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CLIMATE POLICY WITH THE CHEQUEBOOK –

ECONOMIC CONSIDERATIONS ON CLIMATE INVESTMENT SUPPORT

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CLIMATE POLICY WITH THE CHEQUEBOOK – ECONOMIC CONSIDERATIONS ON CLIMATE INVESTMENT SUPPORT

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ABSTRACT

Across the globe climate policy is shifting away from a carbon price towards investment subsidies, such as grants, interest-subsidised loans or guarantees. This increases the risk of inefficient public spending. This paper shows how the main market imperfections related to the emission externality, knowledge spillovers and capital market imperfections negatively affect the risk-return-profile of a climate investment. To some extent these negative impacts can be compensated through different forms of investment subsidies. Minimising the risk of inefficient public spending is, however, challenging and requires detailed understanding of technologies and markets at the project level. The analysis provides guidance for the design of appropriate investment subsidy schemes. Carbon prices and investment subsidies are not perfect substitutes, and – at least for developed economies – a carbon price remains the single most efficient instrument. This price should, however, coexist with other instruments, e.g. investment support schemes, which can be tailored to address the non-emission market imperfections related to climate change.

Keywords: climate finance, investment support, policy instruments, environmental externality, innovation spillover, capital market failure.

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1 INTRODUCTION – IS CLIMATE POLICY STILL ON TRACK?

For the past few years, climate related policy intervention has witnessed a stark increase in the use of government subsidised financing. The corresponding instruments are neither directly tied to the emissions abated nor do they make carbon emissions more costly, but rather decrease the financing costs of certain projects and thereby increase the attractiveness of the corresponding investment. Essentially, the government moves away from its role as regulator determining the market rules and tackling externalities at their origin by introducing prices through carbon taxes or permit trading schemes. Governments rather take on the role of an actor on financial markets by providing financing to specific projects or programmes, often through their public finance institutions.

This article illustrates this trend and asks the question to what extent climate policy is still on track with regard to implementing the substantial structural change while avoiding excess efficiency costs and inefficient government spending wherever possible. With increasing ambition of climate goals over time, this criterion will gain importance over the decades to come. This article suggests ways in which investment support instruments could be designed and where risks of inefficiencies are located.

Environmental regulation and in particular climate policy has been through a dynamic history. Traditional command and control instruments dominated early policies. They were often characterised by government-defined technological standards such as “best available technologies” or direct input or output controls. The economic literature following the work of Pigou (1920), Montgomery (1972) and Tietenberg (1995) powerfully demonstrated the superiority of market based instruments – at least in terms of their ability to implement a given level of emissions at least cost.¹ One key issue is the decentralised nature of those market-based instruments that allows for a cost efficient implementation without requiring detailed knowledge at the government level of technologies and individual firms’ abatement cost structures. They also perform better in terms of incentivising the development of new technologies which has led to a rapid increase in the use of these instruments since the 1970s across OECD countries (Hahn & Stavins, 1992; Jaffe & Stavins, 1995; Stavins, 2003; OECD, 1999).

The most prominent economic instruments in climate policy are the CO₂ emissions trading scheme introduced by the European Union (EU) and the state-level emissions trading

¹ See Sumner, Bird, and Dobos (2011) for a review of carbon tax policies.

foreseen in the Kyoto Protocol to the United Nations Framework Convention on Climate Change in 2005 or 2009, respectively. Other policy schemes were introduced in parallel that mainly aim for the promotion of renewable energy.² In very recent years the trend of increased climate related government investment subsidy appeared mainly through grants, interest subsidised loans or (less often) guarantees. Even the use of more complex so-called structured investment vehicles can be observed.³ The EU has recently set regulations on the use of financial instruments of various European funds for, among other goals, reducing pollution.⁴ The International Development Finance Club (IDFC) – consisting of 20 national development banks operating nationally and internationally – reports total green financing by 18 reporting institutions of USD 99 billion in 2013 (International Development Finance Club, 2014). The majority of these funds are delivered to projects in the respective countries of origin. Out of the USD 51 billion from OECD based institutions, USD 33 billion was provided for projects in the home country of the respective institution. In the case of non-OECD institutions, some USD 45 billion out of USD 48 billion was provided to projects in the respective home country of an institution.⁵ Multilateral Development Banks – not included in the figures above – report USD 28 billion of climate finance in 2014 compared to USD 27 billion in 2011 (World Bank, 2015).

Consistent with this development, the international climate policy debate drifted from “emission targets” towards “financing commitments”. A major element of the United Nations (UN) climate process is the promise of the industrialised countries to mobilise climate financing of USD 100 billion per year from 2020 on, to finance mitigation and adaptation in developing countries (UNFCCC, 2012) and the establishment of the UN Green Climate Fund (GCF) by the Conference of the Parties (COP) in Durban (2011).

This trend does not appear to be in line with many lessons learnt in the recent decades of environmental economics and policy: It moves away from the explicit internalisation of externalities, it requires technology-specific information to formulate the investment subsidy programmes and, by subsidising individual projects, it also moves away from the decentralised approach. Considerations from a political economy perspective might explain

² For a detailed analysis of these schemes see, e.g., Menanteau, Finon, and Lamy (2003).

³ An example is the *Global Climate Partnership Fund*, structured similarly to a credit default obligation (CDO) where the riskiest tranche is held by the government and serves as a risk buffer to attract private investment for the less risky tranches.

⁴ EU Regulations No 1303/2013 and No 480/2014 as well as the Commission Implementing Regulation No 821/2014.

⁵ Note that in some countries the economic crises might also have motivated some increase in promotional bank activities.

parts of this trend. For a policy maker it is more attractive to promise money for climate friendly investment than to introduce additional costs for established conventional technologies. To our knowledge, this trend emerged but was largely unobserved in the economic debate. An exception is, e.g., Bowen (2011), who highlights the increasing role of public finance compared to emission prices and the tendency of governments to subsidise the goods rather than tax the bads. The focus of this article is to provide an economic analysis of the emerging dominance of subsidy instruments and to provide guidance on how to use them appropriately.

The following chapter two will introduce and characterise the three major instruments for investment support (grants, interest subsidised loans and guarantees). Chapter three first establishes the impact of market imperfections on the investment attractiveness and then seeks to determine whether these impacts can be compensated through investment support. The chapter then suggests some rules for appropriate programme design. Chapter four concludes.

2 INSTRUMENTS FOR CLIMATE RELATED INVESTMENT SUPPORT

Subsidies to financing renewable energy or energy efficiency occur in a variety of instruments (see Mclean, Tan, Tirpak, Sonntag-O'Brien, and Usher (2008) for an overview).⁶ In this analysis, (i) simple grants, (ii) interest-subsidised loans, and (iii) loan guarantees are considered. While this set of instruments is not exhaustive, it still covers the majority of the subsidised financing volume and represents the main elements more complex instruments, such as structured funds, are composed of. Table 1 provides an overview of the major design parameters of a grant programme compared with concessional loans and loan guarantees. These design parameters largely determine the value of an instrument to the recipient (subsidy element) and the cost to the government.

⁶ A comprehensive comparison between the different instruments for government-intervention would be complex, since the different instruments imply different rights and obligations on the side of the investor (in our case sometimes the government). While the right for a debt-provider is merely restricted to receiving information and interest, the right of an equity provider may be different and involve decisions of the respective company. Similarly, the risk taken on by the institution providing the instrument is different according to the instrument. In our analysis, we concentrate on debt.

2.1 Grants

A grant is typically a simple payment that is tied to a specific investment. As a support instrument used by a government or a public finance institution, the grant-provision as such and its volume can be flexibly coupled to any politically justified parameters. In the field of clean energy, these parameters may be a list of technologies or activities that are eligible for support. It may also be a more abstract description of activities (e.g. by their goal or purpose) in order to keep the instrument flexible. In general, one may also link the grant provision to parameters such as “emissions saved”. This is, however, rarely the case, since it is often difficult to determine the emissions saved through an investment. If at all, expected savings for standardised technologies, which may be estimated up-front, are used.

The parameters may not be limited to climate-policy-related political goals, but include other policy goals. Typical examples of requirements are a certain maximum-income of the supported household in order to focus the support on low-income households, or so-called local-content rules that require part of the investment to be spent on technologies produced in the country that is funding the support scheme to support the regional economy.

In any case, the support scheme needs rules to determine whether support is granted and the volume of the support as well as the timeframe. The latter has strong implications as, e.g., a credible long-term commitment of a government provides different dynamic incentives than one limited to a year or a programme that is provided until a certain budget is spent.

2.2 Concessional Loans

Concessional loans use public money to extend loans for politically desired projects at more favourable conditions (maturity, interest, seniority) as compared to commercial loans available on the market. If a concessional loan programme is used as a support policy, the conditions for the loan provision can – similar to the case of grants – be coupled to any parameters.

A number of reasons make the efficiency analysis for concessional loans fundamentally more complicated than the case for grants. One reason is that a concessional loan is characterised by more variables than a grant. While a grant is largely determined by volume and time of payment, a concessional loan needs to be further specified with respect to maturity, interest rate, including potential interest-free years at the beginning plus the

seniority relative to other loans. A so-called senior loan will have to be paid back with priority while a “junior”-ranked loan might leave the priority to other loans, perhaps commercial lenders, who would find themselves in a more secure situation.

A second complexity relative to grants stems from the fact that the costs of a concessional loan to the public entity is not completely determined by the characteristics of the offered loan, but also by the risk profile of the recipient: At market prices a “high-risk-customer” will normally be charged a higher interest rate than a “low-risk-customer”. Therefore, a concessional loan programme with a standardised interest rate will effectively mean a higher support for the high-risk-customer than for the low-risk candidate.⁷ This support-bias may give rise to standard adverse selection problems. Further, it is obvious that the absolute value of support increases with the volume to be financed.

2.3 Guarantees

Public guarantees to loans are typically used in order to lower the financing costs for a specific project. If a lender (e.g. a bank) receives a guarantee for some risks or part of a loan by a credible public institution, he is confronted with less risk and as consequence may ask for a lower risk-premium on the interest rate, provide a higher loan amount or provide a loan at all.

A potential investment support programme structured as guarantees needs to specify the type of loans (often loan purpose) which are eligible for a guarantee. So implicitly, most characteristics of the loan are part of the support scheme (maturity, seniority, volume, etc.). The added complexity of guarantees versus concessional loans comes from defining the trigger of the guarantee, what it actually covers and its pricing. While the pricing is often very similar to loan pricing (as a percentage of the covered loan volume), guarantees usually do not cover the full loan, but only a certain fraction – say 70% – of the full amount. The major complexity – also when it comes to implementation – is the specification of risks to be taken by the public guarantor. In an event of default, it might be difficult to determine the drivers for this default ex-post. Depending on the risks covered by the guarantee, the value (or the subsidy embedded in the guarantee) may be higher for high-risk borrowers/projects.

⁷ This may be different if the interest rate is formulated relative to some interest rate that the borrower would have been offered on the market.

Table 1: Variables characterising the three major instruments for investment support which need to be determined when deciding about a corresponding support programme.

<i>Grant</i>	<i>Concessional Loan</i>	<i>Guarantee</i>
<ul style="list-style-type: none"> • volume • timing 	<ul style="list-style-type: none"> • volume • timing • interest (& risk free years) • seniority 	<ul style="list-style-type: none"> • (implicit: loan characteristics.) • loan fraction covered • risks covered • trigger event • pricing

3 ECONOMIC ANALYSIS OF THE FINANCING INSTRUMENTS

Two reasons that are frequently used to justify the promotion of energy efficiency and renewable energy are (i) the externality caused by greenhouse gas emissions through climate change and (ii) the innovation spillover externality (Acemoglu, Aghion, Bursztyn, & Hemous, 2012; Fischer, 2008; Popp, 2010).⁸ Other reasons frequently used to justify policy intervention are a contribution to “energy security” since renewable energy sources are typically not imported, or reasons related to strategic industrial policy, aimed at establishing competitive advantages for the local firms expecting to be future exporters of the respective technologies.

One class of market imperfections is typically not part of the analysis in the context of instruments for environmental policy: potential imperfections on the capital markets.⁹ This article argues, however, that these market imperfections need to be included into the practical analysis for at least two reasons: Firstly, policy strongly shifts towards acting through the capital markets, as demonstrated above. Secondly, because renewable energy investments need the services provided by capital markets more than “traditional” energy investments. The reason being that up-front investment is typically higher, while the variable costs later on are lower (e.g., free provision of wind and sun). Therefore, the analysis of the economic efficiency of clean investment support through the capital market is performed along three dimensions (i) environmental emission externality, (ii) innovation spillovers and (iii) capital market failures. Following Dinica (2006), the investor perspective is included in the analysis to illustrate the effects of market failures and policy

⁸ Empirical evidence on the importance of innovation spillovers for clean energy is provided by Braun, Schmidt-Ehmcke, and Zloczyski (2010).

⁹ An exception is Bowen (2011).

instruments on the risk-return profile of projects. A key component of the economic analysis is then to examine to what extent the investment support instrument can compensate or counteract the negative effects of the market imperfections.

3.1 Market imperfections and their drivers at the project level

This section briefly describes the three main market imperfections (environmental externalities, innovation spillovers and capital market imperfections). Their drivers and impacts at the project level are illustrated using two prototypical cases: an investment in power generation based on renewable energy and an investment in energy efficient technology or infrastructure.

Environmental Externalities

Emission externalities are characterised by a (negative) impact of one agent's emissions on the well-being of others. If this externality is not "internalised", e.g., through a price on emissions via taxes or a tradable permit scheme, then this will lead to renewable energy or energy efficiency projects being less commercially attractive as compared to otherwise similar projects based on conventional thermal power generation. For the potential investor this would mean a lower return which will make it hard for those projects to compete for financing.

For an investment in a *renewables based power generation* project the investment volume is largely determined by the technology used and the power plant capacity. The emissions that will be saved through this project can be estimated based on the plant capacity, the expected lifetime of the project and some baseline, reflecting the emissions of power production in a reference scenario. While the estimation of the "emissions saved" appears a rather easy case, the last step in quantifying the externality requires an emission (shadow) price assumption to value the avoided emissions.

A corresponding estimation for an *energy efficiency project* (e.g. a new technology) might be less straight forward. With some assumptions, it might be possible to estimate the expected emissions saved, but the business-as-usual reference is less obvious if the new technology was also bought for other reasons than just increased energy efficiency. Again, a social costs estimate for each ton of emissions is needed to quantify the total externality (avoided).

Innovation Spillovers

Innovation spillovers refer to the positive effect of inventions or innovations on other market actors. As these positive effects are not reflected in the individual incentive of the innovator to invest in the innovation, the situation results in suboptimal levels of innovation. Technological change can be roughly divided into three stages: (i) invention: the creation of ideas, (ii) innovation: creation of new products or processes based on the ideas, and (iii) deployment and diffusion: the actual penetration of the relevant market by the new technology. This paper focuses on the second and third stages and will be referred to as innovation throughout this analysis.¹⁰ Different sources may induce innovation spillovers. It might be learning from others in operating a certain technology, it may also be broader in the sense of gaining experience from realising a certain project. As this learning will lower the risk perception by others, it carries aspects of a public good.

For our example of power production based on renewable energy, this innovation spillover tends to be higher if a new technology is applied and other market actors will observe the lessons learnt and be able to use that knowledge in the future (e.g. the first solar thermal power plant in Asia). Similarly, such lessons learnt may originate from the realisation of more complex renewables based infrastructure projects – not necessarily directly related to technology (e.g. the first offshore wind farms in the North Sea). In general, the case of an energy efficiency investment is similar: Learning induced by the application of a new technology or some other new concept plus the effect that other market actors learn and profit from the experience.

Although we are aware of the drivers, quantifying the spillover effect is complicated.¹¹ Some spillovers might be generated by the simple fact that a certain project happens at all (e.g. a pilot project using a new technology). Others might critically depend on the project or investment size (e.g. a certain financing approach using asset backed security structures).

Capital Market Failures

Less specific to renewable energy or energy efficiency, but relevant for the discussion of the government acting through the capital market, are imperfections on the capital market itself. This refers to cases where – despite hypothetical absence of other market failures –

¹⁰ For an overview of the technology innovation path of climate friendly technologies see e.g. Mclean et al. (2008).

¹¹ See Kaiser (2002) and Nelson (2009) for an overview of alternative approaches of approximating knowledge spillovers.

the market does not allocate the capital such that it is used most productively from a social point of view.¹² In this context, we consider two types of capital market failures that systematically occur more frequently when financing decisions on clean energy projects are made.¹³ These are (i) the lack of a (liquid) market for long-term debt and (ii) imperfect credit markets.

A missing (liquid) market for some risks and also for *long-term debt* is especially relevant to investments in renewable energy projects, since they are typically characterised by higher upfront investment costs, but then lower operating costs in the long run, since the fuel (wind, sun, etc.) is not costly as conventional alternatives such as gas, coal or oil. These projects therefore need one of the financial markets' functions – to transfer money over time – more urgently than conventional alternatives.

The *imperfect credit markets* are caused by information asymmetries. This article focusses on two major adverse selection problems that are particularly relevant for climate related projects and both have similar effects on the risk-return profile of projects. The first imperfection refers to the relationship of the lender (bank) and the potential borrower. The conditions of a loan a potential borrower will be offered by the bank are based on the established relationship or private information the bank possesses. If the client approaches a bank for the first time, the bank has no experience with the potential borrower and they are likely to be considered as a higher risk and would potentially be offered a loan at less favourable conditions in order to compensate for that perceived risk. This effect of *relationship banking* is shown in Boot, 2000, and Bräuning and Fecht, 2012.

A similar effect is generated by the so-called *monitoring externality*. This refers to cases where investors interpret a positive financing decision by others as a signal that they have thoroughly analysed the project and have concluded that the investment is attractive. Other investors use this information as part of their financing decision. Consequently, it will be easier for the project to raise additional financing. Furthermore, similar projects (e.g. using the same technology) will receive credits easier or at better terms. These effects remain even if other market failures, such as environmental externalities, are corrected. Again, while the major drivers can be identified, a quantification of these imperfections is challenging.

¹² For an overview of such imperfections on the capital markets see Stiglitz (1993).

¹³ This is especially true for developing and emerging countries. Brunnschweiler (2010) shows that financial sector development is crucial for the deployment of renewable energy.

Potential consequences for financing in two of the cases described above are: if the renewable energy based power generation project or the energy efficiency investment are using new and not yet fully established technologies, they might be subject to credit market imperfections, namely the monitoring externality. Consequently, their costs of capital will be driven up since the technologies are factually more risky as they are new. On top of this, the financing costs might be higher, because (i) the potential lender (e.g. project developer) does not have established long-term relationships with banks compared to clients typically investing in conventional projects and/or (ii) borrowers try to invest in a first-of-its-type technology and lenders do not want to take on the monitoring that has a positive externality on other banks, without compensation. Finally, if the technologies require long-term financing, they might also be subject to the lack of the liquid long-term market. For renewable energy technologies this is the case, e.g., for solar thermal power generation, while for energy efficiency this effect naturally increases with the pay-back-time of the efficiency investment.

3.2 Fighting market failures with finance?

Table 2 summarises the effects of the (economic) market imperfections as they appear at the project level and from the perspective of a potential investor: through a negative impact on the risk return profile. In other words, (uncorrected) market imperfections decrease the attractiveness of a clean energy investment relative to other investments. This risk-return profile is, however, where instruments of public investment support have a direct impact. Those instruments may provide financing below market interest rates or take risk, which can rather directly make an investment more attractive.

They are, however, not necessarily tied to the market failure as close as typical economic instruments for climate policy, e.g., as an emission tax is based on emissions. Therefore, the framework for the economic analysis of these support instruments looks as follows. First, the inefficiencies introduced through the market failures are considered. It is subsequently analysed to what extent the market failures can be corrected by compensating the resulting effect on risk or return through direct public provision of investment support instruments such as grants, subsidised loans or guarantees.

The market failures are analysed separately, looking at how the main public finance instruments may perform. First, general considerations are provided followed by illustrations along the two prototypical projects of renewables based power generation and an energy efficiency investment.

It will become important to consider how much value is transferred through such an investment support, i.e., the subsidy element of such an instrument. The value of the subsidy element contained in the different instruments is driven by the key variables as shown in table 1 above. For the grant it is simply and mainly the volume. For the concessional loan the subsidy element is higher the lower the interest rate, the higher the volume and the lower the seniority of the loan. A guarantee is more valuable if the guaranteed volume is higher and if the risk of the loan that is guaranteed is (perceived to be) higher.

Environmental Externality

In order to achieve the internalisation of the emission externality through investment support, the value of the respective financial instrument has to match the value of the avoided externality. Thereby, the incentive to realise the project would be increased, exactly compensating its disadvantage relative to other projects emitting CO₂ (see table 2 above). Note that this would rather achieve a level playing field in the sense of adjusting the relative attractiveness. From an overall economic perspective subsidising carbon free technology is not, in general, equivalent to introducing a price on carbon, as the subsidy to low carbon will also improve the attractiveness relative to all other (not climate related) investments, as will be illustrated for energy efficiency investments below.

To determine this value basically requires the emissions and a hypothetical price per unit of emissions. Assumptions about CO₂ prices are needed anyway and can be based on other areas where CO₂ prices exist.¹⁴ The estimation of the emissions avoided through the project will typically need more information about the project type, size, lifetime and probably assumptions about some operating decisions later on. This estimation needs to happen at the same time a decision on investment support is made. Then the instrument support needs to transfer the corresponding value to the project. This value could be interpreted as the subsidy element of the instrument.

For example, an investment support to a *renewable energy based power generation* project would be able to estimate the expected emission savings of this project largely based on assumptions about: the technology, the capacity, the expected lifetime and some reference generation technology. As it can be assumed that the technology will be running as much as technology and resource provision (e.g. wind and sun) permit, this estimation does not

¹⁴ Note that in general one might argue that the socially optimal CO₂ price should be based on some global cost benefit considerations. We abstract from the issue of a globally optimal emission level but rather look at the question of cost-efficient abatement.

seem fundamentally inaccurate.¹⁵ Note that for a given technology the emission savings are proportional to the capacity and therefore more or less to the investment volume. This implies that a grant could be determined based on technology and capacity and a concessional loan might carry a subsidised interest rate determined by the technology as the subsidy element then “automatically” scales with the capacity or the investment size. To design a guarantee that contains this subsidy element would require the knowledge of the interest rate difference that could be induced by the provision of a guarantee (assuming the public guarantee is provided without charging a fee) and then the value would behave similarly to the case of a concessional loan. This, however, seems rather indirect as the market imperfection does not increase risk and value transfer through a concessional loan (or a grant) appears to be more straight forward.

Investment in increased energy efficiency is affected by an un-internalised emission externality through the price for energy (as it does not reflect the carbon externality). Consequently, the emission savings from such an investment typically require more assumptions than a renewable energy investment. While the price for carbon needs to be assumed for the project lifetime, the estimation of the emissions savings relative to a business-as-usual scenario might be more challenging as even in a reference case it would be fair to assume that a new technology might be more energy efficient. So the savings have to be based on this consideration and also need estimations on the lifetime and usage of the technology. Depending on the project specifics this might be more challenging than in the case of a renewable energy investment. When formulating a support programme, it will therefore be easier to approach the correct internalisation of the market imperfection if it could define technologies or cases where the emissions saved can be well defined. Support programmes open to many technologies might try to refer to the energy saved relative to certain standard technologies. Again, grants and concessional loans might then be capable of generating the appropriate value transfer.

Note that subsidies to an energy efficiency investment illustrate the non-equivalence of putting a price on carbon on the one hand and subsidising carbon free technology on the other: Inefficiencies particularly result if the (subsidised) investment also raises the emission baseline. An example would be the provision of low-interest loans for cars with relatively low emissions. On top of making relatively efficient cars more attractive, the

¹⁵ It could rather be argued that for longer project lifetimes the CO₂ price assumption seems problematic. While for a volatile price this seems less of an issue, in cases of increased climate policy ambition over time (i.e. rising CO₂ prices) this might be taken into account.

low-interest loan may have two additional effects: (i) it subsidises the use of cars in general (leading to additional emissions, especially if clean/cleaner means of transportation are substituted) and (ii) the subsidy element increases with the price of the vehicle, which typically means a higher subsidy to bigger (more expensive) cars often emitting more carbon than lighter ones.

Innovation Spillovers

Internalising knowledge or innovation spillovers is conceptually more challenging as it generally requires the quantification of the spillover. On the other hand, it appears easier to relate the expected innovation to the project in question. Frequently there are justified expectations, whether *the amount of* learning and gathering experiences will be driven by the fact that a certain type of project takes place at all or whether the size of the individual project (e.g. power plant capacity) becomes important. Frequently, the fact that experience (of whichever type) is generated and lessons are learned does in the first place depend on the fact that this is done, and only in the second place on how precisely this is done.¹⁶

For a *renewable energy* as well as for an *energy efficiency investment* project un-internalised knowledge spillovers show up as increased risk typically not being rewarded at market rates. A project could therefore be made attractive through grants, concessional loans as well as through public guarantees. Commercial debt providers are often reluctant to provide loans to projects where the risk is not simply higher but hardly quantifiable. Concessional finance will often not help to address their concerns (unless it comes with taking a substantial part of the risk). It is then important to formulate expectations beforehand, what exactly will lead to higher learning. Note that this does not mean to know beforehand, what will be learned, but simply which activities will generate learning or valuable experience. This will help to determine whether grants or guarantee instruments will support this activity/spillover. The incentives are also different: while a grant tends to linearly decrease the amount that needs to be financed by debt, it by and large leaves the incentives in place to balance the risk taking but may not fundamentally change the fact that the risk (probabilities) are unknown. This appears favourable in many cases, as long as the risk-carrying capacity of a project or company is not smaller than the project in question. If risks increase, e.g. in the case of a smaller developer in geothermal energy in the expensive and uncertain exploration phase, then simple risk-taking by the public finance institution may be an option. In such a case, the standard problem of moral risk

¹⁶ Note that we consider learning and making experiences as such as a value, independent of whether they are connected with a success or failure of a certain project or idea.

emerges and needs to be taken care of. Likewise, if the learning is expected in the project appraisal and risk estimation process, then this might be an argument in favour of a grant.

Note, however, that this does not solve the issue of determining the appropriate level of support (which exists for clean energy technologies as well as for all other innovations) as it is not possible to reliably quantify the size of innovation spillovers.

Capital Market Failure

Providing public finance instruments means that the government acts as player on the capital market. In contrast to compensating emission externalities or spillovers, this public intervention is aimed at the market where the failure actually occurs, the capital market. Previous analyses show that public intervention on financial markets can effectively correct for market imperfections (Anginer, de la Torre, & Ize, 2014; Arping, Lóránth, & Morrison, 2010; Gale, 1990; Honohan, 2010; Janda, 2011; Minelli & Modica, 2009). The lack of a market for long-term capital can be directly addressed by providing long-term debt. Similarly, lacking markets for some risks may be addressed through the provision of specified guarantees. Grants may be of limited scope here as they do not change the general unwillingness to provide long-term capital.

The imperfect credit markets emerge from asymmetric information. Providing information symmetry through government intervention would help but is not always realistic. Interventions may support smaller (new) actors in combination with new technologies or new financing models in order to compensate for the credit market imperfections. If the projects materialise, then actors and technologies will be known and the credit market imperfections will decrease. The involvement of a government actor may help to address the monitoring externality as it signals political and financial support by the government. This signal is stronger if the government participates in potential gains and losses and if the government has a good reputation with respect to the project quality they support. While for the first capital market failure (lack of long-term capital and risk) grants do not seem to be the most direct approach to tackle the issues, for the latter (credit market imperfections) the instrument should be chosen with a view to what is decreasing the information asymmetry most effectively. In the latter case, the issue of moral hazard may arise in the standard way.

Note again that the issue of quantification is not solved. The appropriate value of the subsidy is challenging to determine. Therefore, the correction of capital market failures should stay as close to the imperfection as possible.

For the prototypical project examples of a renewable energy and an energy efficiency investment, this implies, the longer-term the capital-needs are and the newer the technology, the more they are subject to capital market failures. For renewable energy, long-term capital needs evolve from high capital intensity together with low variable costs (e.g. sun, wind). For energy efficiency long pay-back times are a sign for long-term capital needs. For a given project the reasons for the capital market imperfection need to be determined based on the aspects such as: (i) new technology / new actors; (ii) long-term financing needs; (iii) specific risks without markets; (iv) general “experience of the market”. In cases of long term capital or much defined risks the lacking instrument may simply be provided, in other – more challenging – cases less so.

Table 2: Effect of the different market imperfections on the investor's perspective. Examples for two standard cases of a renewables and an energy efficiency investment.

<i>Market Imperfection</i>	<i>Economic Mechanism</i>	<i>Mapping to Investor's Perspective</i>	<i>Case: Renewables based Power</i>	<i>Case: Energy Efficiency</i>
<i>Emission Externality</i>	A missing emission price leads to socially inefficient high return for conventional investments	Relative return below social optimum (as compared to conventional alternative)	Without a price on CO ₂ emissions (tax or tradable permits), conventional fuels will have a comparative advantage.	Without a price on CO ₂ emissions, energy savings do often not lead to cost savings which reflect the contribution to emission reduction.
<i>Innovation Spillover</i>	Higher risk of innovative projects provides social benefit through spillovers that is not reflected in the return.	Increased risk not adequately rewarded	New technology may be risky but the project will lead to learning which will reduce the risk for all future investors (not just the current investor).	New technology may be risky but the project will lead to learning which will reduce the risk for all future investors (not just the current investor).
<i>Capital Market Failure</i>	Financing for clean energy is inefficiently expensive or not available at all	Return below social optimum	With high investment but no fuel costs, the project needs long-term debt (problem: illiquid long-term-debt market). If new technologies are involved, loan providers are more familiar with conventional technologies and first-investor-signals are needed (problem: credit market imperfections).	Energy saving projects with long pay-back time need long-term debt (problem: illiquid long-term-debt market). If new technologies are involved, loan providers are more familiar with traditional technologies and first-investor-signals are needed (problem: credit market imperfections).

3.3 Designing practical support policies

Treating the different market imperfections as well as policy instruments separately appears rather academic. Real renewable energy and energy efficiency projects (as well as many others) are subject to more than one market imperfection and frequently a number of policy instruments and incentives coexist. Designing appropriate support policy schemes in such a context is challenging (Fischer & Preonas, 2010; Sijm, 2005, Sorrell & Sijm, 2003). Nevertheless, they will profit from a clear understanding of the individual market imperfections: Note that to implement the first-best optimum, each externality needs to be internalised and this could be achieved with one instrument per externality. If we assume, however, that this design of multiple internalisation policies is not possible, then an approach could be the following: In general, and if all the externalities could be quantified, one would be able to aggregate them with respect to their effect on risk and return. These aggregate effects could then be compensated through support policies.

The prototypical cases attempt to provide some guidance as to how individual support instruments act, such that they can be combined in a programme design that is likely to address more than just one market imperfection. Investment support intervention as of today is often justified by referring to “what is needed in order to make the project commercially viable”. This argument uses the assumption that an in depth analysis beforehand has produced the result that the project should happen. The considerations in this article, however, provide criteria along which a policy designer might think when trying to answer exactly this question.

One general issue appears when looking at all the imperfections: unlike the emission externality, the innovation spillover and the credit market imperfections are of a transitory nature and can be eliminated in the longer run through learning (which inter alia means “doing projects”). The emission externality will remain a market imperfection. In fact, as politically induced carbon scarcity is expected to rise in line with the two-degree goal of the international community, the shadow price of a ton of carbon is likely to increase.

Against this background and looking at the enormous challenges lying ahead, it appears worthy to consider different policies for the emission externality on the one hand and the capital market failures and innovation externalities on the other. A carbon price of whatever form reduces the risk of inefficient government spending on investment support related to the carbon externality and can at the same time provide orientation for areas where a price on carbon does not seem possible. Public instruments for investment support may still be used

and can be tailored more flexibly to the capital market and innovation related issues, based on our considerations above.

4 CONCLUSIONS

This article demonstrates and discusses a trend towards a strong role of public finance mechanisms related to climate policy. Given the global consensus of limiting global warming to two degrees a substantial structural change in the energy infrastructure is required. Hence, the article raises the issue of whether the trend towards public finance instruments is compatible with facilitating the structural change at least cost to society, or whether they run the risk of being overly expensive or extensively using scarce public funds, and hence impeding the transition towards a low carbon economy. Therefore, the article analyses to what extent these instruments can efficiently correct market failures as caused by the CO₂-externality or innovation spillovers and which of the instruments are suited to correct the respective capital market failures.

To perform this analysis, the relevant market imperfections are mapped onto the investor-relevant criteria of risk and return. As public finance instruments for investment support are able to directly influence risk and capital cost (i.e. return), they can be flexibly designed to compensate where climate related investments appear less attractive from the investors' perspective than they should – based on societal/economic considerations.

The analysis may be used in the design of public investment support programmes as the article also shows to what extent it is possible to determine the appropriate amount of compensation at the time when investment decisions are made and which of the public finance instruments may be better suited to do so, at the programme and project level.

The article argues that it is conceptually easier to determine, quantify and compensate the emission externality as compared to knowledge spillovers or capital market imperfections. If classical regulation for correcting the imperfections is not possible, then public finance instruments can attempt to compensate this, but they need to be applied with great care and based on profound knowledge of the region-, market- and technology specifics.

Finally, the analysis shows that, in a real world economic context, the internalisation of a (negative) emission-externality is not equivalent to compensating for emission abatement through clean-investment-subsidies as the latter introduces distortions relative to other sectors. On top of this, the emission externality, which is based on emissions and their

politically induced scarcity (i.e. the value of avoided emissions), is likely to increase over time. Capital market and innovation related imperfections are often related to asymmetric information and learning which (at least when looking at a given technology) are more of a transitory phenomenon, with the imperfection decreasing over time. Given the substantial structural change, requiring increasing carbon scarcity, this strongly speaks in favour of introducing carbon-price-based regulation to cope with the corresponding externality and focus on understanding the mechanisms of the other market imperfections when designing investment support policies in order to avoid spending limited government money on sub-optimal policies.

If climate policy wants to stay on track, carbon price signals are inevitable and efforts are needed to understand and deal with the other market imperfections that are strongly related to climate change.

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