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Early Stage Investing in Green SMEs: The Case of the UK

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ABSTRACT

How might a Green New Deal be applied to the early stage financing of Cleantechs? Amidst rising interest and adoption of Green New Deals in the US, the paper explores the need for more focused policy to address early stage long horizon financing of Cleantechs. We argue that insufficient focus has been applied to early stage investing into these types of innovative SMEs that could lower CO2 emissions across a range of sectors (including renewable energy, recycling, advanced manufacturing, transport and bio-science). Adopting a resource complementarity lens and borrowing from transaction cost theory, we illustrate and build theory through longitudinal UK case studies. These demonstrate how government policy can scale-up through international collaboration public-private, principally venture capital, co-finance to facilitate cleantech innovation with potentially game changing impacts on reducing CO2 emissions in order to meet the Paris 2015 Climate Change targets.

Introduction

A Green New Deal would represent an unprecedented, massive, mobilisation and deployment of resources to tackle the accelerated Climate Change crisis, requiring regions, nations and ultimately global acceptance (The Guardian, 23/04/2019).

How might a Green New Deal (GND) be applied to the early stage financing of Cleantechs? Amidst rising interest and adoption of Green New Deals in the US and potentially in the UK (NEF, 2019; The Guardian, 2019) and declaration of a 'Climate Emergency' by the Welsh Government (2019), the paper explores the need for more focused policy to address early stage long horizon financing of Cleantechs.

Over 100 national governments have signed up to the Paris 2015 agreement to work together to form a more cohesive approach to tackling Climate Change (UNFCCC, 2019). The major contributors to CO2 emissions in developed countries like the US are energy, heavy industry and transport (81%; EPA, 2018). Therefore, arguably, a key issue is to raise investment and overcome current market failures whereby private investors perceive that the risks of investment outweigh potential returns and investors are not appropriately remunerated for green investments (Lehner, 2016; Owen et al, 2018; Polzin, 2017). Whilst recent efforts have focused on developing Green Investment Banks and tackling larger infrastructural renewable energy projects, such as wind farms (Mazzucato & Semieniuk, 2018), less attention has been given to early stage Cleantech SME investment (Owen et al, 2018).

The paper focuses on early stage investment in Cleantech, which is broadly defined here as private for-profit SMEs which may be pre or early trading that have a mission to develop and adopt innovative technologies to reduce CO2 emissions in their products and processes (Kenton, 2018). They typically undertake long horizon research and development (R&D) and struggle to obtain sufficient, often high, levels of private investment required to reach commercialisation (Owen et al, 2019; BEIS, 2017; Rowlands, 2009).

Focusing on the example of the UK, post the 2008 Global Financial Crisis (GFC), we examine the role of the UK Innovation Investment Fund (UKIIF) as a leading example of government intervention to address market failure

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through public-private co-financing to raise the level of early stage venture capital (VC) investment into Cleantechs. Adopting a resource complementarity lens we are able to examine the operation of the UKIIF programme to establish what works well or less well and address the question as to how a GND approach might be applied, principally to venture capital (VC), to improving the under-developed Cleantech early investment market.

The paper proceeds by examining the role of the UKIIF within the entrepreneurial finance system and the emerging UK green finance escalator. We then adopt a complementarity lens to develop propositions which consider policymaker, VC financier and innovative early stage cleantech UKIIF investee SME perspectives, focusing on the experiences and outcomes of seven longitudinal UKIIF case study SMEs. Our findings lead to three emerging themes which, through discussion across the wider evidence base of policymakers, VCs, stakeholders and assisted SMEs, contribute to theory and policy by demonstrating a way forward to supporting key disruptive green innovation to impact on Climate Change under an overarching Green New Deal type policy initiative.

Positioning the UKIIF in the VC literature

The arguments for the importance of private VC in the development of innovation are well established (Gompers et al. 2010; Lerner, 2010; Munari & Toschi, 2014; Cumming & Johan, 2016; Baldock, 2016). Private VCs develop specialist skills and knowledge to invest in earlier stage innovative ventures and sectors, often preferring to invest locally in order to have hands-on contact with the venture management teams. Adopting Markowitz (1952) pareto principles they need to invest in sufficient numbers of portfolio ventures and at sufficient scale over time in order to obtain returns, which are principally made up of the most successful venture exits (usually through trade sales or IPOs). The problem for VC is that early stage investment is risky and the returns are longer horizon, typically taking 5-7 years and lengthening in times of recession (Owen et al, 2019).

Early stage Cleantechs may, therefore, be considered particularly vulnerable as they often exhibit long horizon intensive R&D with long valley of death periods spanning proof of concept to early commercialisation (Mazzucato & Semieniuk, 2018). Additionally, they suffer from a higher Liability of Newness compared to the already known issues of traditional new ventures (Lehner & Harrer 2018; Lehner & Nicholls, 2014), which may be because of their Cleantech hybrid business-models (Quelin 2017) that aim to combine a commercial logic with an environmental mission (Doherty et al, 2014). Since investors are not appropriately rewarded for the full environmental-societal value, the risk-reward balance is often viewed as unfavourable (Bocken, 2015; Bak, 2017; Owen et al, 2018). As a result, there is an increasing resource-scarcity in these ventures with large funding-gaps (Lehner, 2016; BEIS, 2017).

Mazzucato and Semieniuk (2018) refer to the well-established role of government to address market failure for public good. Furthermore, Lerner (2010) makes a compelling case for public intervention to co-invest with private VC to address the early stage funding gaps of innovative ventures. He also raises lessons from past programme failures, advocating; sufficient funding scale and appropriate consideration of follow-on funding requirements, long fixed-term VC co-finance arrangements (with powers to extend to obtain optimal value portfolio venture exit) with recruitment of experienced private fund managers to take the lead in investment decision-making, and the cultivation of a suitably supportive financing ecosystem which integrates University and R&D centres with the finance support intermediaries (e.g. accountants and lawyers) and public-private VC programmes. Owen and Mason (2019) take this forward with their vision for a mature economy institutional framework for the early stage innovation finance escalator, noting the need for an international approach to scale-up VC finance (supported in Baldock, 2016). What is missing, is a more focused approach to developing early stage green VC.

Owen at al. (2019) draw on Lerner's (2010) and others' (e.g. Cumming & Johan, 2016; Munari & Toschi, 2014; Colombo et al, 2014; Grilli & Murtinu, 2014; Technopolis, 20011) lessons, indicating that the UK is a global leader in co-financing with business angels and VCs. They point to the £330m UK Innovation Investment Fund (UKIIF), established in 2009, as a leading programme addressing early stage innovation investment – second in size only to the more generic £1.2b Enterprise Capital Funds - and the only UK national VC programme with a clear focus on low carbon sectors (renewable energy, recycling, advanced manufacturing, digitech and bio-science; see BIS, 2012). It is worth noting that the proposed UK £20m Clean Growth Fund announced in 2017 was still to be established in Autumn 2019.

The UKIIF has some ground-breaking features (BIS, 2012). It operates pari passu on an equal footing between public and private investors, unlike ECFs which provide an upside incentive to encourage private investment. This is to accommodate EU policy, since the programme has £100m of European Investment Fund investment. UKIIF operates as a fund of funds, so although it is regulated and monitored by the British Business Bank, it is privately operated, with two umbrella funds (UK Future Technologies Fund and Hermes Environmental Impact Fund) contracting (unlike the more direct contracting of private VCs operated by the British Business Bank for ECFs) and

overseeing the underlying frontline venture investment VC funds. Oxford Research (2015) points to a dearth of private VC fund of funds operating in Europe, due to poor track records and high administration costs of having two layers of fund management. However, on balance they suggest that public co-finance fund of funds can achieve sufficient scale to attract larger private institutional and international co-investment. They conclude that this provides the most suitable approach to international scale-up of VC funding and addressing the dual issues of achieving sufficient fund size and serving thin markets with insufficient viable business propositions (Nesta, 2009).

Although beyond the remit of this paper, it should be noted that numerous studies recognise that stimulation of demand-side early venture creation is crucial to co-financing VC programme success (see for example Owen & Mason, 2019; Cumming & Johan, 2016; Lerner, 2010; Avnimelech & Teubal, 2006; Gilson, 2003) particularly in more peripheral, smaller regional/national economies that lack critical mass of entrepreneurial innovation.

A unique feature of UKIIF is that the underlying funds are international – being based across Europe – and that it can invest globally in ventures, provided that at least the £150m UK government programme funding is invested in UK-based ventures. In this way UKIIF addresses many of Lerner's (2010) lessons by being private sector-led, contracting with leading international VCs with appropriate track records in early stage and Cleantech sector investing and not constrained to thin national/regional markets. Furthermore, as Owen et al (2019) observe, the scale of UKIIF underlying funds (at over £60m) is typically more than double that of ECFs, suggesting greater ability to provide large long horizon investment and follow-on funding. This addresses one of the key perceived failings of UK and European public and private VC, that they are too small when compared to their more successfully established US counterparts (Arundale, 2018; Deakins & Freel, 2012; Technopolis, 2011). Indeed, unlike the ECFs it was not constrained by EU state aid regulations to an initial £2m. It should be noted that in January 2014 the EU state aid cap was raised to £5m. However, many UK funds such as the English Regional Investment Funds subsequently remain constrained to a £2m investment cap per venture and 10% of fund cap on investment per venture, typically amounting to circa £3m. Furthermore, UKIIF's fund lifespan is 12-15 years, compared to 10-12 years for ECFs, taking heed of the long horizon investment requirements of the Cleantech sectors and enabling a longer period for follow-on funding and to achieve optimal portfolio firm exit values.

Positioning UKIIF within the UK green financing escalator and ecosystem

It is helpful to use the concept of a green finance escalator (Owen et al, 2018) to position UKIIF within the evolving post GFC UK early stage green innovation financing landscape. The finance escalator adapts Berger and Udell's (1998) theory of decreasing opacity of early stage ventures as they develop, suggesting that as venture track record develops and information asymmetries between ventures and potential financiers reduce, more and different private funding options and larger sums of money become available.

Table 1 demonstrates that the UK early stage innovative venture market contains a range of public interventions – including investor tax breaks, grants and equity funds, to address perceived early stage private equity funding gaps (where banks will not lend, North et al, 2013), particularly in the key, high risk valley of death area from proof of concept to early trading (up to 2 years). This is the so-called Macmillan gap (1931), currently thought to extend in the UK between £250k to £5m (Owen et al, 2019) and which may extend further for long horizon Cleantech R&D (BEIS, 2017).

North et al. (2013) highlight the importance of early stage funding complementarity to meet the financing demands of early stage ventures, suggesting that a fluent funding escalator requires effective bundling of different forms of finance, whilst Hopp (2010) recognised the value of syndication – notably between VCs (although increasingly occurring in recent times between seed VCs, accelerators, equity crowd funders and business angels (Baldock & Mason, 2015; Owen et al, 2019) - to raise investment levels, share risks, introduce more diverse investor skills, facilitate longer distance equity investment (between some investors and ventures) and open up international markets. Hopp (2010) and Baldock and Mason (2015) recognize that VC typically prefers to invest locally for easy hands-on access and support to venture teams, but that more distant national and international VC and angel investors will invest in syndication with trusted local lead investors who provide the hands-on support.This suggests the increasing opportunities for a more international approach to equity investing (Owen & Mason, 2019).

Table 1. Contemporary UK Green Innovation Finance Escalator for Early and Growth Stages

Pre-start	**Start-up to early market development**	**Early growth and development**	**Later stage**
Funds: <£50k	£50k - £2m+	£2m – £5m	£5m - £10m+
Timescale:	Start to 2 years trading	2-5 years trading	5-15 years trading
Internal funding (3Fs)	Internal funding (3Fs, consultancy income)	Re-invested profits	Re-invested profits
Credit cards	Early stage business angels/HNWIs	Joint ventures and licensing	Bank credit
Personal loans	Business angel syndicates	Bank credit (*Loan guarantees)	Venture capital
**'Proof of concept' grant funding (e.g. Innovate UK grants)	Crowd equity	*Public and private VC	Potential exit, trade sale, MBO/MBI, Initial Public Offering (IPO)
*Incubator support and funding (e.g. **CLT)	Accelerator finance	*Peer-to-peer lending	Corporate/institutional finance (private equity)
*SEIS tax breaks	*Start-up Loans	**Technology development grants	Business Growth Fund (BGF)
	**Technology development grants (e.g. Innovate UK)	*Help to Grow (H2G) loan guarantees and mezzanine	*Business Finance Partnership (BFP) funds
	**Innovation Accelerator Programme (IUK)	*Innovation Loan Pilot (IUK)	**Green Investment Bank (GIB)
	**UKIIF	*EIS/VCTs	
	*Public and seed venture capital (VC) including ACF		
	*S/EIS tax breaks		

Source: Adapted from Nesta (2009a), Mason (2016), Baldock and Mason (2015) and Baldock et al. (2019): * marks public sector/government funding intervention, ** where this has some expressed green innovation intent.

Table 2 demonstrates that whilst the UK has vast sums invested into early stage SME financing in the period of study, from 2009, a relatively small proportion has been directed at early stage Cleantechs. Indeed, the programmes with direct reference to early stage Cleantechs amount to under £600m, with the majority of this coming from UKIIF. To further contextualise the value of UKIIF, British Venture Capital Association (BVCA, 2017) data on members' investment into UK venture stage Cleantechs (which may include co-finance) shows a total of £95m into 151 ventures for the period 2014-2016 (representing around 10% of all recorded member venture stage investment in that period).

Of course, the UK Department for Business, Energy and Industrial Strategy (BEIS, 2017a) has a £2.5b Clean Growth Strategy to support R&D through work with UK research councils, but this is centred around renewable energy and much of the financing is aimed at Catapult programmes for offshore and renewable energy solutions, with direct finance to SMEs being mainly directed at their energy efficiency. This forms a familiar pattern to that of the Green Investment Bank (GIB), which was established by the UK government to lever in private investment for infrastructure projects and successfully delivered £2.3b of investment between 2012 and GIB privatisation in 2017, but demonstrated little evidence of supporting early stage Cleantechs (Owen et al, 2018). A final addendum here is the signs of tensions between the British Business Bank's sector agnostic (indicated in discussion with British Business Bank on 31/05/2019) approach to early stage government VC programmes, as opposed to the more directly targeted schemes recently developing through BEIS (such as the proposed Clean Growth Fund) and Innovate UK (through programmes like the Investment Accelerator Pilot).

An important source of early stage Cleantech finance has also been Innovate UK grants, notably Smart awards which have traditionally supported proof of concept through to early commercialisation, with grants of up to £250,000 requiring match funding. However, the evaluation of Smart (SQW, 2015) revealed that only 9% of grant funding went to Cleantech, whilst Owen et al (2019) demonstrated that failure to secure match-funding and follow-on funding led to a systemic funding for failure. Subsequently, Cleantech has become a priority sector focus through the early proof of concept £50m Investment Accelerator Programme (IAP) piloting matching grants and seed VC for low

carbon infrastructure projects of up to £150k and new Smart grants which offer tranches of funding of up to £3m over three years.

Overall, what we see is a proliferation of government public-private co-financing, creating a complex map of finance, much of which is not clearly linked with Cleantech objectives, and which is increasingly difficult for interested parties to navigate and achieve optimal investment outcomes.

Table 2. Positioning Key Sources of Public SME Green Innovation Finance (marked in green) in the UK, 2009-2019

Type of finance	Funding Description	Administering Body
Tax		
R&D Tax Credits	SME scheme (<500 employees & £100m sales) for corporate tax rebate or cashback	HMRC
Seed Enterprise Investment Scheme	Start-up (<25 employees) investor tax relief, up to 50%: investor cap £100k, firm cap £150k pa	HMRC
Enterprise Investment Scheme (EIS)	Early stage (<500 employees) tax relief, up to 30%: investor cap £1m, firm cap £5m pa	HMRC
Venture Capital Trusts (VCTs)	VCs funded through EIS investing in SMEs (<£15m assets)	BBB
Grants		
Innovate UK	Various match fund grants: Knowledge Transfer Partnerships (<£80k), SMART awards/grants (<£3m), Launchpad and Feasibility (<£400k), Collaboration and Catapult (£10m+), including £165m annual funding from 2016 for new forms of finance (e.g. repayable loans) **Investment Accelerator Programme (£50m) matching grants with seed VCs (max £150k)	UKRI Innovate UK
European grants	Horizon2020 and Eurostars grants (up to E300k at 50% match-funding)	EU
Regional Growth Fund (RGF)	Loans and grants through the £2.6bn RGF for English Local Enterprise Partnerships (LEPs)	BEIS
Energy Entrepreneurs Fund	**£150m Energy Entrepreneurs Fund (EEF) and £10m Energy Innovation Fund	BEIS
Debt/loans		
Enterprise Finance Guarantee (EFG)	75% government guarantee on loans, overdrafts and invoice finance capped at £1m	HMRC
Business Finance Partnership (BFP)	£100m govt co-invest in invoice, supply chain, asset, mezzanine (growth loans) and P2P (e.g. Funding Circle, Zopa)	BBB
Green Investment Bank (GIB)	Funding complex projects tackling greenhouse gases, natural resource efficiency, natural environment, biodiversity, environmental sustainability. £2.3bn invested 2012-2017 including **£2m Green Energy Savings Fund for SMEs	GIB

Type of finance	Funding Description	Administering Body
Big Society Capital	£488.2m invested into charities and social financing organisations by June 2016	Cabinet Office
VC/equity		
Angel Co-investment Fund (ACF)	£100m evergreen business angel co-invest fund, from 2011	BBB
Enterprise Capital Funds (ECF)	£1.2b co-investment VC funds, from 2006	BBB
UK Innovation Investment Fund (UKIIF)	**£330m UK government and European Investment Fund - fund of funds for health and Cleantechs, from 2009	BBB
Regional Venture Capital Funds (RVCFs)	North West (£190m), Yorkshire & Humber (£90m+), North East (£125m), **East of England (£20.5m Low Carbon Innovation Fund) - range of loans and equity (£2m cap)	EU JEREMIE/ERDF, BBB
UK Government Regional Investment Funds	From 2016 VC and loan funds: Northern Powerhouse Investment Fund (NPIF) - £400m for North West, North East and Yorkshire & Humber; Midlands Engine Investment Fund (MEIF) - £250m for Midlands region; Cornwall & Isles of Scilly Investment Fund (CoSIF) - £40m	BBB
Devolved UK Governments	Scottish (£185m), Northern Ireland (£160m),,Wales (£150m+) VC and loan funds (£2m cap)	ERDF/JEREMIE SIB/DETI/FW
Universities Innovation Fund	£160m (Higher Education Innovation Fund) and University Enterprise Zone Pilots (£15m), Knowledge Transfer Networks	Research England
Export finance		
UK Export Finance	£1.5b scheme 2012-15 to assist export trade credit arrangements	UK Export Finance

Note: ** programme has expressed green innovation support; BBB - British Business Bank; BEIS – Dept for Business, Energy and Industrial Strategy; UKRI – UK Research and Innovation; RE – Research England; HMRC - Her Majesty's Revenue and Customs; DETI – Northern Ireland Dept for Enterprise Trade and Industry; ERDF – European Regional Development Funds; FW – Finance Wales; JEREMIE - Joint European Resources for Micro to medium Enterprises SIB – Scottish Investment Bank. Sources: Adapted from Owen et al (2019)

Adopting a resource complementarity lens

The research question addressed in this paper is how a Green New Deal can generate improved external financing for early stage innovative Cleantechs. The literature establishes that substantive public-private co-financing with VC can address finance gaps for longer-horizon, capital intensive R&D and early commercialisation of Cleantech ventures. Taking the case of the UK's market-leading approach with UKIIF we are able to critically assess what

works well, or less well, and to take on board lessons and address the areas for further improvement. To achieve this we construct a resource complementarity research framework (Chi and Levitas, 2007). This accounts for the interdependencies which occur between innovative (Cleantech) businesses and institutions, within a societal framework. From a resource-based perspective the balance between such interdependences is critical in how the value of a Cleantech innovation is assessed and supported financially (the purpose of this paper).

This interdependence – resource-complementarity framework operates on two levels (Table 3): first, the role of co-financed VC programmes within the Cleantech strategic policy sphere; second how the co-financed VC process can operate better in addressing the financing needs of Cleantechs. The first addresses the need for clearer objectivity in policy to target and assist Cleantech (which is evidently lacking from the current UK green finance escalator), whilst the second relates to programme operation. We argue that both can benefit from lowering transaction costs to improve capital market functionality. Mindful of tier 1, in this paper we focus on tier 2 and the operation of UKIIF.

Public-private partnerships (PPP) based on a Green New Deal (GND) can affect the standardisation and institutionalisation of the search, contracting and monitoring phases of Cleantech hybrid ventures (Lehner, 2016; Lehner and Nicholls, 2014; Lehner, Harrer and Quast, 2018). Standardisation may also be a catalyst for subsequent funding from private institutional investors as a successful PPP enhances the legitimacy of both involved parties and lowers the transaction costs in order to create a functioning market (ibid). With this we contribute to the ongoing research and discussion on hybrid business models and public-private collaborations (Achard and Di Berardino, 2018).

Table 3. Two-tier Framework for UK Cleantech Policy and Programme Delivery

Tier one players: the macro policy environment *strategy* and ecosystem concord • Transnational public bodies (EU, World Bank) • Government departments (national, regional and local): UK key players BEIS, Government Offices, Devolved Governments (NI, Scotland, Wales), Regional/City governments and Mayors (e.g. London and Manchester) • Specialist economic development and financing / green financing non departmental bodies: British Business Bank, Innovate UK, • Private financing bodies (financial intermediaries): Green Investment Bank, Carbon Limiting Technologies, Carbon Trust • Business support and finance intermediaries (private and public sponsored advisory services): Local Enterprise Partnerships (38 in England), Local Enterprise Hubs
Tier Two players: the micro delivery *process* of policy programmes • Government VC co-financing programmes (hybrids): UKIIF, IAP • Private financing bodies (financial intermediaries); Banks (Challenger, Regional) VCs Angels Private Equity (PE), Crowdfunding (CF), Peer to Peer (P2P), Asset finance • Business support and finance intermediaries (private and public sponsored advisory services): Accountants • R&D centres/universities: Catapult Centres, University R&D commercial spin-out centres (e.g. Maxwell Centre, Cambridge University) • Cleantech early stage Ventures: ventures trading less than 2 years undertaking R&D to reduce CO2 emissions

Focusing on a resource complementary lens and drawing on the literature of hybrid VC (Murray, 2007; Lerner, 2010; Munari & Toschi, 2014; Cumming & Johan, 2016; Owen et al, 2019 etc.) we are able to construct a series of propositions for the different types of resources that will most prominently benefit from this type of public – private partnership (PPP) which transacts between government, Private VC and entrepreneur/venture. Whilst table 4 is by no means exhaustive, it nevertheless presents key elements derived from leading, current literature where we can propose that PPP will enhance operation and delivery of:

(1) P1 - Funding: improved early stage funding escalator and availability of early stage VC
(2) P2- Management: Enhanced VC management, investment decision-making and Entrepreneurial/venture team management
(3) P3 – Risk-sharing: enhanced risk sharing environment will benefit VC investors and ventures

(4) P4 – Networking: enhanced networking will assist viable venture pipeline and increased VC and complementary investment including through syndication
(5) P5 – Skills Development: will lead to improved VC investment and venture performance
(6) P6 – Cleantech innovation / economic growth: enhanced cleantech innovation and economic growth through adequate and effective VC financing market.

Table 4. Resource Complementarity Framework for UKIIF

Government	**Private VC**	**Entrepreneur**
1.Funding		
Substantial government funds, accountable to HMT, provide value for money, effective flowing finance escalator (Baldock, 2016)	Insufficient funds and appetite in early stage investing, increased scale can increase institutional investment (Technopolis, 2011)	Asymmetric barriers to early stage risk finance (Carpenter & Petersen, 2002)
2.Management		
Government bureaucrats lack skills to invest directly in early stage ventures (Lerner, 2002)	Skills, experience to address agency failures (Lerner, 2010; Gompers et al, 2009)	Commercial and financial management skills (Baldock & Mason, 2015)
3.Risk sharing		
Improved likelihood of returns investing with private VC track record and scale-up (Lerner, 2010)	Government funding safety net, increases funding scale and likelihood of pareto return (Markowitz, 1952); VC syndication linkages (Hopp, 2010)	Cede share of ownership, but obtains certification of VC finance, increasing likelihood of further follow-on finance (Cumming & Johan, 2016)
4.Networking		
Government policies promote entrepreneurial ecosystem networks for SME growth /sustainability (Brown & Mason, 2014 & 2017)	Need pipeline of viable ventures (Mason & Brown, 2013). Provide access to complementary finance, skills and commercial markets (Owen et al, 2019)	Require access to management skills/training, supply chain, commercial markets (Owen et al, 2019a)
5. Skills Development		
Skills development increases productivity and competitiveness (Gambin et al, 2009) and virtuous cycle of development (Lerner, 2010)	Early stage VC skills and sector specialisms development (Gompers et al, 2009) and recycling of new VC manager talent (Lerner, 2010)	Management team development through recruitment, training, mentoring and oversight (Baldock, 2016; Munari & Toschi, 2014)
6. Cleantech Innovation / economic growth		
Policy promotes cleantech innovation for Climate Change (Owen et al, 2018), raising GDP through vibrant SME jobs, sales, export growth (Lerner, 2010)	VC seek early stage innovation with risk/reward potential for financial return (Burchardt et al, 2016), create venture growth, scale-up (Baldock, 2016)	Create innovative disruptive cleantech R&D start-ups (Owen et al, 2019), creating jobs, sales and competitive exporting SMEs (Owen et al, 2019)

Table 4 clearly demonstrates the overall key to addressing Climate Change in the interdependency of the three main actors studied. Government policy framework can fund and support early stage Cleantech, whilst early stage

VC can reduce agency failures (moral hazards and adverse selection) using key skills to select and nurture portfolio ventures, with the ventures developing game changing disruptive green innovations to lower carbon emissions.

Methodology

We adopt a mixed methods approach (Creswell, 2003) in order to triangulate primary evidence drawn from in-depth longitudinal case studies of seven UKIIF assisted Cleantechs (in renewable energy, recycling and advanced manufacturing) with other relevant contextual sources in the 2010-15 period (Tables 5 and 6).

Table 5. Breakdown of business interviews 2010-2015

UK GVC Fund recipients/study	F/F, or extended telephone interview	Interview dates	Longitudinal follow-up interviews, Summer 2015
Innovative SME journey	30	Feb 2015	-
ECF (Enterprise Capital Funds)	12	Feb 2010 & Feb 2014	7
ACF (Angel Co-investment fund)	15	Feb 2014	-
UKIIF (UK Innovation Investment Fund)	16	Feb 2012 & May 2013	14 - **including 7 Cleantech case studies**
Technology Based Small Firms (TBSFs)	49	Feb 2011	1
Aspire	4	Feb 2010 & May 2013	2
EGF (Early Growth Fund)	9	Feb 2010	-
Total	133	(2010-15)	24

Source: interviews undertaken by CATI (computer assisted telephone interviews), F/F on business premises or by extended telephone interview

In total the CEOs of 133 young potential high growth and innovative UK ventures were surveyed either face-to-face, or by extended telephone interview by the authors. This includes six UK early stage venture investment programmes overseen by the British Business Bank and two studies (technology based small firms, North et al, 2013; innovative firm's journey to finance, BEIS, 2017) specifically examining early stage innovative venture finance. Ventures were purposively selected in order to provide insight into a range of different early stage sectors, including Cleantech. Overall, they are characterised as follows; ventures are typically under 2 years established and pre-trading when first interviewed, micro-businesses with less than 10 employees and undertaking innovative market leading R&D in science, engineering and advanced manufacturing, or digitech service sectors (e.g. App and Fintech). One quarter of the base sample and 63% of the longitudinal sample are Cleantech, represented by renewable energy (e.g. solar PV, biomass), digitech (e.g. smart energy metres), recycling (e.g. water, rubber/plastics and aluminium) and advanced engineering (e.g. digital efficiency controls, robotics, electric vehicles, lightweight plastics and battery storage solutions).

All data was systematically collected by the authors using integrated interviews (Owen et al, 2019), typically taking 1.5 hours, covering business profile, nature and stage of innovation, external financing requirements, finance search times and costs, and extent of impact of VC/equity finance and non-financial assistance on subsequent business performance, including follow-on financing and investment exit information. The seven Cleantech case studies were selected as exemplar cases of UKIIF assistance (and exclude health sector cases, which represented around half of UKIIF's early stage investments) and longitudinally tracked through 3 surveys between 2012-15, with supporting information coming from VC investors, programme management data and company websites.

Additional triangulatory qualitative contextual data was provided by 58 semi-structured telephone and face-to-face interviews with investors (business angels and VC fund managers), intermediaries and industry experts (Table 6, see

Owen et al, 2019a; Baldock, 2016; Baldock and Mason, 2015; Baldock and North, 2015), with particular consideration given to the Cleantech UK early stage government co-financing market, post GFC.

Table 6. Breakdown of fund manager and investor interviews

Fund	**Location/ time of interview**
Enterprise Capital Funds (ECFs):	**Spring 2014**
The Catapult Growth Fund (ECF)	Leicester
IQ Capital Fund	Cambridge
Oxford Technology	Oxford
Seraphim Capital Fund	London
Sustainable Technology Partnership	London
Amadeus and Angels Seed Fund	Cambridge
Dawn	London
MMC	London
UK Innovation Investment Fund (UKIIF):	**Spring 2012**
Hermes GPE Environmental Innovation Fund	Fund of funds manager, London
European Investment Fund UK Future Technologies Funds	Fund of funds manager, Luxembourg
Underlying funds:	
Zouk Cleantech II	Hermes fund, London
Scottish Equity Partners (SEP) Environmental Energies	Hermes fund, Glasgow and London
WHEB Ventures	Hermes fund, London
DFJ Esprit	EIF UKFTF fund, London and Cambridge
Advent Life Sciences	EIF UKFTF fund, London
Gilde Healthcare III	EIF UKFTF fund, Utrecht and Cambridge USA
Angel Co-Investment Fund (ACF):	**Spring 2014**
19 Lead business angel investors from investment syndicates, of which 16 were successful ACF applicants and were unsuccessful	10 angel groups, 5 in London, 2 in South East, 1 East Midlands, 1 in South West England and 1 in Scotland
3 Investment Committee (IC) members - experienced angel or institutional investors	UK-wide representation
Alternative Investors and Experts	**Spring 2010 to Spring 2014**
13 alternative private investors: Private VCs (4) and seed VCs (3), Venture Capital Trusts (3) Angel Capital Groups (3)	8 in London, 1 North East, 1 Yorkshire and Humber, 1 Scotland
6 industry stakeholders and experts: British Venture Capital Association (BVCA), UK Business Angels Association (UKBAA), Angel News, St John's Innovation Centre, European Investment Fund (EIF), Professor Dylan Jones-Evans (Finance Wales reviewer)	UK-wide coverage

Source: CEEDR studies 2010-2015

Data collected provides a rich source of qualitative information on the financing requirements of early stage Cleantechs and the extent to which public-private co-financing programmes are meeting these needs. The data gave rise to the possibility to consider a-posteriori how a GND could establish a more systematic and institutionalised approach to assisting Cleantech early stage investing, leading to lower corresponding transaction costs through the standardizing of the search, contracting and monitoring phases (Lubell et al, 2017).

In addition, we apply a resource-complementarity lens to understand how a public-private collaboration (Shi et al, 2016) based on a GND can result in effective, optimized value-creating solutions towards the climate goals that far out-weigh the involved costs (De Schepper et al, 2015). In this, we understand resource-complementarity lens (Sayeed & Onetti, 2018; Soda & Furlotti, 2017) as the degree to which the joint use of distinct sets of resources (e.g. the innovative mindset and skills and the financing power) produces a higher total return than the sum of returns that could be achieved if the resources were only utilized independently.

Findings

Adopting our resource complementarity framework (6 propositions), we present findings from the 7 case studies' perspectives to examine how in practice the UKIIF has addressed their Cleantech early stage financing requirements. We take into account transaction cost and impact measures to assess what has worked well or less well, before proceeding to a discussion on the implications for policy. Analysis of the research propositions revealed considerable interrelationships between the propositions and is presented here under four emerging major themes, of which theme 2 (search times, negotiations and costs), may be considered a subset of the first funding theme (notably in addressing proposition 1).

Funding, bundling and risk-sharing (P1, P3)

Early stage Cleantechs require substantial amounts of external financing. Table 7 demonstrates that the 7 case study ventures were seeking either first round, or early round finance for R&D and early commercialisation. They were all independent micro businesses and pre-trading at the time of their search for external finance. The size of the funding rounds to which UKIIF contributed ranged from £300k to £13m, but were typically over £1m (median £2.1m). UKIIF typically provided at least half of the funding round (median £2m), frequently syndicating with other VCs and notably bundling with other funding providers to generate larger rounds (Baldock & Mason, 2015), providing evidence of syndication with overseas VCs to share early stage investment risk (Hopp, 2010), scale-up investment (Baldock, 2016) and facilitate access to international markets (Owen et al, 2019). Case D's CEO commented "SEP brought in a US VC at the commercialisation stage to introduce us to the US market."

It is worth reflecting that the scale and size of funding for these UKIIF cases is considerably higher than for comparable, but more generic UK ECF funds (median £750k ECF investment), with considerably more syndication taking place to achieve the financing round requirements (Owen et al, 2019). Crucially, UKIIF was a lever to other private investment with one CEO mentioning that "the UKIIF SEP fund encouraged Zouk's later stage VC fund to invest £3m earlier in the business than otherwise possible." The high share requirements of the UKIIF VCs is indicative of the high risk and early stage investments taking place (median 25%), with follow-on funding in case D leading to a 75% share. Notably, none of the interviewed CEOs complained about the proportion of ownership share taken by UKIIF VCs, supporting Gompers et al (2010, 2009) proposition that experienced early stage VCs offer both vital finance and also the required non-financial sector, management and networking skills. The evidence here strongly supports the propositions that government can co-fund with private VCs to leverage increased volume of early stage private sector equity funding (Lerner, 2010; Owen et al, 2019). Furthermore, this is interlinked with encouragement of VC syndication, notably through UKIIF's fund of funds model (Owen et al, 2019), which demonstrates the value of risk sharing in generating increased funding (Hopp, 2010).

Search times, negotiations and costs (P1, P4)

Government VC programme assessments often focus on additionality and leverage, without sufficiently considering transaction costs (Baldock, 2016; BEIS, 2017; Owen at al, 2019). Most of the 7 case studies experienced relatively short search times of under 3 months. This was mainly serendipitous, highlighting the timeliness of UKIIF and existing VC connections and the excellent fit of the programme to the ventures' funding requirements. The UKIIF funds were described by CEOs as "the fund of choice" and "the most experienced and proven fund" in the sector.

This might suggest that the level of UKIIF additionality is low (Owen et al, 2019, indicate that it is lower than for ECFs), since the funds were selected quickly and sometimes over other competing private VC funds. However, this narrow view overlooks important contributary factors. First, the CEOs perceive that selecting the most suitable and experienced fund, and fund managers to work with, is more important than lower cost/share options and second that the speed and scale of access afforded by UKIIF in most cases led to more rapid R&D and commercialisation and increased the scale of activity. Additionally, from the fund managers' perspectives, UKIIF was reported as facilitating more rapid and larger-scale fund closes (reported by the BBB and fund managers as particularly helpful in the aftermath of the GFC), suggesting that the case study investment – particularly in terms of their early stage and large size of investments would not have been available without the government programme. This is underlined by the more severe experiences of the cases where funding was required before UKIIF was established and highlighted by case E.

Case E: Three-year round 1 funding search (2008-2010)

Seeking a package of equity and bank finance to fund a management buy-in to an existing UK-based business and undertake internal R&D to commercialise 'PET' lightweight plastics technology. Total project cost was £13m, of which UKIIF provided £2.6m for a 21% equity share. The funding search process took three years, hampered by lack of bank and early stage equity finance available in the UK and Europe. UKIIF was found using an accountant VC finder, and was not problematic, but took nine months to negotiate.

"Getting a UKIIF VC on board as lead investor was a catalyst to getting further VC investment and European bank finance… critical to business development, transforming a business that was closing down into a global market leader."

The negotiation time to undertake due diligence and agree terms and conditions was typically around 3 months, but could take up to nine months for more complex transactions such as case E which required a syndication bundle of additional bank and VC finance to undertake a manufacturing factory buy-in, or case A, described by the CEO as "involving complex IP rights for a spin-out from Cambridge Innovation."

Transaction costs for VC are high, typically amounting to 5% of ECF deals (BIS, 2010) and often an even higher proportion of smaller value deals. These can involve the search costs for accountant and VC finder services and direct costs for consultancy and accounting services to undertake due diligence and legal fees for negotiating and agreeing contractual terms and conditions, with applicants frequently responsible for both parties' legal costs or VC administration fees. Additionally, there is the management search time and opportunity costs associated with lengthy searches and compliance work for applications which take time out from other core business development activities (BEIS, 2017); which could typically require a day or two a week of senior management time for several months (BIS, 2010). Despite the high costs of obtaining VC, none of the UKIIF case CEOs complained. They stated that costs were at the expected market rate, which was particularly acceptable if search times were reduced and for case F which used UKIIF syndicated with the Scottish Co-investment Fund (SCIF), it was "…less expensive because it saved on the time and cost of finding and agreeing investment terms with individual angels."

Overall, there is strong evidence to support proposition 1 that government co-finance programmes can increase the supply of early stage finance (Lerner, 2010). There is also support for proposition 4 with increased VC networking capacity being catalysed by a government backed fund of funds allied to VC syndication (Hopp, 2010). This can generate sufficiently large early stage funding rounds and capacity to follow-on fund, reducing search times and costs for initial and succeeding rounds.

Table 7. Case Study Funding Requirements and Search Details

Company/ Established	UKIIF Fund	Activity/green	Round/ amount	UKIIF/ share	Leverage	Search Time	Time Neg
A (2010)	DFJ	3D Radar, windfarms near airports	1: £2.1m	£1.6m (50%)	0%	<3 months	6-9 months
B (2010)	Zouk/ SEP	Energy, smart metres, battery R&D	1: £6m	£3m (50%)	50%	<3 months	<3 months
C (2009)	SEP	Renewable grid connection	1: £1m	£0.5m (24%)	50%	<3 months	<3 months
D (2005)	SEP	Domestic water recycling	3: £2m	£2m (25%/75%)	0%	<3 months	<3 months
E (2009)	WHEB	Lighter PET plastic	1: £13m	£2.6m (21%)	500%	3 years	9 months
F (2010)	SEP	Drones energy inspection	1: £300k	£150k (25%)	25% (SCIF)	1 year	<3 months
G (2009)	WHEB	Domestic Smart energy controls	1: £6.5m	£3m (27%)	0%	<3 months	5 months

Management, networking and skills development (P2, P4, P5)

Early stage VC perform a vital role in nurturing their portfolio business development. This helps to overcome agency problems, particularly moral hazard where early stage venture management deficiencies can lead to sub-par performance (Baldock and Mason, 2015). It was widely evidenced by the case studies (via CEOs and UKIIF fund managers) that VC were in regular, at least monthly, contact, acted as board advisors, appointed non-executive directors and recruited specialist managers to strengthen the management team, notably financial and commercial directors.

A distinction was made here between technical development, which is typically the domain of the founding venture team and which VCs are usually less able to assist and broader commercial marketing expertise. Several interviewed CEOs mentioned the importance of commercial rigour, developing tight financial management controls and regular monthly reporting, and this was an important contributory factor in all of the CEOs feeling more confident about raising follow-on finance. These processes established various positive outcomes. For example, case A recruited a Chief Finance Officer, whilst for case E the VC was "..massively helpful, providing a strong steer on corporate finance and governance and constructive input at all times. They have been particularly helpful in finding new overseas customers." It is notable that this company now has board representatives from Russia and South Asia which have proved huge growth markets in recent years.

Another aspect of skills development, unrecognised in some studies, is early stage fund management. Whilst some funds like DFJ (Draper Esprit) have considerable track records in early stage finance, others such as Zouk have been encouraged to enter earlier stage venture financing, learning by operating with shared syndication risk. Lerner (2010) recognised the value of this process (e.g. Israel's Yozma funds and New Zealand's Venture Investment Fund) whereby experienced fund managers demonstration affects can encourage others into the market, but also upskill other local fund managers (Baldock, 2016).

Here there is clear evidence of upskilling for VCs and entrepreneurial management teams, particularly in support for proposition 2. VC fund managers particularly benefit from the oversight network of UKIIF's fund of funds management structure that can offer early investing skills support (Oxford Research, 2015) and wider VC syndication opportunities to enhance investor skills and share risk (further supporting proposition 4; Hopp, 2010). Furthermore, proposition 2 is supported by the evidence of entrepreneurial management skills improvement delivered by VCs' advice and management recruitment practices (Owen et al, 2019), although it is noted that this is largely focused on financial management and marketing, rather than R&D and technical support.

Cleantech economic impacts and global Climate Change game changers (P6)

Since receiving early stage Cleantech funding from UKIIF the 7 case study ventures have performed well. Collectively, they have generated over 840 FTE jobs since receiving UKIIF investment and moved from pre-trading R&D through to commercialisation and in 2018 £106.7m sales (median £6m). Their impacts on reducing CO2 emissions have also been considerable. Whilst it is worth noting that there is no consistent measurement in place for these businesses, they demonstrate enormous energy savings through the operations of smart energy controls (e.g. case G's 23% savings on domestic energy use, and case B's smart controls for business and high end domestic users), windfarm development and maintenance (cases A, B and F) and advanced 'PET' lightweight and fully recyclable plastics which have transformed the drinks/liquid foods distribution industry, reducing plastic container materials by 90%, reducing container weight by 85% and eliminating empty container return costs through 100% recycling technology. Cases A and F are intriguing examples of Cleantech whose impacts are more difficult to quantify. Case A's holographic 3D radar should enable highly efficient large-scale wind turbines to be located on and nearby defence/military sector land and close to airports without affecting flight control (unlike conventional radar systems); it is undergoing trials with the UK Ministry of Defence (MoD) in 2018-19. Case F's inspection drones have been used for conventional oil and gas industry rig inspection and for renewable energy windfarms.

All UKIIF cases reached commercialisation and have delivered cleantech products and services, although case D's domestic grey water recycling product failed to gain a market foothold in 2013-14 and the company subsequently closed. The remaining 6 cases have all successfully exited UKIIF within a nine year period, producing substantial returns to the UKIIF underlying funds and the UK tax payer. Exits have included a trade sale and an IPO which raised US$20m for case G in 2014. The majority of cases have refinanced and exited UKIIF, through Private Equity (PE) and joint venture arrangements and, for case C, through debt refinancing in 2015. It is notable that these businesses are highly innovative market leaders that service global markets. For example, case G has trialled smartphone controls on domestic energy use in Denmark and New Zealand, whilst case E's joint venture provided access to the vast Indian sub-continent market, with the company also very active across Eastern Europe, Russia and North America. Crucially, the surviving businesses retain considerable UK presence, notably R&D activity, and with several former CEOs involved in investing in and managing new Cleantech start-ups, thus supporting Lerner's (2010) and Owen and Masons' (2019) belief in the local recycling impact of public VC (an important bi-product of proposition 5).

Table 8. Case Study Status, June, 2019

Co.	Jobs Created	Annual Sales	UKIIF Status/Exit year	Green Impacts / Mega Watt (MW) estimations
A	50	£10m	Acquired, 2017	Enabling giant wind power on MoD land, tests from late 2018
B	480	£75m	Private Equity, 2014	480MW renewable generation; 380MW battery storage by 2020
C	125	£6m	Debt refinance, 2015	250MW in Grid Renewables Input
D	0 (10*)	0	launched domestic grey water recycling in 2013	Grey water recycling product marketed, but failed in 2014
E	75	6m	Joint venture buyout, 2014	PET containers reduce 90% weight, 85% material, 100% recyclable
F	60	3.9m	Private Equity, 2019	Drone inspection of windfarms
G	50	5.8m	Raised $20m in IPO 2014	Smartphone control of domestic heating with 23% energy saving
Total	840	£106.7m	6 Exits, 1 closure	All made impacts, 6 ongoing

Note: * 10 staff at time of closure

Case B has focused on the UK market and, whilst becoming a global top 100 Cleantech, it has created nearly 500 FTE jobs in the UK and generated annual sales turnover of over £75m in the decade since start-up. This case provides a compelling example of how UK government VC funds can assist hugely impactful Cleantech outliers.

Case B: A Global 100 Cleantech Growth company

The first UK company offering total energy solutions, following North American and German models, focusing on the larger commercial business market, provide consultancy and advice on a full range of renewable energies. Established 2010 with UKIIF providing 50% of start-up capital, the company offers initial concept, R&D, monitoring, financing and all technical solutions and have patented their own energy monitoring devices, developed in-house through strategic company acquisition and key staff recruitment.

Key Green Impacts

The company's products and services over the last decade have reduced UK carbon emissions by an estimated 480MW (2017) of renewable energy generated through solar and wind. The company's dual strategy of short-term digitech smart control and energy consultancy and long-term battery storage R&D enabled rapid Global 100 scale Cleantech sales growth and early exit from UKIIF via scale-up PE investment in 2014. A recent deal with a major utility company has put them at the forefront of battery storage and on track to meet 380MW by 2020.

"*As the UK market leader in energy storage, we command the industry's most accurate revenue modelling tool and are on track to exceed 380MW of battery storage by 2020. We have constructed over 100 solar farms, and our O&M service, 'XYZMeter', monitors over 21,500 sites. We were first in the UK to achieve subsidy-free solar, first to introduce utility-scale energy storage, and first to co-locate energy storage with existing solar sites. To date [March, 2019], our technologies deployed and managed are generating over 1GW of renewable energy."*

UKIIF additionality

Whilst the CEO acknowledges other VC funding was available, UKIIF's fund was their first choice: *"I trusted them as a leading VC in the cleantech field. The fund manager knows and understands the sector and provides an excellent sounding board for day to day management decisions. Their industry connections and commercial rigour helped prepare the company for scale-up PE and built the platform for our later growth."*

In summary proposition 6 is very strongly supported by the longitudinal evidence from the case studies. Whilst it is too early to comment on whether a sustainable early stage cleantech VC market has been created, as this could potentially take decades to establish (Lerner, 2010, Baldock, 2016), there is evidence of green economic impact and of successful investment exits which will enable fund recycling. Crucially, this offers the opportunities for a growing cleantech early financing ecosystem with increasingly experienced early stage VC fund managers and serial entrepreneurs (Owen and Mason, 2019).

Discussion

Summarising the findings through a complementarity lens, all of the hypothesised benefits have accrued to some extent, but the findings also reveal important lessons for future programmes, particularly around evaluating green impacts (Owen et al, 2018) and the potential benefits of paying greater attention to transaction costs.

Table 9 presents a synthesis of key transaction cost factors where complementarity between government policy and programmes, private VC and cleantech entrepreneurs has led to demonstrable benefits for all parties. This synthesis is formed from our complementarity framework findings for the 6 propositions. The findings demonstrated considerable interrelationships between the 6 propositions and the emergence of three key themes which can inform theory, policy and practice.

Funding, bunding and risk sharing (propositions 1, 3 and 4)

Funding, bunding and risk sharing (including propositions 1, 3 and 4) are all enhanced by UKIIF with key reductions in transaction costs for government relating to lighter touch oversight management required by the British Business Bank (e.g. compared to in-house management of their Angel Co-investment Fund), whilst the increased scale of activity of the UKIIF fund of funds enables direct investment from institutional pension funds (£80m was raised from two pension funds) and the oversight of an experienced Cleantech specialist fund with knowledge of over 60 VC funds:

"Hermes contributes … by referencing providers (i.e. underlying funds) and introducing new investors to funds that Hermes are working on for investments. Also advising these funds on how to improve due diligence materials." Hermes fund of funds manager.

The scale-up of activity possible through a fund of funds mechanism and flexibility of funding with potential top-up funding to underlying funds provides greater opportunity to reach Markowitz (1952) portfolio investments numbers and to follow-on fund to generate optimal exit value. Furthermore, operation across international boundaries through international fund linkages across Europe and US reduces the adverse selection risk of thin markets (Nesta, 2009). For the cleantech entrepreneurs the search time savings and single deal structure of UKIIF investments potentially saves costs – particularly in relation to follow-on funding which is critical to the generation of smooth flowing green innovation funding escalator (North et al, 2013; Baldock, 2016). However, there is always room for improvement on due diligence and legal negotiation fees, which can be off-putting to some ventures (Baldock and North, 2015), although this was not evident amongst the UKIIF cases studies here. Here a critical issue still lies with the selection of Cleantech innovation, which ideally requires knowledge and application of circular economy assessment measures and tools (Owen et al, 2018).

Management, networking and skills (propositions 2,4 and 5)

Management, networking and skills (incorporating propositions 2, 4 and 5) are all enhanced by UKIIF. Contracting the management of the UKIIF to highly experienced private VC umbrella fund managers, with light touch oversight required by the British Business Bank, enables government to focus greater attention on the wider policies (which should be associated with GND policy strategy) necessary to generate the pipeline of early stage Cleantechs and deliver the support services to facilitate VC take-up. One aspect is the promotion of programmes to equity finance trade bodies such as the British Venture Capital Association (BVCA) and UK Business Angels Association (UKBAA) and intermediary advisory services such as accountants through the Institute of Chartered Accountants in England and Wales (ICAEW). As Baldock and North (2015) suggest, more could be done to promote programmes, particularly in more remote UK regions from London. This has only recently been recognised through the increased regional presence of British Business Bank staff (since 2017) to assist the promotion and delivery of the English Regional Investment Funds. The additional umbrella tier of private VC creates additional management costs, but these are potentially off-set by the superior investment performance and quality of oversight provided by leading early stage Cleantech fund managers. As the Hermes fund manager suggested, they can diffuse skills downline to the underlying funds, contributing to Lerner's (2010) concepts of upskilling of VC fund managers. They also generate between the funds a considerable global network, increasing opportunities for syndication, further investment and international market entry. Cleantech entrepreneurs are shown to benefit considerably from the superior finance, market and network knowledge of top tier VCs – reducing search times and transaction costs in these matters. However, a potential deficiency here is that VCs appear to be more focused on financial management and marketing skills development, whilst other studies demonstrate that technical and regulatory issues are major hurdles for cleantech innovations (Owen et al, 2019a).

Table 9. Positive Impacts on Transaction Costs Development Framework for Cleantech Financing

Government	Private VC	Cleantech Entrepreneur
1.Funding, Bundling and Risk Sharing (propositions 1, 3 and 4)		
Government funds encourage earlier stage, scaled-up private VC, shared risk, increased investments and greater likelihood of returns Government promotes funds, working with business support and private finance trade bodies	Larger VC funds more attractive to institutional investors, leverages more private funding VC networks increased syndication, sharing risks, increasing investment, opening up international markets (e.g. through international syndication)	Increased early investment facilitates faster R&D, follow-on funds and commercialisation Reduced search times/costs, competitive set-up fees less than fragmented (angel) investment costs
2.Management, Networking and Skills (propositions 2, 4 and 5)		
Government pays VC to manage funds, minimises government administrative costs of BBB Complementary policies promote entrepreneurial pipeline, entrepreneurial support infrastructure	Fund of Funds extra tier of costs, gaining expert fund selection, fund management and private financial leverage VCs network/syndicate to enhance their fund manager and portfolio management skills	Expert fund managers deliver commercial rigour and acumen in the boardroom, recruit and appoint key NEDs, managers, assist with market development and prepare and find further private finance, easing flow of finance escalator.
3. Cleantech Innovation, Climate Change Mitigation and Economic Growth (proposition 6)		
Policies support early stage Cleantech to lower CO2, creating sustainable green economy and global impacts Optimal firm exists along with jobs, sales, multipliers, international trade provide tax revenues and 'green kudos'	Specialist VC funds select most viable Cleantechs, financing and managing their commercialisation and scale-up. Successful early stage co-finance VCs demonstrate attraction of specialist market for private VC and spin-out new fund managers	A greater number of Cleantechs with disruptive green innovation reach commercialisation and international scale-up quicker, impacting on reducing CO2 and increasing renewable energy. Sustainable firms, job creation, supply chain multipliers, global sales. Recycling of entrepreneurial wealth and IP – 'virtuous cycle'

Cleantech innovation, Climate Change mitigation and economic growth (proposition 6)

Cleantech innovation, Climate Change mitigation and economic growth (proposition 6) form the fundamental raison d'etre for the UK government's co-finance UKIIF programme (Owen et al, 2018). All benefit from reduced transaction costs through the complementarity approach of UKIIF. Successful optimised investment exits generate returns of funds as well as a range of economic multipliers which are shown to benefit the UK exchequer, notably because these businesses are keeping a major presence in the UK, even after international trade sales and PE investments. Furthermore, there is evidence of Lerner's (2010) recycling and the virtuous cycle of entrepreneurial VC ecosystem development (Owen and Mason, 2019) through fund manager development, increased early stage Cleantech VC financing and serial entrepreneurship and investment activities of former UKIIF portfolio venture managers. However, serious questions remain about how early stage cleantech innovation is selected for co-finance programme investment and evaluated (Owen et al, 2018). Greater consideration is required for the measurement of

full socio-environmental impacts, including circular economy longevity and recycling aspects, of investments. In this respect perhaps the most crucial requirement is for improved metrics to assess green outcomes and assist government policymakers in their efforts to rebalance the operation of the private VC market and its institutional investors to encourage increased early stage green innovation SME investment.

Conclusions

The paper has demonstrated a clear way forward for a Green New Deal policy to address the financing gaps facing early stage innovative cleantech SMEs that can provide game changing low carbon impacts to tackle Climate Change. The adoption of a novel resource complementarity research framework to assess the interrelated positions and requirements of policymakers, VC financiers and early stage innovative Cleantech ventures, demonstrates the catalytic value of government co-finance programmes like UKIIF, when they have sufficient international vision and funding scale.

Whilst the study is limited to the examination of UKIIF, a UK government and EIF co-financed VC programme, it has demonstrated through 7 case studies how such a targeted early stage Cleantech fund can make a difference. This has occurred both in terms of transition to a lower carbon economy through a variety of Cleantech innovations impacting on sectors relating to renewable energy, advanced manufacturing and recycling, and also wider economic benefits. These are clearly articulated through the research framework and relate to sustainable ventures, high quality job generation and financial return to the economy through UKIIF's investment returns to the British Business Bank within a nine year period, substantial sales revenues and tax returns to the exchequer, supply chain multipliers and recycling of CEO investment and time through serial entrepreneurship.

An important observation is the retention of investee firms and employment in the UK, even in cases where there has been considerable international investment, although a cautionary tale surrounds case E which has outsourced manufacturing and several hundred jobs to Eastern Europe. This appears particularly pertinent, given the swathe of multinational company job losses taking place during the Brexit period.

In conclusion, our emerging theoretical framework offers the opportunity for further studies, through demonstrating considerable savings in transaction costs and major socio-economic and environmental outcomes. However, it also highlights the need for considerably more work in developing appropriate metrics and tools to assist in the selection and evaluation of investee ventures.

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