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Entrepreneurial Finance for Green Innovative SMEs

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Key Words: Cleantech; SME; Early-Stage Innovation; Finance; Policy; Research Agenda

Abstract

The Autumn 2022 COP27 Conference of the Parties of the United Nations Framework Convention on Climate Change demonstrated that the need for a clear research and policy agenda to assist the financing of early stage Cleantech and green SMEs innovation and green practice adoption has never been greater. Green, cleantech innovators hold important keys to unlocking vital globally game changing technologies that can scale-up to mitigate climate change and humanity's wider environmental damage to ensure planetary sustainability. The paper provides a contemporary overview of the financing issues facing green SME innovators and adopters by reviewing seven papers published in this IEEE Transactions on Engineering Management Special Issue on green entrepreneurial finance. The papers provide deep insights into SMEs' external financing requirements, barriers to private finance and the shortcomings of public tax and financing policies. This editorial paper concludes with a series of key recommendations for researchers, SME finance practitioners and public policymakers which provide guidance for more holistic policies to deliver longer horizon

patient capital investing and facilitate green innovation commercialization, scale-up and adoption for a sustainable planet.

Managerial Relevance Statement

This editorial paper has considerable relevance to practitioners, notably Cleantech and green SME managers, impact investors, the wider green business support ecosystem and policymakers. Academic research into the financing of early stage green innovation has been limited. However, it is urgently required as an essential element in mitigating climate change and nurturing wider environmental nature positive impacts for a sustainable planet. Thus, financing the commercialization and scale-up of green SME innovation and its take-up by SMEs should form an essential part of overarching Green Deal policies.

This paper provides a contemporary academic overview and deep insights into the diverse, and yet limited, approaches to assisting green SME early stage financing, exploring different perspectives of the actors in the entrepreneurial finance ecosystem and the academic approaches to improving theoretical and finance practitioner understanding and informing policy. The paper concludes with a set of key findings and recommendations for further research and the need for better integrated government policy mix to improve the provision and accessibility to green innovation SME financing and SME adoption of innovative green practices. Only through such a holistic approach, established on long horizon substantive patient capital investing and improved understanding of the value of wider environmental impacts are scalable globally sustainable solutions likely to take place.

Introduction

The route to net zero requires green finance for small and medium-sized enterprises (SMEs) to be at the top of the agenda for governments globally! This view was defended by Owen et al. (2018) in response to the Conference of the Parties of the United Nations Framework Convention on Climate Change (COP21) Paris 2015 call for a net zero carbon and greenhouse gas emissions approach to tackling climate change. Subsequently, Dasgupta's (2021) towering report which centers all business activity within an environmental context has helped to broaden the debate to include a nature positive approach to business finance to help manage the Earth's biosphere. This is proposed by the Taskforce for Nature-related Financial Disclosures (TNFD) and many of the World's Central Bankers (Network of Central Bankers and Supervisors for Greening the Financial System (NGFS), 2022) in response to the United Nations (UN, 2020) call for protection of 30% of land and water by 2030 (the so-called '30 by 30' goal).

Owen (2018) and Owen et al., (2020) make the case for entrepreneurial finance representing an important part of the climate and wider environmental mitigation global policy response required. This is due on the one hand to SME green and cleantech innovations potential to offer global game changing solutions. On the other hand, SMEs also represent a substantial part of the global economy (often representing 99% of national private business and over half of employment and GDP) and pollution (representing over half for many nations) according to the Organization for Economic Cooperation and Development (OECD, 2018). Yet, SMEs are also typically overlooked in terms of government environmental regulations, environmental and social governance (ESG) reporting standards and environmental mitigation finance policies (Owen, 2021). This poses two central issues, first that there does not appear to be sufficient private finance currently being invested in SMEs and second that where market failure exists there is also insufficient public gap finance provision. For example, the Intergovernmental Panel on Climate Change (IPCC, 2022) reports the continued deficit in public finance to meet the \$100bn per annum global mitigation requirements. These shortfalls are

most acute in developing countries, suggesting an important role for globally scalable innovations and adoption (Owen et al., 2018). However, due to the combination of the aftermath of the COVID-19 pandemic, subsequent Ukraine conflict and resultant energy crisis, and European trade uncertainties derived from the United Kingdom's (UK) exit from the European Union (EU), the green policy agenda is in danger of being overlooked (Owen et al, 2022). With COP27 in Egypt reigniting environmental awareness and the failure by governments globally to deliver sufficiently on the Paris agreement (2015) and subsequent investment pledges, this once again heightens the requirement for green business finance action by public and private investors, underlining the importance of this special issue, which the editors and contributing authors hope will stimulate further, much needed research.

SMEs have limited financial resources and face the dual issues of funding their own innovations and investing in the adoption of new green technologies and business practices that will mitigate climate and environmental catastrophe (Owen et al., 2022). This is problematic because SME green innovations are often disruptive and deeptech oriented (Gaddy et al., 2016), requiring long horizon and substantial patient capital investments into hardware to facilitate commercialization and required scale-up which the private sector is not meeting (Cojoianu, 2020). A further issue is that green innovations offer new business models (Mrkajic et al., 2019) which require behavioral change to induce market acceptance (Petkova et al., 2014) and may therefore incur atypically high marketing costs (Peattie, 2001; Hockerts and Wustenhagen, 2010), long payback periods and are unlikely to fully remunerate investors for their wider public good (Polzin, 2017; Harrer and Owen, 2022). Owen et al., (2018, 2022) make the case that public investment – which can take into account wider public good - can substantially close the green SME innovation and adoption finance gaps. This is particularly the case for earlier stage perceptibly higher risk innovation development, in order to facilitate more rapid commercialization, adoption and mitigation for the transition to net zero and 30 by 30. However, Owen et al., (2018, 2020) and Owen (2021) also recognize that there is insufficient public funding currently and that it is not sufficiently directed at SME innovation, due to

a combination of government and private finance short-termism and lack of attention to seeding and scaling up longer horizon cleantech.

Owen et al., (2018) also highlight the predilection for public policy to focus on big infrastructure projects, citing the example of the United Kingdom (UK) Green Investment Bank (GIB) which invested more than half of its funding raised between 2013 and 2017 on the development of wind farms. This trend has also extended to the more recently established (2019) UK Green Finance Institute's (GIF) focus on electric vehicle (EV) infrastructure, energy storage and hydrogen energy solutions (Owen et al., 2022). Indeed, the lack of attention and mention of SMEs within the UK roadmap for green finance (Her Majesty's (HM) Government, 2021) prompts the question as to whether GIF is simply GIB version 2.0?

Furthermore, the current global economic turbulence generated by the COVID-19 pandemic and the ensuing conflict between Ukraine and the Russian Federation (as well as the UK's confirmed exit from the EU in 2021), whilst highlighting the need to address safe and secure energy, food and water supplies, is also ironically leading many European governments to turn their back (at least in the short-term) on green policies. France presents an exception, in promoting green policies under President Macron (notably in his recent 24/08/2022 speech to the French Council of Ministers) offering a sustained green vision with clear strategic support for green innovative startups through the national French Tech 'Green20' programme.

As a major contributor to the economy (OECD, 2018), SMEs have a responsibility of social supervision which can include how they disclose their environmental information on increasing the efficiency of energy usage and reducing their resource consumption that can produce non-recyclable wastes. This underpins the EU's concerns for establishing SME ESG reporting under European Directive 2021 / 01014 (Gholami et al, 2022; Faccia et al, 2022). Green finance is, therefore, closely tied to green innovation technology. However, at the same time, SMEs are also aware of their economic benefits while focusing on their green business (Harrer and Owen, 2022; Golani et al,

2022). Thus, a critical triangulation of business survival during a turbulent economic condition, environmental protection and, at the same time, a continuous innovation is a prime goal for any sector and any country (Riva et al., 2021). On the one hand, green innovation invites risks, demands significant research and development (R&D) investment, and expert skill sharing for the SMEs. On the other hand, if these aspirations are not met and supported by the Government or private financiers, entrepreneurs may lose their motivation to engage in independent R&D (Harrer and Owen, 2022). Additionally, institutional pressure from various environmental agencies and regulatory bodies put pressure on businesses to comply with new rules and policies. So, the economic contribution from them becomes stagnant. This approach needs a positive and productive discussion (Gholami et al, 2022). The solution may lie with specific and targeted transparent and easy to report environmental (non-financial) measures (Faccia et al, 2022; Hassan et al, 2021) so that the burden of regulations on SMEs can be lifted and the credit supply can be facilitated.

Finally, even where green SME innovation policies exist, multiple issues in terms of extra financial support, investment selection, funding availability and market conditions will affect their outcomes, as reflected in this special issue call and its introductory IEEE paper (Owen et al., 2020) and the resulting papers presented in this special issue (see Botelho et al.,2023; Cowling and Lui, 2023; O'Reilly et al., 2023; Owen, 2023; Owen and Vedanthachari, 2023; Owusu-Manu et al., 2023; Tingbani et al., 2023). These papers offer important contemporary insights of what we know and what we need to know in order to improve the availability of green innovation financing that can transform the current global economy into a desirable future sustainable environment and society.

Articulating the green SME finance problem

Critically, Owen et al. (2022) and Seagal Quince Wicksteed (SQW) (2021) note that SME green finance falls into two broad and distinguishable categories. First, 'adopters' are typically established SMEs that seek to 'go green' by adopting new environmentally positive practices and, second, 'innovators' are typically new or transitioning SMEs that are developing the new green practices.

Owen et al., (2018; 2020) highlight that that SME green innovations require more attention from scholars and policymakers, since these have the highest potential to deliver the globally scalable disruptive game changing product, service and business model changes (rather than simply following third party innovations) environmental mitigation impacts required for example by the IPCC (2022).

So, what are these green practices and why are they so important? The special issue call and supporting paper (Owen et al., 2020) set out quite a narrow cleantech definition based on the prevailing low carbon climate change net zero call, following COP21 in Paris. This approach is embodied in the Massachusetts Institute of Technology (MIT) (Gaddy et al., 2016, p.6) description that cleantech *“companies are those that develop technologies for energy generation, energy storage, advanced fuels, energy efficiency, energy software, and energy software appliances, as well as those that deploy or finance clean energy technologies.”* To this definition we also added a circular economy *cradle to cradle* perspective encompassing the need for green innovation products to reduce rare mineral material use, increase life expectancy and facilitate repair, repurposing and recycling (Bergset, 2018). However, in light of the broader all-encompassing requirements of nature-positive SME innovation creation and adoption and concurring with Scheidering et al. (2012), Gao et al. (2018, p727) suggest that: *“So called green innovation refers to product innovation and process innovation that has the purpose of reducing adverse impacts on the environment that tend to occur in the course of economic activity.”* This broader view of green innovation appears best suited to addressing Dasgupta’s (2021) report and what SME green finance should consider.

However, as Harrer and Owen (2022) point out, even when we have a definition of green SME finance for innovation creation and adoption, the problem for the investors – whether SMEs, or their financiers – remains how to measure and assess the intended positive environmental impact and then how to assess the value to the market and likely financial return. This approach encapsulates what can be described as the green impact investment dilemma, which is particularly exacerbated for SMEs and disruptive early-stage green innovators, where information asymmetries are greatest

between entrepreneur innovators and their prospective financiers (Carpenter and Petersen, 2002) and where SMEs suffer from limited resources – the liabilities of newness and smallness (Lehner et al, 2018) relating in a lack of internal finance, trading track record and the ability to search and successfully access external finance. These aspects all contribute to the early innovation equity finance gap (Cosh et al., 2009). It is further exacerbated by the long horizon, capital-intensive, high risk financing which is required to bridge the extended *valley of death* which faces many green tech innovators during the period of R&D prior to establishing the commercial traction that can enable successful investment exit and remuneration for investors (Mazzucato and Semieniuk, 2018). Deffains-Crapsky and Sudolska (2014) also find that disruptive innovation, such as green tech, is neither linear nor incremental, often requiring pivots and spikes in external investment requirements. Additionally, Polzin (2017) recognizes that green and social impact investors are unlikely to receive the full remuneration for their investment impacts, which will flow beyond their traded market value – how, for example, do we value clean air?

Here we return to the crucial role of this special issue in bringing together leading SME entrepreneurial finance research into the financing of green, cleantech innovation and SMEs' abilities to invest in the adoption of new green business models and practices (Owen et al, 2022; SQW, 2021). This approach requires the articulation of specific SME green financing gaps at particular stages of SME development and resource capabilities and greater understanding of the behavioral interactions which take place within the sustainable stakeholder triple nexus where policy, investor and entrepreneur intersect and decide on investment (Harrer and Owen, 2022). Here all of the special issue papers concur that private markets require an appropriate policy mix of support (Uyarra et al., 2016) to facilitate closing the SME green finance gaps in order to offer the required investments for a more sustainable environment.

Review of the special issue papers

As Table 1 indicates, the seven papers in this special issue offer a wide-ranging view of the different stages of green innovation funding and green process adoption investment. They offer quantitative and qualitative data insights, drawn mainly from more mature OECD economies that have longer established private and public financing mechanisms that form the operation of their evolving green innovation investment escalators (Owen et al., 2018). The exception is Owusu-Manu et al., (2023), whose paper presents an initial insight into how green bonds might be most effectively introduced into Ghana's developing African economy to stimulate much needed foreign investment into the country's low carbon economy, including for green innovating SMEs. The remaining papers examine the countries which are mature and major polluters and which are able to afford mitigating impact investments. They provide evidence of what actions are taking place and relatively early insights into what works well or less well and potentially what might be transferrable to investment practices in emerging markets. As alluded to earlier, it is helpful to consider the distinction between green R&D innovation within SMEs and investment into SME green practice adoption.

Green innovation R&D investment

Owen and Vedanthachari (2023) explore the earliest stage of green innovation by examining the UK government's Innovation Knowledge Centre (IKC) programme which is concerned with translating university research into commercial industry outcomes. The paper focuses on two IKC qualitative case studies which are contributing to low carbon and wider environmental innovation impacts in industry and highlights the importance of sector and long horizon disruptive technology nuances on the investment and adoption processes of industry. On the one hand, Cambridge University's novel redeployment of existing remote sensor technology was about developing industry acceptance. A few university SME spin out innovators operating in the construction sector have proven to be major catalysts for fundamental material and energy savings in large construction and maintenance projects, such as London's recently completed Crossrail Elizabeth line, which has seen a one third reduction in concrete use for tunnelling. On the other hand, Imperial College London's synthetic

biology programme was fundamentally about assisting around 40 university spin-outs and early stage innovative SMEs to develop computer modelled solutions, leading to a fast growing software tech sector in West London around the Imperial's White City campus. Here, the importance of university managed flexible rapidly available proof of concept grants, alongside incubation staff support, has provided a pipeline of attractive technology start-ups for early stage private investors which have collectively reached over a £1bn valuation. However, there is lack of substantive Series A commercialization funding for the longer horizon hardware required to trial and manufacture the new material and energy saving solutions promised by the emerging synthetic biology tech platform ventures, with few yet progressing to commercialization.

The problem of long horizon cleantech funding is a recurring theme, notably in Owen (2023) who presents a qualitative longitudinal case evaluation of four co-financed public-private government venture capital funds (GVCFs) specifically targeting early-stage SME low carbon innovation ventures. The paper points to the relatively small proportion of UK SME investment through key government agencies, such as the British Business Bank and Innovate UK, that specifically targets green innovation, despite successive government claims during the last decade advocating a globally leading green growth economy (HM Government, Clean Growth Strategy, 2017). The paper centres on the perennial criticism that GVCFs under-achieve (Lerner, 2010; Owen and Mason, 2019) and that VC may not be a suitable way of funding cleantech (Gaddy et al., 2016), stating that having a clear theory of change and logic model underpinning GVCF design, operation and evaluation is critical to their success. The paper supports Lerner's (2010) statement that GVCF is a long game (requiring 10 years plus fund design structures), and stresses the requirements for patience and a stable policy framework that nurtures the development of private sector-led financial intermediary expertise in the assessment and selection of early stage investment in complex disruptive new tech markets, such as cleantech. As such, Owen (2023) argues that government is failing to sufficiently target cleantech and to invest the large sums of money required to leverage the levels of private investment to enable cleantech venture commercialization and optimal investment exits. By

applying a novel policy design perspective, the paper demonstrates that disjointed government policies and agencies in the UK are perpetuating the GVCF design failures of the past. A key finding, therefore, is that improved organizational learning within government which incorporates better integrated departments and agencies can provide the coherent long horizon public supported finance escalator for cleantechs to thrive. The paper concludes that this situation is not currently evident within the UK under the Government-appointed British Business Bank or Green Finance Institute and supports Mazzucato and Semieniuk's (2018) call for an overarching SME green finance banking body to more effectively design, deliver and monitor co-financing GVCFs.

Also, at the earlier stages of green innovation investment, Botelho et al. (2023) point to the important role that business angels can play within the pipeline of finance to develop green/clean tech innovative ventures. They identify a gap in the entrepreneurial finance literature in terms of understanding what are the business angels' motivations for investing in environmental impact ventures. In doing so, they present a novel research framework that combines angel motivation (Sullivan and Miller, 1996) and the social return on investment (SRI) literature to offer important insights into what green ventures should present to angel investors and also what policy interventions might encourage more green angel investment. The paper reports on interviews with 65 UK business angel investors and specifically examines the relationship between the 'weight' of their green investment portfolios and their motivations in terms of altruism, hedonism and economic return. The paper finds that angels with proportionally larger green investment portfolios are typically younger and less experienced in either SME management or new venture investing. From a policy and practice perspective, this analysis suggests that angel networks are more likely to become greener through the recruitment of younger angels, but concerningly these angels may not have the experience to deliver the extra financial managerial support effective venture development which may require involvement from more experienced angels in the network. The findings also reveal different motivations and a general concurrence with (Harrer and Owen, 2022) that higher weighting green impact investors retain a strong motivation for financial return, underlining the

importance of a strong financial model to green venture propositions. The paper stresses the importance of future research to gain greater understanding of the private investment motivations of business angels, since they represent a major contribution to the early-stage green innovation funding escalator and yet little is known about their green investment screening and environmental impact assessment practices or the likely outcomes of their often long horizon and highly speculative investments.

O'Reilly et al. (2023) present a quantitative analysis of the financing of cleantech SMEs that successfully raised finance on equity crowdfunding platforms in 16 European countries. They note that this relatively new form of earlier-stage equity risk finance which first emerged in the UK after the Global Financial Crisis (GFC) of the late 2000s is playing an increasingly important role in funding new venture innovation, but little is known about the extent of their activity and impact on cleantech innovation ventures. In particular, they explore the relationships between venture accounting practices and their intangible assets, postulating that high levels of the latter will necessitate equity funding over debt (which typically requires tangible asset-based collateral), whilst high levels of the former will improve access to equity crowdfunding and also post funding venture performance. Analysis of 177 European equity crowdfunded cleantechs reveals that the average establishment age of these ventures is five years and that they are mainly in R&D and expansion stages and raise significant sized rounds of equity crowdfunding investment of over 800,000 Euros. Longer established firms are more successful in raising larger sums and cleantech raise twice the average round sizes of other sector agnostic European equity crowdfunding studies (Hornuf et al., 2018). The indications are that cleantech are long horizon and highly expensive R&D investments requiring transparent accounting data and founder 'skin in the game' investment, which longer established ventures can offer. It is also evident that these investments offer good signalling for further equity rounds and considerably improved valuations over time. However, these findings also raise concerns about the suitability of equity crowdfunding platforms for earlier stage cleantechs and the substantial funds that they require, suggesting from a policy perspective that government

co-financing (Owen et al, 2018) can help to create a smoother early-stage green finance escalator in connection with equity crowdfunding platforms (such as evidenced in the operation of the London Co-investment Fund). Public funded initiatives can also instil the accounting practices required to improve access to equity crowdfunding and improve signalling for post-crowdfunding equity and debt funding rounds.

Financing SME green innovation adoption

The remaining three papers are quantitative. Two address the wider issues of SME finance to adopt green practices, whilst the third paper by Owusu-Manu et al., (2023) relates specifically to the Paris 2015 call for the reduction of greenhouse gases ostensibly through financing the expansion of renewable energy infrastructure. Cowling and Lui (2023) use the UK national Small Business Survey (SBS) of SMEs, drawing on the waves of data collected between 2007 and 2012 to provide a substantial-size grouped data set of 9,894 valid employer SME (1-249 employee) observations. This data is used to explore four hypotheses which relate to SMEs embracing cleantech being: (i) more likely to require external finance; (ii) more likely to use alternative non debt (bank) finance; (iii) to be less likely to experience full credit rationing (where no external finance is available to them) due to the UK being comparatively well supported by government funds and policies to support green finance (Criscuolo and Mennon, 2015); but (iv) that this funding will more likely come from alternative equity risk financiers who are more likely to commit to longer term investments and to invest in intangibles (rather than banks who will require collateral). 'Going green' is defined from the data set variable recording the business steps taken to reduce energy consumption and/or waste and/or switch to recyclable/sustainable materials. It is worth noting that the UK SBS in its more recent longitudinal reincarnation since 2015 does not include this question, preventing more recent comparative analysis (Owen et al., 2022). Furthermore, Cowling and Lui ingeniously examine the intentions of high tech (defined by Bakhshi et al., 2018 as companies having knowledge and R&D intensity activities and workforce) sector SMEs to do more to reduce their environmental impact, in

order to offer a proxy for cleantech R&D activity. Regression analysis reveals that going green employer SMEs investing in cleantech have a higher demand for external finance than their non-green counterparts, but that they tend to rely heavily on alternative sources such as government grants. Their findings also indicated that SMEs going green also opted out of available debt finance in favour of using grants. Whilst it is acknowledged that grants may act positively to encourage SME cleantech adoption by adjusting the long run risk return on investment, the indication here is that government grant and subsidy programmes should be better targeted to avoid crowding out the private market. Furthermore, a crucial finding is that high tech cleantechs that appear to be viable credit rated investment propositions are facing a shortfall in bank and equity funding – whilst cleantechs do receive investments, they appear to suffer from underinvestment. This finding appears to support the perennial ongoing problem of long horizon underinvestment in the UK (and Europe) reported by recent British Business Bank Small Business Equity Tracker reports (BBB 2021) which may well apply to cleantech. The paper concludes with a series of powerful policy recommendations for long term strategic, coordinated public support to co-invest into cleantech alongside a suitable regulatory and tax regime and demand-side investment readiness support. The authors conclude with a call for improved SME cleantech data, which is roundly supported by other recent papers (see Owen et al., 2020).

Tingbani et al., (2023) point to the lack of studies that examine the relationship between environmental policies and innovation and the contention that tax instruments are an efficient means of encouraging cleantech emission reduction and adoption (Bergek et al., 2014). They, therefore, set out to examine the impacts of environmental tax on SME innovation and the relationship on this of SME finance constraint. A cross-country quantitative analysis of 24 OECD European and North American countries is undertaken for the period 2000 to 2019, using panel data for 480 SMEs to examine two hypotheses: (i) that environmental tax has a negative impact on SMEs; innovation and that (ii) this relationship is positively moderated by financial constraints. This analysis reveals that environmental taxes have a negative impact on SMEs ability to innovate. This is

exacerbated by the difficulties that SMEs face in raising the external finance that they require in order to adopt cleantech innovation. A significant finding of this paper, when controlling for individual country level macro economic factors (such as interest rates, GDP and inflation) and stable governance, is that environmental taxes will exacerbate the existing finance gap for cleantech innovation and act as a constraint to SME environmental practices, such as the reduction of pollution. A major policy recommendation is, therefore, to engage in stable governance and supportive policies to enable cleantech investment.

Owusu-Manu et al., (2023) examine how green bonds (GB) might be introduced to assist Ghana's developing low carbon economy, through their potential as a wholesale financing instrument to encourage international and national investment into developing the country's strategically vital renewable energy (RE) sector. Whilst RE from thermal, hydro and solar power provides all of Ghana's electricity, there has been more than a 50% increase in demand for electricity during the last decade and there is significant forecast demand for major investment into new RE infrastructure over the next decade in order to provide national energy security. The authors note that GBs have been used extensively in more advanced economies to provide the large capital financing required for RE infrastructure projects. By 2019 GBs represented \$228.2 billion of climate investment globally, but only 2% of this investment had been in Africa and none in Ghana. Given that GBs offer a potentially stable and effective structural financial instrument for RE investment, the authors question what features of GBs are most attractive to Ghana's major investment institutions (pension funds, insurance companies and investment banks). Twelve key elements of GB were derived from an extensive desk study and literature review. These were presented in Likert scale survey format to a sample representing half of Ghana's major financial institutions from which a 60% valid and sufficiently robust response rate was gained (n=33). The quantitative findings from a relative importance ranking index and significance tests revealed that relatively low interest rates, similar long horizon payback periods (periods of 7-15 years are acceptable), economic convenience (large scale and reduced transaction costs of capital pool) and transparency of issuance (including ensuring

green credibility) were the significant top features. Additionally, in-line with other studies of RE financing, the specificity of GB design to provide clear and transparent tailored and homogenous working financing facilities is crucial. These findings offer important guidance for the successful introduction of GB facilities in Ghana and potentially for research and practical advancement in other African and developing economies.

Conclusions and vision for future SME green finance research

Collectively, the papers in this special issue offer one of the most comprehensive set of insights into SME green finance innovation and green practice adoption yet published. The focus has been on low carbon and addressing climate change for net zero, but there has also been consideration of the wider environmental concerns in relation to pollution and circular economy. The emerging themes are remarkably consistent and should offer practitioner and policy guidance for designing, implementing and improving SME green financing programmes. The focus has been on OECD (European and North American) more advanced economies. Whilst these papers offer examples of the more mature government SME green finance policies and their lessons and implications, it should be acknowledged, as stated by Tingbani et al. (2023), that the potential transferability of policies between different countries in terms of their degree of economic maturity, governance and cultures is unknown, and more research is required. A further common theme is that, even within the mature country economies studied, SME green finance data remains patchy and limited. There is an urgent requirement for improved SME environmental data collection through national surveys and also via lowering of the threshold on ESG reporting regulation to enable at least a light touch of SME environmental impact recording (Williamson et al., 2006). This approach, for example, might involve some form of SME energy or carbon footprint rating or a wider environmental impact inventory approach (Hassan et al, 2021) that can more effectively serve SME financial market environmental risk and impact assessment. Certainly, this approach underpins the EU's drive

towards a Green Taxonomy (EU, 2021) and the recently formed global Taskforce on Nature-related Financial Disclosures' drive for science-based targets (NGFS, 2022; TNFD, 2022).

Summary of the main findings for theory, practice and policy

Critically, these papers consistently point to the finance gaps for green innovation SMEs which are disrupting the flow of the innovation finance escalator (Cowling and Lui, 2023). This disruption is occurring across the mature SME finance markets of Europe and North America (Tingbani et al., 2023) and preventing the more rapid commercialization of potential game changing low carbon and nature positive solutions for our environmental sustainability (O'Reilly et al., 2023; Owen, 2023; Owen and Vedanthachari, 2023).

These papers contribute considerably to the emerging field of green SME entrepreneurial finance theory by investigating the causes of the finance gaps, which are found to be more complex than the simple resolution of the information asymmetries that exist between entrepreneurs and their potential financiers. This special issue thus contributes to greater understanding of the interactions and behaviours taking place within the green entrepreneurial finance ('entfin') ecosystem where multiple actors converge in the sustainable stakeholder triple nexus ('SSTN') where financiers (public and private), green entrepreneurs and policy and SME support activities impact on the financing decision making process (Harrer and Owen, 2022).

The papers also point to the rise of alternative, non-bank, finance for SMEs – and particularly green innovation SMEs – in the aftermath of the late 2000s Global Financial Crisis (Cowling and Lui, 2023), notably in the form of expanded angel networks (Botelho et al, 2023), equity crowdfunding (O'Reilly et al, 2023) and the expansion of public co-financing programmes (Owen, 2023). In this respect, Owen and Vedanthachari (2023) stress the need for public (proof of concept grants, launchpad and accelerator small-scale equity) funding to catalyse and nurture the initial pipeline of green innovative ventures, as well as follow this up at later stages where finance gaps may exist. O'Reilly et al. (2023) find that equity crowdfunding is offering significant levels of finance to early

commercialization and scale-up cleantech and strong positive signalling effects for follow-on private finance, but find evidence for a funding gap for longer horizon intangible cleantech. Cowling and Lui (2023) also evidence a patient capital green tech funding gap, but caution that whilst public policy is important to developing a green tech venture pipeline, it must ensure that public and private finance can operate in a complementary fashion to avoid crowding out of banks and private fundings and lead to a more efficiently operating green innovation SME finance escalator.

A common emerging theme is that access to patient capital (Rowlands, 2009) remains a major barrier for green/cleantech and this is revealed in recent British Business Bank (2021) reports detailing the extensive 'deeptech' funding shortfall experienced in later funding rounds for long horizon capital intensive disruptive R&D ventures, such as cleantechs that need to build and manufacture prototypes (Owen, 2023; Owen and Vendanthachari, 2023). This funding gap continues to present a major barrier to the successful commercialization of green technology and further research is, therefore, required to develop the public-private funding mechanisms that can unlock sufficient institutional (i.e. pension fund) finance to deliver the game-changing environmental technologies to the market and more effectively mitigate net zero and deliver nature positive solutions.

Finally, alongside the long horizon investment required for green tech, Tingbani et al. (2023), echoing Owen et al. (2018), point to the need for a holistic mix of SME green finance programmes and instruments (e.g tax and financial inducements) that are supported by coherent and cohesive policy mix (Uyarra, 2016; Owen, 2020) which offers business support (e.g investment readiness: Cowling and Lui, 2023) and a suitably strong environmental regulatory regime. Since innovation technology financing is a long game (Lerner, 2010), this approach also requires stable government that can encourage the substantial long horizon private financing required.

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Table 1: Entrepreneurial Finance for Green Innovative SMEs, Summary of IEEE Special Issue Papers

Authors/title	Subject	Method	Geography	Findings
Botelho et al., (2023) 50 Shades of Green—Angel Investing in Green Businesses	Green business angel investment motivations	Qualitative	UK	Solely green angel investors are less altruistic than occasional green investors
Cowling and Lui, (2023) Access to Finance for Cleantech Innovation and Investment: Evidence from U.K. Small- and Medium-Sized Enterprises	Cleantech SME debt and equity finance	Quantitative	UK	Cleantech SMEs exhibit high demand for external finance, often met by alternative non-traditional financiers
Owen, (2023) Lessons from Government Venture Capital Funds to Enable Transition to a Low-Carbon Economy	Government VC Funds (GVCF) for cleantech	Qualitative	UK	Provides a novel, qualitative, systems learning approach to support cleantech finance policy, practice and theory
Owen and Vedanthachari, (2023) Exploring the Role of U.K. Government Policy in Developing the University Entrepreneurial Finance Ecosystem for Cleantech	University-related cleantech innovation finance	Qualitative	UK	Catalytic role of universities for cleantech in entrepreneurial finance ('entfin') ecosystem nuanced by sector investment horizons
O'Reilly et al., (2023) Financing Early Stage Cleantech Firms	Cleantech equity crowdfunding (ECF)	Quantitative	16 European countries	ECF ameliorates early innovation cleantech SME illiquidity, with positive signals to follow-on equity investors
Tingbani, et al., (2023) Environmental Tax, SME Financing Constraint, and Innovation: Evidence from OECD Countries	Environmental tax impacts on SME innovation	Quantitative	24 OECD countries	Increased environmental tax reduces innovation. Financial constraint is a positive moderator.
Owusu-Manu, et al., (2023) A Cognizance of Green Bond Features Preferential to Renewable Energy Project Financing in Ghana	Green Bonds for Renewable Energy projects	Quantitative	Ghana, Africa	GBs offering low interest rates, long horizon investment, transparency of issuance, economic convenience and tailored solutions can deliver institutional investment into renewable energy projects and SME micro generators.