buy and sell allowances that let them emit a certain amount of emissions. If a firm exceeds its number of allowances, heavy fines are applied. If the firm cuts its emissions, it can use the spare allowances by selling them to another firm that is short of allowances or "banking" them for future needs. As the number of allowances is limited, a value is attached to each of them, set by the supply and demand in this market. **This carbon price** should **promote innovation** and the **use of low-carbon technologies** that allow firms to cut their emissions. Hence, it provides a strong incentive for firms to decrease their emissions in an efficient way.

The EU ETS has already been subject to several reforms to keep it aligned with the climate goals of the EU, being organized in trading phases. The scope has increased in terms of geography[2], sectors[3] and type of GHG[4] from phase to phase. We are currently under the 4th phase. The EU ETS operates in all EU countries plus Iceland, Liechtenstein and Norway. It covers around 11 thousand installations in the manufacturing industry, power sector and airlines that operate between these countries.

The four phases of the EU ETS

Source: EU ETS Handbook (https://ec.europa.eu/clima/system/files/2017-03/ets_handbook_en.pdf)

[2] The EU ETS started off with the 25 EU Member States. Nowadays it covers the EU 27 and expanded to cover also the European Economic Area (EEA).

[3] While in phase 1, the EU ETS covered GHG emissions from the most-GHG-intensive sectors in the power and manufacturing industry, nowadays, it also covers aviation, aluminum, CCS, heavy energy-using installations, oil refineries, coke ovens, iron and steel, cement clinker, glass, lime, bricks, ceramics, pulp, paper and board, ammonia, nitric, adipic and glyoxylic acid production and transport in pipelines.

[4] The EU ETS now covers the following gases, focusing on emissions that can be measured, reported and verified with a high level of accuracy: carbon dioxide (CO_2), nitrous oxide (N_2O) and perfluorocarbons (PFCs).

The release of the "Fit fir 55" package in July 2021 made room for another revision of the EU ETS that should result in a **reduction of 61% on the emissions** in the sectors under its scope by 2030, compared to 2005 levels. To achieve this target, the EU ETS is planning to include other sectors of activity under its scope and reinforce current provisions.

Recently, some proposals are under discussion, namely: (i) the inclusion of the maritime transport in the scope of the EU ETS, from 2023 onwards; (ii) a separate fuel ETS for buildings and transport; (iii) the incorporation of the carbon price in the price of imported goods in some sectors of activity under the CBAM; (iv) the strengthening of benchmarks and the implementation of the phase out of free allocation of emission allowances to aviation and to the sectors covered by the CBAM; (v) the revision of the market stability reserve in order to continue ensuring a stable and well-functioning EU ETS; and (vi) the one-off reduction to the cap and increased linear reduction factor (from 2.2% to 4.2%). Furthermore, funding instruments are also reinforced, namely the modernisation fund and the innovation fund, and the Social Climate Fund is created to address distributional effects of climate transition policies.

1.2 Carbon Border Adjustment Mechanism

As the EU raises its climate ambition and implements these more stringent policies in this domain, as it is the case of EU ETS, there is an increasing **risk of carbon leakage**. If this asymmetric carbon price subsists, European producers face a competitive disadvantage, that can result in a loss of market share to third party countries that have less ambitious climate standards and a substitution of European products by cheaper and carbon-intensive products. Ultimately, carbon leakage can promote the relocation of entire production facilities abroad, and shift emissions from Europe to other parts of the world, undermining European climate efforts.

Carbon risk is currently addressed by the issuing of **free allowances** under the EU ETS, for a selection of sectors where the risk of carbon leakage is considered high. The EU recognizes the effectiveness of this initiative in mitigating the risk of carbon leakage, but it also "dampens the incentive to invest in greener production at home and abroad", one of the recognized advantages of a cap-and-trade system, such as the EU ETS.

To fulfil this gap, the Commission proposed the implementation of a CBAM, that is expected to enter into force in 2026, being currently under discussion within the scope of the "Fit for 55" package[5]. According to the Commission, CBAM "introduces a market dynamic that protects the integrity of EU and global climate policy by reducing GHG emissions in the EU and globally, and **induces the relevant sectors to modernise**, become more sustainable, and drive down their carbon content". For this purpose, this initiative targets European imports for a **selection**

[5] According to the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions "'Fit for 55': delivering the EU's 2030 Climate Target on the way to climate neutrality" (COM/2021/550).

of sectors, and it is designed to **mirror the EU ETS**, while free allowances under the EU ETS are going to be gradually phased out during a 10-year period starting in 2026, for the "CBAM sectors".

Under the CBAM, EU importers will buy **carbon certificates** that correspond to the carbon price that would have been paid if the goods were produced in the EU, under the EU's carbon pricing rules and EU ETS. However, if it is proved that the third-party country producers already paid the carbon price, then the corresponding cost is fully deducted for the EU importers. Therefore, it is argued that the **CBAM equalises the price of carbon** between domestic products and imports from extra-EU countries, ensuring that European climate goals are not undermined by the relocation of production to less stringent countries extra-EU.

The distribution of free allowances to prevent carbon leakage under the EU ETS dampens innovation and the use of less pollutant technologies both in the EU and abroad[6]. The ambition is that CBAM addresses carbon leakages, while also **promoting the adoption of greener technologies**. CBAM will be implemented gradually, and, in the beginning, it will only be applied to **selected sectors at a high risk of carbon leakage and high carbon emissions**: iron and steel, cement, fertilizer, aluminium and electricity generation. The financial adjustment of CBAM will start to take place in 2026. In parallel, free allowances under the EU ETS will be gradually phased out during a 10-year period starting in 2026, for the "CBAM sectors".

1.3 Economic implications

Within the "Fit for 55" package, the **CBAM** will be implemented to address carbon leakage and target the imports. It is considered fundamental to ensure a level playing field with other economic players extra-EU, by equalising the price of carbon between domestic products and imports from extra-EU countries. Free allowances, which are distributed nowadays to prevent carbon leakage under EU ETS, will be gradually phased-out, while CBAM will enter into force for a **selection of sectors at a high risk of carbon leakage and high carbon emissions[7].** These sectors of production in EU will be the first ones to stop benefiting from the free allowances and it is expected that they will be disproportionately affected by the urgency of decarbonization imposed to European firms by this initiative. These sectors, which are in the *ring of fire* at decarbonization efforts, in a context of increasing energy prices and fierce foreign competition, are the focus of our analysis.

[6] Pellerin-Carlin T., Vangenechten D., Lamy P. & Pons G. (2022). No more free lunch. Ending free allowances in the EU ETS to the benefit of innovation.
https://institutdelors.eu/en/publications/no-more-free-lunch-ending-free-allowances-in-the-eu-ets-to-the-benefit-of-innovation/

[7] Note that these sectors are already covered by the EU ETS: iron and steel, cement and electricity generation since phase 1 and fertilizers and aluminum since phase 3.

Thus, this paper aims at better understanding the importance and dimension of these sectors in Portugal and how resilient these sectors have been, especially in a context of greater changes ahead.

2. Industry trends at the European level

The evolution and future perspectives for the high-carbon intensive sectors of activity analysed in our work are bounded by the **European Green Deal**[8], the plan to make the economy sustainable and the EU climate neutral by mid-century, and the **New Industrial Strategy for Europe,** that lead the climate and digital transitions, setting as key drivers for the industrial transformation, the global competition, climate neutrality and digital future. Besides the regulatory and financial instruments, these sectors are also constrained by Member States' own policies and strategies. These sectors are also covered by the EU ETS.

Aluminium

Aluminium is mainly used for **transport**, **construction**, and **packaging**, also having a pivotal role in the green transition. Aluminium is the most used non-ferrous metal, and it is the second most used metal, following iron.

Generally, we can distinguish between **primary** and **secondary aluminium**. Primary aluminium is produced from extracting the pure aluminium elements from aluminium oxide, using a process called electrolysis, while secondary aluminium uses recycled waste and scrap.

There are in the EU around 600 plants covering the entire value chain of this sector of activity, mainly SMEs, according to European Aluminium[9]. The preferred locations of aluminium plants are next to dynamic industrial places and in countries with reliable and cheap electricity. In the last years, because of the increase in power prices and ETS indirect costs, primary aluminium producers faced a **loss of competitiveness**, despite the steadily growing demand for aluminium, which resulted in a greater competition from abroad, a substitution with **imports with a higher carbon footprint** and secondary aluminium, and in an exit of firms, according to European Aluminium. Europe has lost more than 30% of its primary capacity since 2008, despite growing global demand for aluminium. The demand is expected to increase further in the future, given the wide use of this material in low-carbon technologies, such as wind turbines, solar panels, and energy storage.

The primary aluminium sector is extremely **electricity-intensive**, with the indirect emissions exceeding significantly direct emissions[10], while secondary aluminium has an electricity intensity which is only 5% of that required to produce primary aluminium. According to the European Aluminium, indirect emissions are high, with electricity corresponding to more than 40% of the production cost of primary aluminium.

Direct CO_2 emissions per tonne from the European primary aluminium production have been reduced in 21%, compared to 2020, according to JRC Institute for Energy and

[8] More details here: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52019DC0640&from=EN

[9] European Aluminium is composed by more than 95 members that include primary aluminium producers, downstream manufacturers of extruded, rolled and cast aluminium, producers of recycled aluminium and national aluminium associations, representing more than 600 plants in 30 European countries.

[10] Direct emissions are emitted from sources which that owned or controlled by the firm, while indirect emissions are a consequence of the activities of the firms, but they occur at sources that are owned or controlled by another entity.

Transport[11]. Nowadays, the aluminium industry in Europe is one of the **least carbon intensives in the world**, being half of the global average carbon footprint. This positive indicator is related to the **fully electrification of the production process** and the recent **decarbonization of the power grid**, and to improvements in **electrolysis energy efficiency** and **electricity grid management**. Further developments in carbon capture and storage (CCS), carbon capture and utilisation) and inert anodes can further reduce direct emissions in this sector. The contribution of this sector to emissions will continue to be reduced, as the electricity mix decarbonizes. There are various technological options, but the financial and regulatory costs are still significant.

According to the JRC Institute for Energy and Transport, Europe is already the world's **greatest per-capita recycler**, with 270 recycling plants, sufficient technology, and sources of scrap to be economically competitive. In transport, building and drink cans recycling rate is now over 70%. The recycling trend will increase further in the future, accelerated by the increased competition on raw materials and energy costs. In 2050, it is expected that the demand for aluminium will be met by equal share of primary and secondary aluminium, which requires a **boost in recycled aluminium production**, through an increase in quality recycling, innovation in the collecting and sorting of used aluminium, and in incentives to circularity. Recycling can contribute to CO_2 savings of more than 45% per year in 2050.

According to the Eurostat, in 2019, the relative weight of aluminium imports by value to domestic consumption was 36.6% and 23.7% of the exports as a share of domestic production. Aluminium producers are relatively exposed to foreign competition, as it is a **globally traded commodity**. China is today the first producer of aluminium at global scale, producing 60% of primary aluminium ingots, stimulated by subsidies to production and excess production capacity, according to European Aluminium.

Iron and steel

The iron and steel sector is key for the European economy, and it is one of the main suppliers for the **automotive, machinery and construction industries**.

Due to the financial crisis in 2008-09, these sectors registered a significant **demand loss**. According to McKinsey & Company[12], steel industry lost 35 million tons driven by the reduction of orders from end-use sectors, such as construction and oil and gas, due to the decline in the drilling activity and large pipeline projects. Also according to the McKinsey & Company's report, the COVID-19 pandemic led to a **temporary supply shortage** and to a **price increase**, as demand was restored with the faster recovering of automotive and construction industries, but

[11] Joint Research Centre of the European Commission (2015). Energy efficiency and GHG emissions – Prospective scenarios for the aluminium industry.
https://op.europa.eu/en/publication-detail/-/publication/55b4092a-1120-4458-9e90-ae37ff17cc7f

[12] McKinsey & Company (2021). The future of the European steel industry.
https://www.mckinsey.com/~/media/mckinsey/industries/metals%20and%20mining/our%20insights/the%20future%20of%20the%20european%20steel%20industry/the-future-of-the-european-steel-industry_vf.pdf

supply did not follow rapidly this demand increase. Nowadays, the European steel industry employs directly around **330 thousand workers** and provides approximately 2.5 million indirect jobs. It represents around **9% of the value added** for the European economy, according to McKinsey & Company.

We can distinguish between two **main steelmaking processes** in the EU: 60% of the steel is made via an integrated route, where virgin steel is produced from iron ore, generally operated by large national and multinational steelmaking firms, and 40% is made via a recycling route, where scrap steel is reprocessed in an electric arc furnace (EAF), mainly in mini-mills. Overall, this is a highly raw material-intensive and **energy intensive industry**.

Outputs in the form of solid waste, heavy metals, off-gases and by products are a result of a relevant percentage of mass inputs. Despite being one of the most efficient at global level, the European Commission reports that the steel industry accounts for approximately **6% of total emissions** at the EU level [13], with carbon intensity of steel production varying significantly according to the production process, with the integrated route being more carbon intensive than the recycling route.

There is a positive trend, with its emissions being reduced in 26% in 2015 compared to 1990 levels[14], mainly due to **energy efficiency improvements** and **higher recycling rates**. However, these sectors face an increase in costs related to CO_2 and a need for further investments to decarbonization in the short/medium term, under the right investments and policies. There is a call for action now since the steel sector is characterized by long-lasting capital assets and **2050 is just one investment cycle away**. Further reductions in the carbon intensity of steel production can be achieved through technological developments on the smart carbon usage, carbon-direct-avoidance, CCS, circular economy, and the replacement of fossil fuels in the direct reduced iron process with renewable energy or hydrogen. In what concerns the hydrogen-based steel production this is not cost competitive yet, according to McKinsey & Company report. New investments into pilot and demonstration plants are necessary today to rapidly rollout the new technologies into the market. The **expansion of the recycling route** could also contribute to the reduction of the carbon intensity of this sector, conditional on the availability of scrap steel.

In 2019, the EU was the second biggest steel producer in the world, although presenting higher producing costs, due to higher costs for raw material, energy, and labour. With a focus on high-value-added steel products, Europe is now a **net importer of steel**, with continued growth of imports. Steel is imported into the EU from both neighbouring countries and from overseas. According to the Eurostat, in 2019, the relative weight of basic iron and steel imports to domestic consumption was 19.7% and 15.6% of the exports as a share of domestic

[13] European Commission (2021). Towards competitive and clean European steel. https://ec.europa.eu/info/sites/default/files/swd-competitive-clean-european-steel_en.pdf

[14] Wyns, Tomas (2018). Industrial Value Chain: A Bridge Towards a Carbon Neutral Europe - Energy Intensive Industries' contribution to Europe's long-term climate strategy. https://ec.europa.eu/energy/sites/ener/files/documents/institute_for_european_studies_-_industrial_value_chain_-_a_bridge_towards_a_carbon_neutral_europe.pdf

production, resulting in a **high trade exposure**. Despite the surge in trade defence measures deployed by the EU, there was an increase in imports, which, combined with a permanent demand loss, resulted in reduction of capacity utilization of the assets of EU steel producers. At global level, one can observe that prices and demand patterns vary greatly, and this can induce the rise in carbon-intensive imports in Europe, replacing more expensive European production, as environmental regulation gets stricter, or the relocation of the industries to other countries that have a less ambitious climate standards. The **high carbon price of steel** and the **growth of imports** from abroad make this sector a candidate to be covered by CBAM.

Cement

Cement is considered a basic material for **construction** and **building**. Therefore, the evolution of this sector is highly cyclical, closely following the economic activity. In 2015, according to Eurostat data, this industry accounts to 15.2 billion euros of turnover, 4.8 billion euros of value added and employs around 46 thousand employees[15]. European production corresponds to **4% of global production** and the EU is the third largest producer, behind China and India. Throughout the years, some major groups have emerged in this sector, owning multiple production locations. The economic crisis of 2008 reinforced this concentration trend. It is a mature and highly integrated sector.

The cement industry is considered an **energy-intensive industry**, where energy constitutes around 30% to 40% of the production costs and, according to the European Cement Association, **CO_2 costs correspond to approximately 10% of total costs**. This sector is also characterized by a fuel mix highly biased towards carbon-intensive energy sources, while the production process also emits high quantities of CO_2. According to the New Climate Institute[16], cement sector **reduced its emissions by 15%** since 1990, because of fuel savings and raw materials efficiency, while this industry also faced a contraction due to COVID-19 pandemic. However, traditional mitigation measures do not target the emissions related to the production process, according to the New Climate Institute. This poses a great challenge since it requires technological maturity and the rollout of new technologies that are still not fully developed or economically feasible. New Climate Institute mentions that the **technological progress** in this sector is characterized by a greater degree of **uncertainty**, while the possibilities range from the more conservative roll-out of ambitious technologies to more innovative scenarios, including novel cement, new clinker substitutes for alternative cement making processes, and the use of CCS and electrification of thermal heating supply.

[15] Germany, France, Italy, Spain, Poland and Belgium accounted for 71% of EU's turnover, 70% of EU's firms and 68% of EU's workforce in the cement sector.
European Commission (2017). Competitiveness of the European Cement and Lime Sectors.
https://ec.europa.eu/growth/publications/competitiveness-european-cement-and-lime-sectors_pt

[16] New Climate Institute (2020). Decarbonisation pathways for the EU cement sector: Technology routes and potential ways forward.
https://newclimate.org/2020/12/15/decarbonisation-pathways-for-the-eu-cement-sector/

This industry is also characterized by high capital intensity and **long-term investment cycles** and asset specificity.

As transportation costs of cement are relatively high and its raw material is not rare, cement remains a local product, which is sold in a close location to the production site, so that the role of the international trade is relatively limited if compared to the other sectors. However, there is evidence of a **greater international trade intensity** for cement, especially for cement clinker and for countries most affected by the economic crisis of 2018, that registered an excess capacity relative to the domestic demand. Currently, the EU is **net exporter of cement**, although the trend is reversing fast. According to the Eurostat, in 2019, the relative weight of cement imports to domestic consumption was 2.6% and 7.0% of the exports as a share of domestic production.

Since its 3rd phase, the EU ETS freely allocates allowances to some industrial installations including cement clinker plants, considering CO_2 intensity benchmarks.

Fertilizers

Fertilizers increase the production of biomass in the planet and yields, addressing **agricultural needs** and **food security** on a global scale. According to the Fertilizers Europe, that represents most fertilizer producers in Europe, this industry accounts for **9.5 billion of euros of turnover** and employs around **74 thousand employees**. The European market is dominated by top players, in addition to many small firms that compete with world leaders. Nowadays, the EU is responsible for **less than 10% of the global production of fertilizers, behind China, United States and India**. The use of fertilizers in Europe is now stabilized, after some years of reduction, because of the successive reforms of the Common Agricultural Policy. Recent performance of this sector is also challenged by the limits to the use of bioenergy and biofuels, new farming techniques and high feedstock prices.

Nowadays, the production of nitrogen fertilizers is considered **energy intensive**. The **costs related to energy are very significant** for this sector. For instance, the cost for natural gas correspondents to 60% to 80% of the variable input costs to produce nitrogen fertilizer, according to the European Commission[17]. Thus, the price is also highly correlated to the energy prices.

This industry releases GHG during the production of mineral fertilizers, while CO_2 is also emitted from the energy in the ammonia production, generally produced with natural gas. Throughout the years, fertilizer industry has invested in the production process, namely in **energy efficiency** and **emissions abatement technologies** to limit nitrous oxide emissions, resulting in a **decrease of 40% in GHG emission**, comparing to 2005 levels. Today, the EU fertilizer industry has the lowest levels of emission worldwide, even though there is still

[17] European Commission (2019). Fertilisers in the EU - Prices, trade and use. https://ec.europa.eu/info/sites/default/files/food-farming-fisheries/farming/documents/market-brief-fertilisers_june2019_en.pdf

heterogeneity in plant efficiency, due to the use of different technologies. Although there is a physicochemical limitation of current technology for fertilizers' production, in the future it is expected the production of hydrogen through renewable-energy powered electrolysis, avoiding the significant CO_2 emissions from using natural gas, and the use of CCS, targeting the emissions from the methane steam. Major developments in energy infrastructure, **price competitiveness** of green energy, **scientific advances** and **markets for low carbon products** can further enable the decarbonization of this sector of activity.

The production of ammonia and the production of nitric acid are activities that are covered by the EU ETS. Traded goods in this sector are mostly final goods. The EU is significantly dependent on imports for most of mineral fertilizers. Export intensity is not high (exports amounted to 21.3% of European production, in 2019), but it is significant, and a small number of firms are set up primarily for export. According to the Eurostat, in 2019, the relative weight of fertilizer imports to domestic consumption was 29.5% and 21.3% of the exports as a share of domestic production. **Emission intensity** and **trade intensity** of this sector place it among the industries with a higher risk of carbon leakage.

Electricity generation

Electricity production sector plays a **key role in the decarbonization process** in the EU, driven by the widespread electrification (with some CO_2 emitting sectors, such as transport and building, shifting from fossil fuels to electricity), the shift in energy sources to renewables, carbon pricing in the framework of EU ETS and the development of technological solutions as storage. The recent evolution of this sector is already mostly related to changes in sources for energy production. In 2020, renewables overtook fossil fuels for the first time, becoming the EU's main energy source, with a share of 38%, according to Agora Energiewende and Ember[18]. The increase of renewables is powered by wind and solar, being responsible for one fifth of Europe's electricity in 2020. On the other hand, coal generation fell 20% and gas decrease 4% in 2020, compared to 2019. Prospects indicate further increases in European power demand, driven by decarbonization efforts, and a greater increase in renewable sources of energy and possible nuclear. By 2050, 80% of the power production in Europe will be provided by renewables.

In 2018, the EU had 82 main generating firms and 3,944 generating firms in this sector of activity, according to Eurostat.

Overall, according to Agora Energiewende and Ember, carbon intensity has fallen around 30%, compared to 2015, but this sector still produces almost one third of direct CO_2 emissions.

[18] Agora Energiewende and Ember (2021). The European Power Sector in 2020 - Up-to-Date Analysis on the Electricity Transition.
https://www.agora-energiewende.de/en/publications/the-european-power-sector-in-2020/

This sector requires significant investments in the near future, mainly due to a growing power demand, plant closures due to ageing or phase out from fossil fuels, and the replacement/repower of old wind turbines and photovoltaic panels, increasing this sector capital intensity. Technological developments in this sector might include the use of renewable hydrogen from electrolysis.

According to the Eurostat, in 2019, the relative weight of electricity imports by volume to domestic consumption was 3.4% from all countries of origin and 3.3% the exports as a share of domestic production. However, the share of imported electricity from *border* countries is increasing. This fact can be related to carbon pricing applicable in the sector, with the implementation of EU ETS. The risk of leakage is also aggravated by deregulation, a greater focus on efficiency and new transmission technologies in electricity production. Overall, this makes the renewable energy produced in border Member States compete with electricity from neighbouring countries outside the EU from power sources not incorporating carbon pricing.

This sector is covered by the EU ETS since phase I. However, electricity does not benefit from free allocation (with some possible exceptions).

3. Recent evolution at the national level

For this characterization at national level, we use the firm-level panel data from IES (Simplified Corporate Information) that covers the universe of Portuguese firms that annually fulfil their reporting obligations to the Ministry of Finance, Ministry of Justice, Banco de Portugal and the Statistics Portugal (INE). The database gathers detailed annual information for the non-financial firms in Portugal, and it is available in BPLim, the Microdata Lab from Banco de Portugal[19]. The dataset includes variables that characterize the firm and yearly balance sheet and profit and loss data. It is also possible to characterize the firms in terms of economic activity code (CAE) and size. It has also information concerning the location of firms, using the postal code. Firm information, such as assets, number of workers and net income, is available on a yearly basis.

This analysis considers firms whose primary sector of activity is one of the following: "classes"[20] 2410, 2420, 2451 and 2550 for iron and steel; 2351 for cement; 2015 for fertilizers; 2442 for aluminium and 35111, 35112 and 35113 for electricity generation. These codes are based on the information provided by the "sectoral scope of CBAM" on the Proposal for a Regulation of the European Parliament and of the Council establishing a CBAM (COM/2021/564).

3.1 Aluminium

The aluminium sector has a marginal direct share of gross value added (GVA), turnover and jobs at the industrial level (less than 1% in 2019). Although the increase in the GVA from 2010 to 2019, its share on industrial GVA remain relatively stable. The turnover and number of jobs decreased in the period of analysis, both in absolute number and share on industry. This sector employs more than 1300 workers.

[19] Banco de Portugal Microdata Research Laboratory (BPLIM) (2021): Central Balance Sheet Harmonized Panel. Extraction: February 2022. Version: V1. BANCO DE PORTUGAL. Dataset. https://doi.org/10.17900/CB.CBHP.Jun2021.V1

[20] According to the Portuguese Classification of Economic Activities (National Statistics - INE).

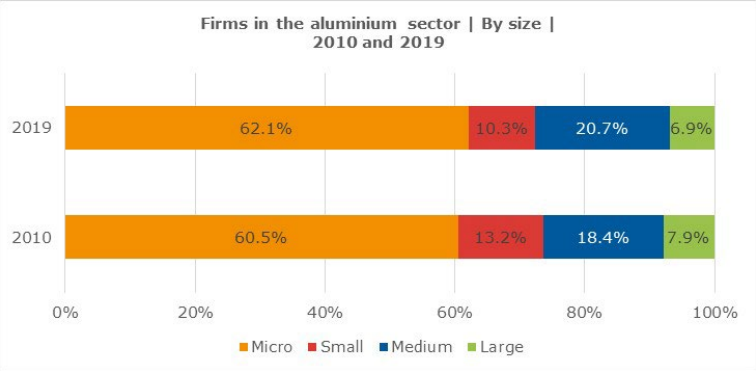
Source: IES

Characterization

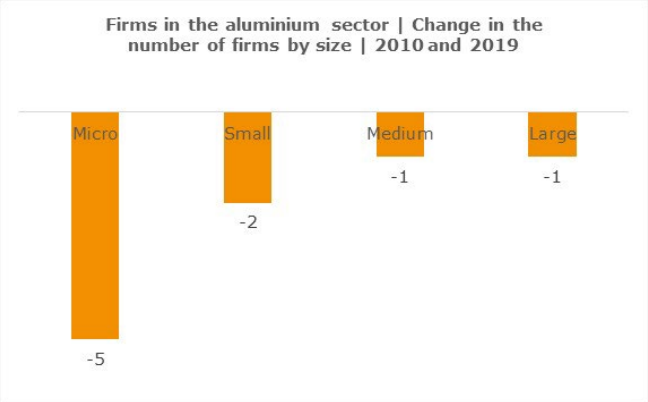
In 2019, the aluminium sector was composed by 29 firms in Portugal, which compares to 38 firms in 2010. Despite the entrance of five new firms in the last five years, the sector has been displaying a decreasing trend in the number of firms.

Source: IES

In 2019, most aluminium firms (62.1%) are micro firms[21], followed by medium firms (20.7%) and small (10.3%). Only 6.9% are large firms. The distribution by size is relatively stable from 2010 to 2019, with a slight reduction in the share of small firms (-2.9 p.p.). In absolute terms, there is a decrease across all size-categories in the period of analysis, more remarkably for micro firms (-5) and small firms (-2).



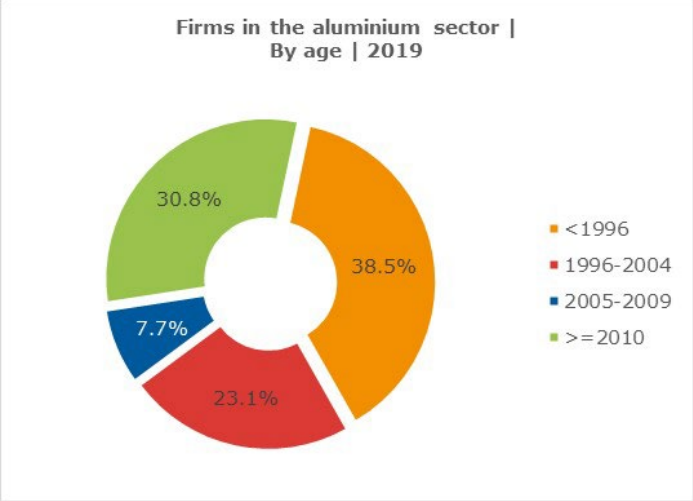
Source: IES



Source: IES

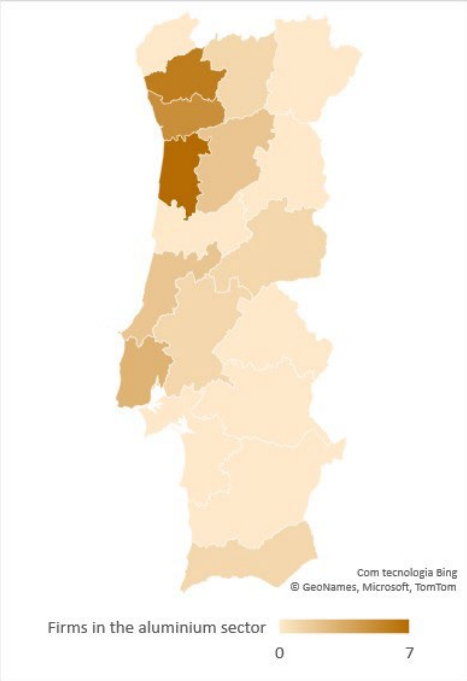
[21] The variable *size* classifies the firms according to four-dimension categories: micro firms, small firms, medium-sized firms and large firms. The definition of micro, small and medium-sized firms follows the Commission Recommendation of 6th May 2013 (2003/361/CE). The criterion based on the number of employees is the main one, but the combination with the financial criterion, such as the turnover and annual balance sheet total, "is necessary in order to grasp the real scale and performance of a firm and its position compared to its competitors", according to the Commission.
The category of micro, small and medium-sized firms is made up of firms which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million. Within the SME category, a small firm is defined as a firm which employs fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 10 million. Within the SME category, a micro firm is defined as a firm which employs fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed EUR 2 million.

In 2019, there is a high proportion of firms with a constitution year before then 1996 (38.5%) and newer, with a constitution year after 2009 (30.8%). The constitution year of 23.1% of firms was between 1996 and 2004 and only 7.7% of firms started operating from 2005 to 2009.



Source: IES

Aluminium firms are geographically concentrated in the North of Portugal, more specifically in the districts of Aveiro, Braga and Porto.



Source: IES

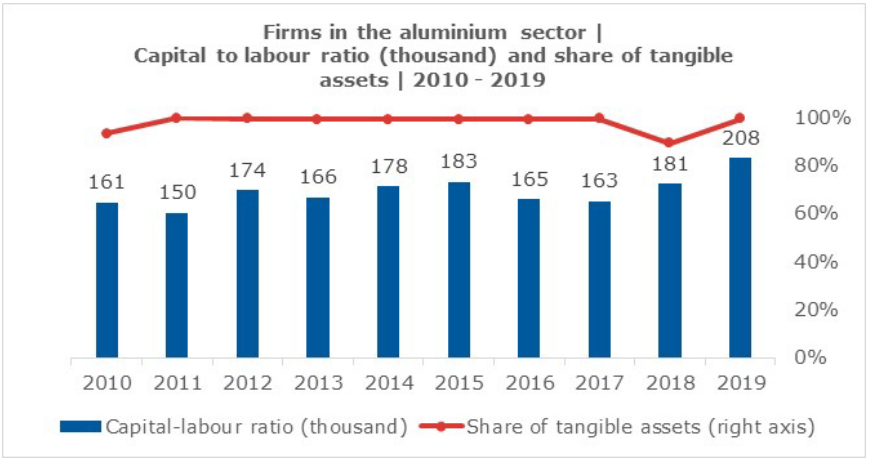
Sales destination

The destination of 63.1% of sales of aluminium firms is the domestic market, while 36.9% are to sell abroad, mainly in the EU. The share of sales exported increases from 32.1% in 2010 to 36.9% in 2019.

Source: IES

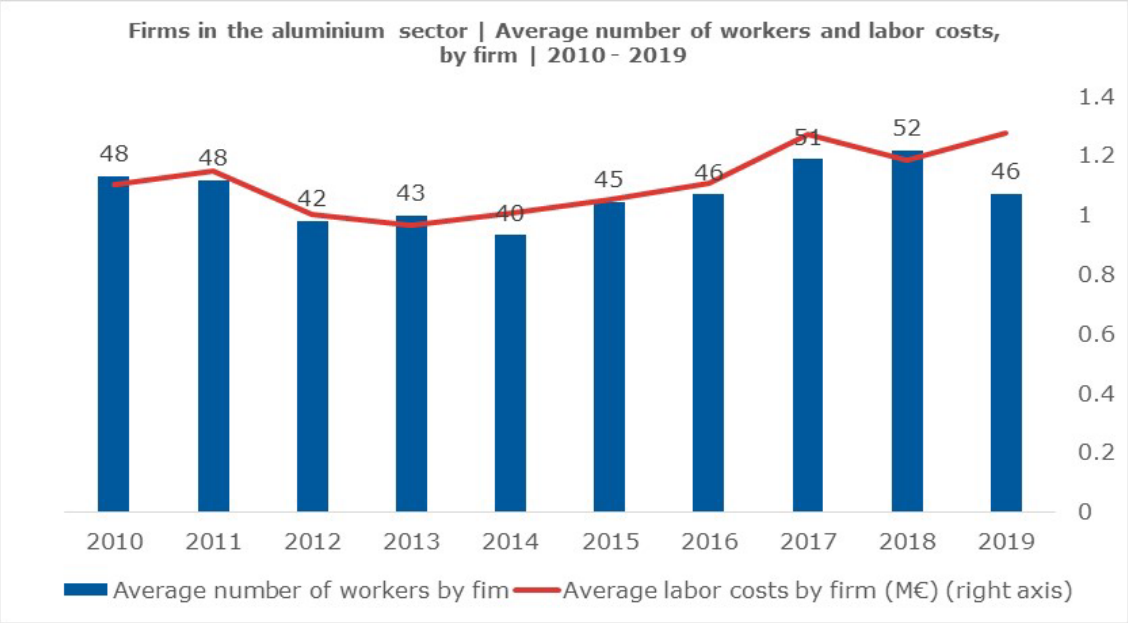
Capital and labour

In the case of the aluminium sector, there is an upward trend in the capital intensity, measured by the capital-labour ratio, since 2017. In 2018, this ratio was around 208 thousand euros, per worker. The aluminium sector is also characterized by a high ratio of tangible assets, which was 99.4% in 2019.



Source: IES

In 2019, aluminium firms employ, on average, 46 workers and there are 6 firms employing more than 50 workers. There is an upward trend in the average number of employees since 2014, but it has been interrupted in 2019, when the average drops from 52 in 2018 to 46. Generally, the average labour costs by firm closely follows the trend of the average number of workers.



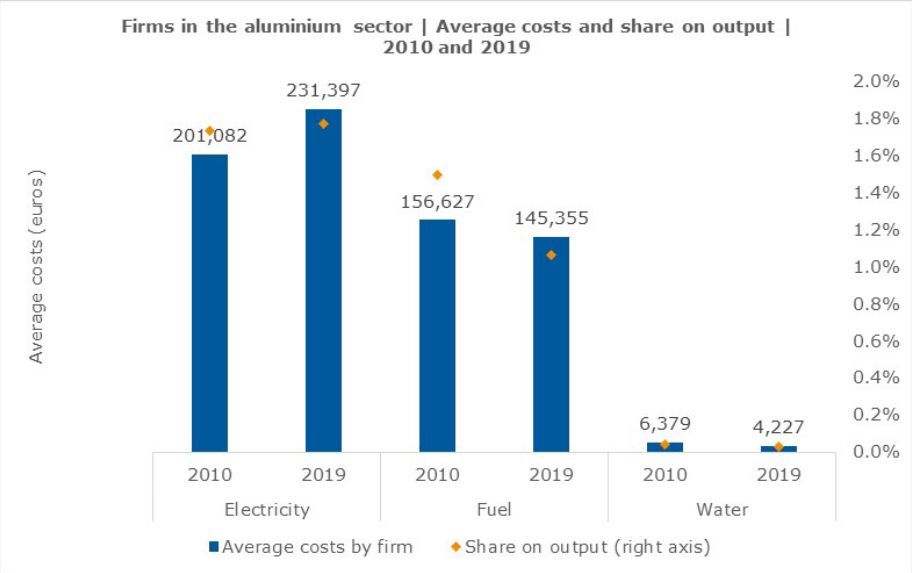
Source: IES

Electricity, fuel and water costs[22]

Average electricity costs increased from 2010 to 2019, although the share of costs to output level remained relatively constant. Water costs are relatively smaller, when compared to electricity and fuel costs.

Fuel and water costs decreased over time, both in absolute value and share of production, which may result from an efficiency improvement in the use of these two types of inputs.

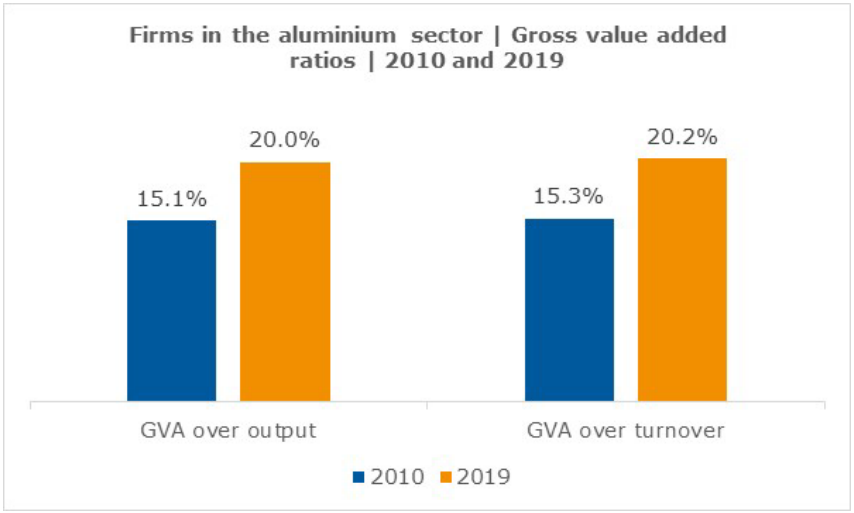
[22] Since there are some firms presenting missing values for electricity, fuel and water expenses, the analysis presented here is based on the average of the reporting firms.



Source: IES

Productivity

The gross value added (GVA) per unit of output in the aluminium sector presents an improvement, increasing from 15.1% in 2010 to 20.0% in 2019, which is consistent with the evolution of the GVA relative to turnover. This suggests a high difference between the value of aluminium produced in the period of analysis and the cost of raw materials and other inputs used in the production process, both for each unit of aluminium produced and relative to sales.

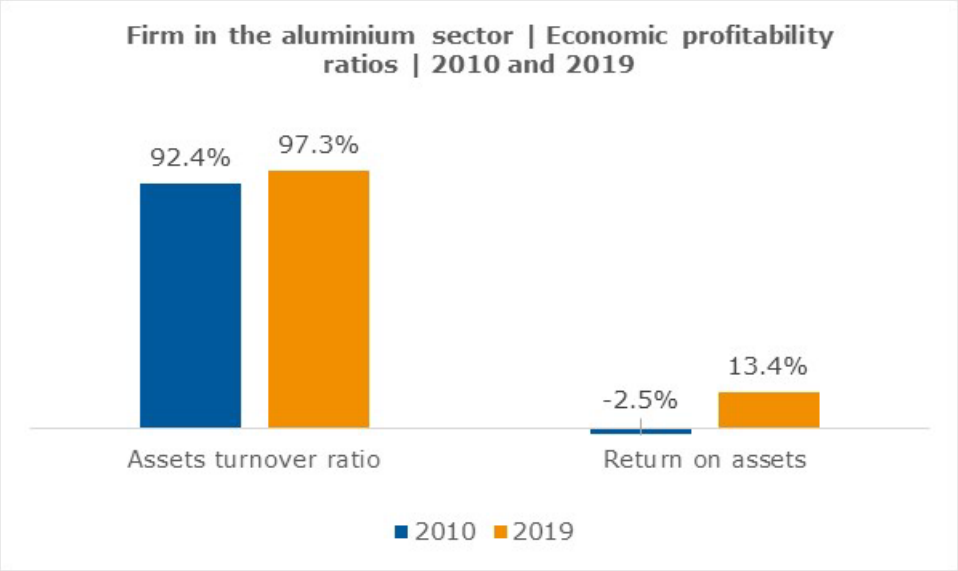


Source: IES

Economic profitability

In the aluminium sector, there is an improvement on the asset turnover ratio, from 92.4% in 2010 to 97.3% in 2019. This suggests a greater ability of this sector to generate revenue from assets.

The increase in the return on assets (ROA) ratio, from -2.5% in 2010 to 13.4% in 2019, suggests a greater efficiency of firms in the aluminium sector in generating earnings from their own assets.

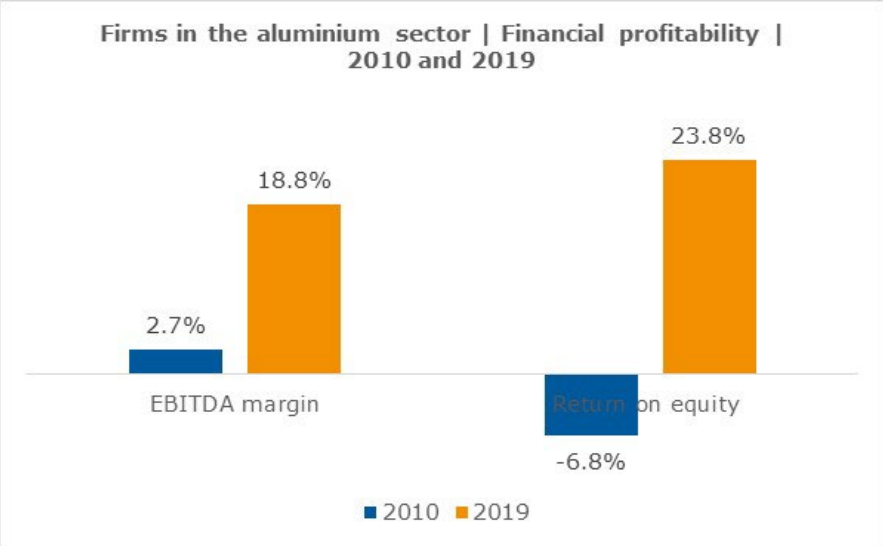


Source: IES

Financial profitability

The earnings before interest, taxes, depreciation, and amortization (EBITDA) margin for firms in the aluminium sector increased from 2.7% in 2010 to 18.8% in 2019, suggesting that more earnings before interest, taxes, depreciation, and amortization are generated, as a percentage of revenue.

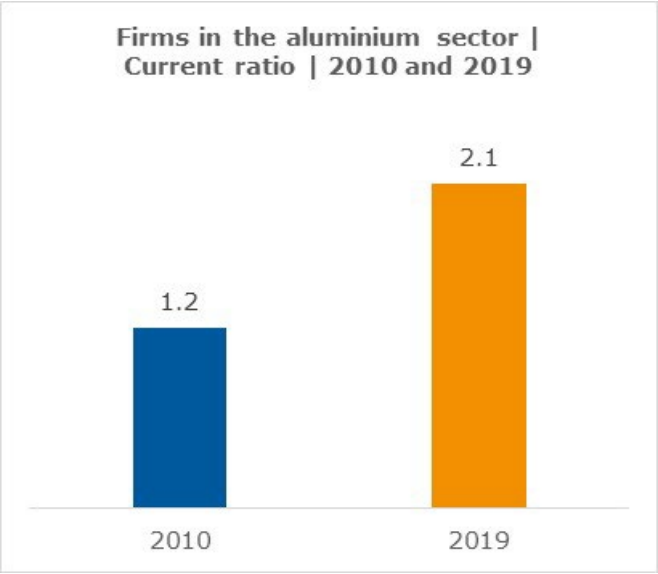
In the aluminium sector, the return on equity (ROE) went from -6.8% in 2010 to 23.8% in 2019, revealing a greater efficiency in the use of shareholders' equity to generate income.



Source: IES

Liquidity

Firms in the aluminium sector present an improvement of the current ratio, from 1.2 in 2010 to 2.1 in 2019, suggesting a greater ability to pay short-term obligations.



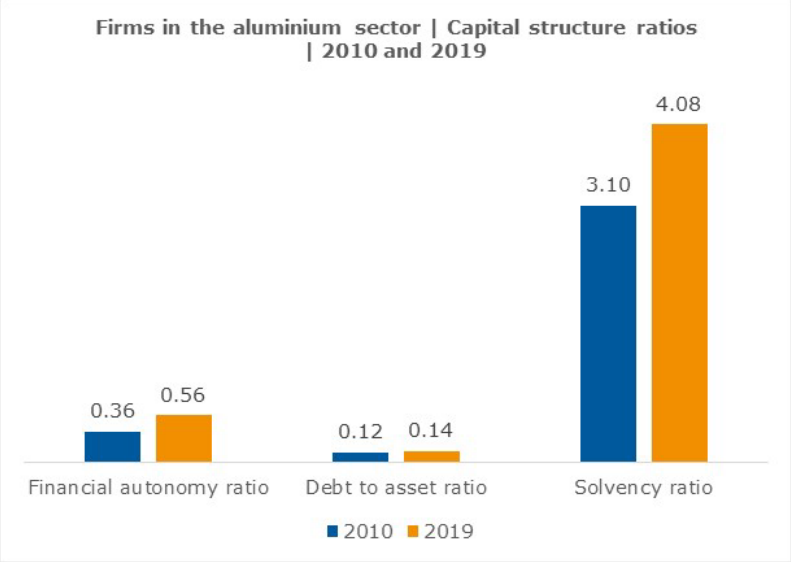
Source: IES

Structure indicators

For firms in the aluminium sector, there is an increase in this ratio from 0.36 in 2010 to 0.56 in 2019, which suggests a higher ability of firms of generating assets by issuing equity shares.

Also, the debt to asset ratio in this sector went from 0.12 in 2010 to 0.14 in 2019, suggesting a greater degree of leverage in this sector.

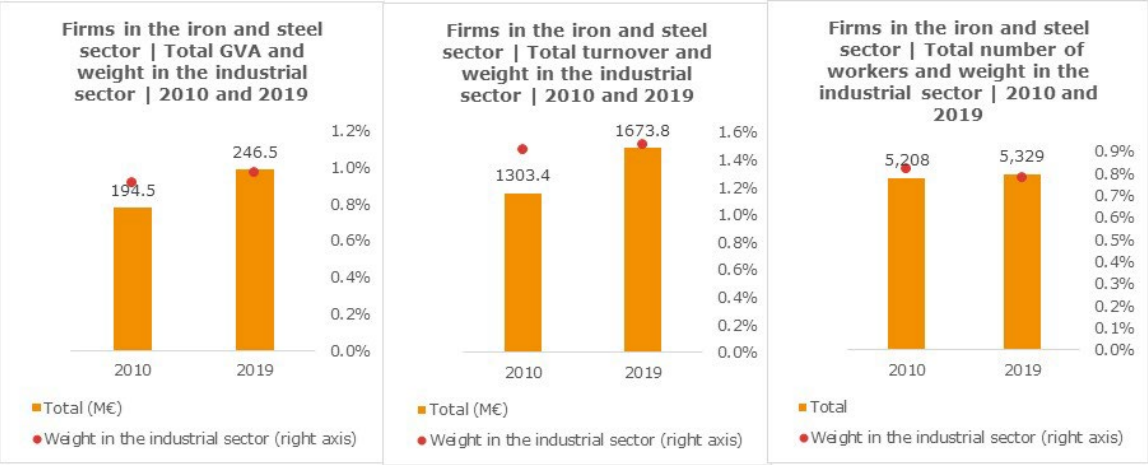
The aluminium sector registered an improvement of the solvency ratio from 3.10 in 2010 to 4.08 in 2019, that translated a greater ability at meeting long-term debts and obligations.



Source: IES

3.2 Iron and steel

This sector of activity represents approximately 1.0% of GVA and 1.5% of turnover of the industrial sector in Portugal, in 2019. In the period of analysis, the iron and steel sector registered an increase in GVA, total turnover and employees. This sector employs more than 5,300 workers.



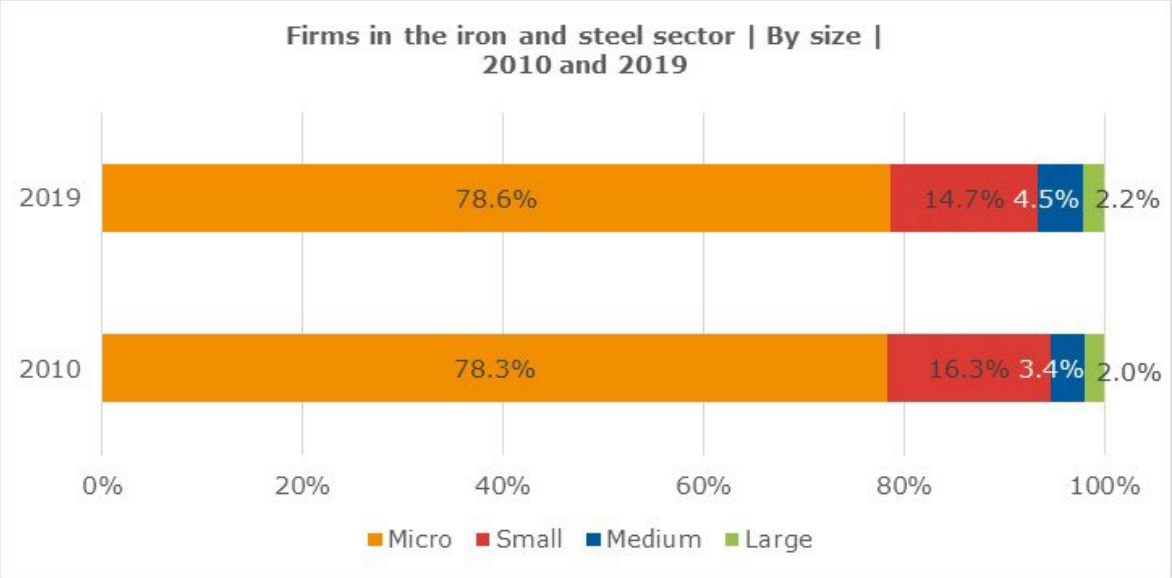
Source: IES

Characterization

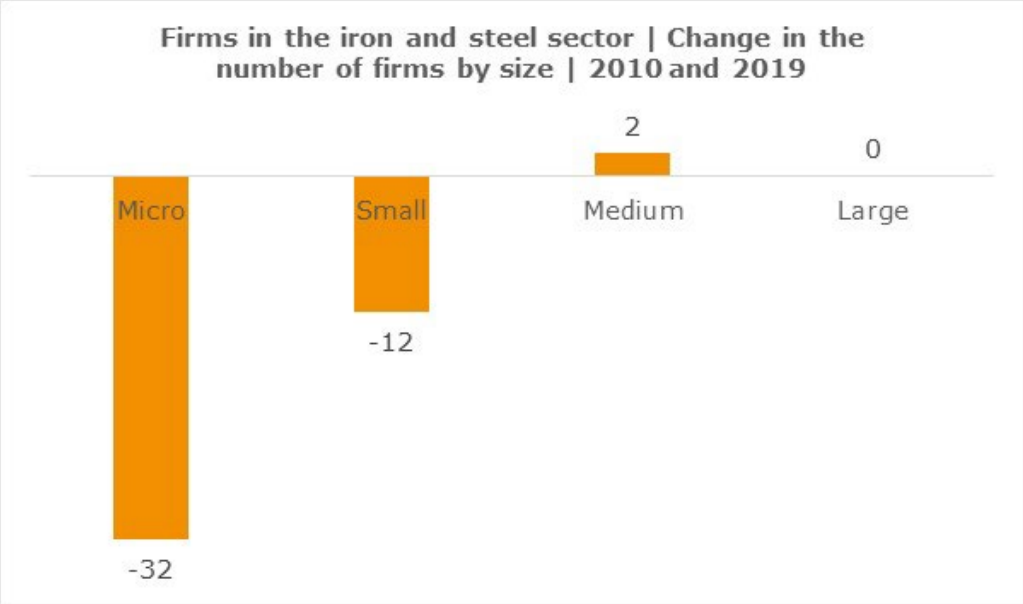
In 2019, there are 313 iron and steel firms in Portugal, having the highest number of firms among the sectors under analysis. This sector presents a decrease in the number of firms in the period of analysis, although the consistent entrance of new firms in this market, most remarkably from 2013 to 2015.

Source: IES

In 2019, most firms are micro firms (78.6%), followed by small firms (14.7%). The share of medium and large firms are 4.5% and 2.2%, respectively. The distribution by size is relatively stable from 2010 to 2019, with a slight reduction of small firms (-1.6 p.p.) and increase in the share of medium firms (+1.1 p.p.). In absolute terms, there was a decrease in the number of micro (-32) and small firms (-12).

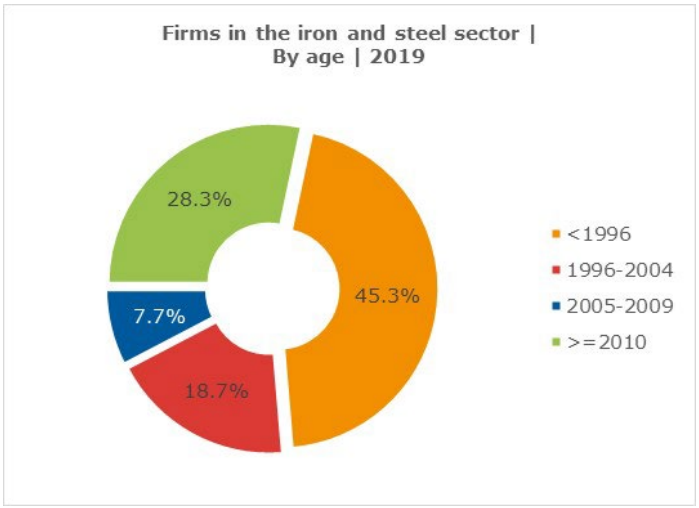


Source: IES



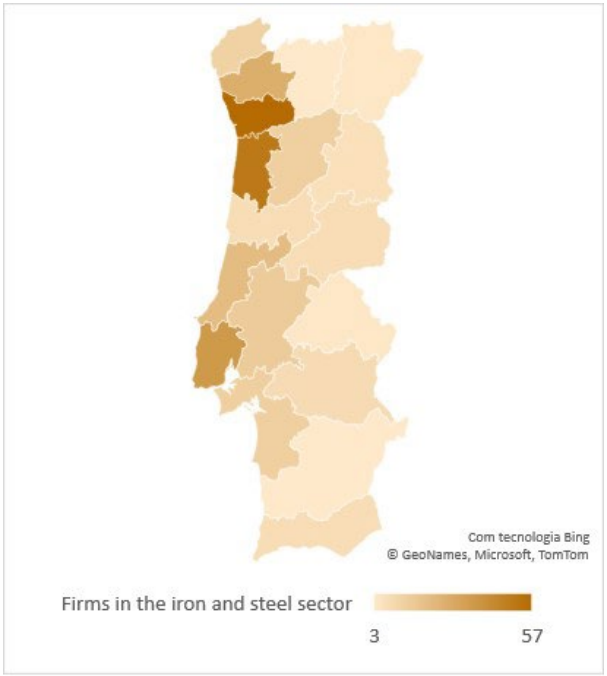
Source: IES

For the universe of reporting iron and steel firms in 2019, there is a greater predominance of older firms, with 43.5% of firms created before 1996. By contrast, 29.1% are more recent firms, with a constitution year after 2009. Moreover, 18.7% of firms have a constitution date from 1996 to 2004 and 7.7% from 2005 to 2009.



Source: IES

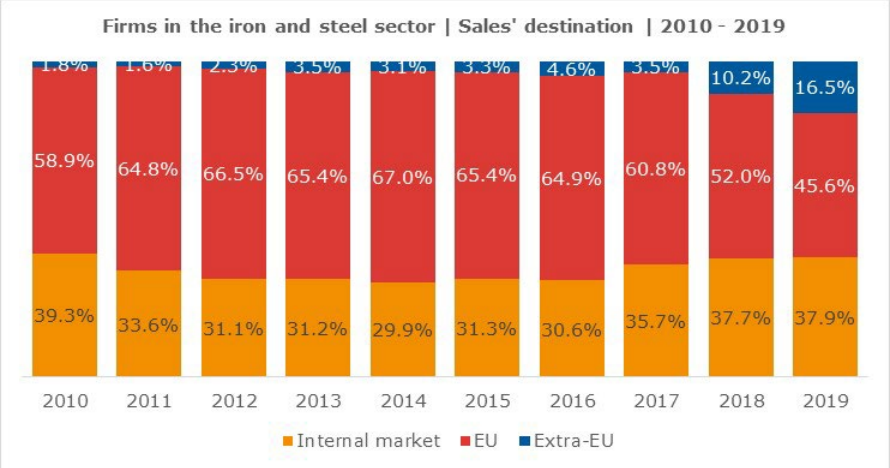
Iron and steel firms are more geographically concentrated in the North area, more specifically in the districts of Porto and Aveiro, and in the district of Lisboa.



Source: IES

Sales destination

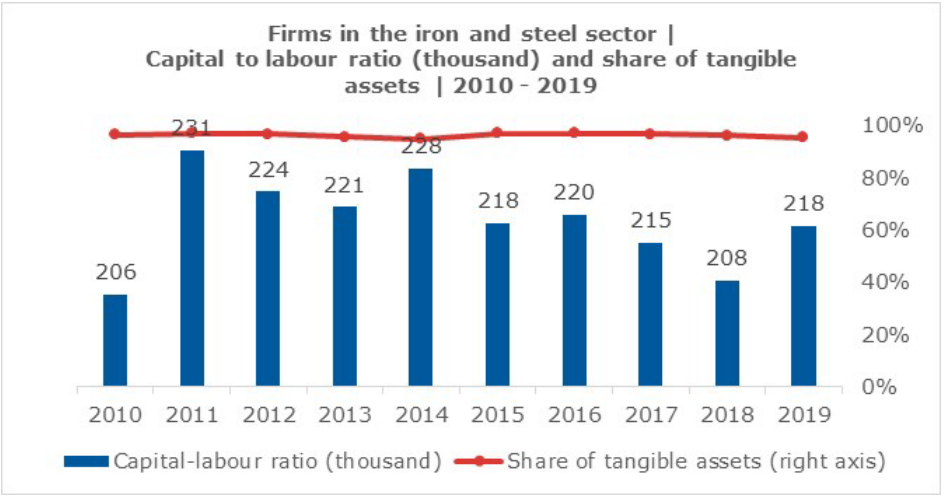
In 2019, most of sales from iron and steel firms have some destination market (62.1%), with the domestic market representing 37.9% of total sales. Although the share of exports presents a modest growth from 2010 (+1.4 p.p.), there is a shift of exports from the EU to extra-EU countries from 2018 onwards. In 2019, 16.5% of sales of iron and steel are exported to extra-EU countries.



Source: IES

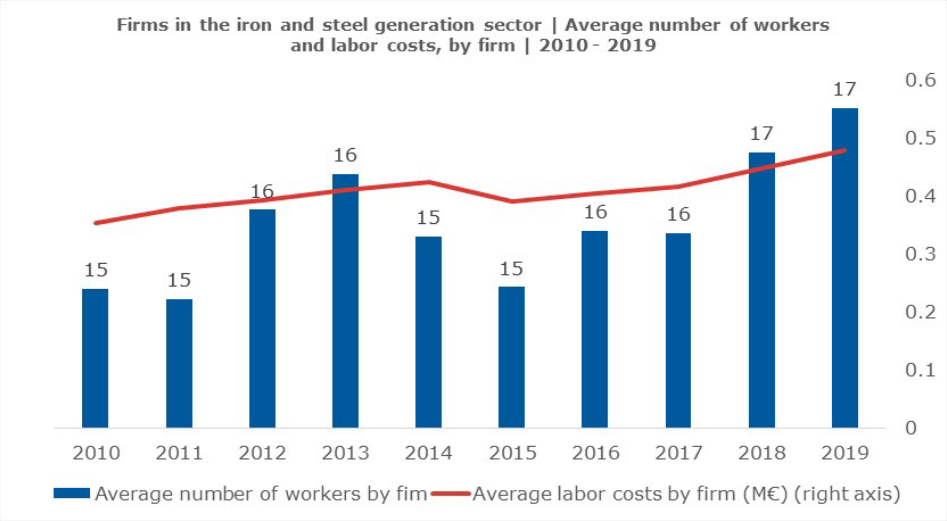
Capital and labour

The capital and labour ratio for the firms in the iron and steel sector is 218 thousand euros per worker in 2019, increasing from 206 thousand euros in 2010. The iron and steel sector is characterized by a very high share of tangible assets (95.5% in 2019), and it has been relatively stable in the years under analysis.



Source: IES

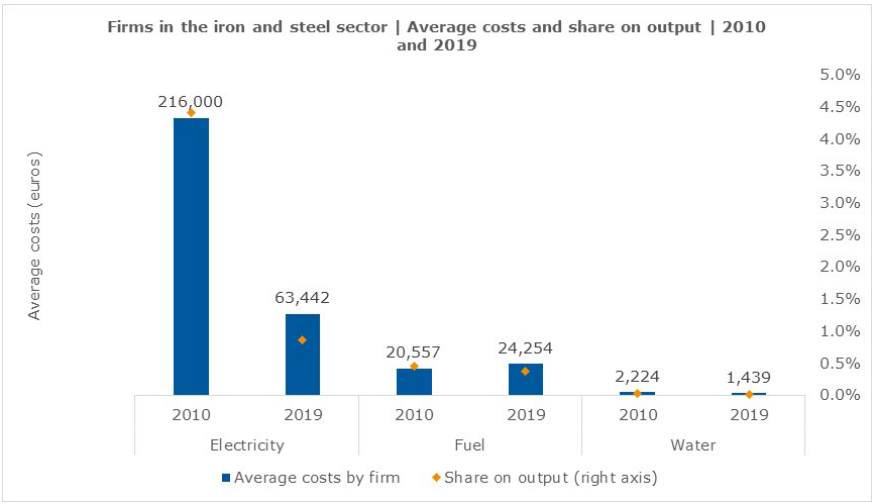
In 2019, each iron and steel firm employed, on average, 17 workers. There are 20 firms with more than 50 employees. The average number of workers presents an increasing trend since 2015. The average labour cost follows the same trend of the average number of workers by firm.



Source: IES

Electricity, fuel and water costs

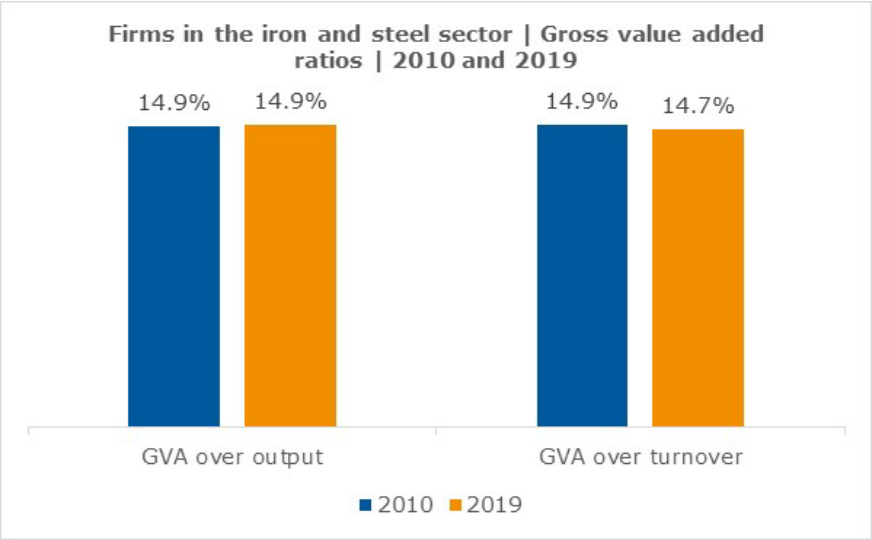
Average electricity and water costs decreased from 2010 to 2019, consistent with the corresponding shares on production, which may result from an efficiency improvement of inputs use. Despite the increase in average fuel costs, in absolute terms, the share on production slightly decreased.



Source: IES

Productivity

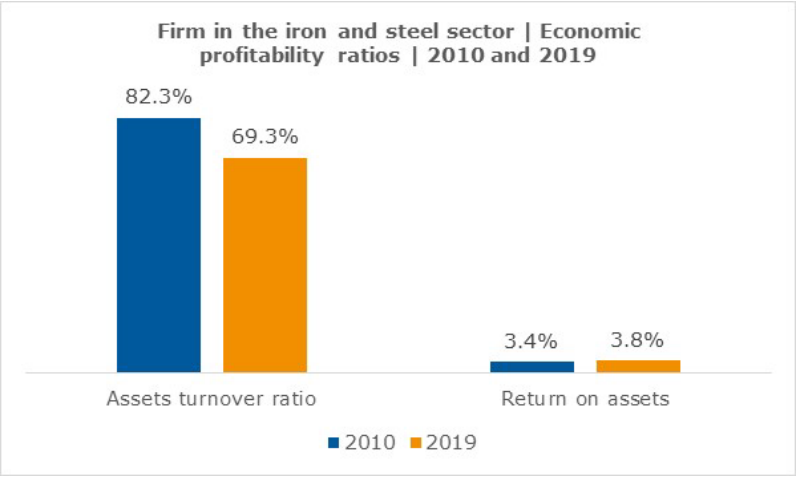
The GVA per unit of output in the aluminium sector remains relatively stale from 2010 to 2019, both the GVA over output (14.9% in both years) and the GVA over turnover (14.9% in 2010 and 14.7% in 2019).



Source: IES

Economic profitability

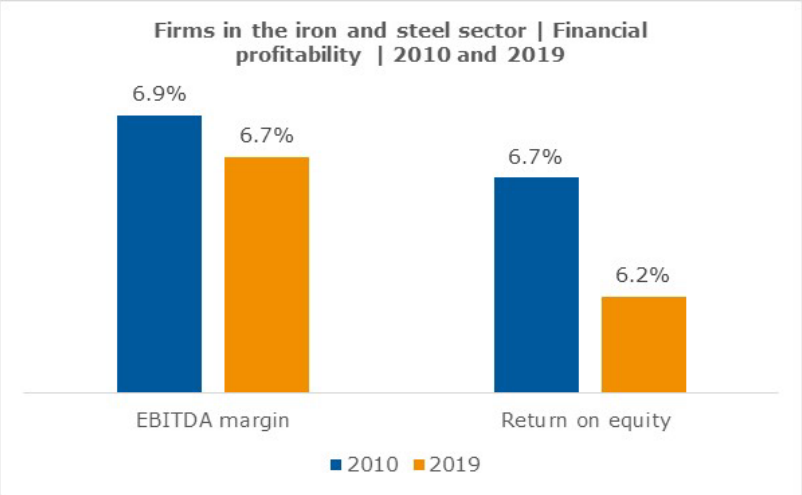
The ability of generating revenue from their assets decreased. While in 2010 this ratio was 82.3%, in 2019 it decreases to 69.3%. On the other hand, the ROA for firms in the iron and steel sector is 3.4% in 2019, in line with the value presented in 2010 (3.4%), suggesting similar efficiency level in generating income from assets, in both years.



Source: IES

Financial profitability

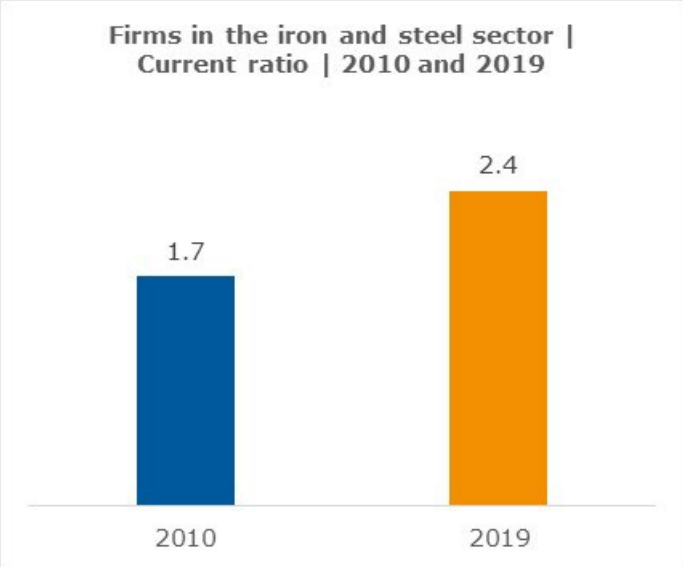
In the iron and steel sector the EBITDA margin presents a slight decrease from 6.9% in 2010 to 6.7% in 2019. A similar trend is presented by the ROE that went from 6.7% in 2010 to 6.2% in 2019, revealing a slight decrease in of the efficiency in the use of shareholders' equity to generate income.



Source: IES

Liquidity

The current ratio for firms in the iron and steel sector increased from 1.7 in 2010 to 2.4 in 2019, suggesting an improvement in iron and steel firms to pay short term debts.



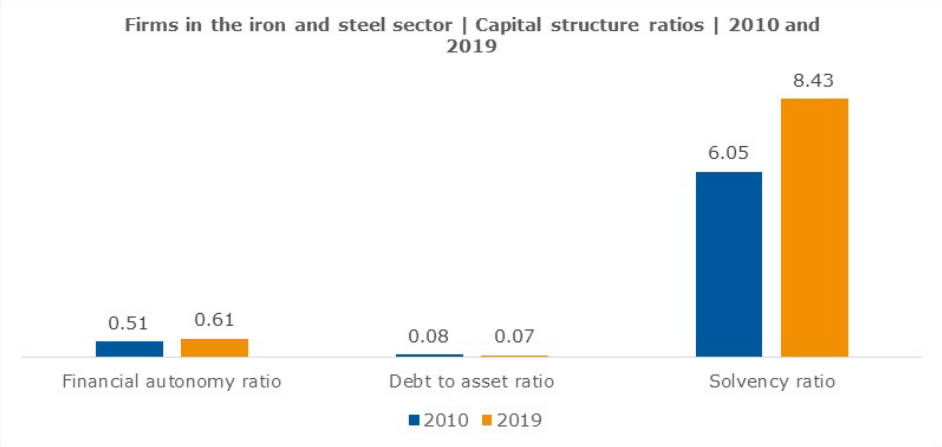
Source: IES

Structure indicators

For firms in the iron and steel sector, the ratio of financial autonomy increased from 0.51 in 2010 to 0.61 in 2019.

On the other hand, the debt to asset ratio remained relatively stable in the period of analysis, being 0.07 in 2019, which reveals that firms in the iron and steel sector have, on average, more assets than debt and a modest degree of leverage.

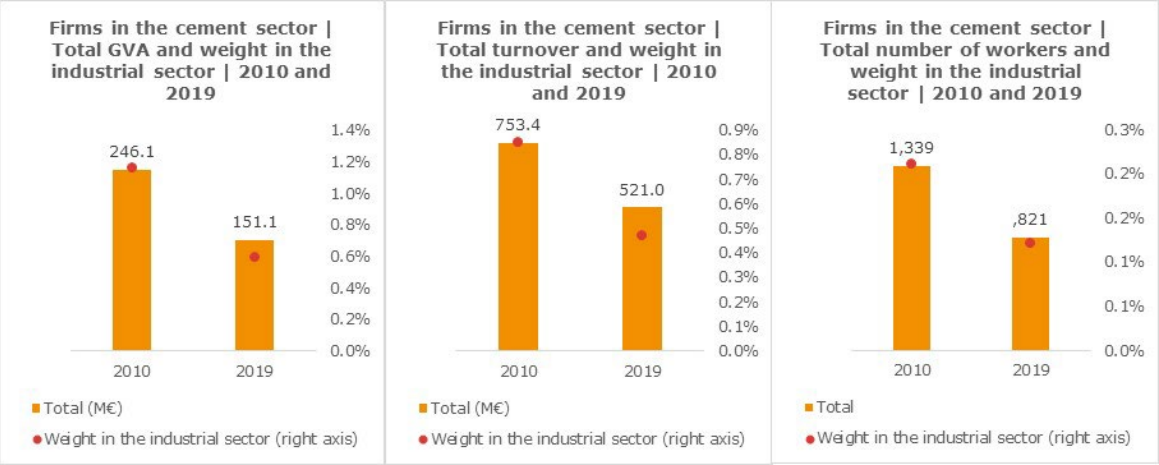
The solvency ratio increased from 6.05 in 2010 to 8.43 in 2019, translating a higher ability of iron and steel firms to meet their long-term debts and obligations.



Source: IES

3.3 Cement

The share of this sector in the industrial sector of Portugal is marginal, corresponding to less than 1%, in terms of GVA, turnover and jobs. From 2010 to 2019, the cement sector decreased the GVA (-38.6%), turnover (-30.8%) and the total number of employees (-38.7%). The correspondent shares on the industrial sector also have been reduced, suggesting a decrease in its importance. Nowadays, this sector provided around 820 direct jobs.



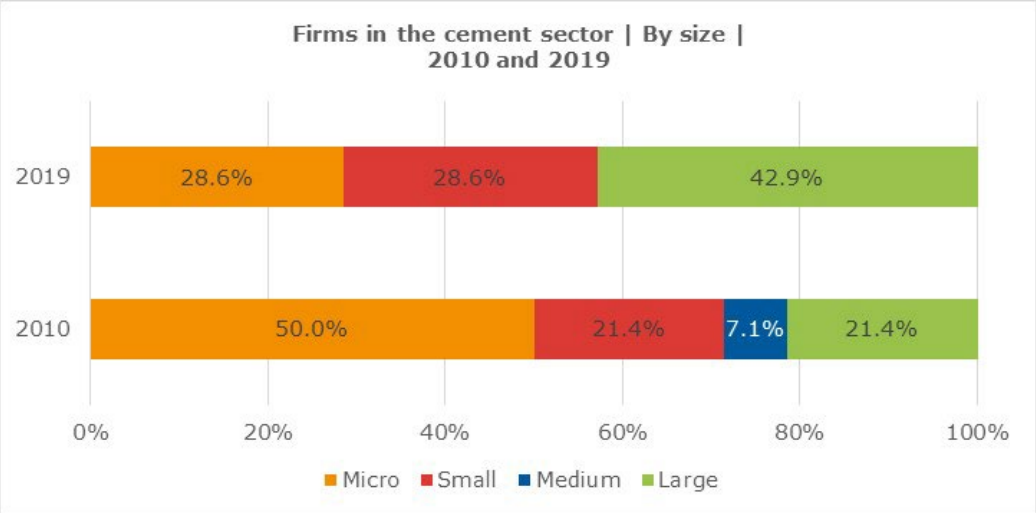
Source: IES

Characterization

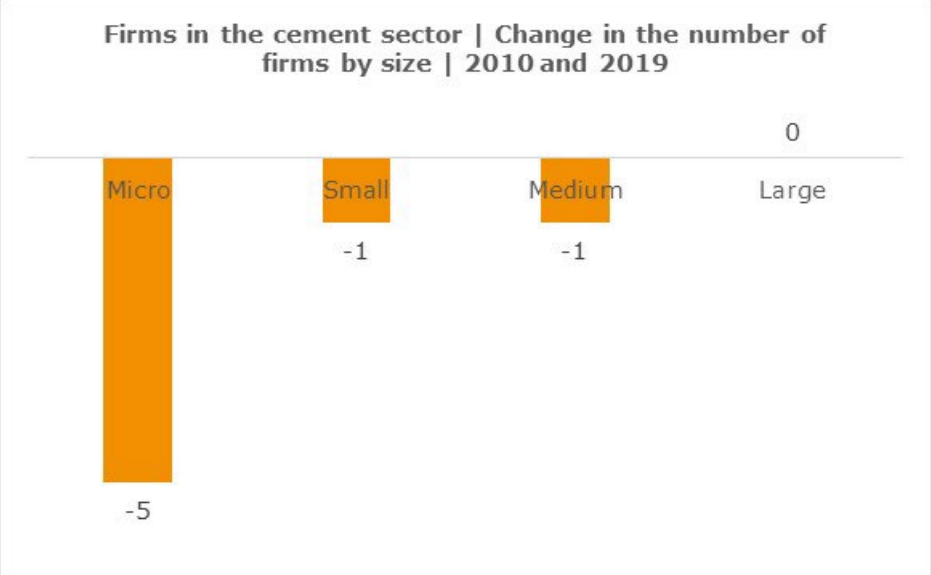
In 2019, there are seven firms in the cement sector in Portugal, half of the number observed in 2010. No new firms have entered in the market since 2012, contributing to the downward trend of the number of firms registered since 2011.

Source: IES

In 2019, most cement firms (42.9%) are large, followed by micro and small firms, both with 28.6% of share. The reduction in the number of micro firms (-5) resulted in a decrease in their relative importance (-21.4 p.p.). There was also a reduction in the number of small (-1) and medium firms (-1), while the number of large firms remained the same, from 2010 to 2019.

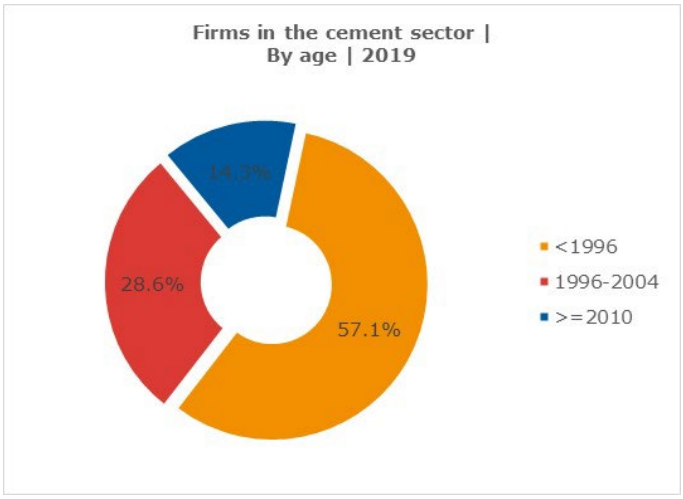


Source: IES



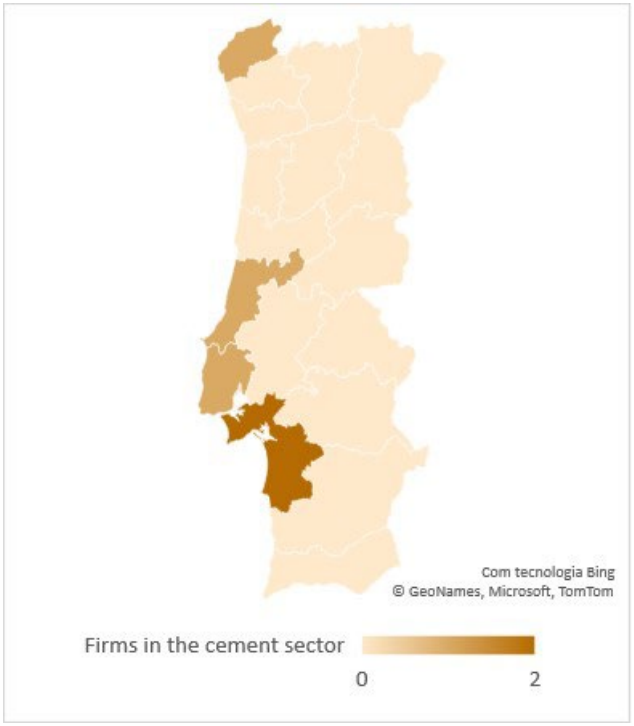
Source: IES

Among firms in activity in 2019, four firms (57.1%) started operating prior to 1996. The second most important interval of constitutions is from 1996 to 2004 (28.6%), and only 1 firm (14.3%) was constituted more recently.



Source: IES

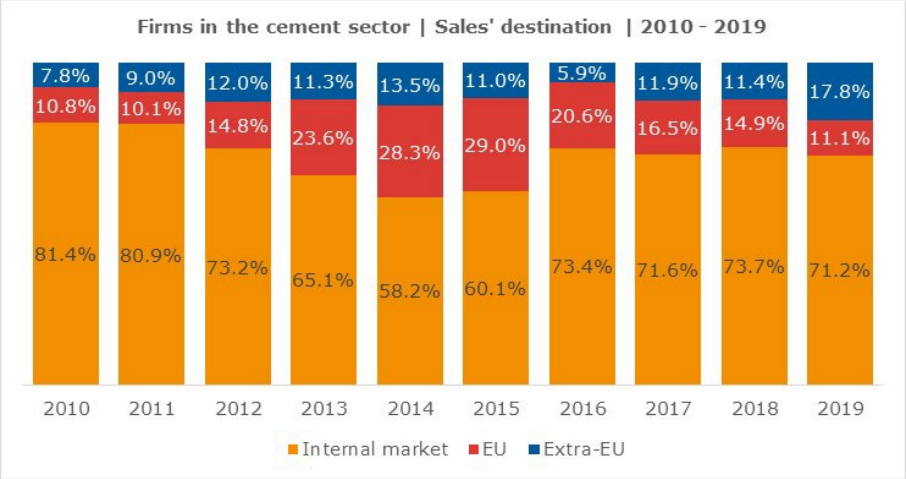
Cement firms are geographically located in the central coaster regions, in the districts of Setúbal, Leiria, Lisboa, and in the North, in Viana do Castelo.



Source: IES

Sales destination

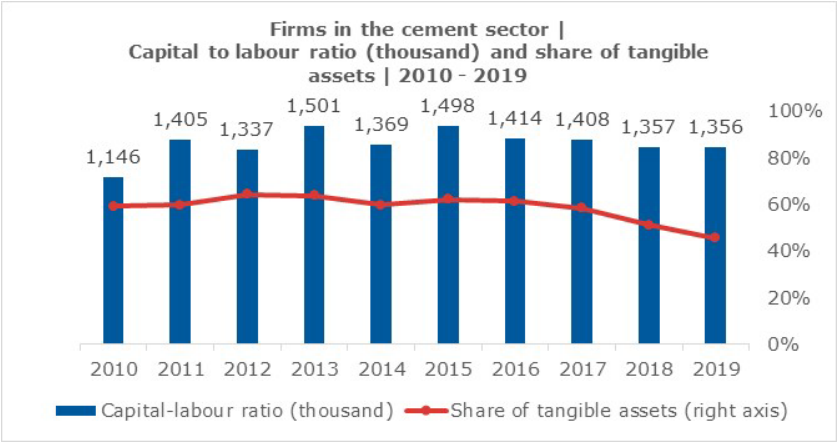
In 2019, 71.2% of sales targeted the domestic market, while for 28.8% the destination would be the foreign market. The share of sales to extra-EU markets is relevant (17.8%). Comparing to 2010, the share of sales that is exported increased from 18.6% to 28.8% in 2019, mainly driven by the sales to extra-EU countries. The increasing trend in the exports to the European countries which was observed from 2011 to 2019 has been reverted in more recent years.



Source: IES

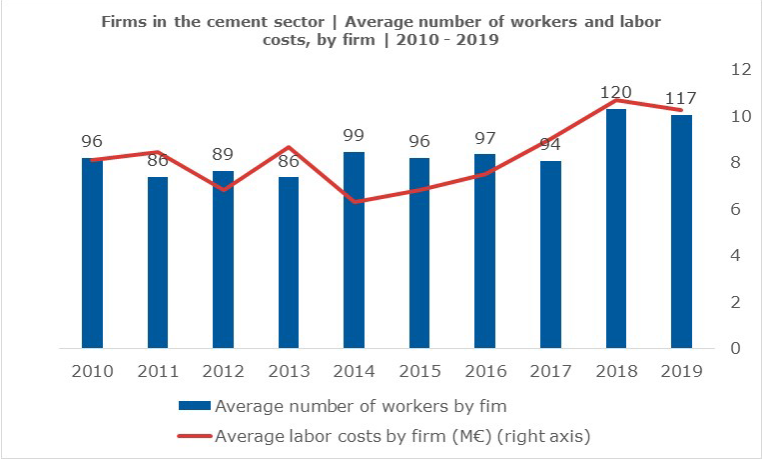
Capital and labour

The capital-labour ratio is 1,356 thousand euros per worker in 2019. The capital intensity of the sector is decreasing since 2015, despite being still higher than the value depicted in 2010. The share of tangible assets is 45.6% in 2019, also showing a consistent decreasing trend since 2015.



Source: IES

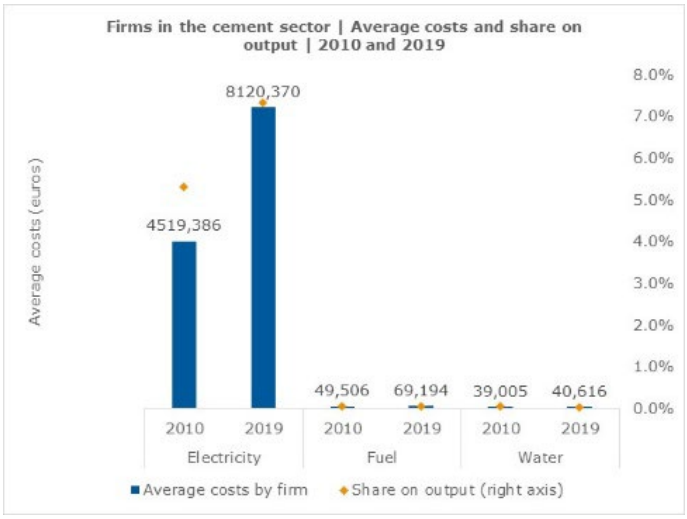
By contrast, the labour-input has increased its predominance. In 2019, the average number of workers by firm was 117. From 2017 to 2018, there was an increase in the average number of workers, from 94 to 120, with a slight reduction in 2019 to 117. There are 3 firms in 2019 that employ more than 50 workers. Once again, average labour costs by firm closely follow the trend of workers by firm.



Source: IES

Electricity, fuel and water costs

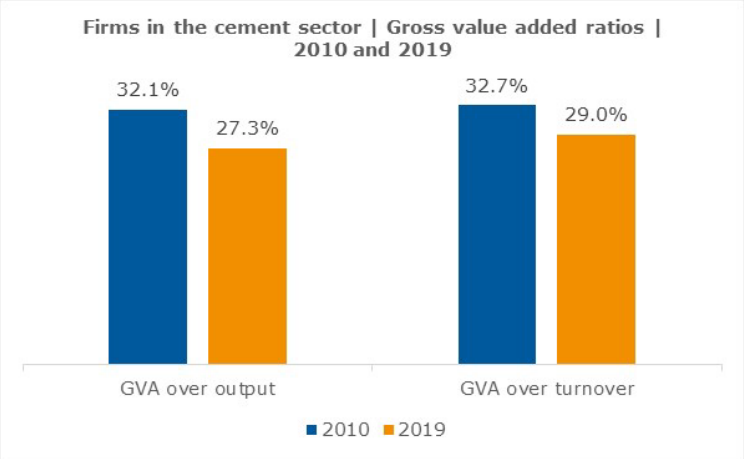
Average electricity and fuel costs increased from 2010 to 2019, both in absolute value and relatively to output. Electricity costs grew 44.3% from 2010 to 2019 and the share on output went from 5.4% to 7.8%, while the average costs by firm related to fuel grew 28.5% in the period over analysis. Water costs remained constant.



Source: IES

Productivity

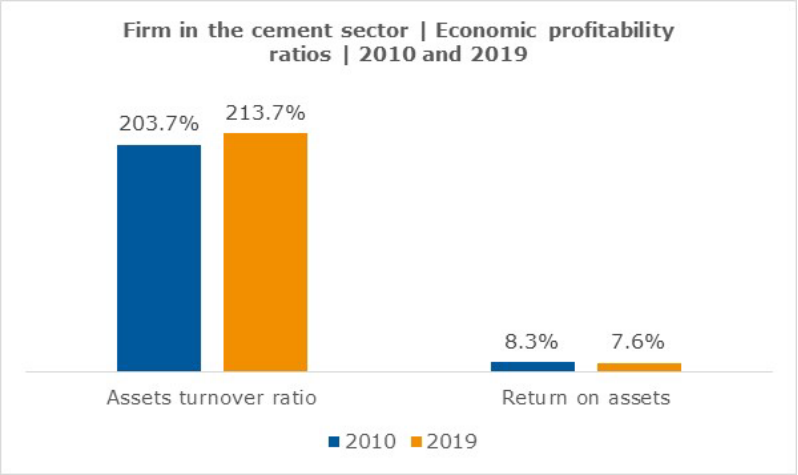
Both the relative GVA ratios present a decrease in the period of analysis, suggesting a reduction of the difference between the value of cement produced and the costs of raw materials and other inputs used in the production, for each unit produced and relative to sales. The GVA over output decrease from 32.1% in 2010 to 27.3% in 2019 and the GVA over turnover went from 32.7% in 2010 to 29.0% in 2019.



Source: IES

Economic profitability

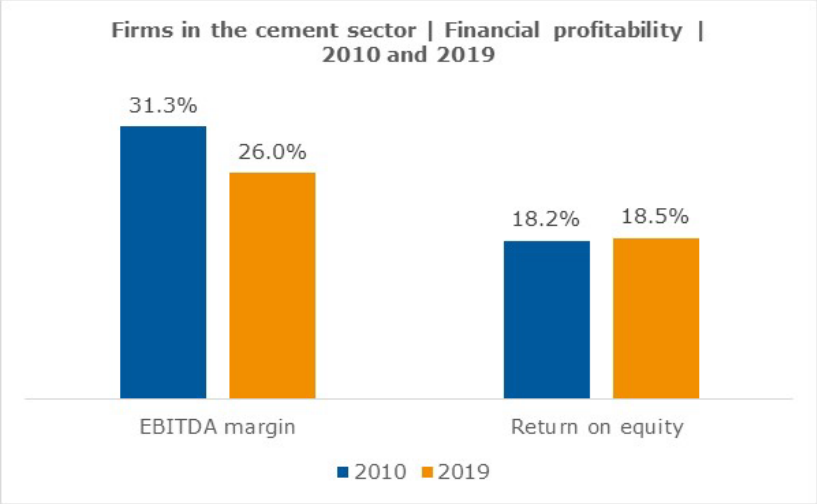
While the ability to generate turnover with the owned assets increased in the period of analysis (from 203.7% in 2010 to 213.7% in 2019), the efficiency to generate profits from the same assets decrease from 8.3% in 2010 to 7.6% in 2019).



Source: IES

Financial profitability

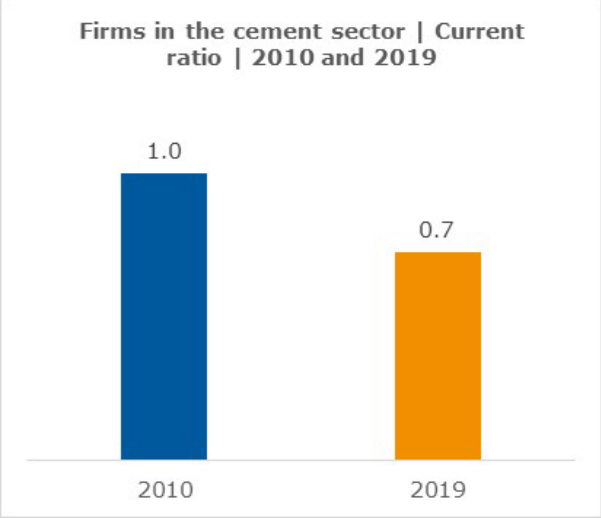
The EBITDA margin for firms in the cement sector decrease from 31.3% in 2010 to 26.0% in 2019, suggesting that less earnings before interest, taxes, depreciation, and amortization are generated, as a percentage of total revenue. However, this does not undermine the cement firms' efficiency in the use of shareholders' equity to generate income, given by the evolution of the ROE (18.2% in 2010 and 18.5% in 2019).



Source: IES

Liquidity

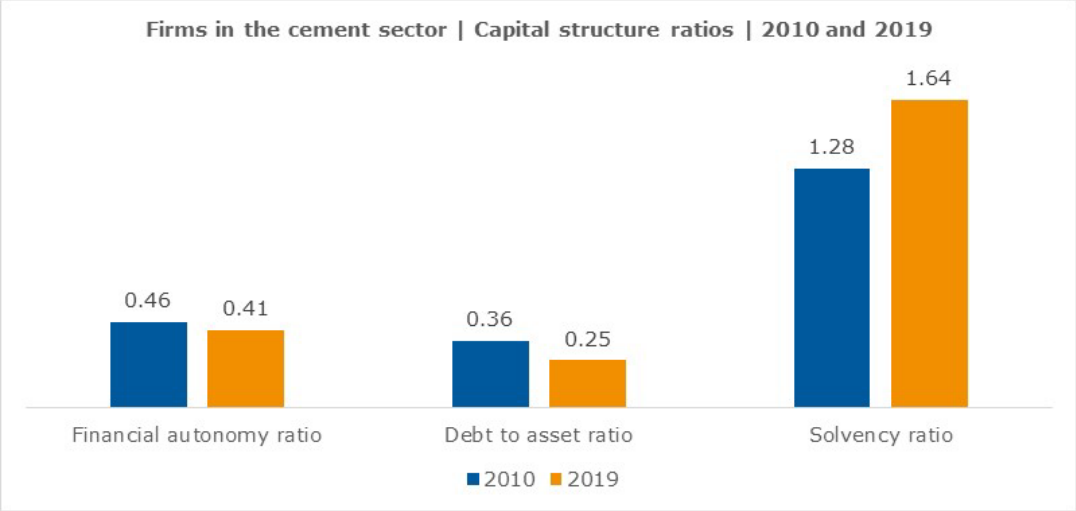
Firms in the cement sector present a decrease in the current ratio, suggesting a reduction in firms in this sector to pay short-term obligations.



Source: IES

Structure indicators

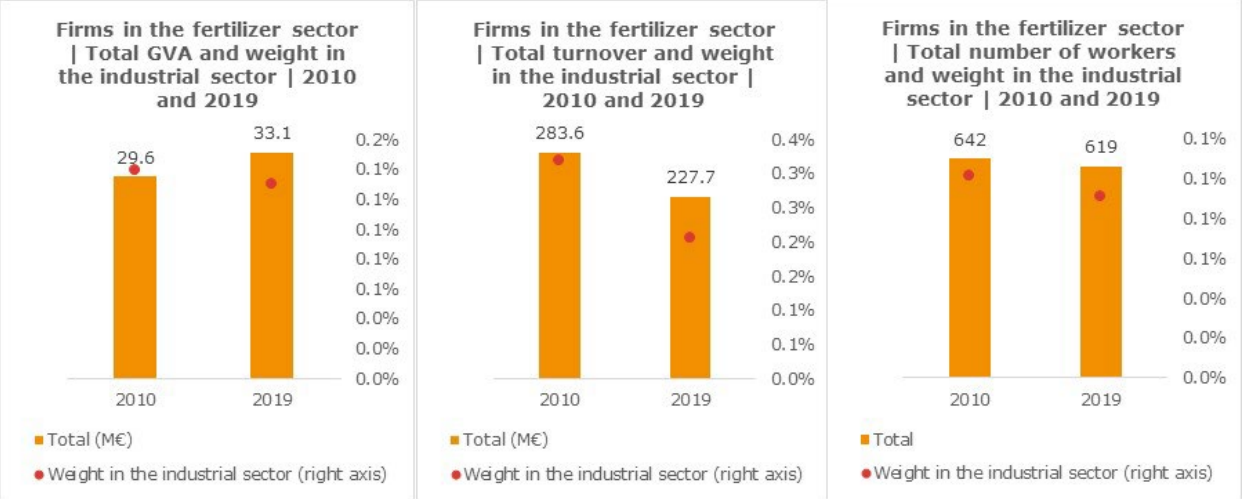
There was a modest decrease in the financial autonomy ratio for cement firms, from 0.46 in 2010 to 0.41 in 2019, suggesting a reduction in the ability to generate assets by issuing equity shares. Along with the lower degree of leverage suggested by the evolution of the debt to asset ratio (0.36 in 2010 to 0.25 in 2019), cement firms have a higher ability to meet long-term obligations, since the solvency ratio increased (1.28 in 2010 to 1.64 in 2019).



Source: IES

3.4 Fertilizer

The share of the GVA, turnover and jobs of this sector in the Portuguese industry is less than 1% in 2019. Although the GVA increased by 12%, the turnover and number of workers decreased by 19.7% and 3.6%, respectively, from 2010 to 2019. The shares of this sector in the industry also decreased. This sector provides around 620 direct jobs in 2019.



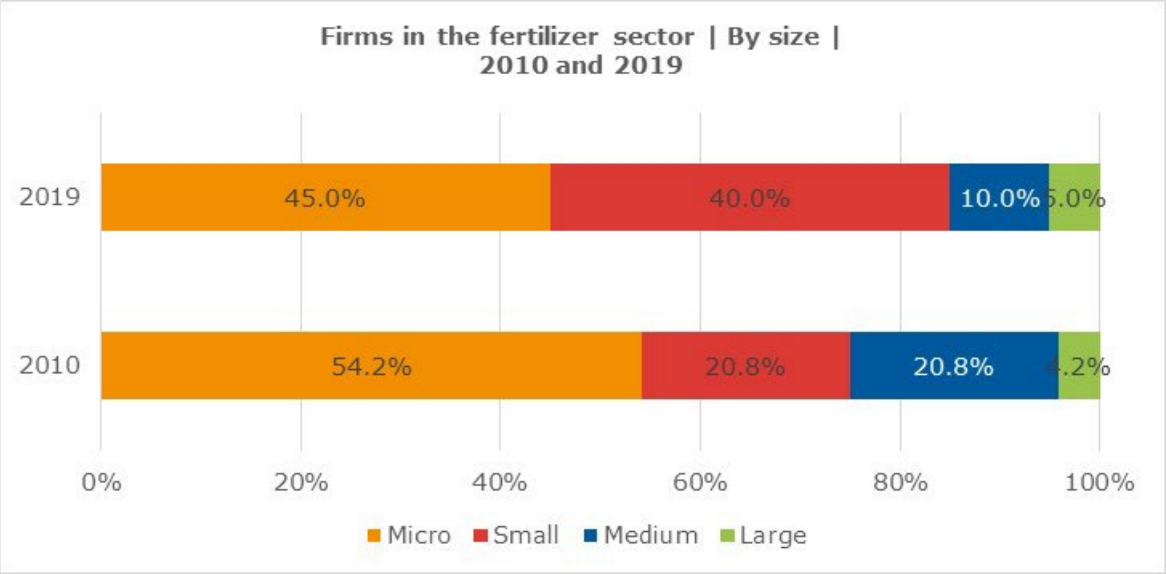
Source: IES

Characterization

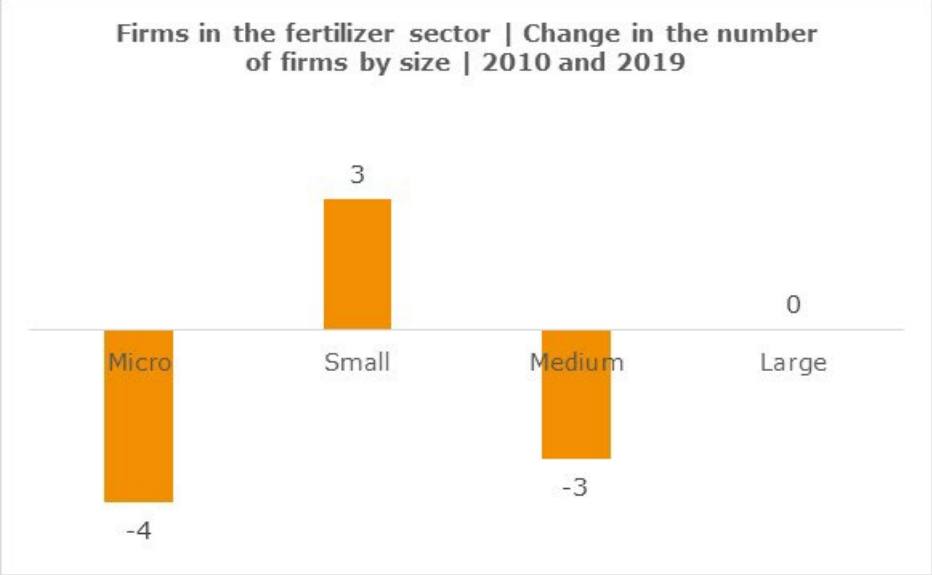
In 2019, there are 20 fertilizer firms in Portugal, which compares to 24 firms in 2010. This sector presents a decreasing trend in the number of firms since 2017, being characterized by the lower number of firms entering in this market. In the last five years, there are only two new firms.

Source: IES

In 2019, 45% of firms are classified as micro and 40% as small. Only 10% as medium-sized firms and 5% as large. Comparing to 2010, in 2019 there is a higher proportion of small firms (-19.2 p.p.) and a reduction in the share of medium (-10.8 p.p.) and micro firms (-9.2 p.p.). This is the result of a lower number of micro (-4) and medium firms (-3) and the increase of small ones (+3).

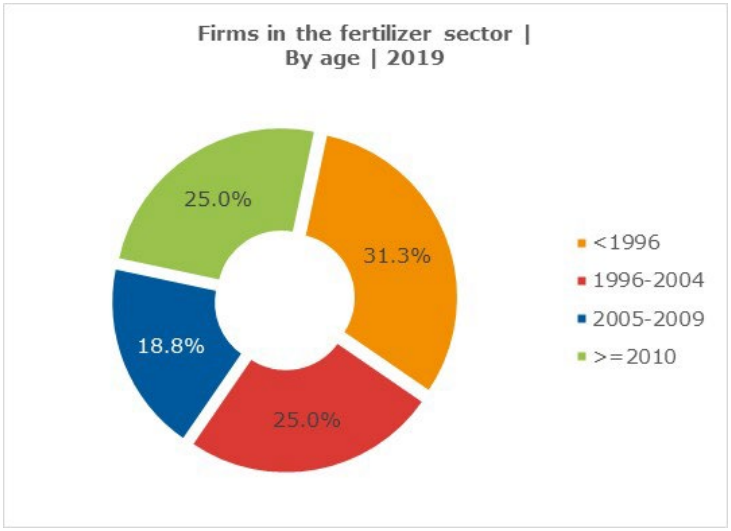


Source: IES



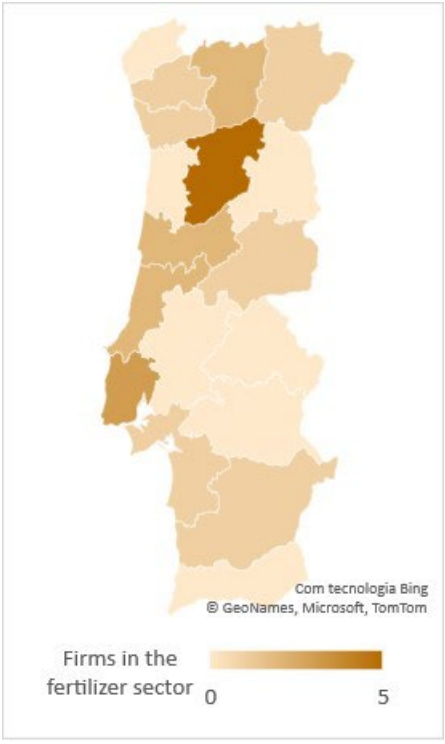
Source: IES

In 2019, 31.3% of firms are older, with a constitution year prior to 1996, followed by the interval of constitution year of 1996 to 2004 (25.0%). More recent firms also represent 25.0% of firms in the fertilizer sector and 18.8% started operating between 2005 and 2009.



Source: IES

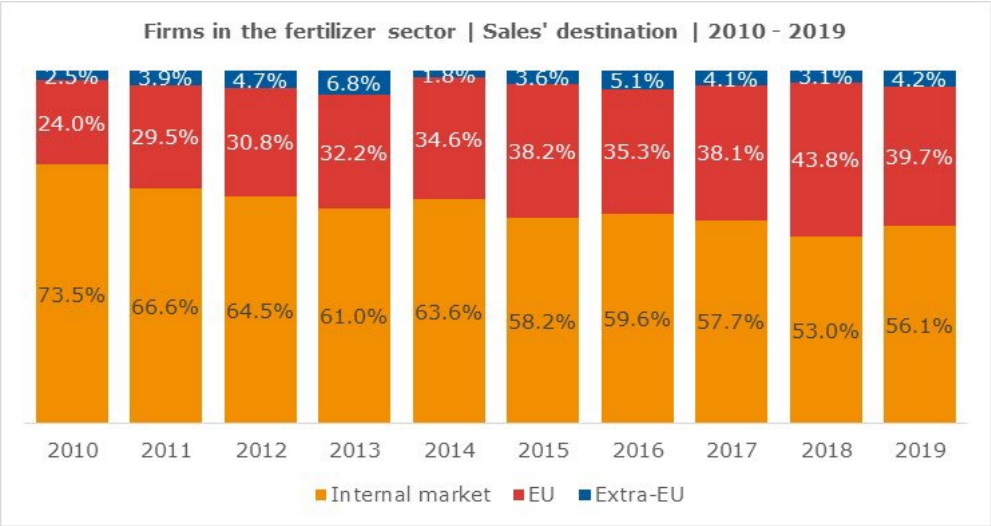
In 2019, 25% of fertilizer firms are located in Viseu and 15% in Lisboa.



Source: IES

Sales destination

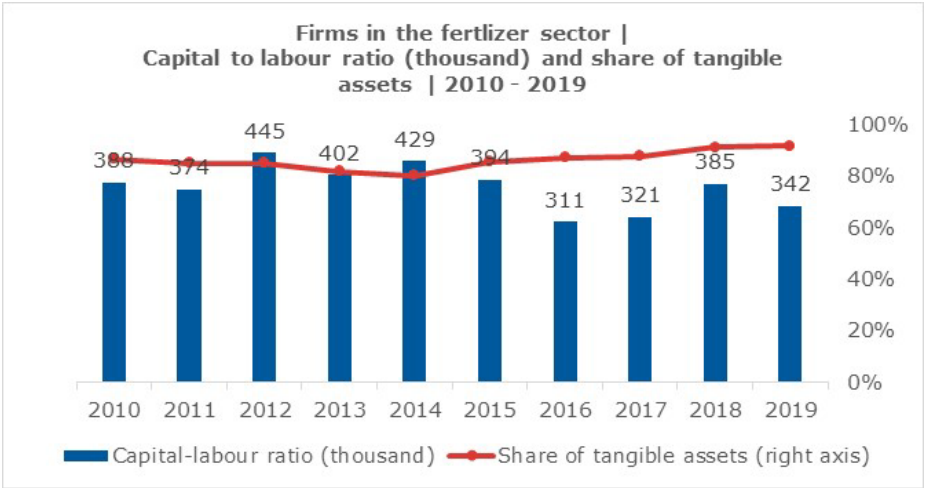
The destination of 43.9% of sales of fertilizer firms is the external market, mainly the EU, and 56.1% go to the domestic market. The proportion of exports grew 17.3 p.p. from 2010 to 2019, in a consistent way.



Source: IES

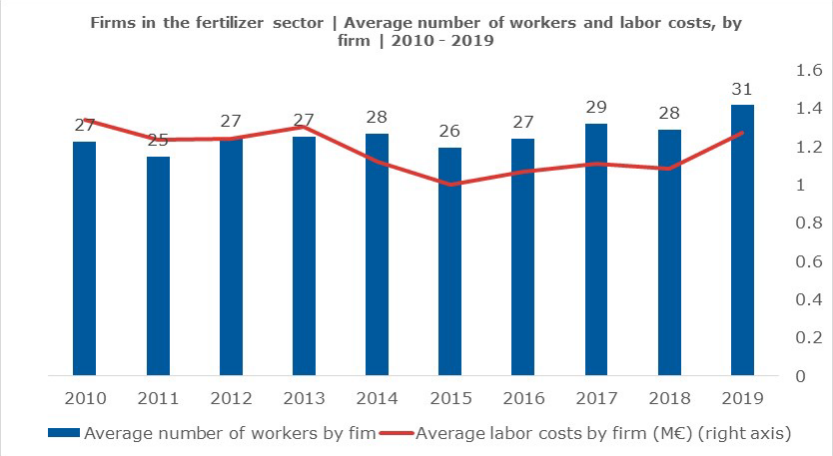
Capital and labour

Fertilizer firms have a share of capital to labour of 342 thousand euros in 2019. Although this share increased from 2016 to 2018, it decreased in 2019. This is a sector that heavily relies on tangible assets, being its share 91.8% in 2019 and exhibiting an upward trend since 2014.



Source: IES

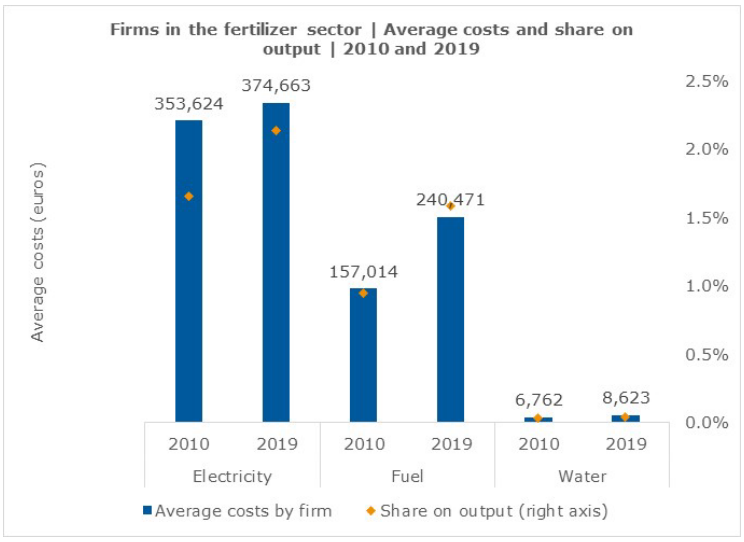
The evolution of the capital-labour ratio in more recent years is at least partially justified by the upward trend of the average number of workers by firm. In 2019, this average was 31 workers employed by firm. There are three firms in 2019 that employ more than 50 workers. Again, average labour costs are following the trend of the average number of workers.



Source: IES

Electricity, fuel and water costs

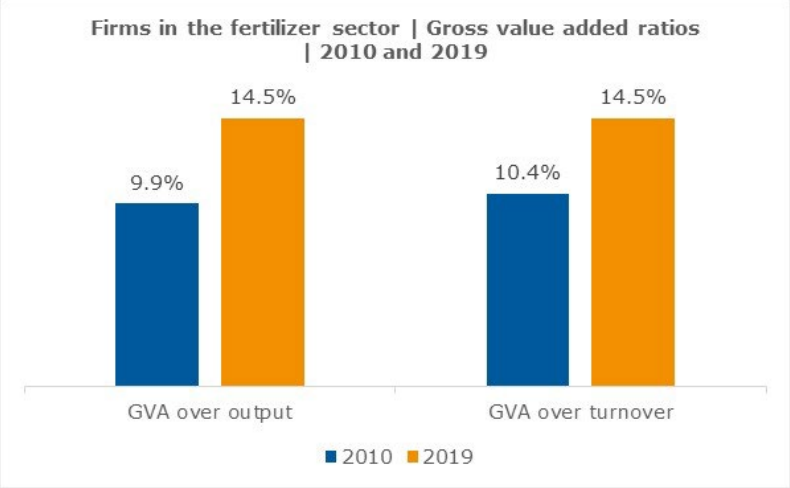
Average electricity fuel and water costs increased from 2010 to 2019. Most remarkably, fuel costs increased by more than 53% in the period of analysis. The corresponding ratios on output levels also increased, implying that producing one unit of fertilizer today implies higher costs in terms of all the inputs under analysis.



Source: IES

Productivity

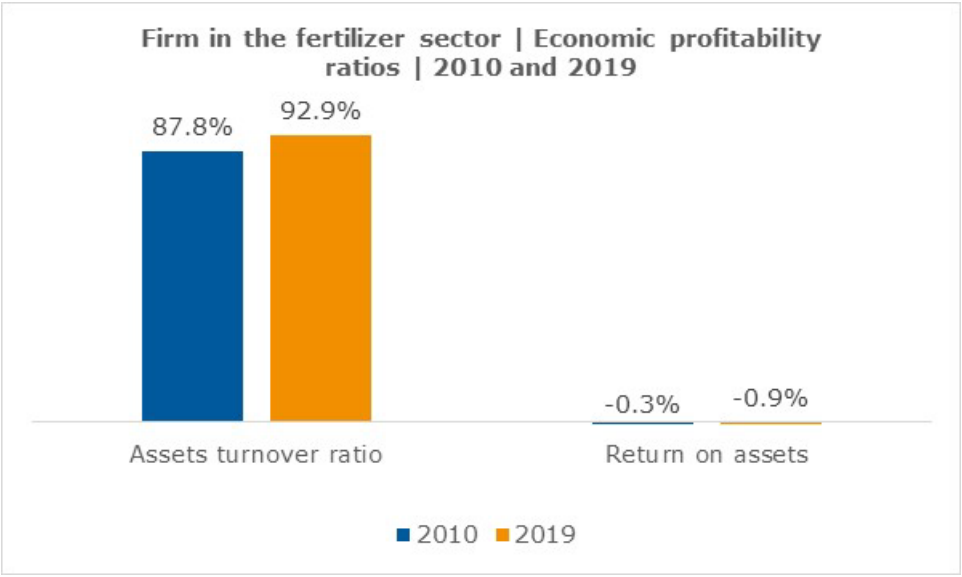
The ratios of GVA over output and turnover present an improvement in the period of analysis, translating an increase in the difference between output and intermediate consumption, in relative terms.



Source: IES

Economic profitability

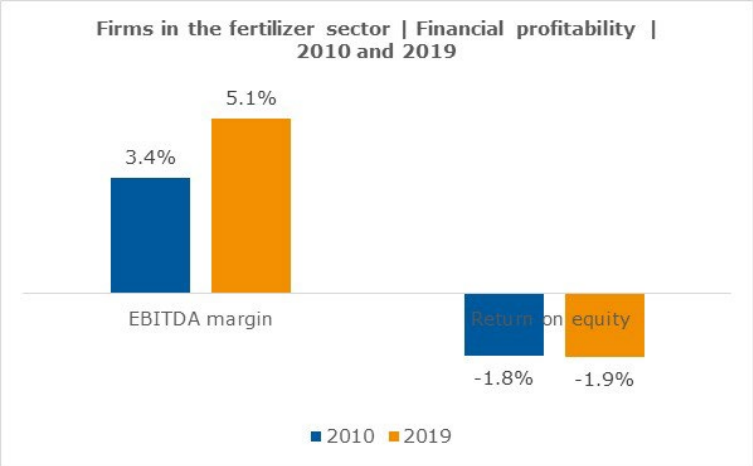
Despite the improvement in the assets turnover ratio (from 87.8% in 2010 to 92.9% in 2019), reflecting the higher ability of firms in this sector to generate revenues using their assets, the ROA kept being negative. In 2019 it was -0.9%, implying that firms are not able to use its assets efficiently enough to make a profit.



Source: IES

Financial profitability

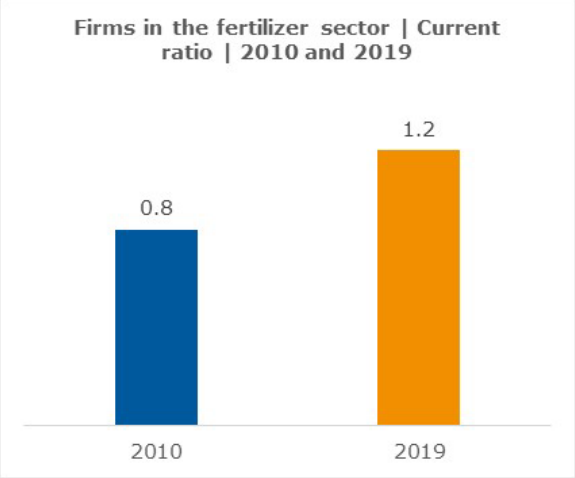
In the fertilizer sector, the EBITDA margin grew from 3.4% in 2010 to 5.1% in 2019, revealing a greater firm's operating profit as a percentage of its revenue. Despite the improvement if the EBITDA margin, the ROE ratio is negative (-1.9%), and in line to the observed value in 2010 (-1.8%).



Source: IES

Liquidity

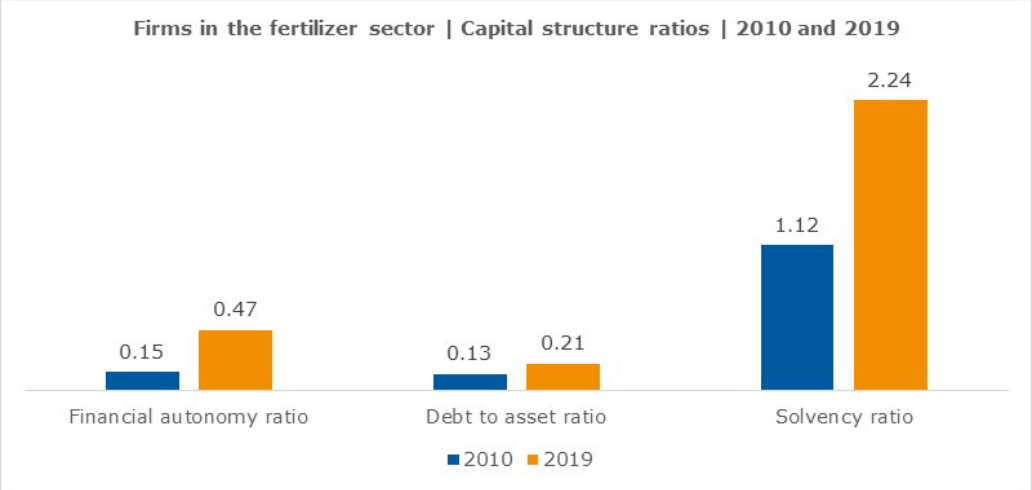
An improvement of the current ratio is observed for firms in the fertilizer sector, from 0.8 in 2010 to 1.2 in 2019. This suggests that firms are more able to pay short-term obligations in 2019, than in 2010.



Source: IES

Structure indicators

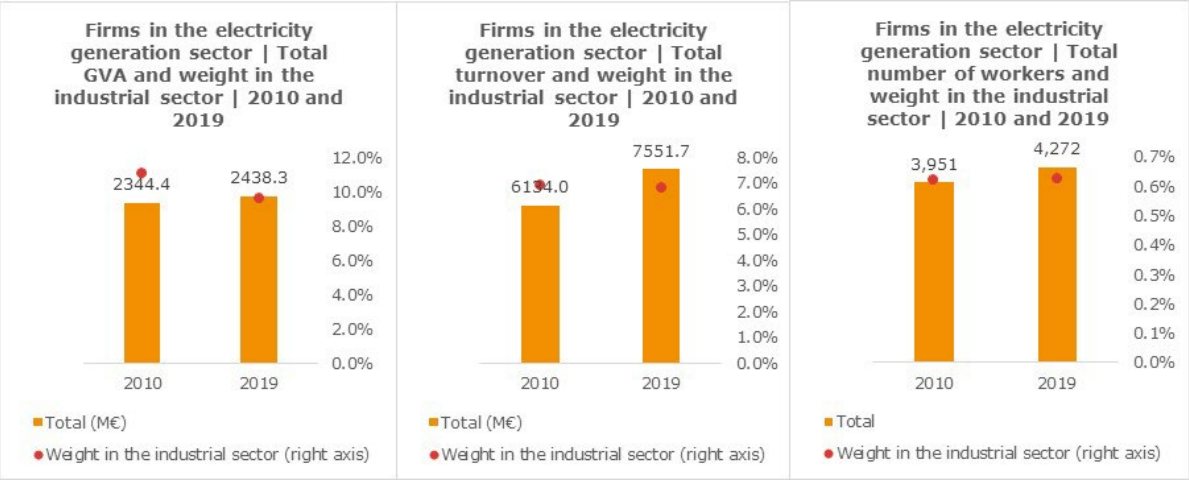
The financial autonomy ratio for firms in the fertilizer sector increased from 0.15 in 2010 to 0.47 in 2019, implying a greater ability generate assets by issuing equity shares, rather than taking debt. Firms have more assets than debts, although the degree of leverage has increased, since the ratio of debt to assets went from 0.13 in 2010 to 0.21 in 2019. In the fertilizer sector, the solvency ratio improved from 1.12 in 2010 to 2.24 in 2019, implying that firms are more able to meet its long-term debts and obligations.



Source: IES

3.5 Electricity generation

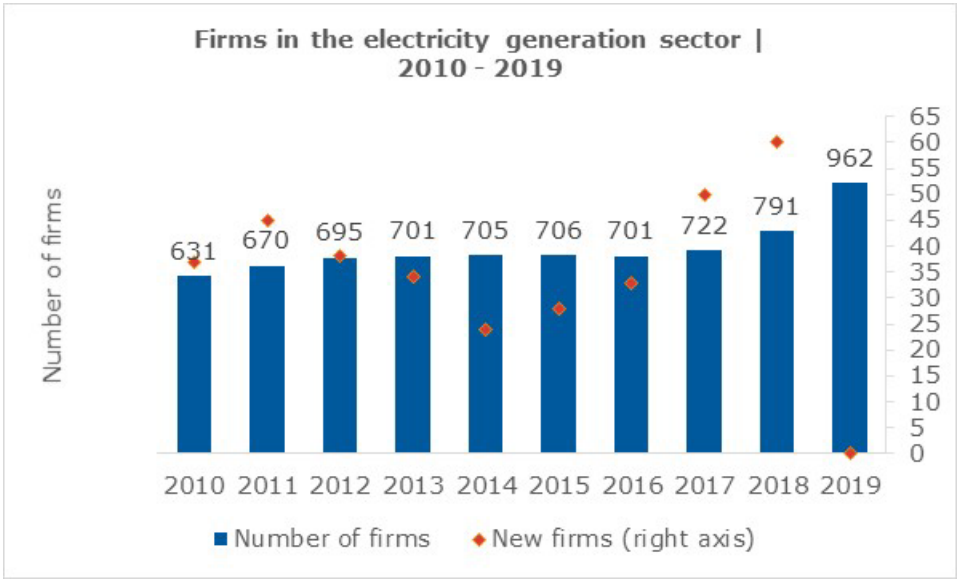
The GVA and the turnover of the electricity generation sector corresponds to 9.6% and 6.8% of the industrial sector in 2019. However, the counterpart share in terms of jobs is less than 1%. Although, the electricity generation sector has increased the GVA, total turnover and jobs in absolute values, the share in the industrial sector of the GVA and total turnover has decreased from 2010 to 2019. This sector provides approximately 4300 direct jobs in 2019.



Source: IES

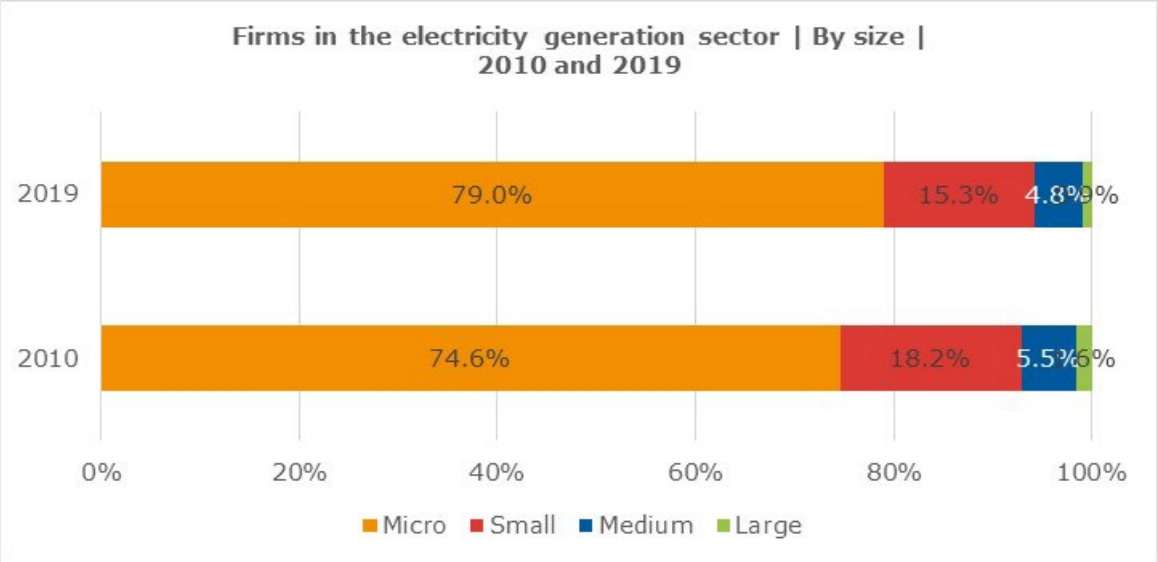
Characterization

In 2019, there are 962 firms in electricity generation sector Portugal, which compares to 631 firms in 2010. This sector presents an increasing trend in the number of firms, especially since 2016. There is a significant number of new firms in this market most remarkably in 2017 and 2018.

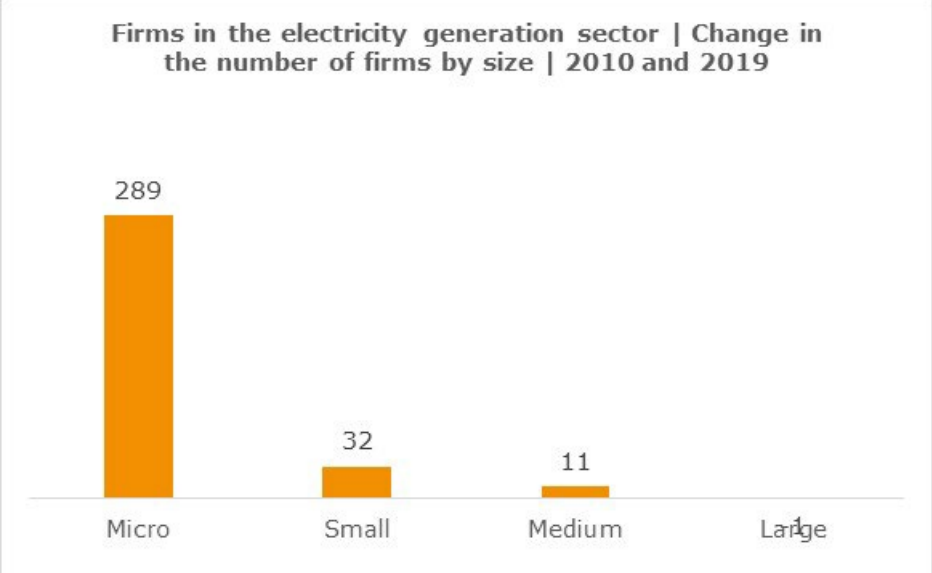


Source: IES

In 2019, most firms in the electricity generation sector (79.0%) are micro firms, followed by small firms (15.3%). Only 4.8% are medium and 0.9% are large firms. Comparing to 2010, there is a higher share of micro firms (+4.4 p.p.) and a lower share of small firms (-2.9 p.p.). In absolute terms, there was an increase across all size-categories in the period of analysis (except larger ones), more remarkably for micro (+289) and small firms (+32).

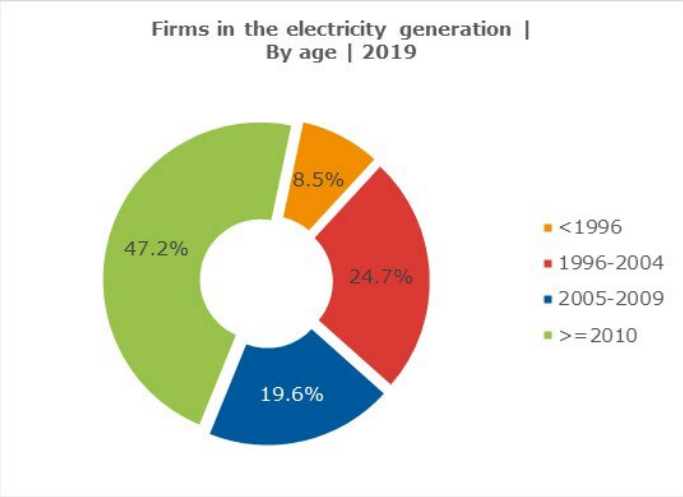


Source: IES



Source: IES

In 2019, 47.2% of firms have a constitution year after 2009 and 24.7% between 1996 and 2004. A proportion of 19.6% started operating between 2005 and 2009 and 8.5% are older firms, which were constituted prior to 1996.



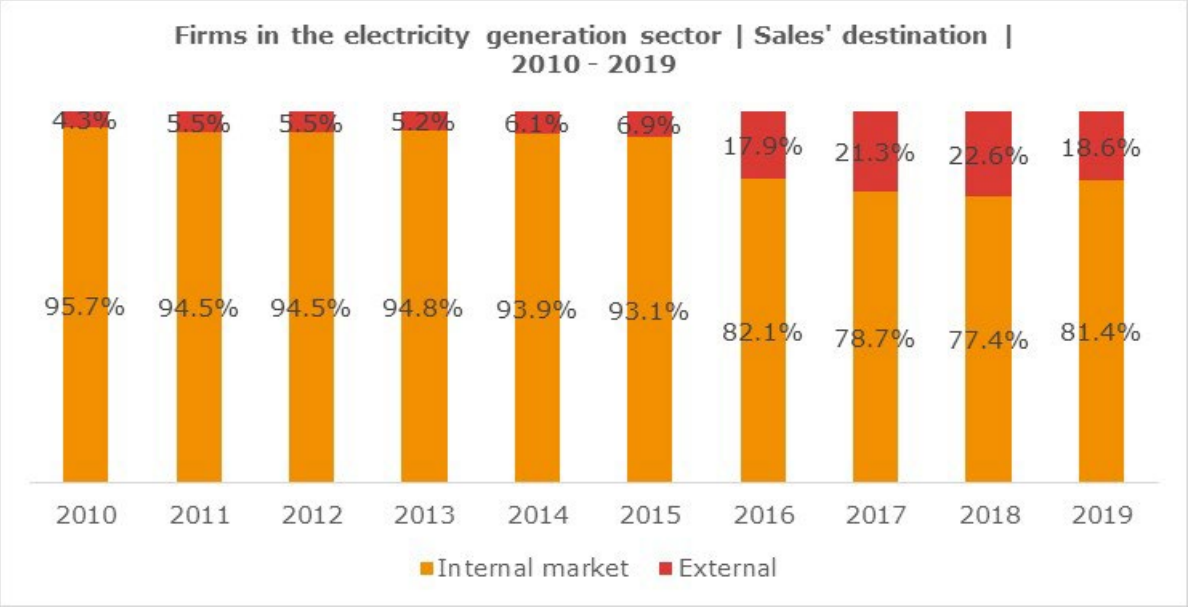
Source: IES

Firms in the electricity generation sector are mainly located in Lisboa, Porto and Braga.

Source: IES

Sales destination

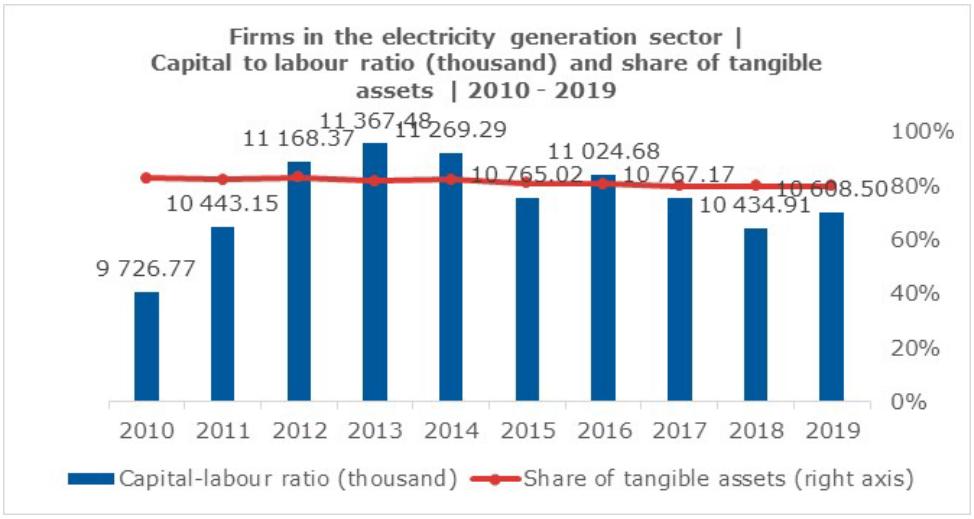
The electricity generation sector relies mainly in the domestic market, with 81.4% of sales being devoted to it.



Source: IES

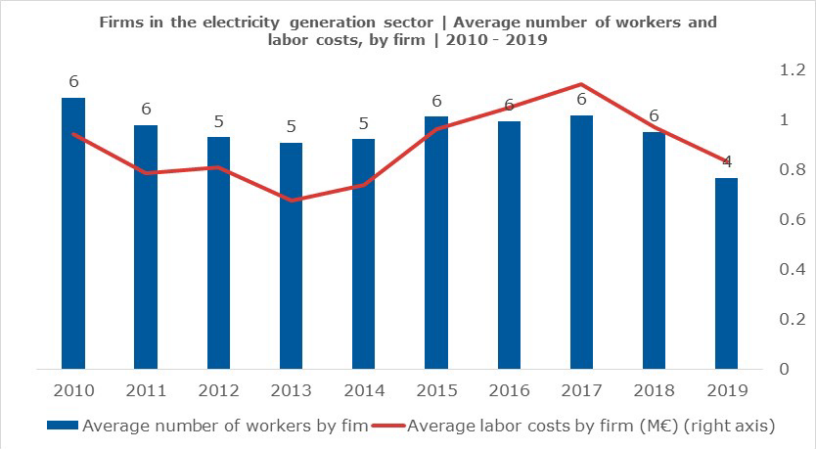
Capital and labour

In the case of the electricity generation sector, the capital-labour ratio was 10,608 thousand in 2019. This ratio compares to 9,727 thousand in 2010. The share of tangible assets is 79.8% in 2019, being relatively stable in the period of analysis.



Source: IES

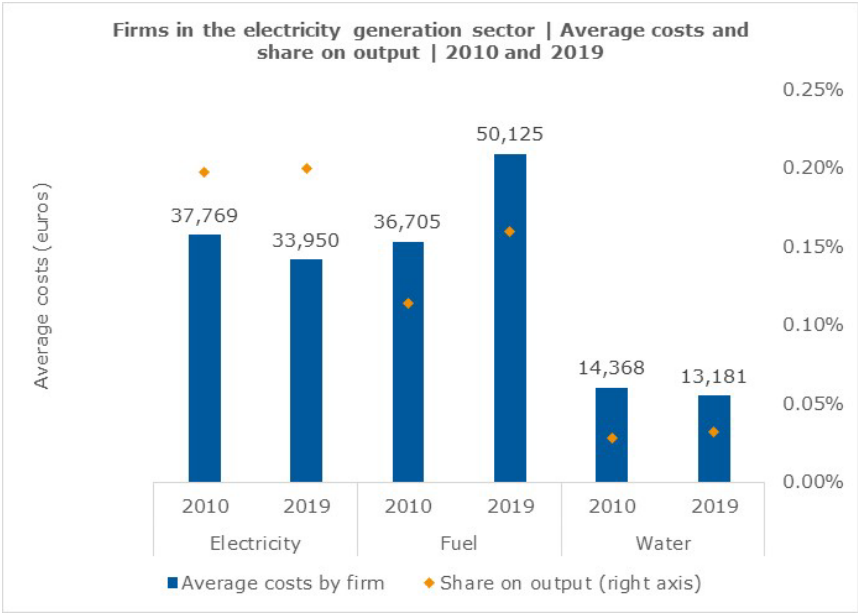
The average of workers by firm has been stable and equal to six from 2015 to 2018, and it dropped to four in 2019. There are nine firms in 2019 that employ more than 50 workers. The average labour costs closely follow the trend of the average number of workers by firm.



Source: IES

Electricity, fuel and water costs

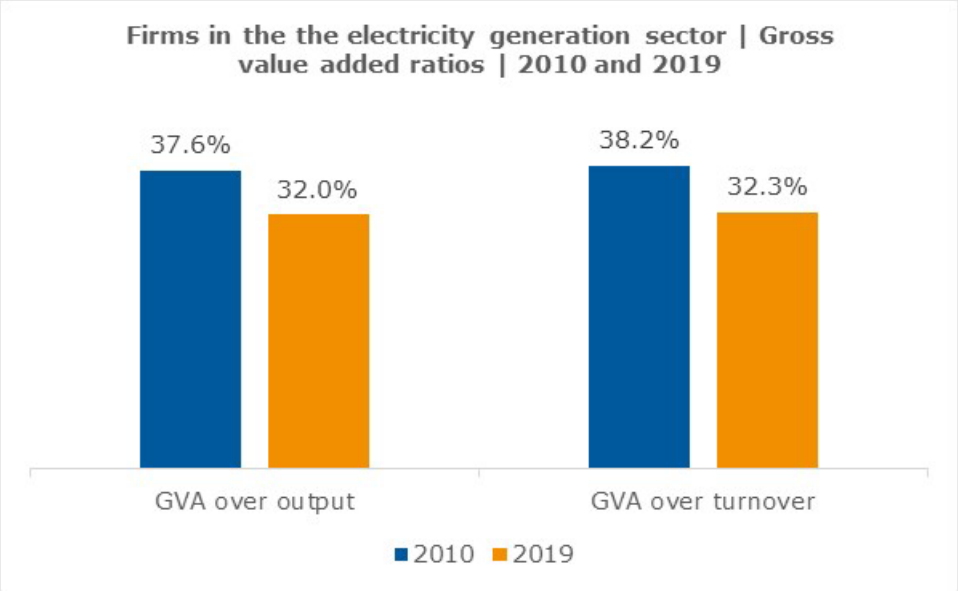
Average electricity and water costs decreased slightly from 2010 to 2019. Fuel costs increased, both in absolute and relative terms.



Source: IES

Productivity

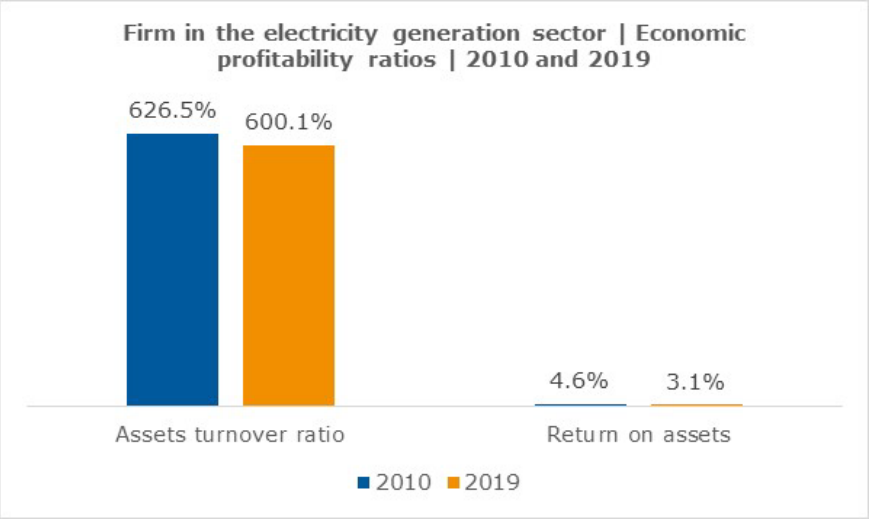
The electricity generation sector presents a decrease in the ratio of GVA to output, from 37.6% in 2010 to 32% in 2019. A similar trend is presented for the GVA over turnover.



Source: IES

Economic profitability

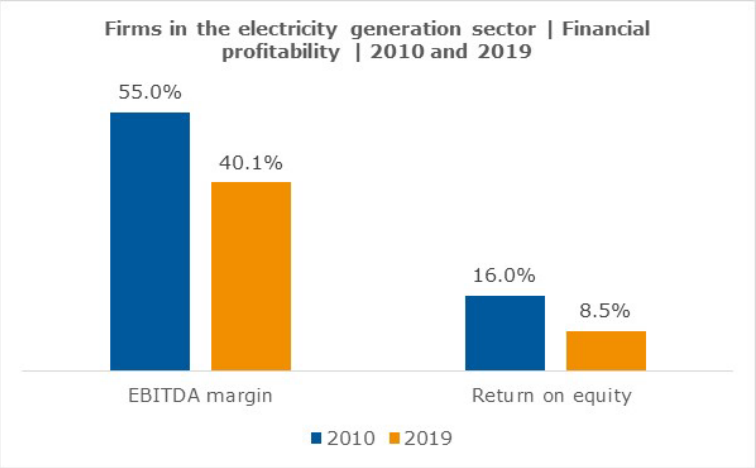
While the assets turnover ratio decreased from 2010 to 2019 from 626.5% to 600.1%, firms in the electricity generation sector are less efficient at generating profit from their assets. The ROA ratio decreased from 4.6% in 2010 to 3.1% in 2019.



Source: IES

Financial profitability

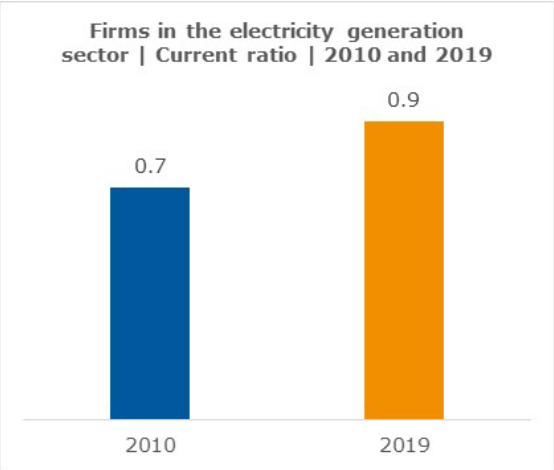
Both the earnings before interest, taxes, depreciation, and amortization as a percentage of the revenue and the ability of firms at generating from their invested capital have been reduced in 2019, when compared to 2010. The EBITDA margin went from 55.0% in 2010 to 40.1% in 2019, while the ROE ratio decreased from 16.0% to 8.5% in 2019.



Source: IES

Liquidity

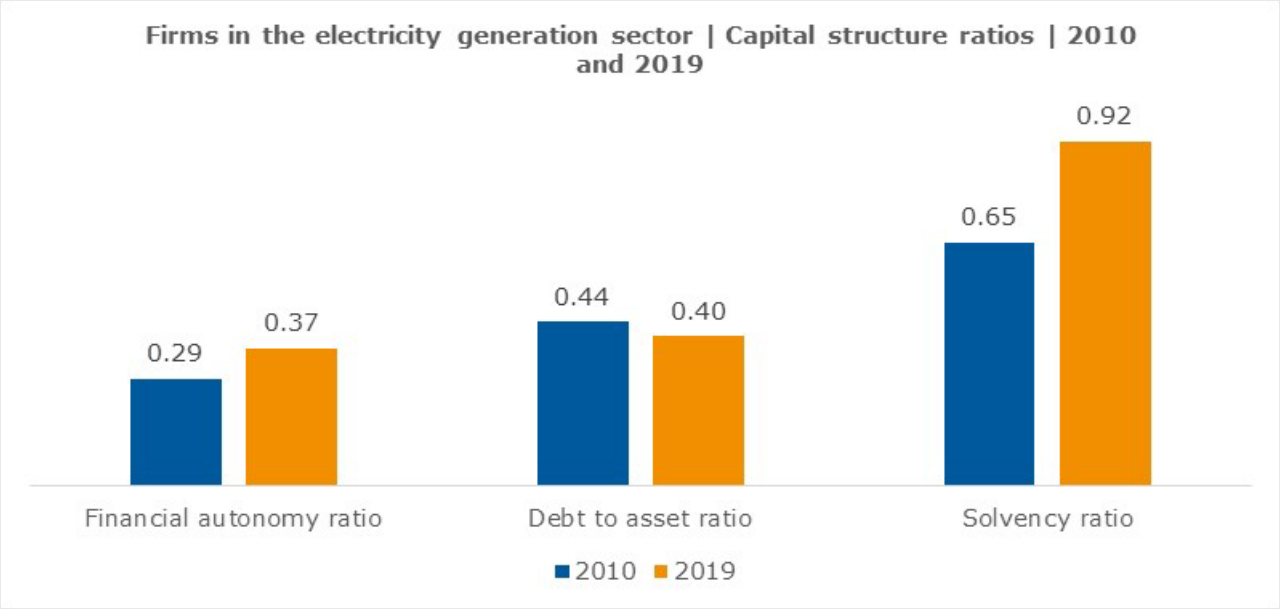
The current ratio from firms in the electricity generation sector when from 0.7 in 2010 to 0.9 in 2019, which may suggest a slightly greater ability to pay short-term obligations.



Source: IES

Structure indicators

The financial autonomy ratio grew from 0.29 in 2010 to 0.37 in 2019, suggesting that a higher proportion of assets is generated by issuing equity shares. Firms in the electricity generation sector have, on average, more assets than debts. However, there was a reduction of the debt to asset ratio, from 0.44 in 2010 to 0.40 in 2019, which reflects a lower reliance on lenders for continued solvency. The ability to meet long-term debts and obligations also increased, since the solvency ratio went from 0.65 in 2010 to 0.92 in 2019.



Source: IES

4. Conclusions

Embodied by the aspiration of becoming the world's first climate neutral continent, the EU is currently preparing a set of proposals, the "Fit for 55" package, to accomplish that vision.

Currently, the EU Emission Trading System already exists, being a key policy to reduce GHG emission by attaching a carbon price to domestic products, within selected industries. Some of these sectors benefit from free allowances to prevent carbon leakage under the EU ETS.

In the scope of the "Fit for 55" package to prevent carbon leakage, a CBAM is proposed to mirror the EU ETS, by equalizing carbon price between domestic and imported products. EU ETS' free allowances will be gradually phased-out, while CBAM enters into force for sectors with a high risk of carbon leakage and high level of emissions - aluminium, iron and steel, cement, fertilizers, and electricity generation. These sectors, which are in the *ring of fire* at decarbonization efforts, are the focus of our analysis.

At European level, these energy-intensive sectors have recently experienced an increase in energy prices and ETS indirect costs, resulting, in some case, in a loss of competitiveness and greater competition from abroad. Characterized also by high levels of emissions, these sectors underwent efforts to reduce direct emissions, being nowadays the least carbon intensive in the world, in some cases. The financial and regulatory costs are mentioned as barriers to further technological developments. Most of these sectors are very capital intensive and long-lasting capital asset industries, so 2050 is just one investment cycle away, pressuring them to act now. The evolution and future perspectives for these sectors are bounded by the European Green Deal and the New Industrial Strategy for Europe, that lead the climate and digital transitions, setting as key drivers for the industrial transformation, the global competition, climate neutrality and digital future.

Although subject to this decarbonization urgency, these sectors in the Portuguese economy are very different in their characteristics among them. The **aluminium sector** counts on 29 firms in 2019, employing more than 1300 workers, presenting some dynamism, with a relatively high share of newer firms. This sector is very reliant on capital and capital intensity has increased in recent years. Aluminium firms are dependent on the exports to European markets, which share has increased. In recent years, it was noticeable an increase in the efficiency of water and fuel use and there was an improvement in the liquidity and economic and financial profitability ratio, while the GVA of the sector also increased.

The **iron and steel sector** is the sector with the second sector highest number of firms, 313, providing more than 5,300 jobs. Most iron and steel firms are micro, characterized by high shares of tangible assets and a recent increase in capital intensity. More than 60% of sales are exported, with the countries extra-EU representing 17% of sales. While indicators suggest an improvement in efficiency in the use of utilities and in liquidity, economic and financial profitability ratios are relatively stable, compared to 2010.

The **cement sector** presents a low dynamism in last years, with only 7 firms in 2019, half of which was observed in 2010, as a result of no recent entries and the exit of micro firms. This sector provides approximately 800 direct jobs. Capital intensity has decreased, while more workers are employed by firm. The share of exports has decreased, compared to the years of 2013 to 2015. There is no evidence of efficiency improvements in the use of energy-related inputs. The ratios of liquidity, financial profitability and GVA deteriorated in recent years.

The **fertilizer sector** has 20 firms in 2019, but the number of firms presents a downward trend, to which contributes the few entries of recent years. This sector provides more than 600 direct jobs. The distribution according to size is now more biased towards small firms. Despite being a sector that heavily relies on tangible assets, the average number of workers by firm has increased. Fertilizer firms export to foreign markets, especially EU, more than 40% of their sales. Although energy-related costs are today relatively higher than in the past, the GVA has increased. However, ROA and ROE remain negative.

The **electricity generation sector** has 962 firms in 2019 and employs almost 4300 workers. This sector presents an increasing trend in the number of firms and the entrance of a relevant number of new firms in the period of analysis. The capital intensity of firms in the electricity generation sector is high, while a firm employs, on average four workers. A very high share of sales is to the domestic market. Despite the increase in liquidity, a degradation of GVA, ROE and ROA is observed.

Transformational pathways to limit global warning, which might disrupt businesses, call for action of firms, especially high-carbon intensive ones. These sectors are disproportionately affected by the urgency of decarbonization, and these changes might also affect workers and, ultimately, communities, which might justify a policy action for a just transition. The differences in importance for the Portuguese economy, in terms of number of firms, jobs and trade intensity, and recent evolution might justify the implementation of tailored policies and a sectorial approach, considering the different specificities of each sector here presented.

Glossary

The **asset turnover ratio** measures the value of a firm's turnover relative to its assets. It translates the ability of a firm at generating revenue from its assets.

Carbon Border Adjustment Mechanism (CBAM) is a system in which EU importers will buy carbon certificates corresponding to the carbon price that would have been paid, had the goods been produced under the EU's carbon pricing rules.

Carbon capture and storage (CCS) is the process of capturing carbon dioxide before it enters the atmosphere, transporting it, and storing it.

The **capital-labour ratio (K/L)** can measure the capital intensity of a given firm or sector. A higher capital-labour ratio can be the result of technological improvements from capital investments and productivity improvements.

Current ratio is a liquidity ratio that measures the firm's ability to pay short-term obligations. It is given by the ratio of current assets over current liabilities.

Debt to asset ratio is given by the ratio of firm's debt obligations, both short- and long-term debt, to total assets. If this ratio is greater than one, then firm owns more debt than assets. If it is less than one, the firm has more assets than debt. A high debt to asset ratio revels a firm or sector that has a high degree of leverage, the more a firm relies on lenders for continued solvency.

The **EBITDA margin** it is a measure of firm's operating profit as a percentage of its revenue.

The **EU Emissions Trading System (EU ETS)** is considered by the EU a fundamental tool to fight climate change by reducing certain GHG from the regulated sectors, working under the "cap-and-trade" principle. The cap limits the total amount of GHG that can be emitted by the covered sectors.

IES is the Simplified Corporate Information. It it a firm-level panel data that covers the universe of Portuguese firms that annually fulfil their reporting obligations to the Ministry of Finance, Ministry of Justice, Banco de Portugal and the Statistics Portugal (INE).

Financial autonomy ratio is given by the ratio of equity to total assets. It indicates how much of a firm's assets are generated by issuing equity shares, rather than taking debt.

Return on assets (ROA) ratio tells how much a profit the firm can generate from its assets.

Return on equity (ROE) ratio is the measure of firm's net income over its equity. It reflects how profitable a firm is, by telling how well a firm or a sector generates profit from its invested capital.

The **solvency ratio** is given by the ratio of equity over firm's liability. It translates firm's ability to meet its long-term debts and obligations.

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