WORKING paper

BANQUE DE FRANCE
EUROSYSTÈME

# Climate Risk Measurement of Assets Eligible as Collateral for Refinancing Operations – Focus on Asset Backed Securities (ABS)

**Loris André[1], Alice Grept[2], Nadia Laut[3], Gabriel Plantier[4], Zako Sapey-Triomphe[5], Pierre-François Weber[6]**

January 2022, WP #858

## Abstract

This paper analyses the exposure to climate risk of ABS, an asset class frequently pledged as collateral in the European Central Bank (ECB) refinancing operations. This paper focuses on ABS backed by auto loans or loans granted to Small and Medium Enterprises (SMEs) and explores ways to measure their climate risk based on the characteristics of the underlying loans, using existing loan-level data requirements. The ultimate goal was to come up with an alignment metric, i.e. to judge whether ABS related emissions would meet the Paris Agreements objectives, a task hindered by the lack of data available. Despite these limits, we were able to come up with relevant indicators related to ABS carbon impact, enabling the computation of ABS climate related risk proxies. Without necessarily being able to measure a concrete impact, we carved a series of indicators to serve as a reference. However, we conclude that an improved and harmonized framework for the provision of non-financial information seems essential to achieve an accurate analysis and monitoring of the financial sector's exposure to climate change.

Keywords: Collateral Framework, Asset-Backed Securities (ABS), Securitisation, Climate Change, Risk And Uncertainty, Monetary Policy; Eurosystem

JEL classification: D81, E51, E52, E58, G21, Q51, Q54

[1] Ecole Nationale des Ponts et Chaussées, loris.andre@eleves.enpc.fr
[2] Ecole Nationale des Ponts et Chaussées, alice.grept@eleves.enpc.fr
[3] Banque de France, nadia.laut@banque-france.fr
[4] Ecole Nationale des Ponts et Chaussées, gabriel.plantier@eleves.enpc.fr
[5] Ecole Nationale des Ponts et Chaussées, zako.sapey-triomphe@eleves.enpc.fr
[6] Banque de France, pierre-francois.weber@banque-france.fr

# NON-TECHNICAL SUMMARY[7]

This report describes an exploratory study regarding exposure to climate risk of ABS, an asset class frequently pledged as collateral in the ECB refinancing operations. ABS are notes backed by multiple loans, mainly issued by commercial banks. This paper focuses on a model that could best approximate the carbon footprint of Auto and SME ABS, considering the data available on the underlying loans and assets. Two aspects largely determined this purpose: the availability and quality of the extra-financial information provided, and the possibility of linking them to external databases on climate exposure or impact. The ultimate goal was to come up with an alignment metric, i.e. to judge whether ABS related emissions would meet the Paris Agreements objectives. We therefore explored the possibilities of combining ABSs loan-by-loan data with relevant indicators to assess their environmental footprint, a task hindered by the lack of data available.

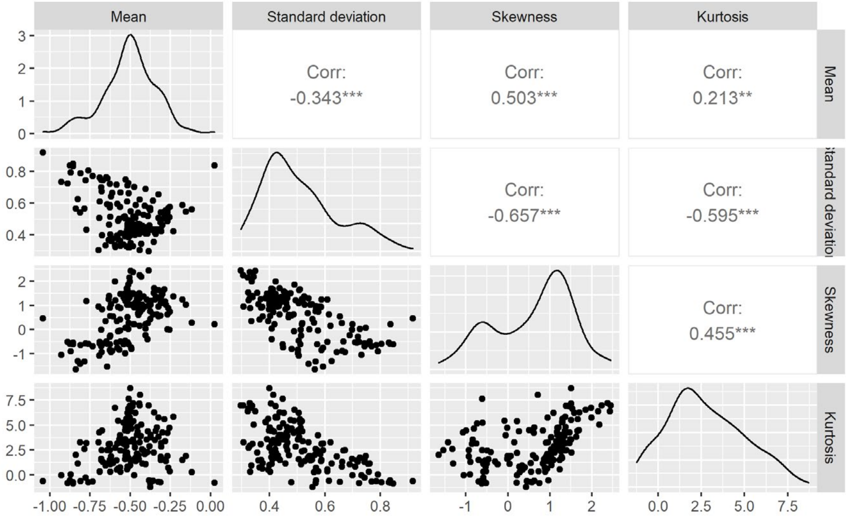
Several conclusions emerged from our analysis: it seems difficult to accurately assess Auto and SME ABS climate risk at this stage, although there are ways of building a proxy. Keeping in mind the data related limits, we developed a climate impact assessment that is dynamic, differentiating and consistent. Without necessarily being able to measure a concrete impact, we carved a series of indicators to serve as a reference, as well as an analytical and monitoring tool for the composition of ABS portfolios. However, an improved and harmonized framework for the provision of non-financial information is essential to achieve an accurate analysis of ABSs exposure to climate change.

As an example, we calculated normalized indicators of the carbon intensity[8] of loans that underlie an ABS. In the correlograms below, each point corresponds to one ABS. We show how the intensities are distributed amongst ABSs, and how their higher order moments are linked with each other. For Auto ABS we note strong correlations between statistical moments, indicating the tendency for instance that ABSs with high mean intensity are skewed to the right and have heavy tails. This would suggest that some ABSs have many standard vehicles, and a number of highly polluting vehicles, high above the intensity referential (SUVs, perhaps). There is, at this stage, no strong evidence of selection criteria based on the loans related carbon intensity.

[7] The authors would like to thank for their comments participants in Banque de France internal Climate Seminar, Stéphane Voisin (Institut Louis Bachelier) who was a discussant during a Banque de France research seminar. Pauline Lez, Franck Auberger, Anne de Tricornot-Auboin, Jean-Michel Boucarut and Maxime Barthe who reviewed an earlier draft and provided useful suggestions. We also would like to thank EDW for granting us access to useful data. Potential errors are our own.

[8] SMEs carbon intensity computation is based on the company country average scope 1 carbon intensity per euro of value added, for the given sector of activity. For Autos, the level of emissions after homologation tests is used.

**Figure: Auto ABS histograms and correlations between different indicators: carbon intensity (gCO2/€), its average, standard deviation, skewness and kurtosis.**




# Mesure des risques climatiques des titres adossés à des actifs (ABS) éligibles aux opérations de refinancement de l'Euroystème

## RÉSUMÉ


Ce document rend compte d'une étude explorant la possibilité de mesurer l'exposition au risque climatique d'une classe d'actifs fréquemment déposée en collatéral auprès de la Banque Centrale Européenne : les ABS, des produits titrisés adossés à des milliers de prêts. Ce rapport explore l'attribution d'une mesure de risque climatique aux ABS à partir des données à l'échelle des prêts. Cette étude est grandement déterminée par deux aspects : la quantité et la qualité des informations extra-financières accompagnant les ABS, ainsi que la possibilité de les relier à des bases de données externes portant sur une exposition ou un impact climatique. Le but final étant d'aboutir à une métrique d'alignement 2°C, c'est-à-dire permettant de juger si la composition d'un ABS se situe sur une trajectoire d'émissions permettant de remplir les objectifs de l'Accord de Paris. Il ressort de notre étude que l'évaluation du risque climatique relatif à un ABS reste difficilement envisageable à ce stade compte tenu des données disponibles, bien qu'il existe des pistes pour en obtenir un proxy. Nos travaux nous ont néanmoins permis d'obtenir une évaluation de l'impact climatique des ABS dynamique et cohérente, bien qu'encore à un stade expérimental. Sans nécessairement parvenir à mesurer un impact réel, il est possible de déterminer une série d'indicateurs servant de référence et d'outil d'analyse de la composition du collatéral titrisé détenu par les banques centrales. Nous concluons également, qu'une analyse et un contrôle fin des expositions du secteur financier à la question climatique, nécessite l'amélioration, l'harmonisation et l'encadrement de la mise à disposition d'information extra-financière supplémentaire.



Mots-clés : politique de collatéral, titres adossés à des actifs (ABS), titrisation, changement climatique, risques et incertitudes, politique monétaire, Eurosystème

# Introduction

Central Banks conduct monetary policy by acting on the supply of money, traditionally through liquidity providing operations.

Many research articles have highlighted the role of monetary policy and central banks in a low carbon economy transition (D'Souza, R. and T. Rana (2020); Dafermos Y., M. Nikolaidi, and G. Galanis (2018)). More recently, the Network for Greening the Financial Systems (NGFS) published a report presenting options for central banks to adapt monetary policy operations.

The European Central Bank provides credit to its monetary policy counterparties only against adequate collateral. Eligible collateral may take the form of marketable financial securities, such as sovereign, corporate or financial bonds, or other types of assets, such as non-marketable assets.

**This paper explains the steps taken to develop a measure of the environmental impact of certain classes of securities used as collateral in the frame of the ECB refinancing operations**: Asset-Backed Securities (ABS) backed by automobile or SME loans. The European Securitisation Regulation (EU 2017/2402) requires ABS originators to regularly produce and publish loan-by-loan data for each ABS issued. The loan-by-loan data available was combined with other relevant public data in order to obtain appropriate indicators. This paper aims to:

- Estimate the feasibility of different climate risk measurement approaches (GHG emissions, thresholds, alignment with European taxonomy, etc.)
- Develop a **theoretical framework** to create indicators for any type of ABS, and imagine the **ideal model**, subject to comprehensive data availability
- **Assess the quality of data available** and improvements needed to be able to successfully exploit it
- **Explore ways to develop indicators** to assess ABSs, monitor a portfolio of securities, or possibly propose regulatory amendments to enable such indicators computation

These objectives may seem ambitious, mainly because of the exploratory status of such task. Indeed, to our knowledge no similar attempt was previously endeavored. Hence, **in order to achieve these goals, the related obstacles were first identified**. This paper presents the methodology used, the main results obtained, and the conclusions drawn.

We used data recovered from the European Data Warehouse (EDW), on a sample exclusively composed of homogeneous ABS (*ie* not mixing different types of loans), active or not. In this study, we focused on ABSs composed of automobile and Small and Medium Sized Enterprise (SME) loans. **In an exploratory approach, we operated in three stages**:

1) Find external relevant data and link it to loan-by-loan data
2) Identify relevant metrics derived from these datasets ($CO_2$ emissions, GHG intensity, variations...)
3) Extend these measures to all outstanding ABS and assess their characteristics to establish a ranking

The ideal metric would apply to all data, cover a broad spectrum of values, and represent an actual climate impact or exposure. It is also important to develop a user-friendly metric, which would be broadly accessible.

As the methods used differ for ABS Auto and SME, they are presented separately.

Several conclusions were drawn from this study. First, it is currently not possible to assess the climate risk exposure, or the alignment of an ABS, both tasks requiring information on the underlying loans which are not available. However, it is possible to compute sensible indicators of the underlying loans carbon impact, which could be considered proxies of their climate risk exposure. The indicators we suggest are easy to read and manipulate, can be computed on vast amounts of data, and are built to be comparable across different assets. However, all the indicators do not lead to the same conclusions, each one representing a different objective, which is why we suggest several of them. Finally, the main hindrance to scale these indicators to all the ABS pools is the uneven quality of the asset-related data and the availability of external data. We believe both limitations could be greatly reduced by taking certain steps, which are suggested at the end of this study.

# I. Context

In this section, we first define the context and key terms of this project and then conduct a literature review of existing methods for assessing financial assets related climate risk.

## a. The role of ABSs in the ECB collateral framework

An ABS is a financial instrument derived from a securitization process that enables a bank to transfer a set of loans it originated and subsequently "delink itself" from the related risk by selling the notes to investors. An ABS is tranched, allowing the risk/return ratio of the securities to be adjusted by investor profile. The originating bank pools together a large number of loans, usually of the same type (automobile, real estate, etc.) in a portfolio subsequently sold to a special purpose vehicle (SPV). The SPV finances the purchase of these loans by issuing securities. Issuing an ABS gathers several benefits for a bank. First, by issuing an ABS, a bank can grant additional loans by freeing up its balance sheet. In the Eurosystem monetary policy framework, a bank can also retain ABSs, and pledge the senior eligible tranches as collateral against liquidity. By selling the notes to third-party investors, the issuing bank can also transfer some of the risk it originally held. ABSs play a somewhat important role in the European Central Bank's monetary policy. They currently represent 14% of the collateral deposited, i.e. 401,5 billion euros[1]. An ABS pledged as collateral must comply with specific criteria. These criteria are mainly risk related; they relate to the nature of the ABS underlying loans, its structure, and impose loan-by-loan transparency requirements.

Given the proportion of ABSs in the collateral landscape, mostly because the majority of them are issued for the sole purpose of being used as collateral, the eligibility criteria set by the ECB have a direct impact on the European ABS market. For this reason, the inclusion of environmental criteria in the ECB collateral framework is regularly mentioned as one of the main tools available to the ECB to manage its environmental risk. Such an action would also signal the ECB's wish to promote an orderly transition, moving away from a neutral approach towards climate. To better understand how a potential ECB action could influence the ABS market, we first review the existing methods for assessing climate-related financial risk, and how they could apply to ABS.

[1] Source: ECB as of Q3 2021: Eurosystem Collateral Data (europa.eu)

## b. What climate risk exposure measures dedicated to financial assets currently exist?

### i) Definitions of climate risks

The risks associated with climate change can be divided into two categories: physical risks and transition risks.

The term *physical risks* refers to the potential financial losses generated by the physical impacts of climate change (heat waves, floods or water stress to name a few). Measuring these risks is complex because of the difficulty to accurately predict the physical impacts of climate change and subsequently assess the extent of the potential financial losses. There are currently no specific methods for quantifying these risks at a corporate level. It is otherwise recommended to monitor, depending on their location and activity, their exposure to different climate events.

*Transition risks* relate to the potential financial losses related to the transition toward a low-carbon economy. The low-carbon transition includes all the socio-economic changes implemented in our societies to limit global warming to a target regarding the increase in temperature. This target is often set at 1,5°C or 2°C, as mentioned in the Paris agreements. According to the TCFD, these transition risks can be broken down into four categories (TCFD, 2017):

- Political and legal risks associated to an amended political or legal framework. They affect companies differently depending on their activity. One of the regulatory instruments often mentioned is a carbon tax, which would affect the revenues of highly-polluting companies.
- Market risks following changes in demand and supply of certain raw materials or products impacting a company's value chain.
- Reputational risks linked to a bad image due to an overly polluting activity.
- Technological risks when a product is replaceable by a more energy-efficient solution, making the product sold by the company obsolete.

The proxy for measuring this overall transition risk for a company or portfolio is called “low carbon path alignment measure”.

### ii) Asset transition risk: measuring the alignment of an asset to a temperature trajectory

In the literature, alignment measures could be seen as proxies used to assess transition risks. An economic player is considered aligned to a low-carbon trajectory, for example 2°C, when the rate of decrease in its greenhouse gas emissions corresponds to the decrease required for a given trajectory. If aligned with the predefined low-carbon trajectory, it would therefore be less exposed to regulatory, technological, market, or reputational risks (I4CE & al., 2017). By extension, an asset portfolio is considered to be aligned on a 2°C trajectory if it selects assets aligned on the trajectory on average, i.e. implementing the de-carbonization efforts required for their respective sectors of activity.

The Louis Bachelier Institute details the different existing methods of alignment measurement. Twelve methods are analyzed and compared (Institut Louis Bachelier & al., 2020). These are all built around the following four steps:

1. Measure climate performance at an asset or portfolio level
2. Choose a baseline scenario for the low-carbon transition
3. Decompose this scenario into low carbon trajectories by sector and then by asset
4. Compare the results obtained in steps 1 and 3 listed above

Each method may have a distinct approach for each step and faces several trade-offs. For example, as regards to the measurement of climate performance, the scope, the analysis perimeter or the performance indicator must be selected beforehand. Steps 2 and 3 are the most uncertain and therefore vary greatly depending on the methods. Indeed, a deep uncertainty is associated with the measurement of climate risks; factors such as the changes occurring, their speed and magnitude are unknown as well as the final temperature reached. The breakdown of the global scenario at a sector or company level is an additional source of uncertainty. Finally, during step 4, new trade-offs must be made on the expression of the final measure (a boolean, a quantified deviation, a historical or future comparison of the evolution).

**Alignment Measurement steps:**

| **Step** | Examples |
| --- | --- |
| 1. Measure climate performance at an asset or portfolio level | - Select a measure (e.g. carbon footprint, GHG emissions)<br>- Define a specific scope |
| 2. Choose a baseline scenario for the low-carbon transition | - Transition scenario to achieve a 2° alignment<br>- Difficulties to select a scenario, possible combinations<br>- Granularities at distinct levels (e.g. International Energy Agency, well below 2°, above 2°) |
| 3. Decompose step 2 scenario into low carbon trajectories by sector and then by asset | - Several methods to translate, within a sector, the level or reduction targeted (e.g. Science Based Initiative) |
| 4. Compare the results obtained in steps 1 and 3 | - Metric selection: Boolean (aligned/not aligned), deviation from the target, historical evolution comparison |

*Source: Institut Louis Bachelier, 2020*

A measure of alignment would be a good indicator to assess the transition risk of a financial asset or portfolio and could measure a player's contribution to the low-carbon transition. This metric is useful when the aim is to direct capital towards assets participating in the climate transition, a strategy included in the Paris Agreements. However its relevance towards these two objectives (*ie* measurement of transition risk and measurement of an appropriate orientation of capital) is still debated today (I4CE & al., 2017).

Existing methods developed by research institutes or consulting firms have not yet been adapted for the ABS asset class and are currently only available for equity or corporate bond portfolios.

### iii) Integration of climate risk by rating agencies in ABS methodologies

Particular attention has been given by market participants to rating agencies, which are often pioneers in integrating different risks into their methodologies.

Overall, so far, climate aspects do not seem considered as a dedicated component in an ABS credit rating. However, some companies and agencies are offering securitization dedicated ESG scores. Rating agencies are beginning to explore the subject:

- Fitch offers a score regarding the inclusion of ESG criteria for a given rating decision. It is therefore not a rough measure of risk, but rather indicates their influence into the analysis. Scores scale ranges from 1 to 5 where "1" indicates no credit relevance while "5" indicates a single identified Environmental, Social or Governance related risk impacted the rating level change to the current rating level. Regarding the ABS asset class, they conclude that this consideration is generally not relevant[2] (Fitch, 2019).
- S&P provides separate ESG scores, on top of ABS credit ratings. ESG risk is not integrated into S&P ABS "traditional" credit risk analysis (S&P, 2019).
- Moody's has also published a methodology for taking ESG criteria into account but does not have a specific approach dedicated to ABS, and notes that the impact of these risks will still be limited in the coming years (Moody's, 2019).

Companies specializing in ESG ratings have shown interest in ABS but none of them currently publish a dedicated methodology.

In conclusion, there is currently no accurate methodology for assessing ABS climate risks. Hence, we have attempted to develop a methodology to assess the climate risk exposure of ABS mobilized as collateral in the frame of the ECB refinancing operations based on the available data on underlying loans.

After an initial data analysis, we realized that an alignment measure was currently not computable due to the high uncertainty of the first step listed above (*ie* assessing environmental performance), even before integrating the uncertainties related to the scenario choice. This report therefore focuses on an approximate measure of the environmental performance of ABS and subsequently discusses the conclusions, particularly in terms of the exposure to transition risks. Finally, we propose disclosure improvements and regulations amendments necessary to the computation of an ABS alignment score.

[2] Structured Finance and Covered Bonds ESG Relevance Heatmap – 1Q21, Fitch 28 April 2021

# II. Moving from theory to practice – how to define environmental characteristics for ABSs?

In this section, we present the theoretical model around which this study was developed. The aim is to illustrate the reasoning behind an alignment measure computation as well as to provide a terminology facilitating a comparison between Auto and SME ABSs. It is also a first step into building a methodology that could be applied to all ABS categories, and potentially translatable to other types of securities.

## a. General Emissions Model

For any given ABS, we call *Index* the annual environmental impact of an ABS underlying asset which characteristics are representative of the overall pool. The environmental impact computed relates to direct greenhouse gas emissions.

Let A be an ABS which loan-by-loan reporting file contains N loan lines. The total annual emissions (General Emissions; GE) that can be attributed to the underlying assets of ABS A can be assessed using the following formula:

$$GE_A = \sum_{i=1}^{N} \frac{loan_i}{val_i} \times vol_i \times e_i$$

For each loan i :

- $loan_i$ is the amount of money granted by the bank to the asset owner which is valued $val_i$ €.
- $vol_i$ is the annual operating level of the underlying asset. For example, for a car, it is the number of kilometers driven within a year.
- $e_i$ is the carbon intensity assessment of the underlying asset. The unit of the operating level should be the same as the denominator of the carbon intensity.

The average loan of ABS A has an annual climate impact of:

$$Index_A = \frac{1}{N} \sum_{i=1}^{N} \frac{loan_i}{val_i} \times vol_i \times e_i$$

The lower this index, the “greener” ABS A is considered to be.

Although this index would be the proper way to assess the level of emissions of an ABS (in terms of absolute emissions), it is not efficient when comparing ABSs with each other. We therefore propose the following corrected model.

## b. Temporal Emissions Model

While the General Emissions Model is relevant in terms of absolute emissions, and therefore can fit in the framework of a carbon budget, it presents a weakness when comparing ABSs with each other. For almost two decades, in many economic sectors, the direct European emission intensities have steadily decreased. Because of this declining tendency, the more recent an ABS, the more recent the loans, therefore the "greener" it will result in the General Emissions Model. A detailed justification on the need of a temporal normalization is given in Appendix section II. B. It is therefore crucial to develop a model in which we do not solely compare ABSs direct emissions, but rather emissions corrected by a temporal factor $t$.

For a type of asset, we define the temporal average of emissions intensities per year as:

$$\overline{e_t} = \frac{1}{|A_t|} \sum_{a \in A_t} e_a$$

- $A_t$ is the set of all unique underlying assets for this type of ABS at year t,
- $e_a$ is the emissions intensity of the asset a.

We can then calculate the temporally-corrected emissions (TE) of ABS A following the below formula:

$$TE_A = \sum_{i=1}^{N} \frac{loan_i}{val_i} \times vol_i \times \left(e_i - \overline{e_{t_i}}\right)$$

- $t_i$ is the year of origination of the loan *i*.

It should be noted that the average emission intensity for a given year does not reflect the level of average emissions for a specific type of asset (for which we would have to weigh the emissions by the proportion of each asset in the economy), but rather the average emissions that *could be achieved on that year*. As an example, for vehicles, in the calculation of $\overline{e_t}$, the Peugeot 208 (best selling car in Europe) has the same weight as the Porsche Cayenne (which is sold in much lower numbers): the asset intensities are not multiplied by their sale numbers. In other words, it corresponds to the average emission based on the market offer. The idea behind that is to reward an intensity that is low compared to the market offer, as opposed to the average sale numbers.

The temporal emissions model thus allows to compare ABSs across distinct vintages.

## c. Neutral Temporal Emissions Model

In the two previous models, we were comparing emissions from underlying assets of various environmental profiles, even though they pertained to the same broad category. Indeed, between two economic sectors (eg. energy or agriculture) or two types of car models (eg. city-dweller or utility), the expected emissions can vary tremendously. The model gives a better score to assets that have inherently low emissions, and although it makes sense from an environmental perspective, it may not fit a central bank's market neutrality objective.

In order to correct that bias, we introduced the notion of *optimal carbon intensity* for a category of asset, which is an assessment of the lowest emission intensity this category could achieve. For a given loan $i$, of category $c_i$, let $e_i$ be its emission intensity, and $e'_{c,i}$ be its optimal emission intensity.

- We can then define :

$$\epsilon_i = \frac{e_i}{e'_{c_i}}$$

- the average ϵ for a given year t being :

$$\epsilon_t = \frac{1}{|A_t|} \sum_{a \in A_t} \epsilon_a = \frac{1}{|A_t|} \sum_{a \in A_t} \frac{e_a}{e'_{c_a}}$$

- the Neutral Temporal Emission (NTE) of an ABS A is hence defined as :

$$NTE_A = \sum_{i=1}^{N} \frac{loan_i}{val_i} \times vol_i \times \left(\epsilon_i - \overline{\epsilon_{t_i}}\right)$$

That value allows to build a ranking of ABSs in terms of carbon impact, and is also a first step in incorporating a notion of *past* alignment to an emissions' reduction scenario, through the optimal carbon intensity. Please find in the Appendix I. A. b, a discussion on a possible value this *optimal carbon intensity* could take, in the case of SMEs.

## d. Ideal model: Auto and SME ABS

In this section we describe two concrete examples of the models described above. For each abstract notion that was defined in sections II.a to c, we assign the **ideal** metric it would represent. Hence these examples would only be achievable in case perfect and comprehensive data was available. However, in order to address the current data gaps, we propose to use approximate indicators, as described in section III.c.

| Theoretical metrics | Ideal metrics for Auto loans | Ideal metrics for SME loans |
|---|---|---|
| **Carbon intensity ($e_i$)** | CO2 emitted per kilometer | CO2 emitted per euro of annual turnover |
| **Loan value ($loan_i$)** | Price of the car(s)[3] | Share of the loan actually used in the production process |
| **Asset value ($val_i$)** | Price of the car(s) | Enterprise value of the company (equity + debt) |
| **Annual operating level ($vol_i$)** | Distance traveled annually | Annual turnover |
| **Optimal carbon intensity ($e'_{c,i}$)** | Assessment of the lowest emission intensity this class of vehicle could reach | Assessment of the lowest emission intensity this sector could reach |

*Table 1: illustration of the theoretical model*

Some of the examples listed above are problematic and prone to triggering debates. For instance, the idea of *annual operating level*, rather straightforward for vehicles, is harder to define for SMEs: which indicator best represents the annual value gained from the activity of the company? We believe it ought to be the economic value added, which can be approximated by its accounting definition, *ie* the difference between sales and raw material usage. The appendix includes a complete discussion around the difficulty of deriving the real values behind these abstract notions applicable to Auto and SME loans.

[3] Which can be different from the principal of the loan. The reasons for this choice are exposed in section III. C.

# III. Data Analysis – how far are we from the ideal model with the current data available?

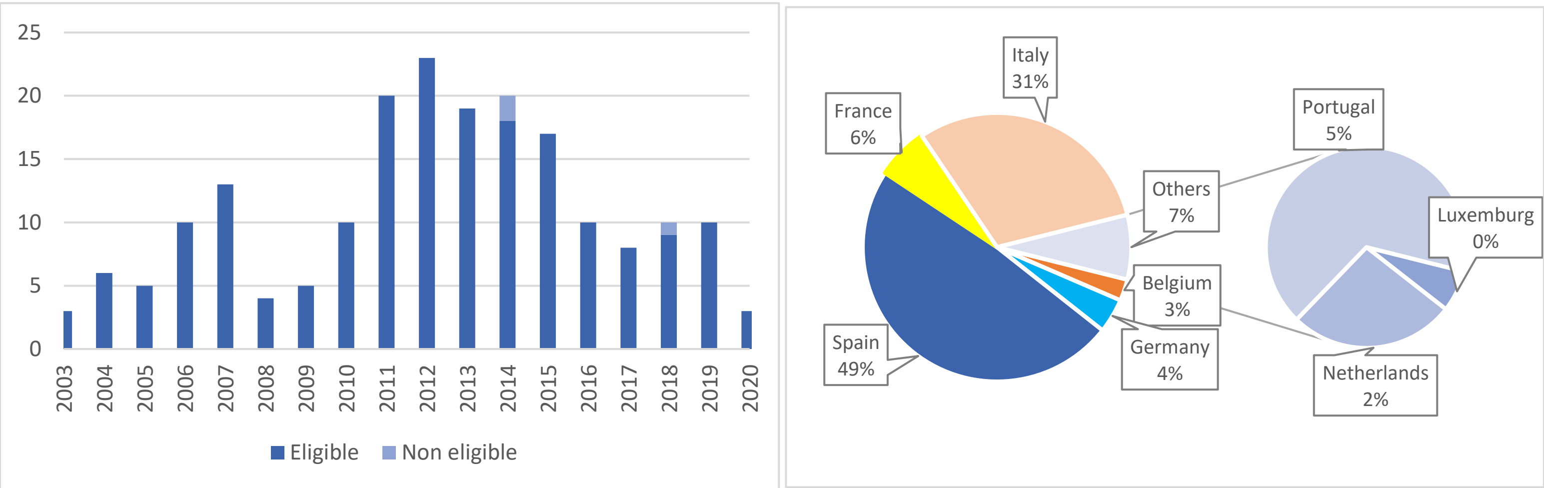
To conduct our exploratory research, we used data describing the underlying loans of a number of ABSs, compliant with the ECB collateral framework transparency requirements. The EDW database reports 200 SME ABSs and 263 Auto ABSs issued in Europe between 2003 and 2020 (30 % of the whole ABS pool), of which respectively 193 and 233 are eligible to be used as collateral in the frame of the ECB refinancing operations. Our work was built upon these two datasets[4].

In this section we briefly present the sets of ABSs, the different sources of external data, and the way we aggregated them in order to build our indicators. A more detailed description of our approach is available in the appendix section. Given the sources of data differ for each type of ABS, this section will be split between SME and Auto ABS.

[4] The study was based on the ECB format template as opposed to the ESMA templates which entered into force within the ECB collateral framework in October 2021

## a. SME ABS

- **ABS data**: SME ABS underlyings are loans to Small and Medium Enterprises. The 193 ABS made available to us in the EDW database covered the period from 2003 to 2020, and their main characteristics are described in box 1, which summarizes ABS distribution by issuing country and their temporal distribution by vintage year, along with the share of eligible and non-eligible ABSs under the ECB collateral framework. The large majority of SME ABSs were issued in Spain and Italy: 80% of the ABSs in our database were originated in these two countries.
  **The loan-by-loan data** of SME ABSs contain several fields of interest in the context of our study, the main one being the NACE code, which allows us to attribute to each loan line the emission indicators of its sector. For a more detailed description of ABS loan-by-loan data and its use, see the appendix (section I. A. a.).




Box 1: SME ABS vintages and geographical distribution, number of transactions (country of the issuer), source: EDW

- **External data** :

  1. *Greenhouse Gas Emissions by source sector* database (Eurostat, Greenhouse gas emissions by source sector, 2020): we retrieved the emissions intensities for every sector and every European country, in gram-equivalent of CO2 per euro of value added (accounting definition). For a detailed explanation of the statistics given by Eurostat, please refer to the appendix.
  2. *Impact assessment : Stepping up Europe's 2030 climate ambition, investing in a climate-neutral future for the benefit of our people* (European Commission, 2020)*:* table 6 of this report outlines the emission reduction targets for all NACE1 sectors depending on different scenarios. We used this data to define our *Optimal carbon intensity*, which is the intensity in the country with the least emissions for the given sector, reduced according to the targets set by the European Commission. For further details, please refer to appendix, section I.A.b.

Using the NACE codes and the countries of origin across all loans, we were able to join the two sources of data and attribute to each loan the average emissions intensity corresponding to its sector and country. Join rates are presented in the section I. A. c. of the appendix section.

However it should be noted that:

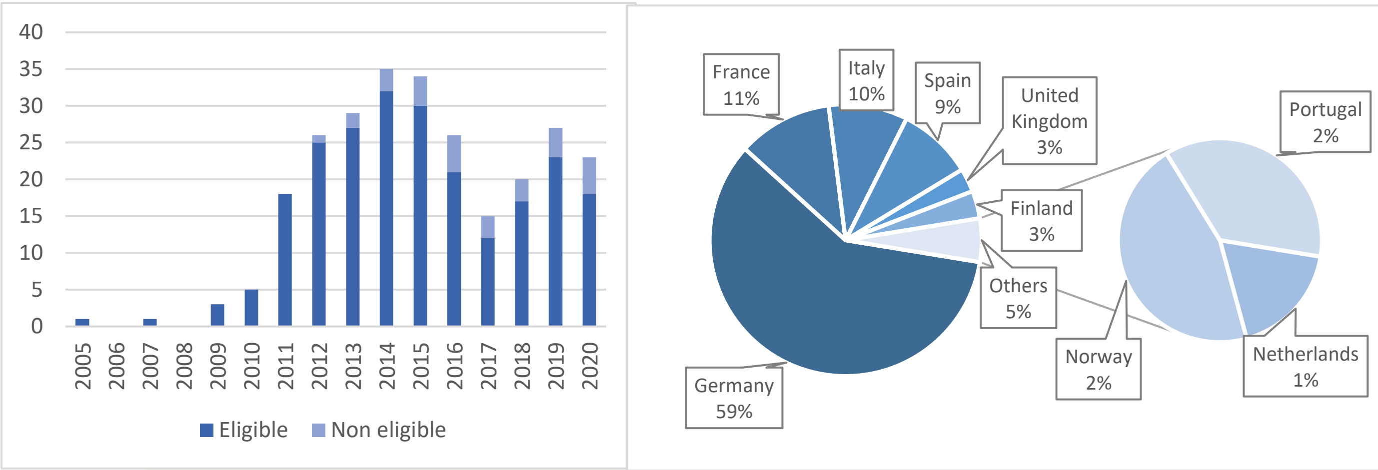
1) Eurostat database emission intensities are averaged by sector and country. They therefore do not take into account the company's specific environmental performance.
2) Eurostat database is not dedicated to SMEs but rather includes a broader spectrum of companies across sectors. Depending on the sector, a SME level of emissions may be well below or above average.
3) Eurostat database includes **Scope 1** data, which only accounts for the direct emissions induced by the activity of a company, and misses all the indirect emissions emitted to produce its materials, deliver its goods, etc.

From this database, we were able to derive most of the variables presented in the theoretical model. The values each variable takes, in the case of SME ABSs, are presented in section III c.

It is important not to associate these emission intensities with a physical reality: they can only be used as **tools for comparison but not for an objective assessment**. Nevertheless, they remain relevant as they constitute benchmarks, and allow sectors to be aggregated over tens of thousands of lines. Within the theoretical model, they allow us to compare unrelated industries such as food, textile, retail or chemicals.

## b. ABS auto

- **ABS data:** Access to the EDW database allowed us to analyze 263 "auto" ABS, active or not. The objective of our work is to define consistent environmental indicators that can be computed from the imperfect data currently available. Details of the calculation mechanisms are available in the appendix section. We describe below the main steps required to come up with consistent indicators and the conclusions we draw from them.




Box 2: Auto ABS vintages and geographical distribution, by number of transactions (country of the issuer), source: EDW

As can be seen in box 2 the majority of European auto ABS are issued in Germany (55%) while 90 % of them are concentrated in Germany, France, Italy, Spain or the UK.

Several pieces of information present in the current ABS loan-by-loan files seem relevant for the construction of physical indicators, the main ones being the *Car Manufacturer*, the *Car Model* and the acquisition year. For a more detailed description of ABS loan-by-loan data and its use, see the appendix (section I. B. a.).

- **External data**: *Monitoring of CO2 emissions from passenger cars,* by the European Environment Agency (EEA, 2020). This database contains the environmental caracteristics of all vehicles that wish to enter the european market. As it is filled by the manufacturers, the data is not standardized nor consistent. Fortunately, the large amount of data (several hundred lines per car model), allowed us to compute average carbon intensities for most of the car models in our ABS database. For a complete description of the merging method between databases, and the subsequent join rates, see the appendix (section I.B.b.).

We were therefore able to attribute to each loan in the Auto ABS database the mean carbon intensity of the underlying car model. The value is a mean of the intensities on the year of acquisition of the vehicle.

The main limits of this database are:

1) The intensity can vary substantially between cars of the same model, mainly depending on the type of engine they carry. The fact that we have mean values does not signify that a hybrid model would be preferred to a diesel one.
2) The emission values are given by the car manufacturers, and it is generally accepted that they tend to be underestimated.

In the next section, we will summarize the model that we were able to derive from the data currently available.

## C. Ideal model vs current model: a comparative analysis

The models presented above have limits, inherent to the quality and amount of data we could gather, which are presented in the two following tables. The tables can be read as follows: the “ideal value” presents the value each variable should have in a world where the information is perfectly available. The “current value” corresponds to the values we could compute with our databases. The “possible future value” describes values that could be computed in a close future, if certain steps were taken (see section V. c. for policy proposals). The “reasons” explains why we had to settle for the current value, and why we believe the future possible value might be the one we suggest. Finally, the “limitations of the current value” field details the consequences of settling for the current value.

a. SME ABSs

| | Variable | Ideal value | Current value | Reasonable future value | Reasons | Limitations of the current value |
|---|---|---|---|---|---|---|
| SME ABS | **Carbon intensity** | All scope 3 emissions of the company, divided by its annual turnover | Country average scope 1 carbon intensity per euro of value added, for the given sector of activity | Country average scope 3 emissions of SMEs, for the given sector of activity | It is currently impossible for all SMEs to assess their scope 3 emissions. It is although possible to assess the average intensity of SMEs by sector. | It can be very far from the real intensity, because it varies much within the sector, and because scope 2 and 3 are not accounted for. |
| | **Loan value** | The share of the principal directed to the production process (and not to refinancing operations for example) | Not defined in current model | An estimation of the share of the principal that will be used in the production process | The data regarding the usage of the loan is almost never collected, but it could be done if commercial banks decide to. | |
| | **Asset value** | The liabilities of the company (Equity + Debt) | Not defined in current model | The liabilities of the company (Equity + Debt) | Financial informations about the borrower are optional fields, although they are present in current templates, and could be turned mandatory. | |
| | **Annual operating level** | The annual turnover of the company | Not defined in current model | The annual turnover of the company | Same as above | |
| | **Optimal carbon intensity** | The lowest carbon intensity that the SME could reach in a foreseeable future | The european average scope 1 carbon intensity of the sector multiplied by the emission target in 2030, as set by the European commission (in percentage) | The country average scope 3 carbon intensity that SMEs could reach in 2050. Targets could be set with a more detailed separation of sectors. | The maximal intensity reduction depends on many factors as well as future scenarios. But assessing average reduction targets is a task that will certainly be adressed in the years to come | It sets targets for very broad sectors (eg. "Industry", "Services"), and we can only deduce intensities in scope 1. |

Table 2a: SME ABS comparative analysis of the values taken by the abstract variables of the model, with ideal values being the best possible scenario, current values the ones used in this paper, and reasonable future values propositions for forthcoming developments. In the “Reasons” section we expose why we settled for the given current values, while the “Limitations” outlay the main consequences it bears.

## b. Auto ABSs

| | Variable | Ideal value | Current value | Reasonable future value | Reasons | Limitations of the current value |
|---|---|---|---|---|---|---|
| Auto ABS | **Carbon intensity** | Real emissions per kilometer | Values published after homologation tests | Estimated emissions per kilometer for an average driver. This indicator does not take into account the more or less flexible driving style of a driver | To know the real emissions from a driver would require a report to the bank on the amount of fuel consumed during the year, which is unrealistic. Thus, estimated emissions from homologation tests are satisfaying. | The values obtained from the homologation tests can be different from the real emission values of the vehicles, as we have seen with the dieselgate. |
| | **Loan value** | Purchase value of the vehicle | Purchase value of the vehicle | Purchase value of the vehicle | We do not see any reason why the banks would indicate purchase values different from the actual purchase values. | |
| | **Asset value** | Purchase value of the vehicle | Purchase value of the vehicle | Purchase value of the vehicle | Same as above | |
| | **Annual operating level** | Actual vehicle mileage | Average mileage of a vehicle (which is the same for all vehicles) | 2 possibilities: 1. to estimate an average mileage for each class of vehicle / 2. to make it compulsory for the bank to indicate an estimation of the mileage based on the testimony of a client. Unfortunately, this would incite banks to attribute low mileage to highly poluting vehciles. | Operationally, it is difficult/impossible for the bank to collect the actual mileage of the vehicles for which it makes a loan. | If actual mileage is not distributed independently of vehicle pollution intensity, a bias is introduced into the ABS scores. If polluting vehicles actually travel longer annual distances than clean vehicles, our indicators introduce a bias in favor of ABS with low environmental performance. |
| | **Optimal carbon intensity** | The lowest carbon intensity that the auto industry could reach in a foreseeable future | Trajectories defined in the technical annex to the TEG final report on the EU taxonomy | | If we consider that the European taxonomy is sufficiently demanding, then the current optimal carbon intensity is quite satisfactory. | |



Table 2b: comparative analysis for Auto ABS

As tables 2a and 2b suggest, translating our theoretical model into practical examples immediately raises discussions and debates. There are numerous ways of understanding notions such as the *value*, the *operating level*, the *utility* of an underlying. It should be reminded that an ABS level of emissions depends on its underlying receivables[5], hence key questions should be borne in mind when trying to define its characteristics:

- **What is the role of the loan in the underlyings emissions?**
  For Auto ABSs, we assumed that even if the loan did not fully fund the vehicle, the purchase could not have occurred without it. Therefore, we state that the *value* of the loan, from an environmental point of view, is the value of the entire asset, in this way, we can attribute all the emissions of the vehicle to the loan.
  For SME ABSs, the same assumption is not sensible: except in exceptional cases, the existence of the company does not rely on a single loan. Therefore, we need to assess how to link a loan to the company emissions. This assessment might also raise the question of the intentionality of the loan. We decided to attribute to the loan a share of all emissions of the company proportional to the ratio of the loan on its liabilities. In order to account for the magnitude of the output (assumedly proportional to the emissions), we require the emissions per euro of turnover.
- **How intensively is the underlying used?**
  It is not realistic to theorize a world where we know the exact emissions of all assets. Because we are compelled to use average values, it is essential that we estimate the *operating level* of the underlying, to attribute each loan with its actual (approximated) emissions, and incentivize sobriety.
  For Auto ABSs, the intensity would clearly be the *annual kilometers traveled*, but it seems hard to gather this information (see section V) c.).
  For SME ABSs, the intensity is hard to define. Because it seems to be the best mirror of Scope 3 emissions, we settled for the *turnover* of the company.
- **What is the utility derived from the loan?**
  Even if all emissions are considered bad, they do not bear the same fruits, and it seems essential that any comparison be laid out upon the relative use of the loans. Since it is also crucial to account for emissions and not for intensities, we decided to define the utility in a categorical approach: two assets have the same utility *if they operate within the same usage category*. Within a given category, we estimate the *optimal carbon intensity*, which reflects the lowest emissions we could reach for the same general utility.
  For Auto ABS, *utility* is the purpose of the vehicle. We cannot compare light urban travel and heavy-load transportation, but we can compare SUVs to small city-dwellers. Besides it should be noted that the location of the purchased car might also impact its utility (eg. rural area vs city).
  For SME ABSs, *utility* is the sector of the company. We cannot compare air travel and retail, but we can compare intensive and environmentally friendly agriculture.

[5] The use of proceeds generated by the securitisation was not considered in this paper as this information was not available to us

This approach to utility integrates the idea that economic sectors or vehicle uses have intrinsic values, which cannot be translated directly into numbers.

# IV. Resulting indicators – what conclusions can be drawn?

This section presents the key results we gained from our study. It is not extensive since our goal was to explore how to build the relevant indicators needed to the measurement of ABSs' environmental impact. We present some insights we gained on the characteristics of the set of ABSs analyzed, although a full exploitation of the database would be warranted to get further results. Section II of the appendix presents additional general results obtained on the ABS dataset.

## a. Distribution of indicators between ABSs: correlograms

Within the framework of the *Temporal Emissions model*, we calculated normalized indicators of the carbon intensity of loans that underlie an ABS. In the correlogram below, each point corresponds to one ABS. We show how the intensities are distributed amongst ABSs, and how their higher order moments are linked with each other. Figure 1a and b can be read as follows:

- The diagonal corresponds to the histograms of the aggregated indicators
- The lower part shows precisely the links between the different indicators thanks to the observation of one point per ABS on an X-Y diagram
- The upper part corresponds to the correlations between the different indicators.

**For SME ABSs:** It is interesting to note the negative correlation between emissions averages and the moments of order 2 and 4, which suggests that when an ABS has highly intensive loans (raising the average), it tends to be more specialized in this sector (thus lowering the standard deviation and kurtosis). The positive correlation between skewness and kurtosis stresses another point: when the distribution of an ABS is shifted to the right (more emissive loans), it tends to have thicker tails.

**For Auto ABS:** Again we note strong correlations between statistical moments, indicating the tendency for instance that ABSs with high mean intensity are skewed to the right and have heavy tails. This would suggest that some ABSs have many standard vehicles, and a number of highly polluting vehicles, high above the intensity referential (SUVs, perhaps).

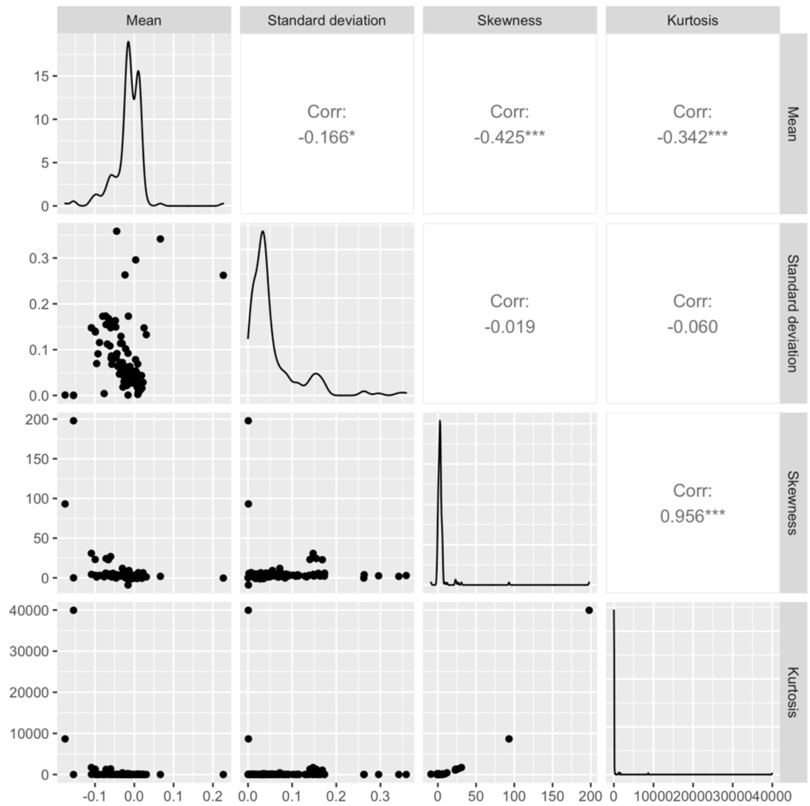



*Figure 1a – SME ABS: histograms and correlations between different indicators: carbon intensity (gCO2/€), its average, standard deviation, skewness and kurtosis.*

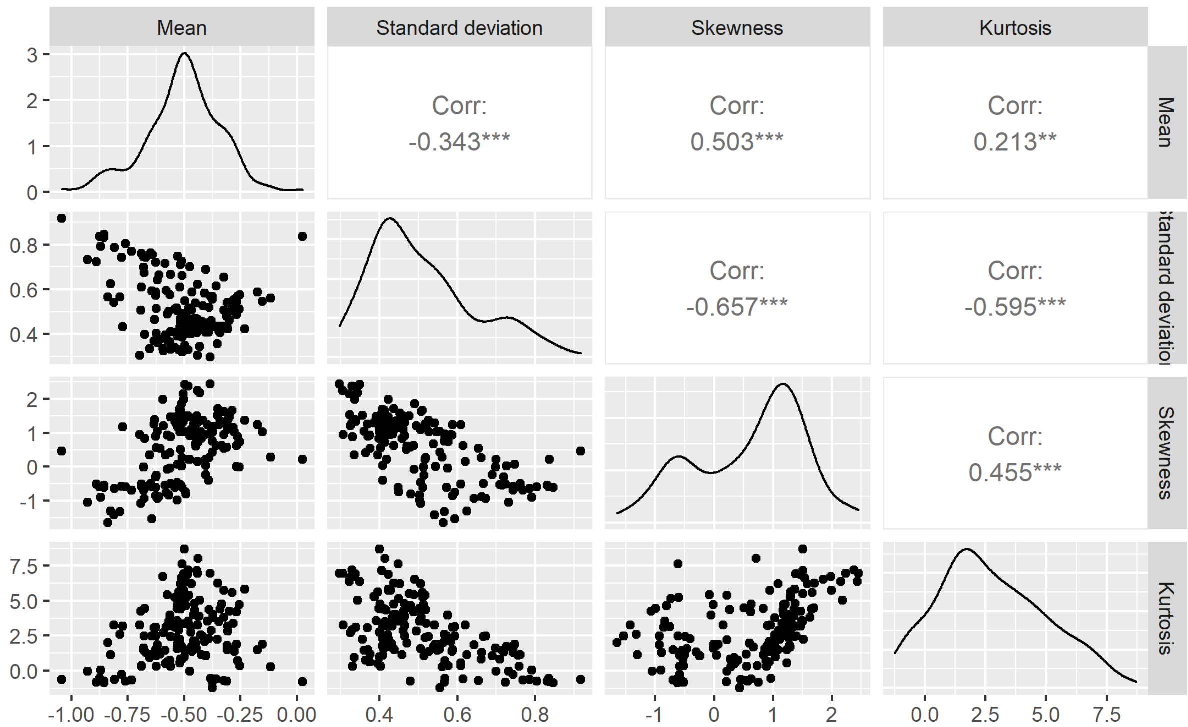



*Figure 1b Auto ABSs: histograms and correlations between different indicators: carbon intensity (gCO2/€), its average, standard deviation, skewness and kurtosis.*

## b. Use of indicators : relative comparisons or thresholds ?

Calculating comparable indicators is only one aspect of the task, once they are computed the question of how to use and understand them remains. The final goal is to create requirements, based on these indicators, that all ABSs should comply with. Two main methods enable to achieve this goal:

- Compare the **statistical moments** of the distribution of variables, which gives a **relative comparison** of ABSs, outlining which pools of loans have characteristics that differ from the majority:
    - The average intensity makes it possible to assess the energy performance level of the ABS by applying the same weight to all the underlying assets.
    - The standard deviation tells us how representative the average can be: for ABSs with high standard deviations, it is preferable to go further and inspect the moments of order 3 and 4.
    - For a fixed mean, it is preferable to have distributions with a negative moment of order 3 (*skewness* coefficient, *skewness*), which indicates that the tail of the distribution is heavier where the variable of interest takes low values.
    - Again, for a fixed average, it is preferable to have moments of order 4 (acuity coefficient, *kurtosis*) of the lowest possible value. This guarantees a small proportion of vehicles with very high carbon intensities or masses.

- Compare the **proportion of underlying assets whose characteristics exceed a certain threshold**: this measure is in line with the spirit of the European taxonomy, which sets a threshold at 50 gCO2e/km until 2025 and then 0 gCO2e/km beyond for private vehicles. This method has the disadvantage of taking into account little information on the whole distribution within an ABS, although the indicator is very readable. Furthermore, this method creates an **absolute comparison**, and allows to set targets that are independent from the current distribution of loan intensities.

## c. Selected examples: “good and bad students”

As a practical case, we tested our indicators on three distinct ABSs, for each category Auto and SME assets, the results are described in Table 3 below:

| AUTO | Carbon intensity | | | Threshold indicators | | |
|---|---|---|---|---|---|---|
| | Mean | Skewness | Kurtosis | >2sd | >1sd | >0,5sd |
| ABS A | -1,04 | 0,46 | -0,61 | 0,0% | 1,5% | 2,2% |
| ABS B | -0,52 | 1,28 | 2,89 | 0,0% | 0,5% | 0,8% |
| ABS C | 0,03 | 0,21 | -0,77 | 0,3% | 13,9% | 37,8% |

*Table 3a – Indicators for 3 examples of Auto ABS*

| SME | Carbon intensity | | | Threshold indicators | | |
|---|---|---|---|---|---|---|
| | Mean | Skewness | Kurtosis | >0,5sd | >0,1sd | >0,01sd |
| ABS A | -0,11 | 31 | 1700 | 0,3% | 3,5% | 4,0% |
| ABS B | -0,01 | 2,02 | 19,1 | 0,0% | 0,6% | 10,4% |
| ABS C | 0,22 | -0,32 | -1,55 | 32,0% | 64,0% | 67,0% |

*Table 3b – Indicators for 3 examples of SME ABSs*

*Table 3 – Indicators for selected examples. On the left, the tables indicate the values taken by moments of order 1, 3 and 4 of the distributions of the loan pools. On the right, the tables indicate the proportion of the pools that are above a given value ("sd" stands for standard deviation, the higher the threshold, the more polluting the loans are).*

We can observe that despite the correlations displayed in Figure 1, the **different indicators do not necessarily lead to the same ranking of ABS**. For Auto ABSs, ABS A, which is largely the best performer in terms of average (the measure used in the theoretical model), is no longer the best performer if we use a threshold model. Indeed, in spite of a very satisfactory average, ABS A presents a significant proportion (2.2%) of very polluting vehicles (above 0.5 standard deviations above the average). The same can be said for SME ABSs: between ABS A and ABS B, the ranking not only depends on whether we are looking at absolute or threshold indicators, **but also depends on the value chosen as a threshold**.

For SME ABSs, another aspect has to be accounted for, as it has already been discussed, the emission values we gathered are only in scope 1, which means that they only capture direct emissions. This can lead to disconcerting situations: the least emissive ABS in our dataset is composed entirely of loans to German SMEs operating in retail sale of motor vehicles. If we accounted for scope 3 emissions, such an ABS would probably be among the most emissive one.

Another point to underline is that, even though the indicators are given in relative terms (because they are normalized), they cannot be compared across different ABS types. Indeed the normalized average carbon intensities for SME ABSs will usually go from -0.1 to +0.1, whereas for Auto ABSs they will vary between 0 and -1.

To conclude, we are able to calculate indicators which allow the comparison between ABSs of the same nature, which are consistent and easily readable. Although these indicators have drawbacks, which are discussed extensively in this paper, they do offer some insights on the composition of ABSs in terms of environmental impact. Such insights are useful to start improving indicators and designing effective policies and regulations. In the next section, we will stress the main possibilities and limitations our study has encountered, and suggest a number of future improvements that we believe could greatly enhance the quality of the environmental impact assessment of ABSs.

# V. Risk management and environmental policy

In the previous section, we presented the different metrics we have developed to assess ABS environmental impact. This approach was hindered by data availability. However, we believe it is still possible to create indicators that are easily replicable, meaningful and relevant for an analysis of the environmental impact of ABSs. The relevance of such indicators is another topic. Within the strict framework of the ECB mandate, we primarily consider the risk of the collateral portfolio, so we will first try to imagine how our metrics can provide information on this risk. We will then discuss how our work could be useful beyond risk management.

## a. Towards a risk proxy?

Based on the environmental performance measurements established in section II, we have sought to deduce possible proxies to assess Auto and SME ABS related climate risks. The discussion below highlights that the notion of climate risk first needs to be qualified with regard to ABS.

### i) ABS Auto Risk Proxy

Regarding automotive ABS, climate risk is not directly derived from the loans that make up the ABS. Indeed, these risks may affect the manufacturer or the borrower. Depending on who is bearing the risk, the recovery of the car loan in case of default may be affected by climatic risks.

The first climate risk identified is the transition risk faced by the manufacturers of the vehicles financed by the loans. Indeed, a manufacturer that has not invested enough in green vehicles or whose models are heavy $CO_2$ emitters faces a high transition risk. We should keep in mind that loans backing ABS are loans to individuals or companies who purchase a vehicle. Hence, borrowers do not bear transition climate risk, which is rather borne by the manufacturer. The loan credit risk should not be affected by the first component of climate risk.

In a second step, we analyzed the climate risk borne by borrowers[6]. In our opinion, its measurement and integration is not linked to the environmental performance of the car. First of all, car loans are short-term loans, generally 3 to 5 years, and the time horizon of climate risk is generally longer. Thus, loans should only be impacted in the case of a rapid ecological transition of our socio-economic environment. Second, few national policy measures (relating to automobiles) could have an impact on borrowers' repayment capacity. In our opinion, only measures to exclude "polluting" vehicles in certain agglomerations could affect borrowers. However, the data we have on borrowers

[6] In this analysis we did not consider the impact of climate risk on the probability of default of the borrower

are not granular enough to conduct a study of this risk, especially since it seems somewhat difficult to assess.

We have nevertheless identified potential climate risk derived from ABS based on their climate impact assessment. Indeed, many banks and investors are likely to seek to reduce the climate impact of their investment portfolios, which could be achieved either:

- by aligning their investment portfolio to a low global warming trajectory (e.g. 2°C trajectory)
- through policies excluding certain polluting sectors or sub-sectors.

This could lead some of them to divest form highly polluting car loans. The impact on demand of the most polluting ABS could reduce their market value. To this extent, a simple carbon impact metric could be used for risk management purposes.

Nevertheless, while paradoxical at first sight, it still seems difficult, if not simply irrelevant, to seek to associate an environmental risk with Automotive ABS. One could also argue that investors wishing to green their portfolio might redirect their investments towards asset classes with identifiable climate risks. In this vein, ABS for which such a metric is not computable would lose attractiveness.

### ii) Risk proxy for SME ABS

Similarly, the climate risk assessment of SME ABS seems difficult at this stage given the inconclusiveness of the risk proxy computable based on the data available.

Indeed, the calculation of the environmental performance of SME ABS carried out in section II of this paper did not enable us to propose a measure of alignment or even a comparison /threshold in order to rank SMEs in terms of emissions. The sector average measures did not allow us to distinguish the good from the bad performers in a given sector, even though the belonging to a same sector does not necessarily ensure a similar risk exposure. Moreover, this static measure of GHG[7] emissions does not give any indication on emissions reduction efforts and therefore does not provide any information on compatibility with a low-carbon transition.

In the coming years, with the increasing amount of data available, it will surely be possible to refine the environmental performance measurement to propose a first consistent measurement, taking into account each company's specific emissions' intensity and trends and allowing exposure to the transition risk assessment. As an example, since 2018, under Directive 2014/95/EU[8], large companies have to publish information related to their environmental matters. This requirement will be further strengthened by the upcoming implementation of the CSRD (Corporate Sustainability Reporting Directive) which aims at standardizing the reporting format as well as broadening the scope of companies subject to such disclosure requirement. Further proposals to accelerate this process are proposed in section III.c.

[7] Greenhouse gases
[8] Also called the Non-Financial Reporting Directive (NFRD)

This paper did not further assess the physical risk of SME ABSs, which would require precise data on the regional impacts of climate change coupled with their impact on the different sectors, which would depend on companies' activities' location. The availability of data on these points is therefore necessary to deepen the current work. However, unlike Auto ABS, we believe that it is quite relevant to consider that SME ABS are indeed exposed to climate risk. Loans granted to SME have larger balances than auto loans, with longer maturities, besides the companies that have contracted them are likely to face difficulties related to climate change. In addition, the limitations encountered were mainly related to data external to ABS (in particular from Eurostat, (Eurostat, Greenhouse gas emissions by source sector, 2020)). If studies were to be conducted on the exposure of SMEs to environmental risks, the resulting data would be readily applicable to ABS.

## b. Carbon metrics and regulations

Once it has been established that measuring risk, both on its own and through proxies, is currently difficult, it is still relevant to question the usefulness of the indicators we have developed. The present analysis is part of a lively public debate on the role of Central Banks in climate change mitigation. Indeed, existing treaties leave room for interpretation.

The Treaty on the Functioning of the European Union (EU, Traité sur le fonctionnement de l'Union Européenne, 1958) defines the role of the European System of Central Banks (ESCB) in Article 127:

*1. The primary objective of the European System of Central Banks, hereinafter referred to as the 'ESCB', shall be to maintain price stability. Without prejudice to the objective of price stability, the ESCB shall support the general economic policies in the Union with a view to contributing to the achievement of the objectives of the Union as laid down in Article 3 of the Treaty on European Union. The ESCB shall act in accordance with the principle of an open market economy with free competition, favouring an efficient allocation of resources, and in compliance with the principles set out in Article 119.*

Therefore, it seems interesting to conduct further work to understand whether the application of carbon metrics to the eligibility of ABS (or more broadly of other assets used as collateral) would jeopardize the objective of price stability.

Moreover, in the context of climate change, we believe that the application of carbon metrics allows for a more efficient allocation of resources, which should, in our view, be promoted by the ESCB.

Keeping this in mind, we believe that our paper invites to think about how the ESCB could, in practice, steer markets towards EU environmental objectives. In the specific case of mobilized ABS, we have presented which metrics are applicable as they stand. Additional work remains to be done to better understand these metrics, and to reflect the incentives that a central bank could provide depending on whether it sets requirements for averages, thresholds, composition, etc.

Since its origins, the environmental problem has been governed by the lack of visibility, understanding and analytical tools available to discuss it. Whatever the goal, it is therefore essential to continue to carry out additional studies on environmental impacts, particularly in the realm of finance.

## c. Possible ways forward

### i) ABS : an important role to play in the greening of the financial industry ?

Even if the computation of an alignment score for ABS does not seem feasible at this stage, this asset class cannot be dissociated from climate risk. The financial engineering of ABS may blur the link between a securitized note and a heavily polluting company or, conversely, sustainable industry, however this data remains accessible through loan-by-loan data.

When thinking of greening the financing system, ABS might not be the first asset class coming to mind, however this instrument makes 14%[9] of the collateral pledged as collateral by the Eurosystem monetary policy counterparties, contributing notably to the liquidity provided by the ECB to its monetary policy counterparties. This figure shows that ABS might have a role to play in the greening of the financial industry.

It should also be reminded that the 2020 Capital Markets Recovery Package aims to integrate sustainability attributes within the European securitisation framework. The EBA is therefore expected to draft a proposal to this effect in 2021. More recently, the European Commission has launched a consultation on securitisation, including a section related to sustainability disclosure.

More recently, the Association for Financial Markets in Europe (AFME) has published a report, which discusses, among other things, how securitisation could contribute to the development of sustainable finance [10].

It should now be reminded that ABS loan-by-loan reporting was initiated by the ECB in 2013 to promote transparency in the securitisation market. At that stage, this requirement was only applicable to ABS seeking Euorsystem collateral eligibility. To comply with these requirements, banks issuing ABS have gone through heavy IT evolutions to be able to collect and report the loan-by-loan data required within the ECB collateral framework.

In 2019, this requirement was broadened to all European ABS falling under the scope of the Securitisation Regulation (EU 2017/2402). Market players made additional efforts to comply with new reporting format templates.

The reason for these heavy developments is that, in order to be able to report specific data periodically, banks need to make sure they collect and store this data at the loan origination process stage, in other words when they grant the loan to the ultimate borrower. Hence, imposing a new field in a compulsory reporting template might transform, and at the same time standardize, the origination process of European banks.

At the stage of the origination process it is difficult to gauge if a loan will be eligible for securitisation (each ABS underlying legal documentation contain specific eligibility criteria), hence all loans are

[9] As of Q3 2021, source ECB: https://www.ecb.europa.eu/paym/coll/charts/html/index.en.html

[10] Discussion Paper: ESG Disclosure and Diligence Practices for the European Securitisation Market; AFME (March 2021)

expected to be treated equally. Similarly, if a bank issues recurring ABS, it should make sure that the required data for reporting purpose will be collected across all loans. If the ABS issued are seeking ECB collateral eligibility, the underlying loans will need to comply with additional specific criteria.

Therefore, by imposing ESG reporting requirements to eligible ABS, central banks have the power to accelerate underlying loans disclosure process by encouraging banks to adapt their IT systems and originating processes accordingly. These requirements would improve transparency and data quality for all loans and not only the portion of those that will end up securitized.

Such a requirement could only apply to eligible assets or more broadly to all securitisations. In this case, one way to accelerate green attribute reporting could be to amend the Securitisation Regulation accordingly.

ABS loan-by-loan files could for instance include compulsory fields related to the taxonomy compliance or enable originators to flag “green” loans. A detailed methodology would be needed to make sure reporting is standardized across all issuers. As an example the loan purpose could include enhanced pre-defined multiple choices, enabling issuers to flag loans granted to finance green eligible projects, as well as an explanatory grid avoiding loans misclassification. ESMA underlying exposure template for auto loans currently include fields related to Energy Performance Certificate however these fields are not compulsory.

### ii) A reflection on ABS loan-by-loan reporting and integration of ESG criteria

The ability to analyse a pool of underlying assets from a transition risk or ecological perspective relies on the quality and comprehensiveness of the data available. This paper focused on a model that could best approximate the carbon footprint of Auto and SME ABS, considering the data available on the underlying loans and assets. As the current quality of data available was mainly influenced by transparency directives from the ECB – through the implementation of dedicated loan-by-loan templates– additional efforts in the collection of relevant data could allow a better and much more precise analysis of the “ecological impact” of eligible ABSs. A detailed methodology would be needed to make sure reporting is standardized across all issuers.

The following chapter suggests recommendations regarding additional data deemed necessary to conduct further and more precise “carbon footprint” reviews of Auto and SME ABS. This part introduces considerations linked to the EU taxonomy, considered an efficient and replicable framework. Indeed, since the taxonomy aims to become the reference for green and sustainable investments in Europe, using metrics deduced from it will give legitimacy for advocating changes at the European level. Furthermore, the direct use of taxonomy thresholds and criteria will allow a smooth adaptation of the model as regulations evolve over the years. As such, the model should be dynamic and in adequacy with moving EU climate ambitions and objectives.

- Auto ABS

The auto ABS model relies on the carbon intensity of the underlying vehicle. This data could be extracted from two sources: an official external database or directly from a mandatory “carbon intensity” field in an ABS template. The analysis conducted in this paper used information from the European Environment Agency (EEA, 2020) that associates a carbon intensity to each vehicle. However, as developed previously, inconsistencies between the car identification in the ABS loan-by-loan files and the ADEME database led to approximations and loss of precision: the vehicle's performances were aggregated to its car model. For example, the model does not differentiate between two versions of the same car even if one has a hybrid engine and the other a gas one.

To overcome this difficulty, we suggest implementing a standardized format of vehicles identification at the European level. In doing so, information would be easily gathered from any dedicated database. A proper identification system could be the French CNIT (National Vehicle Identification Code) which is unambiguous. Adding a mandatory field "carbon intensity" in ABS loan-by-loan templates would also allow the availability of necessary data.

In case these changes are not feasible in the short to medium term, a proxy could be built based on other information such as mass or engine power. Collecting this information seems therefore relevant in the meantime to conduct further research about climate risks. However, we strongly believe that implementing either one of the two first propositions is a necessary step.

Additionally, we believe that auto loans for professional or personal uses should be differentiated; therefore a mandatory field "use-case" with these two possible answers should be added.

Furthermore, the carbon intensity, coupled with the engine type, should reflect whether a vehicle is compliant with the EU taxonomy. Indeed, the EU taxonomy deems eligible "Zero tailpipe emission vehicles (incl. hydrogen, fuel cell, electric)" (EU, EU Taxonomy Report : Technical Annex – Technical screening criteria: substantial contribution to climate change mitigation – chapter 6.5. , 2021). Therefore, this paper recommends adding a mandatory field "engine type" that would allow characterizing as "taxonomy eligible" a good share of vehicles. As of today, it is not possible to build a metric characterizing the proportion of vehicles which carbon intensity respects the taxonomy thresholds for a whole pool. More precise data and further studies will certainly be able to come up with a consistent indicator of the percentage of EU taxonomy compliant vehicles.

- SME ABS

Regarding SME ABS, the model is built on the assumption that the ecological impact of a loan and its climate risk exposure, primarily depends on the activity of the company it was granted to and on the purpose of this loan.

The current ECB SME ABS framework reports the activity category via the NACE Code 3, but the actual carbon footprint of the company is unknown. In this paper, the model uses a carbon intensity database aggregated at the NACE Code 2. Again, it led to a loss of information due to average sectorial values.

To run more precise risk and carbon footprint assessments, we would ideally suggest creating a mandatory field for reporting scope 1, 2 & 3 carbon emissions for each SME. This field would enable a perfect accounting of the emissions of the companies to which loans were delivered. However, such a proposition does not seem very reasonable, as carbon emissions accounting might be a challenge for some SMEs. An additional study should explore the feasibility of such a move in concertation with SMEs delegates and commercial banks.

Another impactful data is the loan's purpose. It can be used in an ecological impact analysis by measuring the proportion of loans that serve specific purposes. As with Auto ABS, the European Taxonomy would be a good reference for selecting specific purposes. The ECB could make the "loan purpose” field mandatory with preselected available entries. A further step would be to add a “taxonomy activity” field to identify which activity category the loan purpose refers to, and thus the eligibility criteria it has to comply with. Finally, the inclusion of a “taxonomy eligible” field could prove useful. Some companies may struggle to fully apprehend the functioning of the taxonomy, hence the first field would serve as a safety net, in case too many companies are not taxonomy literate.

This paper has shown the importance of data in the ability to assess ABS carbon footprint and climate risk exposure. The above paragraphs suggest steps that could, in the incoming years, allow an improved modeling and risk assessment. It seems also important to raise this topic on a regular basis in order to adapt and anticipate changes in the markets. For example, as electric vehicles share increases in the European market, carbon emissions in scope 3 or Life Cycle Analysis should be made available to take into account both carbon intensity by kilometers and the environmental impact of batteries fabrications. As regards to SMEs, the same could apply to average sectoral emissions, which should be available on scope 3 and weighted depending on the sizes of the companies. Additional studies on the subject could focus on these points.

# Conclusion

In this paper, we have presented the main findings of an analytical mission, which main objective was to explore the possibilities of measuring the environmental risk exposure of certain assets deposited as collateral with the European Central Bank. These assets, Asset Backed Securities - securitized products backed by loans to individuals or SMEs - are accompanied by a quantity of data enabling us to study their underlyings loans. We have therefore set ourselves the objective of using the data available to develop, as far as possible, indicators on the climate risk of Automobile and SME ABS.

It quickly became clear that we could not directly measure a risk, or an alignment to a 2°C trajectory, from the data we had at hand. We therefore sought to build a carbon impact measure, which was the most easily accessible indicator. We explored the various possibilities for constructing this indicator, with varying degrees of accuracy, carrying different meanings, and with or without eliminating certain biases. The conclusion of this exploration was to come up with a general, theoretical model which could be applied to any type of ABS. This model is not entirely feasible as of now, and the current indicators are somewhat limited. Built from data external to the loans themselves, our indicators did not reflect an exact physical reality, but rather made it possible to compare ABS among each other and offered an evaluation prism that was both understandable and discriminating.

In the course of this work, we also focused on identifying what, in the data available to us, restricted the construction of these metrics. While the information provided by the issuing banks is limited, lacking in consistency or coherence, the information from external databases is often too general or does not directly address our problem. This shows that a considerable effort of harmonization, transparency and measurement is, in our view, necessary at the European level, both from public and private actors, in order to design an analytical framework that is as unbiased as possible. That said, we have also noted that some minimal and easily implemented efforts could significantly improve the relevance and accuracy of the indicators we propose.

Finally, we asked ourselves how to link these carbon impacts to the notion of risk, our initial mission. It seems difficult for us to conduct a climate risk management policy on these assets as they stand, either because they do not seem to present strong risks (in the case of Auto ABS), or because it would require unavailable information. However, we believe that this should not discourage central banks from conducting studies on the subject. On the one hand, because the quantity and quality of data is bound to increase in the years to come, and acknowledging the current limits is the first step to levy them. On the other hand, because relevant analytical tools are rare at this stage. We hope that the few questions that we have modestly tried to shed some light on throughout this paper will find their answers, or at least continue to be raised.

# References


ADEME. (2018). *Consommations de carburant et émissions de CO2 des véhicules particuliers neufs vendus en France.* Récupéré sur Agence de la Transition Ecologique: https://www.ademe.fr/consommations-carburant-emissions-co2-vehicules-particuliers-neufs-vendus-france.

EEA. (2020). *Monitoring of CO2 emissions from passenger cars.* Récupéré sur European Environment Agency: https://www.eea.europa.eu/data-and-maps/data/co2-cars-emission-18.

EU. (1958). *Traité sur le fonctionnement de l'Union Européenne.* Rome: Journal officiel de l'Union Européenne.

EU. (2021). *EU Taxonomy Report : Technical Annex – Technical screening criteria: substantial contribution to climate change mitigation – chapter 6.5.*

European Commission. (2020). *Impact assessment. Stepping up Europe's 2030 climate ambition, investing in a climate-neutral future for the benefit of our people.* Brussels: Commission staff working document.

Eurostat. (2015). *Manual for air emissions accounts.* Eurostat.

Eurostat. (2020). *Greenhouse gas emissions by source sector.* Récupéré sur https://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_air_gge&lang=en.

Fitch. (2019). *Introducing ESG relevance Scores for Structured Finance and Covered Bonds.*

I4CE & al. (2017). *Pourquoi aligner son portefeuille financier sur une trajectoire bas carbone pour gérer ses risques de transition?* .

Institut Louis Bachelier & al. (2020). *The Alignment Cookbook - A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-carbon Trajectories or Temperature Goal.*

Moody's. (2019). *General Principles for Assessing Environmental, Social and Governance Risks.*

S&P. (2019). *ESG Credit Factors in Structured Finance.*

TCFD. (2017). *Recommendations of the Task-Force on Climate-Related Financial Disclosures.*

Battiston S. and I. Monasterolo (2019). *How could the ECB's monetary policy support the sustainable finance transition?* FINEXUS: Center for Financial Networks and Sustainability, University of Zurich.

Campiglio, E. (2016). *Beyond carbon pricing: The role of banking and monetary policy in financing the transition to a low-carbon economy.* Ecological Economics, 121, 220–230.

Dafermos Y., M. Nikolaidi, and G. Galanis (2018). *Climate Change, Financial Stability and Monetary Policy.* Ecological Economics, Vol. 152, 219-234.

Dikau S. and J. Ryan-Collins (2017). *Central banks, climate change and the transition to a low-carbon economy.* New Economics Foundation.

D'Souza, R. and T. Rana (2020). *The Role of Monetary Policy in Climate Change Mitigation.* ORF Issue Brief No 350.

HEPBURN, C., STERN, N. and STIGLITZ, J. (2020). *Carbon Pricing*, European Economic Review.

JOURDAN, S. and KALINOWSKI, W. (2019). *Aligning Monetary Policy with the EU's Climate Targets*, Veblen Institute for Economic Reforms & Positive Money Europe.

NGFS (2018). *NGFS First Progress Report*, NGFS.

NGFS (2019a). *NGFS First Comprehensive Report. A Call for Action - Climate Change as a Source of Financial Risk*, NGFS.

NGFS (2019b). *Macroeconomic and Financial Stability: Implications of Climate Change. NGFS Technical Supplement to the First Comprehensive Report*, NGFS.

NGFS (2020a). *NGFS climate scenarios for central banks and supervisors*, NGFS.

NGFS (2020b). "Overview of Environmental Risk Analysis by Financial Institutions", NGFS.

TCFD (2017). *The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities Technical Supplement - Technical Supplement*, TCFD.

OUSTRY, A., ERKAN, B., SVARTZMAN, R., WEBER, P-F., (2020). *Climate-related Risks and Central Banks' Collateral Policy: a Methodological Experiment*, Working Paper.

The Bank of England (2020). *The Bank of England's climate-related financial disclosure 2020.*

The Bank of England (2021). *Options for greening the Bank of England's Corporate Bond Purchase Scheme.*

NGFS (2021). *Adapting central bank operations to a hotter world - Reviewing some options,* NGFS.

# Appendices

## I. Data analysis

This section is complementary to the Data analysis section of the main body of the report. It gives details on the contents of ABS related data, external sources, and the join rates in the final database. We also give insights on the limits encountered while building this database.

The section is divided between SME and Auto ABSs.

### A. SME ABSs

#### *a. Loan-by-loan data*

In the data describing the underlying loans, 3 extra-financial fields are of interest in the context of our study :

- **Nace Code 3 (mandatory)**: characterizes the company's sector of activity. The number (Nace 1, 2, 3) corresponds to the category precision, Nace 3 being the most precise. Identifying the sector of activity enables the company to estimate its emissions, carbon intensity or exposure to climate risks (particularly transition risks). This is the most useful indicator we have, but its major weakness is that it does not take into account a company's potential efforts but only its sector average. Moreover, the public emissions data are at the Nace 2 level only, and relate to all companies and not only SMEs.

- **Postal code (mandatory)**: gives a precise access to the company's location. It is the only physical risk indicator available (for example by identifying if the company is located in a flood-prone area or in a high water risk zone).

- **Loan Purpose (optional)**: specifies the purpose of the loan, in a very broad sense (e.g. refinancing, purchase, renovation, etc.). This qualitative data would make it possible, for example, to reward renovation loans over refinancing loans, which should have a lower impact.

Not all of these fields are mandatory, and even the mandatory fields are not always filled in. Statistics on fields completion are available in Box 1. Please note: **when filled, the fields are 98% complete on average**.

### *b. External data*

In order to associate an estimate of the emissions generated by these loans, we use the Eurostat database *Air Emission Intensity by Activity* (Eurostat, Greenhouse gas emissions by source sector, 2020). The database presents the intensity accounts for the main sectors of activity, for each European country. The **carbon intensity (eq-gCO2/€)** it contains is defined as emissions related to value added, in euros. The database offers the results in current euros or in constant euros for 2010. In order to be able to compare historical data, we have chosen to express the results in constant euros. The calculation of emissions per value added is not precisely detailed in the documentation, the *Manual for air emissions accounts* (Eurostat, 2015) suggests that countries should rely on the income statements of firms to calculate the value added in its accounting definition. On the other hand, we have no information on the method used to calculate the emissions. In particular, the documentation does not provide information on the scope considered, consequently, we consider them to be Scope 1 emissions.

In addition, **Eurostat has a wealth of other data relating to European companies**: environmental investments, water use, energy consumption, quantities of waste produced, etc. These data do not exist for all sectors of activity, which does not allow us to use them as a systematic indicator on loans. We could nevertheless use them to define virtuous or non-virtuous sectors and study the exposure of ABS to these areas. However, we face the following limit: such an assessment would only be determined by the behaviors of the heavyweights in each sector, and not those of the SMEs that are concerned here.

**In order to determine *optimal carbon intensities*,** we need to assess the future lowest carbon intensity a given sector could reach. A possibility would be to use the emission reduction targets set by the European Commission, as detailed in the report *Impact assessment. Stepping up Europe's 2030 climate ambition, investing in a climate-neutral future for the benefit of our people* (European Commission, 2020). Table 4 below presents the targets detailed for each economic sectors:

| | BSL | MIX-50 | REG | MIX | MIX-non-CO2 variant | CPRICE | ALLBNK |
|---|---|---|---|---|---|---|---|
| | *% change 2030 GHG emissions versus 1990* | | | | | | |
| **Total GHG incl. LULUCF**[112] | -46.9% | -51.0% | -55.0% | -55.0% | -55.1% | -55.0% | -57.9% |
| **Total GHG excl. LULUCF** | -45.1% | -49.0% | -52.8% | -52.8% | -52.8% | -52.8% | -55.5% |
| | *% change 2030 GHG emissions versus 2015* | | | | | | |
| $CO_2$ emissions | -32.7% | -37.7% | -42.7% | -42.6% | -41.9% | -42.6% | -46.0% |
| Supply side[113] | -50.3% | -58.0% | -67.3% | -67.5% | -65.7% | -67.5% | -73.1% |
| Power generation[114] | -53.0% | -60.8% | -69.6% | -70.8% | -68.7% | -70.4% | -76.1% |
| Industry[115] | -18.2% | -20.3% | -21.0% | -22.4% | -22.1% | -23.3% | -25.1% |
| Residential | -47.2% | -56.5% | -63.6% | -62.0% | -61.9% | -61.0% | -64.8% |
| Services | -48.7% | -56.5% | -53.5% | -57.8% | -58.1% | -60.4% | -60.6% |
| Agriculture energy | -30.5% | -36.3% | -37.0% | -37.3% | -37.4% | -37.7% | -39.2% |
| Transport | -12.5% | -14.9% | -17.6% | -16.3% | -16.4% | -15.6% | -17.7% |
| Of which Road Transport | -16.4% | -18.3% | -20.7% | -19.6% | -19.6% | -18.9% | -20.6% |
| Intra EU aviation & navigation | 23.5% | 16.7% | 11.6% | 13.7% | 13.7% | 14.4% | 8.5% |
| Non-$CO_2$ emissions | -22.3% | -26.7% | -31.0% | -31.0% | -34.5% | -31.0% | -34.5% |

[112] Including domestic and intra EU aviation and maritime navigation
[113] Power sector, district heating, energy branch and refineries
[114] Excluding district heating
[115] Including process $CO_2$ emissions from industry, excluding refineries

*Table 4: Sectoral GHG emissions and reductions depending on different scenarios,* (European Commission, 2020).

From this table we can estimate several *optimal carbon intensities* : by multiplying each target with the current lowest intensity for a given sector (ie. the intensity of the lowest emissive country for the given sector), we would, for example, have an idea of the intensity each sector might reach. We did not, in this study, calculate and analyse these values for two reasons. The first is that, again, our work aimed to be an exploratory research, as opposed to a conclusive analysis on the environmental performances of ABSs. Therefore our discussion about the *optimal carbon intensities* only aimed at triggering a debate. The second reason is that the method described above is too imprecise to constitute actual values to use in a model. The estimation of optimal emission targets for european SMEs by sector is a heavy task on its own, which we did not set to solve.

### c. Join rates

The database we obtain by joining ABS data with the emission intensities is complete: 100% of loans are associated with an intensity. For a given loan, the intensity can be associated along three levels of detail: join on NACE1, join on NACE1 and country, join on NACE2 and country.

The NACE1 code defines the broad sector of activity (eg. Manufacturing, Construction, etc.), while the NACE2 code is more precise (eg. Manufacture of food products, Civil engineering, etc.). Depending on the country and the sector, the Eurostat data can be expressed at a NACE1 or NACE2 level. For some sectors and countries, no data was provided, we therefore refer to the European average. In average, 54% of loans are joined on NACE2 and country, 46% on NACE1 and country, and a residual amount (<1%) on NACE1 only.

### d. *Limits of the database*

We are looking at aggregate indicators, which do not directly concern the companies in question. In our view, the least biased indicator therefore remains carbon intensity, which can be assumed to vary more between two areas of activity than within the same sector. The efforts needed to overcome this pitfall are substantial, and would assume that banks include environmental alignment issues before granting loans. It seems to us therefore more relevant for the time being to confine ourselves to these general but discriminatory measures.

## B. ABS Auto

### a. *Loan-to-loan data*

Several pieces of information present in the current ABS loan-by-loan files seem relevant for the construction of physical indicators:

- AA22: *Origination Date*. According to ABS ECB *templates*, this is the date the original loan was granted. This date allows us to know the state of the automotive market, in terms of climate performance, at the time of purchase of the vehicle.
- AA44: *Car Manufacturer*. This data is provided in a satisfactory manner, with completeness and uniformity between the different ABS.
- AA45: *Car Model*. This variable has the advantage of requiring a high degree of accuracy from the transmitter responsible for informing the ABS. **It is then potentially possible to identify the environmental characteristics of the asset underlying the loan** in a very precise manner.
- AA46: *Engine Size*. This variable has little information, because the field is optional. It can allow us to obtain a proxy for the engine power.
- AA47: *Year of registration*. As for the date of origination, this variable seems to be useful. However, we don't know exactly what it covers since the ECB *template* only indicates that it is the "vehicle registration" date.

Ideally, rigorous work would consist in associating real environmental characteristics with each underlying asset, in order to build aggregate indicators (on the scale of an ABS) that are also representative of a physical reality. Fulfilling one of the two following conditions - neither of which is satisfied today - would be necessary to enter into this ideal framework:

- The ABS issuer itself fulfills the technical and environmental characteristics described above for each loan, by complying with instructions defined beforehand.
- The transmitter fills the AA45 (*Car model)* field uniformly with a model identification key. It is then up to the environmental agencies, European or national, to provide environmental databases containing this identification key, so that this data can be attached to each ABS loan line.

In order to construct consistent indicators over time, it would also be useful for issuing banks to provide the date of vehicle construction, in addition to the date of purchase, to be able to compare a used vehicle with a new one.

### *b. Join rates*

The first challenge is to assign to each ABS loan line a proxy representing the actual environmental characteristics of the underlying asset. Ideally, we would have a unique identification code for each "type" of vehicle (a type being here the model, its engine and fuel types, and any other characteristic that impacts the emissions). Such a code exists, in France it is called the CNIT, and is easily linkable to environmental databases (such as the one given by the ADEME, the French environmental agency, (ADEME, 2018)). The issue is that very few ABS issuers fill the dedicated field which should contain such a code. Instead, filling methods vary between issuers, and no consistent approach can be found. The method we had to settle with is to attribute to each loan the characteristics of its **model class**. For example, for the model "A7 V6 3.0 TFSI (310hp) QUATTRO S TRONIC 7", the manufacturer is "AUDI" and the model class is "A7".

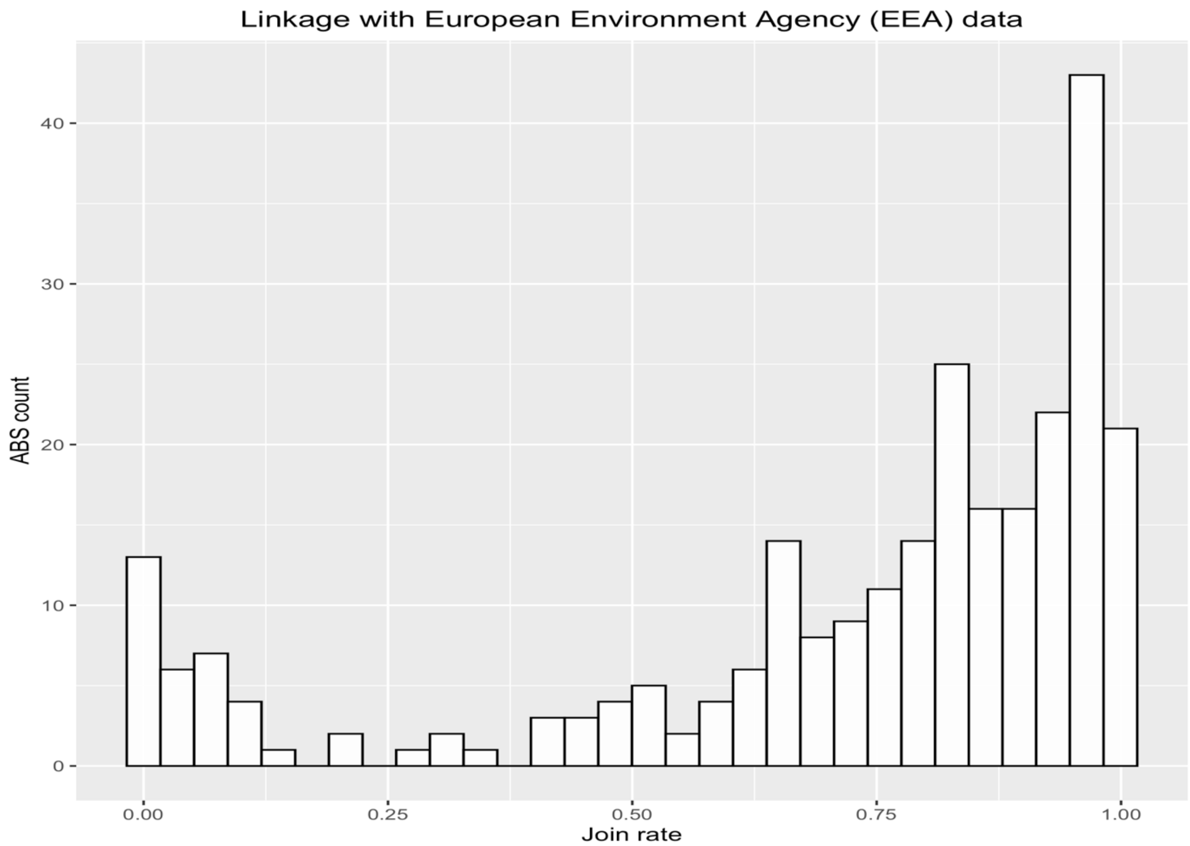


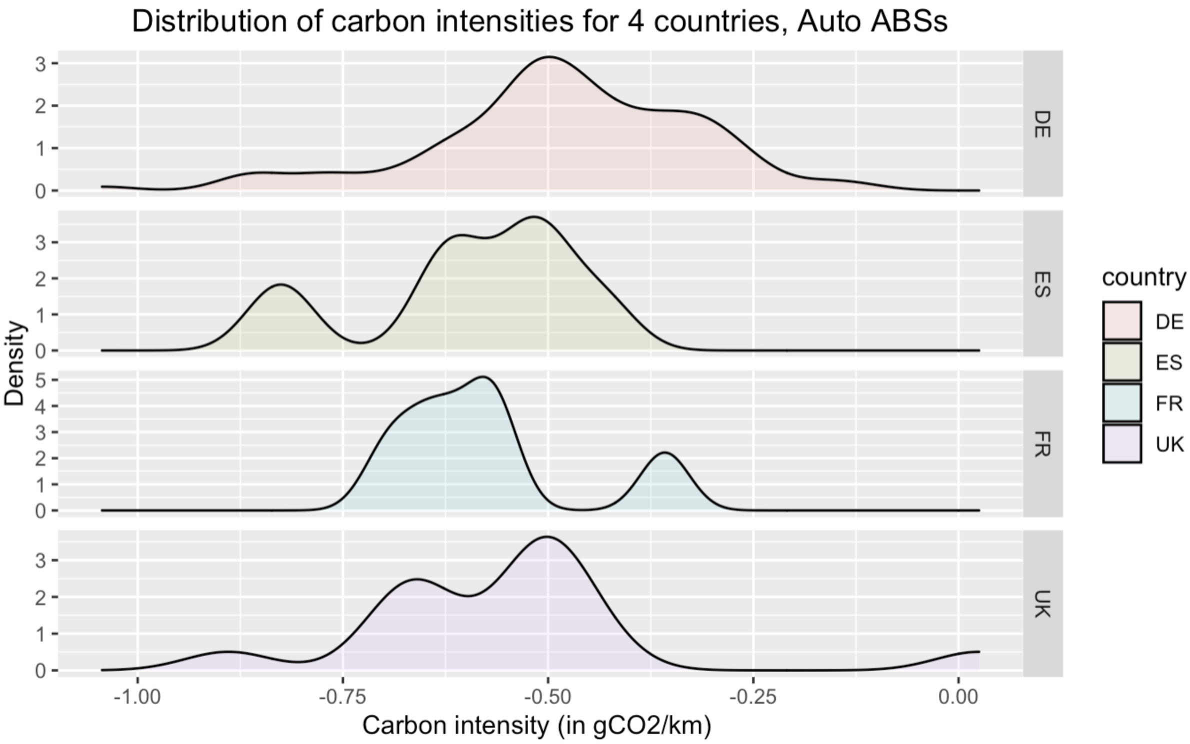

*Figure 2: join rates between the ABS pools dataset and the EEA database* (EEA, 2020).

A second step is to join our environmental characteristics to each ABS loan-by-loan line thanks to the simplification of the joining key which now corresponds to the class. This simplification allows us to reach joining rates for each ABS that are impossible to achieve by taking into account the whole model description, given the great heterogeneity of formats chosen by ABS issuers, intra or inter-ABS. In spite of this simplification, we do not always obtain 100% join rates, as can be seen in the figure above.

# II. Resulting indicators

## A. General results

The distribution of ABSs are highly dependent on the issuing countries, both for Auto and SME ABSs. Results are presented in carbon intensity for vehicles (since we do not have the kilometers traveled by vehicles, and had to settle with the intensity), but it is given in absolute emissions for SMEs.



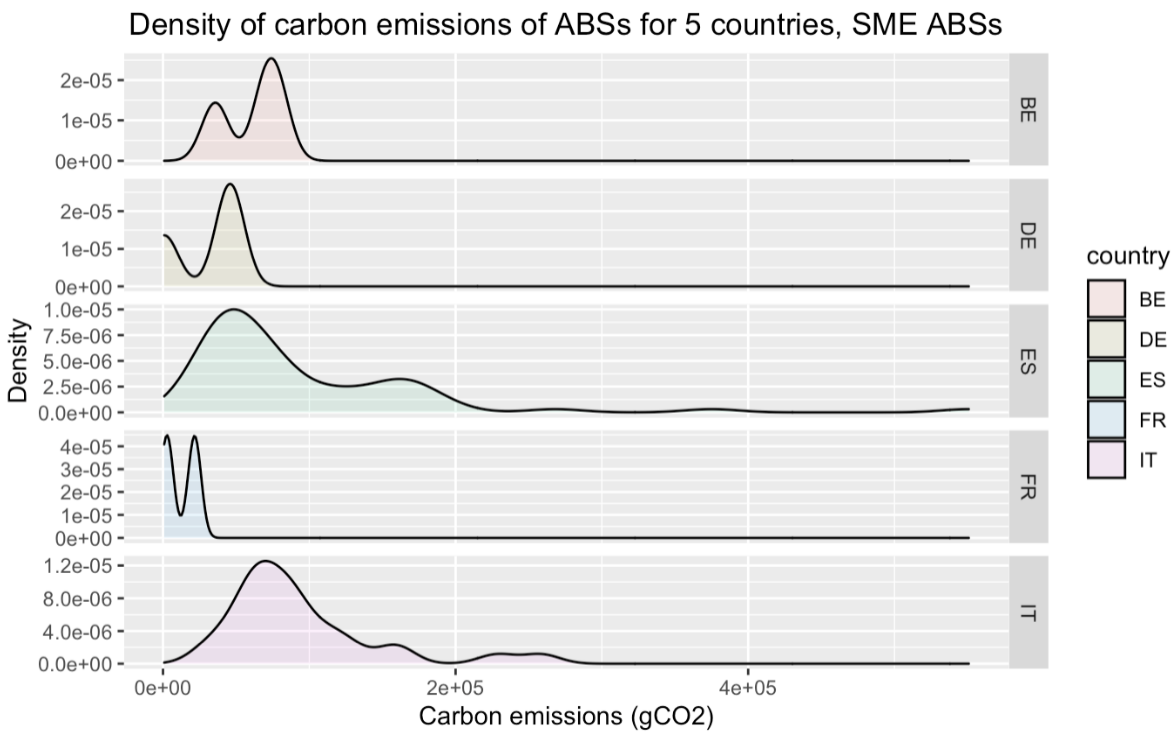



*Figure 3a (above) and 3b (below): distributions of carbon intensities for different countries, for Auto ABSs (3a) and SME ABSs (3b)*

## B. Justification of the temporal correction

In this section we present the elements that lead us to use the Temporal Emissions Model instead of the General Emissions Model. We first discovered the temporal decrease of emissions through the vehicles carbon intensities.

As can be seen in the following graph, the average emission of new models decreases over time (the histograms are constructed from the 640 models in the database):

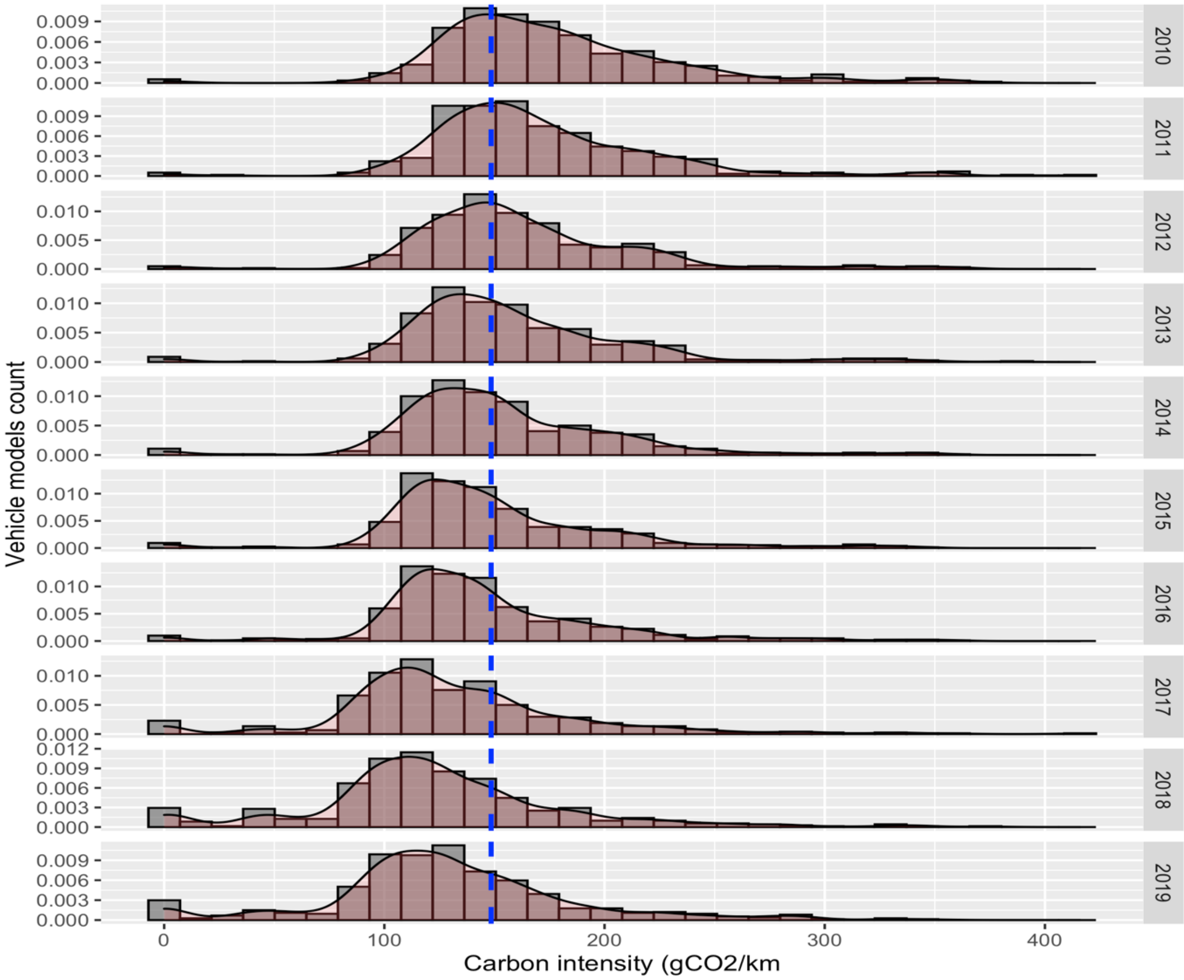



*Figure 4a: Carbon intensity distribution for all vehicle models built in Europe, between 2010 and 2019. The blue dashed line representing the all-time average intensity.*

Our goal is to take into account the environmental performance of a model relative to the market in its year of construction, so we extend the base by assigning each model a new "deviation" score relative to the environmental performance of the market at the time of construction. The score corresponds to the deviation between the value of the model's characteristic and the average of the values for all the models built in a given year. We then obtain repairs of the environmental values of the models offer, which are "rectified" over time:

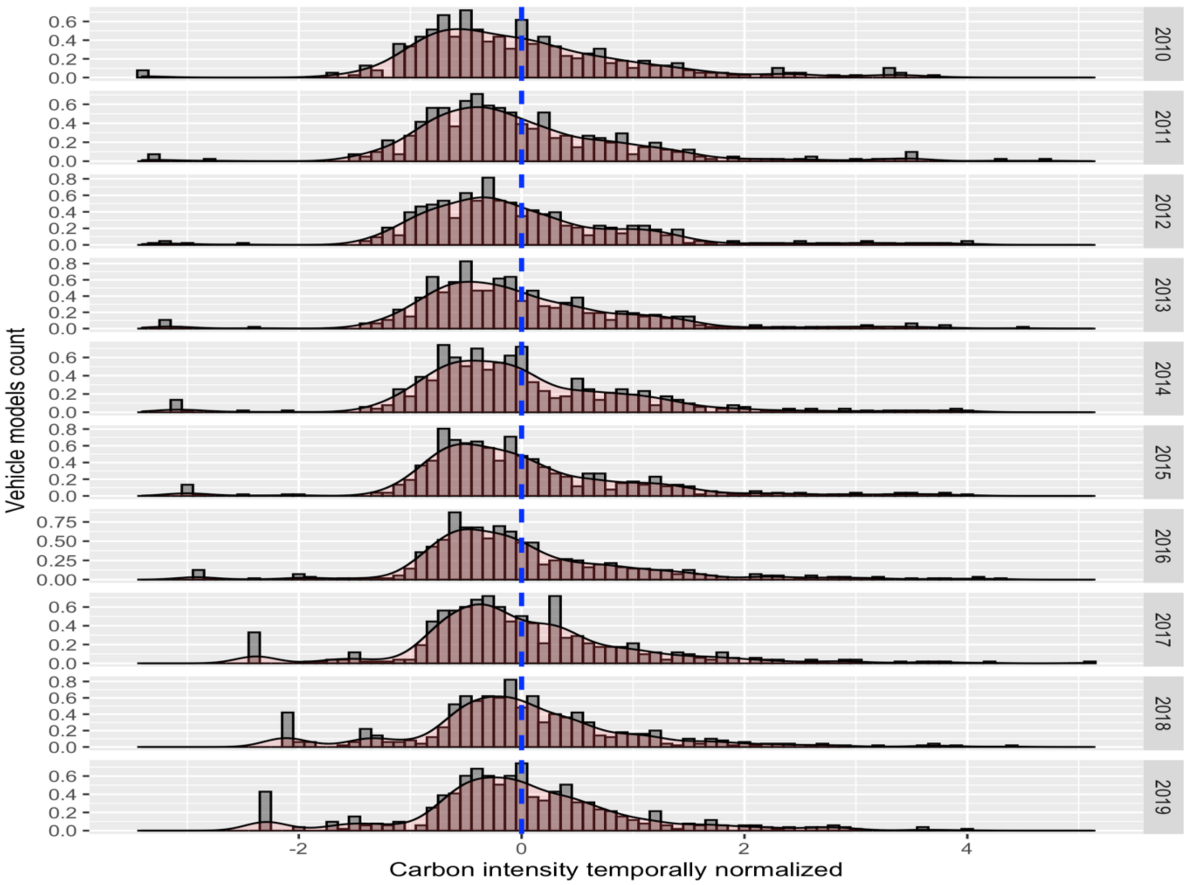



*Figure 4b: Carbon intensity temporally normalized distribution for all vehicle models built in Europe, between 2010 and 2019. The blue dashed line representing the all-time average intensity.*

It is then possible to use indicators similar to those proposed in the static version, based on deviation scores from the market, as opposed to absolute values.