

A diverse and resilient financial system for investments in the energy transition

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Abstract: Diversity makes the financial system more resilient. In addition, there is a diverse investment demand to make the transition to a more sustainable energy system. We need, among others, investment in energy transition, circular resource use, better water management and reducing air pollution. The two are linked. Making the financial system more diverse implies more equity, less debt, more non-bank intermediation and more specialized niche banks giving more relation-based credit. This will arguably also increase the flow of funds and resources to innovative, small-scale, or experimental firms that will drive the sustainability transition. Higher diversity and resilience in financial markets is thus complementary and perhaps even instrumental to engineer the transition to clean energy in the real economy.

Keywords: Financial markets, clean energy investments, diversity, public policy

JEL codes: G23, G24, G28, O33, O38

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1 Introduction

A ‘grand challenge’ facing humanity in the 21st century, perhaps the biggest challenge humanity has ever faced, is to manage the energy transition to a more decentralized and renewable system [1–3]. Technologically and energetically this transition is feasible and even economical [4–7]. Our modern economies have become completely dependent on a reliable and low-cost supply of heat, power and mobility, and fossil fuels still supply 80% of that demand [8]. This has to drop to 0% by 2050 to stay below the 2 degrees Celsius increase in global temperature compared to pre-industrial levels [4]. Transforming our energy systems into more decentralized and renewable energy sources will require a vast deployment of innovations and, accordingly, huge investment [5,9]. Estimates for the total investment begin at about USD 700 billion [10] which amounts to a mere 1% of global GDP [6]. However, this amount simply pales in comparison to the daily trade in global financial markets¹ or total estimated financial losses in the 2008 crisis².

There is no doubt that the financial sector could, in principle, finance the transition [11]. But all too often, this is taken for granted in the literature [2,12,13] neglecting underlying issues³. The financial system gives direction to the development in the real economy. Its traditional role is to mobilize and transform savings into productive investments [22] and the latter crucially includes investments in new capacities of existing firms, new ventures, new technologies and complementary assets such as infrastructure across a range of institutional and geographical contexts [23] that the transition to sustainability will entail [24–26]. The real economy has come to heavily depend on the smooth functioning of financial markets. Especially after the financial crises, a focus on risk reduction and stability is justified. But, paradoxically, minimizing financial risks at the micro level may expose the real economy to large climate risks.

¹Reuters reports foreign exchange trade on a daily basis is about 3-5 USDtn:

<http://www.reuters.com/article/global-forex-volumes-idUSL5N1GK1F5>. Adding global bond and stock markets and total bank credit would multiply that number manifold.

² Global financial losses in the crisis have been estimated at staggering numbers of 10-15 USDtn: <https://blogs.wsj.com/economics/2012/10/01/total-global-losses-from-financial-crisis-15-trillion/>.

³ Theoretically there are *three* underlying problem categories. *First* consider the CO₂ abatement options that are in fact Net Present Value (NPV) positive under current circumstances [14]. With efficient financial markets, such opportunities should not exist, but they do, in fact [14–16]. Incentives and corporate governance structures of large, publicly traded companies focus typically on capital expenditure (CAPEX). Gains from clean energy investments typically come in the form of lower operational costs (OPEX) [17,18]. Any financial intermediary would be willing and able to finance these investments with debt. The collateral is high quality and OPEX reductions cover interest payments and installments. The short time horizon and high discount rates of most shareholders, however, make minimizing CAPEX more attractive than minimizing OPEX. In a *second* situation NPV is close to zero or context-specific. Such specificity can arise from asset complementarity in systemic interdependencies, e.g. (hybrid) electric vehicles and charging infrastructure [13]. Thus, (private) investors may shy away from otherwise perfectly functioning technologies. The *third* category includes deep uncertainty that characterizes (radical) innovation. In such cases an NPV simply cannot be computed [19,20]. While financial intermediaries are specialists in managing risk through diversification and trading, non-calculable uncertainty cannot be managed using advanced risk management tools [21]. If it does not fit the risk model, the dominant players in modern financial markets are unwilling, but also simply unable to engage.

Our contribution in this paper is that we synthesize the literature on clean-energy innovation and finance with a particular focus on innovation policy and financial market regulation, in order to understand why investment in the energy transition is lagging. We argue that innovation policy efforts alone would not be sufficient to jointly achieve financial system resilience and an innovation-led transition towards a sustainable economy. The two are rarely discussed in coherence, so here we identify a gap in the literature, and make the case for diversity as an important element that can both stabilize financial systems and foster funding of investment required for the energy transition.

In the remainder of this paper we first discuss the most relevant trends in the financial system. Then we propose policies promoting more diversity in the financial sector that would address both the valid concern for financial stability and mobilize more resources to promote the energy transition.

2 The financial system and the energy transition

Deregulation, globalization and consolidation waves in the financial sector since the mid-1980s have, perhaps paradoxically, exacerbated a trend towards a homogenous financial system which culminated in the financial crisis of 2007 [27]. Haldane and May [28] and others [29,30] argue that part of the problem is the decline in diversity. It is not a problem per se that some intermediaries made mistakes and missed risks in their portfolio management strategies. A healthy ecosystem will simply flush out such faulty strategies through competition. The problem arises when all intermediaries start using the same strategies. Then risks, fully diversified at the micro level, become highly correlated across the system [31,32]. In addition, a more diverse and therefore more competitive financial environment could actually reduce the capital costs of clean energy, given that capital markets function more efficiently when markets are contested [33].

The crisis caused a regulatory backlash prioritizing size and secure assets (e.g. highly rated government or blue-chip obligations) over diversity and more equity-like risk-bearing assets (e.g. Venture Capital (VC) in innovative startups). Regulatory and supervisory entities reacted to the crisis by banning or severely restricting complex financial products. They formulated stricter resolution mechanisms to reduce implicit public guarantees, requiring high reserves for assets deemed more risky and curbing perverse incentives such as excessive bonuses [34–36]. Some of these tighter rules and regulations are particularly likely to adversely reduce the flow of funds and intermediation to new ventures [37–39]. It is clear that investment through equity and equity-like interest-bearing assets is most urgently needed and best suited for innovative firms (see Figure 1). Such assets are typically deemed risky, also by regulators that require high reserves be held by both banks and institutional investors. In addition, such investors need to price their assets ‘to market’ and as these assets are only rarely priced in deep, liquid markets, it is even often outright impossible to invest in

such asset classes. Thus, a system dominated by regulated banks and institutional investors is likely to underfund the innovations a transition requires.

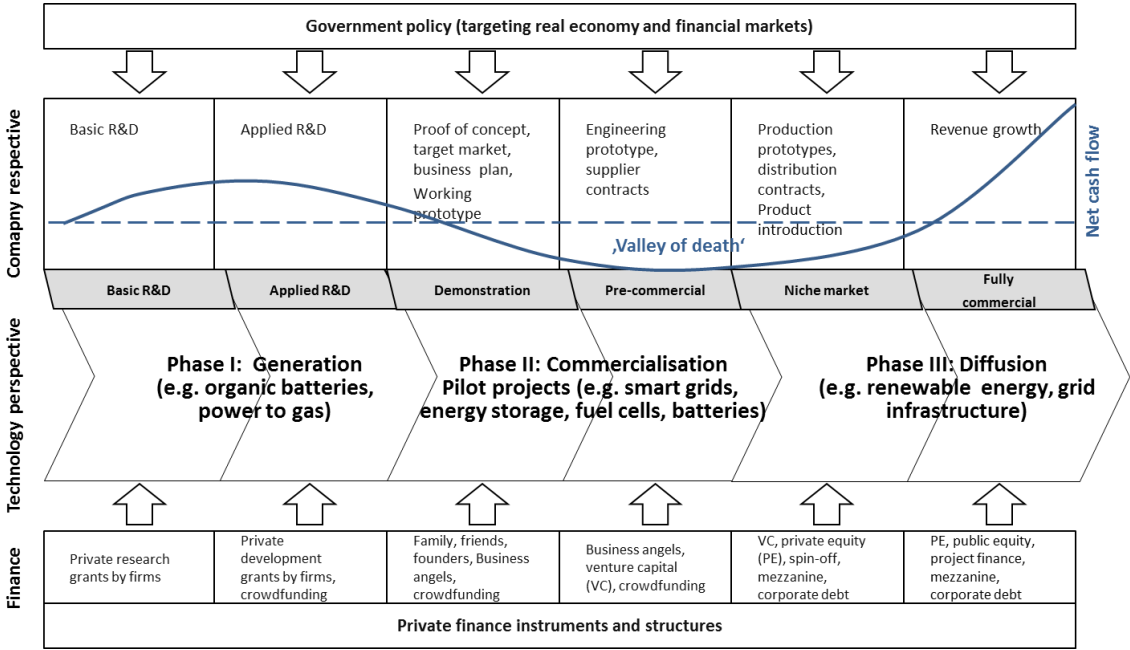


Figure 1: Financial instruments to finance clean energy innovation (Adapted from [40,41])

2.1 Financing early-stage clean energy innovation

In the early stages of the (clean energy) innovation cycle the challenges outlined above are partly overcome through R&D grants and early-stage investors (Figure 1). However, their size is small in comparison, given their importance in driving a transformation to clean energy [42–45]. When it comes to early-stage finance, debt instruments are simply not available due to lack of collateral and track record [46]. Innovative firms often add market and technical uncertainty to the regulatory uncertainty. When investing in such ventures (also new business units by incumbent energy companies), intermediaries cannot rely on standard, modern risk-management techniques [47]. Instead they must establish trust in the investee through soft information and relationships or, alternatively, take a stake in the venture that also gives some control rights. This is what venture capitalists and business angels (and also friends and family) do [48,49].

The problem with this model is that it cannot be easily scaled and involves large amounts of tacit knowledge in any single transaction. Moreover, the only countries in the world that can boast a significant VC and private equity (PE) market are the US, UK and Israel, where many complementary institutions support these sectors [50–52]. In particular Europe, with its highly concentrated and regulated, bank-dominated financial system, channels only a very small and declining fraction of its savings through these PE intermediation channels (to clean energy) [46]. While PE firms are entrusted with funds by institutional investors such as pension funds or, more precisely, their asset managers and banks, the vast bulk of Europe’s substantial savings surplus is invested directly by

institutional investors and banks themselves. These intermediaries are reluctant and, given their regulatory and fiduciary constraints and accounting practices, even outright prohibited to engage with deep uncertainty such as VC/PE investments.

Fintech solutions, such as crowdfunding and peer-to-peer lending, are growing, yet channel relatively small fractions of savings into early-stage investments [43,53]. Such investments for example amount to only 358 USDm [45] compared to 1658 USDbn in corporate debt to non-financial firms in Europe [54]. These funding platforms bring back the judgment call aspect of relationship banking and VC, but 'scale' the investment process through organizing the flow of information in a different, non-proprietary way [55]. By making their decision known to the rest of the investor community, crowdfunders seem to be a promising source of finance for the energy transition by enabling community finance of smaller RE projects [56,57].

2.2 Financing later-stage clean energy diffusion and infrastructure

The energy transition will inevitably feature significant investments in off-the-shelf technologies such as solar PV and wind that need to come from mature firms. In the later stage of the clean energy innovation cycle, additional sources of finance are available (see Figure 1) despite the fact that technology-specific problems such as long payback periods and policy uncertainty still prevail [11]. The remaining regulatory uncertainty implies the default risk on any project is substantial and, importantly, not calculable. This implies credit ratings are low or absent and only (private) equity or junk bonds can channel savings into these types of investments. This also affects established companies engaging in the energy transition.

In developed economies, later-stage corporate finance mostly comes from insurers, banks or pension funds [44]. They finance larger, mature clean energy companies as well as projects and infrastructure with debt or equity. Debt investors do not receive dividends and do not benefit from higher profitability and cost reductions directly. So they care about the downside much more than they do about the potential upsides. Hence incentives for debtors are to reduce capital expenditure (CAPEX) and leverage to have a better credit rating and thus lower cost of capital, increasing the value of the stock in the short run [17]. Asset managers of institutional investors also do not have strong incentives to push for operational expense (OPEX) reductions if such investments do not translate into (quick) capital gains, as they are typically evaluated and rewarded comparing performance to market benchmarks with high frequency. However, more patient capital e.g. from state investments banks, finances large-scale infrastructure projects (e.g. for e-mobility or hydrogen) that are needed to complement the decentralized energy transition [58]. In developing countries and emerging markets, on the other hand, financing of renewable energies takes on a very different stance. Given the lack of electrification in rural areas of regions such as India, Brazil or Sub-Saharan Africa, the

decentralization of energy sources comes center-stage through off-grid energy supply. More importantly, this off-grid access to energy implies a very different, unscaleable business model that cannot rely on any conventional business-oriented financing source. Small-scale solar or wind projects are often funded through some co-operation between local project developers and public (development) banks, rather than multinational asset managers [23,59,60] or crowdfunding [61].

The focus of the ecosystem for financing towards debt and later stages creates a bias towards calculable risks in incremental innovation and, importantly, the maintenance and expansion of the existing capital stock in existing firms. These incumbents have high-quality marketable collateral and established track records, but lack the incentive to introduce and diffuse true innovations, as they cannibalize existing profit flows [62]. For example, oil companies like Shell and Exxon only hesitantly engage in clean energy.

3 Policies to stimulate investments into clean energy

Central governments arguably have the means to break the ‘lock-in’ problems which favor fossil-fuel-based energy technologies [11,63,64]. Mistakes, however, are terribly costly and can create new lock-ins for which politicians do not want to be held accountable. Sticking to the existing system may be more attractive, even at the country level, than running the chance of locking in to a losing technology. But there are some areas of policy where we do see some action.

3.1 Innovation policy

The obvious angle from which policy makers could approach the challenges for the energy transition is innovation policy [11,12,64]. Market-based incentives such as GHG emissions-trading systems represent the theoretical optimum as argued by climate and energy economics since the early 1990s [65,66]. However, due to the lack of global mechanisms, second-best instruments are required. To accelerate the diffusion of clean energy and associated investments, policy makers first could deploy technology-push mechanisms such as direct R&D investments, subsidies and tax-credits that target the early stages of the innovation cycle or early stage VC/PE which favors SMEs [40,42,46]. Direct investments and co-funding also mobilize private early-stage finance [67,68]. Olmos and colleagues [42] suggest public loans, or guarantees provided by public bodies backing private loans, along with public investments in the equity of innovating companies to accelerate the commercialization. By getting more involved in financing investments directly, the government would increase financial diversity, as the criteria and conditions under which such public funds become available will differ from those offered by banks and institutional investors today [64,69].

Second, research conducted on clean energy diffusion and investment highlighted demand-pull policies mostly targeting the later stages of the innovation cycle [40,70,71]. Fiscal and financial

incentives such as grants and subsidies [42,46,72] prove less effective than feed-in tariffs [73–77] that also target smaller distributed capacity and early stage investments that again benefits smaller players [57,78]. To address network externalities and reduce private risks regarding complementary assets (e.g. infrastructure), public investments have been suggested [79,80]. The (quality) regulation of the (clean energy) portfolio and emission standards advances deployment of more mature technologies [81,82]. Systemic policies such as standard-setting, long-term planning and policy support accelerate both early and later investments [41,46,69,83]. Especially consistency, stringency and predictability to reduce deep uncertainty and policy risk are deemed crucial [84,85]. Overall, a policy mix is suggested to make the transition [86]. Most of these policies, however, actually favor mature, established technologies geared towards the existing monoculture of debt-based financial markets.

3.2 Framework conditions and financial market regulation

Unprecedented monetary policies in the Eurozone (Quantitative Easing) have driven the cost of debt finance to zero or below and flooded financial markets with cheap debt finance. Still only very little of that monetary expansion finds its way into the real economy, let alone into clean energy [44,87]. Instead, we argue these policies tend to entrench the existing linear, carbon-based economy, as debt favors the low-risk status quo. More equity and, more specifically, PE investments are needed to finance uncertain but much-needed innovation (both for incumbent firms and new ventures). Hence, the less obvious but equally important angle from which policy makers affect private investment for clean energy consists of framework conditions and financial market regulation.

Framework conditions for either debt or equity-based instruments influence their contribution to a clean energy transition, as a developed capital market is needed to channel resources [52,88]. Most importantly, a fiscal preferential treatment of debt finance, which is widespread today, should be avoided. Typically, interest is deductible as costs, while dividend payments only occur after tax. Policy makers should try to level the playing field across sources of finance. Hence a favorable tax policy could allow for tax deductibility of early-stage company investments [89,90]. A less stringent bankruptcy and labor market legislation would also promote entrepreneurship and experimentation in sectors characterized by high uncertainty, such as cleantech [91]. Securities legislation should allow VC funds to sell parts of their investments [91].

Capital market regulation shapes investment mandates and risk models and thus ultimately determines the feasibility and viability of investments into clean energy [87,92]. Regulation (e.g. Basel III, Solvency II), especially since the crisis, is almost exclusively geared towards stability and security [34,36,90]. Consequently, they encourage or force deposits into ‘safe’ asset classes and calculable risks, such as rated (energy) firms, government debt and real estate. Institutional investors

and their intermediaries are forced to stay away from risky asset classes such as VC/PE [37,87,93]. A solution would be to 'loosen' equity requirements for green investments specifically [87]. But this would put the deposits and pension premium at risk. More fundamentally, one should therefore look for ways to clearly separate intermediation and investment from transactions and savings, as not all deposits are held for investment purposes [94]. A no-regret is to require financial intermediaries to lower their overall leverage ratio and operate with more equity [95]. With more skin in the game, banks and institutional investors can responsibly handle more risk and uncertainty on their balance sheets. The current practice of discriminating among asset classes (e.g. Basel III) on measurable risk seems to make perfect sense, until one realizes this inevitably works against innovative entrepreneurs, who face deep uncertainty and have no track record and collateral to secure their loans.

Alternative intermediaries such as VC/PE have also become regulated, e.g. through Alternative Investment Fund Managers (AIFM) Directive, increasing reporting burdens and forcing funds to accumulate more capital to cover higher costs, hence reducing diversity in the system. Prospects for more VC/PE – or even more traditional friends, family and fools financing – is limited in the more egalitarian European welfare states as there are fewer wealthy private investors than in the US and UK who can freely invest their wealth [90]. Fiscal reforms in the tax treatment of private wealth, gifts and bequests and arms-length investments could go a long way to direct more (equity) investments to ventures and projects that would otherwise stay unfunded [96].

New alternative finance such as equity and debt-based crowdfunding could also benefit greatly from such reforms [97], but instead are also becoming more regulated in many countries [98]. Regulators should abstain from clamping down on shadow banking and new forms of intermediation, for example through a regulatory sandbox [99]. This will prove harder than one might think, as the 'experts' in traditional banking and even PE and VC will warn for 'irresponsible risks' being taken there [100]. Moreover, ordinary people will lose money, inevitably creating political pressure for such regulatory tightening. It is more promising to be clear about the fact that such investments are not regulated and that investors willingly accept uncertainty and risk. As we have argued above, however, the volumes to be expected from these emerging intermediation channels are limited.

While many clean energy investments projects are economical, the question is why even these are not funded under record-low interest rates. This problem stems from unintended consequences of stability-oriented regulation that constrain existing intermediaries to channel funds to risky ventures and even long-term RE projects. In addition, this lack of transmission to the real economy stifles the effectiveness of monetary easing [87]. To alleviate this problem of diffusion, together with issues of innovation financing, a more co-ordinated approach of policy measures is warranted. Such policies

will result in a more diverse and therefore more stable financial system that at the same time channels more resources into the risky, but urgent, transition to a more sustainable real economy.

4 Conclusion

In this paper we show that in the discussion about mobilizing private finance for clean energy innovation, the literature has neglected the structure and regulation of financial markets as potential determinants. In order to mobilize resources to break out of the fossil fuel technology complex and to finance radical and transformative innovations, we need intermediation to take different channels (see Figure 1). More risk at the micro level in a more diverse financial system implies we stand a chance of avoiding macro catastrophe. While low-risk institutionalized debt finance is at best suitable to finance *diffusion* (but more likely channels our resources into the riskless reproduction of the status quo), a shift to more expensive and uncertain equity is needed to finance *innovation*. Financial market regulations are currently ‘boxing in’ intermediaries in a way that biases finance towards the status quo and it is not responding to the financial requirements of an innovation-led energy transition (e.g. early-stage risk capital, equity, risk-bearing debt etc.).

Financial regulatory reforms could free up the resources in banks and institutional investors for more uncertain and equity-like intermediation. This may imply a shortening of bank and pension fund balance sheets and more risk landing with individual small-scale investors. But this risk will be rewarded in higher returns. The ensuing diversity in intermediation will increase financial resilience and shift the bias in intermediation (back to) the innovative experimentation we desperately need. Regulators, however, can also allow banks and intermediaries to take higher risks with their assets, *if* they compensate such higher risk with higher equity ratios. In the end, implicit and explicit guarantees for deposits and other debt liabilities on the banks’ balance sheets must be eliminated altogether. This sets the necessary preconditions for a more diverse financial sector in which all varieties of intermediation compete on a level playing field, and implicit public support for banks no longer tilts the system towards cheap debt finance of status quo assets. A more diverse financial system allows for an (easier) transition towards clean energy.

5 References and recommended readings

Papers of particular interest, published within the period of review, have been highlighted as:

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** of outstanding interest

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This highly policy relevant article, explores theories behind the neoclassical approach to innovation finance taking which assume that capital markets function efficiently and the structural co-evolutionary approach that emphasizes social mechanism to influence financiers behavior. Based on the analysis of the UK electricity market reform and renewable energy finance the authors propose a theoretical lens that takes into account planetary boundaries. The adaptive market hypothesis states that the investment environment together with investors' behavior can change over time implicating that behavioral and structural conditions work in financial markets.

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In this paper, the authors model the necessary large-scale deployment of low-carbon technologies. Next to economic factors hindering the adoption, the analysis points to institutional, behavioral and social factors that relate to both the uncertainty in climate policy as well as technology inherent characteristics. Technological lock-in, network externalities, high upfront investments, uncertainty and policy risk are highlighted. Even without major delays in policy implementation, the diffusion of low-carbon technologies might be hindered, especially if the technologies are interdependent. For some technologies such as CCS and renewables the constraints are more costly than for others (e.g. nuclear and bioenergy).

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The authors outline the environmental problem-shifting phenomenon which occurs when technologies aimed at solving certain problems have reverse salients and negative side effects. Using a qualitative scenario approach the authors show potential rebound effects, using the example of mass-diffusion of solar energy which is an important scenario for the coming years. In a world where fossil fuels are expensive due to a carbon-emission scheme the environmental impact of cheap solar technologies are modest as energy efficiency measures make the overall economy smaller. In unconstrained scenarios cheap solar energy could mean less CO₂ reduction but on the other hand more ocean acidification and increased land-use and loss of biodiversity.

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This article is one of the first to systematically integrate the consequences of barriers to low-carbon innovation for innovation financing along the innovation cycle. Drawing from the innovation studies and

entrepreneurial/innovation finance literatures the author emphasizes that technological, economic, institutional and political barriers have the most pronounced effect on investment. Policy makers possess a variety of instruments to address the barriers ranging from cutting fossil fuel (R&D) subsidies, leveling the institutional playing field and making risks of high-carbon and low-carbon technologies transparent to providing a consistent but adaptive long-term transition strategy.

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The authors show the early-stage finance gap specifically for innovative SMEs in the environmental sector using data from 330 firms. In this seminal study in the green tech sector, they argue that banks but also government support schemes discriminate SMEs that develop nascent technologies and venture capitalists fill this gap only to a very limited extend. Retained profits are hence the only way to finance these activities.

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In this paper, the similarity of loan portfolio in the Japanese banking system over the last 20 years is examined. The author finds that although overall similarity has decreased the banking system has become more concentrated and the largest banks have indeed become more similar. He concludes that the findings are likely to hold for other bank-based financial system such as Germany or the Netherlands.

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This article looks at the origins of financial instability that led to the past financial crises and impact financing the real economy. Based on experimental evidence in constructed asset markets, the authors highlight that male and female markets have comparable volatility, however confidence and risk preference (male attributes) drive financial instability. Hence reducing male domination and creating mixed-gender markets contribute to stability. Overall higher cognitive skills are associated with reduced price volatility.

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The authors of this seminal paper show that during the financial crises, a small (2.5%) but significant number of UK SMEs have been discouraged through the perception of the market environment to apply for a loan. These firms also appear more risky but are aware of their riskiness. The financial crises added noise and uncertainty to the lending process to SMEs. Entrepreneurs also overrated the extent to which credit rationing was ongoing, which led to sub-optimal lending activities.

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This article builds theory around unintended consequences of financial market regulation after the financial crisis for the financing of innovative cleantech companies. Based on 64 semi-structured interviews in the US and Germany the authors shed light on mechanisms of demand and supply for venture capital (VC) and private equity (PE) along the innovation-finance-value chain. Institutional investors emerge as critical players, particularly negatively affected by financial market regulation that restricts their possibilities to investment in risky asset classes such as VC/PE.

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The authors provide a state-of-the-art overview about new actors in financial markets, the antecedents of their emergence and their peculiarities with regard to financing entrepreneurship and innovation. The authors compare nature of the capital (debt or equity), investment approach, goal and targets. They highlight the emergence of disintermediated players such as crowdfunding in addition to 'classical' entrepreneurial financiers such as VC and business angels. However the literature is biased towards these, neglecting other players such as family offices.

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This paper represents an important addition to the discussion about the suitability of venture capital for sustainable start-ups. Based on a series of interviews with investors and other stakeholders the author extracts drivers and barriers for successful venture capital engagement in sustainable firms. Key success factors include an innovative business model, collaborations with other stakeholders and a strong business case, whereas failure factors include a mismatch between investors and entrepreneur, a strong incumbent industry and a short-term investor mind-set of potential investor. The study underlines the important role of venture capitalists play in advancing the sustainability transition.

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This research article provides the first cross-country account of drivers and barriers to venture capital investing in the cleantech sector from 1996-2010. Key drivers for this phenomenon include in descending order of importance: Media attention, rising oil prices and formal (e.g. regulatory quality and government effectiveness) and informal institutions. Uncertainty avoidance on the other hand represents a significant barrier, hence this need to be addressed in order to mobilize more private finance for cleantech.

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This paper starts the discussion about new forms of entrepreneurial finance that increase diversity in the financing landscape for start-ups. They establish an analytical framework for these new alternatives consisting of sources and types of capital, demand for capital (entrepreneurs perspective), resulting ownership and governance structures of the ventures as well as outcomes of the investment process.

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This recent piece contributes to the discussion of how to accelerate the transition towards a green economy. Based on the case-study analysis of wind power, sustainability reporting and microcredit, the authors argue that instead of long-term visioning, planning and other management tools, robust action is appropriate to solving grand challenges such as climate change. Robust action consists of ‘leaders’ (organizations or individuals) that despite limited formal authority are able to leverage networks and actors to spur decentralized innovation.

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Crowdfunding might fill the gap needed for an energy transition. The authors of this paper analyze a potential contribution based on a case study of wind energy in the Netherlands. Due to the low volumes (often too low for renewable energy projects), small scale, limited institutional support (e.g. from financial market authorities) and from incumbent regime actors such as electricity companies the potential for crowdfunding to drive the energy transition is limited.

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This paper presents a first analysis of cleantech crowdfunding, thereby providing insights on the financing of new alternative energy technologies by enabling inferences from large pools of small investors. It provides large sample evidence from 91 countries around the world that cleantech crowdfunding is more common when oil prices are rising, and more common in countries with low levels of individualism and uncertainty avoidance. The evidence is consistent with the view that while alternative energies are viewed as being more risky and investors face greater information asymmetries relative to other types of investment projects, there are mechanisms for entrepreneurs to mitigate these information problems and be at least as successful in cleantech crowdfunding markets.

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In this account, the authors consolidate the literature on policy measures for renewable energy deployment and investment. It investigates the direct effect of policy instruments on investments in renewable energy technologies across a set of OECD countries in a longitudinal panel analysis. Results show that economic and fiscal incentives such as feed-in tariffs, mobilize institutional investors especially for less mature technologies whereas market-based instruments such as greenhouse gas emission trading systems are conducive to investments in mature technologies.

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The authors provide an important perspective on sustainability transitions. They examine how the multi-level processes can be effectively governed taking transnational standard setters and the global coffee industry as an example. Relevant modules for a global governance (e.g. banning environmental harmful pesticides or ensure fair incomes for farmers) emerge in niche-markets and these standard setters ensure compatibility and diffusion across other countries.

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Building on unique investment micro-data (deal level) from Bloomberg New Energy Finance, this paper analyses the effect of a set of public policy instruments on investments in renewable energy in 87 countries from 2000-2011. Price-based instruments such as feed-in tariffs are positively related to private financial contributions. However when public entities co-finance a project no policy instrument mobilizes private finance.

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The study provides an important link between the policies supporting green technologies and early-stage venture capital investments looking at 29 countries over a five year period (2005-2010). The authors show both supply-push policies such as R&D support as well as demand-pull measures such as long-term feed-in tariff programs correspond to the demand for long-term stable policy support systems to mobilize private early-stage investments for green tech. A policy mix including these two elements is thus advisable according to the researchers.

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Effective and efficient policy mixes are an important element of an innovation-led sustainability transition. Interacting instruments and policy strategy are elements of this analytical framework that can be applied to whole innovation systems, sectors or specific technologies. It allows policy maker to assess their impact on technological change in critical sectors such as energy. Consistency in policy instruments and coherence in policy processes are specifically valued by financial market actors.

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This unique paper examines the possible role of banks, banking regulation and monetary policy in a transition towards a sustainable economy. The author argues that in addition to fixing market and system failures surrounding low-carbon innovation, more direct instruments to mobilize private finance such as

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This paper shows that too strong investor protection may harm small firms and entrepreneurial initiatives, which contrasts with the traditional ‘law and finance’ view that stronger investor protection is better. This situation is particularly relevant in equity crowdfunding, which refers to a recent financial innovation originating on the Internet that targets small and innovative firms. The paper shows that optimal regulation depends on the availability of an alternative early-stage financing such as venture capital and angel finance.

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