

Barriers and Instruments of Green Financing for Small and Medium-Sized Enterprises: An Analytical Literature Review

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Abstract. Small and medium-sized enterprises are the main sources of employment, production and local innovation, but they have been neglected by the sustainable finance system. This paper offers an analytical literature review of the barriers and instruments for SME green finance. It believes that the SME green finance gap is not only a lack of funds. Instead, it is the result of the interaction among general SME credit frictions, the special characteristics of green projects, weak internal capabilities, and the transaction costs of environmental verification. The four sources of the literature for this review are SME finance theory, eco-innovation, the energy-efficiency gap, and green finance policy. It builds a taxonomy of barriers, maps financial and non-financial instruments to these barriers, and compares selected cases from China, India, Colombia, Ireland and the European Union (EU), along with firm-level projects supported by the European Bank for Reconstruction and Development (EBRD). Therefore, stand-alone green loans are not suitable for small and medium-sized enterprises. Good designs combine finance and risk sharing, technical support, project preparation, performance guarantees and reasonable reporting systems. Finally, the paper points out research deficiencies in SME-specific causal evidence, green guarantee assessment, digital sustainable finance, and long-term firm-level effects.

Keywords: SME finance, green finance, sustainable finance, credit constraints, green credit, credit guarantees, energy efficiency, eco-innovation.

1. Introduction

Small and medium-sized enterprises (SMEs) anchor economic development, employment and regional production. They are also at the forefront of the low-carbon transition, and environmental upgrading cannot be achieved by large listed companies and capital-market issuers alone. Small and medium-sized enterprises (SMEs) are the main type of enterprise in most countries and take many forms, including manufacturing, services, construction, logistics, etc. Where these enterprises cannot fund energy-saving upgrades, environmentally friendly production methods, new-energy facilities, waste reduction and green-financial disclosure, the transition will fail. The Organisation for Economic Co-operation and Development (OECD) [1, 2] has been quite clear on this matter: no feasible net-zero path forward exists without the green transformation of SMEs, and sustainable finance systems are beginning to show signs of reduced transparency at the borrower level.

SMEs are not the intended beneficiaries of the new green finance system at present. Lending to small and medium-sized enterprises (SMEs) is already subject to information asymmetry, weak collateral and high screening costs [3-6]. Green finance has added new demands: Lenders now require environmental attributes, projected energy savings, taxonomy compliance and the risk of greenwashing. Many small enterprises lack the technical skills to build audited sustainable development indicators or prepare project reports. The gap is therefore not that banks lend too little or that green credit is too expensive. Green investment by SMEs requires funds, verification, risk sharing and managerial ability at the same time.

Therefore, this paper investigates the obstacles to green finance for small and medium-sized enterprises (SMEs) and proposes corresponding countermeasures. Based on the relevant studies of scholars, this is the answer; no new experiments were conducted. It will collect the scattered research paths into a single barrier-instrument system, differentiate between genuine agreement and mere co-existence, and analyze selected policy and programme cases to learn how the instruments function in

practice. The paper will first present the review approach, then the conceptual foundation; next are barriers and tools, consensus and controversy, case studies, research gaps, and finally the conclusion.

2. Methodology and Review Approach

This way, it will be an analytical literature review rather than a full systematic review that screens all the databases. Its purpose is to organise and present the scattered literature on SME green finance by collecting peer-reviewed studies, authoritative institutional reports and selected programme cases.

The four search clusters formed the foundation of the literature basis. One is SME finance and access to credit ("SME finance", "small business credit", "credit constraints", "lending technologies"). The second covered green investment and eco-innovation ("eco-innovation", "environmental innovation", "energy-efficiency gap", "green investment"). A third type of green finance instrument is included: "green credit", "green loans", "green bonds", "credit guarantees", "sustainability-linked loans", "blended finance" and "technical assistance". Finally, the institutional and policy materials for this paper were provided by the OECD, the International Finance Corporation (IFC), the World Bank, the European Investment Bank (EIB), the Inter-American Development Bank (IDB) and the European Bank for Reconstruction and Development (EBRD).

There are three criteria for selection. The review provides basic theoretical support for the mechanisms of SME finance and green investment; it covers recent studies and policy reports from 2021 onwards to reflect the current situation of sustainable finance, reporting rules and digital tools; and it only presents a case where the instrument logic is distinct: regulatory credit steering, finance plus technical assistance, energy-saving insurance or guarantee-based lending. The resulting base runs approximately thirty sources, and more than half of them were published in 2021 or later.

Two deficiencies follow. Most of the empirical studies in green credit focus on listed companies or, at most, on samples of listed companies divided by size; there are few studies that cover micro and small unlisted enterprises in detail, and thus the results may not be applicable to all SMEs. And while institutional or programme sources are useful in terms of design and reported outcomes, they do not equate to peer-reviewed causal evaluations. Separate academic and programme evidence consistently in the paper.

This way is suitable for the topic as SME green finance has not yet been widely studied. Several groups of scholars have conducted research based on different assumptions, methods and outcome indicators under this framework. Research in SME finance covers credit access, collateral, bank lending technology and firm growth; research on eco-innovation studies environmental innovation, externalities, regulation and technological change; energy-efficiency research investigates adoption barriers, audits and managerial decisions; and green finance research focuses on bonds, disclosure, taxonomies, bank regulation and institutional investors. The first bibliometric map can show that these areas share some keywords, but it cannot show the connections among their mechanisms. The purpose is to create and interpret synthetically. The purpose is to show how these literatures, in combination, explain why SMEs have been unable to access green finance and why some instruments are more suitable for SMEs than others.

For the sake of clarity, there are three grades of source reviews. The first is peer-reviewed scholarship that provides the basic mechanism: a classic work on credit rationing and SME finance, studies of environmental innovation and energy efficiency, and recent empirical research on green credit and sustainability-linked instruments. The second tier is institutional reporting by organisations such as the OECD, IFC, World Bank, EIB, IDB and EBRD; while these are not peer-reviewed in the sense of a journal, they are relevant because many SME green finance instruments have been designed and operated by these development banks, international financial institutions and policy agencies. The third is programme and firm-level case material; only instrument design and reported outcomes are presented, but not evidence of a causal effect.

There is a considerable difference; the body of literature on SME green finance has not been classified by type of evidence. A quasi-experimental study of green credit policy, an OECD synthesis

and an EBRD firm case are all useful, but they cannot bear the same weight of claim: a policy study may justify the design logic of an instrument, a programme report may show that implementation is feasible, a firm case may reveal which indicators are tracked, and only a peer-reviewed causal study can estimate effects on credit allocation or innovation. Therefore, this paper will not provide an easy "what works" ranking but will determine what each source can legitimately prove.

The mechanism of the review also employs a barrier-instrument matching logic. Instead of listing the barriers and instruments separately, it asks which instruments address which barriers: collateral gaps point to guarantees, weak project preparation to audits and technical support, uncertainty over savings to insurance and verification, and reporting complexity to standardised norms and digital tools. The match is the main analytical result of this paper, and it supports Figure 1 and Table 2.

3. Conceptual Foundations

SME green finance falls under several research categories. The oldest is the theory of SME finance itself. Stiglitz and Weiss [3] believe that, under imperfect information, the credit market will restrict credit supply for high-risk borrowers at a higher interest rate. Berger and Udell [4, 5] link SME finance to firm opacity, collateral, lifecycle stage and the lending technology used by banks, and Beck and Demircug-Kunt [6] show how severely limited finance restricts SME growth. The above mechanisms will be directly applied to green lending, and a small borrower will need to be evaluated twice: as a credit risk and as the sponsor of an environmental project.

The second type is ecological innovation. Rennings [7] refers to a double externality: knowledge spillovers reduce the private return on innovation, and the environmental benefit is not fully realised by the firm, thus green innovation is structurally underprovided. Ghisetti and others [8] have added a financial dimension to show that a lack of funds is limiting the environmental innovation of European Union (EU) manufacturers in areas where they already face a shortage of external financing. SMEs are even more disadvantaged; eco-innovation projects are often intangible, unfamiliar to lenders, and thus difficult to use as collateral.

The third is the energy-efficiency gap. Allcott and Greenstone [9] have inquired why clearly profitable efficiency investments are so frequently not implemented, and put forward reasons such as information problems, behavioural frictions, organisational inattention and capital constraints. Evidence at the firm level supports this: Trianni and Cagno [10] have found that SMEs face a dense network of barriers to efficiency adoption, and Kostka et al. [11] have shown that in Chinese SMEs, information and capability barriers can be higher than the cost of finance alone. Based on the above analysis, green finance policy needs to address the demand-side and management-level barriers, not just the price of capital.

Green finance policy forms the fourth tradition. Polzin [12] has investigated the impediments to activating private green finance and proposes public-sector instruments, risk-sharing mechanisms, and targeted market-creation policies. Banga [13] believes that the weak performance of green bonds for developing countries and small-scale issuers is due to a lack of minimum scale and high transaction costs. The OECD [2, 14, 15] and IFC [16] have reduced the scope of the discussion to SMEs, and sustainable finance now requires simplified reporting, technical support, digital tools and intermediated products.

Each tradition, in isolation, only presents a part. SME finance theory explains why small enterprises are denied loans in good times, but does not indicate the special attributes of environmental projects. Eco-innovation theory suggests that green innovation is underprovided; therefore, it has focused more on innovation incentives than on lending technologies. The energy-efficiency literature has not yet introduced economically viable technologies, and financing is often treated as a deficiency in a more fragmented way rather than a structural problem. Research on green finance has introduced instruments and policy systems, but has focused on large issuers and listed companies. Only together do the four angles cover SME green finance.

Four links connect the ordinary SME finance to its green version. The first is joint information asymmetry. Traditionally, a bank cannot know if a borrower will be able to repay a loan on time or not. Green lending should also consider the environmental quality of the investment: Is the project genuinely green? Are the projected energy savings realistic? Does it meet the criteria of taxonomy or programme eligibility? Can the firm report the results after the loan has been disbursed? The second type of risk is a higher cost of capital and non-standard lending.

Collateral and asset-specificity constitute the second part. Traditional SME loans generally require collateral in the form of property, equipment or accounts receivable, and green investments often do not meet this requirement: efficient machinery may be specially designed for a single production line, energy-management systems and process improvements have little resale value, and environmental innovation is frequently intangible. Thus, a project can create real private and social benefits despite having poor collateral; therefore, ordinary bank lending fails to provide sufficient green finance even where the interest rate is reasonable.

The third is ability-dependent differences. A large enterprise can summon sustainability teams, finance departments and outside consultants to turn a green opportunity into a bankable project; at an SME, the owner-manager or a small team must wear all these hats simultaneously and often lacks the energy for a manager, sustainability officer or independent finance function. Thus, the pipeline of financeable projects will rise and fall based on awareness, managerial attention and external support; therefore, technical assistance and audits are no longer optional additions. They help to create the very thing that finance will then support.

The fourth is the validation site. Because the "green" label must be earned, green finance bears a heavier burden than regular finance: too little verification, and instruments become greenwashing; too much, and small enterprises are excluded. This is a proportionality problem: strengthen the review to guarantee the reliability of the labels, but do so without excluding small and medium-sized enterprises. Many of the current discussions on the sustainability reports for small and medium-sized enterprises (SMEs), green checkers and artificial intelligence (AI)-powered data tools are attempts to address this problem. Figure 1 presents the strands (theories, barriers, instruments and outcomes) as shown in the framework for the rest of this paper.

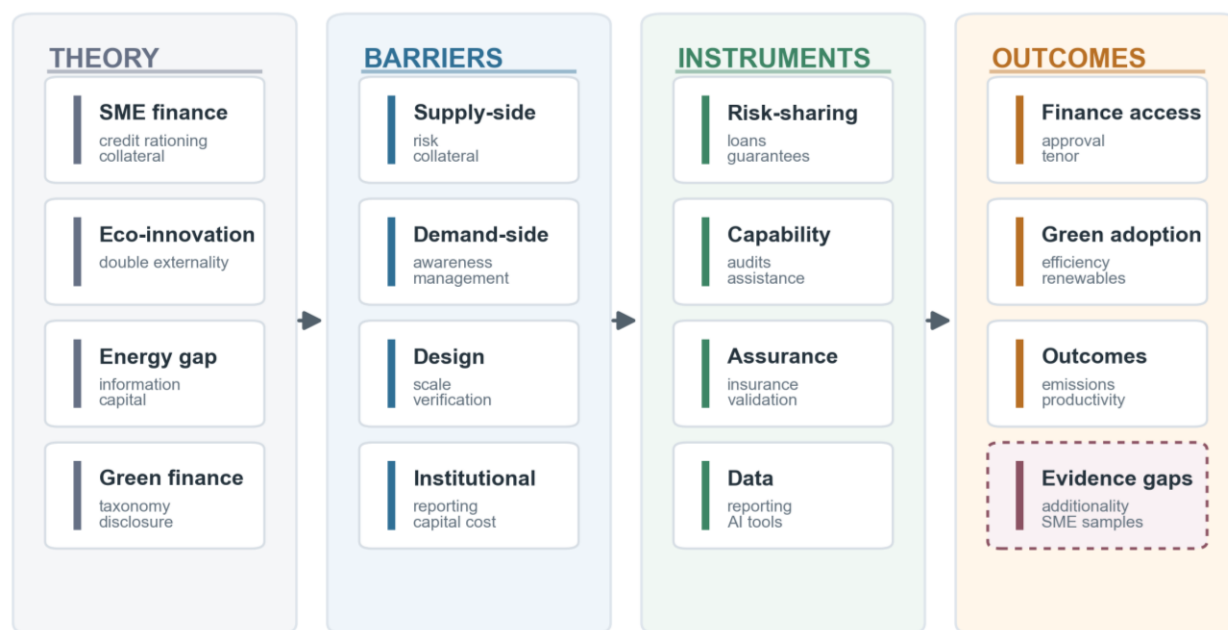


Figure 1. Conceptual framework for SME green finance. The framework reads SME green finance as the matching of barrier domains to instrument bundles: it opens with four theoretical lenses, distinguishes four types of barrier, links these to four instrument categories, and closes on expected outcomes and evidence gaps.

4. Barriers to Green Financing for SMEs

The literature classifies the barriers to SME green finance into four types: supply-side, demand-side, instrument design and institutional. The families are individually weak but do not act alone. A bank's lack of knowledge about green technology is, for instance, the same as an SME not being able to prepare an efficiency proposal; together, these two reasons make the credit application unattractive even if the underlying project is economically viable.

The lender's supply-side barriers originate here. The first reason is information asymmetry; most small and medium-sized enterprises lack audited financial statements, official sustainability data and a record of using green technology, so the bank has no other way to assess credit risk and environmental performance. Collateral mismatch makes it worse; many green investments are embedded in equipment or processes and do not have separable security. Screening and verification costs are relatively fixed and thus fall disproportionately on small loans.

The demand-side barrier starts with the company. Many small and medium-sized enterprises are simply unaware of the green finance products, energy-saving options or reporting obligations applicable to them, and even interested managers may lack the time, technical skills or internal systems to prepare a bankable project. Trianni and Cagno [10], Kostka et al. [11] and De Haas et al. [17] agree that capability is not a subsidiary problem but rather a part of the financing problem itself; that is to say, a lender cannot finance what a firm cannot identify, document and manage.

Design barriers for instruments of green finance arise because they have been developed around large, transparent issuers rather than small enterprises. Green bonds are a typical example: although the literature on green bonds for sustainable finance at large is extensive, direct issuance is rarely suitable for SMEs due to minimum issue size requirements, certification costs and investor expectations [13, 18]. Sustainability-linked loans have eased some of the restrictions but have raised new problems concerning the design and monitoring of credible key performance indicators (KPIs) [19].

Institutional barriers include a large-scale taxonomy and disclosure requirements, poor policy coordination, and a high cost of capital in developing countries. Sustainability reports can reduce information asymmetry; otherwise, they may become a burden that fails to achieve this end. Christensen et al. [20] have examined the economic effects of mandatory sustainability reporting, and the OECD [14] and the EU Platform for Sustainable Finance [21] have also pushed for simplified SME standards. Poorer economies have a weak financial system and expensive capital, and thus the space for green investment is even smaller.

Supply-side barriers are to be investigated further, as they fail to indicate a lower risk for lenders simply because they are "green". Green investment will reduce operating costs and avoid the impact of the future carbon tax on the company. The loan officer will still need to assess the risk of default within the existing credit system in practice. A green project that is small, technically unfamiliar or thinly documented may cost more to appraise than its size warrants; and where the firm lacks collateral or reliable accounts, the environmental upside will not offset the bank's ordinary credit risks. Therefore, the long-standing role of public guarantees, concessional credit lines and standardised eligibility tools continues even for projects that are obviously favourable.

A second supply-side constraint is the reduced monitoring capacity of the banking system for environmental performance. Most people are familiar with the terms "credit ratio", "collateral" and "repayment history"; fewer are aware of "energy efficiency", "renewable energy", "green production" and "circular economy". Small and medium-sized enterprises (SMEs) are also relatively lacking; their small-scale transactions may not be covered by customised technical due diligence, and although large enterprises use consultants and purchase certifications, most small enterprises do not. Therefore, it is a market design flaw: unless appraisal tools are standardised and inexpensive, lenders will avoid SME green projects because each one requires excessive judgment.

The Demand-side barriers are also relatively severe. Energy-efficiency literature shows that firms do not automatically implement profitable saving technologies, and for small and medium-sized enterprises (SMEs), the issue is whether financing is available, whether managers are aware of the

opportunity, whether they trust the projected savings, and whether they have time to act. A small manufacturer knows that its energy bills are too high but does not know which machine upgrades qualify for green finance; a retailer knows that solar panels would reduce electricity costs but does not trust the supplier's figures; a family firm prioritises short-term liquidity over long-term efficiency simply because it lacks the attention. Demand for green finance will remain low; thus, the products will not sell well even if they are available.

Project preparation capacity is a particular and relatively neglected demand-side bottleneck. A green loan application may require energy audits, baseline emissions data, cost-benefit analyses, invoices, technical specifications and post-investment monitoring. These are the ordinary administrative work of a large enterprise, but for many small and medium-sized enterprises, they are also burdens. When a company cannot turn an excellent energy-saving idea into a feasible financing proposal, the funding shortfall appears at the level of the lender, but its root lies within the company; thus, audits, training and investment-grade project reports should be considered part of the green finance system, not as external advisory services.

Instrument design barriers arise because so many green finance instruments have been developed for large borrowers and capital markets first. Green bonds are a typical case; although there is a large body of research on their certification, pricing and environmental signalling, a typical small and medium-sized enterprise cannot issue one due to high fixed costs for legal documentation, external review, listing and investor relations. The lesson to be learned is not that SMEs should issue more green bonds, but that labelled finance is based on a credibility system, and for SMEs, this system needs to be established by banks, public financial institutions, securitised pools or simplified loan products.

Sustainability-linked loans have a different design problem. They will be more suitable for SMEs, as the funds do not need to be used for a single green project: a company can borrow for general purposes and pledge to reduce energy intensity or improve its sustainability performance. However, this same flexibility is a credibility risk. A weak KPI that is not easy to implement or monitor regularly will fail to motivate behaviour change, and overly complicated KPIs will be difficult for SMEs to apply. Set up indicators that are meaningful, measurable and in the right scale for a company.

Institutional barriers colour all of the above. Taxonomies and disclosure standards aim to reduce uncertainty, but they may introduce new compliance costs; therefore, banks and large buyers will need to place sustainability-data demands on SME clients and suppliers. Even companies not formally included in the mandatory system feel this "trickle-down" effect during loan applications, procurement terms and value chain emissions accounting. Eurochambres and SMEunited [22] have surveyed how far sustainable finance regulations have reached small and medium-sized enterprises indirectly. Given the above evidence, proportionality is not a minor administrative issue but rather determines whether SMEs will be included in the green finance system.

Barriers are also changing nationally. The sticking points in the developed world generally are the proportion of reporting, design of bank products and SME capabilities; in developing countries, these problems are further exacerbated by high-interest rates, weak institutions and a lack of long-term financing. A five-year-payback green investment that pencils out in a low-interest environment may be less attractive in a high-cost credit market, and this is why international development finance and blended finance have garnered attention in the debate on SME green finance.

The two conclusions are as follows, and Table 1 presents them in detail. SME green finance barriers are cumulative; a single firm may face weak internal capacity, high verification costs, thin collateral and complex reporting all at once. They are also systemic, and cannot be solved by having SMEs change their behaviour or banks increase lending. For it to be effective, all parties to the intervention need to cooperate, including the enterprise, the bank, public institutions, technical specialists and organisations responsible for issuing reporting norms.

Table 1. Taxonomy of barriers to SME green finance

Barrier category	Specific barrier	Mechanism in SME green finance	Representative sources	Implication
Supply-side	Information asymmetry	Lenders assess credit risk and environmental credibility with limited SME data.	Stiglitz & Weiss [3]; Berger & Udell [4, 5]; OECD [2]	Green finance amplifies classic SME credit rationing.
Supply-side	Collateral mismatch	Green assets may be embedded, intangible or process-specific.	Beck & Demirguc-Kunt [6]; Ghisetti et al. [8]	Useful projects may be weak as loan security.
Supply-side	High transaction and verification costs	Screening and monitoring costs are high relative to small deal size.	Banga [13]; OECD [2]	Large-firm instruments do not automatically scale down.
Demand-side	Low awareness and attention	SMEs may not identify green opportunities or suitable products.	Trianni & Cagno [10]; Kostka et al. [11]	Weak demand can suppress product development.
Demand-side	Weak project preparation	Firms may lack audits, feasibility studies or savings estimates.	World Bank [23]; OECD [26]	Technical assistance becomes part of finance.
Demand-side	Green management gap	Management quality affects implementation and reporting.	De Haas et al. [17]	Capability and finance must be analysed together.
Instrument design	Scale mismatch	Green bonds and labelled products often require large scale.	Banga [13]; Flammer [18]	Direct capital-market access is limited for SMEs.
Instrument design	Verification burden	Certification improves credibility but raises costs.	Auzepy et al. [19]; OECD [2]	Low-cost verification is a core design challenge.
Institutional	Reporting complexity	Taxonomy and disclosure demands may trickle down to SMEs.	Christensen et al. [20]; OECD [14]; Eurochambres & SMEunited [22]	Disclosure must be proportionate.
Institutional	High cost of capital	Green investment is harder where financial systems are weak.	Polzin [12]; OECD [2]	Public risk sharing is especially important.

5. Instruments for SME Green Finance

The four categories of instruments for SME green finance are: financial instruments, risk-sharing instruments, capability-building instruments and information infrastructure. Therefore, a single party should not be blamed; rather, a tool is required to address a particular bottleneck in financing or support green projects for SMEs.

Credit guarantees are relatively well-known instruments of SME finance. They can absorb some of the lender's losses due to default, thus reduce collateral requirements or persuade banks to lend to high-risk borrowers; for green finance, they can be designed to cover eligible environmental investments. The guarantee literature also raises the usual warnings: moral hazard, deadweight loss, weak additionality. A guarantee is only valuable if it supports a loan that would not have been granted otherwise, and only if it does not simply shift the loss to the taxpayer.

Concessional loans and public on-lending are also included. Development banks and international financial institutions can channel long-term funds through commercial banks to lower the cost of capital and extend maturities, which are suitable for energy-efficiency investments and their long payback periods. Concessional funds will be ineffective if SMEs are unable to prepare a feasible project or if local banks fail to approve it.

Green loans and sustainability-linked loans are the private and semi-private ends of the toolkit. A green loan ties its funds to specific eligible projects, and a sustainability-linked loan adjusts interest rates based on the borrower's ESG performance. The first is conceptually pure but subject to eligibility screening and supervision; the second is flexible but loses its authority when KPIs are weak or easily achieved [19]. SMEs have not found a cost-effective way to implement KPI verification that is also effective.

Although generally considered to be within the scope of non-financial assistance, technical support, energy audits and project preparation can be better classified as parts of the financing channel for small and medium-sized enterprises (SMEs). An energy audit can turn an abstract wish into a specific investment plan, and then a technical support team will help determine how much money will be saved and whether one qualifies for the subsidy. The World Bank's program with the Small Industries Development Bank of India (SIDBI) is a typical case that links finance with investment-grade reports, training, and cluster-level support [23].

Performance-risk instruments address a different problem: whether the promised environmental benefits will be realised. Colombia's Energy Savings Insurance is a typical case that combines insurance, validation, standard contracts and credit lines [24]. It will not reduce the risk of default for the borrower but will reduce the uncertainty of the performance of the efficiency project.

Reporting tools, taxonomies and digital instruments have rounded out the set and are gaining attention. OECD [15] believes that AI and other digital tools can help SMEs promote the development of green finance by improving data collection, credit risk assessment and monitoring. However, they are not all-encompassing; reliable data and interoperable systems are required for trusted verification. A good path is not automation for automation's sake, but reduced reporting and green-checking tools that lower transaction costs without sacrificing credibility.

Another way to think about the functions of these instruments is to see how they affect the cost of finance, risk, demand quality and verification expenses. Concessional loans generally focus on price and maturity, guarantees on the lender's risk, technical support on the quality of the project and borrower preparation, and reporting tools on the cost of building an investment. A good SME green finance programme generally covers all four at the same time.

Credit guarantees deserve a second look because they help solve the problems of collateral deficiency and risk aversion for small and medium-sized enterprises (SMEs). SME finance can expand credit access in the general case, but only if the design is reasonable: cover too broadly and lenders relax screening; cover too narrowly and banks are unwilling to budge; support borrowers who would have received credit anyway, and the additionality effect disappears. Green guarantees inherit all these risks and adds a new requirement: the scheme should specify eligible green activities and track environmental results. The Alliance for Financial Inclusion (AFI) [25] has reviewed green credit guarantee schemes and believes that, although they show promise, these instruments for micro, small and medium-sized enterprises (MSMEs) are still in an early stage of development.

Concessional loans from development banks and other foreign financial institutions are also available; these may be suitable for SMEs engaged in green investments, and local banks often serve as the main contact point for such SMEs. Instead of having SMEs directly enter capital markets, a public institution will provide funds, risk-sharing or guarantees for intermediaries to lend under specified eligibility conditions. The two are scale and familiarity: the firm has a relationship with a bank it knows, but it fails in implementation due to a lack of incentives, training and simple tools for identifying eligible projects at that bank.

Blended finance is an all-encompassing term for using favourable public or philanthropic funds to attract private investment. SME green finance has achieved some results in promoting projects with positive environmental effects but uncertain or delayed private returns. It is not a magic bullet; it can be complex to structure, difficult to monitor, and prone to overstatement as soon as the private capital it "mobilises" would have appeared anyway. In other words, blended finance should be applied to address a specific risk or market failure; otherwise, it is merely a subsidy for a loan that would have been granted anyway.

Technical support is the least often mentioned tool in the discussion of finance-led reasons. It can do at least four things for SMEs in green finance: help the company find opportunities, such as high-efficiency machinery or renewable energy projects; quantify the expected cost savings and environmental benefits; prepare the necessary documents for lenders; and build managerial confidence by reducing some of the perceived risk in decision-making. Attached to credit lines or guarantees, they boost both the quality of demand and the confidence of lenders, as shown in the India SIDBI case.

Performance-risk instruments are less widespread but conceptually clearer. Many of the efficiency projects are expected to yield future savings; therefore, as an SME, they have not been included in the investment plan; as a bank, they have not been included in the loan scope; and as a technology provider, trust has evaporated. Energy Saving Insurance addresses this problem by using insurance and verification to bear the risk of underperformance; it is not the same as regular credit insurance

because it considers whether the borrower will repay the debt and, at the same time, whether the technology will deliver the expected energy savings that justified the deal.

Information and reporting infrastructure are likely to be the critical bottlenecks. With the expansion of the scope of sustainable finance regulations, banks require more and more borrower information, and at this time, SMEs cannot provide the same data as large listed companies. A system of information is too advanced for the small enterprises it aims to support. Simplified reporting forms, eligibility verification tools and other digital aids will be introduced to reduce the burden; at the same time, the EIB's Green Checker and the OECD's 2026 study on AI and digital tools have shifted the focus of the discussion from "more disclosure" to "usable disclosure".

Table 2 should therefore be viewed as a design tool rather than a list. That is, match the instrument with the barrier in terms of communication. Where collateral is the problem, seek a guarantee; where the issue is an extended repayment period, a concessional long-tenor loan; where technical uncertainty prevails, audits and insurance; where administrative complexity is severe, simplified reporting and digital tools. That is a more feasible problem than to ask which single instrument is best in an ideal case.

Table 2. Barrier-instrument matching matrix

Instrument	Primary barriers addressed	Mechanism	Evidence strength for SMEs	Main limitation
Credit guarantees / green guarantees	Collateral mismatch; lender risk	Public guarantor absorbs part of lender loss.	Medium for general SME finance; limited for green guarantees	Additionality and moral hazard
Concessional loans / on-lending	High interest rates; long payback	Public funds routed through intermediaries.	Medium to high as programme evidence	Requires capable banks and project pipeline
Green loans	Need for use-of-proceeds finance	Loans tied to eligible green investments.	Medium	Verification and eligibility costs
Sustainability-linked loans	Need for flexible firm-level finance	Pricing tied to sustainability KPIs.	Emerging and contested	Weak KPIs and greenwashing risk
Technical assistance / audits	Awareness and project-preparation gaps	Identifies projects and prepares documentation.	High as complementary support	Does not solve credit constraint alone
Energy Savings Insurance	Performance uncertainty	Insures projected energy savings.	Medium as programme evidence	Requires validators and insurers
Simplified reporting tools	Information asymmetry and reporting burden	Standardises SME information for lenders.	Emerging	Can become burdensome if too complex
Digital and AI tools	Data and monitoring costs	Automates data collection and screening.	Emerging	Data quality and governance risks
Green bonds / securitisation	Lack of capital-market scale	Aggregates SME green loans or funds intermediaries.	Low direct SME relevance; possible indirect relevance	Scale and certification cost

6. Consensus and Debates in the Literature

Several points are now well-known. There is a green finance gap for SMEs, but it is multi-dimensional and not solely financial [2, 16, 27]. Green projects increase the credit friction for small and medium-sized enterprises by adding an environmental risk factor to the borrower's credit risk. Internal capability counts: identify, document and manage green projects that the firm can undertake. Bundled instruments outperform stand-alone credit and work best when combined with finance, technical support, guarantees, audits, insurance or simplified verification. Green bonds are not suitable for most small and medium-sized enterprises directly, but they can reach these enterprises indirectly through securitisation or other intermediaries.

The disagreements are also quite revealing. The first is whether finance or ability is the limiting factor. Finance-first studies have shown that credit constraints restrict environmental innovation [8, 28], and capability-first studies have found that information, awareness and management are also very decisive [11, 17]. The feasible region is defined by the project, equipment replacement is generally credit-constrained, and reporting and process optimisation are capability-constrained.

The second is a controversy over the green credit policy, and China's Green Credit Guidelines provide rich support for it. Some research has found that the policy has improved the environment and directed credit toward cleaner firms [29, 30]; other studies have found that it has restricted financing or reduced the operating efficiency of polluting enterprises [31, 28]. Therefore, green credit is neither inherently good nor bad; rather, its effect will vary according to many circumstances, such as the size and structure of the company, its level of pollution, the strength of the bank, and the ability of the company to prove its green performance convincingly.

The third problem is disclosure. It can reduce information asymmetry but adds costs for small and medium-sized enterprises (SMEs). Eurochambres and SMEunited [22] show that banks and supply chains have increased the demand for sustainable finance from small and medium-sized enterprises (SMEs) even outside of regulation; therefore, the OECD [14] and the EU Platform on Sustainable Finance [21] have proposed simplified, proportionate SME reporting.

The fourth is authority. Green loans, sustainability-linked loans and digital tools all require verification. Auzepy et al. [19] believe that if the KPIs for sustainability-linked loans are too loose, they will fail to motivate behavioural changes; the OECD [15] also thinks that digital tools reduce information and monitoring costs, but only if there is good governance and high-quality data. The unsolved problem is how to make the verification both credible and inexpensive for small enterprises simultaneously.

Return to the first consensus point, and that the gap is multi-faceted; therefore, it cannot be addressed by a single policy. If the only problem were a lack of funds, then special loans would be organised; if it were risk, insurance would be organised; if it were knowledge, training would be provided. The reasons are as follows: Many small and medium-sized enterprises are unaware of which investments are feasible; banks cannot properly evaluate them; the reporting system is too complicated; and the available financial instruments do not suit the scale of small and medium-sized enterprises. Therefore, the most convincing policy reports at present present integrated packages rather than single instruments.

The second consensus point is that SME green finance is not only corporate green finance in miniature. Large enterprises can issue green bonds, hire consultants, meet disclosure requirements, arrange sustainability-linked loans and bear verification costs; small and medium-sized enterprises generally cannot do this. Therefore, although the green-bond literature provides some reference for certification and signalling, it does not offer a ready-made model for SME finance. The SME-relevant lesson is blunt: green credibility has a price, and this price must be reduced or intermediated.

The third consensus point is the synergy between financial and non-financial support; this theme appears repeatedly in the OECD and IFC materials and is clearly evident in the programme cases. The pipeline of green SME finance needs to be identifiable, measurable and feasible. No pipeline, then finance will be idle; no funds, and no incentive for investment will be given. The strongest design integrates diagnosis, project preparation, finance and monitoring into one chain.

The debate over finance vs. capability is also a dispute over the distribution of funds. Read the constraint as finance and fund cheaper loans, guarantees and credit quotas; read it as capability and fund audits, advisory services, management training and reporting tools. Neither reading is universally correct: capital-intensive equipment requires funds, and process-improvement and reporting-enhancement need ability. The productive research move is to classify green actions by their main constraints and avoid putting "green investment" in a single category.

The discussion of the green credit policy is not a simple "yes" or "no". The regulation will impose a penalty on the polluter, reward eco-friendly enterprises, mandate timely disclosure, change bank behaviour; at the same time, it will impose an adjustment cost for firms needing funds for this transition. A highly polluting small and medium-sized enterprise needs funds to purchase new equipment, and a policy that limits loans for polluters will deny it such funds. This is the tension between exclusionary and transition-oriented green finance, and the Chinese literature has provided rich references for both sides: credit steering changes incentives, but distribution effects depend on ownership, size and regional financial development.

The discussion of disclosure will continue. Sustainable finance is based on information, but this information is not free to generate; large enterprises have established environmental, social and governance (ESG) disclosure systems, whereas small and medium-sized enterprises (SMEs) have had to bear the cost of reporting imposed by banks, customers and regulators. The purpose of this policy is to build a relatively simple and feasible system that can support the reasonable credit extension of small enterprises without being overly complex or cumbersome. The EU Platform on Sustainable Finance [21] and the OECD [14] have also attempted to achieve this by reducing SME standards.

Digital tools require the same level of care. It will be easy to build AI models for digital scoring and automated reports to address the data problem of small and medium-sized enterprises (SMEs), and thus reduce transaction costs. But a digital tool is only as good as the data and governance it supports. If SMEs lack stable supply chains, the new digital system will be less transparent; and if algorithms are inscrutable, new forms of exclusion may arise. Digital sustainable finance provides favourable conditions and should not replace institutional trust.

Most of the literature has reached a practical middle ground. No single barrier prevents SME green finance, and no single instrument can unlock it; therefore, the most reasonable conclusion is conditional: different green investments by SMEs require different combinations of finance, risk sharing, capability support and verification. That conditional logic establishes the following cases.

7. Comparative Case Discussion

These cases are presented to demonstrate the application of instrument design in practice and do not claim to be causal. Each one is an application of a different theory of change: regulatory steering, finance plus capability, performance-risk mitigation, guarantee-based lending, and firm-level reporting of green investment.

China's Green Credit Guidelines are a typical case of top-down regulation of banking policy to promote environmental credit creation, and they have been extensively studied empirically. They are also aware of the defects; green credit can strengthen environmental screening, but there will still be an uneven distribution of enterprises based on ownership, disclosure ability and pollution level [31, 29, 30].

India's SIDBI Financing Energy Efficiency at MSMEs project is a finance-plus-capability model. The World Bank's record shows a programme for cluster outreach, project identification, investment-grade reports, training and finance facilitation [23]. It supports the first part of this paper; that is, project preparation is not peripheral but often a prerequisite for finance for SMEs.

Colombia's Energy Savings Insurance program aims to reduce performance risk by offering insurance, technical verification, standardised contracts and credit facilities for efficiency projects [24]. An unstated problem has arisen: the risk that the expected savings will not be achieved. By spreading this performance risk among all parties to the agreement - SMEs, lenders and technology providers - they can increase their own sense of security.

Ireland's SME and Climate Action Investment Platform, operated by the Strategic Banking Corporation of Ireland (SBCI) in collaboration with the EIB, can connect EU-level sustainable finance with domestic SME loans. The EIB documentation introduces portfolio guarantees and long-term loans for Irish SMEs and mid-caps under a climate-action mandate [32]. The case shows how guarantees, longer maturities and eligibility screening can be combined in a national SME-lending system.

Finally, the firm-level cases of the EBRD's Green Economy Financing Facility (GEFF) provide specific, reported data. General Print in Egypt has increased energy-efficient production and solvent recovery to reduce resource consumption, lower emissions and boost productivity [33]. These are only representative mini-cases; they show how development finance institutions report results, not that the programmes achieved them.

The selected cases avoid the common mistake of having all of them show the same instrument. A good portfolio has diversity, and Table 3 presents these five side by side: China for regulatory credit

steering, India for finance plus technical assistance, Colombia for performance-risk mitigation, Ireland/EU for guarantee-based intermediation and sustainable-finance infrastructure, and the GEFF mini-cases for project-level reporting and the metrics developed by finance institutions in practice. Together, they show that SME green finance is a system of instruments rather than a single product.

The China case has both merits and deficiencies, and is therefore not perfect. The green credit guidelines will motivate the bank to extend more favourable credit policies and direct more loans to environmentally responsible enterprises that have been well-disclosed. There will be a fine for the company that fails to show environmental responsibility and is still considered a polluter after investing in green construction. Do not provide a special policy favouring existing green enterprises; rather, the environment for non-green enterprises will continue to deteriorate. A transition-oriented policy needs to address how to finance the upgrade, not only how to cut off credit for high-polluting activities.

The India SIDBI case is a lesson because it has opened both ends of the market at the same time. Cluster outreach and investment-grade reports help SMEs find projects and provide lenders with more reliable information; training raises awareness and management skills; finance facilitation converts preparation into investment. The model regards the SME green finance gap as a pipeline problem; thus, the problem lies not in the lack of credit but in the firms' inability to develop projects that banks can understand and finance.

Colombia's Energy Savings Insurance case focuses on a narrower barrier: confidence in future savings. Efficiency projects are based on the expectation of reduced costs; if these costs do not fall as expected, the SME will fail to reach the cash flow that justified the investment. Insurance, verification and standardised contracts reduce the risk of uncertainty. The case is precisely suitable for showing that the risk in green finance is not only credit risk but also technology-performance risk, measurement risk and a problem of trust among firms, technology providers and lenders.

Ireland/EU is a typical case of institutional infrastructure in a developed financial system. EIB and SBCI arrangements provide EU-level guarantees and support from national promotional institutions for extended-term, lower-security SME loans. The corresponding Green Checker logic is required to unify the criteria for qualification and thus connect the three threads in this paper: guarantees, tenor extension, and simplified verification.

The GEFF mini-cases also do something else. They are not proof that a programme improved a company's performance; rather, they can be used to show the language of green finance, such as investment amount, energy savings, emissions reduction, payback period, and sometimes productivity increase. They bring the discussion down from abstraction and suggest which indicators future researchers may use for coding in the evaluation of SME green finance programmes.

Based on the above cases, one lesson is that instrument bundles reflect the obstacles a programme wishes to address. China uses bank incentives and regulatory classification; India prepares for projects and has capabilities; Colombia deals with performance risk; Ireland/EU provide guarantee-based intermediation and eligibility infrastructure; and GEFF undertakes firm-level implementation and outcome reporting. The variation is in fact the reason: the appropriate tool depends on the specific structure of the barrier.

Secondly, the required standards of proof for the various cases differ significantly. China's green credit policy has been the subject of peer-reviewed empirical research to some extent, although it has not always focused on real SME cases; India, Colombia and Ireland have provided more program documentation, and the GEFF cases are illustrative and descriptive. This hierarchy should be shown more clearly and not all cases are equally strong; the cases show mechanisms, while causal claims stay reserved for the sources that can actually support them.

Table 3. Comparative cases of SME green finance instruments

Case	Country / region	Instrument logic	Barriers addressed	Evidence type	Illustrative role	Caution
Green Credit Guidelines	China	Regulatory credit steering	Credit allocation; environmental screening	Peer-reviewed empirical studies	Main policy-regulation case	Many samples are listed firms, not true SMEs
Financing Energy Efficiency at MSMEs	India	Finance + audits + training	Project preparation; awareness; technical capacity	World Bank project documentation	Finance-plus-capability case	Programme evidence, not randomised causal evidence
Energy Savings Insurance	Colombia	Insurance + validation + standard contracts	Performance risk; savings uncertainty	IDB programme documentation	Performance-risk case	Reported outcome figures are programme self-reports, not independently audited
SME and Climate Action Investment Platform	Ireland / EU	Portfolio guarantee + long-tenor loans	Collateral and maturity constraints	EIB official documentation	EU guarantee case	Newer programme with limited ex-post evidence
GEFF firm mini-cases	Egypt and other EBRD regions	Green facility + technical support	Technology upgrading; project reporting	Official programme case pages	Short outcome illustration	Not causal evidence

8. Discussion

The review refers to a lens of matching rather than ranking. Different barriers require different instruments. If collateral is the binding barrier, a guarantee can help; if the problem is poor project preparation, an audit or technical support system can be employed; when there is significant uncertainty in predicted savings, insurance and verification outweigh the benefits of low-interest loans; and for administrative complexity, standardised forms and digital platforms are better than a capital subsidy.

Two conclusions follow. Policy should stop treating SME green finance as small-scale sustainable finance for large enterprises; green bonds and complex sustainability-linked loans are suitable for large firms with robust reporting, but SMEs generally require intermediary, bundled products. And the literature should pay more attention to the institutional scaffolding for finance. Taxonomies, reporting tools, energy audits, validators, development banks and guarantee schemes are not the background conditions but rather components of the financing system.

Instrument quality of the evidence also varies. Green credit policy has the richest quasi-experimental research in China, but most of this research does not cover small and medium-sized enterprises. Guarantees are based on mature general-SME evidence, and green-specific guarantee evaluations are absent. Technical support and energy-saving programmes have strong programme logic but weak causal identification. Digital tools are promising but early. These differences should remain noticeable: an existing system, a feasible design, and an overlooked innovation; do not present them all as high achievements.

There are several applications of the framework in the study of SME green finance in this area. First, stop referring to SMEs as the "remainder". Many studies on green finance have focused on listed companies, banks and bond markets, and have not extended them to SMEs. The reasons are that SMEs have weaker information and governance, less collateral, weaker management capabilities, and do not report reliably. A framework for large enterprises may overlook the mechanisms at the lower levels. Research should specify whether the evidence pertains to genuine small and medium-sized enterprises (SMEs), listed SMEs, bank portfolios, or large enterprises merely divided by size.

Measurement of "access to green finance" is also lacking. Access refers to the amount and term of the loan, collateral requirements, interest rates, approval time, reporting obligations and technical support availability, not only whether a loan has been approved. A cheap loan with extensive documentation may be out of reach in practice, and an ordinarily priced loan that provides strong technical support and has a long term may be much more beneficial. Given the above, financing conditions should be displayed as a group of factors rather than a single yes/no question.

The framework also shows the project-level results. Financial studies focus on loan volume, spread or firm-level innovation indicators; programme cases report energy savings and emission reductions. These two traditions of results should be combined. A good SME green finance product should ideally

increase access to finance, induce additional green investments, achieve measurable environmental results and avoid excessive credit losses; however, very few studies have combined all these factors, which is why the problem of additionality remains unsolved.

Sequences are also good for learning. An SME needs to be aware of an audit beforehand, undergo an audit before applying for a loan, provide a guarantee before bank approval, and file a simplified report after the investment is made; otherwise, the sequence will be broken and the instrument may fail. A guarantee scheme will not be used if the firm does not know which projects are eligible; a reporting tool will be ineffective if the bank does not accept it; and an audit programme will achieve nothing if credit is unavailable. Therefore, the good programs are coordinated.

There is also a problem of the tension between standardisation and flexibility. Standardisation lowers transaction costs and offers verification; flexibility supports all sectors and technologies of small- and medium-sized enterprises (SMEs). Too much of the first excludes odd but necessary projects; too much of the second will be seen as greenwashing. Tension surfaces in green loans, sustainability-linked loans, reporting standards and guarantee eligibility alike, and the feasible solution is probably to pair standardised low-risk categories with more flexible routes for complex projects.

SME green finance is thus better viewed as a transition policy than as sustainable finance. Some SMEs are already environmentally friendly or can be made so easily; others are in carbon-intensive industries and need funds specifically to go green. A green finance system that only rewards firms already going green may miss the broader structural change and is thus a real risk for manufacturing SMEs, suppliers in large value chains and firms in developing countries. The division to be established is between financing green firms and financing the greening of firms.

9. Research Gaps and Future Directions

Several deficiencies are evident. One is a lack of studies applying these methods to actual SME cases, especially micro and small unlisted enterprises; most research still uses listed companies, bank portfolios or policy documents as data. Another issue is that green guarantee schemes are still under-evaluated; although the general guarantee literature can guide the design, evidence on additionality, environmental outcomes, default risk and deadweight has not been gathered.

Integration of finance and capability is also lacking. Most research has studied credit constraints and management constraints separately; however, the cases here show that SMEs need both funds and the ability to organise, implement and report on green projects. Success indicators are also too narrow; programme reports focus on loan volume, energy saving or emission reduction, etc., but rarely cover long-term productivity, survival and competitiveness or repayment ability.

Proportionality of disclosure is also unresolved. Reporting can help lenders but burden enterprises, and subsequent studies should determine if the reduced SME standards effectively expand credit availability. Digital and AI-based tools also require careful examination; the OECD [15] has identified some promising use cases, but data on SME results are still lacking.

The first is a lack of data. True SME-level green finance data are scarce because many small and medium-sized enterprises do not disclose environmental information, and most green finance datasets are based on listed companies, bonds or bank portfolios. What the researchers want are datasets that link firm characteristics, financing conditions, project types and environmental outcomes: credit registry records linked to energy audit data, programme participation and emissions or energy-use indicators. Otherwise, the area will continue to use proxy samples and programme descriptions.

Related to this is the causal analysis of some tools. Green credit policy has attracted more quasi-experimental attention than others, especially in China; at the same time, green guarantees, green SME credit lines, energy-saving insurance, simplified reporting tools and digital green checkers have been mentioned much more frequently than they have been studied. Future studies should consider whether these instruments increase green investment under a reasonable counterfactual, whether they

reach financially constrained SMEs, whether they reduce collateral or maturity barriers, and whether they achieve environmental gains beyond what would have occurred anyway.

Thirdly, there is additionality. A programme can post a large loan volume without that finance being new; some firms have already invested, some banks have merely relabeled existing loans, and some instruments have only shifted risk to the public purse without any new investment. The three levels of measurement should cover financial additionality (was more or better finance provided?), environmental additionality (did emissions or resource use improve over the baseline?), and behavioural additionality (did firms and banks change their behaviour?).

The fourth is long-run firm performance. Most discussions of green finance assume that green investments enhance competitiveness by reducing costs, promoting innovation or strengthening resilience; although these are reasonable ideas, they have not been widely applied in practice to small and medium-sized enterprises (SMEs). Research should explore whether the supported SMEs have a higher survival rate, increased productivity and profit, better market access and supply chain participation, as well as the risks involved, such as debt burden, implementation failure, technology mismatch and administrative costs. A balanced body of research will not assume that all green investments are beneficial for all SMEs.

Sectoral heterogeneity is a fifth type. Manufacturing, agriculture, retail, transportation, construction and services all have different needs: a small manufacturer needs equipment financing and an energy audit; a logistics company requires vehicle-replacement financing; a food retailer needs refrigeration upgrades; and a supplier to a multinational corporation needs a reporting system. Studies in specific industries can show that the barriers are concentrated there and which tools are more suitable.

The sixth is the aspect of society and distribution. If the green finance products focus on medium-sized enterprises with good reporting capabilities, small and informal enterprises will be left out; if compliance costs are too high, SMEs in weaker areas may be excluded from bank loans and supply chains. The following work will determine whether sustainable finance will expand or reduce the disparity in small and medium-sized enterprises (SMEs), a problem that is more severe in developing countries due to higher capital costs and weaker institutional support.

The last is digital governance. Artificial intelligence and digital tools have lowered transaction costs; at the same time, problems of data ownership, algorithmic bias, lack of transparency and accountability have arisen. A high-speed filter offers little advantage if the underlying data are fragmented or heavily biased in favour of large enterprises; small enterprises may be left out. Therefore, the test for a digital tool should also determine whether it is convenient and trustworthy for small and medium-sized enterprises (SMEs) and banks at the same time.

10. Conclusion

This paper has reviewed the barriers and instruments for green finance in small and medium-sized enterprises (SMEs), and believes that the gap is a compound problem: ordinary SME credit frictions, special features of green projects, internal capability gaps, verification costs and institutional complexity. Being multi-faceted, it is not suitable for any single financial product.

Therefore, the main results are that SME green finance works best as a bundle. Green loans, guarantees and other forms of favourable finance are also available; at the same time, technical support, project preparation, performance monitoring and equitable reporting institutions should be strengthened. The literature on SME finance, eco-innovation, energy efficiency and green finance policy all point in this direction, and the cases from China, India, Colombia, Ireland/EU and EBRD-supported projects do the same.

The two sides are opposite. Policy-level sustainable finance systems need to be built for the actual situation of SMEs and not just reduced versions of large-enterprise finance systems. For research, the task is to move from general statements about green finance to specific problems, such as which

instruments are effective, for which SMEs they apply, under what conditions, and what environmental and business results are achieved.

The paper does not present a single best instrument, but rather an organisation system. The four-part barrier taxonomy has listed the reasons why small and medium-sized enterprises (SMEs) are unable to obtain green finance; an instrument matrix has shown that all these barriers require corresponding countermeasures, and case studies have shown that many actual programmes use multiple instruments simultaneously. Therefore, SME green finance will be more effective if it is presented as a supportive ecosystem rather than an isolated product.

Therefore, there will be a warning. As sustainable finance develops, many of the high-end products will likely be too complex for small and medium-sized enterprises (SMEs) to manage. A feasible SME green finance system should be credible but not too cumbersome; it should be strict enough to prevent greenwashing and simple enough for small enterprises to implement.

The middle ground is the location for the future studies and policies mentioned above. Next, more accurately assess the instruments, comprehensively observe the results, and separate the financing of already-green SMEs from the financing of ordinary SMEs in transition. Achieve this transition and, thus, move from a general aspiration to a practical driving force for inclusive green finance in the low-carbon transition.

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