Utrecht University

Master Thesis U.S.E.

Analyzing attribution factors for sovereign financed emissions

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Financed emissions, PCAF, Attribution Factor, Sovereign Debt.

Abstract

In an effort to facilitate consistent reporting of the greenhouse gas (GHG) emissions of their financial activities, financial institutions establish the Partnership for Carbon Accounting Financials (PCAF). Out of seven asset classes, only the attribution for the sovereign asset class is not aligned with the GHG protocol. The total value of an asset is an essential variable for assigning an attribution factor. For sovereigns, however, it is impossible to estimate their value simply because they are not for sale. Our research illustrates the limitations of the PCAF-2022 attribution factor by presenting practical computation issues. We develop an alternative approach for calculating the attribution factor. Our approach utilizes the Keynesian multiplier effect and allocates emissions based on economic activities that are enabled through recently raised net sovereign debt. We conclude that PCAF-2022 overestimates the attribution factor for sovereign financed emissions. Our approach yields on average 83% lower values than PCAF2022 for EU-27 over the period 2019 till 2022. Our approach aligns towards a more reasonable attribution of financed emissions. While it is impossible to validate the accuracy of attribution factors, our case study on the Netherlands indicates that our methodology is a more reasonable attribution for sovereign financed emissions.

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Introduction

Lord Kelvin in 1883 quoted *"When you can measure what you are talking about, you know something about it. But when you cannot measure it, your knowledge remains meager and unsatisfactory*." This principle applies to the pursuit of sustainable development, emphasizing on the role of quantifiable metrics in measuring greenhouse gas emissions. The term greenhouse gas emissions (GHG) refer to gases, such as CO2, that contribute to global warming and consequently to climate change. Climate change is a central topic for all parts of economy, including the financial industry. Various initiatives aim to facilitate the transition to low carbon society and the reduction of GHG emissions. The Paris Agreement PA is the eminent agreement for setting targets on limiting temperature rise to 2°C above pre-industrial levels (United Nations Climate Change, n.d.). Financial institutions influence the economic activities through investments(GFANZ, 2021). In order to align with the PA (2015) targets, they pledged to lower their financed environmental impact (GFANZ, 2021). Financed emissions result from GHG emissions associated with underlying assets financed by an investor. These consist part of an investor's GHG emissions that fall under the scope 3 (GHG Protocol Team et al., 2011). Investments is one of the 15 "scope 3" categories, and the most important category for financial institutes (Donnelly et al., 2023). In 2015 a number of Dutch financial institutions establish a Partnership for Carbon Accounting Financials (PCAF) and by 2019 PCAF was internationally adopted by financial institutions as a supplementary disclose of financed emissions associated with their activities (PCAF, 2022). The Attribution factor is essential part of financed emissions since it quantifies how many of the emissions, of a financed client, should be attributed to the financial product that the client has received (PCAF, 2020).

For each asset class the corresponding financed emissions are calculated based on the total emissions released and based on an asset-class specific attribution factor. The attribution factor is calculated based on the investor's exposure to an asset, divided by the total value of that asset. For example, if a business with 2 million euro market value has a loan of 1 million €, the total value of that company is 3 million euro. Consequently, 33% the business' GHG emissions are attributed to the loan. Determining the corporate's market value is relatively straightforward, as it corresponds to the sum of the equity value, the available cash and the debt. However sovereign value poses a unique challenge due to the inherent nature of government ownership; governments are not tradable commodities. The PCAF accounting methodology for the attribution of all seven asset classes are approved by the GHG protocol, with the exception of the sovereign bonds asset class (PCAF, 2022, p.15)

We focus on the PCAF methodology since it is applied by institutional investors worldwide and it is also adopted by SFRD disclosure of EU (European Parliament, 2019). The initial PCAF-2019 approach suggests financial institutions to consider only the debt as the country's market value. PCAF acknowledged the limitations of this simplistic metric and as a response, in 2022, it proposed a revised method. Specifically, it introduced the Gross Domestic Product (GDP) adjusted for Purchase Power Parity (PPP) as a more equitable metric for assessing a country's value.

This research focuses on the methodology of attributing GHG emissions to the sovereign debt asset class. We develop a new attribution factor framework based on the key principle of PCAF that suggests practitioners to "follow the money" as far as possible in the value chain (PCAF, 2022, p.39). Our framework links the economic activity that was enabled by the capital provided by debtholders, with emissions (Figure 1). This perspective focuses on an impact-attribution framework that considers the broader economic implications of the sovereign debt. Our research question is: *Can our alternative attribution factor lead to a more reasonable reflection of sovereign financed emissions compared to the PCAF-2022 attribution factor?* In this context, reasonable means that the attribution factor should be a realistic representation of the actual GHG emissions that were enabled due to an investor's financial exposure.

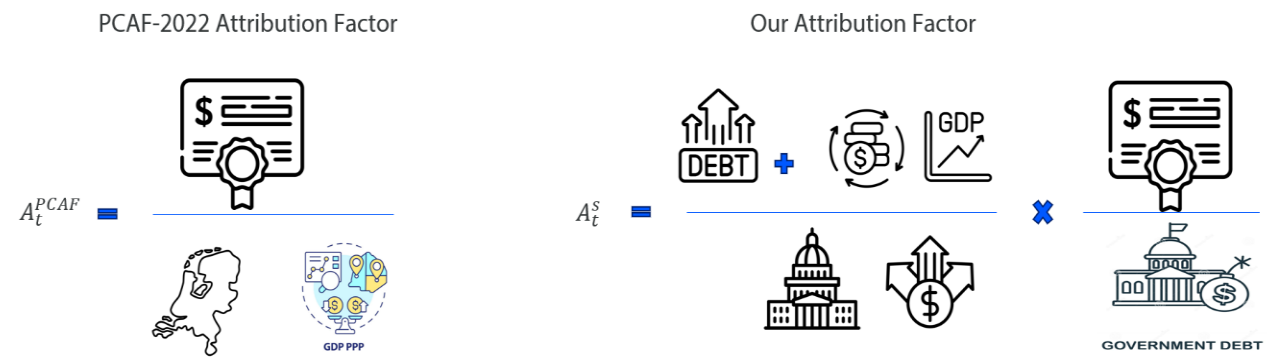

Figure 1. A graphical representation of PCAF-2022 and our attribution factor. Our approach is based on attributing financed emissions associated with economic activity enabled by investments in sovereign debt, building on the "follow the money" principle. The PCAF-2022 approach uses a derivative of the value of a sovereign (PPP-GDP) to attribute financed emissions.

Crafting a diverse approach for the attribution factor would allow institutional investors for informed decisions that could further align their activities with the PA goal. In addition, an improvement in attribution measurement provides policy makers a clear picture of the responsibility of investors on the climate impact. The academic discussion on attribution factors is fairly new, as it has only attracted more attention from industry partners in recent years due to the introduction of reporting requirements on climate impact. We aim to address an under-researched topic and to fill the literature gap of attributing financed emissions to sovereign debt assets. To provide insights, we execute a diverse methodological approach of attributing emissions and we compare it with the existing one. To answer the main question, we will address the following sub-questions: *What are the limitations of the current methods? What are the implication on the EU-27 countries when using our attribution factor and PCAF-2022 ?*

Our analysis reveals that the PCAF-2022 overestimates the attribution factors for EU-27, where countries exhibit attribution factors exceeding the value of one. We strengthen our findings by comparing the multiplier effect implied by PCAF-2022 for the EU-27, with values presented in the literature. Our approach yields consistently lower attribution factors for EU-27 compared to that of PCAF-2022. Both approaches agree on the trajectory of EU-27 attribution factors over time. The PCAF-2022 and our approach differs in ranking order for EU-27, with our approach presenting higher ranking volatility over time.

The remainder of this paper is structured as follows: We first present the current relevant scientific knowledge followed by the formulation of the methodology that supports our approach and the relevant data we use to perform calculations. Next we present the results for the implied multiplier and the EU-27 countries. In the end, we discuss our results, we draw conclusions for the implementation of our approach and for future research.

Literature Review

Review of the state of the art

In the pursuit of aligning with the PA and formulating climate responsible portfolios, the Paris Agreement Capital Transition Assessment (PACTA) is an potential alternative to PCAF. It assesses the alignment of listed equity and corporate bond portfolios with diverse climate scenarios for the heavy industry that constitutes 75% of all GHG emissions (PACTA, 2023). The various climate scenarios correspond to five years forward looking scenarios of necessary sectoral decarbonization pathways that investors would be exposed to when financing climate intensive sectors (e.g. energy, cement, steel) (PACTA, 2023). Any misalignment of a portfolio with the various scenarios indicates potential transition risks and opportunities. The latest climate scenarios for 2022 range from "business as usual" to better than "PA aligned" for steel, cement, aviation and automotive industry. Nevertheless, PACTA does not allow for measurement of financed emissions for the sovereign asset class and it only focuses on climate intensive sectors of the economy.

There is limited literature available on analyzing and proposing methodologies for attributing climate impact related with financing sovereign debt. Ritchie & Dowlatabadi (2014) conducted one of the first studies on portfolio emissions and they outlined the existing methodologies for determining climate impact. In addition, they proposed a methodology that allows investors to formulate divestment decisions based on the climate impact of their investments. They focused on US publicly listed companies, and they used the price-sales ratio for calculating the attributed emissions to investors. Nevertheless, to the best of our knowledge, an equivalent impact attribution framework for sovereign debt assets cannot be implemented.

A study conducted across the G7 countries by Chaudhry et al. (2020) concluded that increased GHG emissions are associated with an increased frequency of flood and drought incidents. This increased risk impacts the sovereign debt dynamics leading to higher borrowing costs. In addition, sovereign debt investments do not only impact the climate, but they are also exposed to climate risk. These implications underscore the importance for policy makers and investors to meticulously allocate GHG emissions in the context of sovereign debt.

Popescu et al. (2023) highlighted the importance of calculating the so-called financed scope 3 emissions, for measuring the sustainability of sustainable and conventional investment funds. These investment funds are exposed on publicly listed equity assets. They used input- output life cycle assessment (LCA) that covered all emission scope of diverse companies. Their findings indicate that financing scope 3 emissions can result in doubling or tripling the total GHG emissions attributed to a fund. As of 2025, large entities of public interest in EU with more than 500 FTE already subject to NFRD, have to report the financed scope 3 emissions (European Parliament, 2022). This highlights the importance for adequate PCAF attribution factors. Popescu et al. (2023) used the relative carbon footprint (RCF) that connects one million of USD investment with emissions creation and the weighted averaged carbon intensity (WACI) that connects the companies' carbon intensity with their corresponding revenues. The first PCAF-2019 approach based on total debt for sovereign bonds could be linked with the RCF metric, while the second PCAF approach (2022) of PPP-adjusted GDP has similarities with the WACI approach. Notably, they stated that sustainable funds score better on RCF than the conventional finds, but their difference is insignificant for the WACI metric.

Recently, the urgency to address climate change has prompted academia to explore approaches of aligning financial investments with the reduction of GHG emission. One approach is the theoretical concept of "investment emission intensity taxation" (IEIT) introduced by Donnelly et al. (2023). IEIT aims to influence the expected rate of return for investors enhancing capital towards low carbon listed assets. While their work focuses on listed equity, it can potentially hold for sovereign debt investment portfolios. Nevertheless, there are inherent challenges of calculating the value of a sovereign as well as constructing low intensity portfolios that emit greater absolute emissions than the PA target. Policy makers should consider this limitation before implementing IEIT to sovereign debt, our approach aims to contribute to the discussion towards a reasonable attribution factor for financed emissions that could eventually foster the implementation of such initiatives in the sovereign assets.

Fraser and Fiedler (2023) explored how different carbon metrics impact the measurement of financed emissions of investment portfolios focusing on corporate equity. They considered absolute emissions (AE), normalized emissions (NE) and weighted average carbon intensity (WACI). Extrapolating these metrics to our research we conclude that absolute emissions (AE) are similar with the first approach of PCAF-2019 of dividing the exposure to the total country's debt, while the carbon intensity (WACI) has similarities with the most recent approach of PPP-adjusted GDP (PCAF, 2022). Their findings state that same portfolios present higher reduction of financed emissions for NE followed by WACI and lastly by AE when considering scope 1 & scope 2 emissions . When considering scope 1, 2 and 3 the NE metric presents lower emissions than AE and CI metrics. The most important finding is that minimizing physical emissions can reduce financed emissions but not the converse. This implication can also be relevant for sovereign debt investors who aim to minimize the GHG emissions of their portfolio. Nevertheless, it is crucial to acknowledge that our methodology does not address the intrinsic challenges associated with standardizing GHG measurements within investment portfolios.

Apart from the time component, climate metrics are subject to changes in climate variables, portfolio rebalancing, or changes on financial variables (Nagy et al., 2023). Nagy et al. (2023) built an attribution-tree model for portfolios exposed in listed equity and compared financed emissions, financed-emissions intensity and weighted average carbon intensity. They created a graphic representation of a decision tree, displaying GHG emissions, changes in data coverage, changes in financing structure of listed companies, changes on portfolio manager's decision to buy or sell assets and changes on market variables (portfolio weights). The tree attribution model indicates the amount of financed emissions for a portfolio and offers a transparent overview of the drivers that caused these changes in financed emissions. Main driver categories are portfolio managers' decisions, market changes and changes in actual emissions. In our case, only the actual emissions and change in exposure can drive changes to financed emissions of an investor exposed to sovereign debt. Lastly, assessing changes in the financial structure of a sovereign asset class category are not relevant.

Jinglei et al. (2023) explore the interconnection among financed emissions, carbon intensity and environmental, social, and governance (ESG) factors for Chinese institutional investors operating in the Chinese equity market. They conclude that financed emissions is a crucial metric for institutional investors that have pledged to align their investment activities with PA targets. Investment funds with increased financed emissions and carbon intensities are prone to carbon related risks while funds that reduce these metrics are frontrunners of ESG metrics. For the special category of funds with increasing financed emissions but decreased carbon intensities, Jinglei et al. (2023) prompts them to adopt lower carbon intensive assets to lower the carbon related risks. The findings are aligned with the recent literature that suggests financed emissions are a less volatile indicator than emission intensity (Nagy et al., 2023). This research underlines the importance, particularly for financial institutions, of quantifying financed emissions to achieve long term decarbonization objectives. Similarly, investors of sovereign debt who aim to construct an ESG portfolio need accurately measured financed emissions and our approach aims to facilitate this goal.

To best of our knowledge the existing literature focuses on attribution factors for **listed equity** assets and identifies available strategies for reducing financed emission. As such, the unique challenges of attributing emissions to sovereign debt holdings are underexposed in academic literature. The intrinsic challenges for sovereign debt results from the fact that governments are not tradable commodities, requiring a sovereign debt-specific methodology. This research aims to fill this gap by proposing an alternative method for sovereign debt.

Bandwidth of multiplier effect in literature

We conducted a literature review regarding the government spending multipliers for European countries. The purpose is to get an understanding of the bandwidth for realistic values for the multiplier effect.

Di Serio et al. (2021) examined the effect of interest rate-growth differential under the conditions of global financial crisis and its influence on the government spending multiplier, they suggest values ranging from 0.51 to 1.77. Amendola et al. (2020) estimated government spending multiples for the Euro Area, for normal times and effective lower bound times related to a shadow monetary policy rate, they presented values of 0.3-1.9. Deleidi et al. (2020) estimated fiscal multipliers for eleven Eurozone countries to investigate the “Keynesian effect “on the GDP, they concluded values ranging from 0.93 to 3.43. Afonso and Leal (2019) computed the value of fiscal multipliers for EU countries since the conception of Eurozone and identified the positive effect of government spendings on the economy’s output, particularly they stated values ranging from 0.29 to 1.09. Deleidi et al. (2021) found that government investments in European countries generate “Keynesian effect” translating into fiscal multipliers close to 1. Batini et al. (2014) stated that fiscal multipliers are positively affected by political events, state of business cycle and other structural (e.g. exchange rate regime, the degree of openness, or public debt). Espinoza (2021) defined the multiplier effect of central European countries compared to Slovakia and he focused on the impact of European Structural Investment (ESI) Funds. He suggested multiplier effect that ranges from 1.2 to 1.8. Saccone et al. (2022) found that public investments have a significant multiplier effect of 2.056 for 31 European countries, especially in the sectors of public services and human capital creation. Batini et al. (2022) compared green energy and biodiversity spending multipliers and the non-green energy and land use spending multipliers. They argue that green energy multipliers range from 1.1 to 1.7 while fossil fuel energy multipliers range from 0.4 to 0.7 (Batini et al., 2022).

Economists tend to use diverse methods for operational work since there is no commonly agreed methodology for isolating and estimating the additionality of an government intervention to the economy’s output (Batini et al., 2014; Haug & Sznajderska, 2024). In addition, literature has contradicting perceptions regarding the duration of multiplier effect, for instance Born et al. (2013) considers that the multiplier effect mutes six years after the government intervention while others like Deleidi et al. (2020) support a permanent multiplier effect on output level. Nevertheless, the literature consensus suggests that the multiplier effect has medium term duration which translates into approximately five years. Concluding, despite various caveats the multiplier effect is a useful concept to understand the relationship between changes in government investments and the economy. As such, it is applicable to the casual relationship between debt-financed government spending and environmental impact of the economy that can be associated with the debt.

We collect a range of possible values for the multiplier effect facilitated by government spendings, in an effort to propose a reasonable attribution factor for sovereign financed emissions.

Methodology

The Attribution Factor

As defined by PCAF (2020), financed emissions consist of the attribution factor and the actual GHG emissions of the counter party that has receive the financing (Figure 2). More details on the GHG emissions can be found in the appendix.

$$\text{Financed Emission} = \text{Attribution Factor} \times \text{GHG Emissions}$$

Figure 2. Formula for calculating the financed GHG emissions associated with an investment, according to PCAF (2019). Financed emissions derive from the attribution factor and the actual GHG emissions emitted by an investee.

The precise formulation of the attribution factor differs per asset class, but they all thrive to be aligned with the guiding principle that it should reflect the share of the investment over the total value of the investee, defined as the equity value plus debt (Figure 3).

$$\text{Attribution Factor} = \frac{\text{Exposure to an asset}}{\text{Market value of underlying asset}}$$

Figure 3. Formula of the Attribution Factor according to the PCAF (2020). The value of the Attribution Factor depends on the amount of the investor's exposure to an asset and the market value of the underlying asset.

For the sovereign debt asset class, the first PCAF-2019 (2020) report was suggesting that the attribution factor is defined as the exposure of sovereign debt proportional to the country's total sovereign value. PCAF used the concept of the market value in terms of equity & debt for diverse asset classes and aimed to express the total sovereign value in terms of sovereign equity & sovereign debt. While the sovereign debt is a known quantity, there is no such thing as sovereign equity, simply because central governments are not for sale.

PCAF-2019 suggested that the denominator could only consist of total debt (Figure 4). This leads to cases where countries with high total debt, have smaller attribution factor than countries with smaller total debt. For instance, countries such as France with big debt compared to their economic activity (GDP) were assigned small attribution factors.

$$\text{Attribution Factor} = \frac{\text{Exposure to Sovereign Bond}}{\text{Total sovereign debt value}}$$

Figure 4. Attribution Factor for sovereign debt according to PCAF (2020). PCAF proposed the total debt metric to illustrate the value of a sovereign.

In 2022, PCAF launched a revised report that redefines the attribution factor for sovereign debt. More specifically, the attribution factor consists of the exposure to the sovereign bond as numerator and from the Purchase Power Parity (PPP)-adjusted Gross Domestic Product (GDP) as denominator (Figure 5). The revised approach presents implications in case of a country has higher outstanding debt value than its PPP-adjusted GDP. As a result, countries with a sovereign debt larger than the PPP-GDP, exhibit ratio larger than 100% and the attribution factor for holding all sovereign debt exceeds 1.

Figure 5. Attribution Factor for sovereign debt according to PCAF (2022). PCAF proposed the PPP-GDP adjusted metric to illustrate the value of a sovereign.

We present Greece as example, where the total debt was *353,848* million euros for 2022, with 0.53 PPP-conversion factor, the GDP was *206,602* million euros resulting in *171,480* million euros *PPP-adjusted* GDP for 2022 (Eurostat, 2023; World Bank Open Data, n.d.; European Central Bank, 2024). Thus according to PCAF-2022, investors that held Greece's total debt for 2022, so *353,848* million euros , are attributed *353,848 / 171,480 = 2.06* times the total emissions. Thus, any financed emissions will exceed the actual emissions.

To overcome the aforementioned implications, we propose a new method for calculating the attribution factor, which is based on the fiscal multiplier effect as described by John Maynard Keynes (Schumpeter & Keynes, 1936). We argue that debt holders should be responsible for the new economic activity that their investment enabled.

Conceptual Framework of the multiplier effect

We propose a distinct approach that aims to quantify the amount of government spendings that was enabled form sovereign debt investors. This framework follows the key principle of the PCAF that suggests practitioners to "follow the money" as far as possible in the value chain (PCAF, 2022, p.39). The concept of the multiplier is used in Keynesian economics to describe the impact of government expenditures in stimulating economic growth. The government expenditures may have capital extraction (taxes) or injection (government spendings) nature. This theory suggest that the net effect of a euro exceeds its nominal value (Schumpeter & Keynes, 1936). In other words, each additional euro spent by governments has an amplifying effect, leading to an increase in economic activity (GDP) larger than the size of the investment. Hence a GDP increase is linked with government spending. Specifically, the revenue of EU-27 for 2022 was 7.4 trillion euro while the expenditures were 7.9 trillion (Eurostat, 2024). Hence, while taxes contribute significantly to government revenues, and thus to spendings, borrowing also plays a crucial role in financing budget deficits.

Since part of the government spendings is fueled by raising sovereign debt, sovereign debt has an amplifying effect on a sovereign's economic activity (GDP). Investors hold big parts of such investment assets; thus they enable economic growth and GHG emissions that are associated with the economic activity. Hence investors should be associated with their contribution to government spendings and consequently this should also be the driver for calculating the attribution factor.

Government spendings are categorized in fiscal and investment multipliers which capture their impacts on the economy. The fiscal multiplier measures the change in GDP resulting from an increase in government spending (including consumption). The investment multiplier is related with the changes in investment spending on GDP, and in the next section we denote the multiplier by m.

As an example we present the scenario of heat pump installation subsidy. Suppose a government decides to invest 1 million euros in subsidies for heat pumps installations to contribute to energy efficiency and reduce reliance on fossil fuels. As a result, the heat pump industry experiences a significant boost. Homeowners install heat pumps, leading to increased demand for heat pump manufacturers, installers, and related services. The initial 1 million euros of government spending has a multiplier effect. For every euro spent on the subsidy, the heat pump industry may generates 3 million euros in revenue (a multiplier of 3). This occurs from home owners that invested into heat pumps, spending money that they would have otherwise kept in their bank account. This stimulates economic activity, creating jobs, income, and additional spending throughout the supply chain.

Our attribution methodology recognizes the multiplier effect resulting from government spendings that are facilitated by increased government debt. Specifically, by borrowing funds, sovereigns can finance public projects and initiatives. The implied economic activity can not only be linked with income changes but also with GHG emissions generated by the country. Thus there is a clear connection between government borrowing , economic activity and environmental consequences (Figure 6).

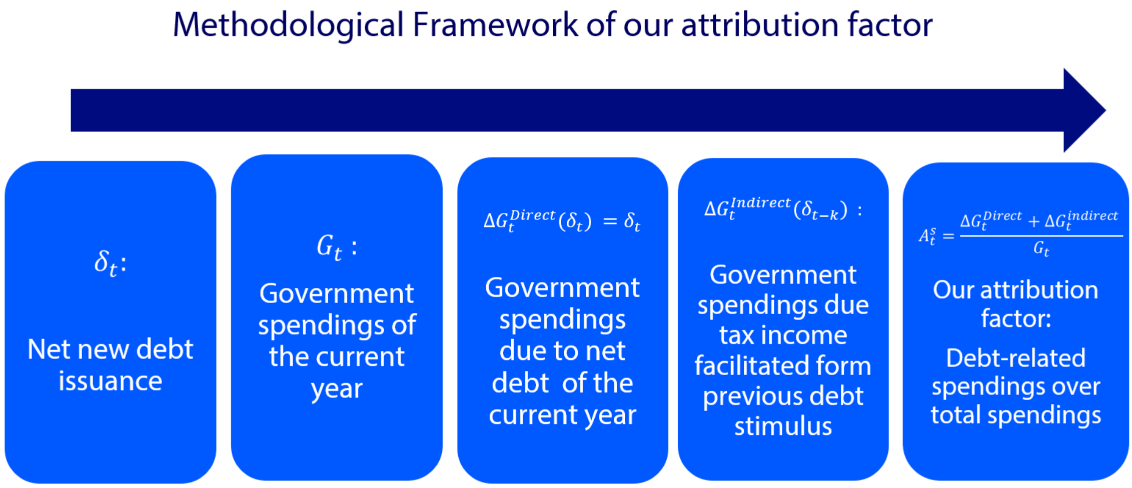

Figure 6. Methodological framework of our attribution factor. From left to right, the blocks represent consequential steps of implementation. We first define the net debt and the total government spendings, then we define the government spendings subject to the net debt issued at year t. Next, we define the government spendings that were originated from government tax income due to the past five years economic stimulus associated with past net debt issuances. By combining the government spendings that resulted from current and previous net debt issuances over the total government spendings of the year t we define our attribution factor.

We expect that our approach will decrease the financed emissions that are attributed to debt holders, since only a part of a sovereign's emissions is financed by debt holders. Hence the following hypothesis derives from our theoretical framework:

H1: The attribution factor derived from economic activity enabled by the capital raised from government bonds, results in lower financed emissions compared to the methodology employed by the PCAF-2022 for the case of EU-27.

Methodology development of our attribution factor

We propose an alternative approach with twofold objective: Firstly, we aim to answer our main research. Secondly, we provide an alternative attribution factor that addresses the limitations of PCAF-2022 attribution factor.

Our attribution factor is built on a key principle of the PCAF that suggests practitioners to “follow the money” as far as possible in the value chain (PCAF, 2022, p.39). We first introduce the variables that are of importance to our methodology:

x: Exposure to sovereign debt in million euro

D_t: General total government debt at year t in million euro

$\delta_t = D_t - D_{t-1}$: net debt change (typically increase) in year t in million euro

$\Delta G\ (\delta_t)$: difference in government spending due to net debt change δ_t in million euro

$\Delta GDP(\delta_t)$: difference in GDP due to net debt change δ_t in million euro

Next, we establish our working assumptions. First we assume that the GDP growth, enabled through an investment, is given by the investment multiplied with a multiplier. The GDP growth due to net debt change equals the net debt change δ_t multiplied by the fiscal multiplier m,

$$\Delta GDP(\delta_t) = \delta_t * m \tag{1}$$

We use a multiplier effect of with value of m=2. We assign this value based on peer reviewed papers in the economic literature that suggest a range of 0.3 to 3.4 for fiscal multipliers (see Appendix).

Secondly, we assume that the net debt issued in period t is completely spent in year t. The government spendings is a category that includes government investments and subsidies, salaries etc. The direct effect of new debt issuance in government spendings is described below:

$$\Delta \mathrm{G}_\mathrm{t}^{\mathrm{direct}}(\delta_t) \quad = \delta_t \tag{2}$$

Next we assume that the increase in government spending, subject to net debt issuance, is proportional to the increase in GDP growth. The underlying reasoning is that government income through taxes is for a large degree a fixed percentage of the GDP. Analyzing the EU-27 data, we conclude that this ratio remains relatively stable in the medium term at approximately 50% (Figure 7). The following equation represents the government spendings $\Delta \mathrm{G}_\mathrm{t}^{\mathrm{indirect}}$ due to the net debt change δ :

$$\Delta \mathrm{G}_\mathrm{t}^{\mathrm{indirect}}(\delta) \ = \Delta GDP(\delta) \ \cdot \frac{G_t}{GDP_t} = \delta \cdot m \cdot \frac{G_t}{GDP_t} \tag{3}$$

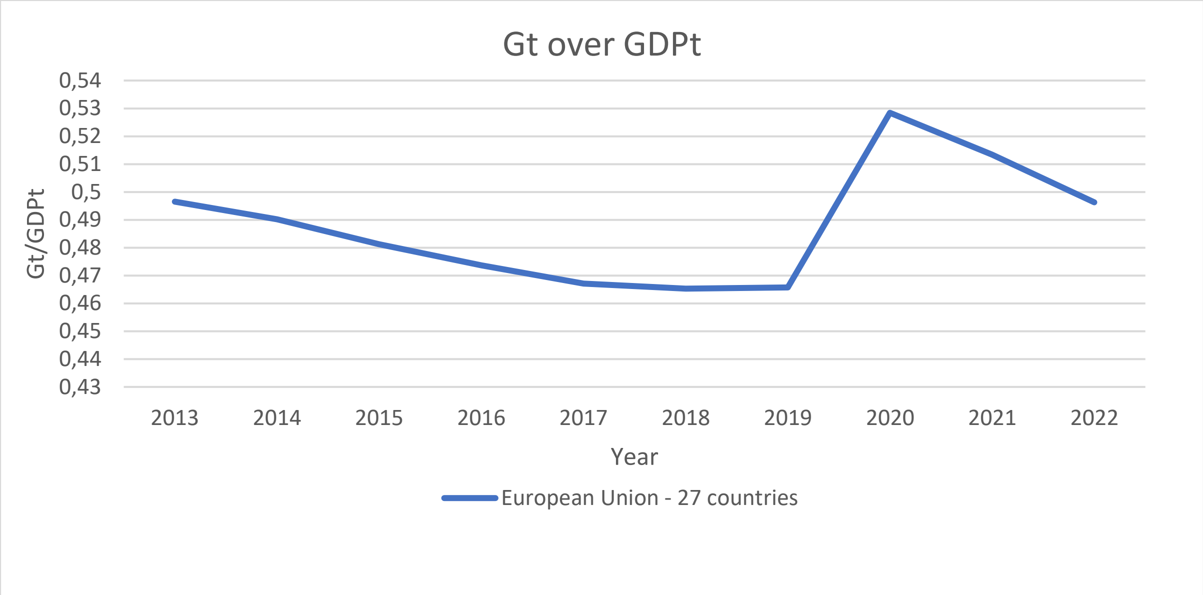

Figure 7. The evolution of the government spendings as percentage of GDP for the average of the EU-27 countries. This period includes the impact of the COVID-19 pandemic which is considered an outlier event. In 2020, economic activity decreased while the government spendings increased to support the social structure. After 2021 there was a correction in government spendings over GDP, with a gradual decreasing trend until 2022.

For implementation purposes we suggest the adoption of the backward looking approach since it considers the net debt changes of past years. The multiplier effect is typically over a few years' time. Following the paradigm of the literature consensus, we work with a 5 year time period (k={1,5}). We represent the median cumulated multiplier m of government spendings as a function of annual S_k over the prior five years (Equation 8). The S_k has diminishing values as the k increases; the k represents the years before the investment (Figure 8). We assign arbitrary values to S_k parameter as shown in Table 1. Even though these values are arbitrary, they were created based on the findings of Amendola et al. (2020) and Deleidi et al. (2020).

Table 1. Arbitrary values for S_k

S_k	Values
S_1	0.9
S_2	0.5
S_3	0.3
S_4	0.2
S_5	0.1

$$m = \left(\sum_{k=1}^{5} S_k \right)$$

(4)

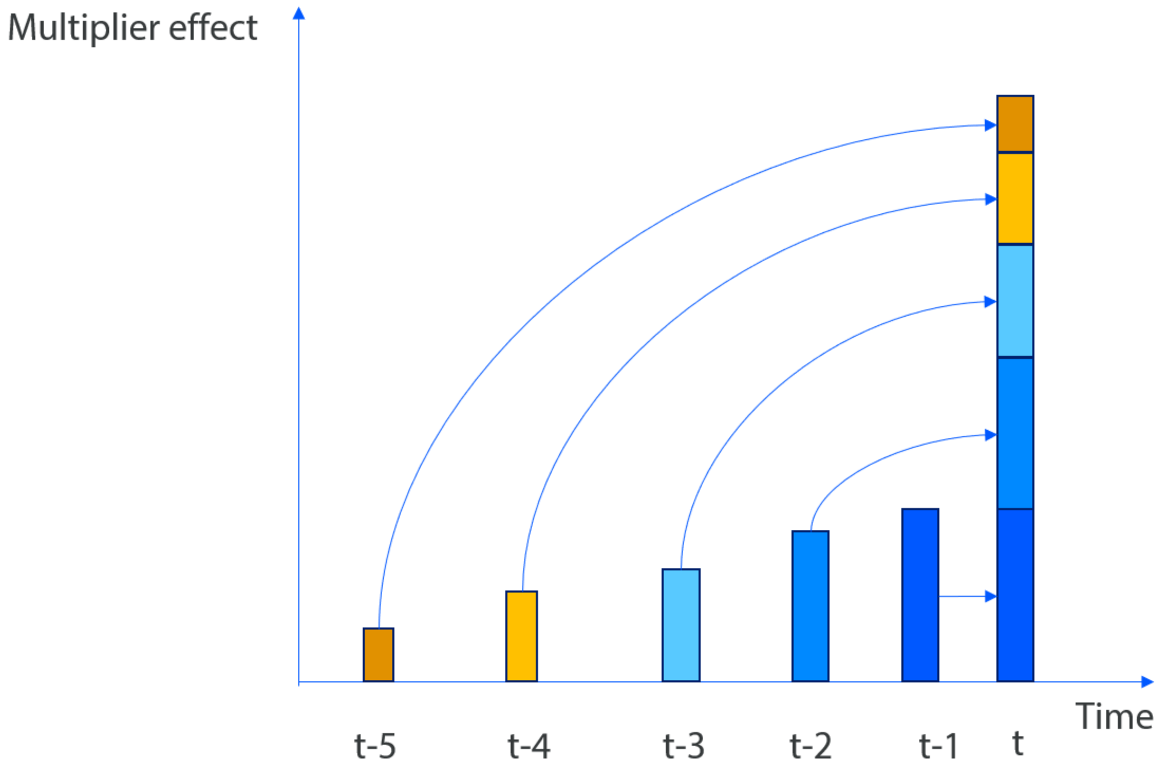

Figure 8. Visual representation of the accumulated multiplier effect resulting from government spendings that are facilitated by increased government debt. Each debt increase of the past five years is multiplied with the corresponding S_k, the summation of the five previous year products result in the accumulated multiplier effect.

Applying the backward looking multiplier effect to the GDP growth results in the following equation:

$$\Delta GDP_t(\delta_{t-1},\delta_{t-2},\delta_{t-3},\delta_{t-4}\,\delta_{t-5}) = \left(\sum_{k=1}^{5} S_k * \delta_{t-k}\right)$$

(5)

Thus the government spendings due to past net debt changes, is expressed as:

$$\Delta \mathrm{G}_\mathrm{t}^{\mathrm{indirect}}\,(\delta_{t-1},\delta_{t-2},\delta_{t-3},\delta_{t-4}\,\delta_{t-5}) = \left(\sum_{k=1}^{5} S_k \cdot \delta_{t-k}\right)\frac{G_t}{GDP_t}$$

(6)

We specify our attribution factor as the government spendings stimulated by net debt issuance divided by the total government spendings, hence this results in:

$$A_t^s(x) = \frac{\Delta \mathrm{G}_\mathrm{t}^{\mathrm{direct}}(\delta_t) + \Delta \mathrm{G}_\mathrm{t}^{\mathrm{indirect}}(\delta_{t-1},\delta_{t-2},\delta_{t-3},\delta_{t-4}\,\delta_{t-5})}{G_t}\,\frac{x}{D_t}$$

(7)

In this way we can identify the percentage of the GHG emissions that resulted from economic activities that were facilitated by the investors' capital. So the final form of our attribution factor is:

$$A_t^s(x) = \frac{\delta_t + \left(\sum_{k=1}^{5} S_k \cdot \delta_{t-k}\right)\frac{G_t}{GDP_t}}{G_t}\frac{x}{D_t} \tag{8}$$

The multiplier effect implied by PCAF-2022

The attribution factor by PCAF (2022) is:

$$A_t^{PCAF} = \frac{D_t}{GDP_{t^{PPP}}} \tag{9}$$

To identify the hypothetical fiscal multiplier that is implied by PCAF 2022 approach, we equate the PCAF attribution factor (Equation 9) with our attribution factor (Equation 8).

$$A_t^{PCAF} = A_t^s, \tag{10}$$

and solve for the multiplier m, which we call the implied PCAF multiplier:

$$m^{PCAF} = \frac{\left(\frac{D_t * G_t}{GDP_{t^{PPP}}} - \delta_t\right) * GDP_t}{\delta_t * G_t} \tag{11}$$

Since we have data on the right-hand side variables, we can calculate the implied multiplier for different years and different countries. Next, we compare the implied multiplier results with the range of values derived from literature.

Results

This section presents the PCAF-2022 implied multiplier results, the comparison between our attribution factor and the PCAF-2022 attribution. To arrive to these results we use the entire debt exposure that investors have in sovereign assets, thus $x = D_t$.

All data used are available on the official site of Eurostat. Specifically, we used general government debt data (gov_10_ggdebt), total government expenditures (gov_10a_main), GDP (nama_10_gdp), PPP- GDP adjusted annual data was derived from combining the same data set (nama_10_gdp) using the different "measurement unit" option within Eurostat site.

Implied multiplier

In this section we report the implied multiplier results from the PCAF-2022 approach. We present the implied multiplier results for the EU-27 countries over 2019 till 2022 (Figure 9), this period includes geopolitical, the corona event and economic events. During this period inflation and the interest rates were increased, affecting the purchase power of countries (the PPP-GDP variable). As discussed in the previous section, the consensus in literature for fiscal multipliers associated with government spendings, suggests values from 0.5 to 3.43 (Table 5). Particularly, the findings of Di Serio et al. (2021) Afonso and Leal (2019) suggest that the increased interest rates and reduced economic growth conditions foster low fiscal multiplier results ranging from 0.29 to 1.26. Nevertheless, our results for the implied multiplier have an average value of 24.31 with values ranging from 0 till 64.01 for 95% confidence interval and a median value of 15.56 (Figure 9). The results indicate an unrealistic perspective of an economic stimulus associated with sovereign debt holders. These results further support our claim that PCAF-2022 overestimates the stimulus of sovereign debt in economic activity.

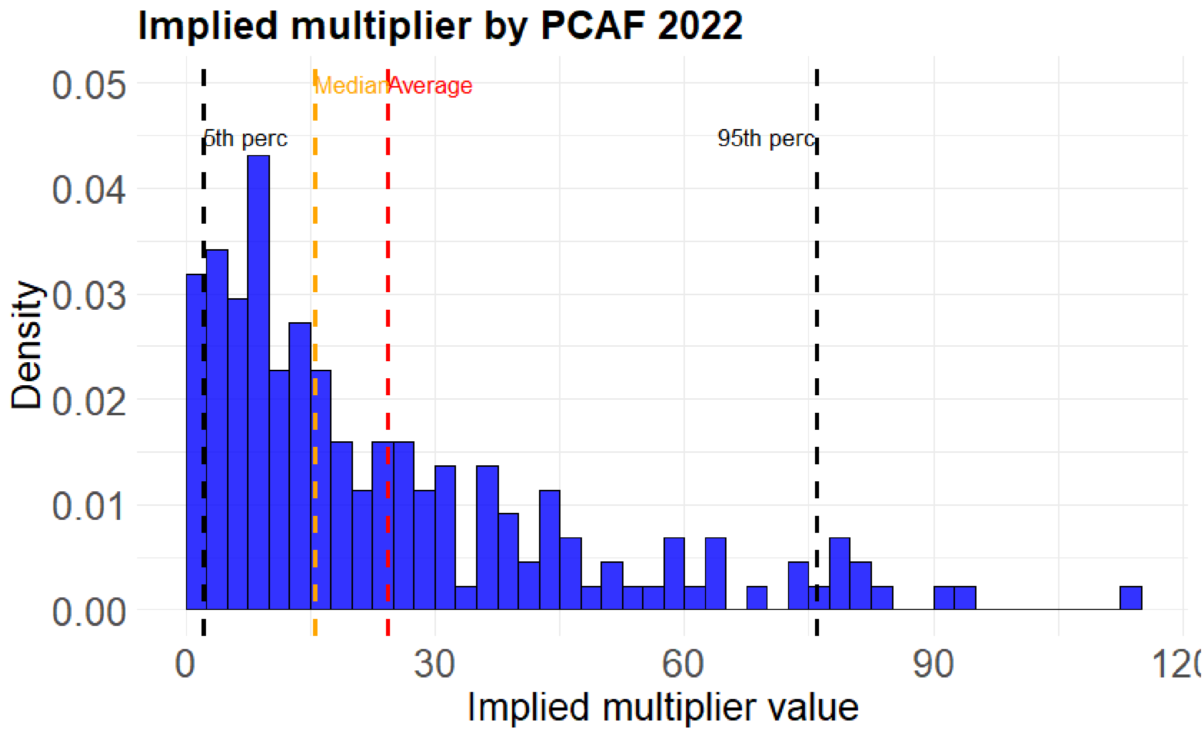

Figure 9. Density distribution of PCAF implied multiplier. The data covers 27 European countries from 2019 to 2022, estimated based on Eurostat data. The negative implied multipliers were excluded (76 out of 252). The distribution is left-skewed, thus both the median and the average value provide valuable insight. The average value is 24.31 and the median is 15.56 . These results challenge the conventional view of debt-driven economic stimulus, suggesting that PCAF-2022 overestimates the impact of debt on economic activity.

The "Follow the money" Attribution factor

We present how our attribution compares with the PCAF-2022 attribution factor. Our model estimates attribution factors for the EU-27 countries for 2019 till 2022, with an average value of 0.129 and a range of -0.029 to 0.262 for 95% confidence interval (Figure 10). The negative sign of our attribution factor arises in cases of a sovereign reduces its debt. That make sense since the ability of a sovereign to emit GHG is reducing when capital is handed back to the debt holders. In a sense this could be interpreted as avoided emissions.

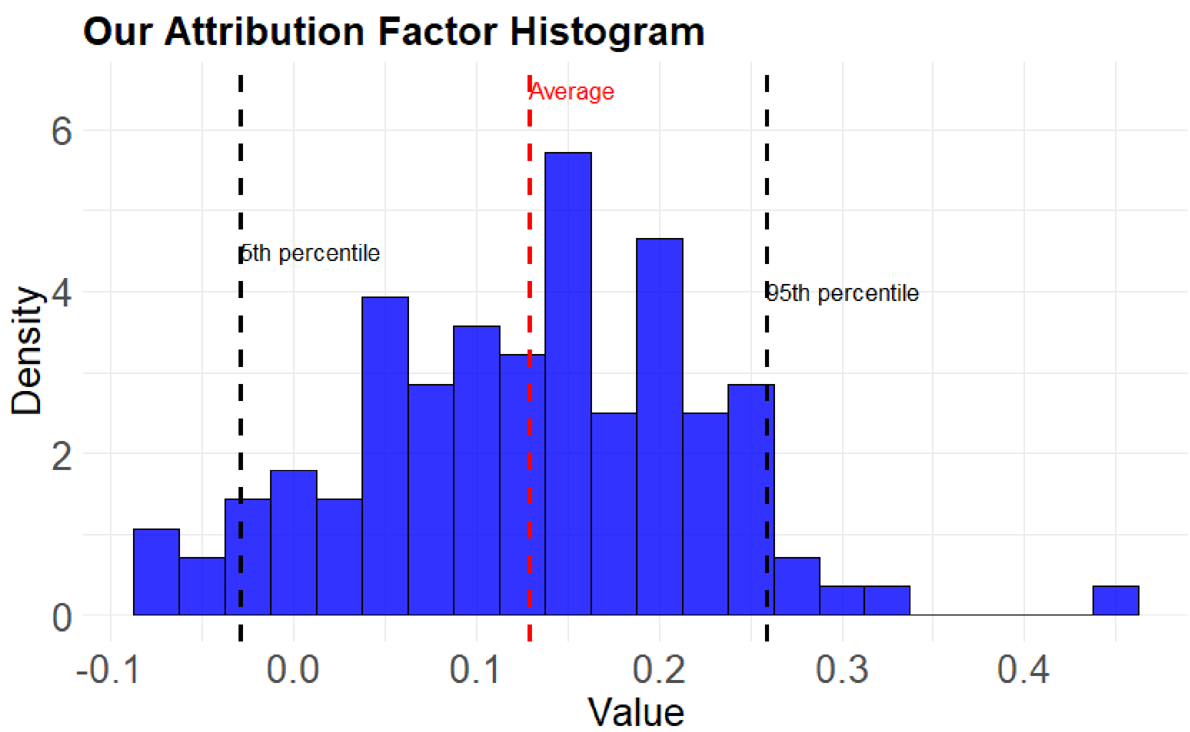

Figure 10. Density distribution of Our attribution factor for the sample of 27-EU over 2019 to 2022. Represents a normal distribution with values ranges from -0.029 to 0.262 for 95% confidence interval and an average of 0.129. Negative numbers occur in case a sovereign reduces it total debt. An outlier value of 0.4 was assigned to Cyprus in 2020 due to a spike in "debt growth to GDP" ratio in 2020.

We also present the values derived from the PCAF-2022 approach with an average of 0.649 (Figure 11). Our attribution factor is on average 80% smaller than the attribution of PCAF-2022. We have also conducted a t-test to identify the statistical significance of this difference. With a t-value of -13.689 (Table 2) we reject the null hypothesis of no difference between the PCAF-2022 and our approach.

Table 2. Statistics of our attribution factor sample and PCAF-2022 attribution factor sample for EU-27 years 2019 till 2022.

Set	t-value	p-value
Our attribution factor and PCAF-2022 attribution factor	-13.689	2.2e^-16

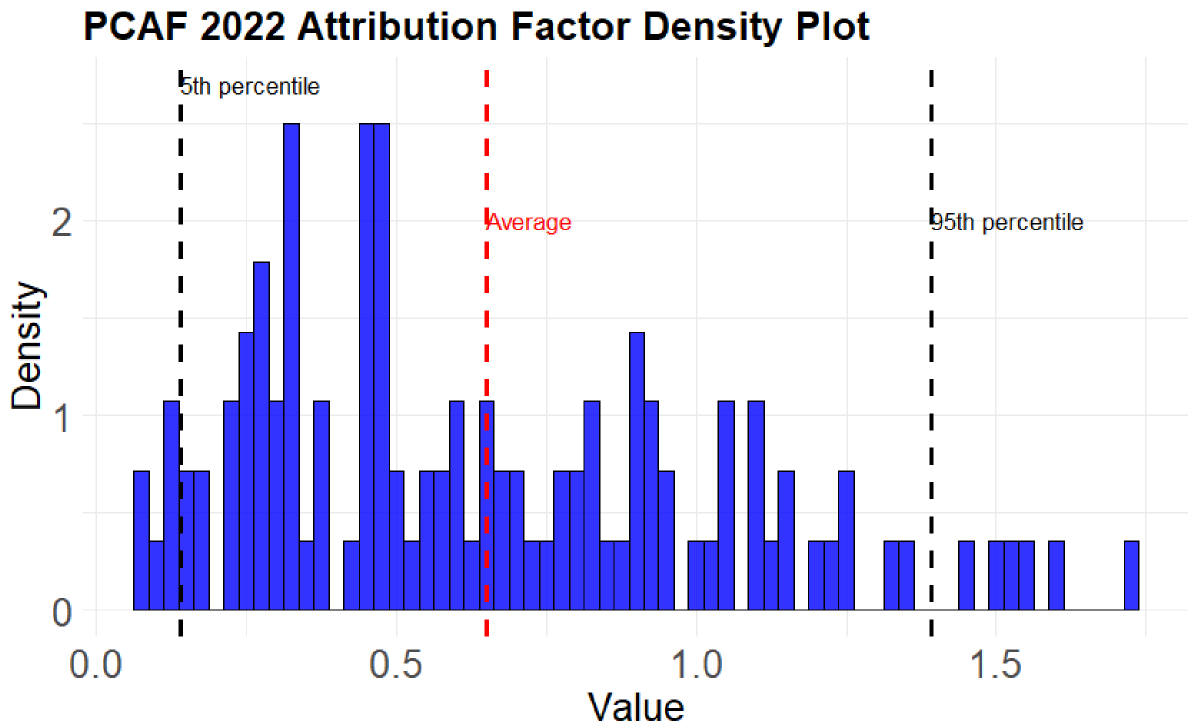

Figure 11. Density distribution of PCAF-2022 factor for the sample of 27-EU over 2019 to 2022. The attribution factor does not take values lower that zero, however it can take values larger than one. Values 0.141 to 1.39 for 95% confidence interval and an average of 0.649. Values over one lead to overestimation of financed emissions.

Implications for EU-27

We present the attribution factor differences for each of the EU-27 countries and the average value of EU-27. We also provide insights into the variability over time and between different EU countries.

We created a scatter plot (Figure 12) comparing our attribution factors with the corresponding PCAF-2022 attribution factors. Most data points cluster on below the diagonal, indicating that our attribution factors tends to have lower values compared to PCAF-2022. When a country has significant debt relative to its GDP , PCAF-2022 assigns greater responsibility to investors for financed emissions than our attribution factor. Particularly, for countries with debt to GDP ratio 1 and higher, PCAF-2022 evidently overestimate the attribution factor of financed emissions. Consequently, in these cases the estimates exceed the value of 100%, attributing more emissions to investors than the real emissions released to the environment. Regarding our attribution factor, values range from -0.073 to 0.447 while for PCAF-2022 values range from 0.07 to 1.7. Negative sign of our attribution factor indicates the reducing ability of a sovereign to emit GHG due to repaying its debt. In other words, the sovereign reduces its total debt thus less emissions can be associated with the debt holders.

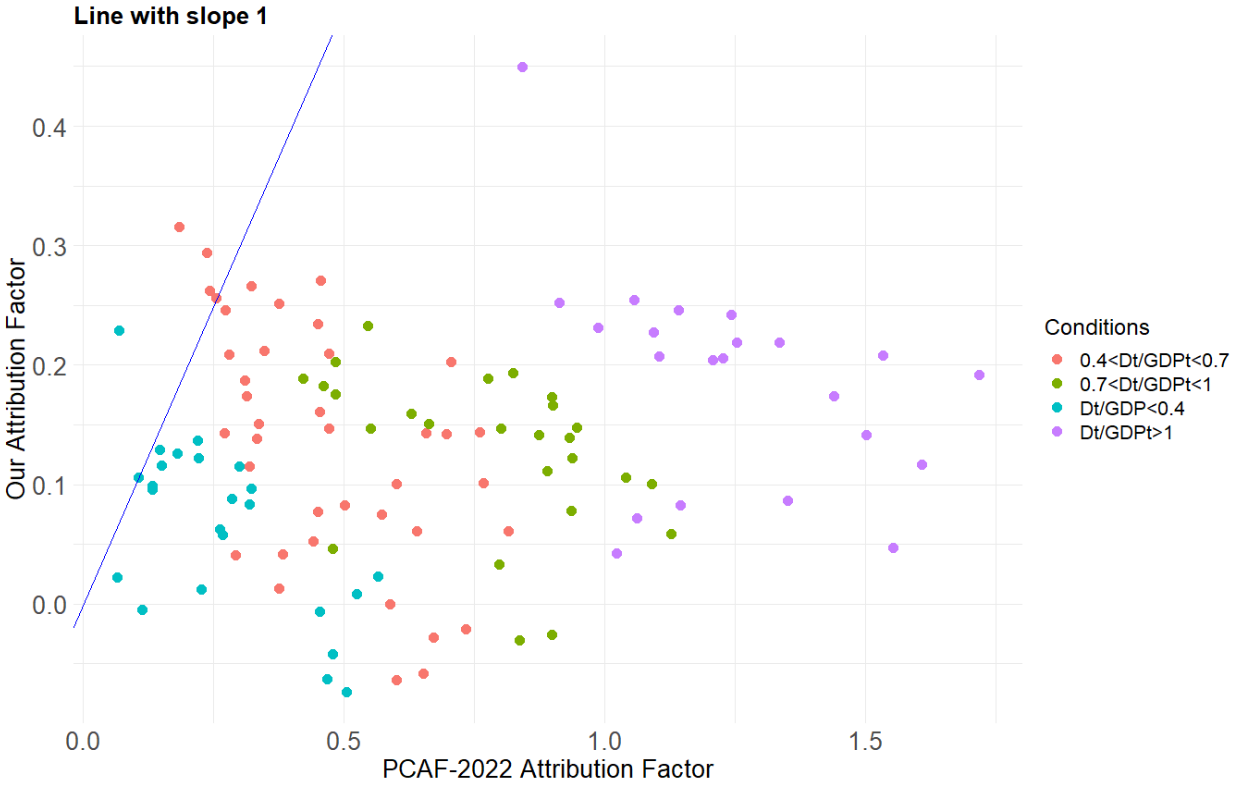

Figure 12. Scatter plot of our attribution factor and the corresponding PCAF-2022 attribution factors. The majority of the points are located on the right side of the graph, indicating that our attribution factors have lower values than PCAF-2022. PCAF-2022 yields higher attribution factors as the Debt/GDP ratio becomes larger. In extreme cases PCAF-2022 overestimates the attribution factor of financed emissions with values exceeding one.

Starting with the PCAF-2022 approach, we observe small volatility over time regarding the attribution factors assigned to each European country (Figure 13). For countries with "debt to GDP-PPP adjusted" ratio larger than one, the assigned attribution factor exceeds the value of one. This argues that all sovereign debt holders are responsible for more emissions than the country emitted. Characteristic example are the South EU countries such as Greece, Italy, Portugal together with Belgium for 2019 (Figure 13). For the following years more countries are associated with attribution factors that exceed the value of one. This is caused due to public health and geopolitical events that negatively affected the economic activity in European countries while central governments were increasing their debt to prompt economic growth.

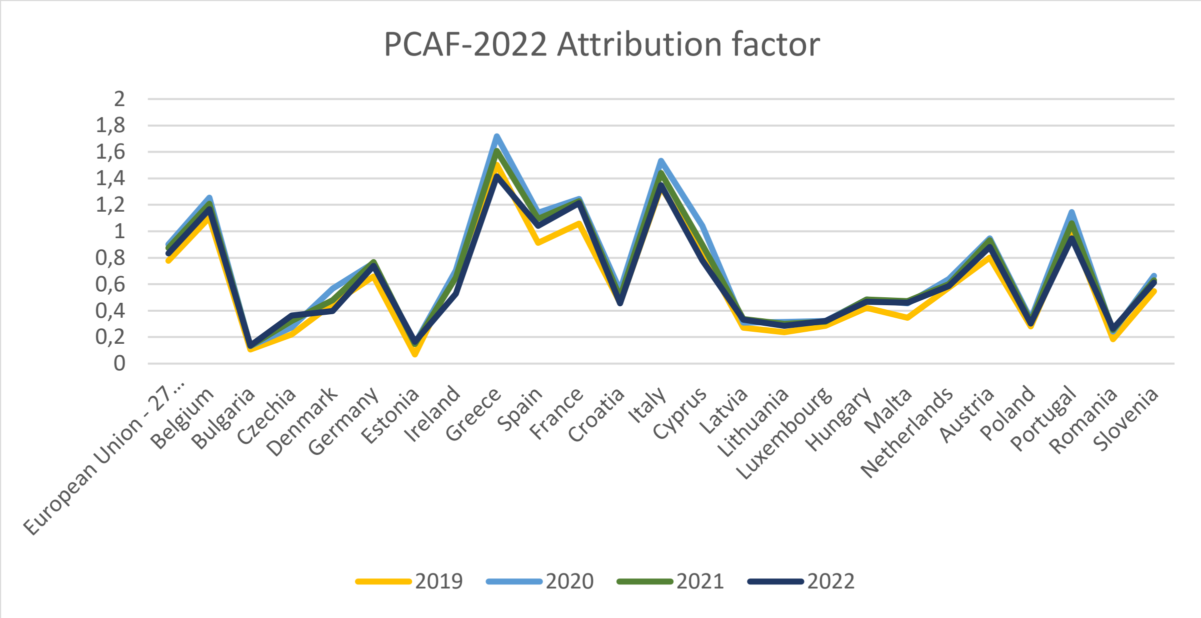

Figure 13. The PCAF-2022 attribution factors for the EU-27 countries are depicted over the period from 2019 to 2022. Notably, there is minimal volatility in the attribution factor values across the years for each country. In a similar fashion with our attribution factor, a discernible pattern emerges. In 2020, all countries exhibit a peak in their attribution factors, followed by a consecutive decrease over the subsequent two years.

Our attribution factor and PCAF-2022 approach illustrate different ranking order regarding the countries with the largest attribution factors. PCAF approach ranks countries consistency over time, thus the time variability is relatively small. This is explained due to the fact that total debt of European country increases at a rather similar pace as its GDP. On the contrary, we do observe changes in the order of countries for our attribution factor (Table 3 & 4). We cannot observe any pattern since the ranking depends on the individual choice of a sovereign to increase its debt and the ratio of government spendings to the level of GDP.

Table 3. Countries with the largest attribution factors for 2019 till 2022 based on our approach.

Ranking	2019	2020	2021	2022
1	Romania	Cyprus	Malta	Czechia
2	Lithuania	Romania	Romania	Romania
3	Cyprus	Lithuania	Czechia	Spain
4	France	France	Spain	Malta
5	Italy	Spain	France	France
6	Spain	Slovakia	Slovakia	Belgium
7	Luxembourg	Slovenia	Belgium	Hungary
8	Finland	Portugal	Italy	Italy
9	Belgium	Estonia	Hungary	Finland
10	Latvia	Italy	Ireland	Slovenia

Table 4. Countries with the largest attribution factors for 2019 till 2022 based on the PCAF-2022.

Ranking	2019	2020	2021	2022
1	Greece	Greece	Greece	Greece

2	**Italy**	**Italy**	**Italy**	**Italy**
3	**Belgium**	**Belgium**	**France**	**France**
4	**France**	**France**	**Belgium**	**Belgium**
5	**Portugal**	**Portugal**	**Spain**	**Spain**
6	**Spain**	**Spain**	**Portugal**	**Portugal**
7	**Cyprus**	**Cyprus**	**Austria**	**Finland**
8	**Finland**	**Austria**	**Finland**	**Austria**
9	**Austria**	**Finland**	**Cyprus**	**Cyprus**
10	**Ireland**	**Germany**	**Germany**	**Germany**

The most significant change is the absence of Greece from the countries with the ten largest attribution factors. Greece was at the top place for all the period 2019-2022 with the PCAF-2022 approach, however in our attribution factor table the first place was assigned to diverse countries throughout the years (Table 3 & 4). Greece's "Debt increase over its GDP" ratio increase was smaller than the EU-27 average for 2019, 2020 and 2022, while for 2021 Greece's "Debt increase over its GDP" ratio was slightly above the EU-27 average. As a result, Greece is not assigned a high attribution factor.

In general, in 2019 we observe the lowest values and then we witness a spike in 2020 that is followed by gradual decreases in 2021 & 2022. The corona event in 2020, led to decreased economic activity that stressed the economy. In 2020, sovereigns increased their debt in order to support the social welfare while the GDPs for that year were decreased. This extreme event has an eminent effect in the results of our attribution factor and the PCAF-2022 attribution for EU-27.

Particularly for our attribution factor, in 2019 Cyprus had the third larger attribution factor, however the differences with the rest of the countries were relatively small (Figure 14). In 2020, its attribution factor presents a spike, reaching the highest attribution factor for Cyprus throughout the examined years and also this value is the highest for all the EU-27 countries for the examined time period. Impressively, the following year Cyprus is assigned with an attribution factor reduced by 71.6% YOY for 2021 and 114% YOY for 2022. During the same period the ratio of "Debt increase to GDP" increased by 170.6% YOY for 2020, then it reduced by 114.9% YOY for 2021 to increase again by 36.3% YOY for 2022. Thus we see a positive correlation regarding the "Debt increase to GDP" ratio and the attribution factor (Figure 14 & Figure 15). Similar increases in "Debt increase to GDP" emerged in Poland, Portugal, Romania, Slovenia, Slovakia (Figure 15) that resulted in high attribution factors for these countries for 2020, as presented in figure 14. Lastly, Sweden with -0.073 in 2019 presented the lowest value of the sample.

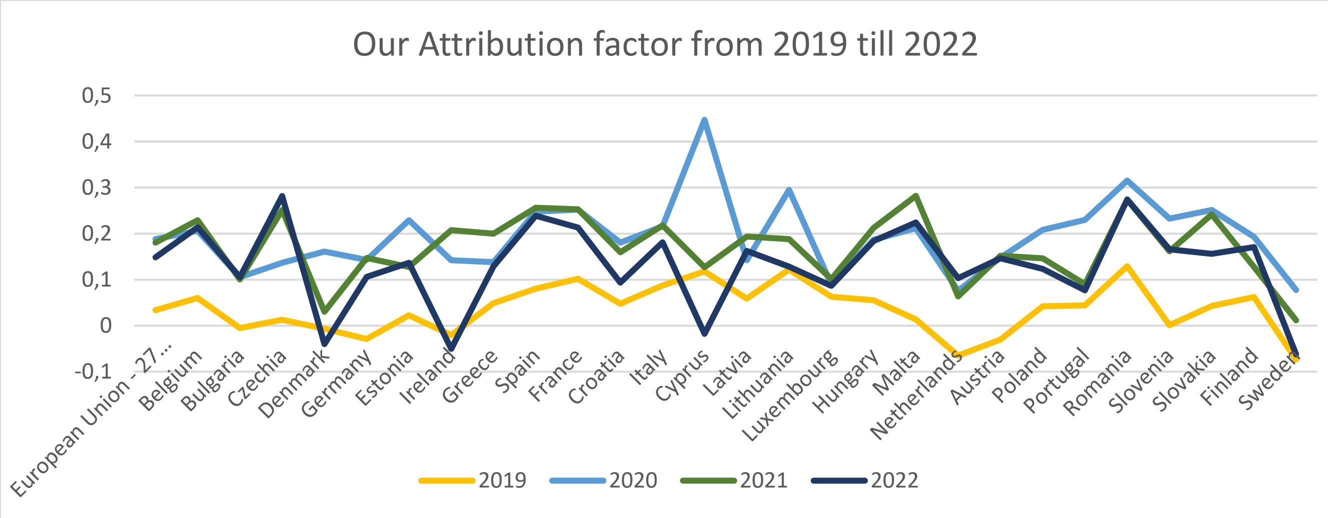

Figure 14. Our attribution factor for Eu-27. We account for total sovereign debt exposure for the EU-27 countries during the period 2019-2022. The attribution factor for several EU-27 countries, most prominently Cyprus, exhibits high volatility throughout the years. In 2019, Cyprus had the third-largest attribution factor, with marginal differences from other countries. In 2020 Cyprus experienced a remarkable spike with the highest attribution factor across all EU-27 nations due increased "Debt increase to GDP" ratio.

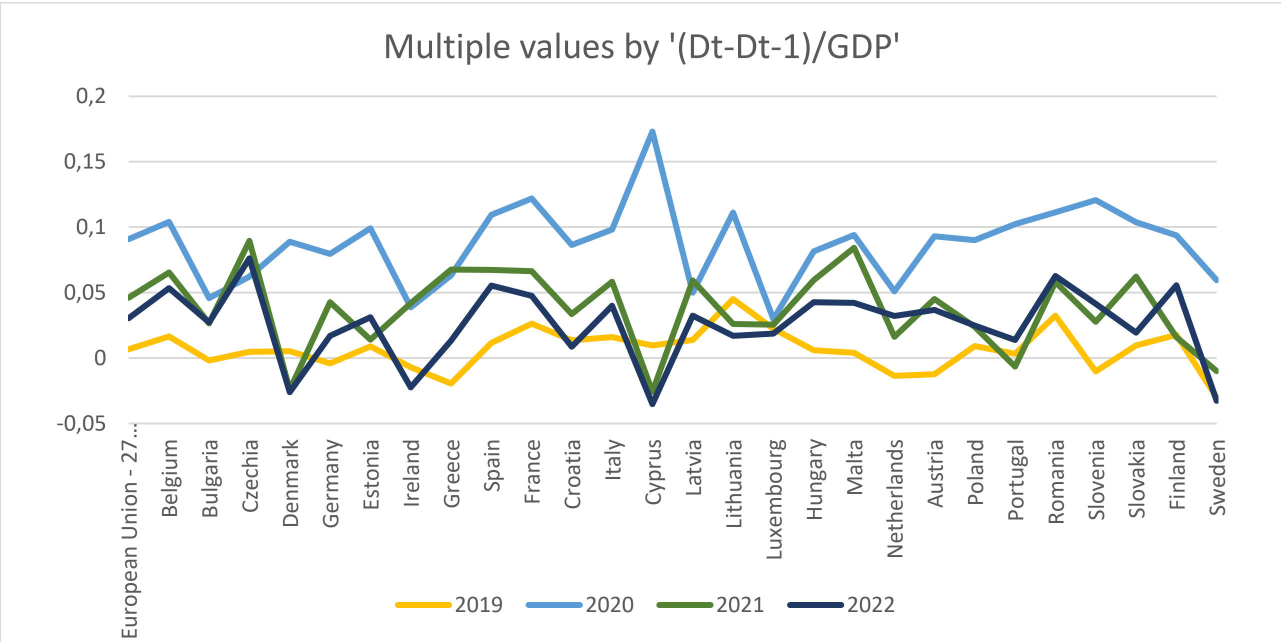

Figure 15. Debt increase to GDP for the EU-27 countries over the 2019 till 2022. Cyprus experienced a significant spike in its debt growth, surpassing all other EU-27 countries. This was followed by a steep decrease in debt accumulation the subsequent years. Similar debt-to-GDP ratio trends were observed in Poland, Portugal, Romania, Slovenia, and Slovakia.

Both approaches align with respect to the trajectory of the financed emissions over time. We see same path of financed emissions but with different magnitudes. More specifically, the lowest attribution factors appeared in year 2019, followed by a spike in 2020 and afterwards they gradually decrease over the next two consecutive years (Figure 16).

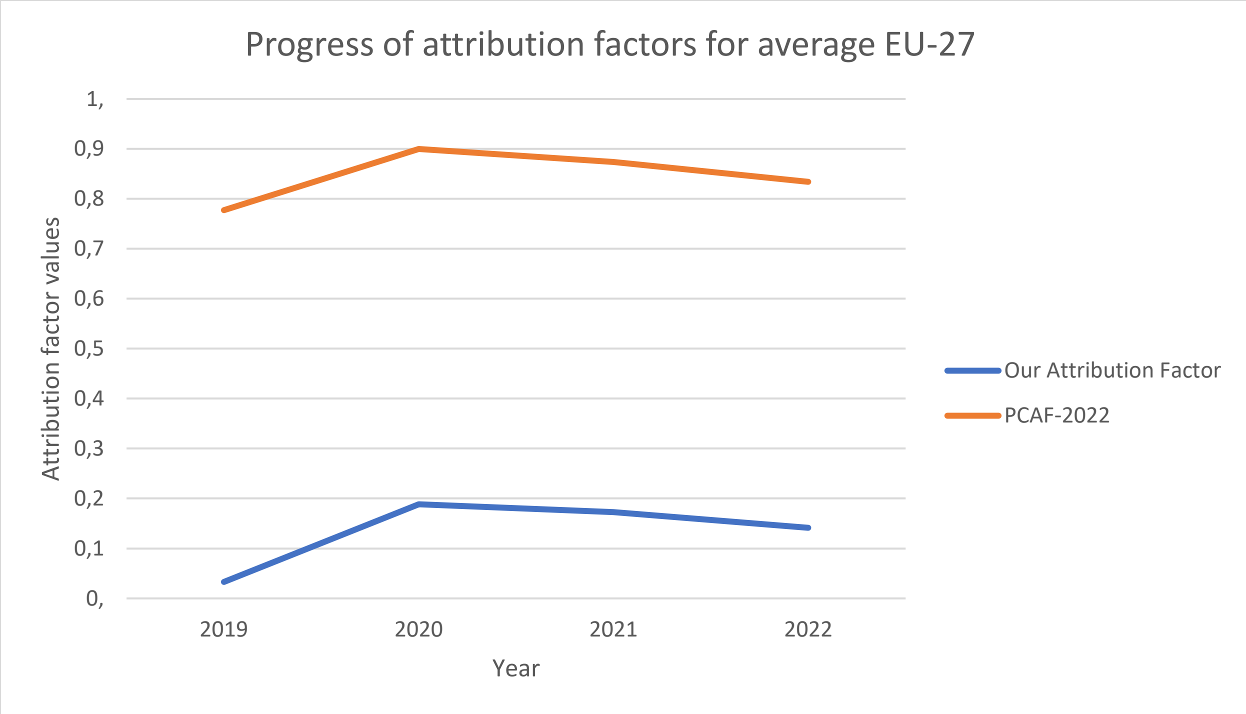

Figure 16. Temporal evolution of attribution factors for the average of EU-27. Both approaches follow the same trajectory regarding changes in the attribution factors over 2019 till 2022. The difference lies in the magnitude of the values that each approach yields. Our attribution factor is approximately 20% of the PCAF-2022 attribution factor.

The case of Dutch sovereign and AEX 25 financed emissions

In order to better illustrate how our attribution factor differs from the PCAF-2022, we choose to calculate the sovereign financed emissions for the Netherlands and the Amsterdam Stock Exchange AEX 25 financed emissions in 2021. We argue that the ratio of emission intensities should be similar to the ratio of financed emissions for different asset classes.

We use the GHG emissions of Dutch scope 1 for sovereign asset class, and AEX-related emissions for AEX 25 equity asset class . Here is important to mention that we follow PCAF suggestions regarding the calculation of the GHG emissions. Specifically, we use the total Dutch economy CO2 equivalent emissions for defining the sovereign financed emissions of the Netherlands in 2021. The PCAF-2022 approach estimates sovereign financed emissions of 148.58 tnCO2e per million euro while our approach estimates 22.88 tnCO2e per million euro. The financed emissions of AEX 25 are 138.21 tnCO2e per m€ for 2021.

The emission intensities of the Dutch economy is 43% smaller than the emission intensity of the AEX 25 (Table 5). As such we would expect the financed emissions of the Dutch economy to be half the AEX 25 financed emissions as well.

As presented in table 5, the PCAF-2022 financed emissions of the Dutch economy are larger than the AEX 25. Our attribution factor suggests that the Netherlands’ sovereign financed emissions are 83% smaller that the AEX 25. This is aligns with the emission intensity comparison of the Dutch economy and the AEX 25.

Table 5. Financed emissions for the Dutch economy, the AEX 25 and their emissions per revenue intensities.

The Netherlands 2021	**emissions [tnCO2e/m€]**
Dutch economy tnCO2e/ Dutch GDP (Emission Intensities)	196,95
AEX 25 tnCO2e/AEX Revenue euros (Emission Intensities)	341,36

PCAF-2022 Financed emission of Sovereign debt	148,58
OUR ATTRIBUTION Financed emission of Sovereign debt	22,88
PCAF-2022 for AEX 25 Financed emission of enterprise value	138,21

The PCAF-2022 approach for financed emissions of listed companies is GHG protocol aligned and thus it can be considered as a reference point. The question is which sovereign financed emissions approach is reasonable?

In conclusion, the case study confirms our claim of PCAF-2022 overestimation of sovereign financed. The financed emissions resulted from our attribution factor aligns with the emissions intensities results for AEX 25 and the Dutch economy. This represents a more reasonable amount of financed emissions for the case of the Netherlands.

Discussion

This research addresses a gap in the literature concerning the GHG emission allocation of financial products, specifically that of sovereign debt asset class. The GHG emission attribution to sovereign debt is an underrepresented topic in financial scientific studies. Our study contributes by proposing a new attribution framework for the sovereign debt that can potentially be GHG protocol approved.

Our findings support our claims that PCAF-2022 overestimates the GHG emissions attributed to sovereign debtholders. In addition , our study confirms the claim that our proposed attribution factor is smaller than the one suggested by PCAF-2022. PCAF-2022 employs a shareholder-attribution approach. While this makes sense for most asset class, this concept does not work for sovereign debt since the value of a country remains elusive. In contrast, we argue that emissions should be linked to the economic activity enabled by the capital provided by debtholders. This perspective shifts the focus from a shareholder-attribution model, which PCAF-2022 appears to adopt, to the key “follow the money” principle (PCAF, 2022, p.39). This perspective considers the government spendings due to sovereign debt, that directly and indirectly amplify economic growth.

We have defined the PCAF implied multiplier by equating the PCAF attribution factor with our attribution factor, and treating the economic multiplier as an unknown variable. The implied multiplier of PCAF-2022 is unrealistically high according to the literature consensus. We present the implied multiplier results against the literature consensus as an additional supporting tool towards our claim that PCAF-2022 overestimates the sovereign financed emissions.

A potential disadvantage of our approach the relatively large year-on-tear variability. This variability is caused due to the net new debt changes are much larger on year-on-year basis than the total sovereign debt of a country (metric used in PCAF-2022 approach). On the other hand the PCAF-2022’s consistent results may not accurately reflect the real-world complexities of sovereign debt and its GHG emission implications.

As a next step, we aim to include different continents to further investigate the differences between the different attribution frameworks for countries in other regions of the world. This lead to a more comprehensive understanding whether our attribution framework could be a suitable replacement of the PCAF-2022 attribution factor. In addition, our objective is to assign country-specific multiplier effects in order to increase the accuracy of the attribution factors.

Implications

The introduction of a reasonable method to assign attribution factors of financed emissions facilitates policy makers to develop policies that aim to accurately reflect the climate impact of financing sovereign debt. Our genie desire is to investigate if our attribution framework could be GHG protocol approved, as this would support a replacement of the current non-GHG protocol aligned PCAF attribution factor by our attribution factor. This is a step forward in standardizing carbon accounting practices across the financial sector.

Investors have the opportunity to make climate responsible decisions since our approach associates the GHG emissions enabled by their investments in sovereign debt. Insights in debt management policies that influence the emissions attributed to sovereign debt allow investors to advocate for or against certain policies based on the climate impact. The current stance of PCAF suggests that Impact and Sustainable Investors should abstain from sovereign bonds to mitigate their financed climate impact. Our study questions the validity of this incentive and we argue that a more nuanced understanding of the role of sovereign debt in stimulating GHG emissions is necessary.

By acknowledging and stressing the need for appropriate attribution factors for sovereign financed emissions, we aspire to ignite further studies in this domain. We aim to stimulate further research and discussions on appropriate attributions of climate impact through sovereign bond investments.

Limitations

Our methodology is built upon certain assumptions regarding the magnitude of the multiplier effect throughout time. We assign arbitrary values for S_k that spread the multiplier effect over five years. We made certain assumption regarding how sovereigns spending the new net debt. We also assume certain stable ratio of government spendings growth and GDP growth. The rather stable ratio of government spending over GDP ratio was disrupted in 2020 due to the outlier event of COVID-19. We used a limited sample of 27 European countries for a relatively short period from 2013 to 2022. This period includes events such as the COVID-19 pandemic, the Ukrainian war, and episodes of high inflation. These events influence the economic activities and, by extension, the GHG emissions linked to sovereign debt, potentially giving a non-representative description of the year-on-year variability of attribution factors. The PCAF-2022 implied multiplier effect results were also affected by these extreme events.

Our methodology is robust, however presents a higher degree of complexity compared to the straightforward calculation of PCAF-2022. This complexity could pose a barrier to its adoption and practical implementation by PCAF. In addition a large year-on-year variability in our attribution factor may suggest long term portfolio steering towards low-emission-intensity government bonds cannot be planned. Particularly, due to political decisions to increase or lower debt-financed government spending influence the GHG emission attributed to the bond holders. Lastly, it is not possible to validate the accuracy of our attribution method. We can only identify that our approach is placed toward the right direction compare the PCAF-2022, since the PCAF-2022 approach evidently overestimates the attribution factor.

Conclusion

The GHG are the central metric for mitigating the climate change. Financial institutions have a significant role in prompting a low carbon economy (GFANZ, 2021). To align with the Paris Agreement goals, financial institutions pledged to lower their financed emissions (GFANZ, 2021). PCAF is the eminent framework used for financed emission disclosure. Noticeably, out of seven asset classes only the sovereign asset class is not GHG protocol approved (PCAF, 2022, p.15). Academic literature focuses on listed equity in relation to financed emissions, leaving frameworks for sovereign financed emissions as an research gap in academia.

The challenge in calculating the attribution factor for sovereign financed emissions lies in the difficulty of calculating the total value of a sovereign as an asset. The latest PCAF report suggests that the total value of a sovereign could be approximated by the PPP-GDP (2022). Our research examines the PCAF-2022 attribution factor and its implications for estimating the financed emissions attributed to sovereign debt holders. Our analysis reveals that the PCAF-2022 overestimates these attribution factors, highlighted by instances where countries exhibit attribution factors exceeding the value of one. The overestimation is further evidenced by the unreasonably large multiplier effect for EU-27 implied by PCAF-2022, which does not align with the values presented in the literature.

Our proposed attribution factor aims to present a reasonable reflection of the emissions financed by sovereign debt. Our attribution factor methodology yields smaller values compared to the PCAF-2022. While our results are reliable within the scope of our study, they cannot be externally validated due to the limitations inherent in estimating the value of a sovereign entity. Looking forward, future research endeavors should expand the geographical scope beyond EU-27 countries, account for the variability introduced by extreme global events and assign country-specific multiplier effects.

As financial institutions aim to align with PA (2015) goals and regulatory requirements of sustainable finance, could our attribution methodology lead to all PCAF asset classes becoming GHG protocol aligned? This rhetorical question encapsulates the broader incentive that led to the conception of this research.

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Appendix

Table 6. Range of values for government spending multiplier. Literature review for EU countries.

Paper	Conditions influencing government spending multiplier	Medium term
IMF, Di Serio et al. (2021)	r-g negative	1.22-1.77
	r-g positive	0.51-1.26
IMF, Amendola et al. (2020)	Normal times	0.3-1.4
	Effective lower bound (in corona times)	1.6-1.9

Deleidi et al. (2020)	multiplier of government spendings subject to government spend growth rate	0.93-3.43
Afonso & Leal (2019)	government expenditure if Debt/GDP >60%	0.29
	Government expenditure if Debt/GDP<60%	1.09
Deleidi et al. (2021)	EU government investments	1
Kempa and Khan (2015)	Government spending multipliers in Europe	0.81-1
Born et al. (2013)	Government expenditure (fixed-floating rates)	0.5-1.5 (after one year)
	After 6 years the output returns to its trend	
IMF, Espinoza (2021)	European Structural Investment (ESI) Funds	1.2-1.8 (after one year)
Saccone et al. (2022)	Public investments in EU	2.056
(Batini et al., 2022)	Renewable energy investment multipliers worldwide	1.1-1.7
	Fossil fuel energy investment multipliers worldwide	0.4-0.7

GHG Emissions

The Kyoto Protocol has set reduction objectives of GHG emissions with 192 countries abide by (United Nations Climate Change, n.d.-b). The GHG comprises of seven gases including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) and they are converted into carbon dioxide equivalents (CO_2 e). Emissions derive from operations of a company or from operations of another company that offers services or products to the reporting company. These emissions are considered direct and indirect respectively and they are categorized in scope 1, scope 2 and scope 3 (WRI and WBCS, 2004).

In principle, emissions occurring from premises or sources of the reporting organization belong to scope 1. Specifically, all direct emissions associated with government expenditures, such as emissions related to infrastructure- construction projects, government travels and emissions from the military, shall be considered scope 1 sovereign emissions. Next, emissions that are directly linked with operations of the reported organization, such as electricity, are categorized as scope 2 and lastly emissions that occur at a point of the value chain that the reporting organization is part of, are allocated to scope 3. This research focuses on scope 3 emissions of financial institutions that corresponds to scope 1 of sovereigns. The time period for computing GHG emissions is defined by the financial institutions (PCAF, 2022).Our research uses predefined values of emissions for a case study.