Theorizing finance in transitions studies – a multi-level perspective analysis of state investment banks' roles in mobilising finance for clean energy transitions

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Abstract

A rapid transition of our energy system is needed in order to avoid dangerous levels of climate change. While much transitions research has focused on energy transitions in general and technology-related aspects in particular, the role of finance has only been sparsely analysed. At the same time, any major socio-technical transition, and particularly the energy transition, requires a fundamental and significant re-direction of financial capital from incumbent to new solutions. The multi-level perspective (MLP) has a wider perspective on transitions and generally covers financial markets as part of the existing regime. We argue that the niche-regime interaction as discussed by Smith and Raven (2012) also is highly relevant for the role of finance and transitions: Redirecting finance towards new niche technologies requires that either the niche is fit for the financial regime or the financial regime is stretched. Based on 56 interviews, we analyse State Investment Bank (SIB) interventions in Germany, the UK and Australia, aimed to mobilise private finance into low-carbon project development, in terms of their effect upon niche-regime interactions, i.e. whether they resulted in fitting-and-conforming the niche for the financial regime or stretching-and-transforming the financial regime. We also determine whether these effects worked through mainstream finance mechanisms (de-risking etc) or evolutionary processes (learning etc). Our results point to several important effects of SIB interventions, with most effects fitting the niche to the regime. However, we also detect secondary effects, which stretch the financial regime – mostly through evolutionary processes. Based on our findings we discuss policy implications on how to accelerate transitions through policies aiming at finance as well as theoretical insights gained through our analysis. One important insight is that mainstream economic theories on finance (as discussed in our paper) only cover part of the observed processes.

1 Introduction

The grand challenges faced by society, such as an aging population and environmental degradation, call for major socio-technical transitions towards sustainability (Geels *et al.* 2017, Markard *et al.* 2012). For example, a major transition of our energy system is needed in order to mitigate climate change (IPCC 2014). Any major socio-technical transition requires a fundamental and substantial redirection of financial capital (Mazzucato 2011, Mazzucato and Penna 2015, Perez 2003, 2010, 2011, Schmidt 2014) and there is currently no alternative to the financial system[1]. In the field of evolutionary (or neo-Schumpeterian) economics Dosi (1990) has described the selection function of capital markets: when investors finance a project, they select which technologies and/or designs, and consequently which innovations, are deployed into the system (Dosi 1990, McKelvey 1997). These technologies can then further improve due to learning feedbacks (Huenteler *et al.* 2016a, Huenteler *et al.* 2016b). Transitions require widespread diffusion of innovative technologies and hence addressing the selection function of downstream finance (and financial actors) for commercialisation, or the 2nd valley of death, is required (rather than upstream R&D and VC finance in the 1st valley of death) (Bürer and Wüstenhagen 2009, Grubb 2004, Karltorp 2016).

However, while it is considered an important enabler to any transition and is generally present in key transitions frameworks, such as in the Resource Mobilisation Function of the Technological Innovation Systems (TIS) literature, or as part of the regime in the Multi-Level Perspective (MLP), finance is largely marginalized by the transitions literature. Recently TIS studies have begun to analyse the role of finance in more depth, recognising that policy is needed to mobilise finance (Karltorp 2016, Karltorp *et al.* 2017). However due to the TIS's focus on the technological niche, the financial system as such is left as a black box. Hence, these studies do not answer how a re-direction of financial flows could be achieved. MLP looking at regimes (selection environments) and niches (technological innovations) and their interactions has a wider perspective on transitions and generally covers financial markets as part of the existing regime (Geels 2002). However, to date no studies exist that analyse the role of finance for transitions in detail, using the MLP perspective.

In this paper, we want to address this gap by analysing the interaction between niches in low-carbon energy technologies (renewable energies and energy efficiency) and the financial regime. We argue that the niche-regime interaction as discussed by Smith and Raven (2012) also is highly relevant for the role of finance and transitions: Redirecting finance towards new niche technologies requires that either the niche is fit for the financial regime or the financial regime is stretched. More specifically, we want to understand how the use of a specific systemic policy institution, state investment banks (SIBs) (Geddes *et al.* 2018), can affect the niche - (finance) regime interaction and thereby answer the question:

How does the technological niche interact with the financial regime and how can this interaction be improved through policy intervention?

[1] The financial system can be a significant driver of technological change (Perez,2003), (Perez,2011).

To answer this question, we draw on mainstream financial literature as well as evolutionary perspectives. We examine the interventions (the roles, activities, provisions, instruments) employed by SIBs in their endeavour to mobilise private finance into low-carbon projects development, in order to classify whether the rationale behind them is more in-line with the mainstream or evolutionary finance perspectives. We then take the MLP transitions theory viewpoint and analyse these interventions in terms of their effect upon niche-regime interactions as discussed by Smith and Raven (2012). With this work we aim to provide the first empirical study that takes a step towards theorising about finance in transitions theory.

The paper is structured as follows. Section 2 introduces the theoretical background to the topic (indicating where our work sits within the literature) and presents our theoretical framework for analysing our results. Section 3 describes our research case, research method and data. Section 4 presents our results and observations within the framework, we discuss our results in section 5 and conclude in section 6.

2 Theoretical Perspective

2.1 Socio-technical transitions and finance

Various approaches have made great contributions to our understanding of socio-technical transitions (for a review see (Markard *et al.* 2012)). From the evolutionary perspective the Technological Innovation Systems (TIS) approach helps to inform policy makers about mechanisms that block the development and deployment of (new) technologies whilst identifying functions that need to gain strength to overcome these obstacles (Bergek *et al.* 2008, Carlsson *et al.* 2010). Recently TIS studies have begun to analyse the role of finance in depth, recognising that mobilising finance for technological change is an important function that needs strengthening, particularly in low-carbon TISs (Bergek *et al.* 2008, Jacobsson and Karltorp 2013, Karltorp 2016, Wieczorek *et al.* 2013). However the TIS literature has an inward looking perspective[2] and thereby overlooks the systems environment (the existing selection environment or regime) that includes the financial system itself (Markard and Truffer 2008, Smith and Raven 2012). Hence although they highlight that policy is needed to mobilise finance (e.g. (Surana and Anadon 2015)) they're less able to answer in detail how this could or would be achieved.

The multi-level perspective (MLP) is an alternative approach to transitions theory (Geels 2002, 2012, Geels and Schot 2007, Geels *et al.* 2014, Smith *et al.* 2005). MLP approaches do not suffer from TIS's inward looking perspective as they include analysis of the new technology (*niches*), the existing context conditions (in the form of *regimes* and the *landscape*), as well as interactions between each. The MLP interprets transitions as resulting from the interactions between processes at these three analytical levels (shown in Figures 1 and 2): niches (defined as protective spaces where path-breaking, radical innovations, such as low-carbon technologies, are generated and developed), socio-technical regimes[3] (in which the financial system sits, also known as the selection environment, defined as the arrangement of established practices, sets of rules and organisational and cognitive routines that affect incumbent actors' resistance or tractability to system change), and an exogenous socio-technical landscape (defined as a set of deep structural trends and technology-external factors) (Geels 2002, Geels and Schot 2007, Geels *et al.* 2014). Knowledge and capability progressions, price/ performance improvements, support from, and protection by, key actors and groups, allow niches to develop internal momentum with a view to successfully entering mainstream markets. However the success of a new technology (niche-innovation) is also determined by changes at the existing regime and landscape levels. Landscape changes can pressure regimes and the destabilisation and reconfiguration of the regime can create openings for the diffusion of niche-innovations. It is the alignment and interaction of all of these

[2] Karltorp (2016) is more outward looking, acknowledging that the financial system is outside the TIS, including an assessment of the finance sector's perspective on, and its interactions with, the TIS. She determines that policy makers "can stimulate investment by increasing alignment between technology developers and the financial sector" (Karltorp,2016).

[3] The regime, in which the financial system sits, is also defined as the arrangement of established practices, sets of rules and organisational and cognitive routines that affect incumbent actors' resistance or tractability to system change, and that stabilise existing transition trajectories via standards, regulations, sunk investments, politics, power, expectations and perceptions (Geels,2002), (Geels, Tyfield and Urry,2014).

processes that can allow for low-carbon innovations to breakthrough and compete with mainstream technologies and sectors within the existing regime (Geels 2002, Geels and Schot 2007, Geels *et al.* 2014).

One key MLP interaction concerns the flow of finance (to low-carbon niches), where the financial sector is part of the regime (Geels 2002). The energy transition requires new low-carbon technologies that are most often developed in niches. Hence the 'low-carbon technology' niche - 'finance' regime interaction is particularly important when studying the energy transition. In addition, given the important role of learning/ knowledge feedbacks (learning-by-doing and -using) in the design, production and use phases for complex technologies such as low-carbon technologies (Huenteler *et al.* 2016a, Huenteler *et al.* 2016b, Lewis and Wiser 2007, Schmidt *et al.* 2016) the selection function of financial actors can result in lower rates of innovation and the lock-out of (presently) more risky technologies (Dosi 1990, McKelvey 1997). Simultaneously these low-carbon technologies have very high up-front capital costs and can display high risks for investors. Hence interactions with the finance regime are especially important to the success of these niches, perhaps more so than to the existing energy system (Geddes *et al.* 2018, Schmidt 2014). Therefore of particular interest is whether and how financial markets support niche development in terms of enabling the diffusion of niche innovations to compete within the regime. Regime resistance usually ensures that niches do not necessarily enter regimes easily (Geels *et al.* 2014).

MLP concepts for observing niche-regime interactions, and for potentially overcoming regime resistance, are the 'stretch & transform' (S&T) and 'fit and conform' (F&C) empowerment processes (See Figure 2) (Smith and Raven 2012). Fit and conform processes allow niche-innovations to be competitive in unaltered, existing mainstream selection environments (i.e. the existing finance regime) by ensuring niches develop in order to fit existing rules and institutions. F&C empowerment includes processes that result in improved alignment with existing industrial norms or structures such as with economic, financial, technological, organisational and other conventional regime selection criteria of existing markets (e.g. improved cost-efficiency/performance). Stretch and transform (S&T) processes, however, alter existing, mainstream selection environments, adjusting the rules and institutions of these conventional regimes, in ways that benefit the niche. S&T empowerment includes processes that restructure, and even undermine, incumbent regimes, transferring some features of the niche such as new norms and routines, and institutional reforms into a transformed regime (Lauber and Jacobsson 2016, Smith and Raven 2012). Lauber and Jacobsson (2016) used the S&T and F&C concepts to trace and analyse narratives within Germany's political discourse on renewable technologies, however to date no scholars have specifically analysed niche-'finance' regime interactions in terms of the F&C and S&T concepts.

In fact, overall there are limitations to the MLP literature with respect to the finance sector. The majority of the existing MLP work focuses on supporting and promoting niche innovations, focussing less on existing incumbent regimes and actors, with scholars usually regarding regimes as "monolithic barriers to be overcome" (Geels *et al.* 2014) (additional citations?). Understanding regimes is important in order to "enact the destabilization and decline of fossil fuel-based regimes" (Geels *et al.*

2014), to understand and affect low-carbon niche-regime interactions and to transition to more sustainable sectors. However, those scholars that have focused on regimes, normally focus on parts that are not considered to be technology-neutral (e.g. utilities, infrastructure etc.) (Geels *et al.* 2014). Mainstream financial theory considers the financial sector to be technology-neutral and hence it might be perceived to be less relevant for the scholarship of transitions. Furthermore, whereas for those parts of the regime that are not technology-neutral there are calls to "enact their destabilization and decline" in order to transition from unsustainable to sustainable sectors (Geels *et al.* 2014), finance is and will still be considered a necessary part of the regime in any transition. There is no substitute for finance, at least within capitalist systems, which seem to be highly conducive to innovation (Rosenberg 1982, Schumpeter 2010). Hence, the existing analysis and policy recommendations for such parts of the regime may not be appropriate for the finance regime. Despite acknowledging the relevance and importance of the financial sector there's little analysis of finance in the transitions literature and particularly MLP. It is necessary to improve our empirical and theoretical knowledge base of the financial network and capital markets within transitions literature in order to have a more holistic picture of the actors and risks involved and thus provide better policy recommendations. In this paper we intend to better incorporate financial theory into the MLP perspective on sustainable transitions.

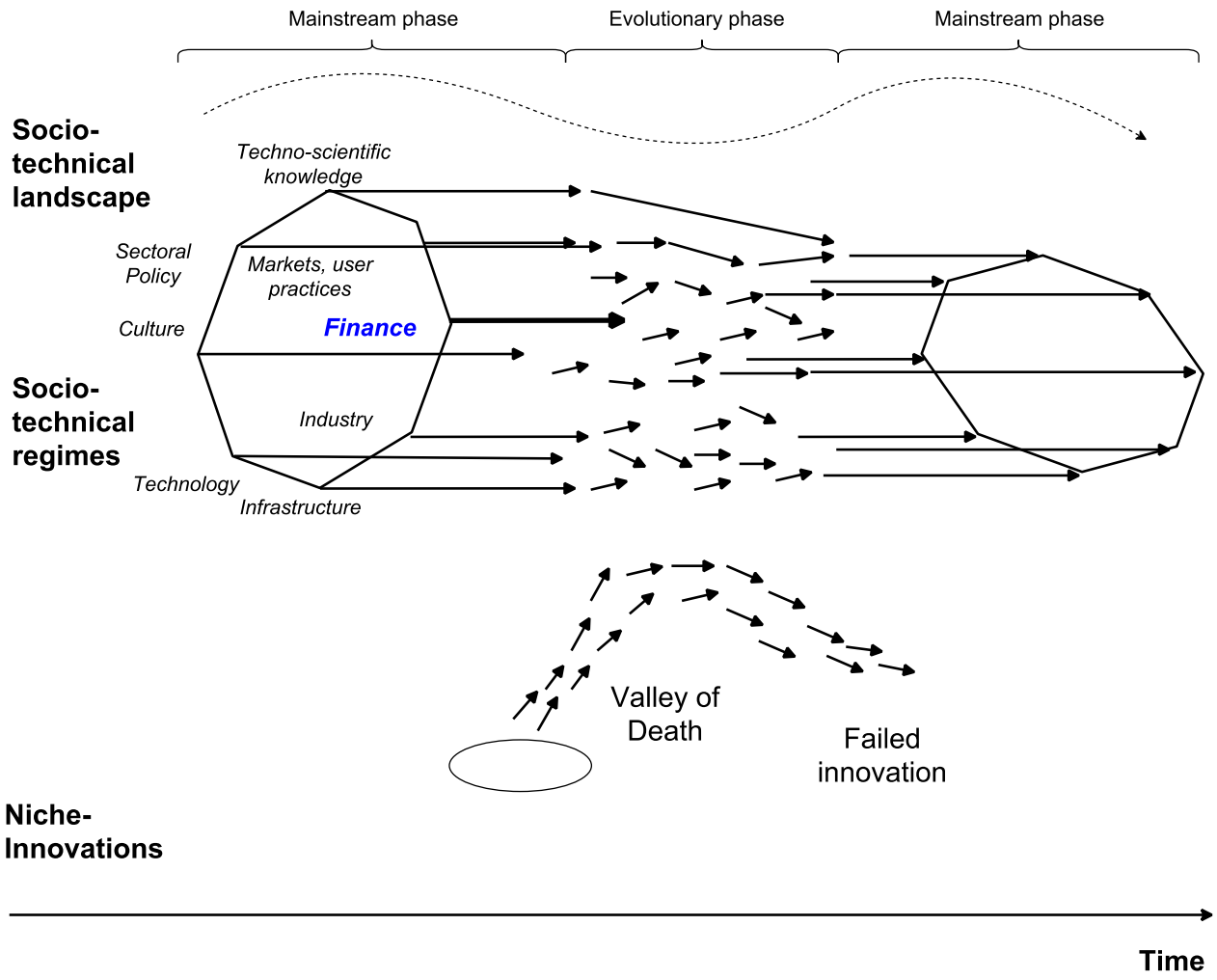

Figure 1: Multi-level perspective on transitions: Failed niche innovation
Adapted from Geels (2002) and Geels and Schot (2007).

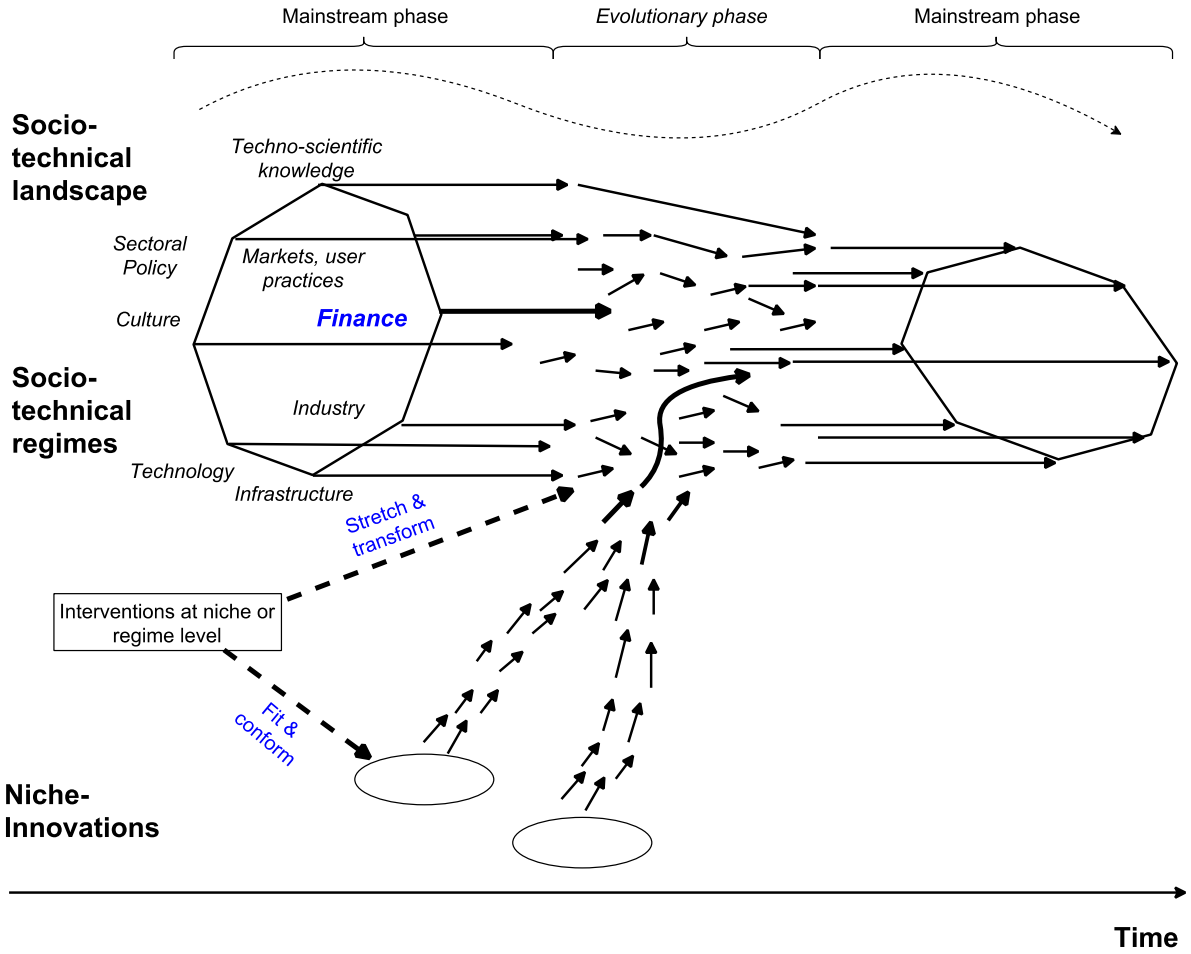

Figure 2: Multi-level perspective on transitions: Niche successfully entering regime with SIB policy intervention.
Policy interventions are shown at the niche and regime levels. The interventions enable the finance regime to Stretch and Transform or the niche to Fit and Conform, allowing finance to flow to the niche and for it to enter the regime. Adapted from Geels (2002) and Geels and Schot (2007).

2.2 Finance theory

The modern financial system encompasses the financial transactions, services, intermediaries and markets that enable the exchange of capital between investors[4] and borrowers. Capital needs to be invested: investors have capital to invest and companies (and projects) need this capital to produce and operate[5]. Investors decide whether to invest or not according to the risk-return trade-off principle: the principle that potential return rises only by accepting an increase in risk (possible losses) (Brealey *et al.* 2017). That is, an investor will consider if an investment displays too much risk or too little potential for return as compared to their pre-determined desired limits, to decide whether to take action and invest. Financial intermediaries (e.g. banks, insurers etc. that facilitate between investors and borrowers) also play a key role in investment decision outcomes. Financial intermediaries[6] are needed to address various issues including, for example, overcoming information asymmetries and lowering transaction costs (Allen and Santomero 1997). In general the banking system has been dominant in taking the role of financial intermediation (Allen and Santomero 1997). We see intermediaries heavily involved in the following key activities: Risk management (via risk transfer, reduction, diversification, delegated monitoring activities), size transformation (capital aggregation and securitization activities to lower transaction costs) and maturity transformation (mitigating discrepancies/ mismatches between borrowing capital on shorter terms but investing or lending to longer term projects) (Allen and Santomero 1997). In addition to financial intermediaries, markets also play a key function in determining how investments are made, by putting a price on risk and return.

The dominant, or mainstream, theory on financial markets specifically is the efficient market hypothesis (EMH) which is underpinned by the neo-classical school of economics (Fama 1970, Sharif 2006). This theory states that markets are efficient in that prices always 'fully reflect' available information (Fama 1970). Accordingly, under mainstream finance theory, markets always price risk and return perfectly, instantaneously and rationally (Fama 1970). In such an efficient market, when new information or investment opportunities arrive (e.g. in the form of new technologies), at any point in time, it is instantly incorporated into asset prices, which quickly reach a new equilibrium (Hiremath and Kumari 2014). In particular, EMH makes assumptions about behaviour: that economic agents, and/or markets, are rational and will rationally price assets and risk (Soufian *et al.* 2014). It also assumes that finance is technology neutral and hence if the risk-return profile of a project or technology is favourable, investors will invest and the finance will flow. In particular, mainstream financial theory assumes the financial sector (regime) is not path dependent and there is assumed to be no technological or institutional lock-in (Hall *et*

[4] We will refer to both investors and lenders as 'investors'.

[5] In addition, the finance system has a role to channel this capital into new and innovative products and projects.

[6] In an ideal system there would be no need for intermediaries but in fact they are needed to overcome various issues including information asymmetries and to lower transaction costs. Over time both of these issues have improved in the financial system however more recently the role of risk management by intermediaries has emerged (Allen and Santomero,1997).

al. 2015, Sharif 2006). Under these assumptions, mainstream financial theory would view finance as a special case of the regime.

But these mainstream finance perceptions may be too narrow given that "change in economic systems is shown to be path-dependent and subject to lock-in" (Foxon 2011, Hall *et al.* 2015, Unruh 2000). Alternative perspectives, such as evolutionary and behavioural viewpoints, challenge the mainstream theory of finance (Foxon and Pearson 2008, Foxon 2011, Grubb 2004). Finance is not considered neutral from these viewpoints (Mazzucato and Semieniuk 2017). Evolutionary perspectives acknowledge that the concept of path dependency, resulting in potential lock-in, is a key concept and that it can be used to describe (finance) regime stability (Markard 2011, Unruh 2000). Only recently Hall *et al.* (2015) showed that the UK energy project market conforms more to an adaptive market, proposing the adaptive market hypothesis (AMH) as an evolutionary perspective on energy investment markets that can co-exist with EMH (Hiremath and Kumari 2014, Lo 2004, 2005, 2007). The AMH assumes that markets are not always efficient but are adaptable, moving between efficiency and inefficiency as though along a spectrum (Buttonwood 2015, Lo 2004, 2005, 2007, 2012). This is due to human behaviour as AMH assumes that economic agents are neither perfectly rational nor irrational but behave as competitive investors that adapt to changing economic environments (Buttonwood 2015, Hiremath and Kumari 2014, Lo 2004, 2005, 2007, Soufian *et al.* 2014). Investors' heuristics (small sets of information used to make decisions and solve problems quickly) must adapt to changing investment environments in periods of change. Key to AMH are the processes of learning, heuristics management and adaptive decision making; economic agents' 'rational decisions' constantly evolve, adapt and are discarded as markets and environments change (Hiremath and Kumari 2014, Soufian *et al.* 2014). A particular implication of interest is that the risk/reward trade-off is changeable, varying as a function of the population of market participants and the changing investment environment (Hiremath and Kumari 2014, Soufian *et al.* 2014). Changes in the investment environment or market can be caused by, for example, changing policy and subsidy support, financial regulation, crises, and/or technological change i.e. transitions (Hall *et al.* 2015). Hence AMH concedes that relatively new markets (such as new or altered markets that develop during transitions) are likely to be less efficient than established markets (citation) and that inefficiency can exist in established markets if the environment or investor population changes (Hall *et al.* 2015, Hiremath and Kumari 2014, Soufian *et al.* 2014). In a transitions market investment conditions are inherently subject to change.

The AMH (an evolutionary finance perspective) and not just mainstream finance perspectives can also be an appropriate lens through which to view investment markets within transition, especially given that evolutionary theories look at new investment opportunities, such as new technologies, and AMH focuses on new information and investment heuristics. These are important features for transitions and the technologies required to facilitate them. Hall et al 2015 made an initial move towards bringing finance and transitions together by showing the UK energy investment market is adaptive, however their analysis doesn't specifically analyse the processes or mechanisms of niche-regime interaction nor how the finance regime changes and responds to mobilise finance (Hall *et al.* 2015).

2.3 Framework merging perspectives

Given the importance of finance for transitions it is necessary to improve our empirical and theoretical knowledge base of finance and financial markets within transitions literature. With this work we aim to merge transition theory, particularly MLP, with the mainstream and evolutionary finance theory perspectives. More specifically we address the research gap by empirically analysing the role of a public finance institution that implements policy interventions with the aim to catalyse finance (by supporting niches and opening and restructuring the finance regime). We want to increase our understanding of how the use of these specific policy interventions aimed to mobilise finance can affect niche-finance regime interactions. Building upon our two streams of literature we develop a framework (See Figure 3) with which we analyse the type of policy intervention to mobilise finance and its effect on niche-regime interactions. First we observe and analyse the policy intervention, categorising it as falling under the mainstream or evolutionary finance perspectives. Then we determine the effect of the policy intervention on the niche-regime interaction, analysing whether it "fits and conforms" (low-carbon technology) niches, or "stretches and transforms" the regime (financial sector) enabling finance interactions that allow the niche to enter the regime. With this work we make a first step towards theorising about finance in transitions literature.

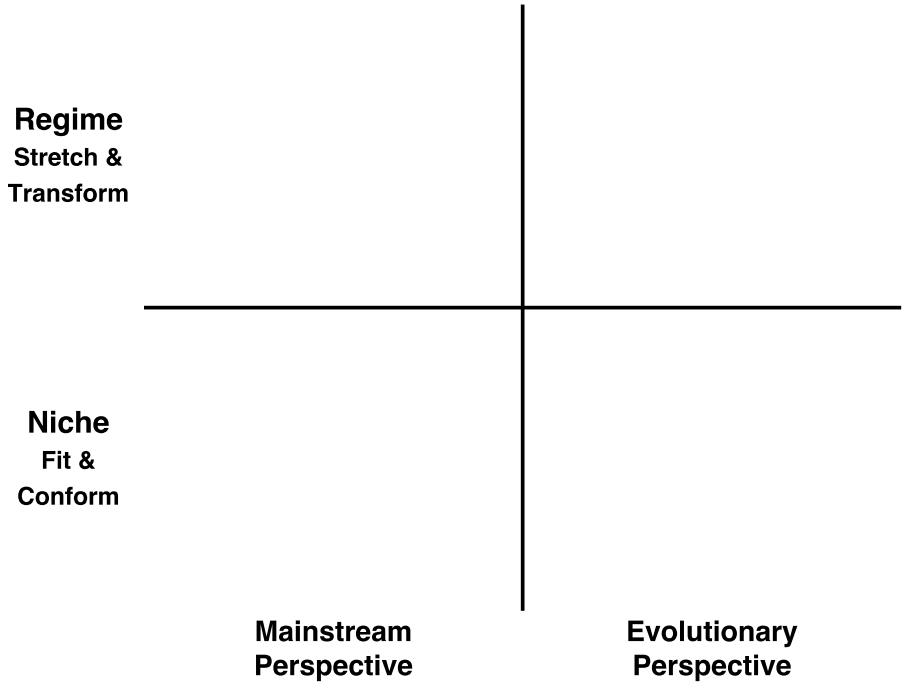

Figure 3: Framework Merging Perspectives: Type of finance policy perspective (mainstream vs evolutionary) and its effect on the MLP niche-regime interaction.

3 Research Case, Method and Data

3.1 Research Case

We chose the energy transition as our research case as it is considered necessary in order to mitigate climate change, and hence is anticipated to be one of the largest and most challenging sustainability transitions facing humankind (Geels *et al.* 2017). In addition, the new technologies required for this transition, such as renewables and energy efficiency, can be capital intensive and display various different risk and cost structures compared to incumbent technologies within the regime (Schmidt 2014, Waissbein *et al.* 2013). Given these unique features and the importance of finance for transitions in general, examining the role of finance in the energy transition with a focus on renewables and energy efficiency, should divulge a wide range of data for study.

We selected SIBs and their policy interventions as our empirical policy case for examining finance in the energy transition for various reasons. More generally, state intervention in financial markets has been widespread (Stiglitz 1993) and SIBs have been applied across a wide range of countries. SIBs are a public finance institution that intervene in investment markets and are simultaneously thought of as part of a country's policy mix (Geddes *et al.* 2018, Mazzucato 2011, Mazzucato and Penna 2015, Mazzucato and Penna 2016, Stiglitz 1993). SIBs may be mandated to help drive a country's sustainable transition via the mobilisation of private finance and can offer many different types of interventions. SIBs have been shown to implement mainstream finance interventions such as de-risking and capital provision (Geddes *et al.* 2018). However initial investigations indicate that they may also perform interventions that support evolutionary approaches to finance and transitions such as via technical support (Geddes *et al.* 2018, Mazzucato and Penna 2016, Mazzucato and Semieniuk 2017). It has also been argued by other scholars that SIBs are a potential catalyser of niche-regime interaction, something we wish to understand in detail (Mazzucato and Penna 2016, Mazzucato and Semieniuk 2017). We did not look at overarching general financial regulation style interventions such as Basel III type interventions because typically these financial regulations are not designed to foster socio-technical transitions.

We selected three SIBs[7] for our study that are primarily or heavily active in financing low-carbon projects: Australia's CEFC, the UK's GIB and Germany's KfW. The GIB and CEFC were set up specifically to help their countries transition to a greener more sustainable economy, and KfW has played a key role in supporting Germany's Energiewende (energy transition) (Geddes *et al.* 2018). We wanted to cover a breadth of investment grade, well-developed financial systems/ markets (e.g. UK's market based financial system, Australia's more concentrated market based financial

[7] We selected our SIBs only from developed countries because we wanted our observations to emerge from well developed and functioning financial and investment markets. In order to focus on the energy transition we didn't want to focus on additional barriers to finance that can accompany developing country markets such as political risk or even a complete absence of an operating banking sector/ investment market. In fact in many developing countries SIBs, development banks and MDBs are part of the regime as there is no fully developed private financial sector. Additional future work would be needed to analyse finance in transitions in developing countries.

system with stronger short-term money market activity, and Germany's bank-based financial system with its extensive network of local banks). In addition these three countries display low-carbon energy sectors at various different stages in terms of technology diffusion and local financial system experience and expertise, as well as variance around the level of energy policy support, type and stability. Hence we want to observe some variance on the niche (low-carbon sector stage variance) and the regime levels (financial system variance) in order to capture a wide range of observations, but not too strong a variance on the regime (financial market) itself that we observe interventions that 'replace' or 'build' non-functioning or non-existent markets (hence the exclusion of SIBs in developing countries).

3.2 Method and data

Following the procedure of Eisenhardt (1989), we undertook a qualitative case study design. Primary data was collected via in-depth semi-structured interviews with project developers, equity and debt providers, bankers, and industry experts. Secondary data was also sourced from publicly available literature on each SIB and their low-carbon projects. The primary and secondary data[8] collection were utilised to investigate the market for low-carbon energy project finance and observe the role and activities of SIBs in that market. We collected data on the variety of activities, roles, provisions and instruments provided by SIBs in their endeavour to mobilise private finance into low-carbon project development. We refer to these activities, roles etc. as 'SIB interventions'. We interviewed 56 participants in total from late 2015 to mid 2016, listed in Table 1. Interviewees[9] were found through searches of project websites, renewable energy associations, Internet searches and snowball sampling. All interviews were conducted under the "Chatham House Rule"[10] and hence no references to interviewees or their affiliations are made. In accordance with Eisenhardt (1989) we continued performing interviews until no new insights were observed.

A qualitative content analysis was performed in order to determine key themes within the data set. Interviews were recorded, transcribed and then coded along with the secondary data using the qualitative data analysis software MAXQDA12. In order to perform the analysis the data set was coded along the literature concepts and framework developed for this work (see Figure 3). For our analysis, firstly we determined whether an intervention was more in-line with mainstream finance theory, including the efficient market hypothesis, or with alternative evolutionary views, including the alternative market hypothesis. We then categorised (coded) an intervention as being a mainstream finance intervention (MSI) or more as an evolutionary intervention (EI). Secondly in our analysis we examined the effect of the SIB's intervention in terms of its impact on niche-regime interactions. Specifically we analysed and then categorised (coded) an SIB intervention based on whether it

[8] The collected dataset was also used for an additional project and publication (Geddes, Schmidt and Steffen,2018) however for each project the data was coded differently for separate analysis

[9] All interviewees were initially contacted via e-mail. Approximately 85% of interviews were conducted via Skype or telephone and 15% conducted in-person Interviews lasted from between 30 min and 90 min with the average interview taking 60 min.

[10] When a meeting, or part thereof, is held under the **Chatham House Rule**, participants are free to use the information received. However neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed.

"stretches and transforms" (S&T) the financial sector (regime) or whether it "fits and conforms" the low-carbon project (niche) to the existing financial sector (regime). Finally we determined whether there were any other additional subsequent niche-regime effects that occurred over time as a result of the SIB interventions and categorised (coded) them using the same logic described above.

Table 1: Interview Sample

Category		Organisation[a]	Technology Focus[b]	Country[c]	Interviewee's Role
Developer	**1**	Project Developer	Wind, Solar PV	AU	Head of Business Development
	2	Project Developer	WtE	AU	Chief Executive Officer
	3	Project Developer	WtE	AU	Managing Director
	4	Project Developer	WtE	AU	Managing Director
	5	Project Developer	Bioenergy, WtE	GB	Independent developer
	6	Project Developer	Wind, Bioenergy	GB	Managing Director
	7	Project Developer	WtE	GB	Managing Director
	8	EPC, OEM	Wind, Solar PV	AU	Business Development Manager
	9	IPP	Wind	AU	Executive General Manager
	10	IPP	Wind, Hydro	AU	Executive Manager, Development
	11	IPP	Renewables	AU, GB, DE	Chief Financial Officer
	12	IPP	Solar PV	DE	Project Developer
	13	IPP	Bioenergy	GB, DE	Independent developer
	14	IPP	Wind, Solar PV	GB, DE	Manager, ESG
	15	IPP	Wind, Solar PV	GB, DE	Executive General Manager
	16	IPP	WtE, Bioenergy	GB, DE	Head of Origination
	17	OEM	Wind, Solar PV	AU	Head Structured Finance
	18	OEM	Small-scale wind	AU, GB, DE	General Manager
	19	OEM	Renewables	AU, GB, DE	Sales Manager, Renewables
	20	OEM	Renewables	AU, GB, DE	Senior VP Project Development
	21	OEM	Wind	GB, DE	Senior Investment Manager
	22	Utility	Renewables, FFs	DE	Managing Director
	23	Utility	Renewables, FFs	DE	Head Business Development
	24	Utility	Wind, Solar PV	GB, DE	Business Development Manager
	25	Utility	Wind, Solar PV	GB, DE	Managing Director
Investor	**26**	Commercial Bank	Renewables, FFs	AU	Executive General Manager
	27	Commercial Bank	Renewables, FFs	AU	Senior Consultant
	28	Commercial Bank	Renewables, FFs	AU, GB, DE	Director Corporate Clients
	29	Commercial Bank	Renewables, FFs	AU, GB, DE	Consultant, Green Banking Expert
	30	Commercial Bank	Renewables, FFs	GB, DE	Consultant, Innovative Finance
	31	Gov't funding entity	Renewables	AU	Transactions and Development
	32	Green Bank	Renewables	GB, DE	Relationship Manager, Arranger
	33	Invest. Advisors	Renewables	AU	Principal Financial Advisor
	34	OEM investors	Renewables, FFs	AU, GB, DE	Managing Director
	35	Invest. platform	Renewables	GB	Managing Director
	36	SIB	Renewables, EE	AU	Division Director
	37	SIB	Renewables, EE	AU	Researcher
	38	SIB	Renewables, EE	AU	Department Director
	39	SIB	Renewables, EE	AU	Associate Director
	40	SIB	Renewables, FFs	DE	Department Director
	41	SIB	Renewables, EE	GB	Department Head
	42	SIB	Renewables, FFs	GB, DE	Investment Officer
	43	SIB	Renewables, FFs	GB, DE	Project Assessor
	44	SIB	Wind, Renewables	GB, DE	Team Head, Wind Power
	45	Sustainable Bank	Renewables	GB, DE	Chief Financial Officer
	46	VC Investor	Renewables, FFs	AU, GB, DE	Director
Expert[d]	**47**	Consultancy	Renewables	AU, GB, DE	Arranger, Due Diligence
	48	Consultancy	Renewables, FFs	GB, DE	Associate Principal, Energy
	49	Consultancy	Wind	GB, DE	Senior Consultant, Power Market
	50	Consultancy	Wind	GB, DE	Partner, Energy and Resources
	51	Energy Think-tank	Renewables	GB	Director, Finance, Energy Policy
	52	Envir. Consultancy	Renewables, FFs	GB, DE	Principal Consultant
	53	Envir. NGO	Renewables, FFs	AU, GB, DE	Director of Strategy and Finance
	54	Legal Consultancy	Renewables	AU	Partner, Project Finance, Energy
	55	Legal Consultancy	Renewables	AU	Senior Associate, Project Finance
	56	Legal Consultancy	Renewables	AU, GB, DE	Partner, Arranger

[a] IPP: Independent Power Producer, OEM: Original Equipment Manufacturer, EPC: Engineering, Procurement and Construction

[b] WtE: Waste-to-energy, EE: Energy Efficiency, FFs: Fossil Fuel based power generation

[c] AU: Australia, GB: The United Kingdom, DE: Germany

[d] Experts include deal arrangers, due diligence experts and expert consultants. These are interviewees who work closely with SIBs or are heavily involved in the development process.

4 Results

4.1 Finance in the existing (energy) regime and why it is important to niches

Finance in the traditional energy regime plays a role that suits and supports, in particular, incumbent energy companies and technologies. Larger incumbents (often listed companies with bonds) in the energy regime have traditionally used mostly corporate finance (on their balance sheet) to raise funds in order to develop projects (Steffen 2017). Banks and other intermediaries also play a role by providing traditional and well-known de-risking instruments (mostly financial instruments and some insurance) to cover any financing gaps encountered by incumbents.
Traditionally new technologies have not been supported or developed by incumbent companies and/or investors (Geels *et al.* 2014). Many new independent developers started out as smaller companies, often without access to appropriately sized balance sheets to develop projects (Steffen 2017). This has been exacerbated by the fact that many low-carbon technology projects are CAPEX intensive (meaning even some larger companies have been unable to develop projects on their balance sheets). Non-recourse project finance[11] has often been used in lieu of balance sheet investment for such developments (Steffen 2017). Hence often niche technologies need to rely on additional investors and intermediaries like banks in order to raise funds and develop projects. SIBs can be important in this space.
As part of this work we observed how mainstream finance in the regime works for incumbents and how and why it plays a part in exacerbating barriers to niche technology uptake. When managing risk, one of the major issues in deciding whether to invest, risk-return profiles are known and well within acceptable (usually pre-determined) limits for incumbent technologies, and intermediaries, investors and lenders are willing to finance such projects and technologies[12]. However many low-carbon energy projects display high risks (especially in the early market stage), and given that there is too little risk-taking by financial markets, particularly by banks (investors and lenders have risk limits), projects are not always financed. That is, the finance regime is not willing to finance the niche and let it enter the regime.
Conforming to these risk-return profiles is an important rule within the financial regime and if niche projects don't conform they are not financed. Initially unfinanced or difficult to finance projects included for example, those in the early phase of Germany's wind industry. Construction risks were very high, development and construction teams were inexperienced and investors, especially commercial banks, did not finance these projects. Australia's solar PV and onshore wind projects displaying high revenue uncertainty have been unable to source finance. Germany's mid to large-scale solar PV developers in the early days of the industry when both

[11] Developers either develop projects on their balance sheet (i.e. using corporate finance), or draw on project finance. When using corporate finance all assets and cash flows from the company (developer) is used to guarantee any credit required. When using project finance, a new entity (i.e. a special purpose vehicle) is created to incorporate the project; credit required is then guaranteed against the cash flows of the new project only, with no or very limited claim (recourse) on the developer's (company's) assets (Steffen,2017).

[12] This is starting to change as low-carbon technologies emerge and divestment and carbon bubble movements against incumbent fossil fuel technologies grow. This is an example of regime decline and destabilisation and, while not the focus of this paper, is a promising area for future research.

the technology costs and risks, and the cost of capital, were still high, also struggled to find investment.
Another issue faced by low-carbon developers is around the transformation of ticket size of their project. Many investors have limits, upper or lower, on the amount of capital per project they are willing or able to invest. Most incumbent technology projects fall within what is considered to be acceptable ticket size limits and hence the regime is willing to finance these. However, large-scale low-carbon investments, such as offshore wind projects, can require very large up-front capital expenditure, and even if structured as a syndicate to bring in several investors, smaller (and even some larger) investors are unable to invest due to their upper capital limits. This has led to a financing gap for some low-carbon projects, particularly offshore wind in the UK and Germany. On the other hand many energy efficiency (EE) and small-scale renewable energy projects are considered too small for many investors, as transaction costs usually remain the same whether the project is large or small.
Finally both incumbent and low-carbon projects face issues around maturity transformation, where investors with short-term horizons are not interested in longer-term projects. Hence low-carbon niches are in a similar situation to incumbents in the regime in these cases.

As part of this work we also observed evolutionary barriers to niche uptake by the regime relating to finance. In new or underdeveloped sectors (such as low-carbon sectors) developers and other relevant project stakeholders, such as OEMs, do not necessarily yet have the experience and expertise to successfully source finance to reach financial close and develop a project. That is, the niches display a lack of financial (and sometimes technical) knowledge needed to attract investment. For example some developers in the UK biomass industry displayed a lack of experience in fulfilling due diligence requirements in order to reach financial close. Similarly, in such new and underdeveloped sectors financiers and other relevant stakeholders have not yet developed the (codified or explicit) knowledge for assessing new asset classes, the tools and processes needed in order to identify project opportunities, identify, assess and mitigate project investment risks nor to sufficiently design and perform new due diligence processes. That is, the financial regime displays a lack of technical (and sometimes financial) knowledge needed to make a fully informed investment decision. This was witnessed by developers in all three countries for projects containing new or early stage technology or other innovative features.
Finally, for early stage technology, different parts of the niche sector are either inexperienced and do not provide well for the needs of the niche (and finance sector) or do not yet exist. This includes partners along the logistics and supply chain, OEMs, O&M companies, insurers etc. A lack of industry co-ordination within an innovation system or niche can lead to a failure to attract investment, and can be thought of as a system failure (Wieczorek and Hekkert 2012). For example, some UK OEMs did not initially provide technology guarantees on parts of their WtE equipment, meaning investors refused to finance such projects.
A detailed analysis of how finance supports the existing energy incumbents and regime is not the focus of this paper. We are more interested in the niche-regime interactions between finance in the regime and low-carbon niches, and in particular how finance can be made to flow to the niche and allow niches to become part of the technology regime. The following sections detail the interventions implemented by

SIBs to address many of the barriers mentioned above. We observed both mainstream and evolutionary barriers and policy interventions in our empirical data: these we have grouped into 2 types of mainstream interventions (section 4.2) and 3 types of evolutionary interventions (section 4.3). We describe each SIB intervention's observed effect upon the low-carbon niche-finance regime interaction and then graphically display the results within our framework in Figure 4.

In addition to the interventions (and effects) that were directly implemented by the SIBs and are described below, we also observed subsequent additional or 'secondary' effects upon the niche-regime interactions. These additional effects generally occurred at a later time to the original intervention and usually as a direct result of one or several of the initial 'primary' interventions. We describe these other additional effects in section 4.4 and also display them graphically within our framework in Figure 5.

4.2 Mainstream interventions (MSIs) and their effects on niche-regime interactions

4.2.1 Risk and de-risking

All three SIBs in our sample deployed various de-risking approaches to manage and mitigate risks to projects and leverage in private finance. De-risking interventions are designed to reduce, share or transfer risk. Examples of pure de-risking tools include guarantees, insurance, off-take and counterparty risk guarantees, technology guarantees etc. However SIBs also commonly deploy instruments that combine both capital provision and de-risking elements. Examples include concessional debt (lower than market rate), grants, mezzanine products, taking a sub-ordinated role in a syndicate, providing market rate or concessional capital featuring long tenures and/ or fixed-rates, co-investing and on-lending (both risk sharing tools) etc. All of these interventions, or some combination of them, act in order to redistribute and/ or reduce the risk, improving the overall risk/ return profile of the project, and are inline with mainstream finance perspectives. Our interviews showed that these de-risking instruments have had an important effect on the niche-regime interaction.

For example, in the early phase of Germany's wind industry when construction risks were very high and development and construction teams were inexperienced, developers were unable to source finance. To address this KfW IPEX were able to provide construction guarantees. This improved the projects' risk/ return profile, lowering the risk to investors and bringing the projects more inline with the existing expectations and performance requirements of the finance sector. This led to the eventual leveraging-in of additional finance and the development of projects. Today construction cost overrun risks are still high, particularly for offshore wind. KfW now guarantee these overruns by offering to finance them if they occur. This guarantee reduces the risk of financial failure and maximises the chance of successful project completion, again lowering the risk to be inline with existing investor expectations and attracting private finance. The CEFC has provided a fixed market rate, long-term debt financing product for solar PV and onshore wind projects displaying high revenue uncertainty with the stipulation that co-investors must also participate. The long-term and fixed-rate features of the debt ensured longer-term certainty for

projects, which was seen a risk reduction by investors and consequently attracted co-investment. This intervention brought the projects inline with current finance sector expectations and led to private investment. KfW also provided a concessional debt-financing product for mid to large-scale solar PV developers in the early days of the industry when both the technology costs and risks, and the cost of capital, were still high, and in general investors were not willing to invest. In addition to providing the necessary capital, the concessional interest rate lowered the cost of capital to projects, simultaneously reducing the risk that the borrower could not make repayments. This intervention allowed many solar PV developments to attract finance via co- and on-lending programs.

Investors will not participate in a project unless the project's risk/ return profile is within desirable (usually pre-determined) limits. So de-risking a project to improve its risk/ return profile brings it inline with the current expectations and performance requirements of the existing finance sector and also allows the project to compete on a more equal footing with others vying for investment in the regime. As these examples illustrate, de-risking interventions (both pure and in combination with capital provision) have the effect of *fitting and conforming* the low-carbon project niche to the requirements of the existing financial sector regime, allowing finance to flow to the niche without changing the financial sector and ensuring niche projects are successfully developed and can enter an unaltered regime.

4.2.2 Capital Aggregation

Many investors have limits, upper or lower, on the amount of capital per project they are willing or able to invest. Large scale low-carbon investments, such as for offshore wind projects, can require very large up-front capital expenditure (they are CAPEX intensive), and even if structured as a syndicate to bring in several investors, smaller investors (and some larger ones) are unable to invest due to their upper capital limits. In addition many energy efficiency (EE) and small-scale low-carbon projects are considered too small for most investors, considering that transaction costs usually remain the same whether the project is large or small. SIBs can provide interventions that address these barriers and change the pattern around how capital can be aggregated or moved around the market. In doing so they allow other investors who previously could not invest in such projects to now do so (e.g. by allowing 50 smaller investors to purchase bonds in projects they could not have accessed previously).

For example, the GIB provided market rate debt and/or equity capital to offshore wind projects that were unable to fully mobilise sufficient debt due to projects' large upfront CAPEX requirements and capital limitations on investors' overall portfolios. In these cases private and institutional investors had shown interest in the projects, and often already committed funding, but were unable to provide the full amounts of capital required. The GIB's intervention to fill the remaining gaps allowed the attracted private finance to be utilised and the projects to reach financial close. KfW also created a wind fund to provide market rate debt to fill such gaps for Germany's wind projects facing the same issues.

KfW also issues Project and Climate bonds based on its own low-carbon projects. These issuances have allowed a greater number of smaller investors to purchase bonds in low-carbon projects they could not have accessed previously. The CEFC

and GIB create funds and tools to aggregate/ securitise small-scale projects, especially for energy efficiency projects. This has reduced transaction costs for investors and enabled investors with lower limits on capital provision to invest in EE and small-scale low-carbon projects that they could/ would not have accessed previously.

These mainstream capital aggregation style interventions have allowed EE and low-carbon energy investments to become more inline with mainstream investment products hence this intervention *fits and conforms* the niche to access finance from an unchanged market.

4.3 Evolutionary Interventions

4.3.1 Development and diffusion of knowledge to the niche

In new or underdeveloped sectors (such as low-carbon sectors) developers and other relevant project stakeholders such as OEMs do not necessarily yet have the experience and expertise to successfully source finance to reach financial close or to successfully develop a project. SIBs commonly intervene with non-financial support for projects, sometimes referred to as technical assistance, in order to help developers (and associated stakeholders in the niche) fulfil their requirements, attract the required finance and ensure projects reach financial close.

Our interviewees provided many examples of SIBs providing technical assistance that resulted in the successful leveraging of finance and completion of projects. GIB offered extensive technical support to the biomass and WtE sectors in order that they meet due diligence requirements for investors early enough to also meet subsidy deadlines. Developers claimed that they were themselves somewhat inexperienced and this support was invaluable to them in sourcing private finance, making deadlines and reaching financial close. The GIB's assistance ensured that the developer had met all investors' requirements, fitting in with what the investors expected from a viable investment project. KfW asked wind developers to perform early stage due diligence, also known as a DD lite (not a full scale due diligence process) to ensure they had considered and mitigated all project risks at an early enough stage and considered all requirements in order to source future private finance. Wind developers claimed that this support ensured they were able to better assess and mitigate project risks inline with the finance sector's expectations and were then able to attract the required private finance, allowing the projects to go ahead.

The technical assistance and standards provided by these SIBs better ensured projects would *fit and conform* with financiers expectations and requirements around investments allowing them to attract finance from an unchanged finance regime.

4.3.2 Development and diffusion of knowledge to the finance regime

In new or underdeveloped sectors (such as low-carbon energy sectors) financiers and other relevant stakeholders have not yet developed the codified or explicit knowledge for new asset classes, the tools and processes needed in order to identify project opportunities, identify, assess and mitigate project investment risks nor to sufficiently design and perform new due diligence processes. SIBs have greatly contributed to the development, standardisation and diffusion of this new codified

knowledge to help the finance sector adapt to the new technologies and to low-carbon sector projects.

Standards are very important for imparting codified knowledge. Codified knowledge is usually knowledge that can be precisely articulated and is easy to communicate via written or verbal format (e.g. formulae etc) (Smith 2001). Standards, in the form of codified knowledge, tools, paperwork and processes can be thought of as an intervention that allows investors and other relevant stakeholders, including due diligence (DD) intermediaries, to easily/efficiently bypass their lack of knowledge by following the standardised forms and processes provided. Standards support financial actors in adjusting to technological change by reducing the time, costs and barriers associated with acquiring and developing the knowledge from scratch. They bring down costs of DD and arranging.

Our findings have shown that many of the standards created and deployed by SIBs have been successfully taken up by the finance sector. KfW provide many of its financial products (capital and de-risking tools) via an on-lending process through Germany's extensive local banking network. This on-lending process includes supply of standardised risk registers, assessment tools, documentation, training etc. The local commercial banks disbursed KfW's provisions, using its standard risk registers and assessment tools and in the meantime have now became familiar with low-carbon projects and their associated risks. Investors and banks are now very competitive. KfW IPEX produced technical and risk standards during the early phase of the wind industry that it shared within fellow investors in project syndicates. The CEFC and GIB create standards for projects containing new/ early stage technology or projects containing something new/ innovative. CEFC also provides standards for EE projects, a particularly underdeveloped sector in Australia, and disburses them via on-lending to various EE funds run by local banks.

The development and diffusion of knowledge (via these Standards) provided by SIBs have changed the way the financial sector perceives and approaches these projects and technologies, allowing the financial sector to *stretch and transform*, and finance to flow to the niches.

4.3.3 Industry Co-ordination

For early stage technology and project sectors, different parts of the niche sector are either inexperienced and do not provide well for the needs of the niche (or finance sector) or do not even exist. This includes partners along the logistics and supply chain, OEMs, O&M companies, insurers etc. A lack of co-ordination within an innovation system or niche can be thought of as a system failure (citation Wieczorek). SIBs actively intervene in the sector, identifying gaps, weaknesses, a lack of knowledge and expertise, absences of services and products etc. and use their position and involvement to co-ordinate what is required either internally or externally to the sector. Often in this case the SIB does not directly provide an instrument or capital but instead uses their expertise and 'position/ reputation' to co-ordinate and negotiate between relevant stakeholders to ensure the required services or products are eventually implemented.

When the GIB entered the WtE sector it recognised that some developers were struggling to source finance because part of their project equipment did not have

guarantees. Developers state that the GIB played a key role petitioning WtE OEMs, helping to convince them to provide technology guarantees. Technology guarantees are seen as familiar mainstream de-risking instruments by the financial sector, which subsequently ensured that investors were more comfortable with the technology risks displayed by the project. Developers reported that the entry of the technology guarantee then helped leverage in private finance. This effect helped the niche fit and conform to the finance sector's existing expectations around technology guarantees.

German wind developers reported that KfW worked extensively with insurance firms, developing and sharing their own technical expertise, to encourage them to provide project specific insurance products for wind projects displaying project-unique and high risks, particularly during construction. Developers say the supply of appropriate wind project insurance products and the subsequent further development of the insurance industry around wind in general was key to helping them eventually attract private finance; the intervention allowed the niche to *fit and conform*. However, the insurance sector is part of the finance sector, so KfW's intervention to encourage and support the insurers to provide products for new projects, simultaneously had a *stretch and transform* effect on the insurance part of the finance regime.

Hence we see industry co-ordination interventions as having effects on both the regime and the niche. Industry co-ordination type interventions have helped the sector (niche) to *fit and conform* to investors' expectations and attract subsequent finance AND to alter the finance sector (insurers for example) to *stretch and transform*.

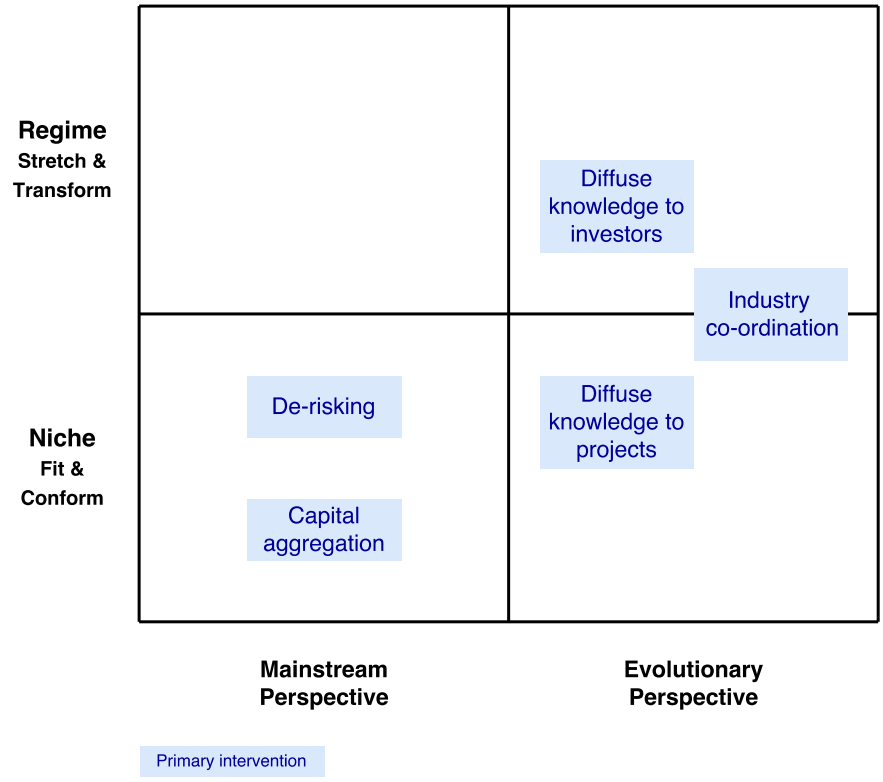

Figure 4: Primary interventions and effects

4.4 Secondary Effects

We also observed subsequent additional or 'secondary' effects upon the niche-regime interactions. These additional effects generally occurred at a later time to the original intervention and usually as a direct result of one or several of the initial 'primary' interventions described previously. Here we describe these other additional effects in section 4.4 and also display them graphically within our framework in Figure 5.

4.4.1 Learning-by-doing

When an SIB ensures other investors participate in a project, such as via part of a syndicate or another type of co-investment environment, we have observed this lead to knowledge spill-overs and learning by doing. For example, the CEFC's mandate states that it cannot be the lone investor or financial participant in a project: it should ensure that co-investors also participate. By implementing its various primary interventions, including de-risking and capital provision the CEFC has attracted private, often inexperienced, co-investors to new and innovative projects. Many investors co-invested with the CEFC (who provided market rate debt, a capital provision intervention) in various commercial grade solar PV projects featuring innovative leasing business models. Developers and investors then report that these co-investors subsequently went on to initiate and invest in similar projects without the CEFC's involvement. Developers and investors working with the GIB and KfW have made similar reports, having seen investors continue to invest in low-carbon projects after their initial co-investment experience.

As co-investors they became familiar with the 'new' projects, the technology and business models and the risks involved, learning how to better assess and mitigate them and how to reach financial close in new and unfamiliar project settings. The private co-investors experienced knowledge spill-overs, or an exchange of information and ideas with the other participants, as well as learning-by-doing (or participating). These knowledge processes and learning-by-doing are very important for imparting tacit knowledge. Tacit knowledge is usually knowledge that is intuitive and experienced based, is hard to communicate via written or verbal methods, and is based on action, involvement and experimentation (e.g. norms, cognition etc) (Nonaka 1991, Smith 2001). These knowledge spill-overs and the 'learning by doing' process changed investors usual investment decisions (heuristics) and activities, opening them up to invest in future low-carbon projects – these processes are evolutionary adaptive processes.

In addition when knowledge spills over from the co-investment process and where private investors 'learn-by-doing' or 'participating', there is a *stretching and transforming* effect upon the finance sector, ensuring the finance regime changes in a way that is beneficial to the niche, allowing finance to flow to low-carbon projects. Figure 5 (matrix with arrow) shows how some primary interventions can lead to this secondary effect.

4.4.2 Establishing a track record

We have observed another secondary effect that an SIB's primary interventions can lead to: demonstrating a project successfully, also known as creating a track record.

For example the GIB provided a primary intervention of fixed, market rate, long-term debt to a first-time biomass developer who was using a new, unproven processing technology and utilising a new feedstock. Thanks to the original intervention the project reached financial close and was successfully developed. Once this 'unproven' project had been shown to be successfully implemented, the developer reported that he had no problems sourcing private finance for subsequent similar projects from financiers who were inexperienced with the technology.

Demonstrating a project successfully creates a track record for the unproven elements of the project. Track records are very important because investors require them before they will invest. Track records allow investors to observe what risks exist and how they can be assessed and mitigated. We have witnessed this effect across all low-carbon technologies where SIBs have taken the first/ early-mover or demonstration role to establish a track record for a project. Our results show that time and again, once a track record has been established, investors start showing interest in similar projects, and private finance is leveraged in. The finance sector's expectations around requiring track records for unproven projects remain unchanged, and the SIB's effect is to help the project (niche) *fit and conform* into these expectations. The successful development of this project, the establishment of the track record has the effect of allowing finance to flow to the niche, eventually allowing the niche to enter the unchanged finance regime. [

4.4.3 Trust creation and signalling effects

We have witnessed a final additional effect of SIB interventions relating to the creation and signalling of trust for projects. The GIB announced its intention to provide market rate debt to several biomass and WtE projects, many of which comprised of something unproven or innovative, such as new technology or a first-time developer. Prior to the GIB's involvement, these projects were unable to source the debt finance they required from private investors. However, once the GIB's announcements were made public, equity and debt providers immediately crowded-in, sometimes offering even better terms than those offered by the GIB, and often resulting in an oversubscription of finance that even excluded the GIB from the project.

Developers and investors reported that the SIBs have developed a reputation for expertise around viable, bankable project identification and development as well as expertise for accurate risk assessment and mitigation. SIBs have in fact created their own successful investment 'record' and other financiers have learnt to trust their decisions. SIBs have created trust both for themselves as an investor as well as for the projects that they choose to invest in; that is, there is a 'signalling effect' on those projects. This effect has developed over time as each the SIB gained experience and legitimacy, rather than as a direct result of a single or several primary interventions. Hence as soon as an SIB 'signals' a project by announcing its intention to invest, previously disinterested investors crowd-in. We observed this 'signalling effect' for projects announced by all of our SIBs, regardless of technology sector. This effect, the SIBs signal, indicates to the finance regime that the project niche is worth investing in, that it *fits and conforms*.

4.5 Synthesis of findings

SIBs' interventions have also been effective at both fitting and conforming the low-carbon niche and stretching and transforming the finance regime. Interventions implemented by SIBs have been shown to fall both under the mainstream intervention (MSI) and evolutionary intervention (EI) finance categories (see Fig 3); our work shows that SIBs provide for and support evolutionary (adaptive) responses from the low-carbon niche-innovation and the finance regime. SIBs' MSIs have the effect of empowering low-carbon niches to fit and conform to existing financial regime requirements, whereas the EIs have a more diverse niche-regime effect, with especially industry co-ordination type interventions having the effect of simultaneously stretching and transforming the regime whilst fitting and conforming the niche in order to catalyse finance.

SIBs often also implement interventions that enable subsequent secondary niche-regime effects that occur over time. The secondary effects we observed all fell under the evolutionary perspective. In particular, knowledge spill-overs & learning-by-doing and the track record effects allowed for private finance to flow to future subsequent projects independently and in the absence of an SIB. Our empirical observations show it's not enough to look only at the immediate effect of an intervention but to also consider longer-term effects on the niche-regime interaction.

Overall although most SIB interventions predominantly fit and conform the niche, we do also see SIB interventions stretching and transforming the finance regime. SIB activity shows that to fit and conform niches to the finance sector's expectations, a mixture of MSIs and EIs is shown to be effective. However, to stretch and transform the finance regime and overcome regime resistance, evolutionary type interventions have had the most effect.

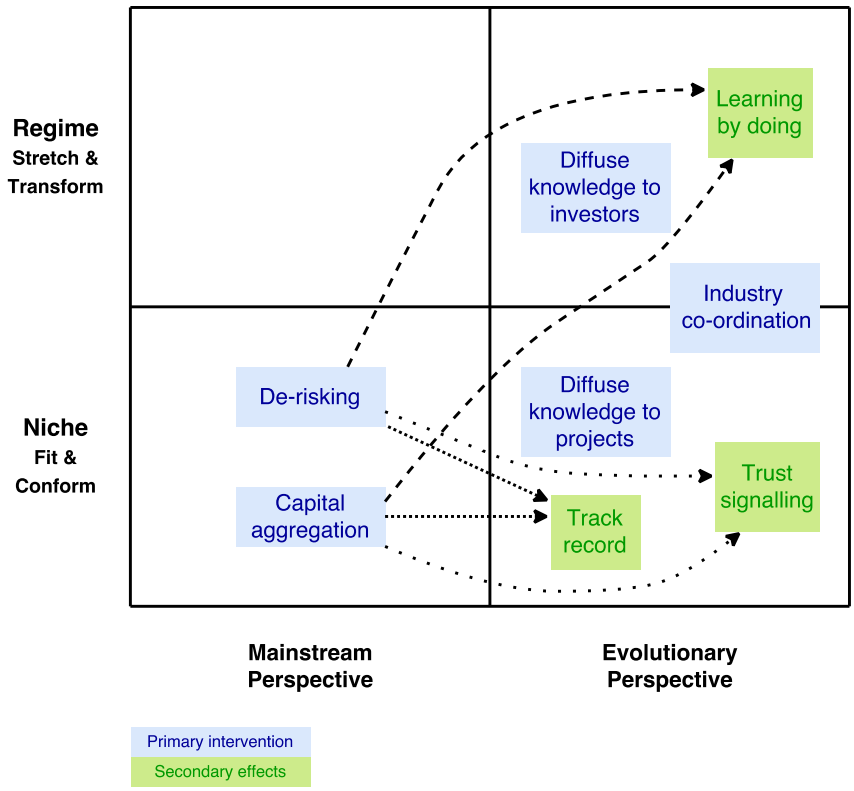

Figure 5: Interventions and secondary effects

5 Discussion

Our work leads to several insights and implications on how to enable niche-regime interactions and allow finance to flow to the niche, and to support sustainability transitions through policies aiming at finance. One important insight is that mainstream economic theories on finance (as discussed in our paper) can only cover a part of the observed processes: if only viewed through a mainstream finance lens we would miss the valuable contribution that evolutionary policy interventions make to mobilise finance for transitions. Given that mainstream interventions predominantly fit and conform the niches into unchanged markets and existing finance regime expectations, focusing on such mainstream finance policies may mean the finance sector remains static and resistant to change. Some form of evolutionary finance intervention to help transform the finance sector should be considered necessary for supporting and enabling socio-technical transitions more effectively. It should also be noted that initial mainstream finance interventions, if implemented in ways that support innovation, can lead to secondary evolutionary effects over time. They can ensure innovations gain a track record, signaling they are worthy of trust and investment, and that investors subsequently experience learning spillovers & learning-by-doing via participation in such innovative projects.

Our work also implies that any public institution considering implementing financial policy interventions to enable a socio-technical transition must consider how best to address both the finance regime and the niche-innovation. The institution needs to employ financiers for their knowledge of the finance sector and to develop legitimacy with financial stakeholders. They should also employ niche technical personnel for their knowledge of projects and technology, and to develop legitimacy with niche stakeholders (e.g. developers, OEMs etc.). This way they can design and implement policy interventions that both successfully fit and conform the niche as well as stretch and transform the finance sector. This work shows that designing, implementing and assessing policy interventions under both mainstream and evolutionary finance perspectives is essential for understanding and accelerating successful socio-technical transitions.

This paper makes a first attempt to theorise on, and incorporate financial theory into the multi-level perspective on socio-technical transitions, highlighting the validity of a finance-focussed regime paper. Perhaps a reason the finance part of the regime has not yet been looked at in detail in the sustainability transitions literature is that transitions researchers assume that the finance sector perceives new technology and investment opportunity in a completely rational way i.e. from the mainstream finance and EMH perspective. (CITATION Geels 26/06/2016 - personal communication). Whereas we have shown this is not the case and that evolutionary perspectives have a role to play. In addition, unlike much previous MLP-regime focussed work, which implies that regime resistance should be overcome via destruction and rebuilding some part of it (utilities, infrastructure etc), our results show that finance regime resistance can be overcome via learning and adaptation. Our results show more of a learning story for the financial regime, than a destruction story, and that non-linear evolutionary mechanisms are at play in the finance sector regime.

6 Conclusions

We have aimed to increase the understanding of the role of finance in transitions, which is essential for designing policy interventions for enabling sustainability transitions. The paper makes both conceptual and empirical contributions. Conceptually, this paper makes a first attempt to theorise on, and incorporate, mainstream and evolutionary financial theory into the multi-level perspective on socio-technical transitions. We provided an empirical analysis based on a dataset of 56 interviews collected from 3 countries with SIBs active in energy finance. We analysed these SIBs' interventions in terms of their effect upon niche-regime interactions i.e. whether they resulted in fitting-and-conforming the low-carbon technology niche for the financial regime or stretching-and-transforming the financial regime, (in both cases allowing finance to flow to the niche), and determined whether these effects worked through mainstream finance mechanisms (capital provision, de-risking etc) or evolutionary processes (adaptive learning etc). Finally, based on our findings, we derived insights and implications on how to accelerate transitions through policies aiming at finance as well as theoretical insights gained through our analysis. One important insight is that mainstream economic theories on finance (as discussed in our paper) can only cover part of the observed processes. Policy makers must consider designing policies along both mainstream and evolutionary finance type interventions in order to catalyse finance and successfully enable sustainability transitions.

As this is a first attempt to bring finance into the transitions literature it is not free from limitations that should be addressed in future research. The work would benefit from incorporating more countries; additional future work would be needed to analyse finance in transitions in developing countries that face additional barriers such as political risk or even a complete absence of an operating banking sector and investment market. Future work should also examine other types of policy interventions designed to catalyse finance apart from those deployed by SIBs (e.g. feed-in tariffs). In addition work should analyse the divestment and re-direction of investment away from high carbon technologies in the regime and analyse regime-landscape interactions and changes. Finally alternate sectors undergoing sustainability transitions rather than just the energy sector should be analysed. Such future work would help to improve the generalisability of findings. Notwithstanding these limitations our approach has helped to fill a research gap and can lead to a better understanding of the role of finance in transitions and how to produce policy interventions to enable such transitions.

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