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Questioni di Economia e Finanza

(Occasional Papers)

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THE CARBON FOOTPRINT OF ITALIAN LOANS

by Ivan Faiella* and Luciano Lavecchia**

Abstract

There is a growing emphasis on the possibility that climate-related financial risks – such as an abrupt transition to a low-carbon economy – might increase the financial vulnerability of borrowers with consequences for lenders and, eventually, on the financial system as a whole. This article presents a first insight on the carbon content of business loans in Italy, proposing different approaches to measure the carbon content of Italian bank loans comparing three methods of identifying the most exposed sectors. According to our estimates, the exposure of the Italian financial system in 2018 ranged between 8 and 10.2 per cent of banks' total assets. This information is the starting point from which to evaluate, within a climate-scenario framework, how different climate policies could influence the stability of the banking sector.

JEL Classification: Q54, G21, G28.

Keywords: climate change, financial stability, climate stress test, transition risk.

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* Bank of Italy, Directorate General for Economics, Statistics and Research and OIPE-Levi Cases.

**Bank of Italy, Rome Branch and OIPE-Levi Cases.

1. Introduction*

Climate-related financial risks are now part of the agenda of central bankers around the world ([Campiglio et al 2018](#); [Bolton et al, 2020](#)). Climate modifications, in terms of gradual changes in temperature and precipitation patterns as well as climate-related natural extremes ([World Bank, 2019](#), [EEA 2019](#)), and climate policies, affect the financial system through several channels ([Carney, 2015](#); [Batten et 2018](#)). More frequent and intense extreme natural events damage fixed capital (buildings, machinery, and infrastructure) hindering the ability of creditors located in the affected areas to repay their debt (**physical risk**). Energy and climate policies to achieve a transition to a carbon-free economy may influence the value of the assets of the companies in the fossil-fuel business, especially if these measures are implemented in a disorderly way (**transition risk**¹). Finally, a risk arises when people harmed by climate change ask for compensation from those who are held to be responsible, who in turn, could transfer this risk to the insurance system, if contracts have been signed to hedge these responsibilities (**liability risk**).

The quantification of these climate-related financial risks is still limited due to a severe deficiency in data availability and to the need for a forward-looking approach in evaluating risks ([Bolton et al., 2020](#)). [Dietz et al. \(2016\)](#) use a Value-At-Risk model to estimate the probability of losses on global financial assets due to climate change and find a tail risk loss involving up to 16.9 per cent of total assets or USD 24.2 trillion. In the case of Italy, there is a scant literature on the economic effects of climate-related financial risk, even though over one-third of Italian cities are located in areas at high risk of landslides and flooding ([MATTM, 2008](#))² and that even a modest rise in sea level will induce severe territorial losses due to coastal erosion ([Marsico et al. 2017](#)).³ A partial exception is the work of [Faiella and Natoli \(2018\)](#) who remark that a fifth of all outstanding loans in Italy are granted to firms located in areas that are heavily impacted by flooding: they find that lending activity is negatively correlated with flooding risk, in particular for loans granted to small and medium enterprises. [Bernardini et al. \(2019\)](#) focus on a sample of European electric utility companies in order to assess how transition risk can affect asset prices and finds a premium for the share prices of low-carbon utilities (known as a ‘greenium’). [Cahen-Fourot et al. \(2019a\)](#) estimate

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¹ The core concept of transition risk is the possibility that many carbon reserves may become unburnable under a strict climate policy ([McGlade and Ekins, 2015](#), [TFCD, 2019](#), [ClimateWise, 2019](#)). [Cui et al. \(2019\)](#) estimate that in order to limit temperature rise to 1.5°C, there should be no new coal power plants (and those currently under construction should be abandoned) while the existing ones should be closed in the next 20 years.

² According to the latest estimates by the Italian Government, in the coming years, Italy will have to spend up to €26 billion to face multiple hydrogeological risks ([ItaliaSicura, 2017](#)) and global warming is estimated to raise significantly the probability of large floods in the long run ([Alfieri et al, 2015](#)).

³ Moreover, while extreme sea level events are projected to increase their frequency at least annually in many locations by 2100, in the case of Italy this will happen by 2040, well in advance ([SROCC, 2019](#)).

that, 2.1 per cent of Italy's capital stock is at risk of being stranded, especially in the electricity and industrial sectors.⁴

In practice, it is still not clear how these risks might affect financial stability, the resilience of individual intermediaries, and, eventually, if they could disrupt the transmission channels of monetary policy and interfere with the price stability target. To better understand how climate-related financial risks might influence the Italian financial system, this article presents some evidence on the carbon content of firms' loans and proposes a simple method to spot the most exposed industries (the so called 'carbon-critical' sectors). We have devised a simple and transparent method to define an industry-level indicator for the exposure of firms' credit to transition risk. While the sectoral approach has the limit of not considering the actual exposure of the single lender, it overcomes many hurdles and, in particular, the scarcity of information that often hampers a firm-level approach. In fact, at present, the information on direct or indirect emissions of small and medium firms is in fact missing. For a few larger firms, it is possible to use their ESG (Environmental, Social and Governance) scores, provided by private firms using methods that are not always consistent (as a result, the ESG scores of individual firms show a large heterogeneity across rating agencies).⁵ In fact, there are neither broadly accepted rules for ESG data disclosure by individual firms, nor auditing standards to verify the reported data.

Our approach also has the merit of making use of wider industry coverage than other similar studies: considering all the sources of greenhouse gases (GHGs), and not only CO₂ emissions (the majority of which is linked to fossil fuels combustion), we are able to include sectors that are usually disregarded (e.g. agriculture). Finally, our method is dynamic and takes into account the development and intensity of emissions as well as the evolution of lending.

The paper is structured as follows: Section 2 accounts for GHG emissions and GHG emission intensity trends in the EU-28 and Italy. Section 3 presents different approaches to measure the carbon content of Italian bank loans, in particular a Loan Carbon Intensity (LCI) indicator computed at the sector level. To overcome some of the drawbacks of the LCI we propose, in Section 4, a different method for identifying carbon-critical sectors. Section 5 concludes.

2. Greenhouse gas (GHG) emissions in Italy

Transition risks arise from the commitments made by the international community to stabilize the atmospheric concentration of greenhouse gases. Climate policies will induce a shift to low-carbon

⁴ This share will possibly increase in the future: for example the 2017 Italian National Energy Strategy established the closure of all its 9 coal-powered power plants (8 GWe) by 2025, with an estimated cost of more than €16 billion.

⁵ See, for example, Aiello and Manzelli (2020).

energy sources, introducing either limitation of the use of fossil fuels or a system to change energy relative prices according to their carbon content (e.g. setting a carbon price or providing incentives for low carbon energy sources).

When these policies are implemented, the carbon-intensive businesses find themselves more exposed to climate-related financial risks. A crucial way to start an analysis of the carbon content of loans is to gather information on industry-specific GHG emissions.

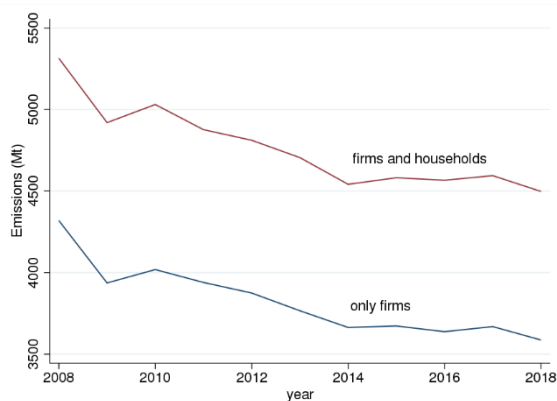
The official statistics on emissions follow the UN’s Framework Convention on Climate Change, reporting guidelines on annual GHG inventories.⁶ At the European level, Eurostat provides a very wide array of data, namely the National Accounts Matrix including Environmental Accounts (NAMEA), integrating National Accounts data with the information on GHG emissions by economic activity (NACE Rev. 2 classification⁷) with data from 2008. For Italy, there are emissions’ data for 63 divisions (out of 88), with several grouped at the section level.

According to these data, in 2017 EU-28 emissions from firms’ and households’ activities totalled more than 4,500 million tons (Mt) of carbon dioxide equivalent (CO₂e),⁸ less than one-eighth of global emissions ([Carbon Budget Project, 2019](#)). Emissions from businesses account for about 80 per cent of the total (largely stable across time and countries; Fig. 1.a)

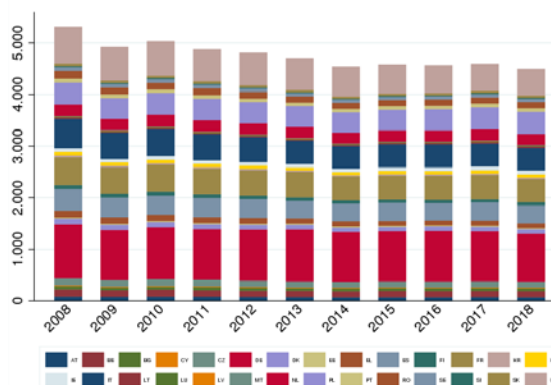
Figure 1

GHG emissions in EU-28
(Mt of CO₂e)

a) EU-28



b) by country



Source: Based on Eurostat data (table env_ac_ainah_r2).

⁶ Time series on countries’ GHG emissions, with details on sector and gases, are available at the [UNFCCC website](#).

⁷ NACE Rev. 2 (ATECO 2007 in Italy) classification has a hierarchical structure consisting of first level sections (alphabetical code), second level divisions (two-digit numerical code), third level groups (three-digit numerical code) and fourth level classes (four-digit numerical code) – Eurostat, NACE Rev.2, [Statistical classification of economic activities in the European Community](#).

⁸ CO₂e expresses the impact of different greenhouse gases in terms of the amount of CO₂ that would create the same amount of warming. Each gas is converted using its global warming potential (GWP), which describes its total warming impact relative to CO₂ over a set period, usually a hundred years. GHG emissions include CO₂, CH₄, HFC, NF₃, SF₆, N₂O and PFC.

The interesting feature of the NAMEA is the possibility of linking this information to other data on the sector coming from the National Accounts (such as value-added, employees, etc.). Merging the information on emissions with the corresponding division-level allows us to compute different estimates of GHG emission intensities. These intensities can be computed as the amount of emissions needed to produce a unit of gross valued added (in constant terms), expressed in grams of CO₂e per euro (gCO₂e/€), or the emissions associated with the use of a unit of labour input (grams of CO₂e per person employed or hours worked).

Carbon intensity is a useful complement to emission data in assessing how each sector is exposed to transition risk; stricter climate regulation (e.g. limits on the amount of CO₂ emitted per km on cars) or a higher carbon price would reduce the profitability of the firms operating in carbon-intensive sectors (see for example Fig. 6 in [Bernardini et al., 2019](#)).

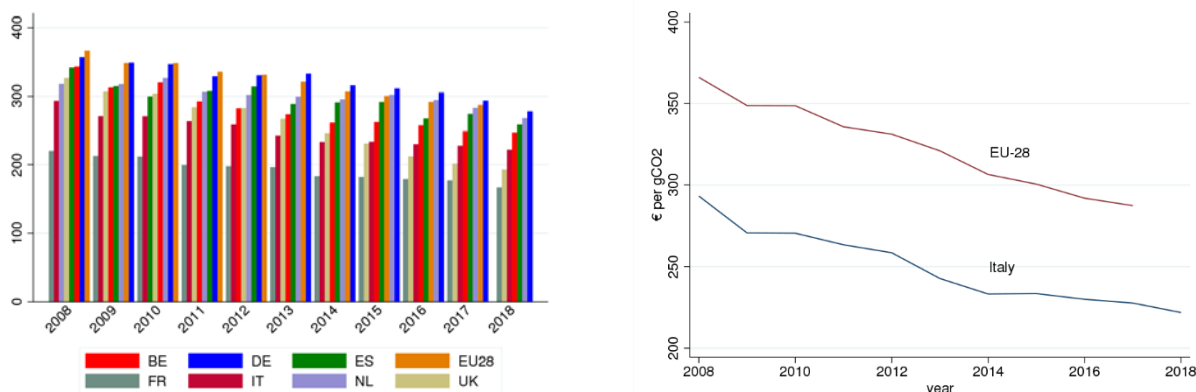
During the decade 2008-18, in EU-28 the average carbon intensity of value added amounted to 324 gCO₂e/€ lower in France, Italy, UK and Spain (respectively, 193, 249, 260 and 295 gCO₂e/€) and almost the same in Germany (323 gCO₂e/€ Fig. 2.a). Over time, it decreased by one fifth. In Italy, carbon intensity, always lower than the EU-28 average, showed a similar reduction (Fig. 2.b).

Figure 2

Average carbon intensity of the value added in Europe
(gCO₂e/€, chain linked prices, base year 2010)

a) by country

b) EU-28 vs. Italy



Source: Based on Eurostat data (Tables env_ac_ainah_r2 and nama_10_a64).

In 2018, in Italy the five (ten) most emitting sectors contributed to 60 (82) per cent of overall emissions (Table 1). Between 2008 and 2018, overall GHG emissions fell by a cumulative 26.1 per cent, a drop of 115.2 Mt of CO₂e. All but one of the 10 highest-emitting sectors reduced their emissions, and cumulatively they represent almost 85 per cent of the overall decrease.

Table 1**Emission trends of the 10 highest emitting sectors in Italy in 2018***(per cent, Mt of CO₂e, gCO₂e/€)*

Sector	Cum. growth	Δ GHG	Share of	GHG intensity of the value
	2008-18	2008-18	GHG	added (2016 at the sector level)
	%	Mt	%	gCO ₂ e/€
Electricity, gas, steam and air conditioning supply (D)	-32.2	-44.1	28.4	4,941
Crop and animal production, hunting and related service activities (A01)	-5.0	-2.0	11.8	1,471
Manufacture of other non-metallic mineral products (C23)	-49.7	-23.5	7.3	2,664
Sewerage, waste collection, treatment and disposal activities; materials recovery and Remediation activities and other waste management services (E37-E39)	-11.3	-3.0	7.2	3,515
Water transport (H50)	-13.8	-2.9	5.5	4,675
Manufacture of coke and refined petroleum products (C19)	-35.3	-9.4	5.3	11,904
Land transport and transport via pipelines (H49)	-23.8	-4.7	4.6	417
Manufacture of chemicals and chemical products (C20)	4.9	0.7	4.3	1,316
Manufacture of basic metals (C24)	-43.2	-9.9	4.0	1,245
Wholesale trade, except of motor vehicles and motorcycles (G46)	8.3	0.9	3.6	134
Total economy	-26.1	-115.2	100	221

Source: Based on Eurostat data.

The most exposed sector is Electricity, gas, steam and air conditioning supply (D, 28.4 per cent of the overall emissions in 2018) followed by Crop and animal production, hunting and related service activities (A01, 11.8 per cent) and Manufacture of other non-metallic mineral products (C23, 7.3 per cent). In terms of the carbon intensity of the value added, the national average was 221 gCO₂e/€ (Fig. 2.b, Tab.1) and three sectors exhibit very large values⁹: Manufacture of coke and refined petroleum products (C19, almost 11,900 gCO₂e/€), Electricity, gas, steam and air conditioning supply (D, ~ 5,000 gCO₂e/€) and Water transport (H50, almost 4,700 gCO₂e/€).

3. The carbon content of Italian loans

To understand the exposure of the financial system, through its loans' portfolio or, indirectly, *via* securities holding (such as equity or bonds), a classification system is necessary to discriminate between the banks' assets. In 2016, the Netherlands Central Bank ([DNB, 2016](#)) surveyed a sample of banks, pension funds and insurers, representing, on average, three quarters of their respective markets, finding that 9 per cent of their assets (bonds, equities and loans) was invested in five carbon-intensive sectors (agriculture, transport, basic industry, power generation and fossil fuels). [Battiston et al. \(2017\)](#) mapped economic activities in five climate-policy-relevant sectors (more on this approach in the following sections).

In the following sub-sections, after a brief description of loan data sources in Italy, we explore different methods to rank the loans of Italian firms according to their carbon content (a proxy of their exposure to transition risk).

⁹ Carbon intensities of valued added at sectoral level are only available up to 2016.

3.1 Data sources for the Italian credit system

We rely on the granular data from the Central Credit Register (*Centrale dei Rischi*), collected by the Bank of Italy since 1962. The Central Credit Register gathers information on all loans, guarantees and derivatives issued by banks and financial companies to all customers living in Italy.¹⁰ We extract the outstanding volume of loans to domestic firms (including households acting as entrepreneurs and excluding monetary financial institutions - MFIs) between 2010 and 2018.

This information is merged with data on GHG emissions provided by Eurostat, obtaining a joint database on loans and emissions, which is used to estimate the indicators of section 3.3 and 4. In particular, to replicate the analysis of [Battiston et al. \(2017\)](#), we extract data on loans at NACE level-4 (classes – see section 3.3) while, to develop alternative measures of the Loan carbon intensity (section 4), we extract data at, at least, NACE level-2 (divisions).

3.2 Climate-policy-relevant sectors (CPRS)

[Battiston et al. \(2017\)](#) build on a previous classification by the [European Commission \(2014\)](#) of the sectors and sub-sectors deemed to be exposed to a significant risk of carbon leakage. These sectors are assessed “*on a number of quantitative and qualitative criteria*”. Battiston et al (2017) refine this assessment, defining a correspondence between sectors at the NACE level-4 and the 5 Climate-policy-relevant sectors (CPRS):

1. **energy-intensive** (mining of metal ores and most of manufacturing activities);
2. **fossil fuel** (mining and extraction of coal and petroleum, manufacturing of coke, refined petroleum products and chemicals, and specialized construction activities);
3. **housing** (construction of buildings, including manufacturing of non-metallic mineral products and furniture);
4. **utilities** (electric power generation, transmission and distribution, including construction of utility projects);
5. **transport** (land, water and air transport, and some supporting activities).

The authors address the direct and indirect exposures, focusing on the equity holdings of the shareholders (banks, pension funds and individuals) of all EU and US listed companies, grouped by climate-policy-relevant sector. As for the loans, given the lack of granular data, they resort to an alternative (and coarser) classification at NACE 1 level (sections), estimating the exposure within the financial sector to assess the indirect effects. [ECB \(2019\)](#) adopts this classification to estimate how banks, insurers, and pension and investment funds, are exposed to transition risk, via their portfolio

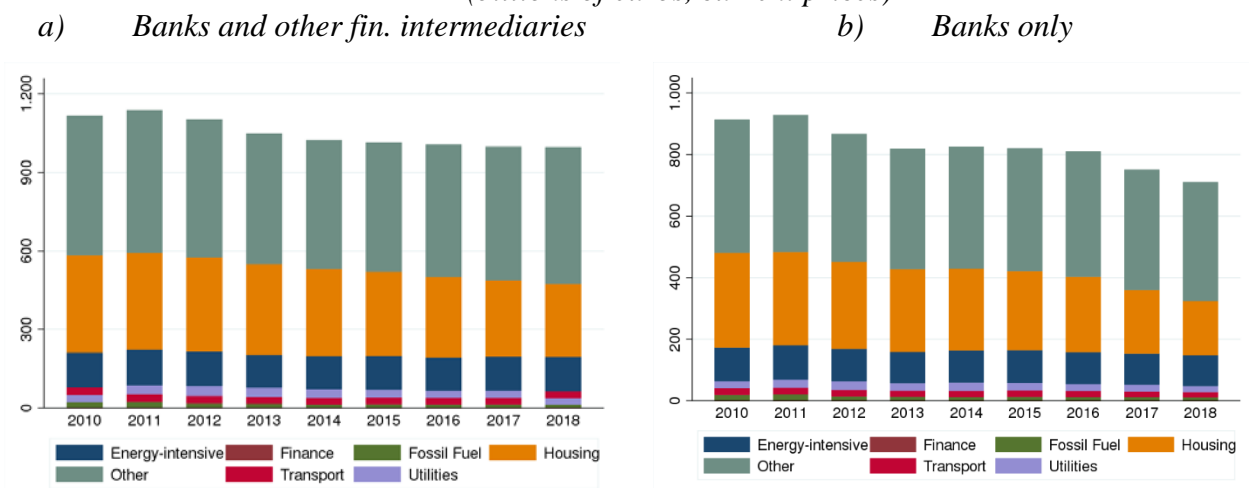
¹⁰ If the sum of all loans is over €30,000, then all loans, including those below this threshold, are reported.

investments, in terms of equity and bonds. We replicate this analysis, using granular data on loans from the Bank of Italy's Central Credit Register, disregarding both interbank lending (not captured by the Register) and equity and bonds held by banks.

Loans granted by banks and other financial intermediaries potentially exposed to transition risk according to this classification have been steadily decreasing since 2010, representing in 2018 just under half of total loans (Fig. 3.a). This trend is the result of a slight increase in the exposure of non-bank financial intermediaries and a decrease in the share of loans granted by banks to CPRSs (Fig. 3.b).

Figure 3

**Exposure of the Italian financial system to transition risk
(Climate-policy-relevant sectors - CPRS)**
(billions of euros, current prices)



Sources: Based on Eurostat and Bank of Italy Central Credit Register data.

3.3 Loan carbon intensity (LCI)

An alternative classification builds on the NAMEA information to define the climate-exposed sector and uses data on emissions at the industry level. The simplest approach is to link the information on GHG emissions with that on the distribution of loans. We collapse the granular data of the Central Credit Register at NACE level-2 on all the loans, both performing and non-performing, provided to non-financial companies and producer households for each type of financial institution between 2010 and 2018.¹¹ The information on loans, $L_{s,t}$ (in current euros), is available for sector s and year t , and merged with GHG emissions $E_{s,t}$ (in gCO₂e), using s and t as keys.

We define, for each year t , the Loan carbon intensity (LCI) as the amount of emissions per each euro borrowed by sector s . This indicator answers a very simple question: how many grams of

¹¹ Our dataset is made up of around 1,200 observations (9 years, 63 NACE sectors, 2 types of financial institution – banks vs. other financial institutions).

GHGs are emitted by sector s in year t for every borrowed euro? The answer is expressed in grams of CO₂e per euro (gCO₂e/€):

$$LCI_{s,t} = \frac{E_{s,t}}{L_{s,t}} \quad (1)$$

Between 2010 and 2018, the LCI averaged out to 330 gCO₂e/€(Table 2), with above-average values for Agriculture, Manufacturing, and, not surprisingly, Energy (Fig 4.a).

Table 2

Loan carbon intensity (LCI) per year
(gCO₂e, billions of euro, gCO₂e/€)

	Emissions (10 ¹² gCO ₂ e) (a)	Loans (10 ⁹ €) (b)	LCI (gCO ₂ e/€) (a/b)
2010	392.0	1,116.2	351.2
2011	384.6	1,139.3	337.6
2012	367.3	1,104.0	332.8
2013	339.5	1,050.5	323.2
2014	326.4	1,024.9	318.5
2015	329.6	1,015.0	324.7
2016	329.0	1,006.4	327.0
2017	331.9	999.1	332.2
2018	326.3	997.6	327.1

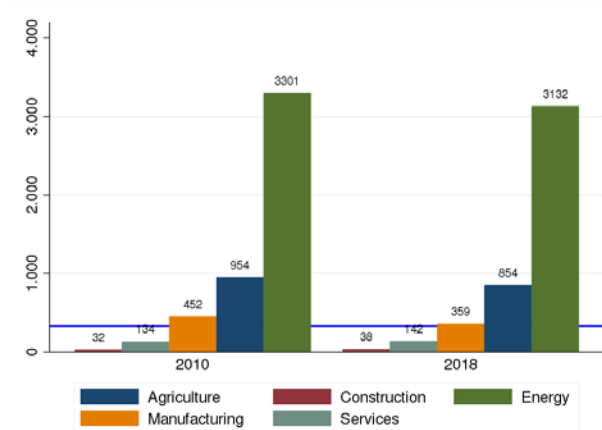
Sources: Based on Eurostat and Bank of Italy Central Credit Register data.

Over the period considered, the LCI of Construction increased significantly (+19 per cent) while there was a reduction in Manufacturing, Agriculture and Energy (-21, -11 and -5 per cent respectively) (Fig 4.b).

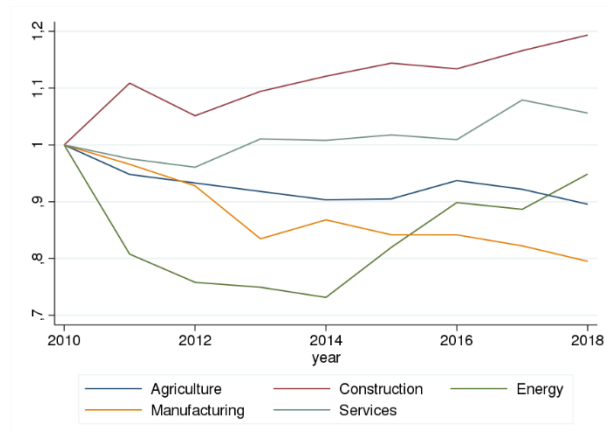
Figure 4

LCI per main economic sector
(gCO₂e/€, base year 2010)

a) LCI in selected years



b) Trend 2010-18



Sources: Based on Eurostat and Bank of Italy's Central Credit Register data.

Focusing on the 10 highest emitting sectors (Table 3), we find that, between 2010 and 2018, the LCI was substantially stable in most sectors. It increased by more than 50 per cent in Water transport (H50), because of a sizable rise in emissions, and by 30 per cent in Manufacture of coke and refined petroleum products (C19), due to a sharp reduction in loans. It decreased by more than 30 per cent in Manufacture of basic metals (C24), and by 17 per cent in Manufacture of other non-metallic mineral products (C23).

Table 3

LCI of the 10 highest emitting sectors
(gCO₂e/€)

Sector	2010	2014	2018
Electricity, gas, steam and air conditioning supply (D)	3.773	2.510	3.444
Crop and animal production, hunting and related service activities (A01)	960	867	860
Manufacture of other non-metallic mineral products (C23)	2.307	2.082	1.914
Sewerage, waste collection, treatment and disposal activities; materials recovery and Remediation activities and other waste management services (E37-E39)	3.120	2.920	3.069
Water transport (H50)	1.851	1.562	2.831
Manufacture of coke and refined petroleum products (C19)	2.080	3.023	2.788
Land transport and transport via pipelines (H49)	910	973	792
Manufacture of chemicals and chemical products (C20)	1.340	1.351	1.411
Manufacture of basic metals (C24)	1.110	882	747
Wholesale trade, except of motor vehicles and motorcycles (G46)	118	135	126
Total economy	351	318	327

Source: Based on Eurostat and Bank of Italy Central Credit Register data.

This approach can be useful in order to compare the carbon exposure across European countries, even if these comparisons should be considered with caution because bank funding is only one of the possible sources of funding, although an important one according to the EU's Financial Accounts ([European Commission, 2017](#)).¹²

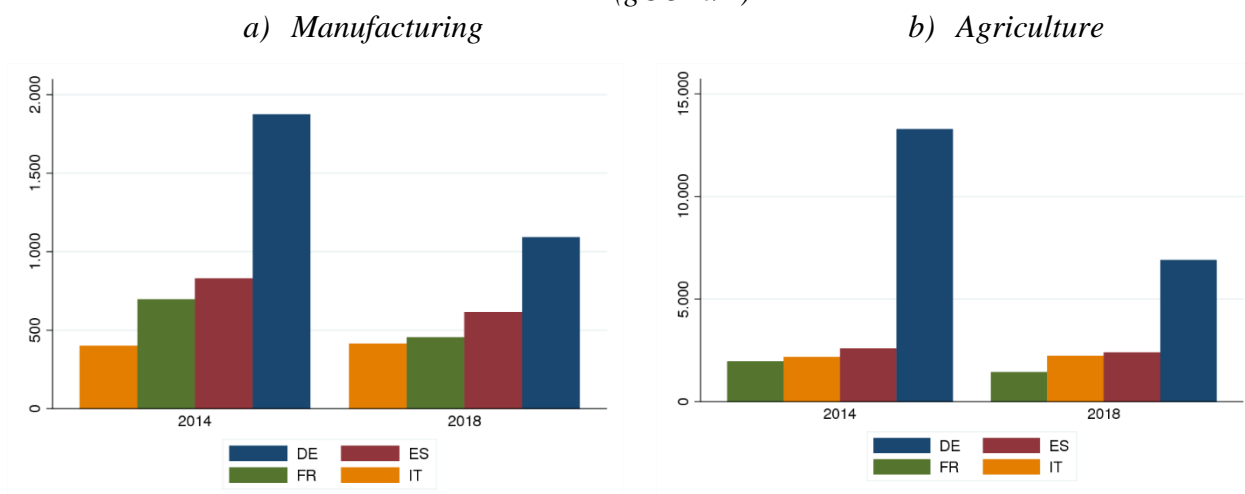
Using ECB Consolidated Banking data (CBD) it is possible to compute and compare LCI across countries and sectors, merging the NACE level-1 information on loans with NAMEA. For example in 2014, the LCI of German manufacturing was almost twice that of Spain and 4 times that of Italy. In 2018, these differences decreased due to a steep reduction of the LCI in Germany (Fig. 5.a). The evidence for the agricultural sectors is similar (Fig. 5.b).¹³

¹² This is especially true for large corporations, which can easily resort to other sources of funding such as equity or bonds.

¹³ For a more comprehensive comparison, see Aiello and Manzelli (2020).

Figure 5

LCI of manufacturing and agriculture in selected European countries
(gCO₂e/€)



Sources: Based on Eurostat and ECB data

The LCI can be used to define a threshold to spot more exposed sectors: for example between 2010 and 2018, the industries with an above-the-median LCI accounted for 34 per cent of all loans and 93 per cent of all emissions.

The LCI is very straightforward to compute, but it suffers from two problems. One is the difference in the underlying firms' populations when one considers the estimates of emissions and loans. As we mentioned previously, for European comparisons, not all the firms in a sector borrow money from the financial system; therefore simply dividing the total emissions by the amount of credit provides a biased LCI estimator, with a bias that grows with the firms' propensity to finance their activities using alternative funding sources. The use of Central Credit Register data partially solves this problem, as it includes loans from all financial intermediaries (not only banks). Moreover, a comparison of the number of employees working in the total private sector, complemented by a further check on the figures for Non-construction industry and Construction, shows no significant difference between data in the Central Credit Register and the official number published by Istat.¹⁴

The second issue is that the LCI mixes up two phenomena: the index can classify as carbon intensive a sector with average emissions and a low volume of loans (for example sector T) while ranking as insignificant an industry with high emissions and a very significant volume of loans (for example sector F – Fig. 6).

¹⁴ At present, the quality of the information in the Central Credit Register at a more detailed sectoral level is more difficult to assess and beyond our scope.

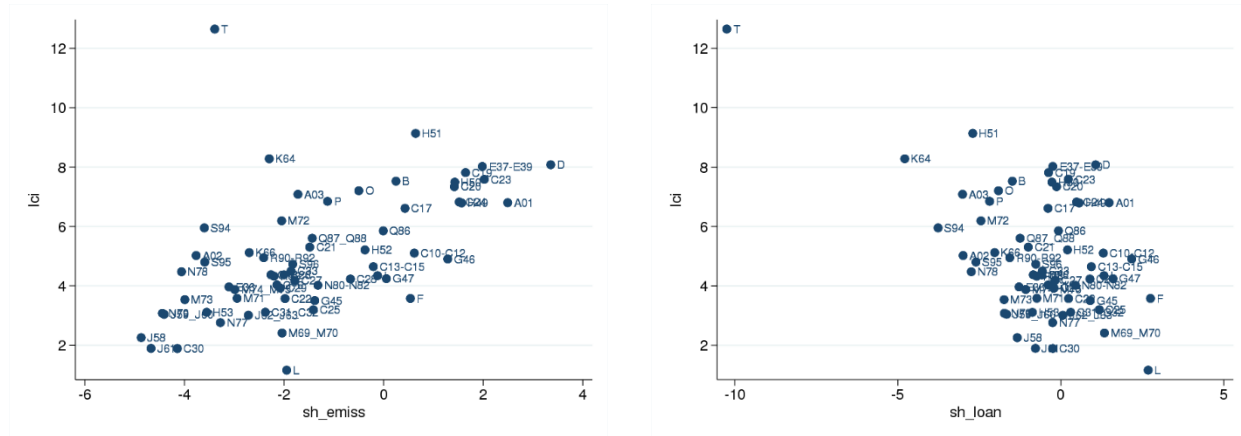
To overcome this limit, we propose a method that takes into account at the same time the contribution of a sector in terms of its GHG emissions and loans, a sector that we deem as “Carbon-Critical” (CCrS).

Figure 6

Loan carbon intensity, emissions and loans in 2016
(logs of LCI and logs of share of emissions and loans)

a) LCI vs. share of emissions

b) LCI vs. share of loans



Sources: Based on Eurostat and Bank of Italy Central Credit Register data. The legend of the sectors is in the Appendix.

4. A proposal for identifying carbon-critical sectors (CCrS)

In order to spot carbon-critical sectors (CCrS), we create two separate rank variables that provide information on sectors’ share of total emissions - $rank_t(E_{s,t})$ - and total loans - $rank_t(L_{s,t})$. We took the simple average of these ranks, obtaining a measure of the relevance of each sector in terms of emissions and exposure to the financial sector ($avg_rank_{s,t}$). There is a significant degree of concentration, with only a fifth of the sectors considered capturing half of the loans and 80 per cent of emissions (Fig. 7.a and 7.b). Therefore, we define as carbon-critical sectors (CCrS) those whose simple average of the aforementioned ranks is in the first fifth of the distribution of $avg_rank_{s,t}$.¹⁵

The rationale of this approach is to focus, each year, only on those sectors that are more critical in terms of emissions and loan exposure. Using the notation adopted before:

$$CCrS_s = \text{average} \left(rank_t(E_{s,t}), rank_t(L_{s,t}) \right) < q_1 \quad , \quad (2)$$

where q_1 is the first quintile of the distribution of avg_rank .

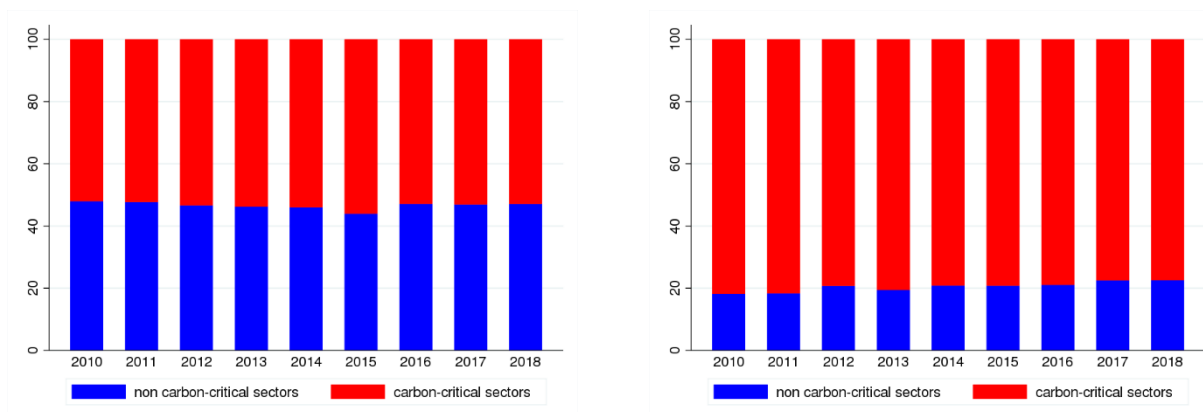
¹⁵ Between 2010 and 2018 these are: A01, C10-C12, C13-C15, C23, C24, D, E37-E39, F, G46, G47, H49 and I. C19 between 2010 and 2011; C20 between 2012 and 2018; C28 only in 2015. For the legend of the sectors see the Appendix.

Figure 7

Loans and emissions: carbon-critical vs. other sectors
(percentage points)

a) Loans

b) Emissions



Sources: Based on Eurostat and Bank of Italy Central Credit Register data.

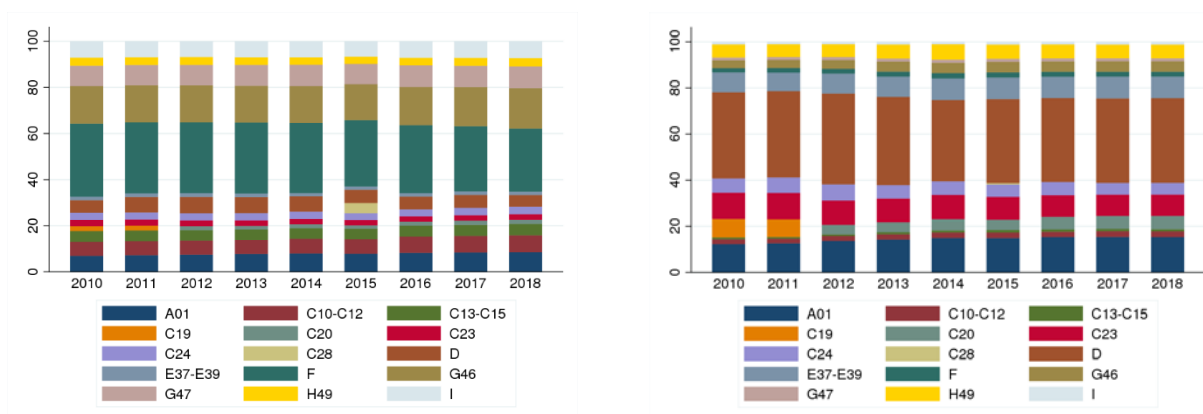
Among the carbon-critical sectors (CCrS, Construction (F), Manufacture of machinery and equipment (C28) and Wholesale and retail trade (G46+G47) account for one third of the loans (Fig. 8.a) but less than 6 per cent of GHG emissions (Fig. 8.b). On the opposite side, the three most emitting sectors, account for half of the emissions but only a tenth of loans.¹⁶

Figure 8

Loans and emissions: carbon-critical sectors in detail
(percentage points)

a) Loans

b) Emissions



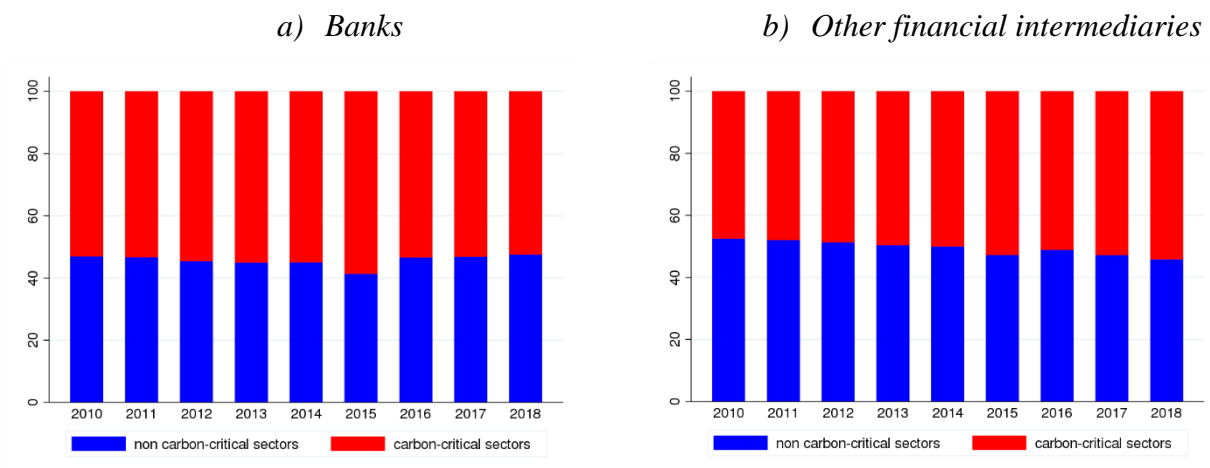
Sources: Based on Eurostat and Bank of Italy Central Credit Register data. The legend of the sectors is in the Appendix.

¹⁶ They are Electricity, gas, steam and air conditioning supply – D; Agriculture - Crop and animal production, hunting and related service activities – A01; Manufacture of other non-metallic mineral products – C23.

Overall, the exposure of the financial system towards CCRs amounts to 53 per cent of total loans (Fig. 7.a); while the exposure of the banking system has been (slightly) decreasing, that of the other financial intermediaries has been continuously increasing (Fig. 9.a and 9.b)

Figure 9

Exposure of the financial system to the transition risk – by type of intermediary
(percentage points)



Sources: Based on Eurostat and Bank of Italy Central Credit Register data.

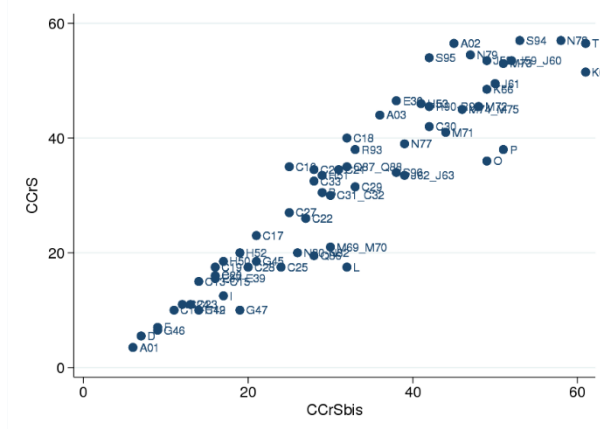
In order to check the robustness of our indicator, we rank the sectors using GHG emissions per unit of gross value added instead of GHG emissions (CCrS^{bis}, see eq. 3).

$$CCrS_s^{bis} = \text{average} \left(\text{rank}_t(E_{s,t}/VA_{s,t}), \text{rank}_t(L_{s,t}) \right) \quad (3)$$

Using one or the other indicator leaves the ranking substantially unchanged (Fig. 10), thus giving the user the freedom to choose one or the other according to data availability.

Figure 10

Two different indicators of carbon-critical sectors (year:2016)



Sources: Based on Eurostat and Bank of Italy Central Credit Register data. See the Appendix for the legend of the sectors.

5. Conclusions and further research

There is a growing appetite for understanding the exposure of the financial sector to climate-transition risk. This is a key starting point in order to evaluate, within a climate-scenario framework, how different climate policies (e.g. different hypotheses of carbon taxation) might impact the financial sector. Some supervisors have started to publish some analyses ([DNB, 2016](#); [ECB, 2019](#)) but the different approaches remain rather fragmented.

To the best of our knowledge, this is the first exercise that assesses total loan exposure, from banks and other non-bank financial intermediaries, whereas previous works focused on equity and bonds (mostly referring to the classification proposed in [Battiston et al, 2017](#), i.e. Climate-policy-relevant sectors (CPRS) or just a sample of loans ([DNB, 2016](#)).

Our focus on loans should provide a fair proxy of the exposure of the entire Italian financial system. The exposure of banks' via their portfolios (equity and bonds issued by climate-exposed sectors) is not particularly significant in Italy and so it is not included. In the end, we disregard around a tenth of total assets, given the predominance of loans and sovereign bonds in banks' balance sheets (68 and 11 per cent of their assets, respectively, at the end of 2018).¹⁷ In particular, loans to firms totalled slightly less than one third of all banks' total assets at the end of 2018. We also ignore interbank lending, that again represents a small share of banks' balance sheets (less than 3 per cent of total assets).

We analyse different approaches to measure the carbon content of Italian bank loans, comparing three methods to identify the most exposed sectors: the Climate-policy-relevant sectors (CPRS), those with an LCI greater than the median, and carbon-critical sector (CCrS) indicator computed at the sector level.

The CPRS approach is a good starting point because it is widely adopted in the financial community but it does not consider some sectors (e.g agriculture) that contribute significantly to total emissions. The Loan carbon intensity (LCI) is very straightforward to compute and it provides industry-level data on the emissions embedded in each euro borrowed. To overcome some of the drawbacks of the LCI method, we propose a simple and transparent alternative to define a set of carbon-critical sectors (CCrS).

According to our estimates, the exposure of the Italian financial system in 2018 ranged between 37 (LCI) and 53 (CCrS) per cent of total loans, representing 9.9, 12.9 and 14.4 per cent of banks' total assets (for LCI, CPRS and CCrS respectively; Table 4).

¹⁷ According to ECB evaluations, banks' portfolio exposure to CPRS (equity and bonds only) for the euro area as a whole is around 1 per cent of total holdings (ECB, 2019).

Table 4

Exposure of the Italian financial system at the end of 2018
(billions of euros and percentage points)

Method	Outstanding loans		Share of total loans		Loans as a share of total assets
	Total	Banks only	Total	Banks only	
CPRS	473.9	323.9	47.5	45.6	12.9
LCI > median	364.2	273.4	36.5	38.5	9.9
CCrS	528.0	372.8	52.9	52.4	14.4

Sources: Based on Eurostat, and Bank of Italy Central Credit Register data and Financial accounts.

What does our evidence mean for the resilience of the Italian financial system to climate risk?

We think there is light and shadow.

In Italy the implicit level of carbon pricing is already high ([Faiella and Cingano, 2015](#)): one can imagine that the level of carbon taxation needed to achieve the new ambitious European targets¹⁸ would take its toll on the real economy. Indeed, increasing energy prices further could in turn reduce firms' competitiveness ([Faiella and Mistretta, 2015](#); [Faiella and Mistretta, 2020](#)) and increase the share of energy-poor households ([Faiella and Lavecchia, 2015](#)).

However, there are also reasons to be more optimistic about the resilience of the Italian economy in adapting to these new challenges. Italy has already significantly reduced its emissions,¹⁹ reaching all its 2020 climate and energy targets ([PNEC, 2019](#)). The carbon footprint of Italy's energy system is quite small compared with other EU countries, also thanks to the fact it has one of the smallest energy intensities in the OECD countries (IEA, 2016) and it will get smaller.²⁰ Finally, as the LCI shows, in Italy the carbon content of loans is rather small compared to the LCI of other EU-peers.

Finally some methodological considerations. We are aware of the limits of sectoral data, and in particular that they do not allow us to take into consideration the large differences in production processes and technologies, and that they are an imperfect substitute for firms' actual emissions ([ECB, 2019](#)). Nevertheless, we think that industry-level information can be a valuable starting point given the lack of good quality and comparable firm-level data; the high costs of acquiring such data

¹⁸ The new targets of the European Green Deal imply a significant reduction of the emissions: between 2020 and 2030 Italy should double its efforts, reducing its yearly emissions by 16 MtCO_{2e}, compared to 7 MtCO_{2e} for the previous target.

¹⁹ In 2017 Italy total emissions were 105 Mt lower than the reference year (1990), a reduction by 20.44 per cent (UNFCCC, - [link](#))

²⁰ Italy has planned to shut-down its coal-powered power stations by 2025; the Italian cars are among the most efficient in Europe with a significant penetration of natural gas in the transport sector (including the plan to use biogas and to extend gas use in tracks and shipping); there is a big potential for improving energy efficiency and renewable deployment in the building sector.

([Monnin, 2018](#)); and the limitations of using ESG scores as proxy information for climate risk ([IMF, 2019](#)).

LCI and CCrS have the merit of being built using a standard method of classification (the NACE codes) available at EU level; moreover, they take into account all sources of greenhouse gases (GHGs) in addition to CO₂ from fossil fuel combustion; finally, they are dynamic considering directly the evolution of emissions and emission intensity. There is only a partial overlap between the sectors considered - CCrS and those with an above-the-median LCI. We have a preference for the CCrS approach because it contains information on the importance of both loans and emissions.

Further refinements of these indicators could include an evaluation of the sectors most exposed to carbon content along the value chain (e.g. using input-output matrices as described in [Cahen-Fourot et al., 2019b](#)) and a correction that considers that not all the emissions produced by a sector correspond exactly to the sectors' loans (e.g. because the financing of the underlying activity uses different sources of funding). Moreover, to consider the total exposure of the banking system as a whole, the exposure via equity and bonds held by each bank in the critical sectors should be included.

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Appendix

NACE code	Description
A01	Crop and animal production, hunting and related service activities
A02	Forestry and logging
A03	Fishing and aquaculture
B	Mining and quarrying
C10	Manufacture of food products
C11	Manufacture of beverages
C12	Manufacture of tobacco products
C13	Manufacture of textiles
C14	Manufacture of wearing apparel
C15	Manufacture of leather and related products
C16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C17	Manufacture of paper and paper products
C18	Printing and reproduction of recorded media
C19	Manufacture of coke and refined petroleum products
C20	Manufacture of chemicals and chemical products
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C22	Manufacture of rubber and plastic products
C23	Manufacture of other non
C24	Manufacture of basic metals
C25	Manufacture of fabricated metal products, except machinery and equipment
C26	Manufacture of computer, electronic and optical products
C27	Manufacture of electrical equipment
C28	Manufacture of machinery and equipment n.e.c.
C29	Manufacture of motor vehicles, trailers and semi
C30	Manufacture of other transport equipment
C31	Manufacture of furniture
C32	Other manufacturing
C33	Repair and installation of machinery and equipment
D	Electricity, gas, steam and air conditioning supply
E36	Water collection, treatment and supply
E37	Sewerage
E38	Waste collection, treatment and disposal activities; materials recovery
E39	Remediation activities and other waste management services
F	Construction
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G46	Wholesale trade, except of motor vehicles and motorcycles
G47	Retail trade, except of motor vehicles and motorcycles
H49	Land transport and transport via pipelines
H50	Water transport
H51	Air transport
H52	Warehousing and support activities for transportation
H53	Postal and courier activities

I	Accommodation and food service activities
J58	Publishing activities
J59	Motion picture, video and television programme production, sound recording and music publishing activities
J60	Programming and broadcasting activities
J61	Telecommunications
J62	Computer programming, consultancy and related activities
J63	Information service activities
K64	Financial service activities, except insurance and pension funding
K65	Insurance, reinsurance and pension funding, except compulsory social security
K66	Activities auxiliary to financial services and insurance activities
L	Real estate activities
M69	Legal and accounting activities
M70	Activities of head offices; management consultancy activities
M71	Architectural and engineering activities; technical testing and analysis
M72	Scientific research and development
M73	Advertising and market research
M74	Other professional, scientific and technical activities
M75	Veterinary activities
N77	Rental and leasing activities
N78	Employment activities
N79	Travel agency, tour operator and other reservation service and related activities
N80	Security and investigation activities
N81	Services to buildings and landscape activities
N82	Office administrative, office support and other business support activities
O	Public administration and defence; compulsory social security
P	Education
Q86	Human health activities
Q87	Residential care activities
Q88	Social work activities without accommodation
R90	Creative, arts and entertainment activities
R91	Libraries, archives, museums and other cultural activities
R92	Gambling and betting activities
R93	Sports activities and amusement and recreation activities
S94	Activities of membership organisations
S95	Repair of computers and personal and household goods
S96	Other personal service activities
T	Activities of households as employers; undifferentiated goods