Energy transition and financial stability. Implications for the Spanish deposit-taking institutions

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Abstract

In recent years, global warming and climate change have become highly prominent among society's main concerns. Most countries are adopting strategies to reduce greenhouse gas emissions as a way of mitigating their associated risks. The financial sector is also exposed to risks in this process. These risks are of two types: i) physical; and ii) energy-transition related. This paper focuses on the latter type of risk, which may impact the credit quality of exposures to the potentially most affected sectors. In the case of Spain, such exposures represent around 25% of the portfolio of loans for productive activities. A retrospective analysis shows that, following the global financial crisis, the non-performing loan ratio in these sectors has been lower than in others. However, this may be a consequence of specific factors that could disappear in an energy transition scenario, when the costs of pollution generated in these sectors are internalised in total costs and they face a more competitive environment. In addition, the question of whether financial regulation should play some role in this transition process is considered.

1 Introduction

The consequences of climate change associated with global warning and the quality of the air we breathe have, in recent years, become very prominent among society's main concerns. Indeed, such concern is no longer limited exclusively to the advanced economies, but also extends to emerging economies. Given that scientific evidence shows that this phenomenon is associated with economic (and human) activity and, specifically, with the emission of greenhouse gases into the atmosphere [IPCC (2013)],[1] many countries have agreed voluntarily to emission reduction targets.

From an economic perspective, the emission of pollutants is considered to be a "negative externality" [Pigou (1920)]. Since polluters do not take into account the cost to society of their emissions when they make their production decisions, the free market leads to a higher level of emissions than is socially optimal. This justifies regulatory intervention to internalise the social cost of emissions in the polluter's decisions.

The European Union (EU) is one of the political entities most involved in these reduction targets for greenhouse gas emissions and air pollutants. In fact, following

1 Greenhouse gas emissions are also the main cause of air pollution.

the logic of internalisation of the social costs of their emission, in 2005, it created the world's first international trading system for CO_2 emission rights [Convery (2009)]. European firms that emit greenhouse gases in their productive activity buy and sell such rights on this market, in order to be able to carry on their activity.

Historically, this cost internalisation process has tended to rely on the use of taxation measures, whereby the more one pollutes the more one pays [Climate Leadership Council (2018)]. However, more recently, it has begun to be recognised that these policies of increasing the costs of emitters have their limitations. This is because they mostly fall on the market price of the polluting intermediate inputs (e.g. petroleum products) and, naturally, these prices will be adjusted downwards precisely as a result of the reduction in demand caused by the fact that this tax makes the product relatively more expensive. For this reason, many new environmental regulations also impose quantitative limits on certain activities and establish new production standards. In addition, there are also many initiatives that subsidise less polluting alternatives or that encourage the development of non-polluting technologies [European Commission (2018)].

Greenhouse gas emissions and their climate-change implications are obviously a global problem and, therefore, to be effective, public policies need to be applied globally. This means that international cooperation is essential. However, air pollution and its associated health problems are local problems that can be resolved without the need for international cooperation and, consequently, effective regulatory intervention is easier to implement. In this respect, addressing the problem of air pollution is a natural starting point for environmental policy.

However, there are also two other factors that may be working in the same direction and are, probably, also global in scope.

First, technological change, the factor that may potentially drive, on a more permanent basis, the transition towards a more environmentally sustainable economy [Vermeulen et al. (2018)]. The development and adoption of less polluting productive technologies appears to be the most feasible alternative for businesses and authorities to achieve an ongoing reduction in particulate pollution in the atmosphere, leading to an ever cleaner economy.

Second, consumer preferences. If society is becoming increasingly aware of the risk of emissions, it is very likely that this will boost the demand for less polluting products, leading to a change in relative prices in favour of a more environmentally respectful ("greener") economy, more orientated towards producing more ecologically [Kok (2013)].

In the case of Spain, proposals from across the political spectrum coincide in the need for a set of initiatives addressing climate change to be developed and implemented, by means of a law providing for the action that needs to be taken if the pollutant emission reduction targets established are to be achieved. These initiatives have been embodied in the draft climate change and energy transition bill. The actions proposed in the draft bill affect every economic sector and most regulatory and supervisory bodies. In the specific case of the Banco de España, Article 26, provides as follows:

> "The Banco de España, the National Securities Market Commission and the Directorate General of Insurance and Pension Funds, within the sphere of their respective competences, shall jointly prepare, every two years, a report on the assessment of the risk to the Spanish financial system arising from climate change and the policies to combat it, which will be coordinated under the auspices of the Spanish Macroprudential Authority - Financial Stability Board (AMCESFI). The report shall include any suggestions that may be considered appropriate to mitigate the risk and will be published and sent to the Parliament."

Moreover, the draft bill requires securities-issuing companies, credit institutions, insurers and other significant companies to provide more extensive information on the financial impact of the risks associated with climate change. Notwithstanding, the truth is that the financial sector as a whole and credit institutions in particular should actively involve themselves in this process of fighting climate change and energy transition. First, on account of the significant risks it poses to their activity, but also because there is a broad range of opportunities involved that they cannot afford to miss.

Many central banks and financial system supervisors are assuming a very active role in the environmental field. In December 2017, an international forum called *Network for Greening the Financial System* (NGFS) was set up, with the aim of boosting the role of the financial system in this process by means of coordination at international level [G-20 Green Finance Study Group (2016)]. Various working groups have been set up within this forum, to share experiences and discuss various related aspects, such as taxonomy definition, risk identification, scenario development, prudential regulation options, etc.[2] This momentum is also spreading to financial industry supervisors at the European (EBA, ESRB) and international levels (FSB).

The Banco de España is an active member of these fora and is beginning to design the framework for carrying out this analysis and the way it will transmit it to the institutions subject to its micro- and macroprudential supervision. In this respect, the starting point has to be an analysis of the financial risks arising from climate change and air pollution, from the policies to combat them, and from the technological innovations and demand-pattern changes mentioned above. These risks can be

2 For further information on the membership, organisation, functioning and work of the NGFS, see: https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system.

divided into two categories: physical risks and transition risks [Bank of England (2018)].

Physical risks are those that are more likely to materialise as the global temperature rises, i.e. when climate change has already begun to occur. This may generate extreme climate phenomena (droughts, floods and other natural disasters) with potential implications for the credit, market and operational risks of deposit-taking institutions. For example, an increase in sea level may mean that some coastal housing is no longer habitable and thus its value as mortgage collateral disappears. These climate events may also severely affect certain economic sectors (e.g. agriculture and tourism), raising the probability of default on credit exposures or reducing the value of collateral, and ultimately impacting banks' profit and loss accounts. In general, these risks are more difficult to measure and will presumably only materialise if the policies to reduce greenhouse gas and pollutant emissions are unsuccessful. Accordingly, if they do arise, they can be expected to do so over a longer horizon.

Transition risks, for their part, can arise from the process of adjustment towards a low-carbon economy. That is to say, they would appear as a consequence of the implementation of policies to curb climate change, the emergence of new "greener" technologies that are disruptive of the currently dominant ones, or changes in consumer preferences towards less polluting products. If these measures are adopted progressively, so that agents can gradually adapt to the changes, the costs of implementing them will be lower. However, the later they are adopted the more aggressive they would have to be, which would multiply their adverse impact.

In any event, this will mean that certain economic sectors or activities will be penalised, while others are boosted. Accordingly, there is a credit risk for financial institutions associated with their financing (granted loans and bonds) for those companies more adversely affected by these changes, and also arising from the value of collateral items, such as housing and vehicles, that do not comply with new emissions standards. There is also a market risk associated with the yields required from more polluting economic activities and a reputational-type risk. In this context, the cost of the transition will also be lower the more readily resources can be reallocated across sectors and firms.

Although there are, admittedly, certain methodological challenges involved in measuring these environmental risks, institutions should already be considering the transition risk. In this respect, the analysis of potential changes in the business environment that may affect company solvency is clearly an essential part of risk assessment and management within the financial system, regardless of whether the changes originate from technology, customer behaviour, regulation or the natural environment.

At the same time, we should not lose sight of the fact that the environmental transition is planned and has been announced. As we know, the European Commission has established the target of attaining a zero-carbon economy by 2050. Evidently, achieving this objective will necessarily involve regulatory and structural changes in the economy that will particularly affect certain sectors. Accordingly, this transition cannot be said to be unannounced or a surprise.

In conclusion, banks should currently be capable of evaluating and measuring these transition risks. Naturally, the appropriate measurement of such environmental risks should itself boost the transition towards a more sustainable economic model. Indeed, an essential element of any viable business model is the need for banks to identify, quantify and reflect in prices and capital all the costs and risks incurred. Therefore, if banks incorporate climate risks into cost and capital they will indirectly become "facilitators" of change, by reducing the cost of financing for those activities that contribute most to the sustainable transformation of the economy, while discouraging the most polluting activities.

Redirecting flows of financing towards more environmentally sustainable activities is a pre-requisite for the success of the transition process and for exploiting the attendant opportunities. It is in this context that discussions in international fora are focusing on whether prudential regulation has an additional role to play and the most effective way of doing so.

In line with the European Central Bank [ECB (2019)], this article explores the transition risks. The challenge is very complex, for various reasons. First, there is a serious lack of data, as firm-level information on CO_2 emissions is not available. This means that the analysis can only be performed at sector level. Thus, the results presented here should be interpreted with great caution, given the significant heterogeneity existing within each sector. In this respect, it seems clear that not all the firms in each sector will be favoured or prejudiced to the same extent. There is also a lack of information at the individual household level on the environmental classification of housing, so that the analysis of this sector is very limited.

A second difficulty arises from the fact that identification of the sectors potentially most affected cannot be static, since the adoption of measures or technological changes that may arise will foreseeably mean that they adjust and, in consequence, reduce their emissions. For this reason the analysis presented here should be understood as the initial phase of an evolving process.

The third difficulty arises from the fact that the sectors most affected by these risks will foreseeably be subject to processes akin to an industrial regeneration, which they have obviously not yet experienced, so that their past credit record can be no guide to their future risk behaviour.

According to the findings of this paper, the exposures of Spanish banks to sectors potentially exposed to energy transition risks, albeit with different degrees of intensity, represent approximately 20% of the portfolio of loans for productive activity.[3] At the same time, according to the evidence available, from the global financial crisis onwards, these exposures are seen to have had a lower non-performing loan (NPL) ratio than other economic sectors. However, this may be partly explained by the elevated mark-ups in some of these sectors, although there is a high degree of heterogeneity among them. This capacity to generate profit partly arises from the fact that they are regulated activities, since they are natural monopolies, and also that, to date, they have only had to assume a small part of the costs of the emissions they generate. Consequently, these favourable mark-ups may be reduced in an energy transition scenario.

The rest of this article is organised as follows. The second section analyses the CO_2 emissions of the Spanish economy, with an international comparison and disaggregated information for the various economic sectors.[4] Within this framework, those sectors that generate higher CO_2 emissions, which may be the ones most affected by possible technological innovation in the generation of energy in favour of renewable sources, as well as changes in agents' preferences, are identified. The third section focuses on Spanish deposit-taking institutions' exposures to these sectors, studying some of their characteristics, such as their non-performing loan (NPL) ratios. The fourth section analyses the possible regulatory initiatives being discussed in this context, while bearing in mind that, from a prudential standpoint, any measure adopted must necessarily be consistent with the financial risks related thereto. Finally, the fifth section summarises the main conclusions of this paper.

2 CO_2 emissions in Spain

According to Eurostat, Spanish CO_2 emissions into the atmosphere in 2017 totalled 285 million tonnes, accounting for 7.5% of total European Union emissions and ranking sixth among the EU members. The country with most emissions was Germany, with 858 million tonnes (22.8% of the total), while Malta, with 3 million tonnes (0.1%), had the fewest.

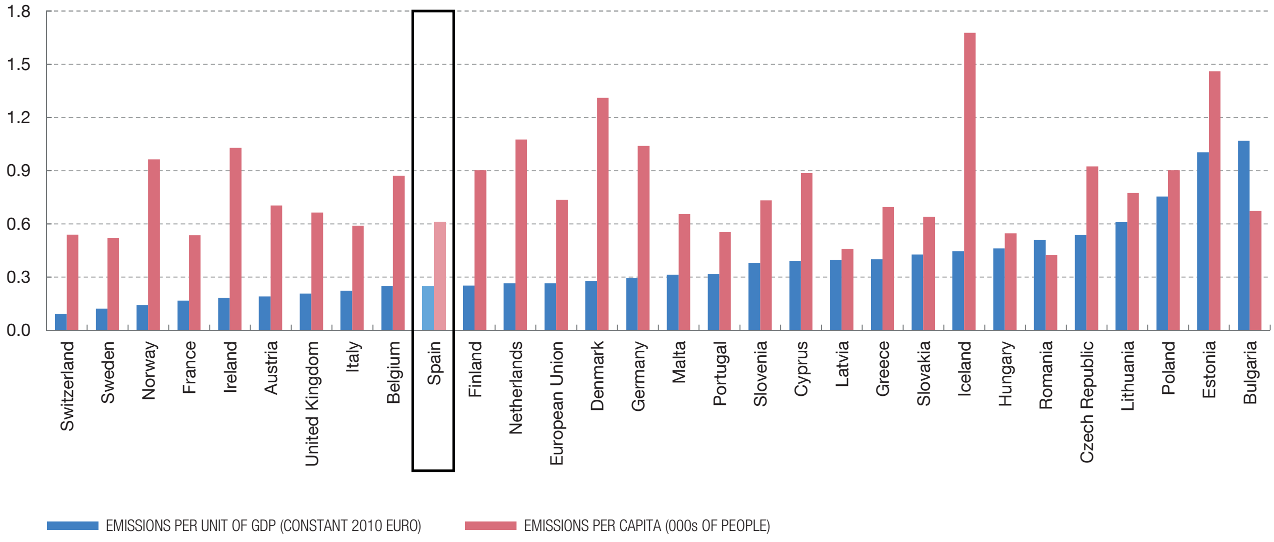
When emissions are viewed relative to the size of the economy or of the population, Spain is in an intermediate position in the European ranking (see Chart 1). Specifically, Spain emitted 0.25 kg of CO_2 per euro of GDP produced

3 Bank loans to finance productive activity account for around 50% of total financing to the resident private sector.

4 To simplify the analysis, the study focuses on CO_2 emissions, although environmental policy should address all types of pollutants (other greenhouse gases: methane, nitrogen oxide and fluorinated gases; and air pollutants: sulphur and nitrogen oxides, SOx and NOx, particulate matter and carbon monoxide).

Chart 1

CO_2 EMISSIONS IN EUROPE PER UNIT OF GDP AND PER CAPITA. 2017



SOURCE: Eurostat.

(at constant 2010 prices), far below the figure for Bulgaria or Estonia (1 kg), but twice that for Switzerland and Sweden (0.1-0.12 kg). Over recent years, emissions per unit of value added have fallen by 14% in Spain since 2012, practically the same figure for the European Union as a whole. Taking emissions relative to population, the conclusions are very similar. Spain emitted 6.1 tonnes per capita, up on Romania (4.1 tonnes) and Latvia (4.6 tonnes), but less than half the figure for Iceland (16.8) and Estonia (14.6). Here Spain stands somewhat below the European Union average, which was 7.3 tonnes per person in 2017.

Within Spain, households are the biggest direct emitters of CO_2 (68 million tonnes). This is both as a consequence of home acclimatisation and of the use of vehicles. As regards the sectors of activity, the biggest polluter is that supplying electricity, gas, steam and air conditioning (NACE group code 35), with 65 million tonnes, followed by various transport sectors (49-51), which overall contribute 47 million tonnes.[5] Other notable sectors in this respect are oil refining (19) and basic metals (24). Conversely, the sectors with fewest emissions are sports, recreational and entertainment activities (93), along with certain industrial sectors that show a low level of activity.

5 Households and the transport sector are, along with agriculture, waste management, fluorinated gas production and other less significant activities, what are known as diffuse sectors, which are excluded from the European market for the acquisition of emissions rights. In Spain, the CO_2 emissions of these sectors account for more than 60% of the total.

2.1 Emissions by the productive sectors

However, for a more complete picture of the most polluting goods and services, two factors should be borne in mind. First, a sector's emissions may be high because the size of the sector is big (extensive margin) or because its emissions per unit of value added are high (intensive margin). Indeed, viewing the direct emissions of each sector relative to value added generated shows that the most polluting activities are once again related to transport (49-51) and energy production, both electricity (35) and oil derivatives (19) (see Chart 2).[6] But, among others, the manufacture of other non-metallic mineral products (23), fishing (03) and paper manufacture (17) also emit more CO_2 than the average for the economy. Only slightly below the average are the textile (13-15) and food (10-12) industries. Several services activities and other sectors such as construction (41-43) show practically zero emissions relative to value added.

Placing the cut-off point at emissions of 0.11 kg of CO_2 per euro of value added (half the average emission per sector), the sectors selected as most polluting would be the 15 detailed in the annex. The emissions of these sectors account for 85% of total emissions (excluding those of households). Individually, each of these sectors emits at least 1% of the total.

Second, the statistics currently available record exclusively the emissions that are added at each stage of the productive process. Given that any finished product includes goods and services produced in other phases of the process (imports), it would be necessary to assign to each final product the emissions generated in the production of the imports incorporating it. This is what is known as incorporated emissions, which should be the basic element for calculating the environmental costs that each product generates. Bear in mind that if, for instance, pollution costs are internalised by taxing the polluting energy products that firms purchase and these costs are passed through to the following link of the productive process, the total increase in the price of a final product will not depend only on the emissions made in the final stage of this process, but also on the previous stages. We should not forget that it is the changes in the relative prices of final products that will determine the change in consumers' consumption patterns and, therefore, in each sector's production.

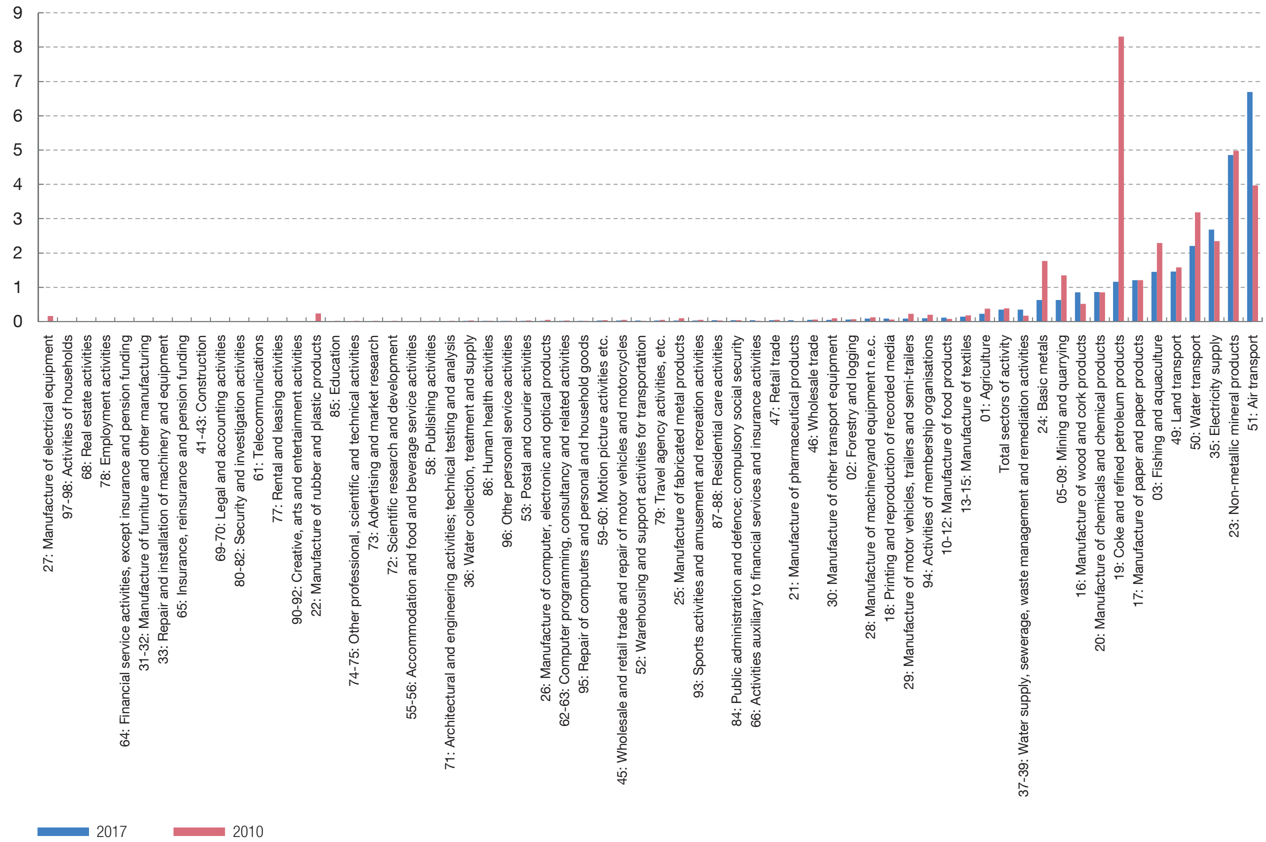
To perform this assignment exercise, information is drawn from the latest Input-Output Tables (IOT) of the Spanish economy for 2015. This source, since it details the acquisitions of inputs by each sector from the other sectors, allows an estimate to be made of the emissions of CO_2 that each final product incorporates.[7]

6 Logically, households are excluded from this part of the analysis since they are end-consumers of the goods and services produced.

7 This procedure implicitly assigns the same CO_2 emissions to both imported and domestic inputs. Wiebe and Yamano (2016) use input-output tables and emissions data from all the developed countries so as to

Chart 2

CO_2 EMISSIONS IN SPAIN BY SECTOR. PER UNIT OF VALUE ADDED



SOURCES: Instituto Nacional de Estadística and own calculations.

These estimates are in Chart 3. As can be seen, the assignments made in this way provide for a more homogeneous distribution of emissions among final products. Indeed, the difference in unit emissions between the most and least polluting product is much less than the difference between the most and least polluting sector. There are some highly significant cases. For example, the construction process (41-43) per se pollutes very little; however finished buildings are moderately polluting since they incorporate construction material whose production is highly polluting. Conversely, transport activities (49-51) notably reduce their emission intensity when it is taken into account that a most significant portion of these services are included in the transport of finished goods and, therefore, form part of these products. Notwithstanding, the list of the 15 most polluting products matches the sectors previously identified as having the highest emission intensity.[8]

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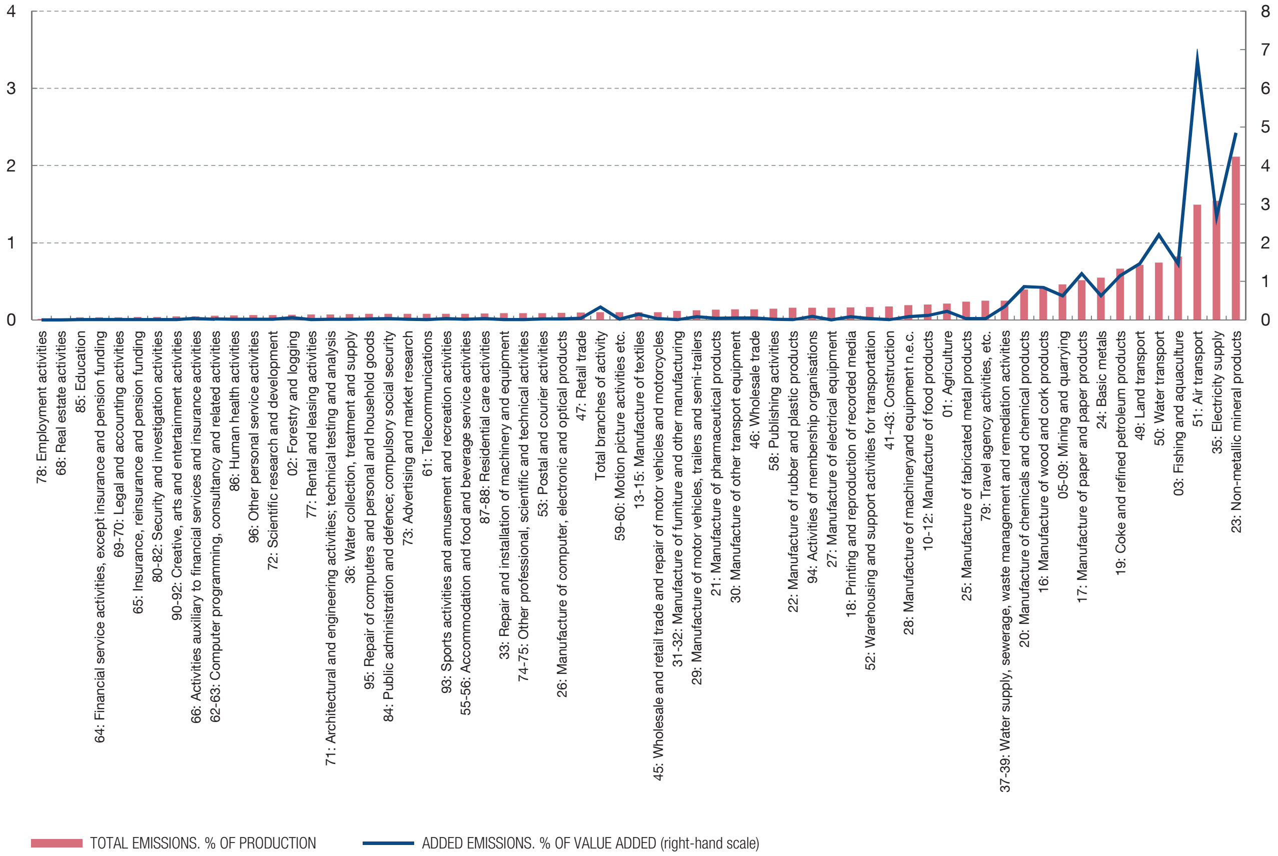
be able to assign to each imported product the emissions that correspond to it according to the country in which it was produced.

8 Logically, the products/sectors with higher emission intensity might be expected to be more effective, but this differentiation is left for subsequent studies.

Chart 3

CO_2 EMISSIONS BY SECTOR AND BY PRODUCT. 2017



SOURCES: Instituto Nacional de Estadística and own data.

Policies for reducing greenhouse gas and polluting emissions can also be geared to promoting the development and use of "green" technologies. Specifically, they can give priority to those technologies that generate energy through renewable sources and which, therefore, do not use fossil fuels as a primary energy source. Clearly, this may have most significant consequences for the sectors of activity directly involved in the extraction (05-09) and refining of fossil fuels (19). But it will also affect the electricity sector (35) which, foreseeably, would increase its size but would in turn face a far-reaching structural change so that the scale of renewable sources in electricity generation might amply exceed the figure of 40% recorded in 2018.

Other sectors might also be affected by the need to replace machinery that runs on fossil fuels with electricity. That entails both direct and indirect adaptation costs. In this respect, the sectors most affected would be those linked to transport (49-51), the chemical industry (20), fishing (03), and manufacture of other transport equipment (30), metallurgy (24), agriculture (01), sale or repair of motor vehicles (45), water collection (36) and manufacture of rubber and plastic products (22). Finally, the sectors producing motor vehicles as transport equipment (29), machinery and equipment (28), and the repair of these products (33) might also be affected by this technological change. As can be seen, some of these sectors were also the most polluting either directly or through their incorporation, but some additional sectors showed moderate emission intensity.

The very changes in consumer preferences about the treatment of the environment, the quality of the air they breathe and the consequences of climate change may also lead specific sectors to lose significance compared with others. Evidently, this would especially affect products that account for the bulk of households' CO_2 emissions. In particular, individual transport vehicles and machinery that uses combustion engines may be replaced by others that use electricity, or by mass modes of transport. The sectors dedicated to repairs of this type of machinery may also be adversely affected. Further, this change in preferences may affect other goods and services-producing sectors that make intensive use of natural resources or livestock (the food, textile and paper sectors) or that produce non-recyclable or heavily polluting goods (plastic, nuclear energy).

As mentioned in the introduction, the intensity and speed with which these changes come about will influence the costs entailed for the economy as a whole. Possibly, specific sectors will ultimately increase their size in the wake of the process, but that would be after having undergone a deep-seated transformation, which will boost firms that use low-polluting technologies and weaken those that are more polluting. In any event, it is worth attempting to characterise the relevance of all these sectors for the Spanish economy as a whole.

Table 1 shows the weight of these groups of sectors in the aggregate value added of the economy[9] in three different years. The figures are broken down in terms of whether the sectors would be affected on the basis of being highly polluting, of technological changes or of changes in consumer preferences. As can be seen, the weight of these sectors was somewhat higher than 23% in 2018, there having been something of a rise between 2012 and 2018.

The sectors potentially affected by technological changes are the biggest ones (18.4%) and, moreover, they have been gaining weight in a sustained fashion in the past decade. For their part, the significance of the heaviest greenhouse gas-issuing sectors (17.3%) diminished following the global financial crisis, but their importance has increased once again in recent years. Given that, as highlighted in the previous section, total CO_2 emissions per unit of value added

9 Excluding rentals of owner-occupied housing.

Table 1
WEIGHT OF SECTORS POTENTIALLY AFFECTED BY TRANSITION RISKS IN THE SPANISH ECONOMY'S AGGREGATE VALUE ADDED (%)

	2007	2012	2018
Polluting sectors	16.2	15.9	17.3
Technological change sectors	16.1	16.7	18.4
Changes in preferences sectors	7.7	7.6	7.4
Total sectors affected	**21.9**	**21.8**	**23.1**

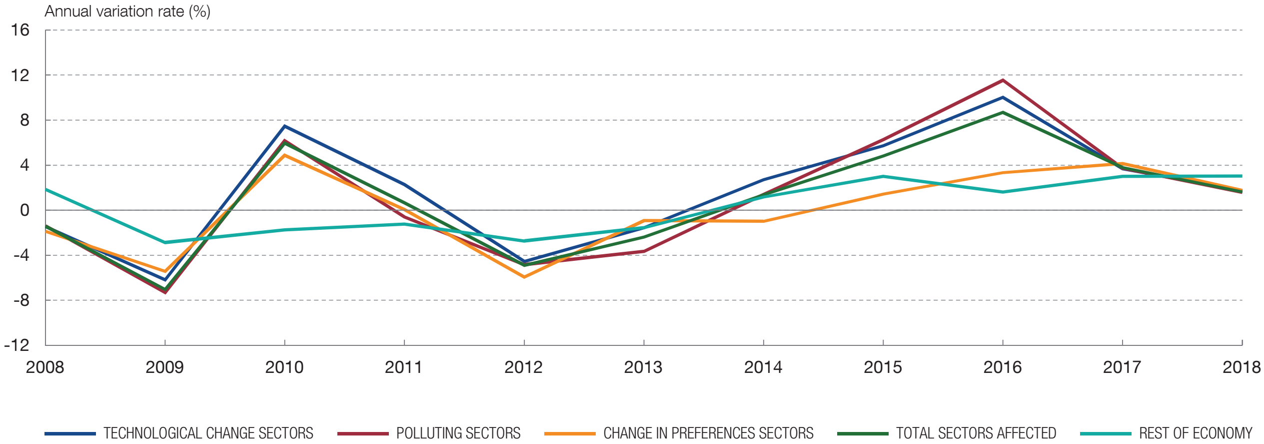
SOURCES: Instituto Nacional de Estadística and own data.

have fallen in recent years, this suggests that the sectors must have incorporated significant improvements in energy efficiency into their productive processes. Last are the sectors potentially affected by changes in consumer preferences, the weight of which was 7.4% in 2018. Unlike the other two groups, their significance in respect of aggregate economic activity has tended to diminish in the past decade.

Given the changes in the weight of these sectors, their average growth in the past decade has, unsurprisingly, exceeded that of the rest of the economy (1% versus 0.3%). In terms of groups, those potentially affected by technological change are those that have most grown on average (1.8%), followed by the most polluting groups (1.2%) and, some distance further back, those potentially affected by changes in consumer preferences (0.1%). Moreover, as Chart 4 shows, these sectors show greater volatility; indeed, they are much more procyclical than the rest of the economy. In fact, just as they fell much more during the global financial crisis, they are now also recovering more sharply. This is especially the case in the group of the most polluting sectors, but it is also seen in the other two groups.

The results on the significance of these sectors for aggregate employment in the economy are similar, though some qualifications are in order. As Table 2 shows, their weight in 2018 stood slightly below 19%, lower, therefore, than the weight in terms of value added. This means that the average apparent labour productivity of these sectors is higher than that of the rest of the economy. This seems logical if regard is had to the fact that industrial activities are over-represented. Moreover, the importance of these sectors has tended to diminish in the past decade; indeed, during the global financial crisis they destroyed more employment than the rest of the economy, and in the subsequent recovery they also created less employment. It is also worth noting that it is the most polluting sectors that concentrate most employment (13.9%), closely followed by those potentially affected by technological innovation (13.7%) and, at a much greater distance, by those subject to a change in preference (7.1%).

Chart 4
REAL VALUE ADDED



SOURCES: Instituto Nacional de Estadística and own data.

Table 2
WEIGHT OF SECTORS POTENTIALLY AFFECTED BY TRANSITION RISKS IN TOTAL HOURS WORKED IN THE SPANISH ECONOMY (%)

	2007	2012	2018
Polluting sectors	14.9	14.8	13.9
Technological change sectors	14.2	14.3	13.7
Changes in preferences sectors	7.2	7.1	7.1
Total sectors affected	**19.8**	**19.7**	**18.8**

SOURCES: Instituto Nacional de Estadística and own data.

2.2 Household emissions

To conclude this section, we should remember that a significant portion of the CO_2 emissions recorded were those emitted directly by households. Specifically, this amounted in 2017 to 68 million tonnes of CO_2, approximately 25% of the total. A portion of these is related to the use of private transport which, in one way or another, has already been addressed in the previous sections. Another portion concerns the acclimatisation of the houses in which they reside. Logically, depending on the quality and, above all, on the degree of the construction's thermal insulation, more or less energy consumption will be required to acclimatise the dwelling and, as a consequence, CO_2 emissions will be higher or lower.

Accordingly, houses might also be affected by the risks of energy transition, risks associated both with regulation and with technology or changes of preference. From the standpoint of financial stability, we should not forget that mortgages, the collateral for which is the house, account for almost half of banks' portfolio of loans to the non-financial private sector. Very few households could afford a house were they not able to mortgage this collateral. Moreover, a house is also a most relevant collateral for other loans related directly to productive activity (that of sole proprietors, for example).

For some years, newly constructed buildings have been obliged to include an energy performance certificate as part of the relevant information to be provided to purchasers and public institutions. At present over 3 million buildings and houses have such a certificate, with the median standing in group E (50.7%), only two categories above the level characterising maximum emissions [see Ministerio de Energía, Turismo y Agenda Digital (2017)]. The most sustainable buildings from this environmental perspective (groups A, B and C) account for only 5% of all classifiable buildings. Fortunately, the situation changes drastically when new buildings are analysed. As these are constructed in keeping with the new building code (2006), they show better climatic insulation and, therefore, produce fewer emissions. Specifically, only 23% of newly constructed buildings show worse energy ratings (groups E, F and G) and over half are positioned in the best three categories.

Regrettably, only aggregate information is available on this matter for the moment; accordingly, it is impossible to conduct a more detailed analysis. However, some recent empirical papers show that a house's energy certificate can have significant consequences for the quality of mortgage loan portfolios.[10]

3 Spanish deposit-taking institutions' exposures to sectors potentially affected by energy transition

As indicated earlier, almost all economic sectors produce some form of polluting emissions in the course of their productive activity. In consequence, as described in section 2, for the purposes of analysis a threshold has been set over which it is considered that an activity causes "sufficient" pollution. Similarly, thresholds have been set to classify sectors as sufficiently affected by technological change or changes in preference.

10 For example, Guin and Korhonen (2018) show how the energy efficiency of housing is a predictor of the risk of the mortgages associated with such housing. They find that those mortgages arranged on more efficient properties in energy terms are less risky.

In the analysis in this section, all the sectors that exceed these thresholds will be treated together, that is, as if the energy transition process had the same impact on each of them. But this is a simplification, as the impact is expected to be greater on the sectors that cause the most pollution or that make the most intensive use of combustion engines. In addition, within each sector, emissions will also vary by company, according to their production volume or the technology they employ (for example, coal-fired plants or wind farms for electricity generation).

However, as complete firm-level data are not available either on CO_2 emissions or the technology used in the production process, this analysis cannot go beyond the sector level. This means that the data presented here constitute the upper bound of energy transition-related risks. This lack of granular data also means that nor is it possible to take into account the potential risks associated with banks' exposures secured by real estate (housing) according to their environmental classification. There are, therefore, statistical and data constraints that impede a more precise analysis. This means that the conclusions drawn should be taken as a first exploratory analysis to be completed in the future.

Bearing the aforementioned in mind, a first group has been established comprising all the sectors potentially affected by the energy transition: those believed to cause the most pollution (CO_2 emissions over 0.11 kg per euro of value added), those subject to technological change and those potentially affected by changes in consumer preferences.[11]

The second column in Table 3 shows the financing that these sectors have received from Spanish deposit institutions, as a proportion of total lending extended to non-financial corporations and sole proprietors. In the period 2009 to 2018, it ranged between 20.1% and 24.6% at December 2018.[12] This is a very similar proportion to the share of these sectors of the value added of the economy. Accordingly, the bank debt ratio of these sectors – just over 50% at the end of 2018 – is very similar to that of the other sectors.

The share of bank financing extended to these sectors has risen by more than three percentage points (3 pp) over the past decade, in all three groups analysed. This increase is similar to the increase in value added, which implies that the debt of these sectors has evolved similarly to that of the rest of the economy. Specifically, the bank debt-to-GDP ratio of non-financial corporations has fallen by 54 pp of GDP in the decade: a decline of 47 pp for the sectors potentially

11 A list of these sectors is included in the Annex.

12 As mentioned in the previous section, the energy generation sector includes renewables. As it is not possible to separate renewables from the other forms of electricity generation at NACE code level, it must be noted, for a complete analysis, that the total percentage of bank financing received by companies and sole proprietors engaged in the renewable energy business is less than 1% of the system-wide financing granted.

Table 3
BANK FINANCING RECEIVED BY SECTORS POTENTIALLY AFFECTED BY ENERGY TRANSITION AND NPL RATIOS (%)

Date	Exposure of sectors affected by energy transition risks/total exposure	NPL ratio of sectors affected by energy transition risks	NPL ratio of total productive activities	NPL ratio of total excluding construction and real estate development
2009	21.1	5.1	7.3	5.1
2010	21.7	6.2	10.2	6.5
2011	21.3	7.9	14.1	8.2
2012	22.6	11.1	20.0	12.5
2013	23.0	14.9	26.2	16.9
2014	23.8	14.6	25.7	17.4
2015	23.6	13.9	26.2	16.1
2016	22.4	6.7	13.0	9.6
2017	23.1	5.9	11.0	8.6
2018	24.6	5.1	8.7	7.2

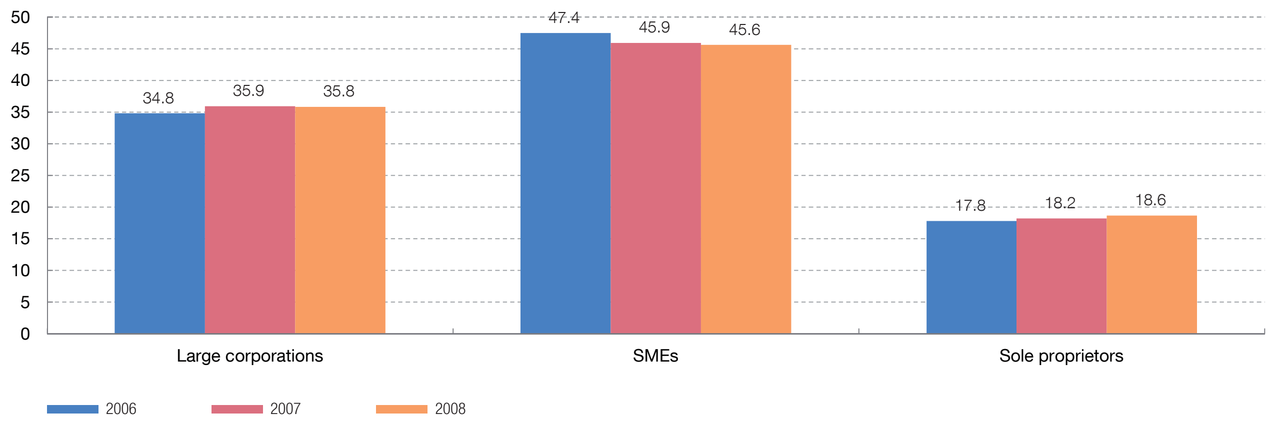
SOURCES: Banco de España and own calculations.

affected by energy transition risks and of 56 pp for all other sectors. At a more disaggregated level, the bank debt ratio of the sectors that cause the most pollution has fallen the most (57 pp), followed by that of the sectors potentially affected by technological change (46 pp) and, much farther behind (10 pp), by that of the sectors potentially affected by a change in consumer preferences.

The third and fourth columns of Table 3 show how non performing loan (NPL) rates have evolved in these sectors and in the system overall. In 2009 the NPL ratio was significantly lower for the sectors potentially affected by energy transition risks (5.1% compared with 7.3% for the system overall). In the global financial crisis years, the ratio rose substantially in both cases, but less so for the sectors potentially affected by energy transition risks (9.5 pp compared with 18.9 pp for the system overall). Since then, NPL ratios in both groups have declined very significantly. Specifically, for the sectors affected by the energy transition, the rise observed during the economic crisis has been fully reversed and the NPL ratio has returned to its levels of ten years ago (5.1%). By contrast, the NPL ratio for the system overall stands at 8.7%, 1.4 pp above the 2009 level. Accordingly, since the crisis the differences have tended to widen.

Nevertheless it is important to note that construction and real estate development are not identified as sectors potentially affected by energy transition risks. Given the nature of the global financial crisis in Spain, these sectors in particular suffered widespread default and this may distort the comparison. Accordingly, in the fifth column of Table 3 they have been excluded from the calculations for the system overall. The differences are now much less marked, as the NPL rate of the system overall (ex-construction and real estate development) is considerably lower.

Chart 5
DISTRIBUTION OF BANKS' CREDIT EXPOSURES BY BORROWER SIZE (TOTAL PRODUCTIVE ACTIVITIES) (%)



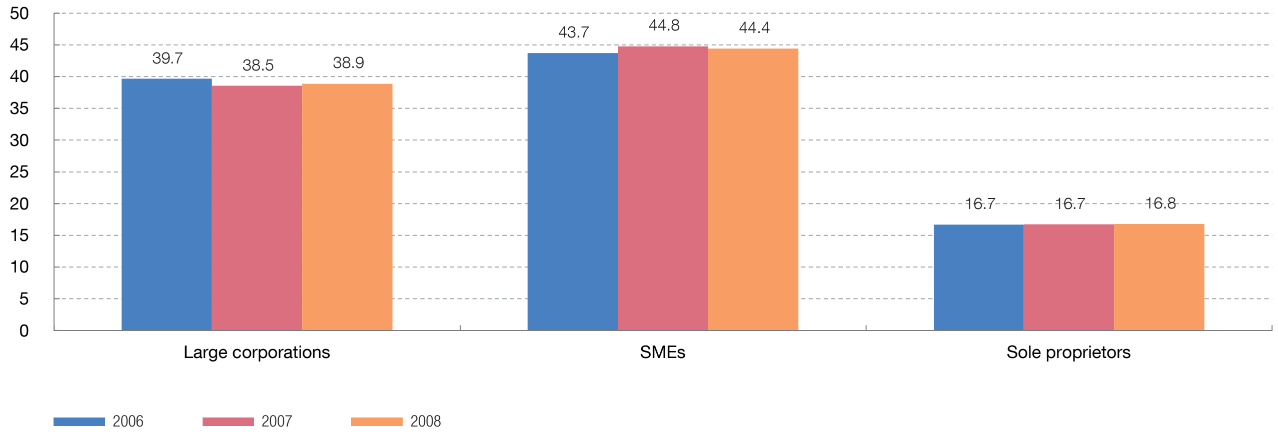
SOURCES: Banco de España and own calculations.

The starting point in 2009 is very similar in both cases. The increase in the NPL rate is still higher for the system overall in the crisis years, but its peak is a bit more than 2 pp higher than that of the sectors potentially affected by energy transition risks (compared with a difference of more than 11 pp) including construction and real estate development). The subsequent decline is very similar, which means that the NPL rate of the system overall (excluded construction and real estate development) is now higher than that for the sectors under study. In consequence, on the experience of the last cycle, it seems that in economic downturns the NPL rate of the sectors potentially affected by energy transition risks is less cyclically sensitive than that of the other sectors, despite the higher procyclicality of their value added as shown in the previous section.

This differential performance of the NPL ratios of the two groups of economic sectors may be explained by a variety of factors. First, average firm size may differ. As a general rule, large firms, as they have more highly diversified income sources than their smaller counterparts, are able to better cushion idiosyncratic and aggregate shocks and, therefore, present lower NPL rates [see, for example, Altman et al. (2011) and Saurina and Trucharte (2004)]. Indeed, available data by firm size for Spain show that, in the economy overall, NPL rates have always been much lower at large corporations than at SMEs, with sole proprietors in an intermediate position between the two. These differences are practically identical in the case of companies in the sectors potentially most affected by the energy transition.

In the sectors under study, the share of financing extended to large corporations (to the detriment of SMEs) is greater than in the economy overall. Accordingly, the composition of the business sector could explain part of the difference in the NPL rate. However, as Charts 5 and 6 show, the differences in share between the two

Chart 6
DISTRIBUTION OF BANKS' CREDIT EXPOSURES BY BORROWER SIZE (SECTORS AFFECTED BY ENERGY TRANSITION RISKS) (%)



SOURCES: Banco de España and own calculations.

groups of companies are small, so this factor would explain only 0.2 pp of the total. Moreover, there appears to have been no substantial change in composition over time, so this factor alone cannot explain why there were no differences in the NPL rates pre-crisis.

Another reason is that there is a measure of inertia in default, or in other words, a company is more likely to default if it has past experience of similar situations [see, for example, Repullo et al. (2010)]. Accordingly, the simple fact of the global financial crisis having a greater impact on the rest of the economy would be sufficient for the pace of the subsequent fall in default to have been slower. But this would still not explain why the crisis had more impact on the other sectors than on those potentially affected by transition risks.

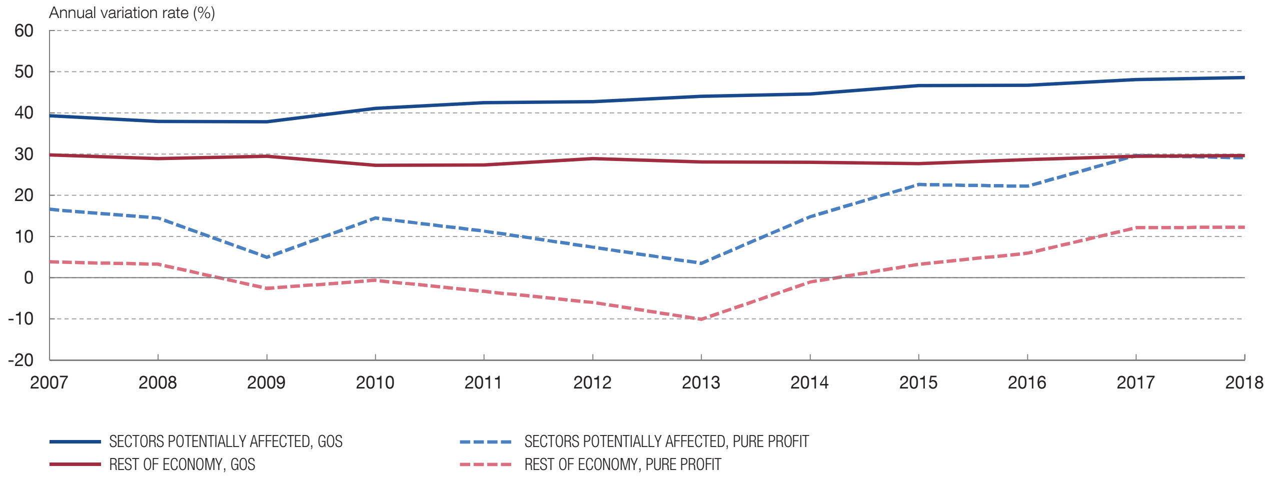
Lastly, the empirical evidence also shows that there is an inverse relationship between NPL and a company's profitability [see Trucharte and Marcelo (2002) for the case of Spain]. This could also explain the difference in NPL rates between the two groups. For this purpose, drawing on Spanish National Accounts data, both the gross operating surplus as a percentage of value added and an approximation of the price mark-up on the marginal cost for each sector were obtained (subsequently aggregated into the groups being compared).

Gross operating surplus is defined as value added produced minus labour costs incurred.[13] This would be the income available to a company for capital remuneration,

13 These costs include the imputed wage of self-employed workers in each sector, equivalent to the average net wage of employees in that sector.

Chart 7

GROSS OPERATING SURPLUS AS PERCENTAGE OF VALUE ADDED AND MARK-UP



SOURCES: Instituto Nacional de Estadística, EU-KLEMS and own calculations.

to be used therefore to service its debts and its bank borrowings. Clearly this income must be positive (at least when counted over a sufficiently long period), and the more capital intensive the sector, among other factors, the higher it will need to be. In consequence, another profit measure is obtained – the mark-up – that subtracts capital remuneration[14] from the gross operating surplus.

This variable may be interpreted as the monopoly power of the sector, as in perfect competition conditions the mark-up should be zero. If it remains positive over time, this could mean that companies are able to charge a price for their products above the marginal cost of producing them, thus generating income in excess of remuneration of the factors of production. In consequence, the mark-up measures the degree of sectors' allocative inefficiency, since if the price charged is higher than the perfect competition price, the amount produced will be lower than under competition [see Estrada (2009) for an in-depth study of this issue for Spain].

As Chart 7 shows, the gross operating surplus to value added ratio for the sectors potentially affected by energy transition risks is much higher than for the rest of the economy. In addition, the differences have widened in the past decade, from somewhat less than 10 pp to almost 20 pp. Indeed, there would appear to be a change in cyclical behaviour, as while this ratio decreased in all other sectors during

14 Capital remuneration is calculated by multiplying each sector's capital stock by its user cost. In turn, user cost is obtained by multiplying the investment deflator by the real return (risk-free interest rate plus risk premium plus rate of depreciation of capital stock minus inflation). These sector-level variables are taken from the Fundación BBVA and IVIE database and are extended to 2018 using aggregated data imputation techniques.

Table 4
NPL RATIO OF SECTORS AFFECTED BY ENERGY TRANSITION RISKS. DISAGGREGATED ANALYSIS (%)

Date	NPL ratio of sectors that cause the most pollution	NPL ratio of sectors affected by technological change	NPL ratio of sectors affected by changes in preferences
2009	4.8	3.9	7.3
2010	5.7	4.8	9.2
2011	7.3	6.2	11.3
2012	10.6	8.7	13.7
2013	14.7	12.4	16.8
2014	14.7	12.0	16.7
2015	14.2	11.6	14.8
2016	6.8	5.6	6.6
2017	6.1	4.9	5.7
2018	5.3	4.5	4.8

SOURCES: Instituto Nacional de Estadística and own calculations.

the global financial crisis, in the sectors under study it increased and this growth path has continued in the subsequent economic recovery.

However, the reason for these differences may be that the sectors potentially most affected by transition risks are also much more capital intensive than the rest of the economy (with a capital stock to value added ratio of around 230, compared with 210 for the remainder). Indeed, when the cost of capital is subtracted from the surplus, the mark-up decreases for both sector groups. Yet the differences between the two remain unchanged. In the case of the rest of the economy, the ratio fluctuates around zero (1.3% on average in the decade), which suggests a situation close to perfect competition. It also seems to be markedly procyclical, recording very negative values during the international financial crisis and the sovereign debt crisis, followed by a return to positive territory in the recovery. By contrast, in the case of the sectors potentially affected by transition risks, positive values were recorded throughout the period (15.9% on average), with a much less procyclical profile. These persistently positive values suggest that these sectors include some dominant companies.

It seems reasonable to believe that the higher profits generated by these sectors and their lack of sensitivity to the global financial crisis explain a substantial part of the differential impact the crisis had on their NPL rate compared with that of the rest of the economy and also part of their subsequent development. These higher profits may be associated, in part, with the dominant position of some of the corporations in these sectors, with the fact that in many cases these are regulated activities, and with the fact that these corporations are not bearing some of the costs they incur, specifically atmospheric pollution costs that are being borne by society as a whole.[15] In any event, the sectors potentially affected by transition risks are very diverse: they include some of the sectors with the highest mark-ups in the economy (such as electricity generation and transmission), and others with some of the lowest (overland transport).

A final point to note here is that when the three groups of sectors potentially affected by energy transition risks are analysed separately, the highest credit quality is observed in the sectors potentially affected by technological change, compared with those that cause the most pollution and those potentially subject to changes in consumer preferences (see Table 4). Until 2007 the highest increase in NPL rates was observed in the sectors potentially affected by changes in consumer preferences. However, in 2019 this is the only group whose NPL rate is lower than in 2009 (although the figures for the other two groups are very close).

4 Possible application of regulatory measures within the framework of the energy transition process

The bulk of the instruments required to internalise pollution costs and stimulate a "green" technological change are in the hands of governments, the repositories of the popular will. Consequently, it should be governments that lead the drive for protection and care of the environment and for the energy transition towards a sustainable economy.

As analysed in previous sections, this will involve a structural change in the economy, with a significant transfer of resources between sectors and businesses. The fewer the frictions in this process the more effectively it will be carried out, allowing all the opportunities that may arise to be fruitfully exploited. Also, the sooner it is implemented the more the time there will be for adaptation and the lower the costs that will be incurred, in comparison with a climate change scenario. Given their central role in channelling the financial resources necessary for economic activity, financial institutions will have to be part of this process.

Accordingly, prudential regulation may also potentially contribute to this process, but always keeping in mind that such regulation must not interfere with the

15 Considering the estimated social cost of CO_2 (between €46 and €68 per tonne according to the US Environmental Protection Agency), the cost of this externality in 2017 would be between €8.7 billion and €13.1 billion for the group of productive sectors classified as causing the most pollution, after deducting the emission rights bought in the year. This cost accounts for 4 pp to 7 pp of their value added; if internalised it would reduce their average mark-up significantly (by up to 11.7%-9.1% of their value added). Higher CO_2 price scenarios than those considered currently ($100-200 per tonne) would practically eliminate these sectors' average mark-up.

correct measurement of the credit risks associated with these activities. In short, this would mean addressing the possibility of attributing the negative externalities of pollutant emissions to those responsible, always in a manner consistent with the correct assignment of climate change risks.

As already mentioned, a first step is to integrate environmental considerations into financial-system operating procedures and regulation. This integration requires awareness on the part of both institutions and regulators and supervisors, to adopt and promote best practices in risk management, in conjunction with an active, effective and efficient focus on environmental issues.

For this purpose, it is absolutely necessary to have appropriate data to know the true situation of economic agents and the potential impact of their economic and financial decisions on the environment and, thus, to be able to perform a complete and appropriate analysis of such decisions. This is a challenge that requires the authorities to act rapidly and decisively, so that the problem we are facing can be put into context.

Financial institutions are also starting to take the first steps towards using products and financing activities that are environmentally sustainable. The inclusion of the energy and environmental dimension in risk and project-viability evaluation is a task that still needs to be worked on further. The energy transition is akin to a structural change, and will therefore render past experience of little relevance for explaining the risks that arise in future. Accordingly, much more attention will have to be given to the simulation of potential scenarios resulting from the measures that may be adopted in this area, possible technological innovations and changes in agents' preferences.

With respect to regulators, environmental risk must be integrated into regulation as part of a global approach to systemic risk and its effects in the financial system. It should not be forgotten that a large part of regulation is based on features and models that use past information to determine requirements, while this type of risk would arise from structural change and resource reallocation across sectors and businesses.

A pioneering initiative that sought to give a different treatment to a particular type of borrower, in order to boost the flow of bank credit to such borrowers, is contained in the European regulation on capital requirements [Regulation (EU) 575/2013 of 26 June 2013 on prudential requirements for credit institutions and investment firms, known as the CRR].[16] This different regulatory treatment is based on the introduction of a supporting factor (in the form of a lower capital charge) for credit to small and medium-sized enterprises (SMEs) [see EBA (2016)].

The purpose of this measure was to recognise the singularity of this type of borrower and boost the bank credit they receive, by means of regulatory-capital-consumption

16 This initiative was limited to the European level and was never extended to the Basel international level.

relief for banks. It should not be forgotten that the cost of supervising SMEs is much greater than that of supervising large firms, and moreover SMEs have fewer possibilities of obtaining funding outside the banking circuit. In fact, the empirical evidence shows that SMEs, the main source of an economy's job creation, are more financially constrained than large firms [see Beck and Demirguc-Kunt (2006)].

As mentioned in the previous section, the NPL rates of SMEs at sector level are higher than those of large firms, but as the individual loans involved are smaller they allow banks to build more diversified portfolios that reduce their exposure to shocks to specific sectors or firms. As a result, the discrimination in favour of SMEs and against large firms, as regards the treatment of their exposures in terms of capital, i.e. in terms of risk (credit losses, basically, probability of default and loss given default) is justified by borrower granularity and diversification.[17]

Many analyses have been performed both with regard to the suitability of the measure and its impact. In particular, the Banco de España's *Financial Stability Report* (2014) showed the impact on SME funding of such measure, which, in the Spanish case, was preceded by the application of the law on support for entrepreneurs (Law 14/2013). The results of the analysis suggest that the regulatory changes introduced in 2013 by means of the law on support for entrepreneurs had a relatively favourable impact on the growth of credit to SMEs, in comparison with that of credit to large firms.

In this respect, it might be thought that the appropriate consideration of environmental risks in regulation has similarities with the case of SMEs. As indicated in the previous section, the current credit risk of less polluting sectors exceeds that of the different groups of industries potentially affected by these risks, especially after the crisis. As a result, at the present time, on the basis of past information, there would be no justification, from a regulatory-capital viewpoint, for a more favourable treatment for firms which, in terms of credit risk, should be considered as poorer quality. Nor would there be justification for the introduction of a factor penalising more polluting firms which, on the basis of past experience, would have lower credit risk.

However, as already mentioned, the measures governments may implement for the energy transition, or technology or preference changes may mean that the potentially affected sectors will see a deterioration in their earnings, when the costs of pollution are internalised and they lose some of their monopoly advantages, so that their credit risk may rise while for other firms it falls. From this perspective, regulation could favour these potential changes. In this case it would not be a matter of recognising that the greater diversification of portfolios reduces total risk, as in the

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17 The EBA document cited [EBA (2016)] states that an analysis of the capital requirements under the advanced approach, IRB, and the standardised approach, SA, showed that the supporting factor for SMEs could be justified, given that the current calibration tended to be conservative compared to the riskiness of these exposures.

case of SMEs, so much as of anticipating a situation that may alter the currently observed credit risk at the same time as the social cost entailed by pollution, that has not hitherto been considered, is assigned to those responsible. However, the measures should be temporary, remaining in force only until the transition process has been completed, since the advantages of the more polluting firms would have disappeared then.

Basically, two alternatives have been proposed for possible regulatory action. First, reducing the capital requirements for less polluting activities ("green supporting factor") and, second, increasing them for more polluting activities ("brown penalising factor"). Both factors would meet the objective of modifying the relative weightings of bank exposures to favour the internalisation of economic and social risks associated with the energy transition process, but there are certain differences that should be mentioned.

The "brown penalising factor" would raise aggregate capital requirements, making banks more solvent, so that this seems to be the most appropriate alternative from a prudential viewpoint. Also, from an operational standpoint, it is much easier to identify polluting sectors/firms than non-polluting ones. Notwithstanding this, the penalising factor has been criticised by some authors for its possible ineffectiveness [see Boot and Schoenmaker (2018)]. In contrast, the "green supporting factor" would reduce aggregate capital requirements, and thus boost the flow of credit between sectors and firms, allowing for a less costly reallocation of financial resources. This would therefore be the best alternative from the standpoint of the efficiency of the adaptation process.

As mentioned throughout this article, measures designed to encourage care for the environment should certainly be welcomed. However, those that may affect solvency regulations must be closely scrutinised before being applied in order to determine their effectiveness and, above all, their impact in terms of credit-risk measurement and recognition, certainly the most relevant aspect for banks. Capital is the ultimate resource banks have available to cover the losses that may arise from their activity, so that any measure that affects their solvency must be exhaustively examined and tested before implemented.

In this connection, the revised capital requirement regulation, CRR2, adopted in May 2019, mandates the EBA to assess the technical justification for, and the potential effects on financial stability of, the introduction of this type of discrimination of the environmental and social risk on credit exposures. The CRR2 requires the EBA to submit a report on its findings to the European Commission by 28 June 2025. The CRR2 itself empowers the Commission to make a legislative proposal to the European Parliament and the Council, should it consider this appropriate in the light of the report's conclusions.

Accordingly, the debate regarding whether "green" or "brown" factors should be introduced into the calculation of capital remains unresolved in the EU, although the timeframe for proposals is lengthy. Irrespective of the option eventually chosen, this treatment should be temporary until the desired transition has been achieved. Any permanent measure of this type should be much more specific, so as not to affect the sectoral composition of activity. It should only favour firms that are more energy-efficient within each sector, using something like the experience rating that some firms use to determine benefits for their employees [Burton (2001)].

5 Conclusions

There is great concern in society over the consequences of climate change, associated with the emission of greenhouse gases and environmental pollution. Unsurprisingly, at the institutional level, awareness of this has also begun to be been raised. Attempts are being made to implement emissions-reducing measures so as to mitigate the global rise in temperature and prevent the harshest version of climate change from materialising.

While finance is one of the lowest greenhouse gas-emitting sectors, it may also be significantly affected by this phenomenon. The risks this sector takes on arise from its exposures to sectors or individuals that would actually be more directly affected. Such risks are twofold: i) physical; and ii) arising from the energy transition process. This article focuses on the second type of risk, derived from the policies implemented to reduce emissions, technological innovations that significantly lower the cost of energy production with non-polluting renewable sources and changes in consumer preferences towards "green" products.

The upshot of all these scenarios (and, almost certainly, the combination thereof) will be the reallocation of productive activity from more polluting to less polluting sectors. And within sectors, from firms generating more emissions to those generating less. This reallocation of productive activity will have consequences for the credit risk of financial institutions' credit portfolios.

Throughout this article emphasis has been placed on the lack of available information at present for building on and thoroughly analysing the previous point, in particular from the household angle. The non-availability of statistical information on household energy efficiency certificates prevents any analysis allowing the financial implications of the potential environmental impact of households to be assessed. In terms of productive activity as a whole, the lack of information at firm level only allows an aggregate analysis by sector; it is not possible to analyse the characteristics of banks' exposures in respect of real estate collateral on the basis of the environmental classification of the latter.

Given the information available, as far as the analysis of Spanish deposit-taking institutions' exposures to the sectors potentially affected by the energy transition is concerned, the financing extended has been shown to account for around 25% of the total granted to overall non-financial corporations and sole proprietors. It has also been shown that these sectors are more creditworthy (they have a lower NPL ratio) than the other sectors, at least in the wake of the global financial crisis.

The analysis has highlighted the fact that this may be due to different reasons, including, among others, the size of the borrower. The presence of large corporations in a higher proportion, with the potential consequences that this entails (diversification of sources of revenue and higher profitability, for instance), has a bearing on the lower NPL ratios. Also, the fact there is notable inertia in NPLs, along with high business concentration, which would provide for higher profits than the normal return on capital, accounts for a significant part of these differences. Nor should it be forgotten that the most polluting sectors do not assume a portion of the costs they incur, specifically those relating to atmospheric pollution, which fall on society as a whole. That is clearly affecting their profitability and justifying a better position in relation to other firms. In any event, it is important to bear in mind that there is high cross-sector heterogeneity, and across the firms within these sectors, and that generalising these reflections calls for the necessary qualifications to be made.

However, what the energy transition is actually seeking is to internalise those costs so that those who actually generate them assume them. Moreover, the new technologies might lead to the concentration of activity falling significantly and to firm-size also becoming smaller. Under an energy transition scenario, these elements would lead the credit risk associated with these exposures to also possibly be affected.

This is a possibility that financial institutions and supervisors should bear in mind. In this respect, the combination of a greater current quality of the credit portfolios of the sectors potentially most affected by transition risks and their potential impairment when the transition process takes place suggests that the possibility of including regulatory changes to accompany this process might be assessed. Logically, such measures, especially if they affect banks' solvency, should be analysed and scrutinised in depth from a prudential standpoint of the proper measurement of the risk the measures incorporate before application, since capital is the last element banks have to withstand the losses that may arise.

Specifically, the debate surrounding the so-called "green supporting factor" and "brown penalising factor" turns on concern to maintain the system's solvency. Such discussion would, in turn, seek to assign the social cost (hitherto not considered) that pollution entails, ultimately providing for the transition process. It seems reasonable to think that such measures should be temporary and confined to the duration of the transition process.

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Table 1
LIST OF ECONOMIC ACTIVITY SECTORS POTENTIALLY AFFECTED BY THE ENERGY TRANSITION

NACE group code	NACE code description (Economic Activity Sectors)
01	Agriculture
03	Fishing
05-09	Mining and quarrying
10-12	Food products, beverages and tobacco products
13-15	Textiles, leather and footwear
16	Wood and cork
17	Paper
19	Coke and refined petroleum products
20	Chemicals and chemical products
22	Plastics and rubber
23	Non-metallic minerals
24	Basic metals
28	Machinery
29	Manufacture of motor vehicles
30	Other transport equipment
33	Repair of machinery
35	Electricity
36	Water supply
37-39	Waste management
45	Sale and repair of vehicles
49	Land transport
50	Maritime transport
51	Air transport

SOURCE: Own data.

Table 2

MOST POLLUTING SECTORS WHOSE EMISSIONS PER EURO OF VALUE ADDED EXCEED 0.11 KG OF CO_2

NACE group code	NACE code description (Economic Activity Sectors)
01	Agriculture
03	Fishing
05-09	Mining and quarrying
10-12	Food products, beverages and tobacco products
13-15	Textiles, leather and footwear
16	Wood and cork
17	Paper
19	Coke and refined petroleum products
20	Chemicals and chemical products
23	Non-metallic minerals
24	Basic metals
35	Electricity
37-39	Waste management
49	Land transport
50	Maritime transport
51	Air transport

SOURCE: Own data.

Table 3

SECTORS SUBJECT TO TECHNOLOGICAL CHANGE

NACE group code	NACE code description (Economic Activity Sectors)
01	Agriculture
03	Fishing
05-09	Mining and quarrying
19	Coke and refined petroleum products
20	Chemicals and chemical products
22	Plastics and rubber
24	Basic metals
28	Machinery
29	Manufacture of motor vehicles
30	Other transport equipment
33	Repair of machinery
35	Electricity
36	Water supply
45	Sale and repair of vehicles
49	Land transport
50	Maritime transport
51	Air transport

SOURCE: Own data.

Table 4
SECTORS SUBJECT TO CHANGES IN CONSUMER PREFERENCES

NACE group code	NACE code description (Economic Activity Sectors)
10-12	Food products, beverages and tobacco products
13-15	Textiles, leather and footwear
17	Paper
22	Plastics and rubber
29	Manufacture of motor vehicles
30	Other transport equipment
45	Sale and repair of vehicles

SOURCE: Own data.