

# *The Impact of Sustainable Innovation Finance on Global Climate Goals*

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## **Overview**

Despite its vital role, not much research exists regarding the way in which the financing of sustainable innovation impacts the achievement of global climate policy and sustainable development goals, which inefficiencies regarding sustainable innovation arise from financing constraints, and which measures can be taken to address these inefficiencies. Our paper investigates the impact of financial frictions on sustainable economic growth based on green innovation in the global economy. We present a model of endogenous directed technical change including a public and private financial sector, allowing for an endogenous financing decision in terms of the deployment of different internal and external financing options deployed for the financing of technical change. Capturing the dynamics between the ‘global North’, i.e., the developed economies, and the ‘global South’, i.e., the developing economies, we allow for technological development to occur through innovation or imitation, hence, capturing technology diffusion processes in the global economy. Our findings substantiate the way in which the presence of financing costs and frictions in the financial markets—which are elevated with regards to sustainable innovation and in the developing world—cause the global economy to converge towards a non-sustainable growth path in the absence of policy intervention. This development can be addressed partially, but not fully, by sustainable public investment. However, to steer the economy to a fully sustainable growth path, an additional regulation or incentivization of private investors is necessary. Alternatively, a sufficiently high carbon price can be set, however, other than in the current reality, this carbon price would have to cover a large share of global emissions.

## **Methods**

We present a continuous-time model of endogenous growth based on directed technical change in a RES-based and a fossil-based sector, with endogenous decisions for innovation finance in both sectors. The model considers two types of global economies, the leader countries, representing the global North, and the follower countries, representing the global South. In both economies, growth is achieved through the emergence of new varieties of intermediate goods (cf. Romer, 1990), which can be created through either innovation, if the product variety has not existed in either of the economies previously, or through imitation, if the product variety has already existed within the respectively other economy. These dynamics are comparable to the growth model based on endogenous innovation presented by Barro and Sala-i-Martin (1997). Within each economy, a RES-based and a fossil-based type of intermediate goods exist. RES-based intermediate goods represent all intermediate goods, which are produced by means of ‘clean’ energies and technologies, and which we assume to be carbon neutral. Fossil-based intermediate goods represent all intermediate goods, which are produced by means of ‘dirty’, GHG-emitting energies and technologies. This conceptualization is comparable to the model of the environment and directed technical change presented by Acemoglu et al. (2012). Intermediate goods producers in both economies and in both sectors cannot finance costly innovation and imitation activities fully internally but are also dependent on external financing options. Based on insights from theories of the optimal capital structure of investments, intermediate goods producers can decide between different debt and equity financing options, as they seek to maximize their firm value and minimize their innovation and imitation costs including their financing costs. Financing options are provided by two types of financial intermediaries. Private financial intermediaries such as lender banks, credit funds or equity funds including venture capital (VC) funds offer private debt and equity, seeking to maximize their shareholders’ revenues. Public financial intermediaries subsume public institutions such as governments and development banks and offer public debt and public financing options with equity characteristics, such as project participations or availability-based public-private partnerships (PPP). Other than private financial intermediaries, public financial intermediaries do not seek to maximize shareholder revenues, but to maximize stakeholder benefits by efficiently—i.e., at the optimal cost-benefit ratio—supporting non-financial goals such as GHG reductions. Based on this model, we present analyses of the development of the global North, the global South, and the overall economy in the absence of policy intervention, given different types of financing frictions such as tax advantages of debt, information asymmetries and transaction costs. Furthermore, we assess the effect of different forms of policy and regulatory intervention, such as green public investment, regulation of the private financial sector, and the effect of carbon taxes in this setting.

## **Results**

We find that in the absence of financing costs and financing frictions, the economy converges to a partially sustainable state, with the level of sustainability being positively influenceable by adequate policy intervention, such as an adequately high carbon price. However, the presence of financing costs and frictions in the financial markets, which are elevated with regards to RES-related innovation and in the developing world, causes the global economy to converge towards a non-sustainable growth path. This development can be addressed partially, but not fully, by sustainable public investment. However, to steer the economy to a fully sustainable growth path, an additional regulation or incentivization of private investors is necessary. Alternatively, a sufficiently high carbon price can be set, however, other than in the current reality, this carbon price would have to cover a large share of global emissions, both in terms of sectoral coverage and the economies participating in such an approach.

## Conclusions

The paper reveals the high significance of the financial sector in the achievement of a sustainable growth path. Existing studies do not consider any change in the dynamics rooted in the financial economy and neglect the explicit consideration of financial frictions. Accounting for a financial sector in our model of endogenous growth reveals that if financing costs prevail under quasi-perfect capital markets, the transition dynamics towards the balanced growth path are impacted, however, as in the absence of financing costs the share between sustainable and non-sustainable innovation converges to a constant level. Also, assuming that financing costs occur at equal levels in RES-based and fossil innovation, the total growth rate of the economy will be impacted negatively, while the relative growth rates amongst sustainable and non-sustainable growth in the two economies remain unchanged. However, *ceteris paribus*, the prevalence of different forms of financing frictions can cause a convergence of the economy towards a non-sustainable growth path. While tax advantages of debt do change the financing mix between private and public equity and debt, do not considerably impact the growth path, other financing frictions, i.e., information asymmetries and uncertainty, as well as transaction costs, which are elevated related to RES, do. The economy is led to a non-sustainable growth path, as sustainable innovation finance becomes more costly. This effect is aggravated in developing economies, where, generally, institutions including capital markets are weaker and risk and uncertainty are even more elevated. The financing frictions occur up to a point at which financing for RES-related innovation in the developing countries becomes unavailable, constituting a major barrier to sustainable growth. Considering different potential cures to this issue reveals that sustainable public financing alone—i.e., the higher valuation of sustainability by public financial intermediaries—does have a positive impact on the share of sustainable in total innovation, does not suffice, however, to steer the global economy to a sustainable growth path in the long run. This can be explained as public financiers cannot fully commit to sustainable investment but must also account for other monetary goals depending on their purpose. In contrast, a stronger regulation or incentivization of private financial intermediaries can lead to a sustainable growth path, albeit only under strong assumptions. Therefore, we consider a case in which both public financial intermediaries value sustainability more strongly, and private financial intermediaries are incentivized towards increased sustainable investment. This form of double-tracked intervention leads to a steering of the global economy to a sustainable growth path, on which also the share of sustainable in total innovation is constantly increasing. This signifies that, in the long run and eventually, a fully sustainable economic setup can be reached. However, referring to previous work on the timing of such intervention such as in Acemoglu et al. (2012), a thorough investigation of the necessary timing of intervention related to the financial sector will be necessary in future work. This is especially to consider a ‘tipping point’, i.e., a critical level of carbon emissions in the atmosphere, from which onwards a self-enforcing degradation of the environmental quality will be unavoidable. Lastly, a sufficiently high carbon price can also lead to the desired outcomes. However, it must be sufficiently high and cover a sufficient amount of carbon emissions. Also, related action must happen in a timely manner. If this is considered unrealistic given the current landscape of global pricing, a joint deployment of all above-outlined approaches might be advantageous to consider.

## References

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