PRICES VS. PERCENTAGES: USE OF TRADABLE GREEN CERTIFICATES AS AN INSTRUMENT OF GREENHOUSE GAS MITIGATION

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Overview

The paper analyzes the problem of achieving a target path of emission reductions in the electricity sector, using a scheme of tradable green certificates (TGC). There are two types of electricity generation, renewable (green) and fossil (black). The latter causes the emissions. In accordance with established policies such as the EU target for emission reductions, we focus on a quantity target where the regulator wants to reduce the levels of CO2-emissions through a specific path. The paper also examines effects of emission regulation on construction of new green generation capacity. Two versions of the percentage requirement are devised for the TGC scheme. First,we derive the common version where the percentage requirement is defined as an optimal target share of generation of green electricity out of total demand for electricity. Then, we devise a version designed to achieve the target path explicitly. The results are compared with an emission fee and a subsidy and we calculate the resulting social surplus for all the instruments.

Earlier contributions to the literature on TGC schemes have applied a static model in the analyses. We are interested in seeing how well suited a TGC scheme is in achieving a specific target path of emission reductions. Such a dynamic target also corresponds to the target of GHG emission reductions set by the EU. In addition, once introduced, a TGC scheme will be in effect for a number of years, making a dynamic analysis even more relevant. An examination of the performance of a TGC scheme in a dynamic setting is also interesting since many countries and regions around the world employ a version of such a scheme

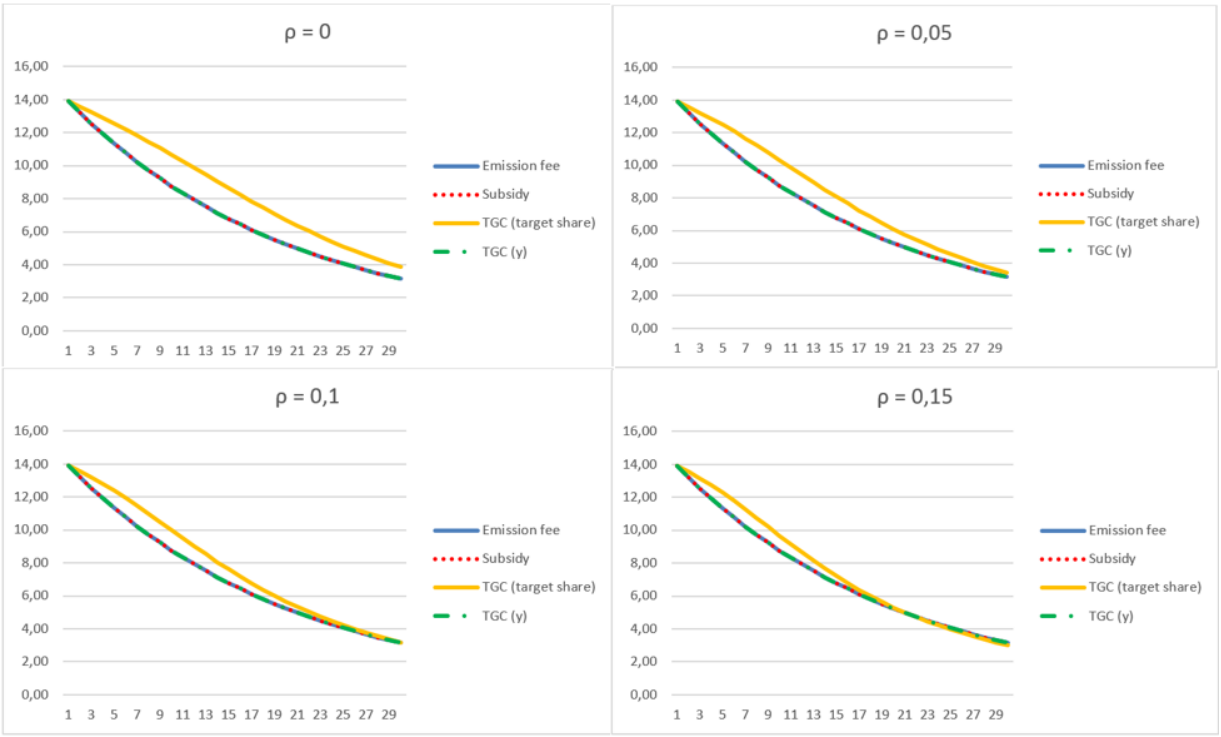
Methods

The paper applies a partial equilibrium model, focusing on the electricity market where there are two kinds of generation technologies. Perfect comptetition and no distribution costs are assumed. We analyze the behavior of the electricity generators under regulation and optimize over time using optimal control theory. Investments in new green generation capacity acts as the instrument variable while the green generation capacity is the state variable. Generation of green electricity is assumed to take place at full capacity utilization. The model incorporates physical depreciation of existing green generation capacity Technological progress in green generation capacity is also included to capture the cost reductions seen in several green technologies in recent years

Results

Previous contributions to the TGC literature have shown that polluting fossil energy generation will decrease as the percentage requirement increases. Results from our analytical model confirm this, when there is no technological progress in green generation capacity. With cheaper green technology however, results are indeterminate. The numerical results do however confirm that a TGC scheme will achieve emission reductions regardless of technological progress, but if the percentage requirement is derived from optimal target shares, the target path is not met. From Figure 1, it is clear that this version (TGC (target share)) is unable to achieve the targeted path of emission reductions. This result holds, regardless of the rate of technological progress in green generation capacity (ρ). On the other hand, the emission fee, subsidy and the alternate TGC version all achieve the target path of emission reductions. It should be noted however that the alternate calculation of the percentage requirement could prove challenging in practice.

Figure 1: Black electricity generation (emissions)



A TGC scheme is intended to promote construction of new green generation capacity, but it is designed to achieve a certain share of green electricity out of total demand. In theory, this could be achieved by a reduction of black electricity generation alone. In our analytical model, results are indeterminate with regards to investments in new green generation capacity. The numerical model do however show that a TGC scheme will result in an increase of green generation capacity. Nevertheless, both versions provide sub-optimal incentives for investments. Unless green generation capacity becomes substantially cheaper over time, a TGC scheme will result in overinvestment. The emission fee delivers the optimal outcome whereas the subsidy results in the most excessive investments.

With a TGC scheme, the price of electricity is lower compared to the social optimum. This holds as long as green generation capacity does not experience massive cost reductions over time. The price of electricity with a TGC scheme will be lower when the percentage requirement is derived from optimal target shares. The main driver here is the higher generation of black electricity, showed in Figure 1. The price of electricity is optimal with the emission fee and the subsidy creates the lowest price. Cost curves derived with the numerical model show that an emission fee is most cost-efficient, followed by both TGC schemes and the subsidy. The resulting social surplus show the same ranking. It is not clear-cut which TGC version that achieves highest level of social surplus, but they both outperform the subsidy.

Conclusions

If a regulator has an ambition of achieving a certain target path of emission reductions, it could be achieved with a TGC scheme. However, it would require a specific calibration of the percentage requirement and it would be a less cost-efficient and accurate instrument than an optimal emission fee. In practice though, an emission fee might not be politically feasible. This was apparent when the EU failed to implement a carbon tax and ended up with the EU ETS. A subsidy could then be an option and our results show that this instrument could achieve a targeted path of emission reductions. However, it is a expensive solution and high costs could make subsides unpopular.

A TGC scheme on the other hand is self-contained and a properly derived percentage requirement can attain a specific target path of emission reductions. A TGC scheme is also likely to have its proponents, to whom less direct involvement from a regulator is appealing. However, the common version of a TGC scheme where the percentage requirement is based on optimal target shares, can only be relied upon to deliver a specific share of green electricity out of total demand for electricity. There are also costs to consumers over the electricity bill. Still, even with its challenges, a TGC scheme could prove to be a viable alternative when regulators make decisions on environmental policy and first-best options are unavailable.