Carbon risk and green steel investments: Real Options Analysis and MonteCarlo simulations to assess decarbonization policies.

Simon Lang[1], Frédéric Lantz[2]
[1] EDF R&D, IFPEN, EconomiX
`Simon.lang@edf.fr`
[2] IFPEN
`frederic.lantz@ifpen.fr`

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1 Introduction

Steel is one of the most CO2 intensive material produced in Europe. Its production represents 4% of France GHG emissions. Even though this industry has been protected from climate regulation, both the potential implementation of stricter policies and new technological progress are putting this ‘hard-to-abate’ industry under pressure. To meet EU decarbonization targets and quit coal, steel producers can rely on several decarbonization options: energy efficiency measures implementation, heat recovery incremental upgrading of existing assets with biomass or carbon capture, investments in new assets that use natural gas or hydrogen, or a shift towards recycled steel. Many challenges appear from this potential transition as producers would face technology and prices uncertainty. First, current assets have a long lifetime from 30 to over 60 years old, highlighting that an inadequate policy timing could result in either a lock-in with very emissive assets or stranded assets. Second, steelmakers would have to develop first-of-a-kind plants and be exposed to new energy markets, technological deployments risks and political uncertainty on the future of the ETS market. Last, investments needs are diverse and while some solutions need a high upfront cost, other investments can be spread over some decades or mainly rely on an increase in operating costs. This results in a high uncertainty over the potential technological choices and the associated energy consumption.

2 Modelisation framework

To capture those challenges to decarbonize the steel industry, we use a compound real options framework with MonteCarlo simulations [1] to model the future of the French primary production of steel. This was adapted to a on a compound options problem as each investment changes the value of investment toward another solution of the 12 technological solutions [2]. This framework allows to represent the different transitions costs associated with incremental or direct investment in low-carbon assets. Different options offered by an investment are modelled:

- The option to defer an investment – it can be done later to wait for an uncertainty to unveil by expanding the lifetime of an asset through an increase of its maintenance costs
- The option to operative changes – some assets and incremental solutions allows to move from coal to biomass, which could be reverted temporarily is CO_2 prices drop. Other short-term substitution is between hydrogen & natural gas in a direct reduction blast furnace.

- The option to retrofit a plant – CCS, TGR or IGAR solutions expand the lifetime of an asset and its energy performances
- The option to make an investment in several phases – hydrogen solutions can be implemented in 1 to 5 steps

This results in a 12-lattices of technological solutions, from 2020 to 2070 to model choices made up to 2050. This lattice is then reduced by carbon budgeting practices trough the limitation of CAPEX spending on the whole period. Carbon and other commodity prices are modelled as correlated geometric brownian movement, with different scenarios of decorrelation, drift and volatility depending on decarbonization hypothesis of the electricity mix. This is linked with potential technological risk scenarios of implementation failures though a Poisson point process to form the basis of the scenarios on which the Monte-Carlo simulations are done. For each scenario, and every point of the lattice an optimal investment sequence is calculated by a maximisation the net present value. This both include the certain cash-flow for the next year, and the expected value of all potential assets depending on the anticipation of the stochastic commodities.

From the optimal decision build for every scenario, at any point of the lattice, a more interpretable representation is constructed as the average optimal investment sequence.

This framework also allows to assess the impact of CfD - Carbon for Difference- schemes, where the governments would derisk investments by guaranteeing a carbon or commodity price over the investment's life. Thus, different policies efficiency to reduce overall CO2 emissions and achieve the 2050 goals can be assessed.

Results & Conclusion

We show that carbon price volatility with a fixed 2050 target, has a strong impact on investment decision and might greatly increase the cumulative emissions by delaying investments in net-zero compatible assets. Common NPV frameworks with deterministic prices consider that a 200€/tCO_2 target in 2050 should be enough to motivate an investment in a hydrogen steel plant, but that this breakeven point could be achieved too late, and many blast furnaces would already have been refurbished at this point. Those analysis tend to anticipate a great demand in coal in 2050. Our analysis shows that considering compound investments override this issue. Nevertheless, adding volatility on the CO_2 price can result in coal lock-in through energy efficiency investments instead of investing in technological breakthrough. This can be partially overcome thanks to carbon capture and storage of biomass use but would result in 2 to 3 times more emitting steel plant in 2050, and 3 to 6 times more CO2 emissions from 2020 to 2050.

Finally, the right combination of public support in the form of CfD and CAPEX subsidies is shown to vary a lot depending on the capital limitation and CO_2 volatility. Under a 5% volality, CfD have no noticeable effect, while they should represent between 60 to 70% of the public support scheme is volatility is over 10%. In all cases CfD have the particularity of being very cost effective while CAPEX subsidies in some high volatility environments are associated with an high social cost of carbon.

References

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