Essays on

Sustainable Finance

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Declaration on the use of Artificial Intelligence

Artificial intelligence tools (large language models, such as Claude.ai and ChatGPT) were used to support grammatical proofreading, language editing, and stylistic improvements of the text. All intellectual content, arguments, analyses, and conclusions are solely the work of the author and co-authors.

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1 Introduction

The emission of greenhouse gases (GHG) gives rise to an externality problem, whereby those who generate emissions do not bear the full costs imposed on others, creating a fundamental misalignment between private incentives and social welfare. Addressing this misalignment calls for policy intervention across multiple dimensions, including carbon pricing and regulatory reform (Stern, 2008). In 2018, the European Commission took a landmark step toward sustainable finance regulation by publishing the Action Plan on Financing Sustainable Growth, which sets out a comprehensive framework to reorient capital flows toward sustainable economic activities, manage environmental, social and governance (ESG) risks, and foster transparency across financial markets (European Commission, 2018). Building on the Action Plan, the European Commission developed a comprehensive regulatory architecture for sustainable finance in the years that followed. Central to this agenda was the recognition that financial market participants require transparency and standardisation to assess the sustainability of economic activities. The EU Taxonomy Regulation was a foundational response to this need, addressing longstanding concerns that voluntary sustainability disclosures had failed to provide reliable and comparable information on corporations' environmental performance (Criado-Jimenez et al., 2007; Vigneau & Adams, 2023) and that existing reporting practices created significant greenwashing risks (Gatti et al., 2019). The Taxonomy establishes a classification system defining which economic activities can be considered environmentally sustainable, thereby providing the conceptual foundation for subsequent disclosure obligations (Regulation (EU) 2020/852). Complementing this, the Sustainable Finance Disclosure Regulation (SFDR) and the Corporate Sustainability Reporting Directive (CSRD) introduced binding requirements for financial institutions and companies to disclose and report on the sustainability of their products and activities (Directive (EU) 2022/2464; Regulation (EU) 2019/2088). However, the momentum behind this regulatory expansion has recently encountered considerable headwinds. The Omnibus simplification package, proposed by the European Commission in 2025, signalled a partial retreat from some of these obligations, easing reporting requirements and narrowing the scope of certain disclosure rules in response to concerns about regulatory burden and competitiveness (European Commission, 2025).

Yet the Omnibus simplification package does not signal an abandonment of the broader sustainability agenda. The fundamental challenges that motivated the EU Action Plan in the first place have not been resolved. Rather, the recalibration of reporting obligations makes it more pressing to understand how banks have responded to the disclosure frameworks already in place. Despite the growing body of regulation introduced since 2018, fundamental questions about how banks interpret disclosure requirements, what drives variation in reporting quality, and whether the activities financed under these frameworks generate meaningful environmental outcomes remain insufficiently answered.

Addressing these questions requires engaging with the challenge of translating regulatory intent into practice at two distinct levels. The first concerns implementation, namely the gap between what regulations prescribe and what financial institutions actually disclose. This gap is particularly evident in the context of the EU Taxonomy, which requires banks to assess and disclose the proportion of their activities classified as environmentally sustainable (Taxonomy aligned), as captured in the Green Asset Ratio (GAR) (Commission Delegated Regulation (EU) 2021/2178). While the Taxonomy disclosure comes with practical and conceptual limitations (Garcia-Torea et al., 2024; Hoepner & Schneider, 2024; Partiti, 2023; Schütze & Stede, 2021; Zetzsche & Bodellini, 2024), empirical evidence on GAR disclosures is still emerging. Early evidence points to very low share of green assets in banks' balance sheets, ranging from below one percent to just above two percent on average across large European banks (Alessi & Battiston, 2022; CRIF, 2024; EY, 2024; PWC, 2024), with substantial variation across institutions and countries, driven by differences in data availability, business model, and asset composition (CRIF, 2024; Hoepner & Schneider, 2022; PWC, 2024). Yet these insights have so far focused primarily on large institutions and non-financial corporates, leaving open both the question of how the design of disclosure requirements shapes banks' reporting decisions and what drives systematic variation in reported metrics across different institutional contexts.

The second level concerns environmental impact, whether activities financed under the sustainable finance framework actually generate measurable reductions in GHG emissions. In general, impact refers to the changes achieved in environmental and social criteria as a result of an activity or investment (Brest et al., 2018; Kölbel et al., 2020), a definition that regulators have increasingly aligned with in the context of sustainability reporting (Commission Delegated Regulation (EU) 2023/2772). Growing attention has been paid to how investors can influence companies' environmental impacts (Busch et al., 2021; Caldecott, 2022; Kölbel et al., 2020; Wilkens et al., 2025). While lifecycle-based approaches have advanced the measurement of environmental impact at the company level (Busch, Bernard-Rau, et al., 2025; Busch, Pruessner, et al., 2025), translating financial flows into concrete, measurable impact at the level of individual assets and investment decisions remains an underexplored challenge. How much GHG reduction is achieved per euro invested, and how such impact can be systematically quantified and compared across different activities and contexts, are questions that current frameworks do not adequately address. Understanding both levels of regulation, implementation and impact, is a prerequisite for designing effective sustainable finance policy and for assessing whether the broader goals of the EU Action Plan are being realised in practice.

These considerations set the stage for the analyses of this thesis. The first part of the following analyses (Part I, "*EU Taxonomy: Article 8 Disclosure in Banks*") comprises four chapters that collectively examine the EU Taxonomy disclosure framework from complementary perspectives. Chapter 2 examines the regulatory requirements and practical challenges of Article 8 disclosure in the first reporting years, when disclosure obligations were limited to Taxonomy eligibility, drawing on a heterogeneous sample of German banks. Data limitations, regulatory ambiguity, strategic incentives, and structural constraints are discussed in relation to the divergent interpretive decisions observed across banks. Chapter 3 analyses the design and limitations of the GAR as a disclosure metric based on the first full Taxonomy disclosure cycle and discusses its usefulness as a management tool for sustainability steering. Chapter 4 provides a broader assessment of the EU Taxonomy disclosure framework, examining both its current challenges and its opportunities as a tool for transparency, and concludes with recommendations for policymakers and authorities to improve the regulatory framework. Chapter 5 analyses the implications of recent regulatory developments under the Omnibus simplification package for banks as reporting institutions. Taken together, the four chapters contribute to the understanding of how Taxonomy disclosure can fulfil its stated objectives of transparency and comparability, and where current design limitations constrain its effectiveness for banks and regulators alike.

Building on the first, the second part (Part II, "*EU Taxonomy: Empirical Evidence from Green Asset Ratios*") analyses Taxonomy disclosures across small and large banks operating in Germany. By analysing reported data from banks' non-financial disclosures, we examine whether the level of public scrutiny and sustainability-related expectations that banks face are associated with the GARs they report. This study contributes empirical evidence on the informational content and limitations of the GAR across a heterogeneous banking sample, with implications for how regulators and market participants should interpret this metric.

While the first and second parts examine how banks implement and disclose EU Taxonomy requirements, the third part of the analyses (Part III, "*The Abatement Impact Factor in Residential Building Renovations*") takes a step further and asks whether sustainable finance delivers measurable environmental impact at the level of individual investment decisions. Drawing on simulated building-level data across different construction periods, we develop and apply the Abatement Impact Factor (AIF), a metric that quantifies GHG emission savings per euro invested in residential building renovations. By systematically comparing renovation measures across building characteristics, we provide evidence on which investments generate the greatest emissions reductions relative to their cost. Thereby, this study contributes a practical impact measurement tool that bridges the gap between financial decision-making and real-world emissions reduction, offering guidance for homeowners, financial institutions, and policymakers.

Taken together, the analyses contribute to the analytical understanding of a regulatory framework that is still in its early stages of implementation and whose real-world effects remain insufficiently understood. At a moment when regulators are simultaneously expanding supervisory expectations in some areas and retreating from disclosure obligations in others, grounded academic evidence on how banks respond to these requirements and whether they generate meaningful outcomes becomes particularly valuable. This thesis aims to provide precisely that, offering insights that connect regulatory intent with real-world environmental impact, advance the understanding of how disclosure frameworks operate in practice, and inform the ongoing debate on how sustainable finance regulation can be designed and evaluated more effectively.

Part I: EU Taxonomy: Article 8 Disclosure in Credit Institutions

2 Herausforderungen für Kreditinstitute im Zusammenhang mit der Offenlegung nach Artikel 8 der EU-Taxonomie

Abstract Die EU-Taxonomie definiert erstmals, welche Wirtschaftstätigkeiten als ökologisch nachhaltig gelten. Für die Geschäftsjahre 2021 und 2022 mussten Kreditinstitute im Rahmen der Artikel-8-Offenlegung bereits Kennzahlen veröffentlichen. Der folgende Beitrag beleuchtet die regulatorischen Anforderungen zur Umsetzung der Artikel-8-Offenlegung für Kreditinstitute. Anhand einer Stichprobe werden mit der Offenlegung verbundene Herausforderungen erläutert; ferner wird analysiert, welche Auslegungsentscheidungen Kreditinstitute als Folge treffen. Im Ergebnis soll bewertet werden, ob die Artikel-8-Offenlegung Kreditinstituten ermöglicht, die Umwelt-Performance ihrer Vermögenswerte und Kontrahenten zu bewerten, und ob sich diese Umwelt-Performance in den Taxonomie-Kennzahlen widerspiegelt.

Acknowledgments This chapter is adapted from my published paper “Herausforderungen für Kreditinstitute im Zusammenhang mit der Offenlegung nach Artikel 8 der EU-Taxonomie” in the WPg 2024.

2.1 Einleitung

Die EU-Taxonomie als Klassifizierungssystem verpflichtet Finanzmarktteilnehmende dazu, die Nachhaltigkeit ihrer wirtschaftlichen Aktivitäten offenzulegen (Regulation (EU) 2020/852, art. 8). Durch die Einführung einer einheitlichen Definition von ökologischer Nachhaltigkeit und der Offenlegung glaubwürdiger Informationen soll die Transparenz in Bezug auf die Nachhaltigkeit wirtschaftlicher Aktivitäten im Markt erhöht werden. Durch die Offenlegung von qualitativen und quantitativen Informationen in Bezug auf die Umwelt-Performance von Vermögenswerten und Wirtschaftsaktivitäten von Finanzmarktteilnehmenden sollen das Risiko von Greenwashing und damit verbundene Reputationsrisiken begrenzt werden (Berens, 2023, S. 630; European Commission, 2021a, Frage 1, 2; Weirich et al., 2022, S. 412). Gemäß der Europäischen Bankenaufsichtsbehörde EBA liegt Greenwashing vor, wenn die nachhaltigkeitsbezogene Offenlegung und Kommunikation das Nachhaltigkeitsprofil eines Unternehmens, Finanzprodukts oder einer Finanzdienstleistung nicht eindeutig widerspiegelt (EBA, 2023, p. 12).

Aus Sicht der Kreditinstitute ist die Artikel-8-Offenlegung Kern der Taxonomie-Verordnung. Sie gilt für alle Unternehmen, die bereits eine nichtfinanzielle Erklärung gemäß der Non-Financial Reporting Directive (NFRD) veröffentlichen müssen (Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1(1), (3); Regulation (EU) 2020/852, Art. 8(1)). Die NFRD[1] ist auf große (Mutter-)Unternehmen von öffentlichem Interesse mit Sitz im Europäischen Wirtschaftsraum (EWR) anzuwenden, die (auf konsolidierter Basis) durchschnittlich mindestens 500 Mitarbeiter beschäftigen. Ab 01.01.2024 wird die NFRD von der Corporate Sustainability Reporting Directive (CSRD) abgelöst. Mit der CSRD fallen gemäß § 289b Abs. 1 in Verbindung mit § 267 Abs. 3 HGB mehr Unternehmen in den Anwendungsbereich der Artikel-8-Offenlegung. Zudem unterliegt die Offenlegung mit Aufnahme in den Lagebericht ab dem Berichtsjahr 2024 der Prüfung mit begrenzter Sicherheit (Limited Assurance) (Directive (EU) 2022/2464, Art. 1(9), 5).

Es stellt sich die Frage, ob die Ausgestaltung der Artikel-8-Offenlegung für Kreditinstitute dazu beiträgt, die Transparenz im Markt zu erhöhen und das Greenwashing-Risiko für Kreditinstitute zu verringern. Zur Beantwortung dieser Frage werden zunächst regulatorische

[1] Die nationale Umsetzung der NFRD ist das CSR-Richtlinien-Umsetzungsgesetz vom 11.04.2017. Da sich die Berichtspflicht nach Art. 8 der Taxonomie Verordnung auf Unternehmen bezieht, die in den Anwendungsbereich der NFRD statt in den der nationalen Umsetzung fallen, wird im Folgenden auf den Verweis auf das CSR-Richtlinien-Umsetzungsgesetz verzichtet.

Grundlagen zur Anwendung der Artikel-8-Offenlegung in Kreditinstituten zusammengetragen. Da die regulatorischen Vorgaben vor allem für die ersten Anwendungsjahre lückenhaft sind, soll der Beitrag einen Überblick darüber geben, wie Kreditinstitute die Offenlegungsanforderungen umsetzen müssen. Dabei wird mithilfe einer eigenen Stichprobe zur Taxonomiefähigkeit von Kreditinstituten ausgeführt, welchen Herausforderungen Kreditinstitute gegenüberstehen und wie Kreditinstitute folglich regulatorische Anforderungen auslegen. Auf Grundlage der Stichprobe wird diskutiert, ob die regulatorische Ausgestaltung der Artikel-8-Offenlegung den Kreditinstituten eine einheitliche Bewertung der Umwelt-Performance ihrer Vermögenswerte und Kontrahenten ermöglicht und ob sich diese Umwelt-Performance in den zu veröffentlichenden Key Performance Indicators (KPI) der Kreditinstitute widerspiegelt. Zuletzt werden die Ergebnisse zusammengefasst und ein Ausblick für die weitere Entwicklung der Artikel-8-Offenlegung gegeben.

2.2 Regulatorische Anforderungen an die Artikel-8-Offenlegung

2.2.1 Taxonomiefähigkeit

In den ersten Berichtsjahren 2021 und 2022 der Artikel-8-Offenlegung verlangen Aufsichtsbehörden von Kreditinstituten, dass diese zunächst qualitative und quantitative Informationen in Bezug auf die Taxonomiefähigkeit ihrer Wirtschaftsaktivitäten veröffentlichen (Commission Delegated Regulation (EU) 2021/2178, Art. 10(3), Annex V, VI, XI). Wirtschaftsaktivitäten gelten gemäß den ersten beiden Umweltzielen „Klimaschutz" und „Anpassung an den Klimawandel" als taxonomiefähig, wenn sie im Climate Delegated Act beschrieben sind oder einem der vierstelligen NACE-Codes (Nomenclature Statistique des Activités Economiques) entsprechen (Commission Delegated Regulation (EU) 2021/2139, Erwägungsgrund 6; Commission Delegated Regulation (EU) 2021/2178, Art. 1(5); Regulation (EC) 1893/2006; European Commission, 2022, Frage 6; Weirich et al., 2022, S. 414). Die Rechtsakte umfassen Wirtschaftsaktivitäten aus neun Sektoren, welche für knapp 80 Prozent der direkten Treibhausgasemissionen in Europa verantwortlich sind (European Commission, 2021c, Frage 7).

Das Kerngeschäft eines Kreditinstituts besteht unter anderem darin, Unternehmen der Realwirtschaft Finanzierungsmittel zur Verfügung zu stellen. Im Rahmen der EU-Taxonomie werden daher die Vermögenswerte Kredite, Darlehen, Schuldverschreibungen, Beteiligungen und wieder in Besitz genommene Sicherheiten berücksichtigt (Commission Delegated

Regulation (EU) 2021/2178, Erwägungsgrund 5; European Commission, 2021a, Frage 7a). Der Disclosures Delegated Act verlangt für die Berichtsjahre 2021 und 2022 die Veröffentlichung der taxonomiefähigen Vermögenswerte als Anteil an den gesamten Aktiva gemäß Gleichung (2.1) (Commission Delegated Regulation (EU) 2021/2178, Art. 1(5), 7, 10(3)(a), Annex V(1.1.2), (1.2.1); European Commission, 2021c, Frage 14).

$$\begin{aligned} \mathit{Taxonomief\ddot{a}higkeit} &= \frac{\mathit{Taxonomief\ddot{a}hige\ Verm\ddot{o}genswerte}}{\mathit{Gesamte\ Aktiva}} \\ &= \frac{\begin{gathered}\mathit{Kredite,\ Darlehen,\ Schuldverschreibungen,\ Beteiligungen\ und\ wieder\ in}\\ \mathit{Besitz\ genommene\ Sicherheiten,\ die\ taxonomief\ddot{a}hige}\\ \mathit{Wirtschaftsaktivit\ddot{a}ten\ finanzieren}\end{gathered}}{\mathit{Gesamte\ Aktiva}} \end{aligned} \tag{2.1}$$

Der Nenner „Gesamte Aktiva“ in Gleichung (2.1) wurde zunächst nicht näher spezifiziert und erst im Rahmen von Frequently Asked Questions (FAQ) aufgegriffen. Die EU-Kommission und das Institut der Wirtschaftsprüfer (IDW) empfehlen Kreditinstituten, für eine bessere Vergleichbarkeit den Umfang der GAR-Vermögenswerte einzubeziehen, die im Rahmen der GAR vorgegeben werden (European Commission, 2022, Frage 21; IDW, 2023, Frage 3.2.4). Im Vergleich zu den gesamten Aktiva enthalten die GAR-Vermögenswerte keine Forderungen gegenüber Zentralbanken und Staaten und keine Handelsbuchpositionen (Commission Delegated Regulation (EU) 2021/2178, Art. 7(1), Annex V(1.2.4)).

Taxonomiefähige Risikopositionen bilden die Grundlage der Positionen, welche für die Bewertung der Taxonomiekonformität berücksichtigt werden (European Commission, 2022, Frage 3).

2.2.2 Taxonomiekonformität

Damit eine taxonomiefähige Wirtschaftstätigkeit als taxonomiekonform und damit als ökologisch nachhaltig eingestuft werden kann, muss sie einen wesentlichen Beitrag zu mindestens einem der sechs festgelegten Umweltziele leisten. Der wesentliche Beitrag wird anhand von technischen Bewertungskriterien geprüft, die bestimmte quantitative Schwellenwerte oder qualitative Leistungsanforderungen festlegen (Regulation (EU) 2020/852, Art. 1(1), 3(1)(a), 9(1)(d), Erwägungsgrund 38). Zudem darf eine wirtschaftliche Tätigkeit keines der anderen Umweltziele wesentlich beeinträchtigen („Do No Significant Harm“) (Regulation (EU) 2020/852, Art. 3(1)(b), 9, 17, Erwägungsgrund 34). Zuletzt müssen soziale Mindeststandards (Minimum Social Safeguards) zu grundlegenden Menschen- und Arbeitsrechten eingehalten werden (Regulation (EU) 2020/852, Art. 3(c), 18). Für Kreditinstitute steht vor allem die GAR im Fokus. Die Kennzahl wird in Gleichung (2.2) als Anteil der taxonomiekonformen Risikopositionen im Verhältnis zur Summe aller bilanzierten GAR-Vermögenswerte berechnet (Commission Delegated Regulation (EU) 2021/2178, Erwägungsgrund 5, Annex V(1.1.2), (1.2.1)).

$$\boldsymbol{GAR} = \frac{\textit{Taxonomiekonforme Vermögenswerte}}{\textit{GAR-Vermögenswerte}} = \frac{\begin{array}{c}\textit{Taxnomiefähige Risikopositionen, die die}\\ \textit{technischen Bewertungskriterien erfüllen}\end{array}}{\textit{GAR-Vermögenswerte}} \tag{2.2}$$

Die Taxonomiekonformität in Bezug auf die ersten beiden Umweltziele muss ab 01.01.2024 für die Berichtsperiode 2023 offengelegt werden (Commission Delegated Regulation (EU) 2021/2178, Art. 10(3), (5)). Die vier weiteren Umweltziele müssen voraussichtlich erst zum 01.01.2026 berücksichtigt werden (Commission Delegated Regulation (EU) 2023/2486). Die Aufsicht verlangt die Offenlegung der Taxonomiekonformität anhand von Templates, welche die relevanten Bilanzinformationen eines Kreditinstituts enthalten. Template 1 enthält die Vermögenswerte für die Berechnung des Zählers und Nenners der GAR (GAR-Template) (Commission Delegated Regulation (EU) 2021/2178, Art. 10(3), Annex VI).

Im Folgenden wird erläutert, wie die Taxonomiefähigkeit ermittelt wird. Dabei dient das Template als Struktur, an der sich Kreditinstitute bei der Bewertung von Exposures orientieren können (European Commission, 2021c, Frage 5).

2.3 Ermittlung der Taxonomiefähigkeit auf Grundlage des GAR-Templates

2.3.1 GAR-Template

Table 2.1 zeigt einen Auszug aus dem Original-Template gemäß Anhang VI des Disclosure Delegated Act.

Table 2.1: Auszug aus dem GAR-Template gemäß Anhang VI des Disclosure Delegated Act

GAR-Template (Auszug)	
1	**GAR – Im Zähler und Nenner erfasste Vermögenswerte**
2	Kredite und Darlehen, Schuldverschreibungen und Eigenkapitalinstrumente, die für die GAR-Berechnung anrechenbar sind
3	Finanzunternehmen
21	Nichtfinanzielle Kapitalgesellschaften (NFRD-pflichtig)
26	Private Haushalte
30	Finanzierungen lokaler Gebietskörperschaften
31	Durch Inbesitznahme erlangte Sicherheiten: Wohn- und Gewerbeimmobilien
33	**Sonstige Vermögenswerte, die nicht im Zähler für die GAR-Berechnung erfasst sind (im Nenner enthalten)**
34	Nichtfinanzielle Kapitalgesellschaften
35	KMU und nichtfinanzielle Kapitalgesellschaften (außer KMU), die nicht der Offenlegungspflicht der NFRD unterliegen
41	Gegenparteien aus Nicht-EU-Ländern, die nicht der Offenlegungspflicht der NFRD unterliegen
45	Derivate
46	Kurzfristige Interbankenkredite
47	Zahlungsmittel und zahlungsmittelverwandte Vermögenswerte
48	Sonstige Vermögenswerte (Unternehmenswert, Waren usw.)
49	GAR-Vermögenswerte insgesamt
50	**Sonstige nicht für die GAR-Berechnung erfasste Vermögenswerte**
51	Staaten
52	Risikopositionen gegenüber Zentralbanken
53	Handelsbuch
54	**Gesamte Aktiva**

Die Originalbeschriftung der Zeilen und Spalten wurde im Wesentlichen beibehalten.

Die Zeilen enthalten Bilanzpositionen gegenüber verschiedenen Gegenparteien, welche jeweils mit dem Bruttobuchwert der Exposures zu befüllen sind. Die Exposures beruhen auf den Beträgen, die im Rahmen des FINREP als Teil des Meldewesens von Kreditinstituten offengelegt werden (Regulation (EU) 575/2013).

2.3.2 Bewertung von Risikopositionen im Rahmen der Ermittlung der Taxonomiefähigkeit

Für die Ermittlung der Taxonomiefähigkeit gibt es keine eindeutigen regulatorischen Vorgaben. Um eine möglichst hohe Konsistenz in der Offenlegung zu erreichen, sollen sich Kreditinstitute laut den Vorgaben der EU-Kommission am Vorgehen zur Bestimmung der Taxonomiekonformität orientieren (Commission Delegated Regulation (EU) 2021/2178, Art. 1(5), 7, 10(3)(a); European Commission, 2021c, Frage 14).

Exposures gegenüber nichtfinanziellen Kapitalgesellschaften und Finanzunternehmen können nur dann taxonomiefähig sein, wenn der Kontrahent der NFRD unterliegt.[2] Für nichtfinanzielle Kapitalgesellschaften ist bei der Berechnung der Taxonomiefähigkeit der Verwendungszweck entscheidend. Entspricht dieser im Falle einer Projektfinanzierung mit spezifischem Verwendungszweck einer Wirtschaftstätigkeit im Climate Delegated Act, ist das Exposure taxonomiefähig. Handelt es sich bei einer Finanzierung um einen General Purpose Loan ohne spezifischen Verwendungszweck (beispielsweise Betriebsmittellinie), gewichten Kreditinstitute den Bruttobuchwert des Exposures mit den Taxonomiefähigkeits-KPI des Kontrahenten. Nicht-finanzielle Kapitalgesellschaften legen jeweils eine KPI in Bezug auf den taxonomiefähigen Umsatz sowie in Bezug auf taxonomiefähige Investitionsausgaben offen. Kreditinstitute müssen beide KPI berücksichtigen und ihre eigene Taxonomiefähigkeit zweimal offenlegen. Bei Finanzunternehmen als Gegenpartei bestimmen Kreditinstitute die Taxonomiefähigkeit immer auf Grundlage der KPI der Gegenpartei, unabhängig vom Verwendungszweck der Risikoposition. In der Regel weisen die Finanzunternehmen ebenfalls zwei KPI aus, basierend auf dem Umsatz und den Investitionsausgaben ihrer eigenen Kontrahenten. Die eigene Taxonomiefähigkeit wird daher ebenfalls zweimal offengelegt werden (Commission Delegated Regulation (EU) 2021/2178, Art. 10(2), Annex V(1.2.1); European Commission, 2021c, Frage 11).

Die Taxonomiefähigkeit eines Exposures gegenüber einem Kontrahenten wird für das Berichtsjahr t gemäß Gleichung (2.3) berechnet.[3] Darin bezeichnet k den Kontrahenten des Kreditinstituts (Beschränkung auf nicht-finanzielle Kapitalgesellschaften und Finanzunternehmen) und b die Bezugsgröße (abhängig von zu veröffentlichenden KPI des Kontrahenten).

$$\begin{aligned} &\boldsymbol{Taxonomief\text{ä}higkeit\ Exposure\ (t)}_{\boldsymbol{k,b}} \\ &= \boldsymbol{Exposure_k} \times \boldsymbol{Taxonomief\text{ä}higkeit\ (t-1)_{k,b}} \end{aligned} \tag{2.3}$$

Kredite an private Haushalte sind derzeit nur dann taxonomiefähig, wenn sie durch Wohnimmobilien besichert sind oder die Renovierung von Gebäuden finanziert wird. Des Weiteren gelten gewisse Kfz-Kredite als taxonomiefähig (Commission Delegated Regulation (EU)

[2] Das gilt auch für Unternehmen, die ab 2024 der CSRD-Pflicht unterliegen. Auf den wiederholten Verweis auf die CSRD als Nachfolge-Richtlinie der NFRD wird im Folgenden verzichtet.

[3] Die Gleichung gilt gegenüber Finanzunternehmen, solange es sich nicht um einen Förderkredit im Eigenvertrieb handelt. Gegenüber nicht-finanziellen Kapitalgesellschaften gilt die Gleichung nur für Exposures ohne (eindeutigen) Verwendungszweck.

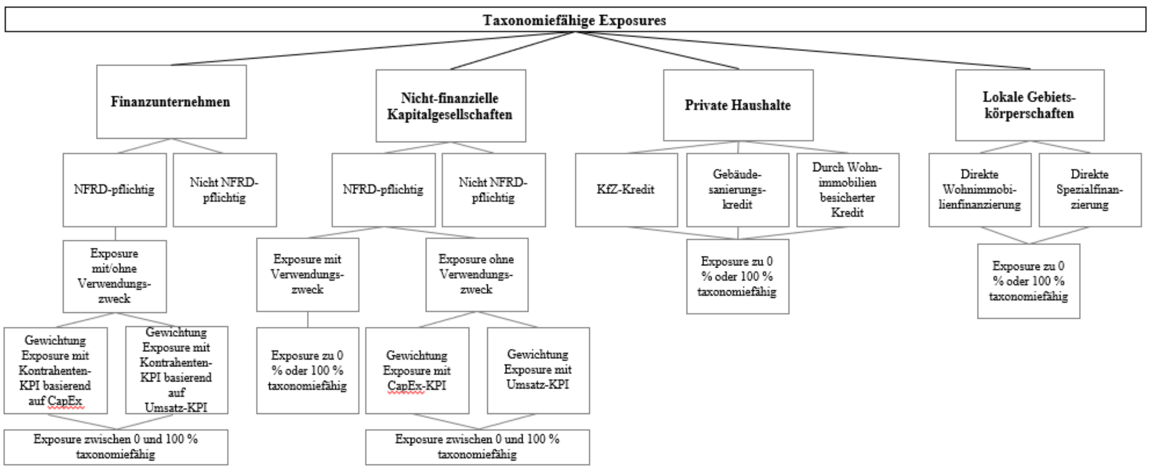
2021/2139, Annex I; Commission Delegated Regulation (EU) 2021/2178, Annex V(1.2.1.3)).

Taxonomiefähige Finanzierungen gegenüber lokalen Gebietskörperschaften sind laut Disclosure Delegated Act Finanzierungen öffentlichen Wohnungsbaus und sonstige Spezialfinanzierungen an öffentliche Stellen (Commission Delegated Regulation (EU) 2021/2139, Annex I; Commission Delegated Regulation (EU) 2021/2178, Annex V(1.2.1.4)).

Für die Taxonomiefähigkeit in Frage kommen auch wieder in Besitz genommene Immobiliensicherheiten (Commission Delegated Regulation (EU) 2021/2178, Annex V(1.2.1.5)). Für die meisten Kreditinstitute hat diese Position allerdings offenbar nur eine geringe Bedeutung.

Figure 2.1 fasst zusammen, welche Exposures und zu welchem Anteil diese gemäß Anhang V und VI der Verordnung (EU) 2021/2178 als taxonomiefähig gelten können.

Figure 2.1: Bewertung der Taxonomiefähigkeit von Exposures, basierend auf regulatorischen Vorgaben gemäß Anhang V und VI des Disclosure Delegated Act (eigene Darstellung)



Nicht-taxonomiefähige Exposures sind vom Zähler der Taxonomiefähigkeit ausgeschlossen. Risikopositionen gegenüber nichtfinanziellen Kapitalgesellschaften und Finanzunternehmen, die nicht NFRD-pflichtig sind, gelten als nicht-taxonomiefähig (Commission Delegated Regulation (EU) 2021/2178, Art 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1(1), (3); Directive (EU) 2022/2464, Art. 1, 4, 7). Derivate sind ebenfalls nicht taxonomiefähig, da ihr Zweck nicht die Finanzierung einer Wirtschaftsaktivität, sondern die Minderung von Gegenparteiausfallrisiken ist (Commission Delegated Regulation (EU) 2021/2178, Art. 7(2); European Commission, 2021a, Frage 10). Kurzfristige Interbankenkredite (Commission Delegated Regulation (EU) 2021/2178, Annex V(1.1.2)), Zahlungsmittel und zahlungsmittelverwandte Vermögenswerte (European Commission, 2022, Frage 22) sind nicht in den Zähler einzubeziehen, da sie in der Regel als Reserve gehalten werden und nicht der Finanzierung einer bestimmten Wirtschaftstätigkeit dienen. Die sonstigen Vermögenswerte sind als Position für übrige Aktiva vorgesehen oder als Sammelposten für Exposures, welche nicht separat ausgewiesen werden. Beispielsweise gilt das für Exposures gegenüber nicht NFRD-pflichtigen Finanzinstituten sowie für Darlehen an private Haushalte, welche keinem Kfz- oder Gebäudesanierungskredit entsprechen (Commission Implementing Regulation (EU) 2022/2453, Annex II, Template 7; EBA, 2022, Frage 2023_6681). Der Nenner der Risikopositionen umfasst die vom Zähler ausgeschlossenen Vermögenswerte, um den Anteil dieser Aktiva im Vergleich zu den Gesamtaktiva der Kreditinstitute zu verdeutlichen (European Commission, 2021a, Frage 8). Folglich erhöhen nicht-taxonomiefähige Risikopositionen ausschließlich den Nenner und senken somit die KPI zur Taxonomiefähigkeit.

Grundsätzlich vom Zähler und Nenner ausgeschlossen werden das Handelsbuch sowie Risikopositionen gegenüber Zentralbanken und Staaten. Wird die Regulatorik im Rahmen der Taxonomiefähigkeit allerdings so ausgelegt, diese Exposures in den Nenner einzubeziehen (gesamte Aktiva statt GAR-Vermögenswerte), werden sie nur aus dem Zähler ausgeschlossen.

2.4 Offenlegung zur Taxonomiefähigkeit: Analyse anhand einer Stichprobe

Nach Angaben der EU-Kommission besteht das Ziel der Artikel-8-Offenlegung für Kreditinstitute darin, die Transparenz im Markt zu erhöhen und damit Greenwashing-Risiken für Kreditinstitute zu verringern (European Commission, 2021a, Frage 1, 2). Um dieses Ziel zu erreichen, „benötigen Finanzinstitute eine einheitliche und strenge Bewertung der Umwelt- und Klimaperformance der von ihnen finanzierten Unternehmen und Vermögenswerte“.[4] Es stellt sich die Frage, ob die Ausgestaltung der Artikel-8-Offenlegung den Kreditinstituten eine einheitliche Bewertung der Umwelt-Performance ihrer Vermögenswerte und Kontrahenten ermöglicht und ob sich diese Umwelt-Performance in den Taxonomie-KPI der Kreditinstitute widerspiegelt. Um diese Frage zu beantworten, wurden Daten zur Taxonomiefähigkeit mittels einer Stichprobe von Kreditinstituten aus deren nicht-finanziellen Berichten

[4] Originalzitat gemäß Europäischer Kommission (2021a, Frage 2): „Financial institutions need a homogenous and rigorous evaluation of environmental and climate performance of companies and assets they finance“.

erhoben. Die Analyse der Taxonomiefähigkeit soll Einblick in die Herausforderungen im Rahmen der Artikel-8-Offenlegung geben.

2.4.1 Überblick über die quantitative Offenlegung der Taxonomiefähigkeit

Um einen Überblick über die Taxonomiefähigkeit von Kreditinstituten im Markt zu erhalten, wurden Taxonomie-Daten von deutschen Kreditinstituten aus unterschiedlichen Geschäftsfeldern (Großbanken, Landesbanken, Hypothekenbank, Umweltbank, Genossenschaftsbank, Universalbank) analysiert. Auf diese Weise wird ein großes Spektrum des Markts abgedeckt.

Table 2.2 zeigt die quantitative Offenlegung der Stichprobe für die Jahre 2021 und 2022.

Table 2.2: Quantitative Offenlegung zur Taxonomiefähigkeit aus nicht-finanziellen Berichten neun ausgewählter deutscher Kreditinstitute unterschiedlicher Sektoren in den Berichtsjahren 2021 und 2022 (eigene Darstellung)

Kreditinstitut	**Deutsche Apotheker- und Ärztebank**	**BayernLB**	**Commerzbank**	**Deutsche Bank**	**DZ Bank Gruppe**	**Landesbank Hessen-Thüringen (Helaba)**	**Landesbank Baden-Württemberg (LBBW)**	**Münchener Hypothekenbank**	**Triodos Bank**
Taxonomiefähigkeit 2022	21,00%*	10,50%*	24,57%*	18,49%	22,00%	18,00%*	6,40%*	47,37%*	39,60%
(2021)	(23,00%)	(6,90%)	(24,10%)	(17,82%)	(19,00%)	(15,70%)	(6,10%)	(41,79%)	(35,10%)
* KPI basiert im Nenner auf gesamten Aktiva (statt GAR-Vermögenswerten)									

Die KPI in Tabelle 2.2 berücksichtigen im Zähler Exposures ohne Verwendungszweck, die auf Umsatz-KPI der Kontrahenten basieren, und im Nenner GAR-Vermögenswerte.

Vergleicht man die Kennzahlen in der Stichprobe, lassen sich Unterschiede in den Werten erkennen. Versucht man diese Unterschiede zu erklären, sollte man sich die Herausforderungen für Kreditinstitute im Zusammenhang mit der Artikel-8-Offenlegung bewusst machen.

2.4.2 Herausforderungen bei der Ermittlung der Taxonomiefähigkeit

Unterschiedliche Werte der Taxonomiefähigkeit können aus einem Mangel an Datenverfügbarkeit und -qualität resultieren. Für die Ermittlung der Taxonomiefähigkeit müssen Kreditinstitute eine Vielzahl neuer Daten über die Aktivitäten ihrer Kunden und deren Nachhaltigkeit sammeln, und zwar sowohl für das Bestandskunden- als auch für das Neukundengeschäft. Auch wenn die Taxonomiefähigkeit deutlich weniger aufwendig zu ermitteln ist als die Taxonomiekonformität, müssen dafür bereits Prozesse und IT-Systeme zur Datenerfassung und -verarbeitung angepasst werden (Weirich et al., 2022, S. 416). Zudem beschränken knappe Ressourcen die Möglichkeit und Bereitschaft, Know-how aufzubauen und die neuen Anforderungen vollständig umzusetzen (Brühl, 2023, S. 18). Zudem sind Taxonomie-Daten zum Teil (noch) nicht verfügbar (Weirich et al., 2022, S. 416ff.). Kreditinstitute konnten erst in der Berichterstattung für das Jahr 2022 auf die Kontrahenten-KPI zurückgreifen. Der Zuwachs an Daten im Vergleich zum Jahr 2021 erklärt möglicherweise die Erhöhung der Taxonomiefähigkeit bei fast allen Kreditinstituten in der Stichprobe. Eine Quelle für einen besseren Zugang zu Daten können Drittanbieter sein, die taxonomiebezogene Informationen der Kontrahenten bereitstellen. Allerdings ist die Verfügbarkeit von Daten, vor allem von kleineren Kontrahenten, begrenzt.

Neben der Datenherausforderung ist der Wert der Taxonomiefähigkeit zunächst auch vom Sektor der Kontrahenten abhängig. In Deutschland und in der EU sind über 99 Prozent der Unternehmen KMU (European Commission, 2023; Platform on Sustainable Finance, 2022a, S. 100; Statista, 2022). Da viele KMU auf eine Finanzierung durch Kreditinstitute zurückgreifen, haben deutsche Kreditinstitute ihnen gegenüber erhebliche Exposures in der Bilanz (Butkowski et al., 2019, S. 2). Da KMU nicht NFRD-pflichtig sind, sind sie nicht taxonomiefähig (Commission Delegated Regulation (EU) 2021/2178, Art. 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1(1), (3); Regulation (EU) 2020/852, Art. 8(1)). Kreditinstitute, die vor allem KMU finanzieren, weisen damit unter sonst gleichen Bedingungen eine möglicherweise niedrigere Taxonomiefähigkeit aus, unabhängig von der Nachhaltigkeit der finanzierten Projekte und Kontrahenten. Kreditinstitute, die vermehrt große Unternehmen finanzieren, könnten damit in Bezug auf die Taxonomiefähigkeit einen Vorteil haben. In der Stichprobe gibt die Triodos Bank an, viele KMU zu finanzieren (Triodos Bank, 2022, S. 77). Dasselbe Problem trifft auf Finanzierungen gegenüber Objektgesellschaften (Special Purpose Vehicles – SPV) zu, welche wegen ihrer Größe und Anzahl an Mitarbeitern häufig ebenfalls nicht NFRD-pflichtig sind (Commission Delegated Regulation (EU) 2021/2178, Art. 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1(1), (3); Regulation (EU) 2020/852, Art. 8(1)). Häufig werden besonders innovative oder nachhaltige Projekte über Objektgesellschaften finanziert, beispielsweise Projekte zu erneuerbaren Energien (Partiti, 2023, p. 11f.). So hat die Münchener Hypothekenbank laut Offenlegung viele Finanzierungen gegenüber Objektgesellschaften und kleinen Wohnungsunternehmen im Portfolio (Münchener Hypothekenbank, 2022, S. 9). Ebenso verhält es sich bei Risikopositionen gegenüber Nicht-EU-Gegenparteien (Commission Delegated Regulation (EU) 2021/2178, Art. 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1(1), (3); Regulation (EU) 2020/852, Art. 8(1); Triodos Bank, 2022, S. 77). Auch die Finanzierung von Aktivitäten in Sektoren mit geringen Emissionen ist im Rahmen der EU-Taxonomie benachteiligt. Der Climate Delegated Act deckt derzeit nur Sektoren mit hohen Emissionen ab. Daher wird die Finanzierung dieser Aktivitäten als nicht-taxonomiefähig eingestuft, obwohl sie möglicherweise nicht umweltschädlich sind (Commission Delegated Regulation (EU) 2021/2139, Annex I, II; Commission Delegated Regulation (EU) 2021/2178, Art. 1(5); Platform on Sustainable Finance, 2022b, S. 9). Für Außenstehende ist dabei nicht ersichtlich, ob Exposures nicht taxonomiefähig sind, weil sie nicht von der Taxonomie abgedeckt sind oder weil sie besonders umweltschädlich sind (Bardens et al., 2022, S. 188; Berens, 2023, S. 634). Da die genannten Exposures nur in den Nenner der Taxonomiefähigkeit aufgenommen werden dürfen, verringern sie unter sonst gleichen Bedingungen die Taxonomiefähigkeit. Risikopositionen gegenüber Staaten und Zentralbanken können die Taxonomiefähigkeit ebenfalls beeinflussen. Sie werden zwar aus Zähler und Nenner ausgeschlossen, gleichwohl bleibt möglicherweise ein nicht zu vernachlässigender Teil nachhaltiger Finanzierungen unberücksichtigt (Commission Delegated Regulation (EU) 2021/2178, Art. 7(1)). Schätzungen zufolge werden etwa 30 Prozent der Staatsschulden der EU von EU-Finanzinstituten (exklusive Zentralbanken) gehalten (European Central Bank, 2021, S. 67; Platform on Sustainable Finance, 2022a, S. 79f.).

Des Weiteren tragen unklare und auslegungsbedürftige Formulierungen sowie unverbindliche Empfehlungen in den regulatorischen Anforderungen zur Taxonomiefähigkeit zu Unsicherheiten in der Anwendung der EU-Taxonomie bei (Berens, 2023, S. 636; Gerwing & Wolff, 2023, S. 611, 615; Schäfer & Schönberger, 2021, S. 635). Grundsätzlich empfiehlt die EU-Kommission in ihren FAQ, sich an den Anforderungen der Taxonomiekonformität zu orientieren (European Commission, 2021c, Frage 5, 11, 14). Dadurch wird die Offenlegung für Stakeholder standardisierter, vergleichbarer und leichter verständlich.

Einerseits versuchen Kreditinstitute mit ihrer Offenlegung das Risiko von Greenwashing (-Vorwürfen) zu reduzieren. Greenwashing kann Reputationsrisiken mit sich bringen, die die Glaubwürdigkeit und das Vertrauen in ein Kreditinstitut gefährden (EBA, 2023, p. 33f.; Gerwing & Wolff, 2023, S. 612). Bei der Auslegung der Regulatorik durch Kreditinstitute aufgrund von Unsicherheit über regulatorische Anforderungen wird seitens der Aufsicht oder anderer Stakeholder nicht notwendigerweise die Absicht unterstellt, dass Kreditinstitute ihr

Nachhaltigkeitsprofil als ökologisch nachhaltiger darstellen. Es kann allerdings bereits dann zu Reputationsverlusten kommen, wenn Stakeholder einen Greenwashing-Verdacht publik machen, selbst wenn nicht die Absicht bestand, das Nachhaltigkeitsprofil „grüner“ darzustellen. Da eine Vielzahl der Auslegungssachverhalte Einfluss auf die Taxonomiefähigkeit hat, besteht dieses Risiko auch in den ersten Anwendungsjahren. Demgegenüber stehen Kreditinstitute vor dem Reputationsrisiko, eine niedrige Taxonomie-KPI und im Vergleich mit Peers eine niedrige Quote auszuweisen (Gerwing & Wolff, 2023, S. 615; Platform on Sustainable Finance, 2022b, S. 6). Das löst einen Zielkonflikt in Bezug auf die zu treffenden Annahmen und die Auslegung regulatorischer Vorgaben in der Offenlegung aus.

Verbleibende Unsicherheit kombiniert mit beschränkter Datenverfügbarkeit sowie -qualität führt dazu, dass Kreditinstitute zur Umsetzung dieser Regelung die Anforderungen entsprechend ihrer Datenlage und ihrem Verständnis auslegen. Diese Auslegung und deren mögliche Auswirkungen auf die Taxonomiefähigkeit sollen im Folgenden betrachtet werden.

2.4.3 Auslegung regulatorischer Vorgaben bei der Ermittlung der Taxonomiefähigkeit

Die Herausforderungen im Zusammenhang mit der Artikel-8-Offenlegung führen zu unterschiedlichen Annahmen und Auslegungen der regulatorischen Vorgaben. Vergleicht man die qualitative Offenlegung innerhalb der Stichprobe der neun deutschen Kreditinstitute, lassen sich grundlegende Unterschiede feststellen, die Einfluss auf die quantitative Offenlegung nehmen.

Derzeit scheint das Reputationsrisiko aus Greenwashing (-Vorwürfen) gegenüber dem Vergleich mit Peers zu überwiegen. Bei der Ermittlung der Taxonomiefähigkeit kann bei Kreditinstituten häufig ein vorsichtiger und konservativer Ansatz beobachtet werden. Dabei werden Exposures im Zweifel als nicht-taxonomiefähig ausgewiesen, um die Taxonomiefähigkeit nicht überzubewerten und einen möglichen Reputationsverlust wegen Greenwashing (-Vorwürfen) zu verhindern (Alessi & Battiston, 2022, S. 4; Partiti, 2023, p. 11f.). Die Sorge, wegen fehlerhafter Umsetzung des Greenwashing bezichtigt zu werden (EBA, 2023, p. 27), senkt unter sonst gleichen Bedingungen möglicherweise die Taxonomiefähigkeit. In der Stichprobe geben die Commerzbank und die Münchener Hypothekenbank an, bei mangelnder Datenlage über den Verwendungszweck Exposures konservativ als nicht-taxonomiefähig zu kennzeichnen (Commerzbank, 2022, p. 53; Münchener Hypothekenbank, 2022, S. 9).

Die EU-Kommission empfiehlt die Verwendung der GAR-Vermögenswerte als Nenner der Taxonomiefähigkeits-KPI, um einen besseren Vergleich mit der GAR zu ermöglichen (Commission Delegated Regulation (EU) 2021/2178, Art. 7(1)). Trotzdem ermitteln einige Institute die Taxonomiefähigkeit mit den gesamten Aktiva als Nenner (BayernLB, 2022, S. 331; Commerzbank, 2022, p. 52; Deutsche Apotheker- und Ärztebank, 2022, S. 54; Landesbank Hessen-Thüringen, 2022, S. 85f. Münchener Hypothekenbank, 2022, S. 9). Andere Kreditinstitute legen die KPI mit beiden Nennern offen (Triodos Bank, 2022, S. 77). Die GAR-Vermögenswerte sind aufgrund ausgenommener Exposures kleiner als die gesamten Aktiva und erhöhen daher unter sonst gleichen Bedingungen die Taxonomiefähigkeits-KPI.[5]

Der Zähler der Taxonomiefähigkeit ist ebenfalls abhängig von der Auslegung regulatorischer Vorgaben. Laut EU-Taxonomie sind nur NFRD-pflichtige Kontrahenten taxonomiefähig (Commission Delegated Regulation (EU) 2021/2178, Art 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1; Directive (EU) 2022/2464, Art. 1). Ist die NFRD-Pflicht von Kontrahenten nicht in IT-Systemen erfasst, müssen Kreditinstitute diese Pflicht anhand der einschlägigen NFRD-Kriterien (Zahl der Mitarbeiter, Sitz, Kapitalmarktorientierung, Größe) bewerten. Innerhalb der Stichprobe geben die LBBW und die DZ Bank Gruppe an, die NFRD-Pflicht gemäß den genannten NFRD-Kriterien zu bewerten (DZ BANK Gruppe, 2022, p. 49; Landesbank Baden-Württemberg, 2022, S. 107). Andere Institute legen die NFRD-Pflicht laut Bericht nur anhand einer Auswahl an Kriterien fest (Commerzbank, 2022, p. 53; Deutsche Apotheker- und Ärztebank, 2022, S. 55; Triodos Bank, 2022, S. 425). Wiederum andere Kreditinstitute wenden bereits die Kriterien der CSRD an. Da die CSRD schon für Unternehmen mit mehr als 250 Mitarbeitern (versus 500 Mitarbeiter laut NFRD) anzuwenden ist, werden mehr Risikopositionen in die Beurteilung der Taxonomiefähigkeit einbezogen werden (Commission Delegated Regulation (EU) 2021/2178, Art 7(3); Directive (EU) 2013/34, Art. 19a, 29a; Directive (EU) 2014/95, Art. 1; Directive (EU) 2022/2464, Art. 1). Zugleich stehen für Kontrahenten mit weniger als 500 Mitarbeitern häufig keine Taxonomie-Informationen zur Verfügung, da diese laut derzeit geltender NFRD nicht unter die Artikel-8-Offenlegung fallen.

Exposures gegenüber NFRD-pflichtigen Kontrahenten mit spezifischem Verwendungszweck sind entweder zu null oder zu 100 Prozent taxonomiefähig, abhängig davon, ob die finanzierte Wirtschaftsaktivität im Climate Delegated Act enthalten ist oder nicht

[5] Es sei denn, die Kreditinstitute haben keine Risikopositionen gegenüber Staaten, Zentralbanken sowie keine Handelsbestände – dann sind die Gesamtaktiva gleich den GAR-Vermögenswerten.

(Commission Delegated Regulation (EU) 2021/2178, Annex V(1.2.1.1)). Exposures gegenüber NFRD-pflichtigen Kontrahenten ohne spezifischen Verwendungszweck werden mit den Kontrahenten-KPI basierend auf deren taxonomiefähigen Umsätzen und Investitionsausgaben gewichtet; sie sind damit zwischen null und 100 Prozent taxonomiefähig. Die Mehrheit der Kreditinstitute in der Stichprobe bewertet die Taxonomiefähigkeit gemäß diesem Vorgehen (Commerzbank, 2022, p. 53; DZ BANK Gruppe, 2022, p. 49; Landesbank Baden-Württemberg, 2022, S. 107; Landesbank Hessen-Thüringen, 2022, S. 86; Triodos Bank, 2022, S. 80). Einige Kreditinstitute nehmen allerdings keine eigene Bewertung der Taxonomiefähigkeit von Risikopositionen vor, sondern gewichten alle Exposures mit den KPI ihrer NFRD-pflichtigen Kontrahenten (BayernLB, 2022, S. 330; Deutsche Apotheker- und Ärztebank, 2022, S. 54; Deutsche Bank, 2022, p. 22). Die Berechnungsmethode ist für Adressaten – je nach Umfang der bereitgestellten qualitativen Informationen – nicht eindeutig nachvollziehbar.

Welchen Einfluss die Auslegungen bezüglich der regulatorischen Vorgaben der Artikel-8-Offenlegung der Kreditinstitute auf die Beurteilung der Umwelt-Performance dieser Kreditinstitute haben, wird im folgenden Kapitel zusammengefasst.

2.5 Zusammenfassung

Die stichprobenhafte Analyse der Offenlegung von Kreditinstituten verdeutlicht die Herausforderungen bei der Ermittlung der Taxonomiefähigkeit. Kreditinstitute müssen mit mangelnder Datenverfügbarkeit und -qualität umgehen. Zudem bestehen Unsicherheiten durch unklare regulatorische Vorgaben der Aufsichtsbehörden, so dass Kreditinstitute Reputationsrisiken fürchten. Als Folge dieser Herausforderungen treffen Kreditinstitute im Rahmen der Offenlegung Annahmen und legen (unklare) regulatorische Vorgaben entsprechend den individuellen Voraussetzungen aus. Dies führt dazu, dass Stakeholder den Wert der Taxonomiefähigkeit nur begrenzt interpretieren und mit Peers vergleichen können. Aus diesem Grund ist die Aussagekraft der Kennzahl und die damit verbundene Transparenz in Bezug auf die ökologische Nachhaltigkeit eingeschränkt.

Die Platform on Sustainable Finance, ein beratendes Gremium der EU-Kommission, bestätigt die mangelnde Vergleichbarkeit der KPI zwischen Kreditinstituten in einer Studie aus dem Jahr 2021 (Platform on Sustainable Finance, 2022a, S. 43f.). Es ist zwar nicht das Ziel der Taxonomiefähigkeit, die Nachhaltigkeit von Wirtschaftsaktivitäten zu bewerten, die Exposures bilden aber die Basis für die Bewertung der Taxonomiekonformität. Verzerrungen, die im Rahmen der Taxonomiefähigkeit entstehen, können sich auf die Taxonomiekonformität übertragen. Ob eine Taxonomie-KPI niedrig ist, weil ein Kreditinstitut viele „schmutzige" Geschäfte finanziert oder weil ein Kreditinstitut hauptsächlich KMU finanziert, geht aus den Kennzahlen nicht hervor. Die Umwelt-Performance der Vermögenswerte und Kontrahenten von Kreditinstituten spiegelt sich folglich nicht notwendigerweise in den Taxonomie-KPI wider und kann daher nur begrenzt bewertet werden. In ihrem Bericht zu Greenwashing schreibt die EBA (2023, p. 12):

> „*The ESAs understand greenwashing as a practice whereby sustainability-related statements, declarations, actions, or communications do not clearly and fairly reflect the underlying sustainability profile of an entity, a financial product, or financial services. This practice may be misleading to consumers, investors, or other market participants*."

Folglich bestehen mit Offenlegung der Taxonomie-KPI Greenwashing- und damit verbundene Reputationsrisiken für Kreditinstitute. Die Ziele der EU-Kommission, Greenwashing-Risiken mithilfe der EU-Taxonomie zu reduzieren und die Transparenz zu erhöhen, ist durch die Ausgestaltung der Artikel-8-Offenlegung zumindest gefährdet.

2.6 Ausblick

Mit der Offenlegung der GAR werden Unklarheiten in Bezug auf regulatorische Anforderungen zum Teil vermindert. Gleichwohl wird die Offenlegung in den nächsten Jahren weiterhin von Unsicherheit und Mangel an Datenverfügbarkeit und -qualität geprägt sein. Kommt die EU-Kommission in ihrer Folgenabschätzung zu dem Ergebnis, KMU als Kontrahenten zu berücksichtigen, könnte sich die Datenlage grundsätzlich verbessern. Zugleich hätten KMU mit der Offenlegung der Taxonomie-Informationen einen deutlich höheren Verwaltungsaufwand, der für zusätzliche Kosten sorgt (Commission Delegated Regulation (EU) 2021/2178, Art. 9(1)(b), (2); European Commission, 2021a, Frage 8). Regulatorische Anpassungen und Leitlinien sind erforderlich, um den flächendeckenden Zugang zu den benötigten Daten zu verbessern und ein realistisches Bild der Umwelt-Performance widerzuspiegeln. Allerdings sollte hier der Trade-off zwischen höherer Standardisierung und Überregulierung mit einhergehendem Datenbedarf berücksichtigt werden (J. L. Arnold et al., 2024, p. 4). Die Prüfung der offengelegten Informationen, welche im Rahmen der CSRD eingeführt wird, kann zudem helfen, die Qualität der Offenlegung zu erhöhen.

3 Steuerungsrelevanz der Green Asset Ratio im Rahmen der Offenlegung nach der EU-Taxonomie-Verordnung

Abstract In diesem Beitrag diskutieren die Autoren die aktuelle Ausgestaltung der Offenlegung nach den Vorgaben der EU-Taxonomie-Verordnung für Kreditinstitute. Nach einer allgemeinen Übersicht zur Green Asset Ratio unterbreiten die Autoren basierend auf der quantitativen Offenlegung einer Stichprobe von Instituten konkrete Verbesserungsvorschläge. Dafür werden aktuelle politische Debattenbeiträge verschiedener Stakeholder einbezogen. Auf der Grundlage der Ergebnisse diskutieren die Autoren sodann die Steuerungsrelevanz der Green Asset Ratio.

Acknowledgments This chapter is adapted from my published paper "Steuerungsrelevanz der Green Asset Ratio im Rahmen der Offenlegung nach der EU-Taxonomie-Verordnung" in the WPg 2025. It was joint work with Dr. Constantin Muranaka from Horn & Company Gmbh.

3.1 Einleitung

Kreditinstitute spielen bei der Finanzierung nachhaltiger Wirtschaftstätigkeiten eine entscheidende Rolle, weshalb die Transformation ihrer Portfolios von großer Bedeutung ist. Da Kreditinstitute sowohl Ersteller als auch Nutzer der Taxonomie-Daten sind, sind sie für die Offenlegung nach Art. 8 der EU-Taxonomie-Verordnung in hohem Maße auf den Informationsfluss von ihren Gegenparteien angewiesen. Die Offenlegung hat zum Ziel, Transparenz über die Umwelt-Performance der Vermögengegenstände eines Kreditinstituts zu schaffen, um Greenwashing zu verhindern (Berens, 2023, S. 630; European Commission, 2021a, Frage 1, 2; Regulation (EU) 2020/852, Erwägungsgrund 5, 6; Weirich et al., 2022, S. 412).

Die Green Asset Ratio (GAR) als Metrik für die Taxonomie-Konformität des Bankportfolios ist definiert als Quotient der Taxonomie-konformen Aktiva und der „GAR Covered Assets“, also der Bilanzsumme des Instituts abzüglich bestimmter Posten. Konkret vom Nenner der Kennzahl ausgeschlossen sind solche Vermögengegenstände, deren Finanzierung in keinem Fall zu einer nachhaltigen Transformation der Wirtschaft beitragen kann oder für die derzeit keine geeignete Bewertungsmethode vorliegt. Konkret sind dies Geschäfte mit Staaten, Zentralbanken und supranationalen Emittenten sowie der Handelsbestand eines Kreditinstituts.

Um die Herausforderungen bei der Ermittlung der GAR sowie deren Steuerungsrelevanz zu untersuchen, fokussieren die Autoren sich im Folgenden auf eine Stichprobe deutscher Kreditinstitute und deren Offenlegung von Taxonomie-Kennzahlen. Ziel der Analyse ist es, die gängigen Kritikpunkte anhand konkreter Berichtsdaten zu belegen und Anpassungsmöglichkeiten ebenso wie die daraus resultierende Steuerungsrelevanz zu diskutieren.

3.2 Aktueller Diskussionsstand zur EU-Taxonomie

3.2.1 Überblick

Als Taxonomie-konforme Aktiva gelten alle Vermögengegenstände, die im Rahmen der Offenlegungsanforderungen nach Art. 8 der EU-Taxonomie-Verordnung und nach dem dabei einschlägigen Delegierten Rechtsakt (EU) 2021/2178 auf Taxonomie-Konformität überprüft werden können. Dabei werden nur Risikopositionen gegenüber Unternehmen berücksichtigt, die selbst einer nicht-finanziellen Berichterstattung nach der Non-Financial Reporting Directive (NFRD) bzw. – perspektivisch – nach der Corporate Sustainability Reporting

Directive (CSRD) unterliegen. Zusätzlich können gewisse Darlehen an lokale Gebietskörperschaften sowie Darlehen für Immobilien- bzw. Kfz-Finanzierungen an Haushalte auf Konformität geprüft werden.

Grundsätzlich ist für die Einwertung der Taxonomie-Konformität bei Instituten zwischen zwei Kategorien zu unterscheiden, und zwar

(1) verwendungszweckgebundene Finanzierungen und

(2) Finanzierungen ohne konkreten Verwendungszweck.

Bei Finanzierungen mit festem Verwendungszweck erfolgt eine Prüfung der Taxonomie-Konformität nach den Technischen Screening-Kriterien (TSC) durch das Institut. Dies ist beispielsweise bei Immobilienfinanzierungen der Fall: Hier sind die finanzierten Objekte unter anderem auf Taxonomie-Konformität für die Wirtschaftsaktivitäten „Neubau“ (Kategorie 7.1), „Renovierung“ (Kategorie 7.2) und „Erwerb“ (Kategorie 7.7) zu prüfen. Bei positiver Prüfung gilt der Bruttobuchwert der zugehörigen Darlehen als Taxonomie-konform.

Bei allgemeinen Finanzierungen erfolgt keine direkte Prüfung der TSC durch das Institut. Stattdessen werden die Taxonomie-KPIs (Key Performance Indicators) der Kontrahenten herangezogen und mit dem Buchwert multipliziert, um den Taxonomie-konformen Anteil der Finanzierung zu ermitteln. Ist der Kontrahent eine lokale Gebietskörperschaft oder ein privater Haushalt, muss die Finanzierung aufgrund fehlender Kontrahenten-KPIs als „nicht Taxonomie-konform“ eingestuft werden.

Unabhängig vom konkreten Verwendungszweck gehen derzeit alle Finanzierungen an nicht nach den Vorgaben der CSRD berichtspflichtige Kontrahenten nur in den Nenner der GAR ein. Das hat zur Folge, dass beispielsweise nachhaltige Finanzierungen gegenüber kleinen und mittelgroßen Unternehmen (KMU) nicht zur GAR beitragen können. Einzige Ausnahme sind Special Purpose Vehicles (SPVs), die nach den FAQ der EU-Kommission über den sogenannten Ultimate Beneficiary und bei Tochterunternehmen über CSRD-berichtspflichtige Gruppen einbezogen werden (European Commission, 2024, Frage 13, 14). Weitere Positionen im Nenner der GAR sind Derivate, kurzfristige Interbank-Kredite und sonstige Vermögengegenstände (unter anderem Sachanlagen und immaterielle Vermögengegenstände).

Institute legen darüber hinaus KPIs zum Abdeckungsgrad offen, und zwar:

- prozentualer Anteil der Erfassung (an den Gesamtaktiva);

- prozentualer Anteil der Vermögengegenstände, die nicht in den Zähler einbezogen werden;
- prozentualer Anteil der Vermögengegenstände, die nicht in den Nenner einbezogen werden.

3.2.2 Aktueller Marktüberblick zur Taxonomie-Offenlegung

In Abgrenzung zu anderen Studien, die häufig große Kreditinstitute in den Fokus stellen, wurden für die vorliegende Analyse solche Institute berücksichtigt, für die ein wesentlicher Anteil des Kreditportfolios aus Immobilienfinanzierungen besteht. Da diese Finanzierungen meist verwendungszweckgebunden sind, ist sichergestellt, dass die Stichprobe entsprechende Taxonomie-Bewertungen umfasst. In Bezug auf Immobilienfinanzierungen sind vor allem Sparkassen und Genossenschaftsbanken relevant, deren Bilanz häufig wesentlich von der Finanzierung von Immobiliendarlehen für Privatpersonen und KMU bestimmt ist. Des Weiteren enthält die Stichprobe einige auf die Immobilienfinanzierung spezialisierte Geschäfts- und Pfandbriefbanken.

Table 3.1 zeigt die acht Institute der Stichprobe und deren im Berichtsjahr 2023 offengelegten KPIs zur EU-Taxonomie.

Table 3.1: Kennzahlen zur Taxonomie-Offenlegung (Stichprobe)

(Angaben in Prozent)	GAR	GAR-Flow	Vom Zähler ausges-chlossene Geschäfte	Vom Nenner ausges-chlossene Ges-chäfte	Erfassung (Coverage)	Anteil Taxonomie-Konformität an Ta-xonomie-Fähigkeit (Conversion Rate)
Münchener Hypothekenbank	11,75	9,09	50,63	8,81	10,72	36,17
GLS Bank	0,20	–	61,89	8,06	0,18	6,61
Aareal Bank	0	0	82,41	11,25	88,75	3,42
BerlinHyp	0,44	2,75	68,05	6,85	25,10	2,16
Deutsche Pfandbriefbank pbb	0,24	0,13	68,17	18,16	0,20	10,49
Hamburger Sparkasse	0,27	0,58	50,94	9,48	0,25	4,72
Sparkasse Berlin	0,48	0,60	48,75	14,10	0,41	4,29
Sparda Bank Baden-Württemberg	0	–	2,15	2,84	97,16	0,34

Hinweise (1) GAR Flow repräsentiert die GAR ausschließlich für Neugeschäfte im Berichtsjahr. (2) Nicht alle Institute haben für das Berichtsjahr 2023 den GAR-Flow ausgewiesen. Das liegt neben der kurzfristigen Veröffentlichung der FAQ der EU-Kommission zu den GAR-Flows zumeist daran, dass Institute systemseitig im Berichtswesen nur schwer die geforderte Definition für Neugeschäfte überprüfen können. (2) GAR und GAR-Flow basieren auf dem Umsatz. Kreditinstitute veröffentlichen GAR und GAR-Flow jeweils basierend auf Umsatz und Investitionsausgaben.

An den Regelungen zur Ermittlung der GAR gibt es vermehrt Kritik, die jüngst in Verbesserungsvorschlägen der EU Platform on Sustainable Finance (2025c, 2025b, 2025a) und in

Änderungen gemäß den Omnibus-Vorschlägen der EU-Kommission zur Reform der Nachhaltigkeitsberichterstattung (Commission Delegated Regulation (EU) 2021/2139; Commission Delegated Regulation (EU) 2021/2178; Commission Delegated Regulation (EU) 2023/2486) adressiert wurden. Im Folgenden zu diskutieren sind die zentralen Kritikpunkte an der GAR und wie sich diese in der Stichprobe niederschlagen. Dabei geht es vor allem um die Steuerungsrelevanz der GAR für deutsche Kreditinstitute.

3.3 Kritik an der Green Asset Ratio

3.3.1 Transparenz und Vergleichbarkeit

Die Befunde der Stichprobe bestätigen die Schwierigkeiten, die Institute bei der Umsetzung der Taxonomie-Bewertung haben. Die GAR der Stichprobe liegen für die meisten Institute unter einem Prozent. Mit anderen Worten: weniger als ein Prozent des zu bewertenden Geschäfts kann nachweisbar als Taxonomie-konform klassifiziert werden. Über die verbleibenden 99 Prozent kann keine Aussage getroffen werden. Dabei könnte es sich um die Finanzierung von umweltschädlichem Geschäft handeln oder um Geschäfte, die nur einen geringen Einfluss auf Umweltziele haben. Es könnte sich aber auch um nachhaltige Finanzierungen handeln, die mangels verfügbarer Daten nicht als solche ausgewiesen werden können. Transparenz für Stakeholder und Vergleichbarkeit der Institute sind damit beschränkt. Verglichen mit dem Bestandsgeschäft wäre für das Neugeschäft eine bessere Datenverfügbarkeit und damit eine höhere Taxonomie-Konformität zu erwarten. Allerdings bestätigte sich diese Vermutung in den veröffentlichten GAR-Flows der ausgewählten Institute nur zum Teil.

3.3.2 Hohe Anforderungen an die Prüfung der Taxonomie-Konformität

Bei Finanzierungen mit festem Verwendungszweck im Sinne der EU-Taxonomie-Verordnung erfolgt eine Prüfung der Taxonomie-Konformität auf der Basis der TSC für die zugrunde liegende Wirtschaftsaktivität. Diese Prüfung ist üblicherweise deutlich aufwändiger als die Ermittlung der Taxonomie-Konformität allgemeiner Finanzierungen anhand von Kontrahenten-KPIs. In der Praxis zeigt sich, dass aufgrund der hohen Anforderungen der TSC – Beispiele: Überprüfung des DNSH-Kriteriums (Do No Significant Harm), Minimum Social Safeguards, fehlende Datenverfügbarkeit, nicht zulässige Verwendung von Schätzwerten – eine positive Prüfung der Taxonomie-Konformität häufig auch bei eigentlich nachhaltigen Finanzierungen aufgrund der begrenzten Datenlage nur schwer möglich ist.

Die Komplexität der Kriterien spiegelt sich in der Conversion Rate der Stichprobe wider, also im Anteil der Taxonomie-Konformität an der Taxonomie-Fähigkeit. Der Vorteil der Conversion Rate im Vergleich zur GAR ist, dass im Zähler der GAR nicht berücksichtigte Kontrahenten und Produkte den Wert der Conversion Rate nicht verzerren. Damit liefert diese Kennzahl Aussagen darüber, für welche Geschäfte eine erfolgreiche Prüfung der Taxonomie-Konformität durchgeführt werden konnte. Gleichwohl liegt die Conversion Rate in der Stichprobe nur zwischen etwa 0,3 und 10,5 Prozent (mit einem Ausreißer von rund 36 Prozent). Damit erfüllen etwa 90 bis 99 Prozent der Taxonomie-fähigen Aktiva die ambitionierten Kriterien der TSC nicht nachweisbar.

Vereinfachungen in der Bewertung – beispielsweise die Akzeptanz bestimmter Zertifikate für den Nachweis einzelner TSC – könnten sich bereits stark auf die ausgewiesenen Konformitätszahlen auswirken. Die Abschaffung der DNSH-Kriterien oder der sozialen Mindeststandards ist aus regulatorischer Sicht aber nicht vorgesehen. Auch könnte die Verwendung von Schätzungen oder Näherungswerten (Proxies) die Prüfung der hohen Anforderungen der TSC erleichtern. Vor allem bei Immobilienfinanzierungen wären Schätzungen zu physischen Risiken im Rahmen der DNSH-Prüfung mittels Geo-Referenzierung denkbar; diese könnten von externen Anbietern bereits zur Verfügung gestellt werden.[6] Schätzungen wären vor allem für das Bestandsgeschäft und alte Gebäude sinnvoll, für die keine Energieausweise vorliegen. Allerdings beeinträchtigt der Informationsgewinn die Vergleichbarkeit und erhöht Greenwashing-Risiken, die ohne standardisierte und einheitliche Vorgaben entstehen. Entsprechende Standards könnten die Anwendung also vereinheitlichen.

3.3.3 Einschränkung auf CSRD-berichtspflichtige Kontrahenten

Mehr Informationen über finanzierte Geschäfte bergen die weiteren veröffentlichten KPIs. Dabei fällt auf, dass vom GAR-Zähler ausgeschlossene Geschäfte bei nahezu allen Instituten einen Anteil von etwa 50 bis 80 Prozent an den Vermögensgegenständen haben. Dabei handelt es sich vor allem um KMU, die aufgrund ihrer Größe keinen Nachhaltigkeitsbericht erstellen müssen. Könnten diese Finanzierungen in die Taxonomie-Bewertung eingehen, böten sich den Instituten Spielräume, ihre GAR erheblich zu steigern.

Obwohl die Einschränkung auf CSRD-berichtspflichtige Kontrahenten bei allgemeinen Finanzierungen aufgrund der anderenfalls fehlenden Kontrahenten-KPIs nachvollziehbar ist,

[6] Beispielsweise entwickelt SkenData digitale Lösungen zur Berechnung von Gebäuderisiken und Gebäudeenergiebedarfen.

ist sie für verwendungszweckgebundene Finanzierungen in Frage zu stellen. Häufig ist zum Beispiel bei der Finanzierung größerer Immobilienprojekte der Kontrahent zwar nicht CSRD-berichtspflichtig, verfügt aber aufgrund umfangreicher gebäude- und energieregulatorischer Vorgaben gleichwohl über die für die Prüfung der Taxonomie-Konformität erforderlichen Daten. In solchen Fällen beeinträchtigt die Einschränkung des GAR-Zählers eine genauere Darstellung der Taxonomie-Konformität des Bankportfolios. Entfiele diese Einschränkung, wären Institute flexibler und in der Lage, auch KMU-Finanzierungen als Taxonomie-konform auszuweisen. Nachteile entstünden daraus nicht, da die Geschäfte bei fehlenden Informationen weiterhin nur in den Nenner der GAR eingehen.

Mit Annahme der von der EU-Kommission vorgelegten Omnibus-Vorschläge würde sich die Zahl der CSRD-berichtspflichtigen Unternehmen weiter verringern und damit den Zähler der GAR einschränken. Zudem sehen die Omnibus-Vorschläge durch Anpassung des jeweiligen Anwendungskreises eine weitere Kategorie an Unternehmen vor, die zwar CSRD-, aber nicht Taxonomie-berichtspflichtig wären. Geschäfte mit diesen Kontrahenten würden demnach im Zähler der GAR berücksichtigt. Indes dürfte sich die Prüfung der Taxonomie-Konformität weiter erschweren, da der Kontrahent keiner verpflichtenden Taxonomie-Offenlegung unterliegt.

Ein Sonderfall in der Berücksichtigung nicht CSRD-berichtspflichtiger Kontrahenten sind Tochterunternehmen und SPVs. Nach den FAQ der EU-Kommission sind für die Berücksichtigung von Tochterunternehmen im Rahmen der GAR zwei Fälle zu unterscheiden:

1. CSRD-berichtspflichtige Tochterunternehmen, die von der Befreiung der Berichtspflicht über den Konzernabschluss nach Art. 19a Abs. 9 der CSRD Gebrauch machen[7];

2. Tochterunternehmen, die nicht unter die CSRD-Berichtspflicht fallen, aber in den Konzernabschluss eines berichtspflichtigen Unternehmens einbezogen werden.

Die Frage 13 in den FAQ der EU-Kommission (2024) liefern zwar Hinweise zu Möglichkeiten der Berücksichtigung, allerdings werden in der Berichtspraxis verschiedene Auslegungen diskutiert. Diese reichen von der Einbeziehung des Tochterunternehmens über die Konzern-KPIs bis zu seinem Ausschluss.

Für SPVs, die vom Zähler der GAR zunächst ausgeschlossen waren, konkretisiert die EU-Kommission (2024) in Frage 14 ihrer FAQ nun die Möglichkeit ihrer Berücksichtigung über

[7] Bis die CSRD in deutsches Recht umgesetzt worden ist, gilt die Umsetzung der Bilanzrichtlinie nach Maßgabe von § 289b Abs. 2 Satz 1 HGB.

den „Ultimate Beneficiary“ des SPV. Allerdings wird dies weder in den FAQ noch in den regulatorischen Vorgaben für Institute weiter definiert, sodass unklar bleibt, auf welches Unternehmen abzustellen ist.

Um die Berichtsdaten zu verbessern, bedarf es für die genannten Kontrahentengruppen konkreter und umsetzbarer Vorgaben ohne Interpretationsspielräume. Vor allem bei SPVs erscheint eine Berücksichtigung im Zähler der GAR wünschenswert, da SPVs aufgrund ihrer zentralen Rolle für eine nachhaltige Transformation der Wirtschaft – etwa bei der Finanzierung nachhaltiger Projekte oder größerer Immobilienvorhaben – regelmäßig eingesetzt werden.

3.3.4 Definition des Nenners der GAR

Die Definition der GAR enthält derzeit eine interne Obergrenze der KPIs auf der Basis des Geschäftsmodells des Instituts, da nicht alle Elemente des Nenners Taxonomie-konform sein können. Mit Ausschluss des Handelsbestands und der Staatsfinanzierungen aus dem Nenner der GAR wird bereits zugestanden, dass sich für bestimmte Aktiva das unternehmerische Handeln des Instituts nicht auf die nachhaltige Transformation der Kontrahenten auswirkt. Das betrifft in der Stichprobe etwa 3 bis 18 Prozent der gesamten Vermögengegenstände.

Auch nach den Omnibus-Vorschlägen enthält der Nenner der GAR beispielsweise mit Sachanlagen, immateriellen Vermögenswerten und Steuerschulden weiterhin Posten, die keine Auswirkung auf die Nachhaltigkeit des Bankportfolios haben. Sie sollten ebenfalls aus dem Nenner ausgeschlossen werden.

Für die Finanzierung regionaler Gebietskörperschaften (vor allem ohne festen Verwendungszweck der Finanzierung) ist fraglich, ob das Institut eine Auswirkung auf das Handeln des Kontrahenten erzeugen kann (etwa bei Anleihen der Bundesländer). Solche Geschäfte waren nach der Auslegung in der IDW Arbeitshilfe zu Art. 8 der EU-Taxonomie-Verordnung (IDW, 2023, Frage 3.2.2.3) analog zu Staatsanleihen vom Nenner ausgeschlossen. Nach ganz überwiegender Auffassung haben die FAQ der EU-Kommission (2024) dies in Frage 14 revidiert.

Zähler und Nenner der GAR sollten so konstruiert sein, dass ein Institut eine GAR von 100 Prozent erreichen kann, sofern es nur Taxonomie-konforme Vermögengegenstände finanziert und darin investiert. Wird die Kennzahl durch den Ausschluss von Produkten und Kontrahenten verzerrt, ist ihre Transparenz in Bezug auf die Umwelt-Performance des Instituts erheblich begrenzt. Diese Einschränkung betrifft wegen der starken Abhängigkeit der GAR vom Geschäftsmodell des Instituts auch die Vergleichbarkeit zwischen Instituten.

3.3.5 Regulatorische Unsicherheit

Die tatsächlich in der Taxonomie-Bewertung zu berücksichtigenden Vermögengegenstände sollen sich in der Coverage widerspiegeln. Allerdings weist diese Kennzahl in der Stichprobe eine hohe Schwankung zwischen 0,18 Prozent und 88,75 Prozent auf. Dies hängt unter anderem mit ihrer Berechnung zusammen. Beispielsweise existieren unterschiedliche Auslegungen, welche Vermögengegenstände im Nenner zu berücksichtigen sind. Damit wird die Vergleichbarkeit und Aussagekraft der Kennzahl erheblich begrenzt. Die größte Aussagekraft hat sie unseres Erachtens als Anteil der in der Taxonomie-Bewertung zu berücksichtigenden Vermögengegenstände an der Bilanzsumme.

Nach Veröffentlichung der ersten Delegierten Verordnung zu Art. 8 der Taxonomie-Verordnung wurden die regulatorischen Vorgaben zwischenzeitlich angepasst, zuletzt vorschlagsweise durch das Omnibus-Paket für die Nachhaltigkeitsberichterstattung. Dies stellt berichtspflichtige Unternehmen zunehmend vor praktische Herausforderungen, da nicht transparent ist, welche Anforderungen zu welchem Zeitpunkt konkret umzusetzen sein werden. Zum Teil ergeben sich wechselnde Anforderungen zwischen zwei Berichtsstichtagen, die Institute nach der Abschlussprüfung häufig nicht mehr konsistent in den Berichtsstrecken umsetzen können. Dies erschwert die Planbarkeit der GAR und mindert die Steuerungsrelevanz der KPIs.

3.3.6 Steuerungsrelevanz der Green Asset Ratio

Laut EU-Kommission hat die Taxonomie-Offenlegung der Institute und damit die GAR das Ziel, Transparenz über die Umwelt-Performance der Vermögengegenstände von Instituten zu schaffen. Dass diese Performance nicht transparent und zwischen Instituten vergleichbar ist, zeigt das Beispiel der Stichprobe. Nicht hinreichend standardisierte Vorgaben können Greenwashing-Risiken erhöhen und die Steuerungsrelevanz der GAR in Frage stellen.

Die einheitliche Sprache und Standardisierung der EU-Taxonomie ist grundsätzlich eine geeignete Basis für steuerungsrelevante Kennzahlen über die Nachhaltigkeit eines Institutsportfolios. Die GAR deckt – anders als andere KPIs wie etwa die finanzierten CO_2-Emissionen – übergreifend alle Umweltziele ab und liefert vor allem im Zusammenspiel mit den Vorgaben der CSRD einen Beitrag zu einer höheren Transparenz. Die Berücksichtigung der Wechselwirkungen zwischen Umweltzielen über DNSH-Kriterien und soziale Mindeststandards trägt hinaus der für ESG-Themen so relevanten „Rundum-Perspektive“ angemessen Rechnung.

3.4 Ausblick

Perspektivisch denkbar sind beispielsweise folgende Maßnahmen zur Integration der GAR in die Controlling-Prozesse der Institute:

- Einbeziehung in die Geschäfts- und Risikostrategie,
- Berücksichtigung in Kreditvergabekriterien und -richtlinien,
- Berücksichtigung als Frühwarnindikator im sogenannten Risikoappetit.

Fraglich ist, ob die Omnibus-Vorschläge der EU-Kommission den aktuellen Herausforderungen im Rahmen der Taxonomie-Offenlegung gerecht werden. Allerdings gibt es durchaus Ansätze zur konzeptionellen Verbesserung der GAR im Hinblick auf Transparenz und Vergleichbarkeit. Zentral ist dabei eine nachvollziehbare Normierung der GAR ohne institutsindividuelle Obergrenze. Eine transparente Darstellung der Nachhaltigkeit des Portfolios ist nur dann möglich, wenn eine GAR von 100 Prozent aussagt, dass alle Taxonomie-fähigen Vermögensgegenstände auch tatsächlich Taxonomie-konform sind.

Zur Verbesserung der Datenqualität müssen Institute ihre Prozesse mit dem Ziel der Erhebung relevanter Informationen weiter optimieren. Hilfreich wäre zudem, ließe der Gesetzgeber bestehende Zertifikate vor allem für die Bewertung finanzierter Immobilien zur Prüfung der Taxonomie-Konformität zu.

Schließlich bedarf es regulatorischer Sicherheit, wenn Institute die Anforderungen an die GAR eindeutig umsetzen sollen. Erst dann können sie auf die GAR als Steuerungsgröße im ESG-Kontext zurückgreifen.

4 Taxonomy Disclosure in the EU – A Useful Framework, Despite Current Challenges

Abstract The EU Taxonomy is a classification system for sustainable economic activities and a framework for various regulatory initiatives. Its primary objectives are to enhance transparency, to reduce greenwashing and ultimately to redirect capital toward more sustainable activities. However, since its introduction, market participants have raised concerns about whether the benefits justify the costs. This article examines current challenges, such as the initial implementation costs, data gaps, sector and counterparty coverage, while also highlighting opportunities like enhanced international competitiveness and improved ESG risk management. The focus of this article is on banks as both preparers and users of Taxonomy data, addressing issues related to Taxonomy eligibility, alignment, and the Green Asset Ratio. The article concludes with recommendations for policy makers and authorities to improve the effectiveness of the Taxonomy disclosure.

Acknowledgments This chapter is adapted from my published paper "Taxonomy Disclosure in the EU – a useful framework, despite current challenges" in The Economists' Voice 2025. It was joint work with Dr. Franziska Schütze from the German Institute for Economic Research (DIW).

4.1 Introduction

Within the context of the EU Green Deal objectives, the EU requires a systematic reorientation of capital flows towards a sustainable economy. To achieve this transition, the market called for a standardised definition of sustainability. The EU Taxonomy is a classification system defining sustainable economic activities and provides a framework for other regulatory initiatives. Article 8 of the Taxonomy Regulation (Regulation (EU) 2020/852) the required annual reporting of quantitative and qualitative information on the sustainability of the undertaking's economic activities (Commission Delegated Regulation (EU) 2021/2178, art. 8). According to the European Commission, the objective of the Taxonomy disclosure is to create transparency, diminish greenwashing and reduce associated reputational risks for financial institutions (Commission Delegated Regulation C(2025) 4568; Regulation (EU) 2020/852, Recital 5, 6; European Commission, 2021b, Question 1, 2). The implementation of disclosure requirements are supposed to spark environmental and social benefits following the shift of capital flows toward more sustainable activities (European Commission, 2021b, Question 2; Regulation (EU) 2020/852, Recital 5, 6). The Taxonomy disclosure applies to large EU corporations and financial institutions, requiring them to assess to what extent their economic activities meet Technical Screening Criteria (TSC). In this context, institutions assess whether their assets substantially contribute to one of the six environmental objectives, do not significantly harm others (DNSH criteria), and comply with Minimum Social Safeguards.

In the context of current political discussions on deregulation and bureaucracy, the European Commission has adopted a set of proposals to simplify sustainability disclosures and boost competitiveness, called the Omnibus-initiative. It covers simplifications in the disclosure according to the EU Taxonomy, Corporate Sustainability Reporting Directive (CSRD) and Corporate Sustainability Due Diligence Directive (CSDDD)[8]. In particular, the modifications in the proposals on the Taxonomy Disclosure and the CSRD reduce the scope of applicants by around 80% and the number of data points to be reported, along with a delayed directive application. Next steps for the Omnibus-initiative are the review and approval of the European Parliament and the Council. The Commission requested to fast-track the review, yet, an agreement for all proposals are not expected before the end of 2025

[8] Financial institutions are not directly applicable to the CSDDD.

(Commission Delegated Regulation C(2025) 4568; European Commission, 2025). In a first vote on April 4th, the Parliament approved the delayed application of sustainability reporting, confirming the current efforts to soften mandatory regulation (European Parliament, 2025).

This article focuses on banks' perspective regarding Taxonomy disclosure. As banks are both preparers and users of Taxonomy data, they are highly dependent on the flow of information from their counterparties. Banks disclose to what extent their assets are covered by the EU Taxonomy (Taxonomy eligibility) and the share of assets meeting TSC (Taxonomy alignment) in their Green Asset Ratio (GAR). Given that most banks assess and disclose their contribution toward climate objectives (climate change mitigation and adaptation), our article focuses on these, leaving other environmental and social objectives to future research.

Despite authorities' efforts to provide a structured framework, financial market participants question whether Taxonomy disclosure meets its objectives. The initial years of implementation resulted in numerous studies, that highlight the significant challenges facing banks, such as the cost of implementation, sector coverage, and data gaps, leading to low values of GAR. However, Taxonomy disclosure also presents opportunities for banks, such as international competitiveness and improved ESG risk management. This article discusses both challenges and opportunities of Taxonomy disclosure, concluding with recommendations for policy makers and authorities to improve its effectiveness for banks.

4.2 Challenges of the Taxonomy Disclosure

4.2.1 Initial costs of implementation

In the first years of reporting, banks must ensure regulatory compliance. The implementation requires employee training, collection of (historical) sustainability data of the counterparty and the financed economic activity for new and the stock of relevant financing and investments, as well as adjustments to reporting processes and IT systems. Moreover, it requires constant screening of regulatory updates from authorities. The initial cost of implementation entails a large investment for the first years of reporting. However, just like with other regulatory initiatives, the costly initial implementation will be followed by declining costs, mostly consisting of monitoring and recurring adjustments of processes (Hoskins & Labonte, 2015, p. 2; Sathye, 2008, pp. 348–354).

If proposed simplifications on Taxonomy disclosure in the context of the Omnibus-initiative are approved by the Parliament and the Council, many banks and companies currently disclosing under the EU Taxonomy will no longer be required to do so. Thus, unless they choose to report voluntarily, their costs for Taxonomy disclosure drop.

4.2.2 Regulatory uncertainty

Despite the efforts of authorities, the implementation of Taxonomy disclosure is associated with challenges. Several Delegated Acts were complemented by FAQ documents which specify regulatory requirements for the sustainability assessment. Since the requirements are not consolidated in a Delegated Act, credit institutions are required to scan hundreds of FAQs - assessing their relevance – thus driving up costs. Moreover, their publication has triggered uncertainty among applying banks due to inaccuracies in the regulatory requirements. For example, the Commission published FAQs outlining approaches to include subsidiaries in the taxonomy assessment, based on whether they fall under CSRD requirements or are covered by group reporting. However, interpretations vary in practice, with some corporations excluding subsidiaries entirely and others using group Key Performance Indicators (KPIs) for evaluation. Consequently, results are not easily comparable between institutions and transparency is limited.

The Omnibus-initiative further adds uncertainty for banks.[9] The proposal's legislative process will take months, creating further uncertainty about its scope and requirements. If adopted, it would ease GAR disclosure for most banks. However, banks still face the strict criteria under Pillar 3 reporting according to Art. 449a CRR III (Regulation (EU) 2024/1623). Unless the EBA aligns its final Implementing Technical Standards (ITS) with the proposal or removes Taxonomy disclosure from Pillar 3, credit institutions will still face strict requirements and demand sustainability data from companies.

Regulatory uncertainty often prompts banks to adopt a conservative approach to avoid (accusations of) greenwashing as it is associated with reputational risks (EBA, 2023, p. 33). However, this approach might underestimate the overall Taxonomy alignment of assets (Alessi & Battiston, 2022).

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[9] According to the proposal, financial institutions who do not exceed an average of 1000 employees during the financial year and a net turnover of 450 million euros, are not mandatorily obliged to provide a Taxonomy disclosure.

4.2.3 Lack of data availability and quality

Financial institutions face challenges in meeting EU Taxonomy requirements due to limited data availability and quality. Assessing taxonomy eligibility and alignment requires access to historical and high-quality data on counterparties and activities, which is often missing from portfolios. Limited availability of data restricts the validity of current assessments and distorts results, which consequently influences the value of the GAR. This, in turn, hinders transparency and comparability between credit institutions.[10]

The EU Commission stipulates that data must be obtained directly from counterparties, while the use of proxies and estimates is prohibited. While the use of proxies could lead to increased greenwashing risks and reduced comparability, allowing them could enhance coverage and transparency (if underlying assumptions are made transparent). The European Commission plans to introduce the European Single Access Point as a central register for corporate, financial, and sustainability information. However, its implementation has been delayed until 2027, when data is urgently required today (Regulation (EU) 2023/2859).

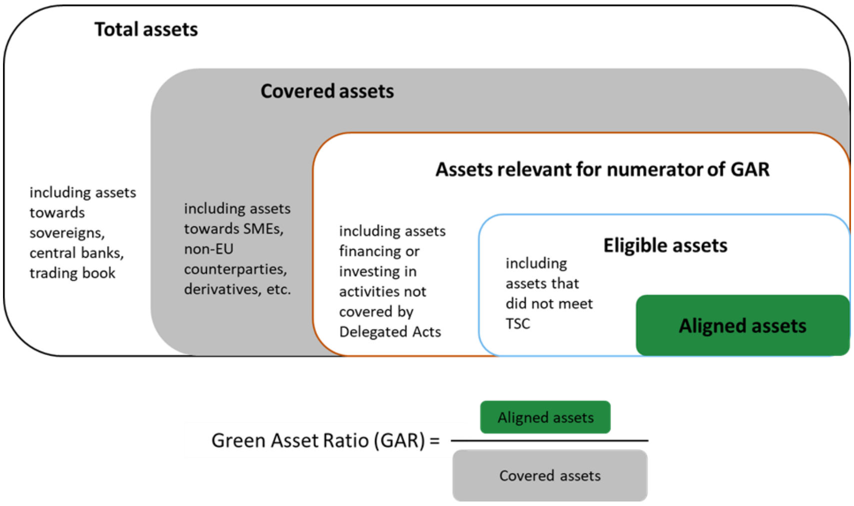
With the extension of corporations applicable to the CSRD in the next years, more corporations are expected to disclose sustainability information. However, the suggestions in the Omnibus-initiative slow down this progress by reducing the scope of applicants and extending the adoption period, thereby aggravating the availability of sustainability data (Commission Delegated Regulation C(2025) 4568).

4.2.4 Sector and counterparty coverage

Another key challenge of the Taxonomy is its limited sector coverage which influences the value of the GAR, as illustrated in Figure 1. The Delegated Acts cover those economic activities in sectors most harming the environmental objectives which can be transformed, e.g. they cover economic activities responsible for about 80% of GHG emissions in the EU.

[10] A study on published KPIs by PWC (2024) provides an example of the influence of available data. It found significantly higher GARs for banks in the Netherlands. As property financings make up a significant part of the bank portfolio, the authors assume that this is because EPC ratings are publicly available in the Netherlands.

Figure 4.1: Composition of the Green Asset Ratio (GAR)



According to banks' disclosures, the share of taxonomy aligned assets compared to covered assets is low, leading to GAR's of about 2% for large banks (CRIF, 2024; EY, 2024; PWC, 2024). Currently, this share has little informative value with regards to the potential climate change effect of non-eligible activities or assets, as there is no further distinction. They could either be brown, low-emission (e.g. education, research and other services), transition, or green activities, with insufficient data for the classification. Companies in a low-emission sector can still influence their indirect emissions in the value chain or they can offer products that reduce emissions further down the value chain (Möllers, 2022). Furthermore, disregarding transition-related activities in the EU Taxonomy can result in a disadvantage for banks financing transition activities. Thereby, the Taxonomy may overlook key sectors of the economy that are required for the transformation. However, setting thresholds too low could lead to carbon lock-in, where fossil fuel-based infrastructure and high-emission technologies persist for decades (Schütze & Stede, 2021; Zetzsche & Bodellini, 2024).

The term "transition finance" has been used and discussed by academia (Boissinot et al., 2016; Caldecott, 2022) and practitioners in sustainable finance but there is no commonly accepted definition in the literature. Some examples of international taxonomies show possible solutions. (Marchewitz et al., 2025) provides an in-depth discussion on transition elements in international taxonomies. Like the suggestion by the EU Platform on Sustainable Finance (Platform on Sustainable Finance, 2022b) some international taxonomies, especially the ASEAN taxonomies, already define a transition (or "amber") taxonomy next to the green taxonomy.[11] This category usually has less stringent thresholds but is only valid for a certain

[11] See ASEAN Taxonomy at: https://asean.org/book/asean-taxonomy-for-sustainable-finance-version-3/

timeframe. For example, the Singapore taxonomy requires companies to meet the criteria for the green category by 2040 at the latest and to have a transition plan that is compatible with the Paris Agreement.[12]

In addition to sectors, the counterparty coverage of the EU Taxonomy is also limited. Counterparties that do not have to disclose sustainability information according to the CSRD are excluded from the taxonomy assessment. Therefore, exposures towards both small and medium sized companies (SMEs) and companies that are not located in the EU cannot be taxonomy aligned. This does significantly influence the value of the GAR, as SMEs make up a large portion of corporations in the EU. Moreover, sustainable projects for example, renewable energy producers are often SMEs, yet banks cannot include these potentially taxonomy aligned activities in their GAR.[13] This problem would be exacerbated by the proposed amendments of the Omnibus-initiative, excluding corporations with fewer than 1000 employees (compared to 250 employees in the current version of the CSRD).

4.3 Opportunities of the Taxonomy Disclosure

Despite the challenges in the design of the Taxonomy disclosure and the GAR, the implementation of the regulation comes with opportunities.

4.3.1 Obtaining a competitive advantage

A clear opportunity is the early development of the EU Taxonomy, which has led the EU to become a standard setter internationally. By the end of 2023, a total of 25 taxonomies in different countries or regions have been published or adopted (Marchewitz et al., 2024).[14] Several use the EU Taxonomy as a main reference. For example, the Taxonomies of the ASEAN countries align their Technical Screening Criteria and emission thresholds with the EU Taxonomy. Because of companies trading globally and the development of several international taxonomies, it is necessary to harmonize the different frameworks, allowing for applicants of the EU Taxonomy to include non-EU green assets. This could be a competitive

[12] See Singapore Taxonomy at: https://www.mas.gov.sg/-/media/mas-media-library/development/sustainable-finance/singaporeasia-taxonomy-dec-2023.pdf

[13] For example, special purpose vehicles (SPVs), often used for renewable energy or infrastructure projects, are not directly considered in the GAR. This problem is addressed in the FAQs. However, open questions in practical implementation remain.

[14] However, some important financial markets, such as the United States, are currently not planning to develop or implement a Sustainable Finance Taxonomy.

advantage for EU companies with a high share of exports or non-EU investments, improving their share of green assets.

Despite its challenges and design limitations, the GAR remains the most advanced sustainability metric disclosed by banks, covering multiple environmental objectives. Allowing banks to define their own sustainability metrics or having different voluntary industry standards instead, would reduce comparability and transparency. Moreover, if the KPI and related goals are integrated in banks' strategy, disclosing the GAR could offer a strategic advantage by enhancing growth, profitability, and value amid evolving customer expectations.

4.3.2 Contribution to ESG Risk Management

Taxonomy disclosure requires banks to assess their portfolio and classify assets accordingly. The Taxonomy assessment requires banks to analyse ESG risks associated with their financed activities and counterparties. Hence, it has become an important element of more standardised ESG risk disclosure and provides a useful foundation for the management of ESG risks.

ESG risks can impact institutions' assets through transitional and physical risk drivers, which are addressed by the EU Taxonomy either through the substantial contribution or through do no significant harm (DNSH) criteria. Climate change and related physical risks are seen as important risk factors with implications on economic output and prices.[15] These costly events, in turn, might require a sudden and faster transition leading to transition risks, which leave the market with less time to adapt.

Transition and physical risks in the portfolio translate to traditional risk categories, which should be mitigated and managed. This is necessary to ensure resilience of the institution's business model in the short, medium and long-term (EBA, 2025, p. 4) as well as to promote the transition to a more sustainable economy. According to the ECB supervisory board vice-chair Frank Elderson, current political developments on deregulation might even risk long-term financial stability (M. Arnold, 2025).

[15] For example, Pankratz and Schiller (2024) find that weather shocks, like extreme heat and floods, harm suppliers' financial performance, which is passed on to customers through supply chains and De Winne and Peersman (2021) report that extreme weather events, like droughts and heatwaves, affect global agricultural commodity prices and economic activity.

4.3.3 Lower bureaucratic burden

As previously discussed, a key limitation of the Taxonomy is its exclusion of low-emission sectors and those with minimal transformation potential. However, it is also an opportunity. The EU Taxonomy was designed to define economic activities that can contribute to the transition of the economy, rather than to encompass a catalogue of all sectors, including low-emission ones. Despite the challenges that come with limited coverage, this approach reduces reporting requirements for banks (and counterparties), as they are not obliged to assess and disclose the taxonomy-eligibility and alignment of all assets.

4.4 Recommendations for policy makers and authorities

Regulatory requirements should be clear and existing gaps must be addressed. To minimize contradictory statements and reduce the effort required for applicants to implement regulations accurately, numerous FAQs should be consolidated with Delegated Acts.

Large amounts of exposures of banks are toward non-CSRD corporations (especially SMEs) that cannot count toward taxonomy-alignment, thereby limiting the value of the GAR that a bank can achieve. The suggestion by the Omnibus-initiative to exclude around 80% of companies from the scope of the CSRD aggravates this data challenge. A solution should be found to assess the sustainability of those exposures, e.g. based on proxies and estimates or simplified standards for SMEs.

Furthermore, to address currently uncovered activities and to avoid misperceptions of these, a crucial step in further development is distinguishing between harmful and non-harmful activities, as well as those with significant supply chain emissions. To address the limited coverage of sectors in the GAR, one proposal is to disclose taxonomy-aligned as a share of taxonomy-eligible assets instead of covered assets.

Furthermore, a clear definition of transition activities is needed and the reporting of an additional KPI covering transition activities should be established. The definition needs to strike a balance between including more transition-relevant activities without leading to long-term carbon lock-in.

Limited data availability and quality is currently hindering progress in assessing assets' contributions to environmental objectives based on complex TSC. Access to corporate sustainability data is urgently needed and public databases could help address this gap. Given that real estate financing constitutes a significant share of credit institutions' portfolios, market participants could greatly benefit from EU wide public databases for EPC labels. It is necessary to reduce the complexity of disclosure requirements, however, a narrower scope of applicants disclosing sustainability information, as suggested in the Omnibus-initiative, is going to aggravate the data challenge.

The EU should continue to play an active role in the development and harmonization of Taxonomies internationally. There is large interest from emerging and developing economies to develop Taxonomies to attract foreign investment and to diversify the investor base. Many Asian, African and South America jurisdictions have developed or are developing taxonomies. It will help to create a level-playing field for companies and financial institutions with international portfolios.

To conclude, there are several challenges in the development and implementation of the EU Taxonomy, impacting the informative value of the GAR. Yet, improving climate and sustainability related transparency for all stakeholders is an important complement to climate policy instruments (e.g. CO_2 price, subsidies, environmental standards or other climate regulation). Therefore, the EU Taxonomy plays an important role in an effective policy mix. Banks can tailor their financial instruments and products based on a common definition, while also improve their risk management. The Omnibus-initiative presents an opportunity for authorities to address regulatory shortcomings. However, current proposals focus on reducing the regulatory burden, mainly by weakening the coverage of the Taxonomy and, hence, the informative value of resulting KPIs.

While ESG regulation being softened globally, the current anti-ESG developments in the US are likely to influence companies and authorities in the EU. However, ESG risks in banks' portfolios will persist, requiring long-term portfolio transformation to mitigate these risks. The recommendations provided in this article aim to improve the implementation for banks, enhancing transparency and comparability while mitigating greenwashing, thereby contributing to the initial targets of the EU Taxonomy.

5 Überarbeitung der EU-Taxonomie: Auswirkungen auf Kreditinstitute

Abstract Die Nachhaltigkeitsberichterstattung steht unter politischem Druck. Dies hat die EU-Kommission zur Veröffentlichung ihrer Omnibus-Vorschläge und insoweit auch zu einer Anpassung der EU-Taxonomie veranlasst. Ziel der Kommissionspläne ist es, die Nachhaltigkeitsberichterstattung zu vereinfachen, Bürokratie abzubauen und die Wettbewerbsfähigkeit der Unternehmen zu stärken. Dieser Beitrag analysiert die Anpassung der EU-Taxonomie durch die Delegierte Verordnung C(2025) 4568 final vom 04.07.2025 und ihre Folgen vor allem für KreditFinanzinstitute. Insgesamt tragen die Neuerungen dazu bei, die Anwendbarkeit der Taxonomie-KPI zu verbessern. Nach wie vor bestehen für die praktische Umsetzung aber konkretisierungsbedürftige Auslegungsspielräume.

Acknowledgments This chapter is adapted from my published paper "Überarbeitung der EU-Taxonomie: Auswirkungen auf Kreditinstitute" in the WPg 2025. It was joint work with Dr. Constantin Muranaka from Horn & Company Gmbh.

5.1 Einleitung

Die Taxonomie-Verordnung (EU) 2020/852 steht als Herzstück der europäischen ESG-Regulatorik zunehmend im Zentrum politischer Auseinandersetzungen um die Nachhaltigkeitsberichterstattung.[16] Vorallem die Anti-ESG-Bewegung in den USA hat die Debatte um regulatorische Anforderungen und deren wirtschaftliche Folgen neu entfacht. Auch in der EU mehren sich Stimmen, die vor einer Überregulierung und einem daraus resultierenden Wettbewerbsnachteil für europäische Unternehmen warnen. Vor diesem Hintergrund hat die EU-Kommission im Februar 2025 das sogenannte Omnibus-Paket zur Konsultation gestellt (European Commission, 2025). Es soll nicht nur für mehr Klarheit in der Anwendung der Taxonomie, der CSRD (Corporate Sustainability Reporting Directive) und der CSDDD (Corporate Sustainability Due Diligence Directive) sorgen, sondern vor allem bürokratische Hürden abbauen und die Wettbewerbsfähigkeit europäischer Unternehmen stärken.

Als Ausfluss ihrer Omnibus-Initiative hat die EU-Kommission bereits am 04.07.2025 den Entwurf der Delegierte Verordnung zur Änderung der Taxonomie-Verordnung veröffentlicht (Commission Delegated Regulation C(2025) 4568). Damit nimmt sie Anpassungen an den drei bestehenden Delegierten Verordnungen zur Taxonomie-Verordnung (EU) 2020/852 vor, und zwar

- an der Delegierten Verordnung (EU) 2021/2178 zur Berichterstattung nach Art. 8 der Taxonomie-Verordnung,
- an der Delegierten Verordnung (EU) 2021/2139 mit technischen Bewertungskriterien für die beiden klimabezogenen Umweltziele,
- an der Delegierten Verordnung (EU) 2023/2486 zu den vier nicht klimabezogenen Umweltzielen.

Neben Anpassungen der technischen Bewertungskriterien wird zudem eine Vielzahl an Vereinfachungen der Berichtspflichten für (Finanz-)Unternehmen vorgenommen.

Die Delegierte Verordnung C(2025) 4568 wurde dem EU-Parlament und dem Rat der EU zur Prüfung übermittelt. Die Änderungen treten in Kraft, sobald der Prüfungszeitraum von vier Monaten abgelaufen ist, wobei dieser um zwei Monate verlängert werden kann. Die Delegierte Verordnung ist Teil der Änderungen der Regelungen für die

[16] Für Hintergründe zum Thema verweisen wir auf Sandbaek und Muranaka (2025) und die darin enthaltenen Referenzen.

Nachhaltigkeitsberichterstattung, wird aber rechtlich getrennt von der Diskussion über den Omnibus-Vorschlag der EU-Kommission behandelt. Im Rahmen des (übrigen) Omnibus-Vorschlags wird nur die Änderung des Anwenderkreises im Kontext der EU-Taxonomie adressiert (Proposal for a Directive 2025/0045 (COD)).

Die Autoren haben kürzlich in WPg 2025, S. 668, die Steuerungsrelevanz der Green Asset Ratio (GAR) für Kreditinstitute untersucht und dazu die Offenlegung anhand konkreter Berichtsdaten von Kreditinstituten problematisiert. Einige der dort diskutierten Punkte greift die Delegierte Verordnung zur Änderung der EU-Taxonomie nun auf.

Ziel des vorliegenden Beitrags ist es, die in der Delegierten Verordnung vorgesehenen Änderungen der EU-Taxonomie zu analysieren und mit den in WPg 2025, S. 668, vorgeschlagenen Verbesserungen abzugleichen. Dabei werden vor allem die Auswirkungen auf Kreditinstitute sowie regulatorische und praktische Herausforderungen diskutiert.

5.2 Anpassung der EU-Taxonomie

5.2.1 Anwendungszeitpunkt

Die vorgesehenen Änderungen der EU-Taxonomie sollen bereits für den Berichtszeitraum 2025 umgesetzt werden. Allerdings lässt die EU-Kommission Unternehmen die Möglichkeit, Änderungen erst für den Berichtszeitraum 2026 anzuwenden (Commission Delegated Regulation C(2025) 4568, Art. 4). Auch wenn die vorgesehenen Änderungen die Offenlegung erleichtern sollen, setzen sie Unternehmen doch unter Druck, da Anpassungen bestehender ESG-Berichtsprozesse erforderlich werden. Diese wurden in den vergangenen Jahren häufig automatisiert, etwa bei der Erhebung von Daten und ihrer Erfassung in Templates. Änderungen der Berichtspflichten, auch wenn sie formal den Berichtsumfang mindern, erfordern oft tiefgreifende Eingriffe in die Berichtssysteme.

5.2.2 Technische Bewertungskriterien

Ein zentraler Kritikpunkt an der EU-Taxonomie betraf die Komplexität der technischen Bewertungskriterien (Technical Screening Criteria, TSC), vor allem der DNSH-Kriterien (Do No Significant Harm). Sie sollen eine 360-Grad-Sicht auf ESG-Belange sicherstellen: eine wirtschaftliche Tätigkeit trägt wesentlich zur Erreichung eines Umweltziels bei, schadet aber keinem anderen Umweltziel erheblich. Die Delegierte Verordnung sieht eine Vereinfachung und stärkere Operationalisierung vor. Ziel ist es, die Kriterien klarer zu definieren, redundante oder schwer interpretierbare Anforderungen zu reduzieren und eine stärkere Verknüpfung mit bestehenden EU-Rechtsvorschriften (etwa der EU-Abfallrahmenrichtlinie) zu erreichen. Damit sollen Unternehmen in die Lage versetzt werden, die Anforderungen effizienter zu prüfen und anzuwenden, ohne dass dies zu Lasten der 360-Grad-Perspektive geht.

Neben den DNSH-Kriterien sind die „Social Minimum Safeguards“ eine weitere zentrale Bedingung für Taxonomie-Konformität. Auch wenn eine wirtschaftliche Tätigkeit die technischen Umweltkriterien erfüllt, gilt sie nicht als Taxonomie-konform, wenn das Unternehmen gegen bestimmte soziale oder menschenrechtliche Grundsätze verstößt. Diese Schutzmaßnahmen beziehen sich auf internationale Standards, etwa auf die OECD-Leitsätze für multinationale Unternehmen oder die Grundrechte-Charta der EU (Sengenberger, 2025, S. 766).

In der Praxis wurde die Anwendbarkeit dieser Mindestschutzklausel kritisiert, besonders deshalb, weil sie inhaltlich vage formuliert und nur schwer zu überprüfen ist. Viele Unternehmen wissen nicht, wie sie „Konformität“ nachweisen sollen – vor allem dann, wenn keine gravierenden Verstöße gegen menschenrechtliche Sorgfaltspflichten, aber auch keine formalisierten Prozesse zu deren Umsetzung existieren. Für Kreditinstitute ergibt sich die Frage, wie Informationen über Kontrahenten (etwa von Darlehensverträgen) zu ermitteln sind.

Konkret finden sich in der Delegierten Verordnung zur Änderung der EU-Taxonomie im Kontext der TSC nur wenige Anpassungen (European Commission, 2025, S. 8). Die Vereinfachung der DNSH-Kriterien besteht aus der Streichung bestimmter Chemikalienprüfungen hinsichtlich des Ziels einer geringeren Umweltverschmutzung. Dies ist vor allem für Sektoren mit komplexen Lieferketten relevant, etwa in der Batterie-, Photovoltaik- oder Wärmepumpenproduktion.

Obwohl sich die Anpassung der TSC damit auf für die nachhaltige Transformation relevante Branchen bezieht, erscheint sie vor allem aus Sicht der Kreditinstitute unzureichend. Konkretisierungen zur Minderung operativer Belastungen bei der Prüfung auf Taxonomie-Konformität – etwa in Bezug auf die DNSH-Kriterien bei Immobiliendarlehen oder auf Social Minimum Safeguards – sind nicht Teil der Delegierten Verordnung. Damit wird die Chance einer deutlich einfacheren Prüfung auf Taxonomie-Konformität verpasst, ohne die grundlegenden Anforderungen an einen nachhaltigen Beitrag (Substantial Contribution), an das DNSH-Prinzip und an die Mindeststandards aufzugeben. Ein „Partial Alignment“ (Teil-Taxonomie-Konformität) wurde mit der Delegierten Verordnung nicht umgesetzt, sondern auf einen eventuell später folgenden „Broader Review“ verschoben (European Commission, 2025, S. 7).

5.2.3 Wesentlichkeitsgrenze

Zur Minderung des Berichtsumfangs sieht die Delegierte Verordnung die Einführung von Wesentlichkeitsschwellen (Materiality Thresholds) vor (Commission Delegated Regulation C(2025) 4568, Art. 1(3)). Demnach sollen wirtschaftliche Aktivitäten, die jeweils weniger als zehn Prozent des Umsatzes, der Investitionsausgaben (CapEx) oder der Betriebsausgaben (OpEx) eines Unternehmens ausmachen, für den betreffenden Key Performance Indicator (KPI Umsatz, OpEx, CapEx) von der Pflicht zur Taxonomie-Prüfung ausgenommen werden. Damit sollen vor allem jene Unternehmen entlastet werden, die nur in geringem Umfang wirtschaftliche Tätigkeiten mit Bezug zur Taxonomie ausüben. Der Fokus soll also auf Aktivitäten gelegt werden, die tatsächlich einen relevanten Beitrag zu Umweltzielen leisten können.

Für Kreditinstitute erfolgt die Berichterstattung über die Taxonomiekonformität auf Basis der GAR und weiterer, bank-spezifischer KPIs. Table 5.1 zeigt die in der Delegierten Verordnung für Kreditinstitute und deren Taxonomie-KPIs anwendbaren Wesentlichkeitsgrenzen.

Table 5.1: Wesentlichkeitsschwellen für Kreditinstitute

Schwellenwerte für Kreditinstitute		
KPI	**Was darf ausgelassen werden?**	**Bedingung**
GAR (Green Asset Ratio)	On-Balance-Sheet-Aktiva, deren Mittelverwendung bekannt ist	Gesamtwert < 10 Prozent der Aktiva mit bekanntem Verwendungszweck, die in den GAR-Nenner einfließen
FinGuar (Finanzgarantien)	Finanzgarantien, deren Mittelverwendung bekannt ist	Gesamtwert < 10 Prozent der Finanzgarantien mit bekanntem Verwendungszweck
AuM (Verwaltete Vermögenswerte)	Verwaltete Vermögenswerte, deren Mittelverwendung bekannt ist	Gesamtwert < 10 Prozent der verwalteten Vermögenswerte mit bekanntem Verwendungszweck
F&C (Gebühren und Provisionen)	Gebühren- und Provisionserträge in Verbindung mit bestimmten Wirtschaftsaktivitäten	Gesamtwert < 10 Prozent aller Gebühren- und Provisionserträge in Verbindung mit bestimmten Wirtschaftsaktivitäten
Trading Portfolio	Handelsbuch-Vermögenswerte, deren Mittelverwendung bekannt ist	Gesamtwert < 10 Prozent der Handelsbuch-Vermögenswerte mit bekanntem Verwendungszweck

Unterschreiten die Aktiva-Positionen der jeweiligen KPI die 10-Prozent-Grenze, entfällt die Verpflichtung zur Taxonomie-Bewertung dieser Positionen.

Diese Positionen müssen aber dennoch explizit und gesondert als „nicht wesentlich“ in den Templates ausgewiesen werden (samt Begründung).

Unklar bleibt, ob in den Gesamtwert auszuschließender On-balance-sheet-Aktiva Positionen gegenüber unterschiedlichen Kontrahenten und Asset-Klassen einbezogen werden können oder ob sich die kumulierten Vermögenswerte auch an der Wirtschaftsaktivität orientieren können. Denkbar wäre, dass ein Kreditinstitut mit nur sehr geringem Exposure gegenüber privaten Haushalten diese Kredite mit Hilfe der Wesentlichkeitsgrenze von der Taxonomie-Prüfung ausnehmen möchte. Offen bleibt, ob auch ein Ausschluss basierend auf der finanzierten Wirtschaftstätigkeit möglich ist, beispielsweise die Finanzierung von Wirtschaftsaktivität „7.7 Erwerb von und Eigentum an Gebäuden". Dies könnte Kreditinstitute den Vorteil verschaffen, Finanzierungen bei schlechter Datenverfügbarkeit von Bestandsgebäuden von der Taxonomie-Prüfung auszunehmen, sofern die Kredite in Bezug auf alle Finanzierungen und Investitionen nicht wesentlich sind. Wäre ein Ausschluss basierend auf der Wirtschaftstätigkeit einschlägig, müssten gewerbliche Immobilienfinanzierungen (gegenüber Nicht-Finanzunternehmen) ebenfalls in Bezug auf die Wesentlichkeitsgrenze geprüft werden, sofern der Erwerb von Gebäuden finanziert wird. Hier bedarf es einer Konkretisierung durch die EU-Kommission.

Für Exposures ohne konkreten Verwendungszweck im Sinne der EU-Taxonomie sind keine Ausnahmen vorgesehen, da erwartet wird, dass unwesentliche Wirtschaftsaktivitäten hier bereits durch die Gegenpartei des Kreditinstituts in der Berichterstattung ausgeschlossen wurden.

5.3 Besonderheiten für Kreditinstitute

5.3.1 Ausschluss bestimmter Positionen aus dem Nenner der GAR

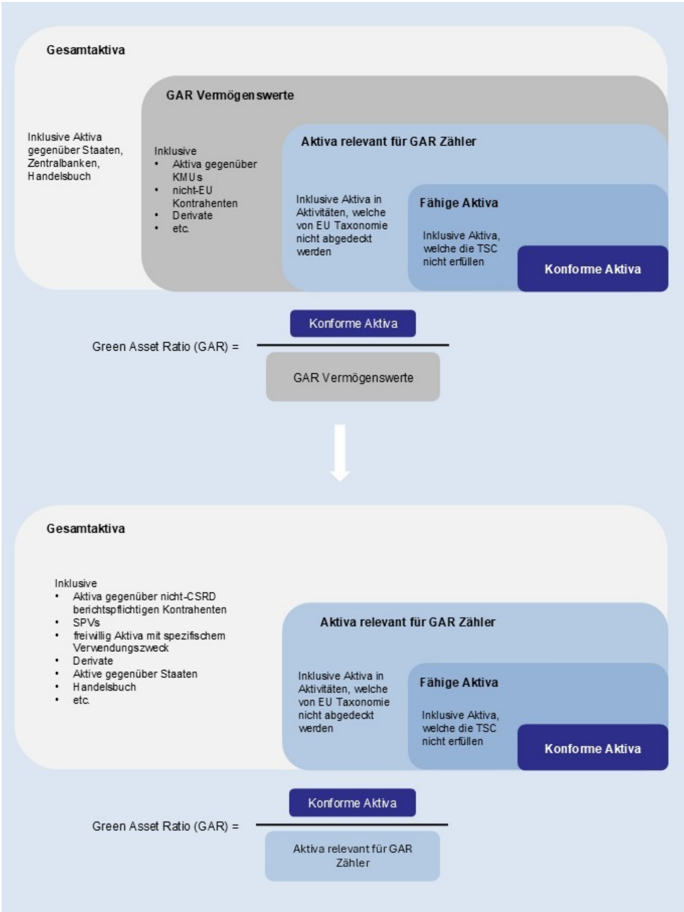
Exposures gegenüber nicht-berichtspflichtigen Gegenparteien (also nicht den Vorgaben der CSRD unterliegenden Unternehmen nach Art. 19a bzw. 29a der Bilanzrichtlinie) gemäß Delegierter Verordnung– wie aus dem Zähler – auch aus dem Nenner der GAR auszuschließen (Commission Delegated Regulation C(2025) 4568, Art. 1(6)(a)). Damit wird eine konsistente Normierung der GAR sichergestellt.

Zu kritisieren ist allerdings, dass der derzeitige Diskussionsstand des Omnibus-Vorschlags zur CSRD zu einer signifikanten Minderung der Zahl CSRD-berichtspflichtiger Unternehmen führen wird. Damit deckt die GAR nur noch einen geringen Portfolio-Teil ab, was ihre Aussagekraft deutlich einschränkt. Vor allem Kreditinstitute mit kleinen, aber stark nachhaltigen Portfolien mit CSRD-berichtspflichtigen Gegenparteien könnten eine hohe GAR ausweisen, die allerdings kaum einen Rückschluss auf die tatsächliche Nachhaltigkeit des Gesamtportfolios zulassen. Die Delegierte Verordnung schließt neben Nicht-CSRD-Kontrahenten beispielsweise auch Derivate und kurzfristige Interbankenkredite aus dem GAR-Zähler und -Nenner aus, um die GAR weniger zu verzerren (Commission Delegated Regulation C(2025) 4568, Art. 1(6)(a)).

Zugleich verhindert der Ausschluss von nicht den Vorgaben der CSRD unterliegenden Unternehmen aus dem GAR-Nenner ein internes Limit der GAR, das unabhängig von der Nachhaltigkeit des Portfolios stark vom Geschäftsmodell (Größe der Kontrahenten sowie Asset-Klasse) abhängt (Sandbaek & Muranaka, 2025, S. 668). Damit ist zu erwarten, dass die GAR im Markt steigen, ohne dass Kreditinstitute ihr Portfolio nachhaltiger ausrichten. Durch den Ausschluss entsprechender Exposures ist die GAR weniger verzerrt und kann unternehmensübergreifend (Peers) besser verglichen werden. Wie stark sie tatsächlich steigen wird, bleibt abzuwarten.

Figure 5.1 zeigt die Änderung der einzubeziehenden Vermögenswerte in die GAR durch die Delegierte Verordnung vom 04.07.2025, basierend auf Schütze and Sandbaek (2025).

Figure 5.1: Änderung der in den Zähler und Nenner der GAR einzubeziehende Vermögenswerte



5.3.2 Optionale Berücksichtigung bestimmter Positionen

Während der zu erwartende Rückgang der Zahl der den CSRD-Vorgaben unterliegenden Unternehmen die Abdeckung der GAR am Gesamtportfolio schmälert, hat die EU-Kommission einen Vorschlag unterbreitet, der der mangelnden Portfolioabdeckung entgegenwirkt: Die Delegierte Verordnung ermöglicht, dass bestimmte Exposures gegenüber nicht nach den Vorgaben der CSRD berichtspflichtigen Kontrahenten auf freiwilliger Basis in die GAR einbezogen werden können, wenn Kreditinstituten geeignete Informationen zur Nachhaltigkeit vorliegen. Freiwillig können gemäß Art. 1 Abs. 6 Buchstabe a Satz 3 der Delegierten Verordnung folgende Exposure mit in der GAR berücksichtigt werden:

- Geschäfte mit unbekanntem Verwendungszweck im Sinne der EU-Taxonomie gegenüber Kontrahenten, die freiwillig Taxonomie-KPI ausweisen;
- Zweckgesellschaften, wenn sie Assets oder Unternehmen finanzieren, die nachweislich taxonomiekonform sind;

- Finanzierungen mit bekanntem Verwendungszweck im Sinne der EU-Taxonomie.

Die Aussagekraft der GAR wird durch diese Maßnahmen voraussichtlich steigen, sofern Kreditinstitute die Möglichkeit der freiwilligen Berücksichtigung nachhaltiger Geschäfte nutzen (können). Voraussetzung dafür ist eine umfangreiche freiwillige Berichterstattung jener Unternehmen, die nicht (mehr) in den Anwendungsbereich von EU-Taxonomie und CSRD fallen.

5.3.3 Temporäre Ausnahmeregelung bis Ende 2027

Kreditinstitute, die ihre Aktivitäten nicht als ökologisch nachhaltig im Sinne der Taxonomie geltend machen, können bis zum 31.12.2027 vollständig auf die Verwendung der detaillierten KPI-Templates verzichten. Stattdessen genügt laut Europäischer Kommission eine standardisierte Erklärung im Lagebericht (Commission Delegated Regulation C(2025) 4568, Art. 1(6)(e)):

> *„No activities are claimed as being associated with economic activities that qualify as environmentally sustainable under Articles 3 and 9 of […] Taxonomy Regulation.”*

Diese Ausnahme gilt jedoch nicht, wenn ein Unternehmen aktiv nachhaltige Wirtschaftstätigkeiten ausweist.

5.3.4 Aufschiebung einzelner KPI auf das Jahr 2028

Nicht zuletzt wird die Anwendung bestimmter zusätzlicher KPI erst ab dem 01.01.2028 (Berichtsjahr 2027) verpflichtend werden:

- KPI für das Handelsbuch (Trading Book KPI),
- KPI für Gebühren und Provisionen aus Dienstleistungen außerhalb des Kreditgeschäfts (Fees and Commission KPI).

Diese KPI gelten in der Praxis als sehr aufwändig zu berechnen und von derzeit begrenzter Entscheidungsrelevanz. Deshalb wird ihre verpflichtende Anwendung zunächst ausgesetzt, bis ein umfassenderes Review abgeschlossen ist (European Commission, 2025, S. 4).

5.3.5 Templates und Berichtsformate

Die Berichterstattungsvorlagen (Templates) werden durch die Delegierte Verordnung in ihrem Umfang erheblich reduziert. Nach Angaben der EU-Kommission enthalten die überarbeiteten Templates für Kreditinstitute 89 Prozent weniger offenzulegende Datenpunkte, 64 Prozent für Nicht-Finanzunternehmen (European Commission, 2025, S. 6). Dies soll den administrativen Aufwand für Unternehmen verringern und die Berichterstattung effizienter gestalten. Die Maßnahmen zielen darauf ab, die Reporting-Pflichten praxisnäher, konsistenter und weniger ressourcenintensiv zu gestalten.

Inwiefern die geringere Zahl der offenzulegenden Datenpunkte auch zu einer Entlastung der Kreditinstitute führt, ist fraglich, denn sie führt nicht direkt zu einer Minderung der zu ermittelnden Informationen: Kreditinstitute müssen weiterhin in den bekannten Kontrahenten- und Asset-Klassen für den Zeilenaufriss bzw. über alle Umweltziele und entsprechende Davon-Positionen (beispielsweise über ermöglichende Aktivitäten) berichten. Die zu ermittelnden Daten werden lediglich als Sammelposten in den Berichtsmeldebögen ausgewiesen.

Positiv hervorzuheben ist, dass die überarbeiteten Templates deutlich kompakter sind und so zur Lesbarkeit der Taxonomie-Berichte beitragen werden. Zudem entfallen laut Delegierter Verordnung jene Templates, die für die Bewertung von Nuklear- und Gasaktivitäten nach offenzulegen waren (Commission Delegated Regulation (EU) 2022/1214, Annex XII). Kreditinstitute werden über entsprechende Wirtschaftsaktivitäten im Rahmen von Template 2 der Delegierten Verordnung nur dann berichten müssen, wenn sie Nuklear- und Gasaktivitäten finanzieren oder in solche investieren.

5.4 Fazit und Ausblick

Der Wunsch nach einer vereinfachten Anwendung der Taxonomie-Prüfung und -Offenlegung ist aus Sicht von Unternehmen und Kreditinstituten nachvollziehbar. Komplexe Anforderungen sowie Konstruktionsfehler in der Taxonomie-Prüfung und in den zu veröffentlichenden KPI sind mit hohen Zusatzkosten verbunden und setzen zu geringe Anreize, um die nachhaltige Transformation zu beschleunigen (Sandbaek & Muranaka, 2025, S. 668).

Die Delegierte Verordnung C(2025) 4568 vom 04.07.2025 adressiert einige der bestehenden Probleme und führt beispielsweise durch die Neudefinition des Nenners der GAR, die Berücksichtigung freiwilliger Berichtsinhalte und den Wegfall der Anforderung an die Unternehmensgröße für Exposures mit bekanntem Verwendungszweck nützliche Instrumente für Kreditinstitute ein, um die GAR in Richtung einer steuerungsrelevanten KPI zu etablieren.

Die Anpassungen bei der Taxonomie-Prüfung hin zu mehr Freiwilligkeit der Berichterstattung (durch Nicht-Finanzunternehmen) bzw. bei der Berücksichtigung in den KPI (bei

Finanzunternehmen) tragen unseres Erachtens dazu bei, die GAR auch bei voraussichtlicher Minderung des CSRD-Anwenderkreises als relevante KPI zu modernisieren. Dieses Vorgehen deckt sich mit der Position der EZB, die von Kreditinstituten weiterhin z.B. im Kreditvergabeprozess ein hohes Maß an Vertrautheit mit den Nachhaltigkeitsinformationen der Kunden fordert (European Central Bank, 2025).

Auch nach Veröffentlichung der Delegierten Verordnung zur EU-Taxonomie bleiben weiterhin offene Fragen in der Umsetzung. Denn komplexe Sachverhalte können üblicherweise nur prinzipienbasiert adressiert werden, so dass im Rechtstext noch zum Teil notwendige Konkretisierungen fehlen.

Anwender werden sich also weiterhin eng mit einem Wirtschaftsprüfer abstimmen müssen, wie genau Auslegungsspielräume der Delegierten Verordnung umzusetzen sind.

Vor diesem Hintergrund lässt sich sagen, dass einige Anpassungen der EU-Taxonomie durch die Delegierte Verordnung die Taxonomie-Prüfung perspektivisch erleichtern können sowie die Aussagekraft der GAR als Steuerungskennzahl verbessern. Dennoch verbleiben, trotz vorgesehener Erleichterungen im Delegierten Rechtsakt, hohe Umsetzungsaufwände für Kreditinstitute und Unternehmen während fraglich ist, ob der Nutzen aus der Offenlegung diese Aufwände überwiegt. Es bedarf dringend einer besseren Verfügbarkeit an Nachhaltigkeitsdaten, welche vor allem durch zunehmende Nachhaltigkeitsberichterstattung von (Nicht-)Finanzunternehmen erreicht werden kann, sowie einen pragmatischen Taxonomie-Prüfungsprozess (beispielsweise über Verwendung von Schätzwerten).

Problematisch bleibt nach der Umsetzung der Delegierten Verordnung indes das zugrunde liegende Narrativ, welches die Nachhaltigkeitsberichterstattung und damit verbundene Sorgfaltspflichten primär als Kostenfaktor und Wettbewerbsnachteile darstellt. Diese verkürzte Darstellung verkennt, dass es kaum belastbare Belege für einen positiven Zusammenhang zwischen weniger Regulierung und höherer Wettbewerbsfähigkeit gibt, zumal Implementierungskosten mit der Zeit erfahrungsgemäß sinken (Dechezlepretre & Sato, 2017; Rasche & Kell, 2025). Stattdessen verkennt die Debatte den strategischen Mehrwert der ESG-Berichterstattung: Sie schafft Transparenz, verbessert das Risikomanagement ebenso wie Investitionsentscheidungen und fördert die langfristige Wertschöpfung. EU-Taxonomie, CSRD und CSDDD sind Managementwerkzeuge, keine bloßen Berichtsanforderungen. Ein modernes Nachhaltigkeitsverständnis darf daher nicht auf Kostenaspekte verkürzt werden – vielmehr bedarf es eines neuen Ansatzes, der Nachhaltigkeit und Wettbewerbsfähigkeit als sich ergänzende Ziele begreift.

Part II: EU Taxonomy: Empirical Evidence from Green Asset Ratios

6 Challenges in EU Taxonomy Disclosure: Empirical Evidence from Green Asset Ratios Across Bank Types in Germany

Abstract Market-based approaches play a central role in the European Union's strategy to reorient capital flows toward environmentally sustainable activities. For disclosure-based market discipline under the EU Taxonomy to function, reported indicators must be informative and reflect stakeholder information needs. Building on prior studies documenting low Green Asset Ratios (GARs) and conceptual limitations for large banks, this paper provides empirical evidence on Taxonomy disclosures for both small and large banks and tests whether reported GARs are associated with stakeholder demand for sustainability information and information environment. Using hand-collected EU Taxonomy disclosures for 72 banks operating in Germany for the 2023 reporting year, the paper analyses bank-level GARs across large universal banks and small regional savings and cooperative banks. I find that reported GARs are generally very low, with a median value of 0.25%, and that only about 40% of banks' balance sheets enter the Taxonomy assessment. While large banks report significantly higher GARs than small banks, they exhibit lower portfolio coverage under the Taxonomy. Eligibility and alignment are strongly concentrated in household real estate exposures across all bank types. I find that banks operating in regions with stronger pro-environmental political preferences report lower GARs. While public pressure is not associated with higher GARs, bank size is positively related to GAR values. Overall, the findings suggest that the GAR does not systematically reflect stakeholder information needs and may not fully capture the external pressures that disclosure-based market discipline presupposes.

Acknowledgments This chapter is adapted from my paper "Challenges in EU Taxonomy Disclosure: Empirical Evidence from Green Asset Ratios Across Bank Types in Germany" submitted to Journal of Banking Regulation.

6.1 Introduction

Does the Green Asset Ratio reporting practice reflect external stakeholder information needs to enable market discipline through disclosure? This study examines the association between banks' disclosed Green Asset Ratios and the stakeholder demand for sustainability information and information environment, using a comprehensive sample of banks headquartered in or with a relevant presence in the German banking market. Financial institutions are frequently assigned a central role in the transition toward a sustainable economy, as their financing decisions shape capital allocation across sectors (Bischof et al., 2025). In pursuit of its sustainability objectives, the European Union therefore places significant reliance on market forces to reorient capital flows, notably through mandatory sustainability disclosure. Within this framework, banks are required to disclose their Green Asset Ratios (GARs) under the EU Taxonomy, which measure the share of a bank's assets that are classified as environmentally sustainable (Taxonomy aligned) to total Taxonomy covered assets (Commission Delegated Regulation (EU) 2021/2178; Commission Delegated Regulation (EU) 2023/2486; Commission Delegated Regulation (EU) 2026/73). These disclosures are intended to provide sustainability-oriented market participants information on banks' sustainability performance (Berens, 2023; European Commission, 2021b; Weirich et al., 2022). This disclosure-based approach is conceptually analogous to Pillar III of the Basel framework, which relies on market discipline to ensure prudent market supervision. Against this background, it is crucial to assess whether the GAR is an informative and comparable metric that reflects external stakeholders' demand of bank disclosure. The study thereby identifies potential challenges in the measurement and interpretation of this key metric across a diverse set of banking institutions.

This paper utilises hand-collected data on the 2023 EU Taxonomy disclosures of 72 banks with headquarters or a relevant presence in Germany to analyse bank-level GARs reported under Article 8 of the EU Taxonomy Regulation. By combining these disclosures with bank-level financial data and controlling for bank characteristics, the study examines the association between banks' disclosed GARs and two theoretically motivated proxies for stakeholder demand of bank disclosure and information environment: firstly, the local election outcomes and countries' Climate Perception Index to approximate green sentiment and, secondly, the local newspaper environment and banks' European Central Bank (ECB) supervision to proxy for public pressure. In addition to the GAR, I analyse related Taxonomy metrics and real estate–specific exposures, given the central role of household real estate lending in banks' balance sheets and in Taxonomy disclosures. The analysis covers both large universal banks and small regional savings and cooperative banks, allowing for a comparative assessment across business models within a single institutional and regulatory setting.

The results show that reported GARs are generally very low, with a median value of 0.25% for capex-based disclosures (0.32% for turnover-based disclosures). Across banks, only a limited share of balance-sheet exposures enters the Taxonomy assessment, which narrows the informational content of the GAR and complicates cross-bank comparisons. While large banks report significantly higher GARs than small banks, they exhibit lower portfolio coverage under the Taxonomy, whereas small banks show broader coverage but substantially lower alignment rates. Taxonomy eligibility and alignment are strongly concentrated in household real estate exposures for both bank groups, underscoring the central role of this asset class for GAR outcomes. Regression results further indicate that banks operating in regions with stronger pro-environmental political preferences report lower GARs. While public pressure is not associated with higher GARs, bank size is positively related to GAR values. Taken together, the findings suggest that the reported GARs do not systematically increase with stakeholder information needs, and therefore cast doubt on the ability of the GAR to function as an effective disclosure-based steering mechanism.

With its data driven approach, this study contributes to the literature in two dimensions. First, it complements recent work examining stakeholder reactions to the EU Taxonomy regulation framework (see e.g. Garcia-Torea et al., 2024; Hummel & Bauernhofer, 2024). Prior studies show that higher Taxonomy alignment is associated with higher stock returns (Bassen et al., 2025) and lower syndicated loan interest rates (Sautner et al., 2022), highlighting the intended role of Taxonomy disclosures in market discipline. At the same time, research on sustainability reporting emphasises that sustainability disclosure and performance are shaped by stakeholder preferences and political environments (Gulenko et al., 2025; Lopatta et al., 2022). While this literature establishes that sustainability-related information can affect capital allocation and disclosure, empirical evidence on whether bank-level GARs reporting practices reflect stakeholder information needs remains scarce. Prior bank studies often rely on estimates of green assets derived from other portfolio disclosures (Alessi & Battiston, 2022), leaving open the question of how informative disclosed GARs are in practice. This study addresses this gap by analysing actual Taxonomy disclosures and testing whether disclosed GARs are associated with stakeholder demand of bank disclosure.

Second, the paper relates to the broader literature on banking regulation and disclosure. Prior research documents that regulatory reforms in the European banking sector have created significant implementation challenges for banks and have raised concerns about both under- and overregulation (Burghof, 2020; Pfingsten & Woyand, 2019). Related work examines banks' adaptation to changes in Pillar I requirements (Pfingsten et al., 2017) and the effects of harmonised reporting standards on disclosure practices (Fülbier et al., 2017). While this literature provides important insights into regulatory adjustment and disclosure, it largely refrains from empirically analysing Taxonomy-based disclosures across different types of banks. Early studies document very low GARs and highlight conceptual and practical limitations of the indicator, primarily based on large banks or estimated data (CRIF, 2024; Hoepner & Schneider, 2024; Schütze & Stede, 2021). As smaller banks with a strong real estate focus play a central role in the banking systems of countries such as Germany and Austria (Deutsche Bundesbank, 2025; Österreichische Nationalbank, 2024), this study provides new evidence on how the disclosed sustainability key performance indicator (KPI) performs in practice and whether it reflects stakeholder information needs across both small and large banks.

This study contributes to the understanding of how the GAR operates in practice within a heterogeneous banking system. Focusing on the German three-pillar banking structure, it examines how disclosed GARs vary across banks with different sizes and business models and whether disclosed GARs reflect differences in stakeholder environments. By combining detailed descriptive evidence with regression analysis, the paper sheds light on the informational content and limitations of the GAR as a disclosure-based sustainability indicator. The findings help clarify under which conditions GAR disclosures may be difficult to interpret and highlight challenges related to its comparability, being relevant to regulators, market participants, and banks alike.

The paper is structured as follows. Section 2 provides an overview of prior literature on Taxonomy disclosure. Section 3 shows the sample selection process and defines the variables used in the empirical approach. Descriptive statistics as well as the empirical results are presented in Section 4. Section 5 discusses the results and its implications. Section 6 concludes.

6.2 Literature and hypothesis development

6.2.1 Related Literature

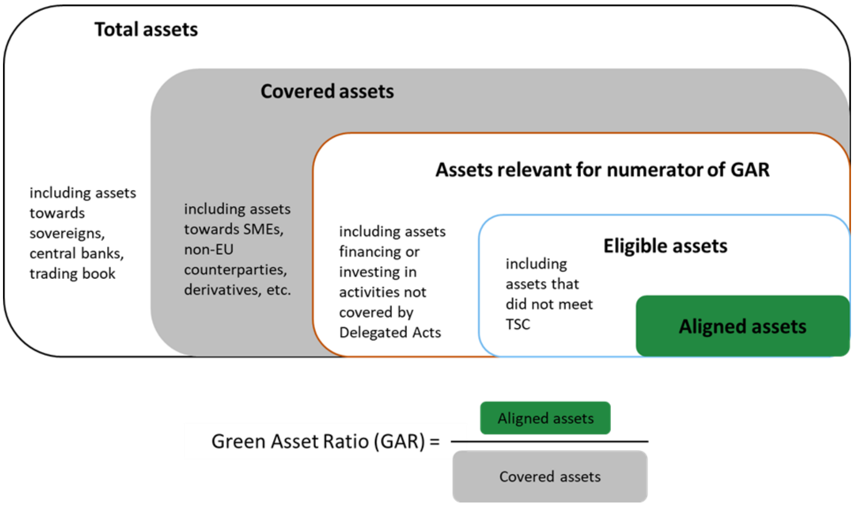
The EU Taxonomy is a central pillar of the EU Action Plan on financing sustainable growth (European Commission, 2018). It aims to reorient capital flows toward sustainable economic activities by defining clear criteria for environmental sustainability and requiring (non-) financial institutions to disclose their alignment with these criteria (Regulation (EU) 2020/852). As voluntary disclosures did not provide transparency on corporations' sustainability performance (Criado-Jimenez et al., 2007; Vigneau & Adams, 2023) and in order to prevent greenwashing (Gatti et al., 2019), the European Commission introduced mandatory Taxonomy disclosure. The mechanism relies on market discipline as disclosure is intended to enable investors, regulators and stakeholders to assess an institution's environmental performance and to exert pressure on institutions to support the transition. For banks, the GAR serves as the key performance indicator meant to capture the share of environmentally sustainable (Taxonomy aligned) assets in the financing portfolio in total Taxonomy covered assets (Commission Delegated Regulation (EU) 2021/2178).

The EU Taxonomy classifies economic activities as Taxonomy aligned if they meet predefined technical screening criteria confirming their substantial contribution to one environmental objective while they do not significantly harm (DNSH) the other objectives: (i) climate change mitigation; (ii) climate change adaptation; (iii) sustainable use and protection of water and marine resources; (iv) transition to a circular economy; (v) pollution prevention and control; and (vi) protection and restoration of biodiversity and ecosystems. Moreover, counterparties must comply with Minimum Social Safeguards. The EU Taxonomy covers those sectors most harmful and relevant for the transformation, e.g. those responsible for about 80% of greenhouse gas (GHG) emissions in the EU (European Commission, 2021a, Question 7). Article 8 of the Taxonomy Regulation requires applicable banks to report not only the GAR, but a set of templates containing Taxonomy data (e.g. the share of assets covered by the EU Taxonomy as Taxonomy eligible assets).

Because the EU seeks to reorient capital flows toward sustainable activities through disclosure mechanisms such as the GAR, its effectiveness depends on whether it provides meaningful and comparable information across banks. However, the construction of the GAR is shaped by regulatory definitions. As illustrated in Figure 2 which is based on Schütze and Sandbaek (2025), exposures to central banks, sovereigns, small and medium enterprises

(SMEs), trading portfolios and non-EU counterparties are partly or fully excluded from the GAR calculation (Art. 7 Commission Delegated Regulation (EU) 2021/2178)[17], which, as noted by industry assessments, means that resulting GAR values are heavily influenced by structural characteristics of banks' balance sheets and customer bases (AFME, 2024; Sustainable Finance Beirat, 2024).

Figure 6.1: Composition of the Green Asset Ratio. Based on Schütze and Sandbaek (2025).



Prior studies further highlight conceptual and practical limitations of the Taxonomy disclosure (Garcia-Torea et al., 2024; Hoepner & Schneider, 2024; Partiti, 2023; Schütze & Sandbaek, 2025; Schütze & Stede, 2021; Zetzsche & Bodellini, 2024). Empirical evidence on GAR disclosures is still emerging, but early studies consistently document very low levels of alignment. Alessi and Battiston (2022) estimate the green share of bank balance sheets at only 0.8%. Several other industry studies similarly report low GAR values for large European banks' disclosure for 2023, resulting in an average of GAR of 2.4% according to CRIF (2024), 1.77% according to EY (2024) and 2.2% according to PWC (2024). They reveal large differences in KPIs between countries which they explain by different data availability in countries. PWC (2024) suggests that the Netherlands seem to have a higher than international average GAR due to better access to Energy Performance Certificates (EPC) ratings, making up a large share of banks' portfolios (PWC, 2024, pp. 18–19). CRIF (2024) shows high Taxonomy eligibility for collateralised loans compared to other assets, suggesting the large strategic importance of data for collateralised loans. Studies on non-financial

[17] This disclosure requirement, along with others, has been revised and will no longer apply from the 2025 or 2026 (depending on when the bank choses to apply the new reporting requirements) reporting period onward, as set out in Regulation (EU) 2026/73. According to the new rules, these exposures are either excluded from the numerator and denominator of the GAR or can be assessed voluntarily for certain exposures. As this study analyses disclosures from the 2023 reporting period, the revised requirements fall outside its scope.

corporations reveal comparable patterns. Hoepner and Schneider (2022) show that alignment varies strongly by business model and data source, leading to substantial variation in reported Taxonomy KPIs. For non-financial undertakings, Arnold et al. (2024) find Taxonomy aligned turnover of 3% (13% for capex).

If the GAR is to function as an effective market-based steering mechanism, it should not only reflect regulatory definitions and portfolio constraints, but respond to external stakeholder information needs. In particular, it is an open empirical question whether banks operating in environments with stronger pro-environmental preferences or higher public scrutiny report higher GARs.

6.2.2 Hypotheses

A growing body of research indicates that public preferences for climate action increasingly shape banks' strategic and disclosure decisions. Banks are under mounting pressure from stakeholders, including customers, investors, civil society groups, and policymakers, to respond to climate change, disclose environmental impacts, and reduce financing of carbon-intensive activities (Haque & Ntim, 2020). This pressure generates expectations that banks align their portfolios with climate-related objectives and visibly support sustainable economic activities. Consistent with this, prior evidence shows that firms tend to communicate more extensive environmental information when they wish to signal compliance with environmental norms or legal requirements and reassure stakeholders of their responsible behaviour (Holland & Boon Foo, 2003). Moreover, companies with more advanced sustainability practices are generally more transparent and disclose higher levels of sustainability information as a means of differentiating themselves from less sustainable peers (Cahan et al., 2016).

Transferring these insights to the EU Taxonomy context implies that banks operating in environments with stronger pro-environmental sentiment face stronger incentives to demonstrate sustainability performance through the GAR. If sustainability preferences are high, stakeholders may demand banks to take visible steps toward green financing, or at minimum to credibly document the sustainability of their portfolios. To sum up, I state the following hypotheses for banks' disclosure:

Hypothesis 1. *Higher green sentiment in a bank's operating environment is positively associated with the bank's Green Asset Ratio.*

Public pressure represents a second mechanism through which stakeholder information needs may influence banks' sustainability disclosures. Prior literature demonstrates that firms respond to social and political scrutiny by increasing the extent and quality of environmental reporting (Brown & Deegan, 1998; Darrell & Schwartz, 1997). Media environments play a central role in this process: prior studies have shown that in regions with higher newspaper circulation or greater public visibility, firms exhibit higher accountability and levels of environmental disclosure (Dyck & Zingales, 2004; Fidiana, 2022). Heightened regulatory and supervisory attention has been shown to induce banks to strengthen their governance and risk management practices related to climate risks, and to expand sustainable financing activities (Schreiner & Beyer, 2024). Such oversight motivates banks to adopt more transparent and comprehensive disclosure strategies, treating environmental reporting as a mechanism to demonstrate prudence and responsible conduct (Kwak, 2013).

Taken together, these findings suggest that banks facing stronger public, media, or supervisory pressure have greater incentives to demonstrate environmental responsibility and to communicate this through their GAR disclosures. I phrase the second hypothesis related to stakeholders information environment as follows:

Hypothesis 2. *Higher public pressure in a bank's operating environment is positively associated with a bank's Green Asset Ratio.*

6.2.3 The German banking sector

Germany's banking system is structured into three pillars based on legal ownership: private commercial banks, government-owned banks (savings and state banks), and cooperative banks (Bischof et al., 2023; Haselmann et al., 2018). Large private and state-owned universal banks are diversified across corporate, retail and capital market activities and typically operate nationally or internationally. Due to their size and systemic importance, they are subject to the European Central Bank's (ECB) direct supervision under the Single Supervisory Mechanism.

In contrast, savings (*Sparkassen*) and cooperative banks (*Volksbanken/Raiffeisenbanken*) are regional institutions with strong roots in local communities. Selected representatives of municipal trustees serve as supervisory board members and participate in important operating decisions of savings banks (Gulenko et al., 2025). Their business models emphasise traditional retail banking, household lending, and SME financing within clearly defined geographic areas. Despite their smaller size, these institutions collectively represent a substantial share of the German banking market and are central intermediaries in local credit provision. Their customer bases, portfolio structures, and stakeholder environments differ markedly from those of large universal banks. State banks (*Landesbanken*) share savings banks' public mission but also operate internationally, serving corporations and local governments (Ayadi et al., 2016, pp. 21–29; Cernov & Urbano, 2018, pp. 9–18; Mann & Püttner, 2011, p. 532; Schrooten, 2009, p. 671).

These structural differences have direct implications for EU Taxonomy disclosures. Large banks typically interact with corporate clients that are more likely to publish non-financial information, potentially facilitating the assessment of eligibility and alignment. Small regional banks, in turn, serve customer segments, such as households and SMEs, with limited sustainability disclosure obligations. Moreover, small regional banks are embedded in local political and social environments, where green sentiment and public pressure may differ from national-level dynamics. Consequently, the determinants of taxonomy-related metrics, including the GAR, may vary across bank types. Prior literature, however, has focused predominantly on non-financial corporations or large, listed banks, leaving the Taxonomy disclosure behaviour of smaller regional institutions largely unexplored. This study contributes to filling this gap by offering the first comparative analysis of taxonomy metrics across large and small banks in the German market.

6.2.4 Real Estate Financing and its relevance for EU Taxonomy metrics

Real estate financing plays a central role in the application of the EU Taxonomy to banks. In Germany, housing loans to households represent approximately 29% of total bank lending to the non-bank sector (Deutsche Bundesbank, 2025), reflecting the strong orientation of regional banks toward mortgage lending. At the same time, households alone are responsible for 24% of the EU's GHG (Directive (EU) 2024/1275). The real estate sector is a major contributor to environmental degradation, accounting for 36% of CO_2 emissions in the EU emissions (Eurostat, 2024). As a result, the decarbonisation of the building sector is a critical component of the EU's climate strategy. Compared to other high-emitting sectors such as transport, manufacturing and energy, the disclosure templates include dedicated reporting lines for household real estate financing and its Taxonomy assessment. This makes it possible to extract taxonomy-relevant, eligible, and aligned real estate exposures directly from disclosures.

Although industry reports highlight considerable variation in real estate–related taxonomy metrics across banks and countries (CRIF, 2024; PWC, 2024), there is a lack of empirical evidence on how real estate lending shapes GAR outcomes within national banking systems. This study therefore includes a focused comparison of real estate–specific taxonomy metrics between large and small banks to understand how business model differences translate into disclosed alignment and eligibility figures.

6.3 Sample and research design

6.3.1 Sample selection and data

Panel A of Table 6.1 outlines the sample selection process and samples composition for small banks. The sample consists of savings banks (Sparkassen) and cooperative banks (Volksbanken/Raiffeisenbanken) operating in Germany as of December 31, 2023. As the EU Taxonomy Regulation requires the disclosure only for taxonomy-applicable institutions under Article 8, the sample is restricted to banks that publish the relevant sustainability disclosures. From this population, the largest institutions by balance sheet total were selected for each banking pillar. The sample was expanded until a coverage of approximately 28% of total assets of the savings bank sector and 26% of total assets of the cooperative banking sector was achieved. This approach ensures a broad and representative coverage of economically significant regional banks while avoiding the need to include the full population. Savings banks and cooperative banks are pooled into a single group of small banks, as both share a highly comparable business model characterized by strong regional orientation, a retail-focused universal banking profile, and a primary focus on households and SMEs. Both banking groups adhere to the regional principle and exhibit similar lending and deposit structures, resulting in comparable risk profiles from a regulatory perspective. The final sample comprises of each 26 savings banks and cooperative banks.

Table 6.1: Sample Selection and Description

Panel A: Sample selection and composition of small banks

	Number of savings banks	Number of cooperative banks
Initial sample of largest banks by category, covering more than 25% of the respective banking market (2023)	27	32
Less: banks disclosing with consolidating entity	1	-
Less: banks with no disclosure data according to Art. 8 of EU Taxonomy	-	1
Less: banks not applicable to disclosure according to Art. 8 of EU Taxonomy		5
Regression sample	26	26
Share of total market of the respective bank category	28%	26%
Median of Balance Sheet Total in Million €	12,089.46	

Panel B: Sample selection of large banks

Selection Criterion	Definition	Rationale for Inclusion
1. EU Taxonomy Disclosure Requirement	Only banks that are applicable to disclosure according to Art. 8 of EU Taxonomy and that are not consolidated with another entity.	Ensures data availability and full comparability of metrics across the entire sample.
2. Universal Bank Business Model	Included banks exhibit a diversified universal banking model, covering retail and corporate banking, capital market activities, treasury functions, and international operations.	Guarantees comparability in business models and balance sheet structures. In addition to large international private universal banks, *Landesbanken* are included as they are structurally, functionally, and economically part of the large-bank segment and clearly distinct from regional savings and cooperative banks.
3. Relevant Presence in the German Banking Market	In addition to German institutions, large European universal banks are	Allows a realistic representation of the large universal banking sector

	included if they display a business model comparable to German large banks and maintain material activity in the German corporate or retail banking market.	affecting the German market while preserving the focus on Germany.
4. Minimum Balance Sheet Size (> €100 bn)	Only banks with total assets exceeding €100 billion are included. This threshold lies well above the ECB's €30 billion criterion for significant institutions.	Focuses the sample on very large, systemically relevant banks under ECB supervision and avoids inclusion of mid-sized institutions.

Panel C: Sample composition of large banks

	Number of large banks	Details
Regression sample	20	The sample consists of three German major private universal banks, four *Landesbanken*, 13 international large private universal banks.
Share of German-headquartered large banks in the total German banking market	33 %	The reported market share captures only large banks headquartered in Germany and thus constitutes a conservative estimate, given that the sample also includes international banking groups with significant activity in the German market.
Median of Balance Sheet Total in Million €	610,482.72	-

The table provides descriptive information on the samples used in the analyses. In Panel A, I summarise the small banks' sample selection process and sample composition for savings and cooperative banks. Panel B explains the sample selection of large banks for the analyses. Panel C summarises the sample composition of the large banks.

Panel B and C of Table 6.1 summarises the sample selection process and composition for large banks. The sample of large banks comprises very large European universal banks subject to direct supervision by the ECB under the Single Supervisory Mechanism, ensuring a comparable regulatory and public oversight regime across all institutions. Given the limited number of large German private universal banks, sample selection follows four criteria. First, only banks applicable to disclosure under Article 8 of the EU Taxonomy Regulation are included to ensure data availability and comparability. Second, all banks exhibit a diversified universal banking business model, covering retail and corporate banking, capital market activities, treasury functions, and international operations. This criterion allows the inclusion of both large private universal banks and German state banks, which, despite their public ownership, are structurally and economically part of the large-bank segment. Third, in addition to German institutions, large European universal banks with material activity in the German banking market are included to reflect the large-bank sector affecting Germany. Fourth, only banks with a balance sheet total exceeding €100 billion are selected, a threshold well above the ECB's €30 billion criterion for significant institutions, thereby focusing on highly systemically relevant banks under ECB supervision. Based on these criteria, the final sample consists of 20 large banks, including three German private universal banks, four German state banks, and 13 large international universal banks. German-headquartered banks in the sample account for approximately 32% of the total balance sheet of the German banking market (Deutsche Bundesbank, 2025). This figure constitutes a conservative coverage estimate, as international banking groups included in the sample are not reflected in the domestic market share calculation. These processes yield a final bank-level disclosure sample of 72 banks.

I construct the dataset by combining bank-level financial information from the Orbis database with hand-collected EU Taxonomy disclosure data. I collect Taxonomy data from Templates 0 and 1 as reported banks' annual reports and non-financial disclosures, including ESG and Deutscher Nachhaltigkeitskodex (DNK) reports. These disclosures are obtained from banks' websites, the website of the DNK and the website of the German Federal Gazette (*Bundesanzeiger*).[18] The extracted data include gross carrying amounts, covered assets, Taxonomy eligible and Taxonomy aligned exposures, and detailed real estate financing volumes for both stock and flow metrics. Taxonomy eligibility and alignment are primarily assessed with respect to climate change mitigation and adaptation, as most banks do not report contributions to the remaining environmental objectives. Based on this information, I collect the GARs for turnover and capital expenditure and construct complementary indicators capturing coverage, eligibility, alignment, conversion rates, and real estate taxonomy KPIs. Metric definitions and computation methods are documented in Table 6.2 and Table 6.3.

[18] In line with the NFRD, firms may publish their Taxonomy information either on their own websites or via the Bundesanzeiger, and either as part of the annual report or in a separate non-financial report.

Table 6.2: Defining Taxonomy metrics

Metric	Explanation for computation of metric	Example for numerator	Symbol (based on Figure 1 for those applicable)
$GreenAssetRatio_i^{TURN}$	Share of Taxonomy aligned assets in covered assets, calculated according to turnover-based disclosures of certain counterparties.	Weight exposure of general purpose loan towards non-financial corporation with their disclosed turnover-KPI.	$\frac{a_1}{a_1 + a_2 + a_3 + a_4}$
$GreenAssetRatio_i^{CAPEX}$	Share of Taxonomy aligned assets in covered assets, calculated according to capex-based disclosures of certain counterparties.	Weight exposure of general purpose loan towards non-financial corporation with their disclosed capex-KPI.	$\frac{a_1}{a_1 + a_2 + a_3 + a_4}$
Excluded Assets from the Numerator	Share of assets not relevant for taxonomy-assessment, but included in GAR denominator, in total assets.	Exposures towards counterparties not applicable to the NFRD/CSRD.	$\frac{a_4}{a_1 + a_2 + a_3 + a_4 + a_5}$
Excluded Assets from the Denominator	Share of assets not relevant for taxonomy-assessment, not included in GAR denominator, in total assets.	Exposures towards sovereigns and central banks.	$\frac{a_5}{a_1 + a_2 + a_3 + a_4 + a_5}$
Coverage	Share of assets relevant for taxonomy-assessment in total assets.	Consumer credit to household is covered, however never taxonomy- eligible.	$\frac{a_1 + a_2 + a_3}{a_1 + a_2 + a_3 + a_4 + a_5}$
Taxonomy Eligibility	Taxonomy eligible assets in covered assets.	Loan to household to build new real estate.	$\frac{a_1 + a_2}{a_1 + a_2 + a_3 + a_4}$
Green Asset Ratio Flow	Share of Taxonomy aligned assets in covered assets, calculated for new exposures during 2023 and according to turnover-based disclosures.	New loan granted to non-financial corporation in 2023.	
Conversion Rate	Share of Taxonomy aligned assets in taxonomy eligible assets: $\frac{Taxonomy\ aligned\ assets}{Taxonomy\ eligible\ assets}$	Taxonomy aligned loan to household to build real estate.	$\frac{a_1}{a_2}$

This table provides explanations of metrics disclosed by applicable banks according to Article 8 of the EU Taxonomy in column 2. Column 3 provides examples for the metrics numerator and column 4 references the classification of assets presented in Figure 6.1. Banks disclose these metrics in the Taxonomy disclosure in annual reports and non-financial disclosures, including ESG and DNK reports.

Table 6.3: Defining Real Estate metrics

Metric	Explanation
Real Estate Loans in Total Assets	Share of collateralised and renovation real estate loans for households in balance sheet total.
Real Estate Loans in Taxonomy-relevant Assets	Share of collateralised and renovation real estate loans for households in total assets covered by the Taxonomy assessment.
Eligibility of Collateralised Real Estate Loans	Share of collateralised real estate loans to households that are taxonomy eligible.
Alignment of Collateralised Real Estate Loans	Share of collateralised real estate loans to households that are Taxonomy aligned.
Conversion Rate Collateralised Real Estate Loans	Share of Taxonomy aligned loans among taxonomy eligible collateralised real estate loans to households.
Eligibility of Real Estate Loans in Total Eligible Assets	Share of taxonomy eligible collateralised and renovation real estate loans to households in total eligible assets.
Alignment of Real Estate Loans in Total Aligned Assets	Share of Taxonomy aligned collateralised and renovation real estate loans to households in total aligned assets.

This table provides explanations for the real estate–related taxonomy metrics computed for the bank sample. All banks in the sample fall under Article 8 of the EU Taxonomy and are therefore required to disclose standardised taxonomy templates. The underlying data are obtained from banks' annual reports and non-financial disclosures, including ESG and DNK reports, which are used to construct the reported metrics.

6.4 Descriptive Statistics

6.4.1 Taxonomy metrics in the full sample

Before distinguishing between small and large banks, the analysis first examines the distribution of key EU Taxonomy metrics across the full sample (Table 6.4). The results show that GARs are very low relative to total assets, with median values of 0.25% and 0.32% for turnover- and capex-based measures[19], respectively. Across institutions, I observe substantial dispersion, with some banks reporting higher values while many report near-zero alignment. More than 99% of covered assets are reported as non-aligned or unassessed, indicating that only a very small portion of banks' balance sheets currently enters the aligned numerator. Large shares of excluded assets also lead to relatively small volumes of exposures that fall within the Taxonomy assessment scope.

[19] Banks disclose GARs based on turnover and capital expenditures (capex), as they are required to use their non-financial counterparties' Taxonomy key performance indicators when the use of proceeds of exposures are unknown.

Table 6.4: Descriptive Statistics of disclosed Taxonomy metrics

	N	Mean (%)	Std. Dev.	P25 (%)	Median (%)	P75 (%)
$GreenAssetRatio_i^{TURN}$	72	0.6345	1.1130	0.0600	0.2450	0.5800
$GreenAssetRatio_i^{CAPEX}$	72	0.7247	1.1623	0.1025	0.3150	0.7300
Assets Excluded from the Numerator	72	42.6074	19.3678	30.1725	43.9900	55.7125
Assets Excluded from the Denominator	72	16.1560	16.0422	3.6100	9.4200	27.2350
Coverage	72	44.5796	19.8801	32.8300	43.7600	52.632
Taxonomy eligibility	72	24.5317	16.9754	9.6525	25.0550	34.4225
Green Asset Ratio Flow	40	1.1725	1.2071	0.5075	0.8500	1.5075
Conversion Rate	72	3.6631	6.5508	0.3025	1.8350	4.6750

The table reports the descriptive statistics for the disclosed Taxonomy metrics used in the analysis of the sample. The sample comprises 72 banks with headquarter or relevant presence in the German banking market for which I have collected disclosed Taxonomy metrics on the bank level for the reporting period of 2023. N for GAR Flow is lower, because some banks do no yet distinguish between GAR Stock and Flow. For metric definitions and details see Table 6.2.

Coverage ratios, eligibility shares, and alignment conversion rates also exhibit wide variation, reflecting heterogeneity in the extent to which portfolios are classified under the Taxonomy. Several metrics display strong skewness, with a small number of banks reporting relatively high eligible or aligned asset shares, while most institutions show very limited alignment. These distributional characteristics are consistent with the early stage of Taxonomy implementation and with differences in reporting practices and balance sheet composition across institutions. The pronounced heterogeneity and non-normal distributions in these metrics justify the use of non-parametric statistical tests in subsequent analyses. To better understand the source of this variation, I next compare taxonomy metrics separately for small regional banks and large universal banks.

6.4.2 Taxonomy and Real Estate metrics by bank type

The descriptive comparison of small and large banks (Table 6.5) reports the median of exposures in each asset category presented in Figure 2. Results suggest structural differences in how the EU Taxonomy applies across bank types. Small regional banks appear to have higher coverage ratios, meaning a larger share of their total assets enters the Taxonomy assessment. Large banks, in contrast, tend to report lower coverage ratios but higher eligibility and alignment relative to total assets. Although fewer assets are assessed, a larger portion of the assessed assets appear to fall within Taxonomy-eligible activities or counterparties. These observations suggest the role of business model and balance sheet composition in shaping Taxonomy metrics. Overall, a substantial part of both groups' balance sheets remains outside the Taxonomy scope. Statistical comparisons are presented in the following subsection.

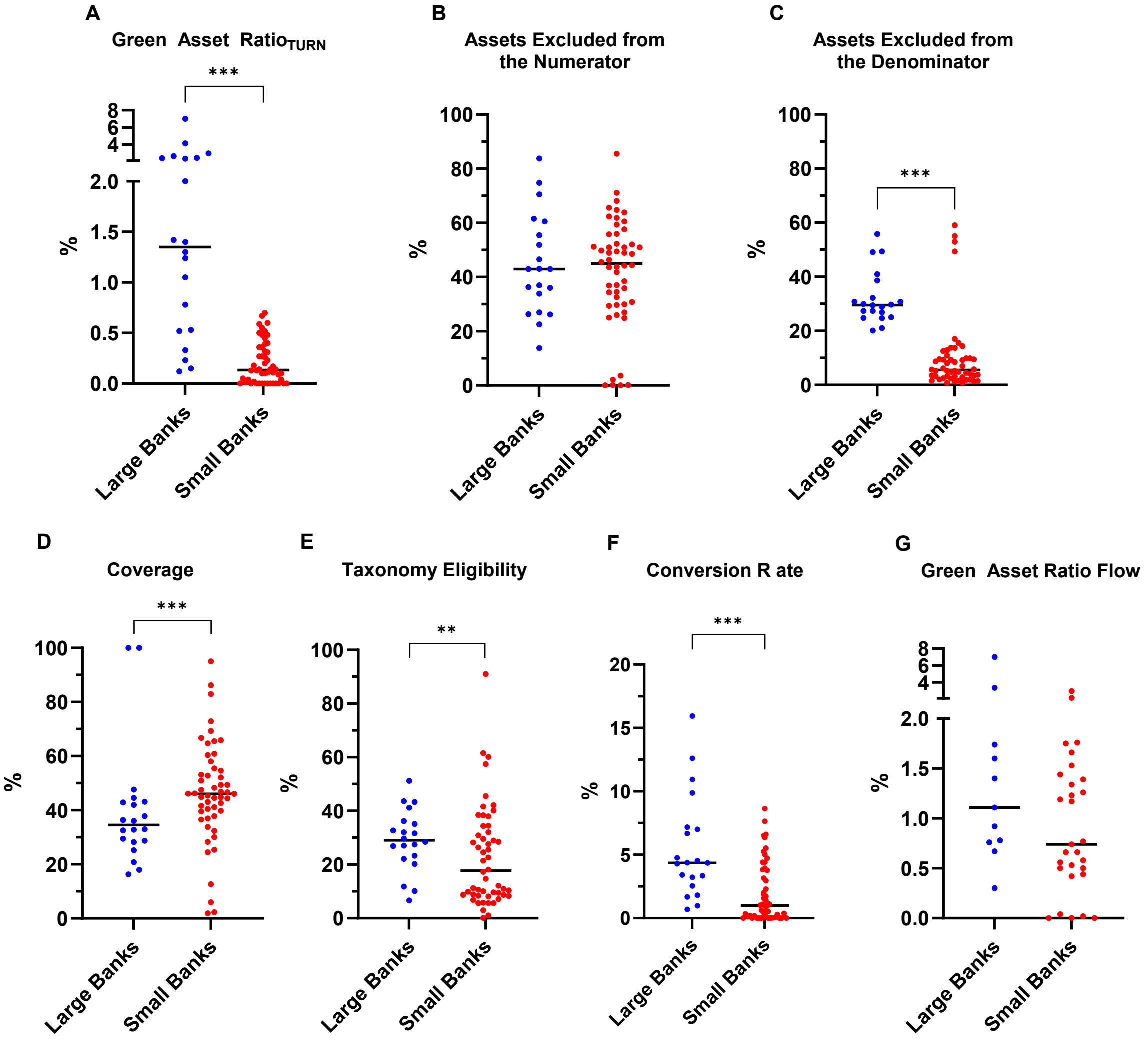
Table 6.5: Overview of classification of assets according to EU Taxonomy of large and small banks

	Symbol (based on Figure 1)	Median large Banks	Median small Banks
Aligned assets in total assets	$\frac{a_1}{a_1 + a_2 + a_3 + a_4 + a_5}$	0.81%	0.13%
Eligible assets in total assets	$\frac{a_1 + a_2}{a_1 + a_2 + a_3 + a_4 + a_5}$	19.31%	16.36%
Assets relevant for GAR numerator in total assets (= coverage)	$\frac{a_1 + a_2 + a_3}{a_1 + a_2 + a_3 + a_4 + a_5}$	34.53%	46.07%
Covered assets (= assets relevant for GAR denominator) in total assets	$\frac{a_1 + a_2 + a_3 + a_4}{a_1 + a_2 + a_3 + a_4 + a_5}$	70.41%	94.79%
Total Assets (€m)	$a_1 + a_2 + a_3 + a_4 + a_5$	610,482 (= 100%)	12,089 (= 100%)

The table gives an overview over the median share of assets that are classified according to the EU Taxonomy for the sample of large and small banks as presented in Figure 6.1. The sample comprises 52 small (savings and cooperative) banks headquartered in Germany and 20 large banks with relevant presence on the German banking market for the reporting period of 2023. I computed the reported values based on disclosed data found in the Taxonomy disclosure in annual reports, non-financial reports such as ESG reports and DNK reports.

Figure 6.2 provides graphical distribution plots for comparing Taxonomy metrics of large and small banks, which visually confirm the patterns identified by the Mann–Whitney tests in Table 6.6.

Figure 6.2: Distributional Plots for Taxonomy Metrics



The figure plots medians and distributions of Taxonomy metrics for large and small banks. The sample comprises 52 small (savings and cooperative) banks headquartered in Germany and 20 large banks with relevant presence on the German banking market for the reporting period of 2023. Banks disclose these metrics in the Taxonomy disclosure in annual reports and non-financial disclosures, including ESG and DNK reports (only for the conversion rate in Figure 6.2F, I computed the values based on data found in the Taxonomy disclosure). Figure 6.2F excludes one outlier (Volksbank Dortmund: 59.96%). See Table 6.2 and Table 6.6 for metrics definitions and statistics of metrics comparing the bank types, respectively. To compare the distributions of metrics between large and small banks, I apply the Mann–Whitney test. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6.6: Comparisons between large and small banks' disclosed Taxonomy metrics

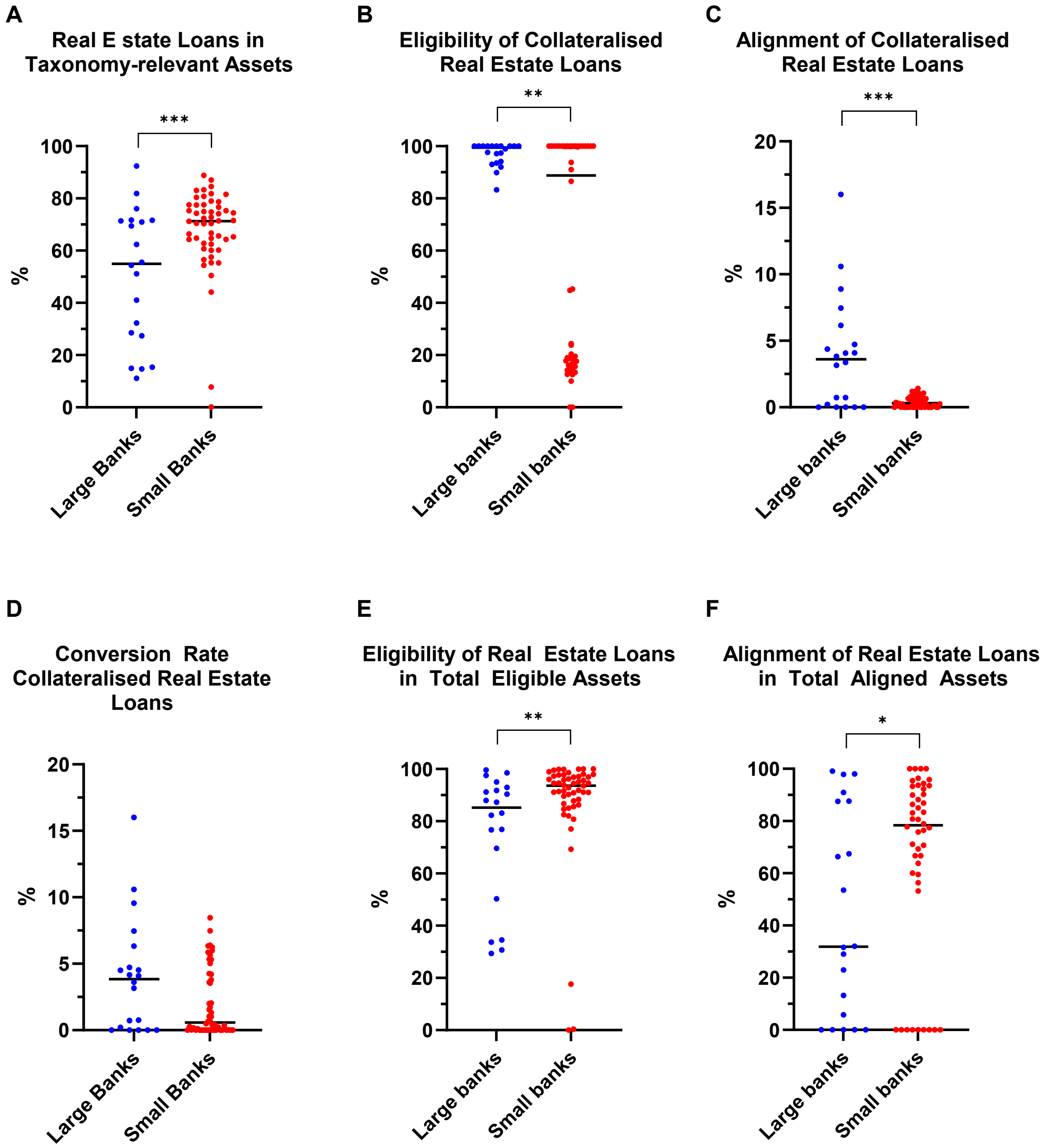
	Median large banks (%)	Median small banks (%)	p-value	Rank-biseral correlation (r_{rb})
N	20	52		
$GreenAssetRatio_i^T$	1.3500	0.1350	< 0.001***	0.8173
$GreenAssetRatio_i^C$	1.5800	0.1500	< 0.001***	0.8885
Assets Excluded from the Numerator	42.9200	44.9900	0.99	0.0029
Assets Excluded from the Denominator	29.5700	5.5200	< 0.001***	0.8519
overage	34.5250	46.0750	0.008***	0.4038
Taxonomy eligibility	29.0800	17.6850	0.04**	0.3183
Conversion Rate	4.3650	0.9900	< 0.001***	0,5673
N	11	29		
Green Asset Ratio Flow	1.1100	0.7400	0.12	0.3229

This table reports statistics of disclosed Taxonomy metrics for 2023 dividing the sample between large and small banks. The sample comprises 52 small (savings and cooperative) banks headquartered in Germany and 20 large banks with relevant presence on the German banking market for the reporting period of 2023. Column 2 reports the median of metrics among large banks. Column 3 reports the median of metrics among small banks. Column 4 reports p-values, column 5 reports the rank-biseral correlation as non-parametric effect-size measure for the Mann–Whitney test, quantifying the strength of differences in rank-based outcomes. N for GAR Flow is lower, because some banks do not yet distinguish between GAR Stock and Flow. For metric definitions and details see Table 6.2.*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

The data for most metrics within the sample exhibit high variability. In particular, the results show statistically significant differences across most metrics. Large banks disclose substantially higher GARs based on both turnover and capex ($p < 0.001$), supported by large effect sizes ($r_{rb} = 0.82$ and $r_{rb} = 0.89$, respectively), while small banks report values close to zero (Figure 6.2 Distribution A). However, this result must be viewed in context, as about 99% of assets in the banks' portfolios are not classified as aligned according to the EU Taxonomy. I found no statistically significant differences between the GARs based on turnover or capex, for both groups. Therefore, for those metrics that distinguish between turnover and capex, unless stated otherwise, the following analysis will focus on turnover metrics. Large banks also exhibit significantly higher eligibility shares ($p = 0.04$, $r_{rb} = 0.32$, Figure 6.2 Distribution E) and significantly higher conversion rates ($p < 0.001$, $r_{rb} = 0.57$, Figure 6.2 Distribution F) with medium to high effect sizes, indicating that a greater proportion of the assets they assess falls within Taxonomy-defined activities and meets alignment criteria. In contrast, small banks display significantly higher coverage ratios with medium effect size ($p = 0.008$, $r_{rb} = 0.40$, Figure 6.2 Distribution D), meaning a larger share of their balance sheet enters the Taxonomy assessment, but this does not translate into higher alignment. Large banks additionally report a significantly greater share of assets excluded from the denominator with large effect size ($p < 0.001$, $r_{rb} = 0.85$, Figure 6.2 Distribution C), suggesting structural differences in balance sheet composition. Assets excluded from the denominator compromise e.g. exposures towards central banks and states (for details, see Figure 6.1). For newly originated assets (GAR Flow), no statistically significant difference is detected ($p = 0.12$, Figure 6.2 Distribution G), indicating that current lending activity may be more similar across bank types than stock metrics imply. Comparing GAR Flow to the GAR based on turnover (for stock of assets) reveals no significant differences for large banks, but significant differences for small banks with a large effect size ($p < 0.001$, $r_{rb} = 0.66$).

Figure 6.3 provides graphical distribution plots for comparing Real Estate metrics of large and small banks, which visually confirm the patterns identified by the Mann–Whitney tests in Table 6.7.

Figure 6.3: The figure plots medians and distributions of Real Estate metrics for large and small banks.



The sample comprises 52 small (savings and cooperative) banks headquartered in Germany and 20 large banks with relevant presence on the German banking market for the reporting period of 2023. I computed the reported values based on disclosed data found in the Taxonomy disclosure in annual reports, non-financial reports such as ESG reports and DNK reports. Figure 6.3D excludes one outlier (Sparda Bank Baden-Württemberg: 100%). See Table 6.3 and Table 6.7 for metrics definitions and statistics of metrics comparing the bank types, respectively. To compare the distributions of metrics between large and small banks, I apply the Mann–Whitney test. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Table 6.7: Comparisons between large and small banks' Real Estate metrics

	Median large banks (%)	Median small banks (%)	p-value	Rank-biseral correlation (r_{rb})
N	20	52		
Real Estate Loans in Taxonomy-relevant Assets	54.9450	71.3100	0.007***	0.4058
Eligibility of Collateralised Real Estate Loans	99.4650	88.8150	0.018**	0.3500
Alignment of Collateralised Real Estate Loans	3.6000	0.3050	0.001***	0.4760
Conversion Rate Collateralised Real Estate Loans	3.8500	0.5750	0.164	0.2115
Eligibility of Real Estate Loans in Total Eligible Assets	85.2150	93.6650	0.010**	0.3808
N	20	46		
Alignment of Real Estate Loans in Total Aligned Assets	31.8600	78.3650	0.089*	0.2641

This table reports statistics of computed Real Estate metrics for 2023 dividing the sample between large and small banks. The sample comprises 52 small (savings and cooperative) banks headquartered in Germany and 20 large banks with relevant presence on the German banking market for the reporting period of 2023. Column 2 reports the median of metrics among large banks. Column 3 reports the median of metrics among small banks. Column 4 reports p-values, column 5 reports the rank-biseral correlation as non-parametric effect-size measure for the Mann–Whitney test, quantifying the strength of differences in rank-based outcomes. N for Alignment of Real Estate Loans in Total Aligned Assets is lower, because some small banks in the sample have no Taxonomy aligned assets. For metric definitions and details see Table 6.3.*, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

The results show several statistically significant differences. Small banks exhibit a significantly higher share of real estate loans towards households within their Taxonomy-relevant assets with medium effect size ($p = 0.007$, $r_{rb} = 0.41$), indicating that real estate exposures form a more dominant component of their balance sheets in the context of Taxonomy assessment. Large banks, in contrast, show significantly higher eligibility of collateralised real estate loans with medium effect size ($p = 0.018$, $r_{rb} = 0.35$) and significantly higher alignment of these exposures with medium effect size ($p = 0.001$, $r_{rb} = 0.48$). These patterns suggest that while small banks concentrate a larger portion of their Taxonomy-relevant portfolio in real estate, they convert a smaller share into Taxonomy aligned assets. Eligibility of real estate loans within total eligible assets is significantly higher among small banks (median 93.67%) than large banks with medium effect size ($p = 0.010$, $r_{rb} = 0.38$), reflecting that banks' total eligible assets in this group are predominantly real-estate-backed. The same applies for alignment of real estate loans within total aligned assets, which is significantly higher for small banks (median 78.37%), but with a slightly smaller effect size ($p = 0.089$, $r_{rb} = 0.26$). This indicates that for the few aligned exposures small banks report, real estate constitutes the overwhelming majority, but face challenges in meeting alignment criteria, whereas large banks classify and align their real estate portfolios more extensively despite holding a more diversified asset mix.

The descriptive results suggest that across all banks in the sample, only a limited share of balance-sheet exposures enters the Taxonomy assessment, which narrows the informational content of the GAR and complicates cross-bank comparisons. While large banks report significantly higher GARs than small banks, they exhibit lower portfolio coverage under the EU Taxonomy, whereas small banks show broader coverage but substantially lower alignment rates. Taxonomy eligibility and alignment are strongly concentrated in household real estate exposures for both bank groups, underscoring the central role of this asset class for GAR outcomes.

Taken together, these structural differences raise the question of whether observed variation in GARs reflect external stakeholder information needs. Against this background, the following section formally examines whether reported GARs are associated with stakeholder demand of bank disclosure and information environment.

6.4.3 Research design

To empirically investigate variation in banks' GARs reporting practice, the paper estimates the following OLS regression as main model:

$$\begin{aligned} GreenAssetRatio_i^{TURN} &= \beta_0 + \beta_1 GreenSentiment_i + \beta_2 PublicPressure_i \\ &+ \beta_3 ln(TotalAssets)_i + \beta_4 ROA_i + \beta_5 Leverage_i + \varepsilon_i \end{aligned} \tag{6.1}$$

and

$$\begin{aligned} GreenAssetRatio_i^{CAPEX} &= \beta_0 + \beta_1 GreenSentiment_i + \beta_2 PublicPressure_i \\ &+ \beta_3 ln(TotalAssets)_i + \beta_4 ROA_i + \beta_5 Leverage_i + \varepsilon_i \end{aligned} \tag{6.2}$$

The dependent variables $GreenAssetRatio_i^{TURN}$ and $GreenAssetRatio_i^{CAPEX}$ measure the share of Taxonomy aligned assets in total covered assets for bank i, based on turnover and capital expenditure alignment, respectively, for the 2023 reporting period.

Our main independent variables of interest are $GreenSentiment_i$ and $PublicPressure_i$. $GreenSentiment_i$ captures stakeholder sustainability information needs in the bank's operating environment. Based on prior literature indicating that public preferences for climate action increasingly shape banks' disclosure (e.g. Haque & Ntim, 2020), I expect that banks operating in environments with stronger pro-environmental sentiment face stronger incentives to demonstrate sustainability performance through the GAR. If sustainability preferences are high, stakeholders may demand banks to take visible steps toward green financing, or at minimum to credibly document the sustainability of their portfolios. For large banks operating at a national or international level, sustainability preferences are proxied using the Climate Perceptions Index (CPI), a country-level sustainability perception measure that reflects public awareness, risk perception, and support for climate action. This approach assumes that large banks are primarily exposed to nationwide political climates and social expectations, rather than localized preferences (Htitich et al., 2025). For small, locally operating banks, however, comparable sentiment measures at the local level are not available. Small savings and cooperative banks are closely embedded in their regional environments and are therefore more directly influenced by local political preferences. For these institutions, regional vote shares of green and left-leaning parties in the 2021 federal election serve as a proxy for local green sentiment, based on the assumption that these parties place greater emphasis on environmental and climate-related policies than conservative parties (Carter, 2013; Gulenko et al., 2025; Thomeczek, 2017). Green and left vote shares thus provide a meaningful indicator of sustainability preferences in the banks' immediate operating environment. Using national CPI sentiment for large banks and regional election-based sentiment for small banks ensures conceptual consistency by measuring sustainability preferences at the level most relevant for each bank type. Detailed variable definitions and data construction are provided in Table A.6.1 and Table A.6.2. In particular, I predict that stronger green sentiment in a bank's operating environment is associated with higher GAR disclosure.

$PublicPressure_i$ reflects the banks' information environment, represented by the extent of external monitoring and societal visibility to which a bank is exposed, consistent with evidence that environmental disclosure responds to public and political pressure (Darrell & Schwartz, 1997). Because the nature of this pressure differs structurally between small regional banks and large universal banks, the measure is adapted accordingly. For large banks, public pressure is proxied by their classification as systemically important institutions under direct ECB supervision, which subjects them to intense public, regulatory and stakeholder scrutiny. For small banks, public pressure is measured by newspaper circulation per capita, capturing the strength of the local media environment. Higher media penetration enhances public monitoring capacity and increases transparency, with research showing that regions with greater newspaper reach exhibit stronger accountability and higher levels of environmental disclosure (Boix et al., 2003; Brown & Deegan, 1998; Fidiana, 2022). To maintain comparability across bank types, large banks are assigned the maximum observed value of the newspaper-based measure, reflecting their structurally elevated and non-local exposure to scrutiny. While a few smaller institutions may also fall under ECB supervision, their overall visibility and systemic relevance remain fundamentally different, justifying the differentiated measurement approach. Operational definitions and data construction are provided in Table A.6.1. I predict that higher public pressure through intensive local media exposure or ECB-level supervisory scrutiny is positively associated with a bank's GAR.

I also include a set of bank-level control variables to account for other factors that might affect a bank's GAR. Specifically, the models controls for bank size, measured as the natural logarithm of a bank's total assets ($TotalAssets_i$), profitability (ROA_i), and leverage ($Leverage_i$). These factors account for differences in banks' size, performance, and capital structure that could influence their ability or willingness to finance green projects (Gallo & Christensen, 2011; Gulenko et al., 2025; Hoque et al., 2024; Yin et al., 2021). I therefore expect bank size and profitability to be positively associated with the GAR, as larger and more profitable banks could possess greater resources and capacity to engage in Taxonomy aligned activities. In contrast, leverage may be negatively associated with the GAR, since highly leveraged banks face stronger regulatory capital constraints that could limit green financing. By including these controls, I isolate the impact of $GreenSentiment_i$ and $PublicPressure_i$ on the GAR from these other influences. The error term ε_i captures unobserved heterogeneity.

Further, as a robustness check, I re-estimate the regression model using only the subsample of small banks (n = 52), excluding large banks for which green sentiment and public pressure are measured at the national level. This test examines whether the baseline results persist within a more homogeneous group of regionally operating institutions and are not driven by structural differences between large and small banks.

6.5 Results

6.5.1 Descriptive statistics

Table 6.8 reports descriptive statistics for the main variables used in the regression analysis. The sample comprises 72 banks with headquarters or relevant presence in Germany for which GARs can be computed for the reporting year 2023.

Table 6.8: Descriptive Statistics for main variables

	N	Mean (%)	Std. Dev.	P25 (%)	Median (%)	P75 (%)
Dependent variables:						
$GreenAssetRatio_i^{TURN}$	72	0.0063	0.0111	0.0008	0.0024	0.0056
$GreenAssetRatio_i^{CAPEX}$	72	0.0072	0.0116	0.0011	0.0032	0.0071
Independent variables:						
$GreenSentiment_i$	72	0.5394	0.0739	0.4969	0.5522	0.5950
$PublicPressure_i$	72	0.1526	0.2205	0.0026	0.0032	0.4880
Bank-level controls:						
$TotalAssets_i$ (ln, EUR mil.)	72	10.5128	1.8696	9.3122	9.5839	12.0209
ROA_i (%)	72	0.3287	0.2764	0.1398	0.2244	0.4224
$Leverage_i$ (%)	72	8.3226	2.2743	6.3677	8.7367	9.7309

The table reports the descriptive statistics for the main variables used in equation (1). The sample comprises 72 banks with headquarter or relevant presence in Germany for which I have disclosure data to compute the GARs on the bank level for 2023. I winsorise all continuous variables at the 1st and 99th percentile to mitigate the influence of outliers. For variable definitions and details see Table A.6.1.

The descriptive statistics show that GARs are generally very low compared to total covered assets across the sample. The median GAR based on turnover amounts to 0.24%, while the corresponding capex-based measure has a median of 0.32%. Even at the 75th percentile, GAR values remain below 1%, indicating that only a very small fraction of banks' balance sheets is classified as Taxonomy aligned. The distribution is highly skewed, with a small number of banks reporting higher alignment levels, while many institutions report values close to zero. This pattern is consistent with prior evidence documenting low levels of Taxonomy alignment. The independent variables exhibit substantial variation across banks. Green sentiment, which captures sustainability preferences in the banks' operating environments, shows moderate dispersion, with values ranging from 0.50 at the 25th percentile to approximately 0.60 at the 75th percentile. Public pressure displays considerably stronger heterogeneity, reflected in a low median value (0.32%) but a high standard deviation. This dispersion mirrors the structural differences between banks that face primarily local public scrutiny and those exposed to elevated national or supranational oversight. The bank-level control variables also reveal notable cross-sectional variation. Total assets span a wide range, reflecting the inclusion of both small regional banks and large universal banks. Profitability, measured by return on assets, shows moderate dispersion, with a median of 0.22%, while leverage ratios vary between 6.4% and 9.7% at the interquartile range. Overall, the descriptive statistics indicate substantial heterogeneity in both bank characteristics and institutional environments, providing a suitable basis for the subsequent regression analysis.

6.5.2 Baseline OLS results

Table 6.9 reports the baseline OLS regression results from examining the association between banks' GARs, based on turnover- and capex-aligned taxonomy shares, green sentiment, public pressure, and bank-level characteristics.

Table 6.9: Determinants of Bank-Level Green Asset Ratios

Dependent variable	$GreenAssetRatio_i^{TURN}$	$GreenAssetRatio_i^{CAPEX}$
Sample	Full sample	Full sample
Observations	72	72
Intercept	-0.0195	-0.0294**
	(0.0135)	(0.0124)
$GreenSentiment_i$	-0.0491**	-0.0445**
	(0.0233)	(0.0221)
$PublicPressure_i$	0.0025	0.0010
	(0.0075)	(0.0070)
$TotalAssets_i$ (ln, EUR mil.)	0.0044***	0.0051***
	(0.0011)	(0.0010)
ROA_i (%)	0.0063	0.0068
	(0.0050)	(0.0049)
$Leverage_i$ (%)	0.0004	0.0006
	(0.0004)	(0.0004)
Adj. R^2	0.4912	0.5622
SE (Standard errors)	Heteroscedasticity robust	Heteroscedasticity robust

The table reports OLS coefficient estimates from regressions of the *Green Asset Ratios* on the independent variables *Green Sentiment$_i$*, *Public Pressure$_i$* and control variables used in equation (1). I collect for each bank the $GreenAssetRatio_i^{TURN}$ and $GreenAssetRatio_i^{CAPEX}$ which is reported according to Article 8 of the EU Taxonomy as a ratio of banks' Taxonomy aligned assets over total covered assets. *Green Sentiment* is an independent variable that captures stakeholder demand of sustainability information as measured by the degree to which societal preferences favor environmental sustainability in the political and social environment in which a bank operates. The metric is proxied by local election outcomes and countries' Climate Perception Index. *Public Pressure* is an independent variable that captures the stakeholder information environment as measured by the degree of external scrutiny and societal expectations banks are exposed to, arising from media visibility and regulatory oversight. The metric is proxied by the local newspaper environment and ECB supervision. The sample comprises 72 banks with headquarter or relevant presence in the German banking market for the reporting period of 2023. The bank-level controls are Total Assets$_i$, ROA$_i$ and Leverage$_i$. For detailed variable definitions, see Table A.6.1. Heteroskedasticity-robust standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Across both specifications, green sentiment is negatively and statistically significantly associated with GARs. The coefficient is significant at the 5% level for both the turnover-based and capex-based measures. Economically, this implies that banks operating in environments with stronger demand for sustainability information disclose lower GARs, holding other factors constant. This finding contrasts with the expectation that stakeholders' stronger societal preferences for sustainability translate into higher reported KPIs. Public pressure does not exhibit a statistically significant association with either GAR measure. Neither local media intensity nor heightened supervisory visibility is linked to higher disclosed GARs in the cross-section of banks. This suggests that variation in external scrutiny does not explain differences in GAR disclosures. Among the control variables, bank size emerges as the most robust determinant of GARs. Total assets are positively and significantly associated with both turnover- and capex-based GARs at the 1% level. Larger banks therefore tend to disclose higher GARs, independent of green sentiment and public pressure. In contrast, profitability (ROA) and the leverage ratio are not significantly related to GARs in either specification. The models display substantial explanatory power for a single-year cross-sectional analysis, with adjusted R^2 values of 0.49 and 0.56, respectively. This indicates that a sizable share of the variation in banks' GARs is captured by the included variables.

These findings show that cross-sectional differences in GAR disclosures are not associated with public pressure, but bank size and green sentiment. However, contrary to what I expected, green sentiment is negatively associated with disclosed GARs. Section 4.3 examines the robustness of these findings.

6.5.3 Robustness

To assess whether the baseline results are driven by the inclusion of large banks, Table 6.10 reports regression estimates for a subsample restricted to small banks only, comprising savings and cooperative banks headquartered in Germany.

Table 6.10: Robustness check: Small banks

Dependent variable	$GreenAssetRatio_i^{TURN}$	$GreenAssetRatio_i^{CAPEX}$
Sample	Small banks only	Small banks only
Observations	52	52
Intercept	-0.0063	-0.0072
	(0.0057)	(0.0058)
$GreenSentiment_i$	-0.0122***	-0.0135***
	(0.0043)	(0.0047)
$PublicPressure_i$	-0.0008	-0.0008
	(0.0016)	(0.0018)
$TotalAssets_i$ (ln, EUR mil.)	0.0014***	0.0015***
	(0.0005)	(0.0005)
ROA_i (%)	0.0003	-0.0002
	(0.0015)	(0.0016)
$Leverage_i$ (%)	0.0002*	0.0003**
	(0.0001)	(0.0001)
Adj. R^2	0.1854	0.1990
SE (Standard errors)	Heteroscedasticity robust	Heteroscedasticity robust

The table reports OLS coefficient estimates from regressions of the *Green Asset Ratios* on the independent variables *Green Sentiment$_i$*, *Public Pressure$_i$* and control variables used in equation (1) for the sample of small banks only. I collect for each bank the $GreenAssetRatio_i^{TURN}$ and $GreenAssetRatio_i^{CAPEX}$ which is reported according to Article 8 of the EU Taxonomy as a ratio of banks' Taxonomy aligned assets over total covered assets. *Green Sentiment* is an independent variable that captures the degree to which societal preferences favor environmental sustainability in the political environment in which a bank operates. The metric is proxied by local election outcomes and countries' Climate Perception Index. *Public Pressure* is an independent variable that captures the stakeholder information environment as measured by the degree of external scrutiny and societal expectations banks are exposed to, arising from media visibility. The sample comprises 52 (savings and cooperative) banks headquartered in Germany for the reporting period of 2023. The bank-level controls are Total Assets$_i$, ROA$_i$ and Leverage$_i$. For variable definitions, see Table A.6.1. Heteroskedasticity-robust standard errors are reported in parentheses. *, ** and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

The specification mirrors the baseline model and includes the same independent variables and controls. The results largely confirm the baseline findings. Green Sentiment remains negatively and statistically significant at the 1% level in both the turnover- and capex-based specifications. Although the magnitude of the coefficient is smaller than in the full sample, the estimates are more precise, reflected in lower standard errors. This indicates that the negative association between green sentiment and disclosed GARs is not driven by large banks but persists within the group of locally operating institutions. Public pressure again shows no statistically significant association with either GAR measure. The coefficients are close to zero, suggesting that variation in local media intensity does not explain differences in GAR disclosures among small banks. Among the control variables, bank size continues to be positively and significantly associated with both GAR measures at the 1% level, even within the more homogeneous group of small banks. This finding reinforces the baseline result that institutional scale is a determinant of GAR disclosures. Profitability (ROA) remains insignificant, while the leverage ratio is statistically significant at the 10% and 5% level for both turnover- and capex-based GAR measures, respectively, although the economic magnitude of this effect is small. The explanatory power of the models is lower than in the full-sample regressions, with adjusted R^2 values of approximately 0.19, which is expected given the reduced variation within the subsample.

Overall, the robustness analysis confirms that the main results are not driven by large banks and that the negative relationship between stakeholder demand für sustainability information and disclosed GARs, the positive significant association with bank size, as well as the insignificance of public pressure, persists among small banks.

6.6 Discussion and Implications

6.6.1 Interpreting the empirical results in light of disclosure-based market discipline

The empirical results indicate that the hypothesised positive link between disclosed GARs and stakeholder demand for sustainability information in banks' operating environments is not supported by the data. Instead, banks operating in regions with stronger pro-environmental political preferences report lower turnover- and capex-based GARs. This finding contrasts with the expectation derived from the literature that stronger sustainability preferences create incentives for banks to signal alignment with environmental objectives through more extensive disclosure. Rather than increasing in environments where demand for sustainability-related information should be stronger, disclosed GARs decrease, holding other bank characteristics constant. This pattern suggests that the Green Asset Ratio, as currently constructed and reported, does not vary in line with the stakeholder demand for sustainability information that disclosure-based market discipline assumes.

Public pressure, capturing the banks' information environment through media visibility and supervisory oversight, is likewise not associated with higher GARs. Even where sustainability issues receive greater public attention or where institutions are subject to more intensive supervisory scrutiny, banks do not report systematically higher alignment ratios. This suggests that even in contexts where sustainability issues receive greater public attention and institutional monitoring is more intense, banks do not disclose higher GARs. This stands in contrast to prior evidence showing that firms often expand environmental reporting when exposed to stronger public or political scrutiny.

In contrast, institutional scale emerges as the most consistent correlate of higher disclosed GARs, both in the full sample and within the subsample of small banks. While the analysis does not identify the underlying mechanisms, this pattern is consistent with the idea that larger institutions differ along dimensions such as portfolio composition, data availability, or reporting capacity, which may facilitate the classification and alignment of assets under the EU Taxonomy.

At the same time, the descriptive evidence highlights that reported GARs remain very small in absolute terms and that only a limited share of banks' balance sheets enters the Taxonomy assessment. As a result, even statistically significant differences in GARs translate into economically small differences in alignment shares. This constrains the economic interpretability of cross-bank comparisons and makes it difficult to attribute observed variation in GARs to substantive differences in banks' sustainability orientation.

The descriptive evidence further shows that household real estate lending plays a central role in shaping GARs across all bank types. For both large and small banks, eligibility and alignment are strongly concentrated in real estate exposures, indicating that this asset class constitutes the primary channel through which Taxonomy alignment enters bank balance sheets. At the same time, alignment remains low in absolute terms relative to total assets, despite comparatively higher conversion rates within eligible real estate portfolios, particularly among large banks. This combination suggests that GAR outcomes are highly sensitive to how this dominant asset class is classified and assessed under the Taxonomy framework, and to the availability of the data required to demonstrate alignment.

Importantly, these findings do not imply that banks operating in more sustainability-oriented or highly scrutinised environments engage more or less in sustainable activities. Rather, they indicate that the Green Asset Ratio, in its current design, does not systematically vary with stakeholder demand for sustainability information or with the banks' information environment. When reported values are very small and sensitive to coverage rules and classification criteria, minor numerical differences may appear meaningful, although they reflect the mechanics of the metric as much as underlying financing behaviour. In this sense, the GAR may not fully perform the role implicitly assigned to it within a disclosure-based market discipline framework.

6.6.2 Structural and mechanical limitations of the Green Asset Ratio

The empirical patterns are consistent with concerns raised in the literature regarding the structural design of the GAR. A defining feature of the GAR is that it measures Taxonomy alignment relative to a restricted subset of assets that fall within the scope of the Taxonomy assessment, rather than relative to banks' total balance sheets. As a result, reported GAR values depend jointly on the extent of alignment in the numerator and on the size and composition of the denominator, which captures only covered exposures. The negative association between stakeholder demand for sustainability information and reported GARs further underscores these structural features. One plausible interpretation, consistent with the descriptive results, is that banks operating in environments with stronger sustainability preferences could be more exposed to asset classes that are environmentally relevant but difficult to assess or align under current Taxonomy rules. Household real estate lending further illustrates this tension. While it constitutes a central component of banks' portfolios and plays a key role in the climate transition, it is subject to stringent technical screening criteria and substantial data requirements. Lower GAR values in such contexts may therefore reflect constraints embedded in the indicator's construction rather than weaker sustainability engagement by banks.

Overall, the results suggest that the GAR is sensitive to coverage effects and mechanical features of the Taxonomy framework rather than stakeholder information needs. This limits its ability to function as an effective market-based steering mechanism, comparing banks' sustainability performance across heterogeneous banking institutions, particularly in early reporting years.

6.6.3 Implications for interpretation and metric design

The findings imply that GARs should be interpreted with caution when used for benchmarking or comparative assessment. These results highlight the importance of complementing the headline GAR with additional indicators that provide context, such as eligibility shares or conversion rates. Such metrics can help disentangle alignment outcomes from coverage effects and improve the interpretability of Taxonomy disclosures without requiring additional data. From a market-discipline perspective, greater transparency about the components underlying the GAR is crucial if disclosures are to support informed decision-making by investors and other stakeholders.

Recent regulatory developments partially acknowledge these challenges. The simplifications introduced by the Delegated Act (EU) 2026/73, including the exclusion of certain assets from both the numerator and the denominator, aim to improve consistency and reduce structural distortions in the GAR. However, these adjustments do not fundamentally alter the indicator's reliance on limited coverage, nor do they eliminate interpretability challenges. In fact, a reduced scope of Taxonomy and CSRD applicability may further constrain coverage in some banking segments.

Accordingly, the relevance of this study extends beyond a specific regulatory calibration at a single point in time. By focusing on the informational properties of the GAR and its relationship to stakeholder information needs, the analysis speaks to more fundamental questions about how disclosure-based sustainability metrics function in practice. Future reporting cycles will allow for an assessment of whether regulatory refinements materially enhance the GAR's ability to reflect sustainability performance and support market discipline, or whether additional conceptual adjustments are required.

6.7 Conclusion

This paper provides an empirical analysis of GAR disclosures using EU Taxonomy data from a sample of both large universal banks and small regional banks with relevant presence in Germany. By combining descriptive comparisons with multivariate regression analysis, the study examines whether the GAR reporting practice reflects external stakeholder demand for sustainability information and information environment. The analysis is grounded in the

EU's disclosure-based approach to sustainable finance and assesses whether the GAR functions as an informative indicator within this framework. In doing so, it complements prior work that estimates banks' green assets or discusses conceptual shortcomings of the EU Taxonomy by analysing actual disclosed data and relating it to observable bank characteristics and external environments.

The results show that banks operating in regions with stronger pro-environmental political preferences report lower GARs. While public pressure is not associated with higher GARs, bank size is positively related to GAR values. These findings suggest that, in its current form, the GAR does not systematically respond to variation in stakeholder information demand and therefore may not fully capture the external pressures that disclosure-based market discipline presupposes. Importantly, this does not imply that banks operating in greener or more highly scrutinised environments engage less in sustainable activities. Rather, the results indicate that observed variation in GARs may be difficult to interpret without careful consideration of institutional context and reporting conditions, which raises the risk of misinterpretation when the GAR is used as a standalone benchmarking indicator.

The findings inform the ongoing political and regulatory debate on the EU Taxonomy by providing empirical evidence on how the GAR behaves in practice across different types of banks. Recent regulatory adjustments aim to simplify the calculation of the GAR and improve comparability, yet it remains uncertain whether such simplifying adjustments will materially enhance the ability of the GAR to capture stakeholder information needs and support market discipline. By focusing on the informational properties of the GAR rather than on a specific regulatory calibration, this study contributes to the broader debate on how sustainability disclosure metrics should be designed and interpreted to fulfil their intended role in the EU's market-based approach to sustainable finance.

Even though this study provides important insights, it has some limitations that lead to further research potential. First, the analysis is based on a single reporting year, and future studies could examine additional reporting periods to assess whether the observed patterns persist beyond the initial implementation phase of Taxonomy disclosures. Second, the sample is restricted to banks headquartered in Germany or with a significant presence in the German market. Extending the analysis to other EU countries could reveal how different institutional and regulatory contexts affect GAR disclosures. Third, the GAR captures only Taxonomy-covered activities and includes "enabling" activities, which may distort interpretation and limit its ability to reflect underlying sustainability engagement. Future research should address these limitations to improve the understanding of how the design of the GAR affects its interpretability and its usefulness for market discipline as the regulatory framework continues to evolve.

A Appendices

Table A.6.11: Description of Variables

Variable	Description
Dependent variables:	
$GreenAssetRatio_i^{TURN}$	Ratio of banks' Taxonomy aligned assets over total covered assets that are reported in bank disclosures (i.e. annual reports, non-financial reports such as ESG reports, DNK reports), based on counterparties' Taxonomy aligned Turnover.
$GreenAssetRatio_i^{CAPEX}$	Ratio of banks' Taxonomy aligned assets over total covered assets that are reported in bank disclosures (i.e. annual reports, non-financial reports such as ESG reports, DNK reports), based on counterparties' Taxonomy aligned Capital Expenditures (capex).
Independent variables:	
$GreenSentiment_i$*	Presents stakeholder demand of sustainability information, proxied by the Climate Perceptions Index (CPI) for large bank i. Where exact numerical CPI scores are not available, I self-construct tier classifications that I convert into a harmonized continuous measure. For further details, see Table A.6.12. For a small and local bank i, green sentiment is proxied by the ratio of left and green party votes (Grüne, Die Linke and the Social Democratic Party) over all valid votes in the 2021 federal election, based on the assumption that these parties place greater emphasis on environmental and climate-related policies than conservative parties (Gulenko et al., 2025; Thomeczek, 2017). In a second step, I manually match the banks to regional election results based on the AGS of their headquarters. Source: Germanwatch, *Bundeszentrale für politische Bildung*
$PublicPressure_i$*	Presents stakeholder information environment, proxied by the ratio of total paid newspaper circulation to population size (newspaper circulation per capita) for small and local bank i. In a second step, I manually match the banks to local newspaper circulation data based on the AGS of their headquarters. For a large bank i, public pressure is proxied by their classification as systemically important institutions subject to direct supervision by the European Central Bank. To ensure comparability with the newspaper-based measure used for smaller banks, large banks are assigned the maximum observed value of the newspaper-based public pressure measure. Source: ZMG Mediaservice.
Bank-level controls:	
$TotalAssets_i$*	The natural logarithm of total assets of bank i in year 2023 in EUR million. Source: Orbis and Annual Reports on individual banks' websites.
ROA_i (%)*	Return on assets, defined as net income divided by average total assets of bank i in year 2023. Source: Annual Reports on individual banks' websites.
$Leverage_i$ (%)*	Total equity divided by total assets of bank i in year 2023. Source: Orbis and Annual Reports on individual banks' websites.

* I winsorize these variables at 1% and 99%.

Table A.6.12: Green Sentiment for large banks

Country	CPI Tier	Rank	Approximated CPI Score Range	CPI Score	Source
Spain	1	6	63 – 66	65.6	CPI score according to Htitich *et al.* (2025)
France	1	9	63 – 66	64.4	CPI score according to Htitich *et al.* (2025)
Italy	1	11	63 – 66	62.8	CPI score according to Htitich *et al.* (2025)
Austria	2	20	58 – 62	60.8	CPI score according to Htitich *et al.* (2025)
Ireland	2	unknown	58 – 62	60.0	Approximated based on Htitich *et al.* (2025)
Germany	2	31	58 – 62	59.5	Approximated based on Htitich *et al.* (2025)
Denmark	3	unknown	53 – 57	55.0	Approximated based on Htitich *et al.* (2025)
Finland	4	unknown	48 – 52	50.0	Approximated based on Htitich *et al.* (2025)
Netherlands	5	unknown	< 48	47.0	Approximated based on Htitich *et al.* (2025)

This appendix reports the construction of national green sentiment used for large banks, based on the Climate Perceptions Index (CPI) developed by Htitich *et al.* (2025). Based on the CPI, the authors rank countries based on public awareness, risk perception, and commitment to climate action. Where exact CPI scores are reported, I use these values directly. For countries without published scores, based on CPI tiers and global ranks, I approximate the scores by assigning conservative midpoint values within the tier-specific score ranges, unless other information is available. For Germany, I assign a score slightly below the tier midpoint due to its lower relative rank within Tier 2 compared to Austria. For the Netherlands, which is classified in the lowest CPI tier without a reported score, I assign a score that represents a conservative low-tier estimate while avoiding an extreme lower-bound assumption in the absence of precise ranking information.

Part III: The Abatement Impact Factor in Residential Building Renovations

7 The Abatement Impact Factor: Linking Sustainable Finance and Carbon Reduction in Residential Building Renovations

Abstract Decarbonising the residential building sector requires substantial investment, yet limited guidance exists on how scarce capital should be allocated at the asset level to maximise climate impact. This paper introduces the Abatement Impact Factor (AIF), an investment-oriented metric that adapts the logic of marginal abatement cost curves to building-level renovation decisions by expressing lifecycle greenhouse gas abatement per euro invested. The AIF is applied to a simulated sample of 4,160 multi-residential buildings representing thirteen renovation scenarios within the German housing stock. The analysis evaluates differences in transformative impact across renovation measures and building characteristics. The results reveal pronounced heterogeneity in abatement efficiency. Low-carbon technologies, particularly heat pumps, consistently achieve the highest impact per euro invested, while older and energy-inefficient buildings offer greater abatement potential. These findings illustrate how investment effectiveness varies systematically across technologies and baseline building conditions. The paper contributes to the sustainable and transition finance literature by operationalising asset-level impact measurement and linking environmental outcomes directly to capital allocation decisions. The AIF further provides a practical tool for portfolio steering, supporting credit institutions in the design of impact-oriented financing, guiding building owners in prioritising renovation measures based on environmental impact and assisting policymakers in targeting limited public and private capital toward renovation pathways with the highest decarbonisation potential.

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7.1 Introduction

The global building sector accounts for approximately 39% of energy-related emissions, rendering deep renovation of the existing building stock essential to achieving the targets of the Paris Agreement (International Energy Agency & Global Alliance for Buildings and Construction, 2019). In response, the European Commission's Renovation Wave estimates cumulative investment needs of more than €3.5 trillion by 2030 (Green Finance Institute, 2024, p. 6). Despite this scale of required capital mobilisation, there is limited methodological guidance on how scarce investment capital should be allocated at the asset level to maximise decarbonisation outcomes. As a result, a gap persists between macro-level climate targets and actionable, budget-constrained investment decisions at the level of individual buildings.

To address this gap, this paper introduces the Abatement Impact Factor (AIF), a novel, investment-oriented metric that adapts the logic of marginal abatement cost (MAC) curves to building-level decision-making. By expressing lifecycle greenhouse gas (GHG) abatement per euro invested, the AIF provides a decision-relevant indicator that links environmental outcomes directly to capital allocation choices. The paper develops a conceptual framework for the AIF and applies it to a simulated sample of 4,160 multi-residential buildings, representing diverse building types and thirteen renovation scenarios within the German housing stock. Using non-parametric significance testing, the analysis evaluates differences in transformative impact across renovation measures and building characteristics, including construction year, heating system, and regional cost variation.

The results reveal substantial heterogeneity in the transformative impact of renovation measures. Low-carbon technologies, particularly heat pumps, consistently achieve higher emission abatement per euro invested than most stand-alone energy-efficiency measures, with large effect size. Transformative impact is pronounced in older and energy-inefficient buildings, where renovation investments deliver significantly greater environmental returns, albeit with small effect sizes. At the same time, the relative ranking of renovation measures remains largely stable across building cohorts and under proportional cost changes, underscoring the robustness of the AIF as a comparative decision-making tool.

This paper contributes to the literature on sustainable and transition finance, which emphasises the role of capital allocation in shaping decarbonisation outcomes and climate-related exposure (Edmans & Kacperczyk, 2022; Sautner et al., 2023). Prior research has examined how assets, investors, and ownership structures influence sustainability outcomes (Liu et al., 2025; Lopatta et al., 2022), thereby highlighting the need for metrics that translate sustainability objectives into actionable investment decisions. While recent studies increasingly analyse investors' influence on companies' impacts (Busch et al., 2021; Caldecott, 2022; Kölbel et al., 2020; Wilkens et al., 2025) and apply life cycle–based approaches to impact measurement at the firm level (Busch, Bernard-Rau, et al., 2025; Busch, Pruessner, et al., 2025), there has been limited research on transformative impact measurement at the asset and project level in the built environment. This paper addresses this gap by introducing the AIF, which operationalises the relationship between life cycle GHG and invested capital. By adapting the logic of marginal abatement cost curves to building-specific investment decisions (Kesicki, 2013; Vogt-Schilb & Hallegatte, 2014), the AIF provides a transparent, decision-relevant metric that supports the prioritisation of renovation measures according to their transformative impact per euro invested.

Beyond its conceptual contribution, the AIF has direct implications for practice. By providing a unified indicator of environmental return on investment, it supports impact-oriented renovation prioritisation by building owners, portfolio steering and impact-linked financing by credit institutions, and the design of policy instruments aimed at maximising emission reductions under budget constraints. In this way, the AIF offers a transparent and scalable tool for integrating asset-level climate impact into renovation finance and policy decisions.

The remainder of the paper is structured as follows. Section 2 reviews the literature on transition finance and impact measurement in the building sector, develops the conceptual framework of the AIF, and derives the research hypotheses. Section 3 presents the simulation design, data assumptions, statistical analysis, results, and sensitivity testing. Section 4 discusses the key findings and their practical implications. Section 5 concludes.

7.2 Literature Review and Conceptual Framework

7.2.1 Transition Finance and Impact Measurement in the Building Sector

Sustainable finance refers to the integration of environmental, social, and governance (ESG) criteria into financial decision-making, with the objective of directing capital flows toward sustainable economic activities. Since the early 2000s, the field has evolved from screening approaches toward more targeted strategies that emphasise measurable environmental outcomes (Kumar et al., 2025; Singhania et al., 2024). Within this broader field, transition finance has emerged as a mechanism designed to mobilise capital specifically for activities that enable carbon-intensive sectors to advance toward climate neutrality. Rather than rewarding already "green" activities, transition finance supports the process of decarbonisation by prioritising investments that deliver verifiable emission reductions (Caldecott, 2022; Piemonte et al., 2019). To activate the sustainable market, the private sector needs to be involved (Maio et al., 2012).

The need for effective transition finance is particularly evident in the building sector, which globally accounts for roughly 39% of energy- and process-related emissions and is therefore central to achieving climate goals (International Energy Agency & Global Alliance for Buildings and Construction, 2019, p. 9). Meeting climate-neutrality targets set by the European Commission in the Renovation Wave requires deep renovation of the existing building stock and substantial investment volumes estimated at over €3.5 trillion euros by 2030 (Green Finance Institute, 2024, p. 6). However, renovation rates remain insufficient due to a persistent set of barriers. Bertoldi et al. (2021) emphasise, technical planning and financial decision-making in building renovations remain insufficiently integrated, resulting in suboptimal capital allocation.

Transformative change requires investing in activities that drive the underlying transition. In this context, the concept of impact is central. Academic literature defines impacts as the changes achieved in environmental and social criteria (Brest et al., 2018; Kölbel et al., 2020). Regulators have aligned with this definition in the European Sustainability Reporting Standards (Commission Delegated Regulation (EU) 2023/2772, p. 269). Building on this foundation, the Impact Frontiers (2023) distinguishes three related processes: impact measurement, defined as selecting relevant metrics and collecting quantitative and qualitative data; impact assessment, defined as contextualising and interpreting this data; and impact valuation, referring to estimating the relative financial value of impacts to enhance comparability and decision-making. Impact finance builds on these principles by seeking positive, measurable environmental or social outcomes alongside financial returns, thereby enabling the identification of concrete impact areas of influence (Bosteels et al., 2018).

Recent research discusses the investors influence on companies' impacts (Caldecott, 2022; Kölbel et al., 2020; Wilkens et al., 2025). In parallel, a growing body of literature highlights the value of life cycle assessment (Kulionis et al., 2024; Schlütter et al., 2024), providing guidance in capturing environmental impacts of processes and assets (International Organization for Standardization, 2006; Liu et al., 2025). Building on earlier studies that apply life cycle-based approaches to measure impact at the company level (Busch, Bernard-Rau, et al., 2025; Busch, Pruessner, et al., 2025), the importance of asset- and project-level decision-making motivates a shift toward evaluating impacts over the life cycle of individual buildings rather than aggregated corporate portfolios.

At the building level, transformative impact is closely linked to the extent and composition of energy-efficiency and decarbonisation measures implemented.[20] Renovation strategies typically combine measures that (i) minimise energy demand and losses, (ii) optimise building systems, and (iii) deploy advanced low-carbon technologies and on-site renewable energy generation to maximise emission reductions (Diakaki et al., 2008). The effectiveness of such strategies is highly context-specific and depends on factors including building type, occupancy patterns, energy price trajectories, and economic feasibility. In the residential sector, additional considerations such as distributional effects and rent impacts further shape renovation decisions.

Despite this growing literature on renovation strategies and life cycle–based impact assessment, a critical gap remains. While prior studies identify which measures are relevant for decarbonising the building stock, they provide limited guidance on how renovation investments can be systematically evaluated in terms of their transformative impact, that is, under which conditions a given measure yields substantial emission reductions per euro invested. A practice-oriented analysis of the residential building stock similarly highlights that ambitious renovation targets do not necessarily translate into proportionate emission reductions and emphasise the importance of cost-efficient prioritisation under real-world constraints (Bienert & Groh, 2022). Addressing this gap is essential for informing investment decisions and motivates the development of metrics that explicitly relate life cycle emission abatement to renovation costs.

In the context of climate mitigation, the most prominent economic tool linking costs and emissions outcomes has been the MAC curve, which ranks mitigation options according to their cost per ton of CO_2 reduced (Kesicki, 2013; Vogt-Schilb & Hallegatte, 2014). MAC curves have been applied across numerous sectors, including transport (e.g. Kesicki, 2012), agriculture (e.g. MacLeod et al., 2010) and the building sector (Mortimer et al., 1998; Xiao

[20] A wide range of partially overlapping terms – such as alteration, renovation, rehabilitation, refurbishment and retrofitting – are used to describe changes in buildings, reflecting the diversity of building types, intervention scales and motivations for modification (Thuvander et al., 2012). Given the absence of a universally accepted definition, as noted by Thuvander et al. (2012), this paper adopts the term *renovation* to describe interventions that upgrade buildings towards current and future standards—rather than those in place at the time of original construction—consistent with the concept proposed by Ástmarsson et al. (2013) and Jensen et al. (2018) and the terminology used in European regulation for building performance.

et al., 2014) and remain foundational as for designing cost-efficient decarbonisation strategies. However, literature documents several limitations. First, the framework typically omits co-benefits and ancillary effects (Kesicki & Ekins, 2012). Second, traditional MAC curves do not incorporate budget constraints, even though real-world decision-makers such as building owners or lenders must choose among competing options under fixed financial resources. While some studies begin to address these gaps (e.g. Rysanek & Choudhary, 2013), literature still lacks building-level methodologies that enable prioritisation of renovation measures when capital is scarce. Third, MAC curves evaluate the cost of an incremental unit of abatement and therefore assume marginal, continuous changes in emissions. This assumption is difficult to reconcile with renovation practice, where measures are often indivisible (e.g., a heat pump or window replacement cannot be installed partially). As a result, marginal abatement cannot be meaningfully defined at the level of individual renovation measures. Moreover, applying a marginal optimisation approach under budget constraints would require detailed marginal abatement functions, marginal cost curves, and interaction effects between measures, information that is rarely available and highly sensitive to modelling assumptions such as future energy prices, discount rates, and system boundaries. These complexities undermine the feasibility of a marginal formulation for practical, building-level decision-making.

These gaps provide the theoretical foundation for developing a new framework that reflects both emission-reduction potential and investment requirements of renovation measures in a budget-constrained context. A metric designed for transition finance should provide transparent, quantifiable, and verifiable impact measurement, enabling scarce capital to be channelled toward activities with the highest decarbonisation potential. It should systematically compare renovation measures based on their GHG-abatement potential per euro invested at the building level. The AIF addresses this gap by operationalising the ratio of lifecycle GHG reductions to required capital expenditure, thereby providing a decision-useful, building-specific indicator for project-level transition finance. Conceptually, the AIF retains the intuitive ranking logic of MAC curves but avoids their marginal assumptions and optimisation requirements, offering instead a transparent, scalable, and practically applicable approach for credit institutions and building owners to determine the transformative impact of renovation investments under real-world budget constraints.

7.2.2 Conceptual Framework: From Marginal Abatement Cost to the Abatement Impact Factor

To operationalize this budget-oriented perspective, we introduce the AIF as a quantitative metric for evaluating the GHG abatement potential of renovation measures. The calculation of the AIF is conducted in three sequential stages:

(1) Quantification of abated GHG emissions

(2) Determination of the total investment costs

(3) Linking abatement to investment costs: the Abatement Impact Factor.

Quantification of abated greenhouse gas emissions

Abated GHG emissions are calculated by comparing a business-as-usual scenario (BAU) with a renovation scenario, comprising either deep renovation or (a combination of) individual measures. Emissions in both scenarios are estimated using current and projected emission factors to reflect the decarbonisation of the energy sector.[21] While some studies discount emissions over time arguing that earlier emission reductions may yield higher climatic benefits, while future reductions could become cheaper due to technological progress (Tol, 2013), this approach is contested given the long-lasting physical impact of carbon emissions (Allen et al., 2009). Accordingly, this analysis applies undiscounted emissions while incorporating forward-looking emission factors.

To model abated GHG emissions[22], the analysis distinguishes between three approaches.

- a "regulated energy demand" approach,
- an "operational and use" approach, and
- a "comprehensive lifecycle" approach.

The first two approaches share an operational accounting scope, deriving abatement from changes in building operation, but differ in granularity. While the regulated approach is limited to energy demand as defined DIN 18599, the "operational and use" approach additionally captures user-dependent energy consumption and refrigerant emissions. The

[21] For the calculation of GHG emissions, emission factors are applied that account for all global warming potentials in accordance to article 5.3 of the Kyoto Protocol. The emission factors are expressed using the 100-year Global Warming Potential (GWP_{100}) in kilograms of CO_2-equivalence (Braune et al., 2020).

[22] It is to be noted that abatement is calculated pre-renovation and therefore does not capture rebound effects arising from post renovation changes in user behaviour. Evidence suggests that such effects can reduce realised energy savings relative to ex ante estimates, leading to an overestimation of decarbonisation impacts (Auer et al., 2024). This limitation highlights the need for post-renovation monitoring to validate and refine impact assessments

"comprehensive lifecycle" approach further expands the boundary to include the embodied emissions across the building lifecycle.

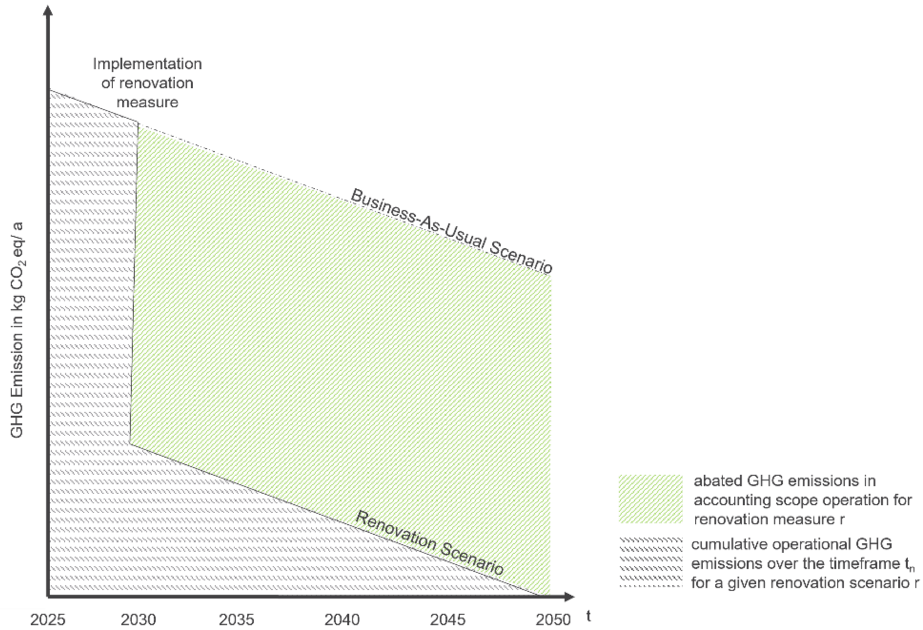
"Regulated energy demand" approach

The "regulated energy demand" approach follows the accounting logic of DIN 18599, which underpins German building energy regulation, and focuses exclusively on regulated operational energy demand. This includes energy use for heating, cooling, ventilation, domestic hot water and lighting, while excluding user-dependent electricity consumption and refrigerant-related emissions. Abated emissions are derived solely from changes in regulated operational energy demand between the renovation and BAU scenario. Reflecting standard practice in Energy Performance Certificates (EPCs), this approach offers high transparency and reproducibility. However, this approach provides only a lower-bound estimate of abatement potential and, due to the calculation rules prescribed by the standard, does not fully reflect a building's actual operational emissions. Emissions are calculated over a fixed 25-year time horizon, with 2025 as the base year and 2050 as the target year, in line with European climate targets.

"Operational and use" approach

The "operational and use" approach extends the regulatory perspective by capturing both regulated building operation (heating, cooling, ventilation, domestic hot water, and lighting) and unregulated energy use. In addition to regulated demand, it includes user-dependent electricity consumption and refrigerant-related emissions, providing a more comprehensive representation of operational emissions at the cost of higher data requirements. Direct onsite emissions, indirect emissions from imported energy (e.g. electricity and district heating), and credits for exported onsite renewable generation are calculated for both scenarios over a fixed 25-year horizon. The assessment uses 2025 as the base year and 2050 as the target year, in line with the objectives of the Paris Climate Agreement, illustrated in Figure 7.1. Declining emission trajectories in both the renovation and BAU scenarios schematically reflect the projected decarbonisation of the energy industry according to projections of the Federal Ministry for Economic Affairs and Energy.

Figure 7.1: Illustration of abated GHG emission in accounting scope operation ("regulated energy demand" and "operational and use" approach) for renovation measure r



The abated emissions in the "operational and use" approach are calculated as modelled in equation (7.1):

$$GHG^{o}_{abated,r} = GHG^{o}_{BAU} - GHG^{o}_{r} \tag{7.1}$$

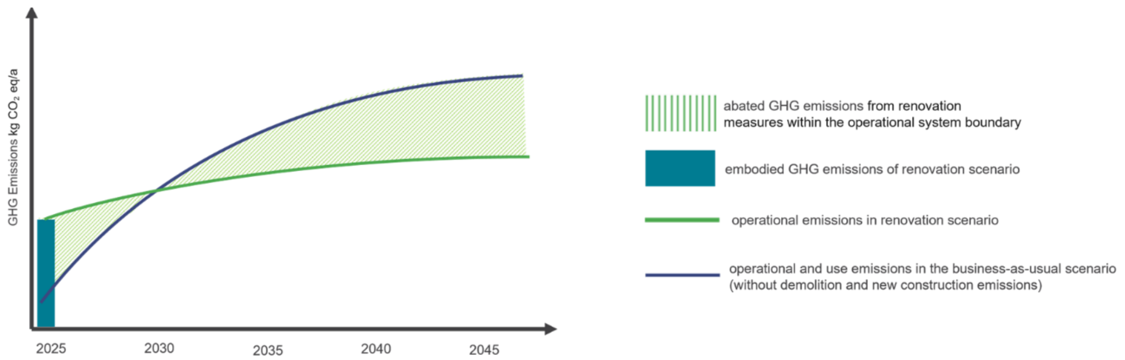
whereby:

- $GHG^{o}_{abated,\,r}$: Abated GHG emissions in accounting scope operation ("regulated energy demand"/"operational and use" approach) for the years t_1 to t_n, for renovation measure r
- GHG^{o}_{BAU}: Cumulative operational GHG emissions for the years t_1 to t_n in BAU scenario
- GHG^{o}_{r}: Cumulative operational GHG emissions for the years t_1 to t_n for a given renovation scenario with renovation measure r
- t_1: Year of renovation implementation
- t_n: Conventional period of 25 years

"Comprehensive lifecycle" approach

The "comprehensive lifecycle" approach accounts for operational, use, and embodied emissions, reflecting the increasing relevance of embodied emissions as operational emissions decline (Ibn-Mohammed et al., 2013). It adopts a holistic lifecycle perspective, encompassing emissions from material production, construction, use, end-of-life, and recycling. In the renovation scenario, material-related emissions from renovation measures are included, while the BAU scenario incorporates emissions from deconstruction and potential new construction, thereby capturing the avoided emissions associated with extending the building's lifespan through renovation. This assessment follows DIN EN 15978[23] and the system boundaries as defined in DGNB criterion ENV1.1 of the renovation system. As illustrated in Figure 7.2, abated emissions are derived by comparing cumulative lifecycle emissions in the renovation and BAU scenario, combining embodied emissions and differing trajectories of operational emissions.

Figure 7.2: "Comprehensive lifecycle" approach



The diagram shows embodied emissions from renovation alongside the differing slopes of cumulative operational emissions in the renovation and BAU scenarios, from which abated GHG emissions are derived.

Abated emissions for the comprehensive approach are modelled in equation (7.2):

$$GHG^{oc}_{abated,r} = GHG^{oc}_{BAU} - GHG^{oc}_{r} \tag{7.2}$$

whereby:

- $GHG^{oc}_{abated,\,r}$: Abated GHG emissions according to "comprehensive lifecycle" approach over the residual lifecycle (t_1 to t_n) for renovation measure r
- GHG^{oc}_{BAU}: Cumulative lifecycle GHG emissions over the residual lifecycle (t_1 to t_n) in the BAU scenario, including operation of existing building, demolition, and new construction
- GHG^{oc}_{r}: Cumulative lifecycle GHG emissions over the residual lifecycle (t_1 to t_n) in the renovation scenario with renovation measures r, including operation and embodied emissions from renovation-related materials and processes
- t_1: Year of renovation implementation (start of residual lifecycle)
- t_n: End of the residual lifecycle of the building, covering the remaining useful life

Although the "comprehensive-lifecycle" approach captures the full environmental impact of renovation scenarios, it relies on assumptions regarding residual life cycle, demolition, and

[23] DIN EN 15978 is a European standard specifying the life cycle assessment methodology for evaluating the environmental performance of buildings. It covers all life cycle stages - including material production, construction, use, and end-of-life - and applies to new, existing and renovated buildings. It standardizes calculations based on environmental product declarations (EPDs) and scenario-based modelling to ensure consistent, transparent, sustainability assessments across projects.

new construction in the BAU scenario (Abbey et al., 2022). These assumptions likely influence AIF outcomes and are difficult to replicate in practical applications.

Determination of the total investment costs

While quantifying abated emissions provides insight into the environmental effectiveness of renovation measures, their investment costs should be considered for assessing the economic efficiency. These comprise of all expenditures related to the implementation of renovation measures. Although an economic assessment of renovation measures disaggregates costs into baseline maintenance costs, abatement-related investments, and additional construction expenditures, for calculating the AIF such differentiation is not relevant. Similarly, the AIF is calculated using the total upfront investment costs in the denominator and excludes discounted operational savings (e.g. reduced energy expenditures, avoided carbon costs, or PV revenues), as negative or near-zero net costs are conceptually contested and would result in unstable or misleading AIF values, particularly as the denominator approaches zero (see Table 7.1).

The Abatement Impact Factor

Linking emission abatement and investment cost allows to evaluate two things: First, the GHG reduction of a renovation measure, and second how effectively financial resources are translated into emission abatement, providing an essential perspective for informed investment decision-making. The AIF links those two dimensions in one KPI. It quantifies the absolute number of emissions abated per unit of invested capital, thereby allowing to rank renovation measures based on their effectiveness of capital allocation toward decarbonising the building stock. Equation (7.3) models the AIF for the "operational and use" approach.

$$AIF^o_r = GHG^o_{abated,r}/I_r \tag{7.3}$$

whereby:

- AIF^o_r: Abatement impact factor for renovation measure *r* for accounting scope "operational and use"
- $GHG^o_{abated,\,r}$: Abated GHG emissions in accounting scope "operational and use" for renovation measure r
- I_r: Investment cost for renovation measure r

Table 7.1 illustrates results of the AIF, depending on abated GHG emissions and investment cost.

Table 7.1: Possible results of the AIF

$AIF^{o}_{r} = GHG^{o}_{abated, r} / I_r$	Positive abated GHG emissions ($GHG^{o}_{abated, r} > 0$)	Negative abated GHG emissions ($GHG^{o}_{abated, r} < 0$)
Positive investment cost ($I_r > 0$)	I. $AIF^{o}_{r} > 0$	II. $AIF^{o}_{r} < 0$
Negative investment cost ($I_r < 0$)	III. $AIF^{o}_{r} < 0$	IV. $AIF^{o}_{r} > 0$

For investments that result in positive abated GHG emissions and has positive investment costs, the AIF will be greater than zero (see I.). In this case, higher AIF values indicate greater GHG abatement per euro invested, enabling clear prioritization among renovation options, while lower AIF values point to limited abatement impact or disproportionately high costs relative to abated emissions.

Negative AIF values may occur when either abated emissions or investment costs are negative (see II. and III.). Such cases pose a methodological challenge, as negative AIFs are evaluated using the same logic as positive values (Ponz-Tienda et al., 2016; Taylor, 2012; Ward, 2014). This can lead to misleading rankings, for example by favouring measures that increase emissions more strongly over alternatives with lower emission increases but similar costs. Consequently, AIF rankings are not meaningful when negative values occur and should be interpreted with caution or excluded from comparative assessment.

On the one hand, AIF values could be negative when discounted operational savings exceed upfront investment costs (see III.). However, the AIF deliberately excludes operational savings and evaluates abatement independently of the financial business case of a renovation measure. Moreover, the economic validity of negative investment costs is widely disputed, as they typically arise from low discount rates, incomplete cost definitions, or unaccounted non-financial barriers (Ackerman & Bueno, 2011; Kesicki & Ekins, 2012). Even when investment costs are low but positive, interpretation remains challenging, as the AIF approaches infinity as costs tend toward zero, thereby undermining meaningful benchmarking. These considerations justify calculating the AIF solely on total investment costs and excluding discounted future savings. On the other hand, negative abated emissions (see II. and IV.), and thus a negative AIF, occur when renovation results in higher GHG emissions than in the BAU scenario. Under the “regulated energy demand” and “operational and use” approach, renovation measures typically reduce emissions, making such outcomes unlikely. Under the “comprehensive lifecycle” approach, negative abatement may arise if embodied renovation emissions exceed operational savings or if lifecycle emissions in the BAU scenario are lower than in the renovation scenario. While the former reflects a documented trade-off between embodied and operational emissions, (Pellan et al., 2023), the latter is considered unlikely, as empirical studies consistently find that renovation yields lower lifecycle emissions than demolition and new construction (Abbey et al., 2022; Storck et al., 2023).

Given these considerations, scenarios with both negative abated emissions and negative investment costs are highly unlikely (see IV.) but should be excluded to avoid misleading AIF results. Given its methodological complexity and strong reliance of assumptions regarding demolition, new construction, replacement cycles and embodied emissions, the "comprehensive lifecycle" approach has limited practical applicability. Approaches focusing on operational emissions therefore offer a more pragmatic basis for decision making.

7.2.3 Derivation of hypotheses

The literature highlights the importance of cost-efficient prioritisation of renovation measures (e.g. Bienert & Groh, 2022), while at the same time pointing to limited guidance on how transformative impact can be systematically assessed at the asset level. Building on these insights, this section formulates a set of hypotheses to empirically examine the performance and applicability of the AIF.

Renovation strategies typically combine energy-efficiency measures and low-carbon technologies (Diakaki et al., 2008), yet the literature offers limited guidance on how these options should be prioritised from an investment perspective. While envelope improvements are commonly justified by the "efficiency first" principle (Mandel et al., 2023), low-carbon technologies such as heat pumps primarily target the decarbonisation of energy supply. These approaches differ not only in their technical focus but also in their capital intensity and emission-reduction profiles. By directly linking lifecycle GHG abatement to capital expenditure, the AIF enables a comparative assessment of the capital efficiency of different renovation strategies. Against this background, technology-driven and combined renovation measures are expected to deliver higher transformative impact per euro invested than stand-alone energy-efficiency interventions.

Hypothesis 1. *Renovations scenarios differ in their AIF, with low-carbon technologies and combined measures yielding a higher transformative impact per euro invested than standalone energy-efficiency measures.*

Building characteristics such as construction year, component age, and energy performance are well-established determinants of energy demand and, by extension, potential emission reductions (Dascalaki & Santamouris, 2002). In the German context, buildings constructed before 1979 predate the first thermal insulation regulations and therefore typically exhibit lower energy efficiency. In addition, buildings relying on more carbon-intensive energy carriers offer greater scope for emission reductions. For example, heating oil has a higher emission factor (0.2518 $kgCO_2eq/kWh$) than natural gas (0.1823 $kgCO_2eq/kWh$), according to Ökobaudat, (BBSR, 2025). Taken together, these characteristics suggest that renovation measures applied to less efficient and more carbon-intensive baseline conditions may yield higher transformative impact per euro invested.

Hypothesis 2. *The AIF is higher for renovations targeting older assets (pre-1979), buildings with low EPC ratings and those utilizing carbon-intensive heating systems.*

Economic effectiveness of renovation measures is also shaped by project-specific and local market conditions. Larger buildings are generally expected to benefit from economies of scale, as fixed planning and installation costs are distributed across a greater floor area, thereby reducing the relative investment cost per unit of abated emissions. In addition, regional differences in construction costs can materially affect renovation economics. In particular, renovation costs tend to be lower in rural areas than in urban centres (BKI, 2024a), which directly increases the AIF by reducing the investment cost component of the indicator. These considerations suggest that economic context plays an important role in determining the transformative impact of renovation investments.

Hypothesis 3. *Economic factors, specifically larger building size and rural locations, result in higher AIF values due to increased cost-efficiencies.*

For the AIF to serve as a decision-relevant indicator for investment prioritisation and portfolio steering, it must provide robust guidance under changing external conditions. Renovation costs have increased steadily over recent years (Federal Statistical Office, 2025), raising concerns about the stability of cost-based impact metrics. While absolute AIF values are expected to respond to changes in investment costs, a useful prioritisation metric should preserve the relative effectiveness of renovation measures when costs change proportionally. This stability is essential to ensure consistent decision-making across different building cohorts and market conditions.

Hypothesis 4. *The relative ranking of renovation measures by AIF values remains stable across heterogenous building cohorts and proportional cost fluctuations.*

Renovation measures are typically implemented under binding financial constraints, which fundamentally shape real-world decision-making. Despite their long-term environmental and operational benefits, renovation projects often face significant barriers due to high up-front capital requirements, limited liquidity, and extended payback periods (Galvin, 2024). As a result, building owners frequently prioritise measures based on short-term amortisation metrics rather than their environmental impact (Hartwig et al., 2024). This reliance on conventional cost-recovery criteria may lead to suboptimal capital allocation from a climate perspective, particularly when the most impactful measures require higher initial investment. Moreover, traditional MAC neglect binding budget constraints faced by real-world decision-makers (Kesicki & Ekins, 2012) and despite calls to address this limitation (e.g. Rysanek & Choudhary, 2013), methods or identifying the most emissions-effective renovation measures under capital scarcity remain scarce, motivating the use of the AIF framework.

Hypothesis 5. *Under budget constraints, the prioritisation of renovation measures based on the AIF differs from prioritisation based on traditional payback criteria, indicating that environmental and financial decision logics may not fully align.*

7.3 Data, assumptions and simulation

7.3.1 Simulation design

To operationalise the AIF, the study provides simulation-based evidence from a macroeconomic perspective, capturing system-level effects across the building stock rather than the microeconomic perspective of owners, portfolios or asset managers. The analysis aims to assess the practical applicability of the AIF, evaluate the robustness of the conceptual framework across varying building characteristics and conditions, and determine the relative impact of different renovation scenarios. The computation of the AIF requires methodological specifications for BAU and renovation energy demand, current and projected emission factors, residual building service life, renovation costs, discount rates, and expected operational energy and cost savings. Under these assumptions, the AIF is computed for the simulated building portfolio using the Vreed renovation modelling tool.

This simulated building portfolio is constructed to systematically explore a wide range of possible combinations of building age and size, thereby enabling an assessment of the conditions under which the highest renovation-related impact can be achieved at the macroeconomic level.

It is based on data provided by Loga et al. (2015), which offers detailed information on the German residential building stock, differentiated by building typologies and construction-year categories. Our analysis focuses on multi-residential buildings as they constitute the second-highest emitting segment after single-family homes and represent a context in which the AIF is particularly suitable for application: ownership structures are less fragmented and decision-making typically involves a portfolio perspective in which alternative renovation scenarios across multiple buildings are compared to identify optimal investment pathways.

The simulated buildings in the sample were constructed in 1953, 1963, 1974, 1981, and 1989, thereby excluding the highly heterogeneous and frequently heritage-protected pre-1949 stock while capturing approximately 61% of Germany's multi-residential building stock. These construction years correspond to representative building typologies for each construction-period category defined by Loga et al. (2015), which groups buildings according to decade-specific construction characteristics relevant to energy performance. Newer constructions are not considered, given Germany's persistently low construction rate and the resulting centrality of the existing building stock for achieving climate targets (Bienert & Groh, 2022). For each construction year, the energy-performance characteristics prescribed in the building regulations of the time, including heat transmission coefficients and typical energy demand profiles, are applied. To capture size heterogeneity, the simulation models four usable-area categories (400 m², 1,000 m², 2,000 m², and 4,000 m²), aligned with the calculations and empirical observations of Bienert and Groh (2022), from which the corresponding building volumes are derived.

The building sample further assumes heating oil or natural gas as energy carriers, consistent with Loga et al. (2015) showing that 38.5% of multi-residential buildings use gas heating and 21.8% use oil. It further applies replacement cycles observed in practice, which typically exceed those assumed in LCA analyses (BBSR, 2025): heating systems are considered to be renewed after 30 years or to remain unreplaced; windows follow a 40-year replacement interval or remain original; and facades are either replaced after 40 years or are assumed to retain the thermal performance characteristics of their initial construction period. These specifications render a building portfolio of 320 multi-residential buildings in Germany.

For quantifying abated GHG emissions, the simulation applies the "regulated energy demand" approach. The GHG abatement is derived by first calculating the energy demand of both the BAU and renovation scenarios using the German standard DIN 18599 and subsequently converting these values into GHG emissions using both current and projected GHG emission factors that reflect the expected decarbonisation of the energy sector. For Germany, all emission factors are sourced from the official reference database Ökobaudat (BBSR, 2025), as listed in Table A.7.10 and Table A.7.11 in the Appendix. Consistent with the conceptual framework outlined above, the abatement is assessed over a time period of 25 years.

For the renovation scenario, a set of 13 scenarios were simulated[24], consisting of individual measures and a combination of measures: (1) facade; (2) full renovation and solar panels (PV); (3) heat pump; (4) PV; (5) PV and heat pump; (6) roof; (7) roof and heat pump; (8) roof and PV(9) windows; (10) windows and heat pump; (11) windows and facade; (12) windows, roof and facade; (13) full renovation (windows, roof, facade and heat pump).

Based on 320 building types and 13 renovation scenarios, and drawing on the assumptions outlined above, a dataset of 4,160 cases is generated, as seen in Table 7.2. This dataset forms the basis for modelling abated GHG emissions, investment requirements and the resulting AIF values, supporting robust comparative evaluation across renovation strategies.

[24] The set of renovation measures included in the modelling is aligned with the requirements of the German Building Energy Act 2024 (GEG 2024) and with current federal funding schemes. Accordingly, the analysis considers both building-envelope measures (roof, windows, facade) and the replacement of the heating system. Exclusively heat pumps are modelled, as they fulfil the GEG 2024 requirement of a ≥65% renewable share, whereas alternative technologies (e.g., biomass boilers, solar thermal systems, fuel-cell heating) are excluded due to site-specific constraints and limited prevalence in the existing housing stock. Building-envelope measures in the simulation follow the component-specific minimum thermal performance requirements set out in GEG Annex 7, ensuring consistency with legal standards and current funding design.

Table 7.2: Overview simulation design

Simulation	Specification	Number of combinations
Construction years	1953; 1963; 1974; 1981; 1989	5
Usable area classes in m²	400; 1000; 2000; 4000	4
Heating system in BAU	Oil (0.2518kgCO_2eq/kWh) Gas (0.1823 kgCO_2eq/kWh) Ökobaudat (BBSR, 2025)	2
Component ages	Heating systems: 30 year replacement cycle Windows: 40 year cycle/ original Facades: 40 year cycle/ original	1 2 2
Regional cost factors	0.95 | 1.07	2
Total number of building types		**320**
Renovation measures	facade; full renovation and solar panels (PV); heat pump; PV; PV and heat pump; roof; roof and heat pump; roof and PV; windows; windows and heat pump; windows and facade; windows, roof and facade; full renovation (windows, roof, facade and heat pump)	13
Abatement modelling	"regulated energy demand" approach and emission factors from Ökobaudat (BBSR, 2025)	1
Cost modelling	Renovation cost estimates based on BKI construction cost data for 3rd quarter of 2024; synergies for roof and PV (cost reduction by 3%) and synergies for windows, façade and roof measure (cost reduction by 5%)	
Budget restriction	25th percentile of modelled investment costs at 138.06€/m²	1
Total number of datasets		**4160**

For the investment cost calculation, the modelling accounts for the substantial regional heterogeneity of renovation costs in Germany, which is reflected in regional cost factors published in BKI construction cost data for 2024 at the postal-code level (BKI, 2024a). To capture the observed variation, ranging from 0.674 to 1.573, the simulation assigns buildings the 30th and the 70th percentile of population-weighted regional cost factors, thereby enabling location-dependent cost differentiation. Renovation cost estimates are based on BKI construction cost data for the third quarter of 2024 (BKI, 2024b). In addition, to reflect cost synergies when implementing combined measures, the model assumes cost reductions of 3% for combinations involving PV systems and roof measures, and 5% for combinations involving windows, facade, and roof measures. Further, the simulation adds a hypothetical budget restriction based on a hypothetical budget of 138.06€/m², corresponding to the 25th percentile of the modelled investment costs.

The analysis is subject to several limitations stemming from its underlying simulation assumptions. To analyse which building type and characteristic yields the highest transformative impact, the building sample is simulated rather than empirical and therefore does not represent the actual building stock nor the specific portfolio of any bank or housing company. As the abatement is calculated using the "regulated energy demand" approach, and therefore based on methodology outlined in DIN 18599, only the abatement of the regulated energy demand in operational building emissions is considered. Consequently, the impact of renovation scenarios on unregulated energy use is not captured. Additionally, costs are modelled and scaled. Given the importance of investment costs for the AIF, rankings may change if actual prices differ. These factors should be considered when interpreting the results.

7.3.2 Statistical analysis

Differences in AIF distributions across renovation measures and building characteristics were assessed using non-parametric statistical tests, as the data are predominantly not normally distributed. Normality was assessed using the Shapiro–Wilk test. For comparisons involving more than two groups, Kruskal–Wallis tests were applied, followed by Dunn's post hoc tests with correction for multiple comparisons. In addition to p-values, effect sizes were reported using rank-based eta squared (η^2), which quantifies the proportion of variance in AIF values attributable to group membership and is suitable for non-parametric analyses. Effect sizes were interpreted using conventional thresholds for small, medium, and large effects. For pairwise comparisons involving two independent groups, Mann–Whitney U tests were applied. Effect sizes were quantified using rank-biserial correlation (r_{rb}), which reflects the strength and direction of group differences in rank-based outcomes. For comparisons involving two grouping factors, non-parametric two-way analyses were conducted to assess main effects and interactions, followed by post hoc multiple comparisons with Šidák adjustment for multiple testing. For these two-way non-parametric analyses, effect sizes were not reported, as no widely accepted and robust effect size measure is available for such designs within non-parametric frameworks. Results are therefore interpreted based on statistical significance and graphical inspection of distributions. To assess the robustness of the results, sensitivity analyses were conducted by varying key input assumptions and re-evaluating AIF distributions and rankings. All statistical analyses were conducted using GraphPad Prism.

7.3.3 Results

Table 7.3 presents the summary of descriptive statistics of AIF values.

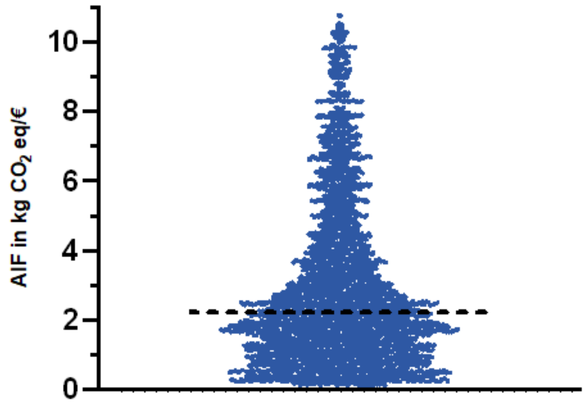
Table 7.3: Descriptive Statistics of the AIF

AIF of	**n**	**P25**	**P50**	**P75**
All renovation measures	4160	1.18	2.22	4.07
Individual Renovation Measures				
Facade	320	1.90	2.46	3.33
Full Renovation and PV	320	1.97	2.36	2.80
Heat Pump	320	6.52	7.56	8.92
PV	320	0.28	0.38	0.52
PV and Heat pump	320	5.85	7.00	8.23
Roof	320	0.73	0.96	1.23
Roof and Heat Pump	320	2.98	3.64	4.09
Roof and PV	320	0.74	0.95	1.17
Windows	320	0.47	1.32	1.63
Windows and heat pump	320	1.63	2.08	2.64
Windows and Facade	320	4.00	4.81	5.62
Windows, Roof and Facade	320	1.23	1.57	2.01
Full renovation	320	1.99	2.39	2.84
Construction years				
1953	832	1.90	3.04	5.03
1963	832	1.25	2.36	4.13
1974	832	0.99	2.02	3.82
1981	832	0.95	1.76	3.45
1989	832	1.17	1.99	3.54

This table presents the sample size (n), 25^{th} and 75^{th} percentile as well as the median of the AIF of all renovation measures, of all individual renovation measures and of all renovation measures grouped for buildings' construction years.

Our analysis reveals that the AIF values in the simulated building sample range from 0.12 to 10.76 kg CO_2eq/€, with a median of 2.22 kg CO_2eq/€. As shown in Figure 7.3, the distribution exhibits a markedly right-skewed, Poisson-type shape, reflecting the concentration of most cases at lower AIF levels and a long tail of high-impact outliers.

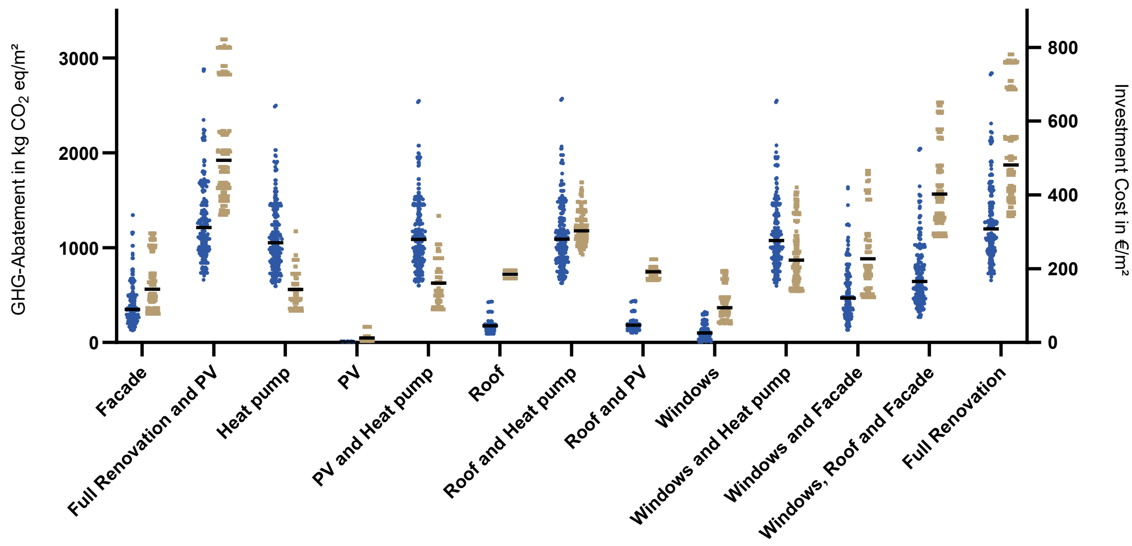
Figure 7.3: AIF distribution across all renovation scenarios in the simulated building sample



Notes: n = 4160. Median = 2.22

Figure 7.4 presents both the investment costs and the GHG abatement for the analysed renovation measures.

Figure 7.3: GHG Abatement and Investment Costs by Renovation Scenario (Simulated Buildings)



Blue distribution (left): GHG Abatement, brown distribution (right): investment costs. For each renovation scenario n = 320.

Full renovation scenarios, both with and without PV, exhibit significantly higher investment costs and emission reductions than all other measures ($p < 0.001$). Heat pump installations achieve significantly higher emission abatement than all renovation measures, except for combined measures that also include heat pumps. In contrast, the abatement effect of PV systems is only weakly reflected in the results. This is primarily due to the restriction of the “regulated energy demand” approaches. As abatement is calculated in accordance with DIN 18599, only emissions associated with regulated building operation are captured. Because PV generation in practice offsets unregulated electricity consumption, its abatement potential is systematically underestimated, which affects all comparative assessments involving PV-based renovation measures. With respect to investment costs, heat pumps exhibit the third-lowest costs among all renovation measures, excluding combined heat pump scenarios. The installation of PV systems is associated with significantly lower investment costs than all other renovation measures ($p < 0.001$), making it the least expensive option. Window replacement represents the second least costly renovation measure. Its costs are significantly higher than those of PV systems but significantly lower than those of most other measures, except for facade renovation and heat pump installation. Table 7.4 presents descriptive statistics for investment costs and GHG abatement of different buildings' construction years, EPCs and sizes.

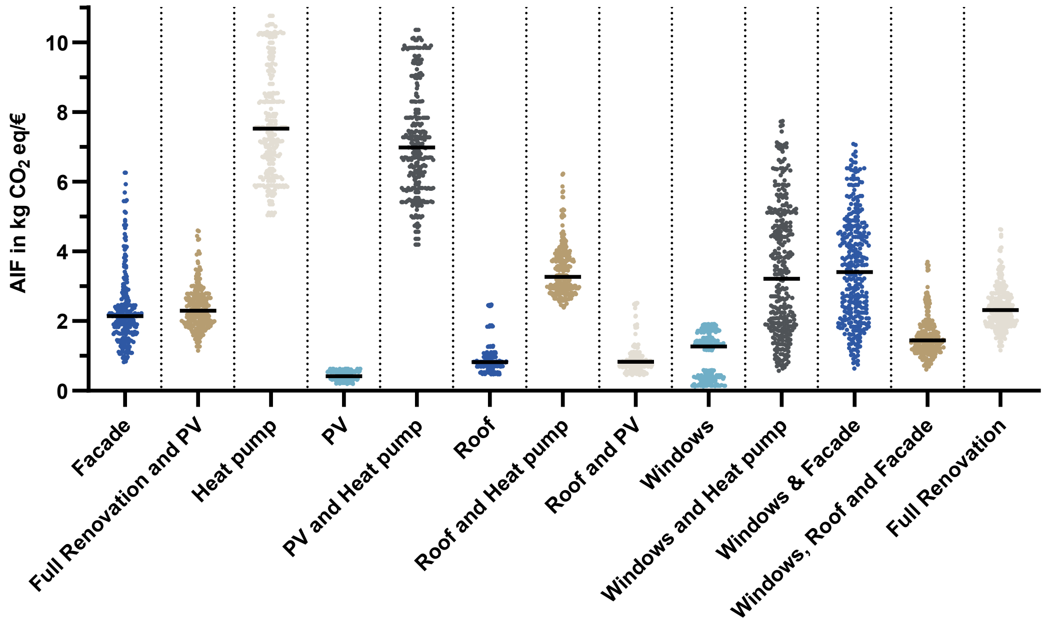
Table 7.4: Descriptive Statistics on Investment costs and GHG abatement

		Investment cost			**GHG abatement**		
	n	**P25**	**P50**	**P75**	**P25**	**P50**	**P75**
Construction years							
1953	832	155,900	302,550	554,926	426,097	1,029,137	2,225,132
1963	832	152,425	275,800	498,884	311,012	761,391	1,641,859
1974	832	150,000	259,750	474,250	286,514	651,212	1,497,950
1981	832	143,600	264,500	517,166	232,816	571,018	1,308,229
1989	832	143,850	262,828	518,476	256,200	604,627	1,420,880
EPC							
C	234	342,200	555,550	931,640	372,879	1,260,348	2,609,986
D	1456	218,175	369,360	692,645	338,743	883,362	1,986,908
E	884	151,200	257,900	474,620	217,185	701,149	1,289,101
F	1066	102,200	201,780	387,600	253,852	585,508	1,453,793
G	416	90,250	161,383	292,761	237,998	586,680	872,634
H	104	81,985	137,200	174,610	171,535	690,301	877,784
Building Size							
400	1040	78,200	114,000	182,685	97,629	401,742	579,175
1000	1040	160,500	201,780	339,300	193,474	769,929	1,152,619
2000	1040	245,450	364,305	609,700	372,868	1,253,146	2,000,386
4000	1040	359,000	636,200	1,124,600	711,631	1,951,158	3,587,843

This table presents the sample size (n), 25th and 75th percentile as well as the median of the Investment costs and GHG abatement for different buildings' construction years, Energy Performance Certificates (EPC) and sizes.

Figure 7.5 presents the distribution of AIF values across the individual renovation measures, while Table 7.5 reports the results of pairwise comparisons between measures.

Figure 7.5: Distribution of the AIF across renovation scenarios



Each renovation scenario n = 320.

Table 7.5: Heatmap of pairwise statistical significance for AIF differences across renovation measures

	Facade	Full Renovation and PV	Heat Pump	PV	PV and Heat pump	Roof	Roof and Heat Pump	Roof and PV	Windows	Windows and Heat Pump	Windows and Facade	Windows, Roof and Facade	Full Renovation
Facade	-	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns
Full Renovation and PV	ns	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$	ns
Heat Pump	$p < 0.001$	$p < 0.001$	-	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
PV	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
PV and Heat pump	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Roof	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	$p < 0.001$	ns	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Roof and Heat Pump	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$
Roof and PV	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	-	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Windows	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	ns	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
Windows and Heat Pump	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	ns	$p < 0.001$	ns
Windows and Facade	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$	ns	-	$p < 0.001$	$p < 0.001$
Windows, Roof and Facade	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	$p < 0.001$
Full Renovation	ns	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$	-

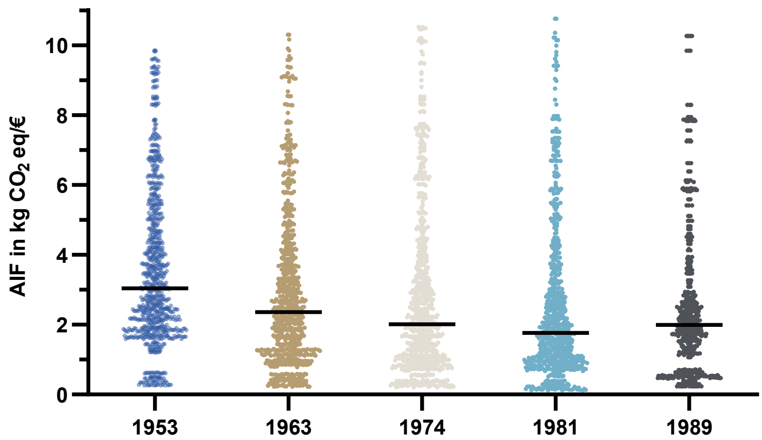
This table presents a pairwise significance matrix of AIF differences between renovation measures, shown in a heatmap. Each renovation measure is applied to n = 320 residential building types from the simulated sample, resulting in 4160 AIF values. Dark green represents a 0.1% level of significance ($p < 0.001$), medium green represents 1% level of significance ($p < 0.01$), light green represents 5% level of significance ($p < 0.05$).

The analysis shows that investments in heat pumps, as well as the combined installation of PV systems and heat pumps, achieve significantly higher emission abatement per euro invested than all other renovation measures ($p < 0.001$). The combination of window and facade renovation yields the third-highest AIF values, together with roof and heat pump and windows and heat pump, all of which are significantly higher than the remaining renovation scenarios ($p < 0.001$). In contrast, measures such as roof insulation, roof combined with PV systems, and window replacement alone exhibit significantly lower AIF values compared to all other renovation options ($p < 0.001$). The effect size of the renovation measure type on the AIF is large ($\eta^2 = 0.84$), indicating that a substantial proportion of the difference in AIF values is explained by the choice of renovation measure. PV systems alone yield the lowest

AIF values, primarily due to the restriction of the system boundary to regulated energy demand.

Figure 7.6 illustrates the distribution of AIF values across all renovation measures, differentiated by construction year.

Figure 7.6: Distribution of AIF by construction year



Each construction cohort n = 832.

Table 7.6 presents the results of pairwise comparisons of AIF values across buildings from different construction cohorts.

Table 7.6: Heatmap of pairwise statistical significance for AIF differences across buildings' construction years

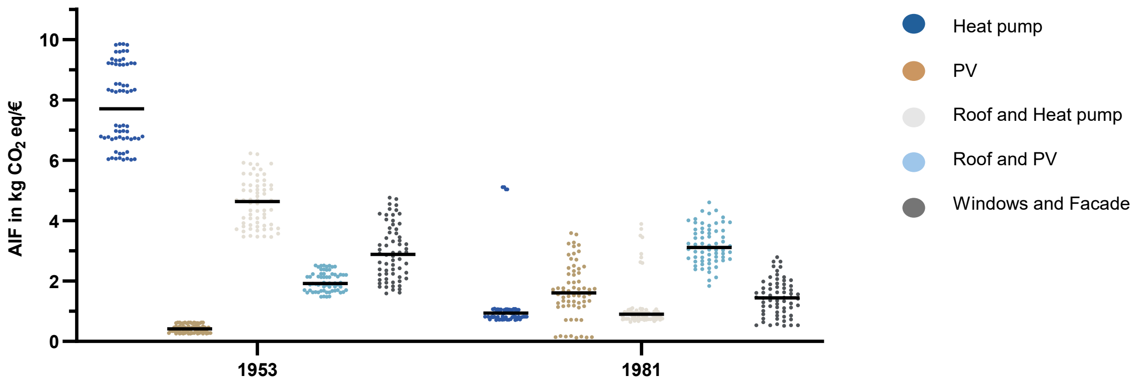
	1953	1963	1974	1981	1989
1953	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$
1963	$p < 0.001$	-	ns	$p < 0.001$	$p < 0.05$
1974	$p < 0.001$	ns	-	ns	ns
1981	$p < 0.001$	$p < 0.001$	ns	-	ns
1989	$p < 0.001$	$p < 0.05$	ns	ns	-

This table presents a pairwise significance matrix of AIF differences between buildings' construction years, shown in a heatmap. Each construction year cohort includes n = 832 combinations of residential building type and renovation scenarios, resulting 4160 AIF values. Dark green represents a 0.1% level of significance ($p < 0.001$), medium green represents 1% level of significance ($p < 0.01$), light green represents 5% level of significance ($p < 0.05$).

Buildings constructed in 1953 exhibit significantly higher AIF values than those from all other construction years ($p < 0.001$). Buildings built in 1963 also show significantly higher AIF values compared to buildings from 1981 and 1989 ($p < 0.001$ and $p < 0.05$, respectively). The widest dispersion of AIF values is observed in the 1974 and 1981 cohorts, with ranges of 0.21–10.5 kg CO_2eq/€ and 0.12–10.8 kg CO_2eq/€, respectively, indicating that mid-period buildings offer both highly effective and comparatively less effective renovation opportunities. However, the effect size of construction year on the AIF is small (η^2=0.04), indicating that construction year explains a modest portion of the difference in transformative impact.

For the comparative analysis of the 1953 and 1981 construction cohorts, five selected renovation scenarios are examined and illustrated in Figure 7.7.

Figure 7.7: AIF values for selected renovation measures by construction year



For each construction cohort n = 320.

The measures were selected based on their AIF performance and investment cost characteristics. Specifically, the heat pump scenario was chosen due to its significantly highest median AIF; window and facade renovation due to its third-highest median AIF combined with a 50% likelihood of payback within 25 years, reflecting a cost-driven decision principle; roof insulation combined with a heat pump due to its highest median GHG abatement among combined measures; PV installation due to its comparatively low investment cost; and roof insulation combined with PV as a representative median-cost scenario. The results of the pairwise comparison of AIF values for these scenarios are reported in Table 7.7.

Table 7.7: Heatmap of pairwise statistical significance for AIF differences across renovation measures for building construction years of 1953 and 1981

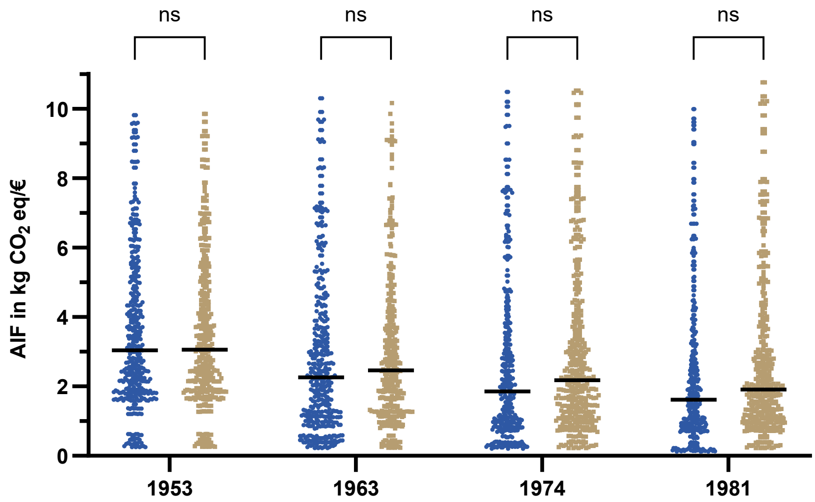
1953 (1981)	Heat Pump	PV	Roof and Heat Pump	Roof and PV	Windows and Facade
Heat Pump	-	$p < 0.001$ ($p < 0.01$)	$p < 0.001$ (ns)	$p < 0.001$ ($p < 0.001$)	$p < 0.001$ (ns)
PV	$p < 0.001$ ($p < 0.01$)	-	$p < 0.001$ ($p < 0.01$)	$p < 0.001$ ($p < 0.001$)	$p < 0.001$ (ns)
Roof and Heat Pump	$p < 0.001$ (ns)	$p < 0.001$ ($p < 0.01$)	-	$p < 0.001$ ($p < 0.001$)	$p < 0.001$ (ns)
Roof and PV	$p < 0.001$ ($p < 0.001$)	$p < 0.001$ ($p < 0.001$)	$p < 0.001$ ($p < 0.001$)	-	$p < 0.001$ ($p < 0.001$)
Windows and Facade	$p < 0.001$ (ns)	$p < 0.001$ (ns)	$p < 0.001$ (ns)	$p < 0.001$ $p < (0.001)$	-

This table presents a pairwise significance matrix of AIF differences across renovation measures for two building construction years, shown in a heatmap. Each construction year cohort includes n = 64 combinations of residential building type and renovation scenarios, resulting 640 AIF values. Dark green represents a 0.1% level of significance ($p < 0.001$), medium green represents 1% level of significance ($p < 0.01$), light green represents 5% level of significance ($p < 0.05$).

For buildings constructed in 1953, the AIF values of all selected renovation scenarios differ significantly from one another ($p < 0.001$), with heat pumps exhibiting the highest AIF values and PV systems as well as roof combined with PV systems exhibiting the lowest. In contrast, for buildings constructed in 1981, the ranking of renovation measures changes, with roof insulation combined with PV systems achieving the highest AIF values ($p < 0.001$). In addition, the distribution of AIF values differs between the two construction cohorts. While renovation outcomes for buildings constructed in 1953 display substantial variability across measures, AIF values for buildings constructed in 1981 are more tightly clustered around the median, particularly for heat pump–based renovation scenarios. All results involving PV systems should be interpreted with caution, as the restriction of the analysis to regulated energy demand under DIN 18599 systematically underestimates their abatement potential.

When examining differences in buildings containing windows of different component age, specifically windows with a 40-year replacement cycle, no significant differences in AIF values are observed between buildings with replaced windows and those retaining original windows, as illustrated in Figure 7.8.

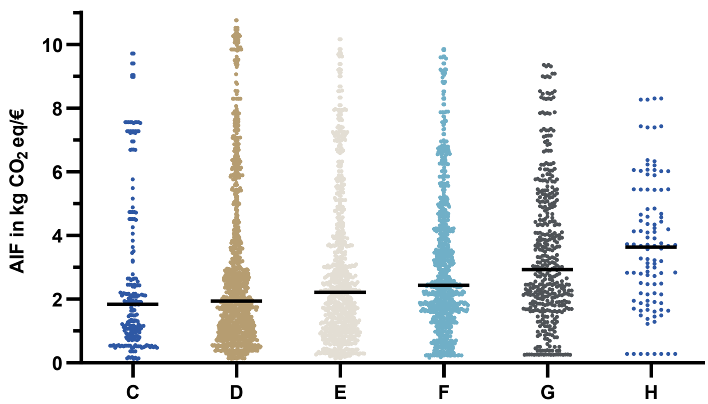
Figure 7.8: Distribution of AIF values for window replacement and original across construction years



ns = not significant. Blue distribution (left): replaced windows, brown distribution (right): original windows. For each construction year cohort n = 832.

As illustrated in Figure 7.9 and Table 7.8, the simulated dataset allows for an analysis of AIF values across EPC labels. Owing to the simulation design, the number of buildings represented differs across EPC categories. The results indicate that higher impact investment potential, reflected by higher median AIF values, is observed for EPC labels F, G, and H, with median values of 2.43, 2.93, and 3.63 kg CO_2eq per euro, respectively. AIF values for EPC label H are significantly higher than those for EPC labels C, D, and E ($p < 0.001$), as well as label F ($p < 0.05$). Similarly, AIF values for EPC label F are significantly higher than those for labels C, D ($p < 0.001$) and label E ($p < 0.05$). This difference in AIF values is of small effect size (η^2=0.02).

Figure 7.9: Distribution of AIF values per EPC class



EPC group C: n = 234, D: n =1456, E: n = 884, F: n = 1066, G: n = 416, H: n = 104.

Table 7.8: Heatmap of pairwise statistical significance for AIF differences across renovation measures for buildings with different EPC ratings

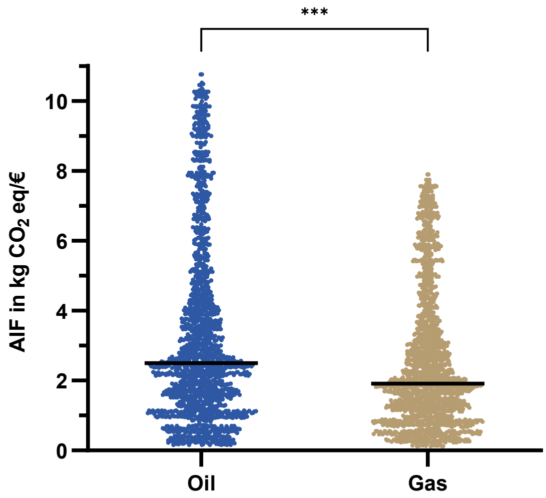
EPC Label	C	D	E	F	G	H
C	-	ns	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$
D	ns	-	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$
E	ns	ns	-	$p < 0.05$	$p < 0.001$	$p < 0.001$
F	$p < 0.001$	$p < 0.001$	$p < 0.05$	-	$p < 0.05$	$p < 0.05$
G	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.05$	-	ns
H	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.05$	ns	-

This table presents a pairwise significance matrix of AIF differences across renovation measures with different energy efficiencies, shown in a heatmap. Each EPC label consist of C: n = 234, D: n =1456, E: n = 884, F: n = 1066, G: n = 416, H: n = 104 combinations of residential building type and renovation scenarios, resulting 4160 AIF values. Dark green represents a 0.1% level of significance ($p < 0.001$), medium green represents 1% level of significance ($p < 0.01$), light green represents 5% level of significance ($p < 0.05$).

The simulated building sample is stratified by usable area into four categories of 400, 1,000, 2,000, and 4,000 m², each comprising 1,040 buildings. AIF values for the largest usable area categories of 2,000 and 4,000 m² are significantly higher than those for the smallest area category of 400 m² ($p < 0.05$ and $p < 0.001$, respectively). This pattern is consistent with economies of scale in renovation costs and the greater emission abatement potential achievable in larger buildings. However, despite statistical significance, the associated effect size is negligible ($\eta^2 = 0.0045$), indicating that building size explains only a very small share of the overall variation in AIF values.

Buildings heated with oil exhibit a median AIF of 2.50 kg CO_2eq per euro, compared to 1.91 kg CO_2eq per euro for buildings heated with gas, as illustrated in Figure 7.10. AIF values for oil heated buildings are significantly higher than those for gas heated buildings ($p < 0.01$), with a small effect size (r_{rb}=0.17).

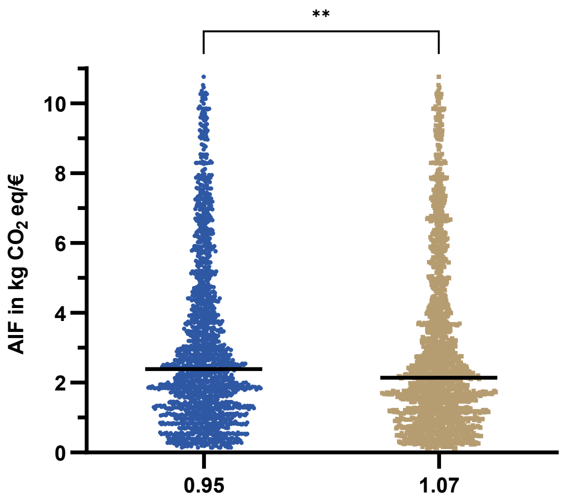
Figure 7.10: Distribution of AIF values by heating type



For each group n = 2080. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The simulation accounts for regional differences, with factors 0.95 for rural and 1.07 for urban locations. As illustrated in Figure 7.11, the distributions of AIF values for both regional factors exhibit a similar range. Nevertheless, buildings in rural areas display significantly higher AIF values than those in urban areas ($p < 0.01$), although the magnitude of this difference is small (r_{rb}=0.06).

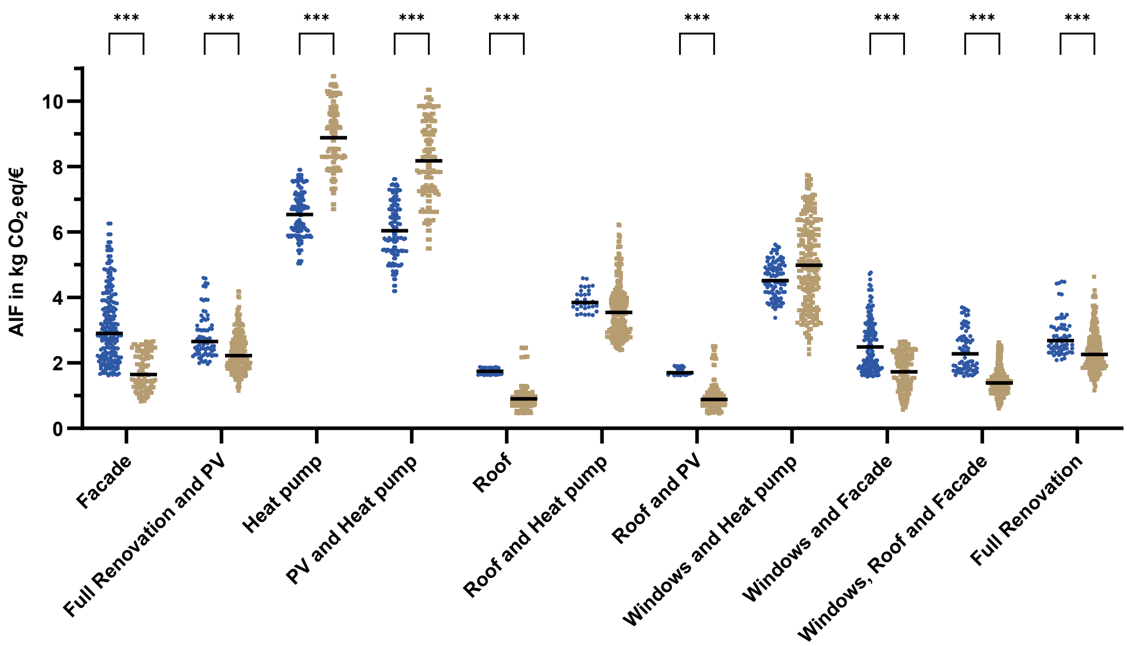
Figure 7.11: Distribution of AIF values by regional cost factors



The y axis shows the distribution for two different regional factors. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

We further distinguish renovation measures based on whether investments amortise within a 25-year period. As shown in Figure 7.12, the results indicate significant differences in AIF values across several renovation measures. Non amortised renovation scenarios exhibit significantly higher AIF values than amortised scenarios for facade, full renovation combined with PV, roof insulation, roof combined with PV, window and facade renovation, windows combined with roof and facade renovation, and full renovation ($p < 0.001$). In contrast, amortised renovation scenarios yield significantly higher AIF values for two measures, namely heat pump installation and the combined installation of PV systems and heat pumps ($p < 0.001$).

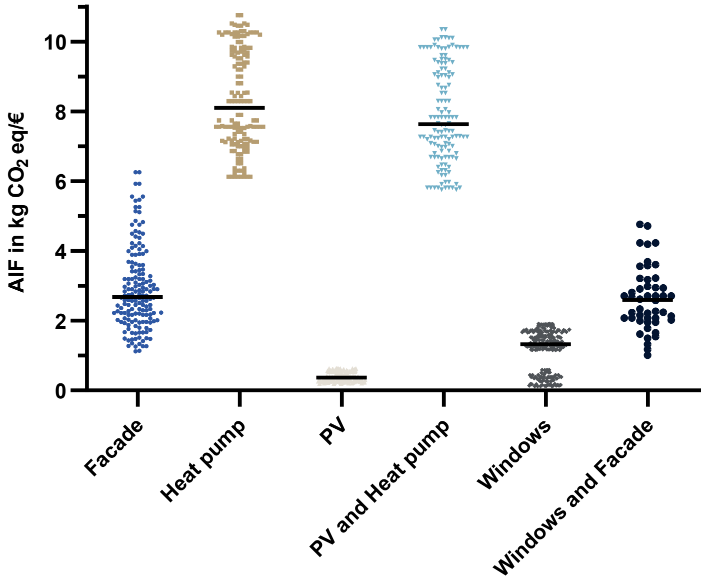
Figure 7.12: AIF values across renovation scenarios with and without amortisation within 25 years



Blue distribution (left): amortisation within 25 years, brown distribution (right): no amortisation within 25 years. For each renovation measure n = 320. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

In the budget constrained analysis, a hypothetical budget of 138.06 €/m² is applied. This constraint reduces the data set to 1,044 simulations and limits the set of feasible renovation scenarios to PV, window replacement, facade renovation, combined window and facade renovation, heat pump installation, and the combined installation of heat pumps and PV systems. As illustrated in Figure 7.13, AIF values under the budget constraint are tightly clustered around the median for window replacement, while facade renovation, heat pump installation, and the combined heat pump–photovoltaic scenario exhibit a wider dispersion.

Figure 7.13: AIF values across budget-constrained renovation scenarios



For renovation scenario Facade: n = 160, Heat pump: n = 144, PV: n = 320, PV and Heat pump: n = 132, Windows: n = 240, Windows and Facade: n = 48.

Pairwise comparison results are reported in Table 7.9. Heat pump installations, both as standalone measures and in combination with photovoltaic systems, yields significantly higher AIF values than all other budget constrained renovation scenarios ($p < 0.001$), with a large effect size (η^2=0.85). Moreover, while adjusting the budget would alter the number of feasible measures included in the analysis (increasing with a higher budget and decreasing with a lower budget), the relative ranking of the renovation measures would remain unchanged.

Table 7.9: Heatmap of pairwise statistical significance for AIF differences across renovation measures for a fixed budget.

	Facade	Heat Pump	PV	PV and Heat pump	Windows	Windows and Facade
Facade	-	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	ns
Heat Pump	$p < 0.001$	-	$p < 0.001$	ns	$p < 0.001$	$p < 0.001$
PV	$p < 0.001$	$p < 0.001$	-	$p < 0.001$	$p < 0.001$	$p < 0.001$
PV and Heat pump	$p < 0.001$	ns	$p < 0.001$	-	$p < 0.001$	$p < 0.001$
Windows	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-	$p < 0.001$
Windows and Facade	ns	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	-

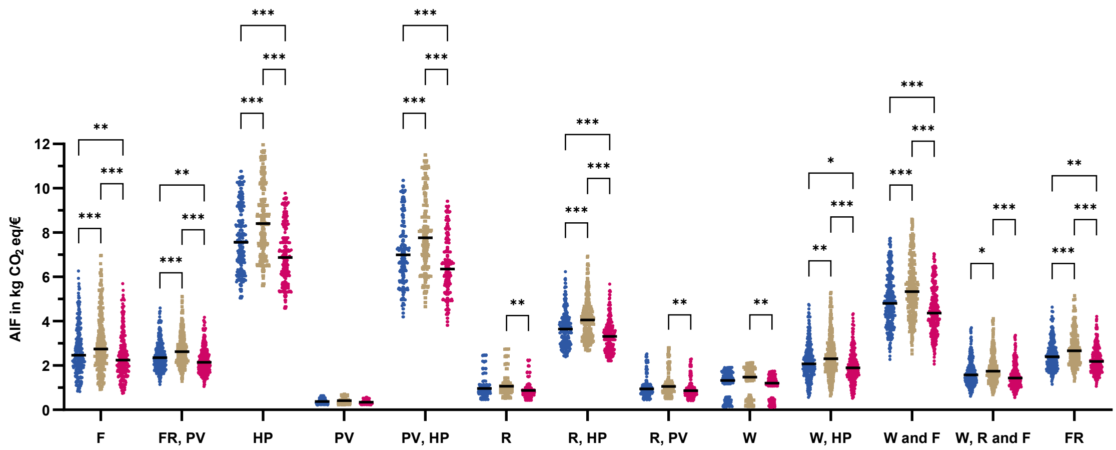
This table presents a pairwise significance matrix of AIF differences across renovation measures for a fixed budget, shown in a heatmap. The renovation measures are applied to Facade: $n = 160$, Heat pump: $n = 144$, PV: $n = 320$, PV and Heat pump: $n = 132$, Windows: $n = 240$, Windows and Facade: $n = 48$ residential buildings from the simulated sample, resulting in 1044 AIF values. Dark green represents a 0.1% level of significance ($p < 0.001$), medium green represents 1% level of significance ($p < 0.01$), light green represents 5% level of significance ($p < 0.05$).

7.3.4 Sensitivity analysis

The AIF is based on a set of input assumptions, most notably with respect to investment costs and calculated emission abatement. While this implies that absolute AIF values are subject to uncertainty, the primary value of the indicator lies in its ability to generate robust comparative insights across renovation measures. To assess the stability of the results, a sensitivity analysis was conducted by systematically varying investment cost assumptions and revaluating AIF distributions and rankings.

Figure 7.14 illustrates the results of the sensitivity analysis and shows AIF distributions by renovation measure under a 10% cost reduction (brown distribution) and a 10% cost increase (pink distribution), relative to the baseline scenario (blue distribution). Variations in investment costs lead to statistically significant changes in AIF values for nine out of thirteen renovation measures. A 10% cost reduction results in significantly higher AIF values for facade insulation, PV, heat pump installation, combined PV and heat pump installation, roof insulation combined with heat pump installation, windows and facade renovation, and full renovation ($p < 0.001$). Conversely, a 10% cost increase leads to significantly lower AIF values for heat pumps, combined PV systems and heat pump installation, roof insulation combined with heat pump installation, and windows and facade renovation ($p < 0.001$), as well as for full renovation and full renovation combined with PV systems ($p < 0.001$).

Figure 7.14: Sensitivity Analysis of AIF distribution across renovation measures for changing investment costs



Each renovation scenario n = 320. Blue distribution (left): Baseline AIF, brown distribution (middle): cost reduction from baseline by 10%, pink distribution (right): cost increase by 10%. F=Facade; FR,PV= Full Renovation and PV; HP= Heat Pump; PV; PV, HP= PV and Heat pump; R= Roof; R,HP= Roof and Heat Pump; R,PV= Roof and PV; W= Windows; W,HP= Windows and Heat Pump; W and F= Windows and Facade; W,R and F= Windows, Roof and Facade; FR= Full Renovation. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

The elasticity analysis indicates that a uniform 10% increase in investment costs reduces AIF values by 9.1%, while a 10% decrease in costs increases AIF values by 11.1%. In this analysis, proportional cost changes applied uniformly across all renovation measures do not alter the relative ranking of measures based on AIF values, confirming the robustness of the comparative results under uniform cost shocks. In practice, however, investment costs may evolve unevenly across technologies and construction products, leading to non-proportional cost changes between renovation measures. Under such conditions, relative rankings may shift, highlighting the importance of accurate, project level cost estimation when comparing the transformative impact of renovation options.

Beyond investment costs, the robustness of the AIF also depends on the estimation of emission abatement. As the analysis relies on simulated buildings and abatement estimates derived from DIN 18599, the results are inherently contingent on these modelling assumptions. Applying the "operational and use" approach to empirical building portfolios would therefore provide an important robustness check for future research, allowing the capture of heterogeneous real world abatement potentials and the validation of findings beyond the simulation setting.

7.4 Discussion

7.4.1 Interpretation of Key Findings

The simulation results reveal substantial heterogeneity in the transformative impact of renovation measures, indicating that capital allocation in the residential building sector is highly sensitive to the choice of renovation scenario. Across the simulated building stock, differences in AIF values are statistically significant with large effect sizes, demonstrating that renovation measures vary markedly in their emission abatement per euro invested. In particular, heat pump installations, both as standalone measures and in combination with photovoltaic systems, consistently achieve the highest transformative impact, providing strong support for Hypothesis H1 and underscoring the capital efficiency of low-carbon technologies. While combinations such as roof or window insulation paired with heat pump installation also exhibit high AIF values, the results indicate that combining multiple measures does not systematically yield higher impact per euro than technology-driven interventions alone.

Baseline building characteristics further shape investment effectiveness, largely confirming H2. Renovation measures deliver significantly higher abatement in older buildings and those with low EPC ratings, even if effect sizes remain modest. This emphasises the value of targeting inefficient assets, particularly pre-1979 construction, where technical and thermal deficits generate larger abatement deltas. Conversely, component age (e.g., window replacement cycles) shows no significant effect, indicating that the transformative potential is driven more by baseline performance than by isolated component conditions. The importance of the heating system further reinforces this finding: renovations in oil-heated buildings produce substantially higher AIF values than in gas-heated buildings due to greater underlying carbon intensity.

Economic conditions also affect investment effectiveness, supporting Hypothesis H3. Larger buildings achieve higher transformative impact because investment costs benefit from economies of scale and energy-system sizing efficiencies. Similarly, regional cost variations affect AIF values, as lower construction costs in rural areas translate into higher environmental return per euro invested. While effect sizes for these factors are small, their direction is consistent with economic theory and highlights that contextual cost structures matter for impact-oriented decision-making.

From a financial steering perspective, the robustness of the AIF of renovation-measure rankings across construction cohorts and proportional cost changes confirms H4 and provides important methodological reassurance. Even though absolute AIF values shift with investment costs, the relative ordering of measures remains highly consistent. This suggests that the AIF can function as a robust prioritisation tool under uniform market fluctuations. However, this robustness does not automatically extend to uneven or technology-specific cost shocks, under which rankings may shift, highlighting the need for project-specific cost evaluation and opening avenues for future research.

Finally, the analysis demonstrates that environmental and financial performance do not align systematically, providing evidence for H5. Under budget constraints, renovation measures with the highest transformative impact, especially heat pumps and combined heat-pump-PV systems, remain superior, even though they do not always offer the fastest payback periods. Conversely, some efficiency-oriented interventions with favourable amortisation characteristics deliver comparatively limited abatement. This divergence confirms that traditional payback-based decision frameworks may overlook renovation measures with the highest climate impact, reinforcing the relevance of the AIF as a complementary KPI for transition finance.

The findings for photovoltaic systems further illustrate the methodological limitations of restricting abatement calculations to regulated energy demand. Because photovoltaic generation primarily offsets unregulated electricity consumption, its abatement potential is systematically underestimated. While this approach is widely used due to its standardisation and regulatory alignment, it fails to reflect the full operational impact of photovoltaic installations and may bias comparative assessments. For more comprehensive decision-making, the use of operational and use-based system boundaries is conceptually preferable, though more data-intensive.

7.4.2 Practical implications of the Abatement Impact Factor on Stakeholder Groups and Policymakers

The application of the AIF to a simulated building sample illustrates its potential to support impact-oriented decision making in the residential building sector. By relating investment expenditures to quantified life cycle GHG abatement, the AIF enables capital allocation decisions that explicitly account for environmental outcomes alongside financial considerations. As a unified indicator that links investment costs with long term emission reductions, the AIF offers a coherent and comparable KPI for building owners, credit institutions, and policymakers seeking to align renovation investments with decarbonisation objectives.

For building owners and portfolio managers, the AIF supports renovation decisions based on transformative impact rather than on individual indicators such as energy efficiency improvements or payback periods alone. By transparently linking renovation costs to associated emission reductions over the building life cycle, the AIF facilitates the prioritisation of measures that maximise GHG abatement per euro invested. This enables more informed decision making, particularly in situations where multiple renovation options compete for limited investment budgets.

For credit institutions, the AIF is a metric that supports the redirection of capital toward renovation projects with measurable decarbonisation outcomes. By comparing AIF values across investment opportunities, banks can identify projects that deliver higher emission reductions per euro invested and complement traditional financial metrics such as loan-to-value ratios or debt service coverage ratios. In this way, the AIF allows credit institutions to evaluate renovation projects not only with respect to financial risk and return, but also regarding their contribution to emissions reduction targets. The AIF could further inform the design of impact linked financing instruments, such as sustainability-linked loans, where financial terms are tied to achieved decarbonisation outcomes. This approach is consistent with emerging ESG risk adjusted pricing frameworks discussed by the European Banking Authority, which emphasise the integration of transition risk considerations into credit decision making (EBA, 2025, pp. 24–54).

For policymakers, the AIF offers a transparent and outcome-oriented basis for designing subsidy schemes and financing programmes that aim to maximise emission reductions under budget constraints. By explicitly linking life cycle emissions, investment costs, and available budgets, the AIF supports policy designs that align individual renovation projects with broader decarbonisation pathways. This can enhance the efficiency of public spending in renovation programmes and provide a structured basis for prioritising funding toward measures and building types with the highest transformative impact per euro invested.

7.5 Conclusions and Outlook

This paper introduces the AIF as an investment-oriented metric to assess the transformative impact of building renovation measures. By linking GHG abatement to renovation investment costs at the building level, the AIF adapts the logic of MAC curves to project level decision making in the built environment. In doing so, the paper contributes to the sustainable and transition finance literature by operationalising impact measurement in a form that directly supports capital allocation decisions beyond firm level or portfolio level aggregates.

Applying the AIF to a simulated portfolio of multi residential buildings reveals substantial heterogeneity in the transformative impact of renovation measures. The results indicate that renovation options involving heat pumps consistently achieve the highest emission reductions per euro invested. Transformative impact is pronounced in older and energy inefficient buildings, while base heating system characteristics further shape AIF outcomes. Importantly, although absolute AIF values respond to cost variations, the relative ranking of renovation measures remains largely stable across building cohorts and proportional sensitivity scenarios, underscoring the robustness of comparative insights, while highlighting the need to consider uneven or technology-specific cost changes in future, project-level evaluations.

The AIF has several practical implications for actors in the finance and building sectors. For building owners, it enables the prioritisation of renovation measures based on long term decarbonisation impact rather than payback considerations alone. For financial institutions, the AIF provides a transparent and comparable indicator that can support lending decisions, portfolio steering, and the design of impact-oriented financing instruments. From a policy perspective, the AIF can inform the targeting of subsidy schemes and renovation programmes by identifying renovation measures that maximise emission reductions under constrained public budgets.

Despite these contributions, the analysis is subject to limitations that point to avenues for future research. The results are based on simulated building data and rely on assumptions regarding system boundaries, emission factors, and investment costs, which may differ from realised outcomes in practice. Future research should therefore apply the AIF to empirical renovation projects and real building portfolios, extend abatement calculations using an operational and use based approach, and further explore the integration of the AIF into financing frameworks and client level transition planning.

A Appendices

Table A.7.10: GHG emission factors according to GHG Protocol for different energy carriers from Ökobaudat (BBSR, 2025)

Heat Carrier	**GHG Emission factors in kgCO_2eq/kWh (excluding the upstream emissions and biogenic emissions)**
Heating Oil	0.2518
Natural Gas	0.1823
Biogas	0.0006
Biomass	0.0029
Coal	0.2621
PV-electricity	0
Environmental heat	0

Table A.7.11: Prognosed GHG Emission factors for electricity, district heating and heating gas in Germany 2025-2050 (as in DGNB (2025)).

Year	**Electricity Germany in [kg CO_2eq/kWh]**	**District Heating Germany in [kg CO_2eq/kWh]**	**Heating Gas Germany in [kg CO_2eq/kWh]**
2025	0.3118	0.2172	0.1591
2026	0.2887	0.2085	0.1479
2027	0.2656	0.1998	0.1368
2028	0.2424	0.1911	0.1256
2029	0.2193	0.1824	0.1144
2030	0.1962	0.1737	0.1033
2031	0.1892	0.1650	0.0983
2032	0.1822	0.1564	0.0934
2033	0.1752	0.1477	0.0884
2034	0.1682	0.1390	0.0834
2035	0.1612	0.1303	0.0785
2036	0.1541	0.1216	0.0735
2037	0.1471	0.1129	0.0685
2038	0.1401	0.1042	0.0363
2039	0.1331	0.0955	0.0586
2040	0.1261	0.0869	0.0536
2041	0.1223	0.0782	0.0493
2042	0.1185	0.0695	0.0449
2043	0.1147	0.0608	0.0406
2044	0.1109	0.0521	0.0362
2045	0.1072	0.0434	0.0319
2046	0.1034	0.0347	0.0275
2047	0.0996	0.0261	0.0232
2048	0.0958	0.0174	0.0188
2049	0.0920	0.0087	0.0145
2050	0.0882	0.0000	0.0101

8 Conclusion and Outlook

Sustainable finance regulation has expanded rapidly in recent years in response to the urgent need for a transition to a cleaner, more resource-efficient and circular economy, yet the gap between regulatory ambition and real-world outcomes remains a central challenge. This raises important questions about how regulatory frameworks operate in practice across different institutional contexts.

This thesis examines the implementation of disclosure frameworks and its translation into real-world environmental impact. Drawing on analytical and empirical evidence on disclosure regulation and impact measurement, it aims to provide new insights for both academic inquiry and evidence-based policy design.

The first part of the analyses (Part I, "*EU Taxonomy: Article 8 Disclosure in Banks*") examines the EU Taxonomy disclosure framework across four complementary studies. In the first reporting years, when disclosure obligations were limited to Taxonomy eligibility, banks are found to adopt conservative reporting approaches to avoid greenwashing accusations, while regulatory uncertainty prompts inconsistent application of disclosure requirements across a heterogeneous sample of German banks. Beyond these behavioural responses, structural factors play an equally important role. The exclusion of non-CSRD counterparties from the Taxonomy assessment mechanically constrains reported GAR values regardless of a bank's underlying sustainability engagement, and differences in denominator definitions lead to substantial variation in reported metrics unrelated to actual portfolio sustainability. Building on the first full Taxonomy disclosure cycle, the analysis further documents that the GAR faces significant design limitations that constrain its usefulness as a management tool for sustainability steering. A broader assessment of the framework identifies both persistent challenges and opportunities for improvement, concluding with recommendations for policymakers and authorities. The analysis of recent regulatory developments under the Omnibus simplification package further reveals that proposed simplifications address some but not all of the structural limitations identified in earlier chapters. Together, these studies add to the discussion on the conceptual and practical limitations of Taxonomy disclosure (Partiti, 2023; Schütze & Stede, 2021), shedding light on how these limitations manifest across different types of banks and what they imply for the effectiveness of Taxonomy disclosure in practice.

Part II ("*EU Taxonomy: Empirical Evidence on Green Asset Ratios*") focuses on the informational content of the GAR as a disclosure-based sustainability indicator, providing empirical evidence across both small and large banks operating in Germany. Drawing on hand-collected Taxonomy disclosures for large universal banks as well as small regional savings and cooperative banks, reported GARs are found to be generally very low, with Taxonomy eligibility and alignment concentrated in household real estate exposures across all bank types. These findings confirm prior evidence of low GAR values documented for large banks (CRIF, 2024; EY, 2024; PWC, 2024) and extend the analysis to smaller institutions. Large banks report higher GAR values than small banks, yet exhibit lower portfolio coverage under the Taxonomy. Surprisingly, banks operating in regions with stronger pro-environmental political preferences report lower rather than higher GARs, and we find no association between public pressure and reported GAR values. Overall, the findings suggest that the GAR does not systematically reflect stakeholder information needs, adding to the growing body of evidence on the informational limitations of the GAR as a disclosure-based sustainability indicator (Alessi & Battiston, 2022; Hoepner & Schneider, 2022).

Part III ("*The Abatement Impact Factor in Residential Building Renovations*") introduces the AIF, an investment-oriented metric that quantifies GHG abatement per euro invested in residential building renovations. Decarbonising the residential building sector requires substantial investment, yet limited guidance exists on how scarce capital should be allocated at the asset level to maximise environmental impact (Bertoldi et al., 2021). Applied to a simulated sample of multi-residential buildings representing thirteen renovation scenarios within the German housing stock, the analysis reveals pronounced heterogeneity in abatement efficiency across technologies and building characteristics. Surprisingly, low-carbon technologies, particularly heat pumps, consistently achieve the highest impact per euro invested, while older and energy-inefficient buildings offer greater abatement potential. These findings illustrate how investment effectiveness varies systematically across renovation measures and baseline building conditions. By operationalising asset-level impact measurement and linking environmental outcomes directly to capital allocation decisions, this chapter contributes to research on cost-efficient prioritisation of renovation measures under real-world constraints (Bienert & Groh, 2022), providing a practical tool for credit institutions, building owners, and policymakers seeking to direct capital toward renovation pathways with the highest decarbonisation potential.

Taken together, the three chapters reveal that the distance between regulatory intent and environmental impact in sustainable finance operates at multiple levels, from how banks interpret and report disclosure requirements, to whether reported metrics reflect genuine sustainability engagement, to whether financed activities generate measurable emissions reductions. Bridging these levels requires both well-designed disclosure frameworks and practical tools for impact measurement at the asset level.

In conclusion, the findings of this thesis underscore that transparency and accountability in sustainable finance cannot be achieved through regulatory ambition alone. Disclosure frameworks such as the EU Taxonomy represent an important step toward redirecting capital flows, yet their effectiveness depends critically on how they are designed, how institutions respond to them, and whether the activities they classify as sustainable deliver measurable emissions reductions. At a moment when regulators are recalibrating their approach, the temptation to reduce complexity by narrowing the scope of disclosure obligations risks undermining the very transparency the framework was designed to create (European Commission, 2025). Future research should continue to explore how disclosure frameworks can be improved to better reflect the underlying sustainability of bank portfolios, and how impact measurement tools such as the AIF can be integrated into financing frameworks to bridge the gap between reported metrics and real-world climate outcomes. The findings of this thesis provide a differentiated perspective on where sustainable finance regulation delivers on its promise and where its limits lie.

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