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Will the Centralisation of Carbon Pricing Revenue in the EU Lead to Laxer Climate Policy?

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Will the Centralisation of Carbon Pricing Revenue in the EU Lead to Laxer Climate Policy?

Abstract

We analyse the economic impact of using carbon pricing revenue to fund the EU budget. Such a reform would redistribute from countries with above average carbon intensive production to less carbon intensive countries. Once the reform is implemented, the low carbon countries will prefer a lower carbon price, i.e. laxer climate policy at the EU level, than before the reform. For high carbon countries the opposite is true. As a result, EU climate policy becomes less ambitious and less disputed. We also analyse an extension of the model in which consumption generates carbon emissions that are not covered by the emission certificate regulation, and we consider the impact of changes in EU climate policy on the rest of the world as well as global emissions.

JEL-Codes: H230, H270, H870, Q580.

Keywords: climate change, global externalities, EU finances, political economy.

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1. Introduction

There is an ongoing debate on reforming the financing of the European Union. This debate has been intensified by the introduction of the new fund Next Generation EU, with the objective to support the economic recovery after the Corona crisis. One reform proposal is to allocate the revenue from issuing carbon emission certificates to the EU. This revenue is currently collected and kept by the member states. The arguments put forward for centralising the revenue include the fact that the EU emissions trading system (ETS) is an EU level policy and that national carbon emissions give rise to externalities across borders (Fuest and Pisany-Ferry, 2020). How much revenue would be collected? The value of these emission certificates in the EU is projected to be around 30 billion EUR per year over the period 2021-2050, where a maximum scenario expects even 50 billion per year (Fuest and Pisany-Ferry, 2020). If this revenue source is used, room would be created to reduce GNI contributions so as to balance the budget. Given the size of the 2021 EU budget of almost 170 billion EUR, such a restructuring of EU finances can be considered as substantial.

Apart from the impact on the revenue structure of the EU budget, this reform would have considerable redistributive effects across countries, and it would change incentives for member states regarding the climate policy they support at the EU level. This paper uses a highly stylised model of climate policy in an economic union to investigate how cross country redistribution and climate policy incentives for member states change as a result of the reform. Our key results are as follows. Giving the revenue from carbon emissions certificates to the EU and reducing GNI contributions accordingly would redistribute from countries with above average carbon intensive production to less carbon intensive countries. This suggests the reform will go ahead if low carbon countries dominate decision making in the EU. Once the reform is implemented, the low carbon countries will prefer a lower carbon price, i.e. laxer climate policy at the EU level, than before the reform. This is because they now benefit more from higher emissions, through the contributions to the EU budget generated by these emissions. For high carbon countries the opposite is true – they will prefer tighter climate policies than before the reform. This implies that the differences in preferred climate policies between these two groups diminish. As a result, EU climate policy becomes less ambitious and less disputed. In an extension of our model,

consumption generates carbon emissions that are not covered by the emission certificate regulation. The impact of centralising the revenue on overall EU wide emissions then depends on the distributional consequences of the reform. Total emissions tend to decline if the cross-country income distribution becomes more unequal, and vice versa. We also consider the impacts of changes in EU climate policy on the rest of the world as well as global emissions. Laxer climate policy in the EU does not necessarily lead to more global emissions because production shifts to the EU will be induced via capital movements.

How different is the carbon intensity of economic activity across EU member states? In 2018, greenhouse gas emissions per capita varied substantially across EU member states with an average of 8.7 tonnes based on the 27 member states without the UK. The top group with emissions exceeding 10 tonnes per capita comprised, among others, the Netherlands (11.6), Poland (11.0), Belgium (10.8) and Germany (10.7). In the lower segment, we find Sweden (5.4), Romania (6.0), France (6.9), Italy (7.3), and Spain (7.5) (Eurostat, 2020). The price of a CO₂ European emission allowance referring to one tonne of CO₂ emissions shows an increasing trend over the last years, rising from about 5 EUR in 2016, around 9 EUR in 2018 to around 25 EUR in 2020 (Businessinsider, 2020).

Our paper is related to different strands of the literature. First, the envisaged reform of EU finances has properties like vertical fiscal externalities within a federation, which have been mostly been analysed in terms of incentives for raising tax revenue and designing grants so as to overcome inefficiencies (Bahlby, 1996; Boadway and Keen, 1996; Köthenbürger, 2007; Arclean et al., 2010). By contrast, our positive approach deals with redistribution across member states and impacts on emissions. Second, we contribute to the large literature on allocative consequences of policy design when using emission certificates, which among others deals with coalition formation, uncertainty and dynamic aspects (eg Helm, 2003; Sinn, 2003; Goulder, 2013; Slechten, 2013; Nordhaus, 2015; Salent, 2016). Our setting is much simpler by having a comparative static approach taking the EU coalition for granted, shedding light on the impacts of reform on setting the joint emissions cap. Finally, our paper also bears relations to the literature on carbon leakage (Babiker, 2005; Eichner and Pethig, 2011; Aichele and Felbermayer, 2015; Böhringer et al. 2017), arguing that

tighter environmental regulation within a country or a group of countries will increase carbon emissions in the rest of the world via capital movements or changes in the pattern of international trade. We confirm that key idea in our setting, where we can identify determinants under which a laxer regulation in an area using emission certificates will not be offset by reactions in the rest of the world.

The rest of the paper is organized as follows. After introducing the basic model in Section 2, Section 3 deals with the redistributive effect of the revenue centralisation. Section 4 considers a variant of the model with additional non-regulated emissions associated with consumption. Section 5 shows how the reform changes the incentives of the individual member states regarding the EU climate policy they support. Section 6 takes a look at consequences for output and emissions outside the EU. Section 7 concludes.

2. Setup

We use the framework developed by Sinn (2003), where emissions generate output. Put differently, avoiding emissions comes at a cost. Each country i is characterized by a constant returns to scale production function $Y_i = F_i(K_i, L_i, Z_i)$ with positive and diminishing marginal productivities, where Y_i is output, K_i is capital input, L_i is labour input and Z_i are emissions. This formulation allows for differences in endowments and technology. Profit of a representative firm that takes prices as given is

$$\Pi_i = F_i(K_i, L_i, Z_i) - w_i L_i - r K_i - p Z_i \quad (1)$$

In this expression, w_i denotes the wage in country i , r is the interest rate in the world market, and p is the price of a certificate related to one unit of emissions.

Profit maximization implies that emission certificates will be used until $p = \frac{\partial F_i}{\partial Z_i}$. Welfare is described by utility of a representative consumer who cares about private consumption per capita C_i , public good consumption G , and aggregate emissions

$Z = \sum Z_i$. The latter is natural when describing CO2 emissions that contribute to global warming, assuming that the EU has a significant impact on the global climate.

Welfare of a representative consumer is $U(C_i, Z, G)$, where G is provided by the European Union. Let U be separable in its arguments with $U_C > 0 > U_{CC}$, and $U_Z < 0, U_{ZZ} < 0$. Keeping the analysis as simple as possible, U_G has a kink at some $\bar{G} > 0$ with sufficiently high marginal utility at lower values and $U_G = 0$ for any $G > \bar{G}$. Fixing G at \bar{G} throughout ensures that otherwise possible impacts working through changes in preferred public good levels can be ignored. Alternatively one could assume that there is a fixed revenue constraint. Note that G and Z are identical across countries. We abstract from country size issues by normalizing population to unity, $L_i = 1$ for all i . Capital is taken as internationally mobile, while labour is treated as immobile. Capital and labour are always fully employed. In order to avoid additional distortions, only wage income is taxed at a rate τ_i , being tantamount to a lump-sum tax in our framework. Denoting capital endowment of country i by \bar{K}_i , consumption of country i is given by

$$C_i = (1 - \tau_i)w_i + r\bar{K}_i + B_i \quad (2)$$

The national budget surplus B_i generally depends on the redistribution rules in the European Union, that has n members. We consider two different regimes. In the separation regime, denoted by superscript *sep*, each country keeps its revenue from issuing emission certificates, where contributions to the EU are some share k^{sep} of GDP. Thus, the EU budget is:

$$G^{sep} = k^{sep} \sum Y_i \quad (3)$$

When revenue from emission certificates is pooled, where related variables are denoted by superscript *pool*, the contribution rate is reduced to k^{pool} :

$$G^{pool} = pZ + k^{pool} \sum Y_i \quad (4)$$

If the budget of the EU is unchanged, we will have $G^{sep} = G^{pool} = \bar{G}$. The respective national budget surpluses under each regime are

$$B_i^{sep} = \tau_i^{sep} w_i + pZ_i - k^{sep} Y_i^{sep} \quad (5)$$

$$B_i^{pool} = \tau_i^{pool} w_i - k^{pool} Y_i^{pool} \quad (6)$$

One key impact of the EU budget reform under consideration consists in redistribution between carbon-rich and carbon-poor countries. Solving for consumption, we obtain

$$C_i^{sep} = (1 - k^{sep}) Y_i^{sep} + r(\bar{K}_i - K_i^{sep}) \quad (7)$$

$$C_i^{pool} = (1 - k^{pool}) Y_i^{pool} + r(\bar{K}_i - K_i^{pool}) - pZ_i^{pool} \quad (8)$$

Under the separation regime, disposable income is output net of EU contributions, $(1 - k^{sep}) Y_i^{sep}$, plus net capital income from abroad, $r(\bar{K}_i - K_i^{sep})$. With pooling of emissions certificate revenue, national revenue pZ_i^{pool} is transferred to the EU, while the contribution rate is now k^{pool} .

3. Pure redistribution

Fixing G and Z here also keeps the emission certificate price p constant. The impact of the reform is reflected in the change of consumption.

Proposition 1. *At given emissions cap Z and given public good provision G , centralising the emission certificate revenue keeps all national output levels constant. National consumption decreases in countries that are carbon intensive in production in terms of the carbon share in national income, and vice versa, $C_i^{pool} < C_i^{sep}$ if and only if $pZ_i/Y_i > p\bar{Z}/\bar{Y}$, with $\bar{Z} = \frac{1}{n} \sum_{i=1}^n Z_i$ and $\bar{Y} = \frac{1}{n} \sum_{i=1}^n Y_i$.*

Proof. The reform does not alter factor prices or labour force levels. Therefore, national input demand and national output remain unchanged. We obtain $C_i^{pool} < C_i^{sep}$ if and only if $(k^{sep} - k^{pool}) Y_i > pZ_i$. Since $k^{sep} - k^{pool} = p(\sum_{i=1}^n Z_i)/$

$(\sum_{i=1}^n Y_i)$, the latter is equivalent to $pZ_i/Y_i > p\bar{Z}/\bar{Y}$, with $\bar{Z} = \frac{1}{n}\sum_{i=1}^n Z_i$ and $\bar{Y} = \frac{1}{n}\sum_{i=1}^n Y_i$. ■

Countries that are carbon-intensive in production lose due to centralisation of revenue from issuing emission certificates, while others win. Hence, carbon-intensive producing countries like Poland and Germany tend to lose as a consequence of centralisation, while France and Sweden would be among the winners. In principle, redistribution can be avoided by individualizing k^{pool} so as to keep consumption constant everywhere. However, individualizing contribution rates would be uncommon in the EU. Instead, following frequent examples in the past, the typical instrument employed consists in granting lump-sum rebates. In the following, we will abstract from such compensating action.

4. Extension: consumption-related emissions

In this section, we extend the analysis by assuming that, next to production-related emissions, there are consumption-related emissions. The latter are not covered by the emission certificate regulation. This implies that the revenue centralisation will change emissions indirectly through its effect on consumption in different countries. Suppose that the consumption-related emissions have the structure $X_i = f(C_i)$ with $f' > 0 > f''$. Formulated in that way, marginal emissions are positive and diminishing in consumption per capita. This is in line with world panel data findings in Holtz-Eatin and Selden (1995), suggesting a diminishing marginal propensity to emit when income per capita rises. Welfare is affected by aggregate emissions, $U(C_i, X + Z, G)$ with $X + Z = \sum(X_i + Z_i)$.

Reorganizing the budget of the European Union as suggested without compensating action tends to reduce consumption in carbon-intensive producing countries. Conversely, it increases consumption of countries that use carbon in production below average. Proposition 2 shows that the net impact on total emissions is positive if and only if the reform increases consumption inequality across countries in the EU.

Proposition 2. *At given emissions cap Z and given public good provision G , centralising the emission certificate revenue increases overall emissions if and only if cross-country inequality in consumption per capita in the EU declines, that is, if and only if $VAR(C_i^{pool}) < VAR(C_i^{sep})$.*

Proof. Recalling Proposition 1, the reform keeps all nationwide production levels and aggregate consumption in the EU constant. As the production-related emissions cap Z is unaffected, the reaction of overall emissions $X + Z$ is determined by the change in consumption-related emissions. Due to the strict concavity of $f(C)$ with unchanged average consumption $\bar{C} = \frac{1}{n} \sum_{i=1}^n C_i$, per capita consumption-related emissions in the EU increase if and only if $VAR(C_i^{pool}) < VAR(C_i^{sep})$. ■

According to Proposition 2, the crucial aspect that determines the reaction of EU wide consumption-related emissions lies in the distribution of disposable income. If carbon-intensive producing countries are comparatively poor, the reform will increase consumption inequality in the EU. This would reduce emissions because the now even richer countries add less to consumption-related emissions compared to what is saved in the poorer countries. Conversely, should the carbon-intensive producing countries be comparatively rich, the reform reduces consumption inequality across the member states, which drives up overall consumption-related emissions. This highlights a certain tension that may arise between climate protection and distributional objectives.

It is not straightforward to assess whether the variance in consumption would decrease or increase upon centralization of revenue from issuing certificates. While some rich countries in terms of income per capita also emit high quantities of carbon dioxide per capita - like Luxemburg, the Netherlands, Belgium and Germany, other rich member states like Italy, France and Sweden are obvious winners of the reform.

5. How does the reform affect climate policies preferred by countries?

In this section we turn to the important question of how the revenue centralisation will affect the EU's climate policy. The reform changes the way in which different

emissions caps or, equivalently, different carbon prices p affect national welfare. To analyse this, we return to the base version of the model, which abstracts from consumption-related carbon emissions. The carbon price is a decreasing function of the cap, that is $p = g(Z)$, with $g' < 0 < g''$.

With separable utility, the most preferred EU emissions cap Z for each country is determined by the national first-order condition

$$\frac{\partial U_i}{\partial C_i} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p} \frac{\partial p}{\partial Z} + \frac{\partial U_i}{\partial Z} = 0 \quad (9)$$

The direct impact of the negative externality from having more carbon in the atmosphere is given by $\frac{\partial U_i}{\partial Z} < 0$. With identical and separable preferences, that component is common for all countries. In the optimum, the marginal propensity to pay for a EU-wide emission reduction, $-\frac{\frac{\partial U_i}{\partial Z}}{\frac{\partial U_i}{\partial C_i}} > 0$, equals the marginal cost in terms of consumption, $\frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p} \frac{\partial p}{\partial Z} > 0$ with $\frac{\partial p}{\partial Z} < 0$. Countries differ with respect to $\frac{\partial U_i}{\partial C_i} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p}$, where $\frac{\partial U_i}{\partial C_i} \frac{\partial C_i}{\partial Y_i}$ also depends on whether or not revenue from issuing pollution certificates is centralised or remains with the national government.

The reaction of national output to a change in the price of an emission cate, $\frac{\partial Y_i}{\partial p}$, depends on technical parameters, where impacts are stronger if the country is producing more carbon-intensive. The term $\frac{\partial C_i}{\partial Y_i}$ captures effective marginal taxation of income; higher output translates into additional consumption net of the marginal EU contribution, the cost of hiring additional capital and - in the centralisation regime - the cost of additional certificates. Finally, poorer countries will exhibit a larger $\frac{\partial U_i}{\partial C_i}$ at any given policy.

When it comes to pooling of the revenue from issuing emission certificates, an *income effect* occurs due to redistribution. At any given level of emission certificates, consumption is lower in carbon-intensive producing countries, increasing $\frac{\partial U_i}{\partial C_i}$, and vice versa. Taken in itself, this income effect increases the utility gain of carbon-

intensive countries from a higher cap Z , which should be translated in a plea for a higher cap. At the same time, the *price effect*, working through $\frac{\partial C_i}{\partial Y_i}$, points in the opposite direction, reducing the rate of income that can be retained for consumption in carbon-intensive countries. Accordingly, countries that are harmed by centralization of certificate revenue in terms of the retainment rate, may now prefer a lower Z or a higher p .

Trying to assess the tendency of the net impact, we consider a Cobb-Douglas production function, $Y_i = A_i K_i^{\alpha_i} Z_i^{\beta_i} L_i^{(1-\alpha_i-\beta_i)}$, where parameters $\alpha_i \in (0,1)$, $\beta_i \in (0,1)$ and $A_i > 0$ may vary across countries. Appendix A derives input demand functions and resulting output. Preferences of the representative consumer, being logarithmic in consumption and quadratic in overall emissions, $U = \gamma \ln C - \delta \frac{Z^2}{2}$, are assumed to be identical everywhere. With that specification, it can be shown that (i) more carbon-intensive producing countries prefer a laxer environmental policy and that (ii) the change in their preferred emissions cap upon the EU financing reform is governed by the price effect.

Proposition 3. *With a Cobb-Douglas production function $Y_i = A_i K_i^{\alpha_i} Z_i^{\beta_i} L_i^{(1-\alpha_i-\beta_i)}$ and preferences of the representative consumer $U = \gamma \ln C - \delta \frac{Z^2}{2}$, the most preferred emissions cap Z increases in the carbon income share β_i under the separation regime. Centralising the revenue from emission certificates at given public good provision G then increases the most preferred emissions cap of country i if and only if its carbon income share lies below average, $\beta_i < \bar{\beta}$, with $\bar{\beta} = \frac{p(\sum_{i=1}^n Z_i)}{(\sum_{i=1}^n Y_i)}$.*

Proof. See Appendix B.

It turns out that income effect and price effect would cancel out if the capital endowment is zero - a well-known phenomenon of Cobb-Douglas specifications. With a positive capital endowment, the shift in consumption due to capital income implies that the price effect will dominate the income effect. Therefore, carbon-intensive producing countries will tend to opt for a more restrictive environmental policy as a result of revenue centralization. The reason is that they no longer benefit from higher national emissions through higher revenue from carbon pricing. Conversely, should

the country display a carbon income share below average, its preferred emissions cap will increase.

If a coalition of countries with low carbon intensity dominates decision-making in the EU, they will decide to centralise the revenue and, once the reform has been implemented, they will opt for a laxer climate policy. A similar outcome is likely to emerge in a median voter setting. If the emissions cap is determined by majority voting, single-peaked preferences ensure that the most preferred cap of the median voter country wins in any pairwise majority voting against all alternatives. While the reform under consideration will change the preference of the median voter country, it is unlikely that the identity of the median voter changes. Hence, we expect a laxer environmental policy if the median voter country has a carbon income share below average. This scenario with a median voter country being among the winners of the fiscal reform is quite conceivable. In that case, it is ensured that the fiscal reform itself is supported by a majority of member states, as mentioned above.

6. Impact on the rest of the world

Denote the countries outside the EU as the 'rest of the world'. They do not take part in the EU emissions trading system, but will be affected if the cost of avoiding emissions in the EU changes. If it increases, mobile capital will flow to the rest of the world. In that event, output and emissions in the rest of the world will increase. It may happen that this leads to an increase in worldwide emissions, in particular if the rest of the world has a lower carbon price so that the distortion in avoiding emissions from a worldwide perspective increases.

However, Proposition 3 suggests that if the median voter country in the EU becomes richer when revenue from issuing emission certificates is centralized, the opposite occurs. A majority is formed to increase the emissions cap. Consequently, capital will flow into the EU. While the marginal return of capital is the same everywhere due to perfect international mobility of capital, changes in world output will be determined by changes in demand for carbon emissions. In that respect it may matter that the marginal productivity of carbon emission in the EU is higher than in the rest of the

world, assuming the EU carbon price level is higher. For example, should worldwide emissions stay constant, aggregate worldwide output will increase.

We consider a two-country version with a representative EU country and a representative rest of the world country, ignoring inefficiencies in the allocation of labor within regions and differentiated emission pricing outside the EU. Both countries are described by a Cobb-Douglas technology, where related variables are indexed by superscripts EU and ROW . As the EU is small relative to the rest of the world, the interest rate r stays fixed, and the price of avoiding emissions in the rest of the world, p^{ROW} , is taken as constant. Hence, the price adjustment in the rest of the world falls on wage rates.

The output change in the rest of the world is due to the capital flow into the EU induced by the higher emissions cap in the EU:

$$\frac{\partial Y^{ROW}}{\partial Z^{EU}} = - \frac{\partial Y^{ROW}}{\partial K^{EU}} \frac{dK^{EU}}{dZ^{EU}} \quad (10)$$

Capital demand in the EU is affected both directly by the cap and by the change in the emission price:

$$\frac{dK^{EU}}{dZ^{EU}} = \frac{\partial K^{EU}}{\partial Z^{EU}} + \frac{\partial K^{EU}}{\partial p^{EU}} \frac{\partial p^{EU}}{\partial Z^{EU}} \quad (11)$$

By considering a benchmark with initial symmetry between the two country blocks in Proposition 4, we gain some insights into the impacts that govern the net change in total worldwide CO2 emissions.

Proposition 4. *In a two-country world with fixed interest rate and fixed emission price in the rest of the world p^{ROW} , worldwide carbon emissions increase with a higher EU emissions cap if production parameters are identical, $\alpha^{EU} = \alpha^{ROW}$, $\beta^{EU} = \beta^{ROW}$, and if the emission price in the EU does not exceed its counterpart in the rest of the world, $p^{EU} \leq p^{ROW}$. An overall increase becomes more likely with a lower emission price in the rest of the world, p^{ROW} , a higher capital share in the rest of the world, α^{ROW} , and a lower carbon income share in the rest of the world, β^{ROW} .*

Proof. With a Cobb-Douglas technology, the technical marginal rate of substitution is equal to the factor price ratio:

$$\frac{Z^i}{K^i} = \frac{r\beta^i}{p^i\alpha^i} \quad (12)$$

with $i \in \{EU, ROW\}$. The change in emissions in the rest of the world can be derived as follows:

$$\frac{\partial Z^{ROW}}{\partial Z^{EU}} = \frac{\partial Z^{ROW}}{\partial K^{ROW}} \frac{\partial K^{ROW}}{\partial K^{EU}} \frac{dK^{EU}}{dZ^{EU}} \quad (13)$$

with $\frac{\partial K^{ROW}}{\partial K^{EU}} = -1$ by construction. Hence, we obtain

$$\begin{aligned} \frac{\partial Z^{ROW}}{\partial Z^{EU}} &= -\frac{r\beta^{ROW}}{p^{ROW}\alpha^{ROW}} \frac{\alpha^{EU}p^{EU}}{r\beta^{EU}} \left[1 + \frac{Z^{EU}}{p^{EU}} \frac{\partial p^{EU}}{\partial Z^{EU}} \right] \\ &= -\frac{p^{EU}\alpha^{EU}\beta^{ROW}}{p^{ROW}\beta^{EU}\alpha^{ROW}} \left[1 + \frac{Z^{EU}}{p^{EU}} \frac{\partial p^{EU}}{\partial Z^{EU}} \right] \end{aligned} \quad (14)$$

Total emissions decline upon capital movement to the EU induced by a higher emission cap if the absolute of (14) exceeds unity. With $\alpha^{EU} = \alpha^{ROW}$, $\beta^{EU} = \beta^{ROW}$, and $p^{EU} \leq p^{ROW}$, we obtain $-1 > \frac{\partial Z^{ROW}}{\partial Z^{EU}} > 0$ since $-1 > \frac{Z^{EU}}{p^{EU}} \frac{\partial p^{EU}}{\partial Z^{EU}} > 0$. Thus, worldwide emissions increase.

Moreover, the absolute of $\frac{\partial Z^{ROW}}{\partial Z^{EU}}$ increases with a lower p^{ROW} , with a lower α^{ROW} , and with a higher β^{ROW} . ■

Proposition 4 demonstrates that worldwide emissions rise with a laxer EU environmental policy in the benchmark case of identical technologies and initially identical cost of emission avoidance. The reason lies in the additional substitution of capital by carbon due to the reduction in the certificate price, which is not mirrored in the rest of the world. This result has to be taken with caution since the symmetry assumption does not seem appropriate. The main factor that may lead to a reverse conclusion lies in the comparatively tight environmental policy in the EU, implying

$\frac{p^{EU}}{p^{ROW}} > 1$. At the same time, however, the capital share in total income in the EU tends to lie below the world average, thus $\frac{\alpha^{EU}}{\alpha^{ROW}} < 1$, which works in the opposite direction.

Summing up, while we are able to identify some relevant channels that decide on the consequences of a higher EU emissions cap on worldwide emissions, our crude analysis does not allow for a clear-cut result regarding the sign of that net impact.

7. Conclusions

The analysis in this paper has shown that centralising revenue from issuing carbon emissions has redistributive effects and adapts the way in which carbon price changes affect national welfare. If a coalition of countries with low carbon intensity succeeds in centralising the revenue from carbon pricing, these countries will benefit - but they also have incentives to implement a laxer climate policy. The carbon intensive countries will lose from the reform and probably ask for compensation. At the same time, they will be less opposed to the EU climate policy because they no longer benefit from higher national emissions through carbon pricing revenue. Whether laxer EU climate policy would also lead to a higher level of global emissions is, perhaps surprisingly, an open question. Our results have also shown that there are tensions between more ambitious climate policies and the objective of reducing prosperity differences across EU countries.

These results should be considered in the light of the stylised theoretical framework in which they have been derived. One important limitation of the analysis is that it obviously neglects medium-term and long-term consequences. Regarding incentives to innovate on a firm level in filtering or carbon-saving technologies, initially unchanged prices suggest neutrality of the centralisation reform. If the prediction of a tendency toward a lenier environmental policy is taken into account, such innovation is expected to slow down. On the government level, incentives to add further regulation, for example implementing or increasing national carbon taxes or subsidizing carbon-saving technologies, may be affected. Since the fiscal cost of carbon

saving now falls on the EU budget, incentives to take national action are strengthened.

Another problem arises with announcement effects when implementing the centralised tax system is associated with compensation by some rebates. If such a rebate is granted according to its emission certificate revenue at some base date, it lies in the interest of each country to manipulate the reference basis. For example, suppose each country also uses a national carbon tax, like the gasoline tax. Reducing that tax would increase national demand for emissions and therefore also the revenue from selling emission certificates. Given unchanged number of certificates, its price increases due to additional demand in the country that has reduced its national carbon tax. While total emissions are unchanged due to the implemented cap, some redistribution of emissions occurs. This redistribution can also affect aggregate output. The net effect on output depends on whether the inefficient structure of emission regulation in the European Union becomes less or more distortive due to differences in total carbon taxes. When the incentive to cut additional carbon taxes works so as to reduce them to zero everywhere, this type of distortion completely vanishes. In any case, such reactions can be avoided by choosing a base date in the past, abolishing incentives for behavioural reaction.

Appendix

A. Production and input demand with Cobb-Douglas specification

Consider a Cobb-Douglas production function

$$Y_i = A_i K_i^{\alpha_i} Z_i^{\beta_i} L_i^{(1-\alpha_i-\beta_i)} \quad (A1)$$

Assuming full employment, the wage rate equals the marginal product of labour:

$$w = (1 - \alpha_i - \beta_i) \frac{Y_i}{L_i} \quad (A2)$$

Capital input and demand for emission certificates satisfy the respective first-order conditions:

$$\alpha_i \frac{Y_i}{K_i} - r = 0 \quad (A3)$$

$$\beta_i \frac{Y_i}{Z_i} - p = 0 \quad (A4)$$

Solving these equations for K_i and Z_i yields

$$K_i = \alpha_i \frac{Y_i}{r} \quad (A5)$$

$$Z_i = \beta_i \frac{Y_i}{p} \quad (A6)$$

Inserting these results into the production function, we obtain

$$Y_i^{(1-\alpha_i-\beta_i)} = A_i \left(\frac{\alpha_i}{r}\right)^{\alpha_i} \left(\frac{\beta_i}{p}\right)^{\beta_i} L_i^{(1-\alpha_i-\beta_i)} \quad (A7)$$

Thus

$$Y_i = A_i^{\frac{1}{1-\alpha_i-\beta_i}} \left(\frac{\alpha_i}{r}\right)^{\frac{\alpha_i}{1-\alpha_i-\beta_i}} \left(\frac{\beta_i}{p}\right)^{\frac{\beta_i}{1-\alpha_i-\beta_i}} L_i \quad (A8)$$

Output is linear in the labour force L_i and decreases in the price of the emission certificate p . Per capita income Y_i/L_i as well as total output Y_i increase in all technical parameters A_i , α_i , and β_i . Further, we obtain a constant elasticity of output with respect to the price of emissions certificate. That elasticity depends on parameters of the production function:

$$\frac{\partial Y_i}{\partial p} = - \frac{\beta_i}{(1 - \alpha_i - \beta_i)} \frac{Y_i}{p} \quad (A9)$$

Note that the derivative is proportional to the output level. Hence, countries that are richer due to a higher total factor productivity parameter A_i will be more sensitive to the price in levels as they exhibit a higher absolute of $\frac{\partial Y_i}{\partial p}$.

Capital demand and demand for certificates are derived as follows:

$$K_i = \alpha_i \frac{Y_i}{r} = A_i \frac{1}{1-\alpha_i-\beta_i} \left(\frac{\alpha_i}{r}\right)^{\frac{1-\beta_i}{1-\alpha_i-\beta_i}} \left(\frac{\beta_i}{p}\right)^{\frac{\beta_i}{1-\alpha_i-\beta_i}} L_i \quad (A10)$$

$$Z_i = \beta_i \frac{Y_i}{p} = A_i \frac{1}{1-\alpha_i-\beta_i} \left(\frac{\alpha_i}{r}\right)^{\frac{\alpha_i}{1-\alpha_i-\beta_i}} \left(\frac{\beta_i}{p}\right)^{\frac{1-\alpha_i}{1-\alpha_i-\beta_i}} L_i \quad (A11)$$

Demand for both capital and emission certificates decreases with a higher price of certificates. The former reflects the complementary relationship of factors in a Cobb-Douglas production function, which also implies a declining wage rate as response to a higher price of emissions. It is immediate that the emission intensity relative to capital input is a declining function of the emission certificate price p , indicating some degree of substitutability: $\frac{Z_i}{K_i} = \frac{r\beta_i}{p\alpha_i}$.

Recalling a well-known result on Cobb-Douglas production functions, the productivity parameter related to each factor is equal to its income share, $\alpha_i = \frac{rK_i}{Y_i}$ and $\beta_i = \frac{pZ_i}{Y_i}$.

B. Proof of Proposition 3

Consider the utility function

$$U = \gamma \ln C - \delta \frac{Z^2}{2} \quad (B1)$$

Differentiating with respect to the cap Z yields the first-order condition

$$\frac{\partial U}{\partial Z} = -\delta Z + \frac{\gamma}{C} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p} \frac{\partial p}{\partial Z} = 0 \quad (B2)$$

Recall that the Cobb-Douglas specification of the production function implies (A5) and (A6). By substituting for factor demand in equations (7) and (8), consumption

can be expressed as function of output and prices.

In the separation regime, we obtain

$$\frac{\partial C_i}{\partial Y_i} = 1 - \alpha_i - k^{sep} \quad (B3)$$

This term can be interpreted of the effective tax rate on additional income. A rate α_i is to be paid to additional (foreign) capital, while the fraction k^{sep} represents the additional contribution to the EU. The outcome in the pooling regime looks slightly different:

$$\frac{\partial C_i}{\partial Y_i} = 1 - \alpha_i - \beta_i - k^{pool} \quad (B4)$$

In the pooling regime, the share β_i shows up because additional income related to carbon emissions is collected by the EU.

The crucial terms determining the impact of increasing the certificate price on consumption per capita under the separation regime are:

$$\begin{aligned} \frac{1}{C_i} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p} &= -[1 - \alpha_i - k^{sep}] \frac{\beta_i}{(1 - \alpha_i - \beta_i)} \frac{Y_i}{p} \frac{1}{[(1 - \alpha_i - k^{sep})Y_i + r\bar{K}_i]} \quad (B5) \\ &= -\frac{\beta_i}{p(1 - \alpha_i - \beta_i)} * \frac{1}{[1 + r\bar{K}_i/[(1 - \alpha_i - k^{sep})Y_i]]} \end{aligned}$$

In this expression, $[1 - \alpha_i - k^{sep}]$ capture the marginal effective tax rate, $\frac{\beta_i}{(1 - \alpha_i - \beta_i)} \frac{Y_i}{p}$ shows the marginal reaction of output to a price reduction, and $\frac{1}{[(1 - \alpha_i - k^{sep})Y_i + r\bar{K}_i]}$ is marginal utility from higher consumption. The absolute of this term is directly increasing in β_i and also in decreasing in Y_i , which according to (A8) rises with higher β_i . Hence, the most preferred cap Z increases with higher β .

The corresponding term under the pooling regime reads

$$\begin{aligned} \frac{1}{C_i} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p} &= -[1 - \alpha_i - \beta_i - k^{pool}] \frac{\beta_i}{(1 - \alpha_i - \beta_i)} \frac{Y_i}{p} \frac{1}{(1 - \alpha_i - k^{pool})Y_i + r\bar{K}_i - pZ_i} \\ &= -\frac{\beta_i}{p(1 - \alpha_i - \beta_i)} * \frac{1}{\left[1 + \frac{r\bar{K}_i}{[(1 - \alpha_i - \beta_i - k^{pool})Y_i]}\right]} \quad (B6) \end{aligned}$$

At given Z , the certificate price p and output Y_i remain unchanged. Consequently, the absolute of $\frac{1}{C_i} \frac{\partial C_i}{\partial Y_i} \frac{\partial Y_i}{\partial p}$ is declining when centralizing revenue from issuing certificates if and only if $\beta_i + k^{pool} > k^{sep}$. Since $k^{sep} - k^{pool} = \frac{p(\sum_{i=1}^n Z_i)}{(\sum_{i=1}^n Y_i)} = p\bar{\beta}$ with $\bar{\beta} = \frac{\sum_{i=1}^n Z_i}{\sum_{i=1}^n Y_i} = \sum_{i=1}^n \beta_i \frac{Y_i}{Y}$ where $Y = \sum_{i=1}^n Y_i$, the absolute is declining if and only $\beta_i > \bar{\beta}$.

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