BBVA Research

Social Welfare and the Social Cost of Carbon

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Introduction

- In this study, we extend the welfare measure proposed by Jones and Klenow (2016) to incorporate the social cost of carbon, defining per capita consumption net of the cost of CO_2 emissions in OECD countries from 1960 to 2019.
- Calibration of the social cost of CO_2 is based on Golosov et al. (2014).
- Golosov et al. (2014) presented a simple formula for the optimal carbon tax (that offsets the negative externality of CO_2 emissions) under quite plausible assumptions.
- The optimal carbon tax is proportional to current GDP and depends on three factors:
  1. Discount rate
  2. Expected damage elasticity of output to an extra unit of CO_2 in the atmosphere
  3. CO_2 depreciation in the atmosphere

Introduction

Our results show that internalising the social cost of CO_2 emissions reduces welfare in OECD countries from 2010 to 2019 by 2.1% on average, but with significant differences between countries.

- The elasticity of social welfare to CO_2 emissions is equal to -0.014.
- A nonlinear relationship exists between social welfare and the discount rate used in the social cost of carbon.
- Calibration of damage parameters giving a higher probability to catastrophic scenarios (due to higher heating) significantly reduces welfare.
- The negative welfare effect is greater in OECD countries when consumed emissions are considered instead of produced emissions. On average, consumed emissions reduce social welfare by an additional -0.6%, from 2010 to 2019.

Structure of the presentation

- Approaches to Measuring Social Welfare.
- Comparison of welfare across OECD countries.
- Incorporating CO2 Emissions on Welfare
- Sensitivity Analysis of the Optimal Social Cost of Carbon
- The Relevance of Differentiating between Consumed and Produced Emissions
- Conclusions

Approaches to Measuring Social Welfare: Introduction

- GDP per capita is a commonly used measure of economic performance, but fails to capture non-market activities and the impact of unequal income distribution on personal well-being.
- To provide a better measure of social welfare, there are four main approaches: composite index, subjective evaluation, dashboard, and monetary approach.
- The monetary approach, as used by Jones and Klenow (2016), offers a theoretically grounded aggregation procedure and cross-country/intertemporal comparability. For these reasons, the welfare cost of CO2 emissions is based on the index proposed by Jones and Klenow (2016).

Approaches to Measuring Social Welfare: Jones and Klenow's Measure

- Jones and Klenow's indicator combines per capita consumption (private and public), leisure, life expectancy, and inequality in consumption distribution.
- The measure is based on individual preferences and is derived from expected welfare (utility) throughout the life cycle, which is a function of consumption (C), leisure (ℓ), and life expectancy (which in turn depends on the probability of survival, S, of living above a certain age, a):

$$U = E \sum_{a=1}^{100} \beta^a u(C_a, \ell_a) S(a) \tag{1}$$

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Comparison of Welfare across OECD countries: Relative measure

- The comparison of welfare between two countries is made in terms of the equivalent annual consumption necessary for a person to be indifferent between living in one or the other country.
- The relative welfare measure of each OECD country relative to the US is calculated using the expression:

$$
\begin{aligned}
\log \lambda_i = \frac{e_i - e_{us}}{e_{us}} & \left(\overline{u} + \log c_i + \nu\left(\ell_i\right) - \frac{1}{2}\sigma_i^2 \right) \\
& + \log c_i - \log c_{us} \\
& + \nu\left(\ell_i\right) - \nu\left(\ell_{us}\right) \\
& - \frac{1}{2}\left(\sigma_i^2 - \sigma_{us}^2\right)
\end{aligned} \tag{2}
$$

where e, c, ν, and σ are, respectively, life expectancy, per capita consumption, a function of leisure, and the variance of consumption among individuals for country i and the United States.

- Data availability allows us to construct an unbalanced or incomplete panel for 35 OECD countries, with observations since 1960.
- Jones and Klenow (2016) show that the approximation with macroeconomic data is quite good in the case of the countries for which microeconomic data, showing individual preferences are available.

Comparison of Welfare across OECD countries: Results

- Social welfare is closely related to public and private consumption per capita for the OECD countries from 2010 to 2019, explaining 89% of the welfare differences.
- The differences in welfare are greater than those observed in consumption per capita. For example, longer life expectancy, a better distribution of income, and fewer hours worked partially compensate for the advantage of the United States relative to the European economies in GDP and per capita consumption.

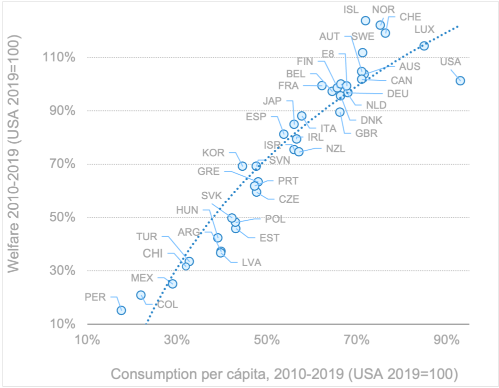

Figure 1. Consumption per capita and social welfare, 2010-2019.
Source: Own elaboration based on Jones and Klenow (2016), PWT10, SWIID, OECD and Gapminder.

Incorporating CO2 Emissions on Welfare: Evidence

- CO2 emissions increase faster than income in the early stages and more slowly when higher levels of GDP per capita are reached. However, there are differences in the consumption levels at which the trend becomes negative.
- The heterogeneity observed has to do with the different sectoral specializations, the endowment of natural resources of each country, the differences in the timing of the industrialization process, and the environmental regulations chosen by each country.

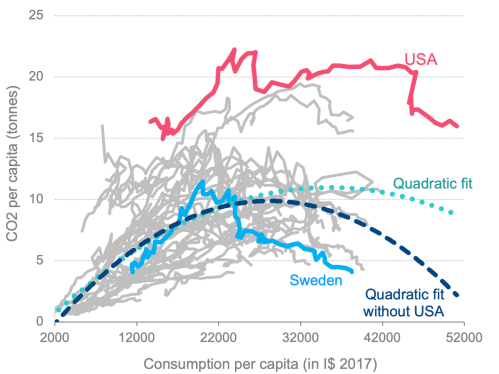

Figure 2. Consumption per capita and CO2 emissions per capita, 1950-2019.
Source: Own elaboration based on PWT10 and Global Carbon Budget.

Incorporating CO2 Emissions on Welfare: Literature Review

- The inclusion of environmental sustainability indicators in measures of well-being has a long tradition in the economic literature.
- Böhringer and Jochem (2007) made a critical review of sustainability indices that take into account economic, environmental, and social conditions.
- The normalization, weighting, or aggregation properties of these indices do not satisfy fundamental requirements and are affected by subjective judgments or some degree of arbitrariness.
- To avoid these limitations, Bannister and Mourmouras (2017) extend the welfare measure proposed by Jones and Klenow (2016) to incorporate the effects of pollution on life expectancy and a tax to internalize the global costs of carbon. In short, we internalize the externalities of CO2 emissions.

Incorporating CO2 Emissions on Welfare: Our proposal

- We focus on the effects of the social cost of CO2 emissions on welfare, ignoring its impact on life expectancy, inequality and the depletion of natural resources.
- As Bannister and Mourmouras (2017), we assume that the representative consumer cares about the risks of global climate change and is willing to sacrifice current consumption.
- Unlike Bannister and Mourmouras (2017), we analyze the effects on the welfare of CO2 emissions over time and the sensitivity of these effects to changes in τ^s, which we allow to vary over time.
- We define c^s as consumption net of the social cost of CO2, i.e., $c^s_t = c_t - \tau^s_t g_t$, where c is private and public consumption, τ^s is the social cost of each ton of CO2, and g are emissions per capita.

$$\begin{aligned}\log \lambda_i^s = {} & \frac{e_i - e_{us}}{e_{us}} \left(\overline{u} + \log c_i^s + v\left(\ell_i\right) - \frac{1}{2}\sigma_i^2 \right) \\ & + \log c_i^s - \log c_{us}^s \\ & + v\left(\ell_i\right) - v\left(\ell_{us}\right) \\ & - \frac{1}{2}\left(\sigma_i^2 - \sigma_{us}^2\right)\end{aligned} \tag{3}$$

Incorporating CO2 Emissions on Welfare: Main Results

- In countries like Sweden, with large levels of welfare and small CO2 emissions, the overestimation of welfare is relatively small, close to 1 percent, whereas it ranges between 3 and 5 percent in countries with higher CO2 emissions like the US. On average, welfare in OECD countries from 2010 to 2019 is reduced by 2.1%.
- The variance of welfare overestimation also increases with the level of welfare. When incorporating CO2 emissions, EU-8 countries exhibit a relatively higher level of welfare compared to the United States.

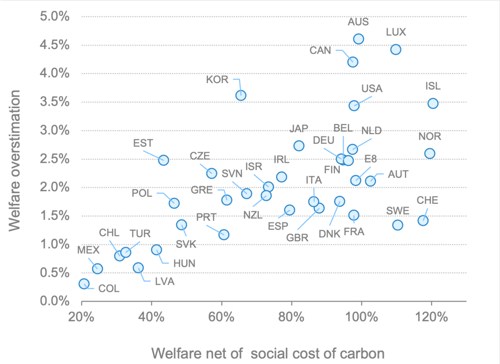

Figure 3. Net welfare of the social cost of carbon (λ)) and overestimation of welfare $(\lambda - \lambda^s)$, OECD countries, averages 2010-2019.
Source: Own elaboration.

Sensitivity Analysis of the Optimal Social Cost of Carbon (I)

- For an annual discount rate of 1.5 percent as in Nordhaus (2008), Golosov et al. (2014) found that the average optimal CO2 tax rate per ton represents 0.00807 percent of global output.
- The global social cost of carbon in our baseline scenario ranges from 7.9 in 1950 to 104.7 in 2019.

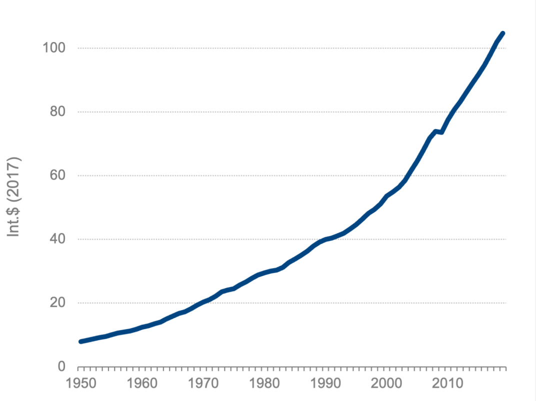

Figure 4. Global optimal social cost of carbon in the baseline scenario, 1950-2019, Int.$2017 per ton.
Source: Own elaboration based on Golosov et al. (2014), World Bank and Our World in Data.

Sensitivity Analysis of the Optimal Social Cost of Carbon (II)

- Our calibration of τ^s is based on Golosov et al. (2014), who propose a simple formula for the optimal carbon tax, which is proportional to current GDP.
- This proportion depends only on three critical factors: the discount rate, the expected damage elasticity of output to an extra unit of CO2 in the atmosphere, and the CO2 depreciation in the atmosphere.

$$\tau_t^s = Y_t \bar{\gamma}_t \left(\frac{\varphi_L}{1-\beta} + \frac{(1-\varphi_L)\varphi_0}{1-(1-\varphi)\beta} \right) \tag{4}$$

where Y is global GDP, $\bar{\gamma}t$ is the expected damage parameter (assumed constant from t onward and equal to 2.3793E-05), β is the discount factor (assumed at 0.985^{10} per decade), φL is the share of CO2 emitted into the atmosphere that stays in it forever (equal to 0.2 in the baseline calibration), φ_0 is the share of emissions that do not exit the atmosphere into the biosphere and the ocean surface (assumed to be 0.393), and φ the geometric decay rate of those emissions that stay in the atmosphere for a limited period (assumed to be 0.0228).

Sensitivity Analysis of the Optimal Social Cost of Carbon: Discount rate

- We have used a discount rate (β) of 1.5% per year, as in Nordhaus (2008). However, Stern (2006) used a much lower rate of 0.1%.
- Different levels of welfare (for the average OECD country) have been calculated under the different values of the discount rate (0.1% to 2.0% per year).
- The effect on welfare of variations in the discount factor is non-linear. For low values of the social discount rate, welfare declines rapidly. In fact, when the social discount rate approaches to 0.017% consumption net of the social cost of CO2 emissions and welfare converge to zero.

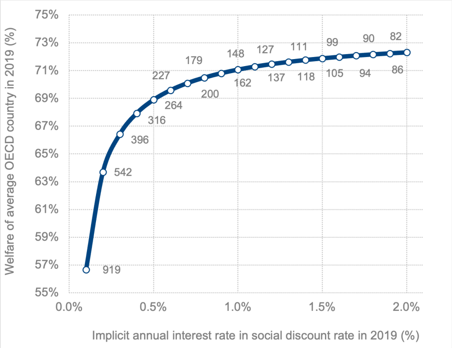

Figure 5.Sensitivity of welfare for the average OECD country in 2019 to changes in SCC. The numbers around the curve are estimates of the SCC per ton in 2017 international dollars. Source: Own elaboration.

Sensitivity Analysis of the Optimal Social Cost of Carbon: Damage elasticity

- In previous exercises, we used the baseline damage parameter ($\bar{\gamma}$), which was derived from the moderate damage scenario outlined by Golosov et al. (2014). However, it is evident that as the concentration of CO2 in the atmosphere increases, the likelihood of experiencing more severe scenarios also increases.
- In the low damage scenario ($\bar{\gamma} = 1.06E - 05$), the SCC falls to I$46.7 per ton and welfare increases by slightly more than 1 percentage point.
- On the contrary, in the catastrophic damages scenario ($\bar{\gamma} = 2.05E - 04$), the SCC would increase to I$900.7 per ton and welfare would fall 15 percentage points.

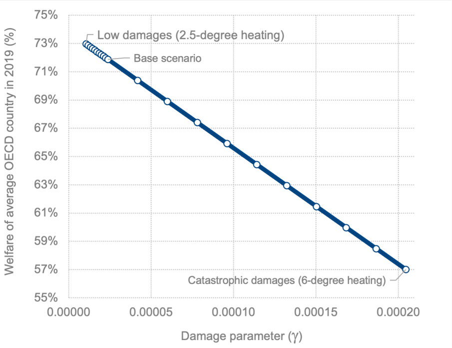

Figure 6. Sensitivity of welfare for the average OECD country in 2019 to changes in the damage parameter.
Source: Own elaboration.

The Relevance of Differentiating between Consumed and Produced Emissions

- The correlation between CO2 consumed and produced, both in per capita terms, is equal to 0.91. However, most of the OECD countries have higher levels of CO2 emissions consumed than produced.
- Thus, consumed emissions reduce social welfare by an additional -0.6% on average, from 2010 to 2019.
- The elasticity of social welfare to CO2 emissions is equal to -0.014.

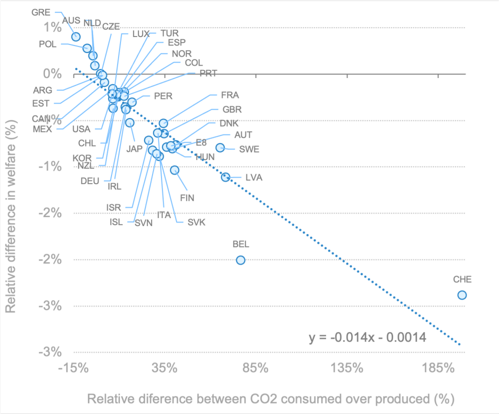

Figure 7. Changes in relative welfare as a function of the relative difference between CO2 consumed and produced, OECD countries, averages 2010-2019. Source: Own elaboration.

Conclusions

- In this paper we have extended the welfare measure proposed by Jones and Klenow (2016) to incorporate the effects of the social cost of CO_2 emissions.
- Our calibration of the social cost of CO_2 emissions is based on Golosov et al. (2014), who propose a simple formula for the optimal carbon tax under quite plausible assumptions, which is proportional to current GDP.
- Our results show that internalising the social cost of CO_2 has reduced welfare in OECD countries by 2.1%, but with significant differences between countries. We find that the elasticity of social welfare to CO_2 emissions is equal to -0.014.
- The relationship between social welfare and the discount rate used in the social cost of carbon is clearly nonlinear. Also, we find that a SCC that gives a higher probability to a catastrophic scenario significantly reduces welfare.
- The negative welfare effect is higher in OECD countries when consumed emissions are considered instead of produced emissions (the former reduces social welfare by an additional -0.6%).

ANNEX. Golosov et al. (2014): Optimal Cost of Carbon

- The formula is simple and transparent, but relies on assumptions such as logarithmic period utility, proportional climate damages, linear atmospheric CO2 stock, and constant saving rate.
- The formula is a discounted expected sum of future damage elasticities resulting from a percentage change in the amount of CO2 in the atmosphere caused by the emission of a unit of CO2 today.
- The formula does not consider future values of output, consumption, and CO2 in the atmosphere, eliminating the need for knowledge about future technology, productivity, or labor supply.
- Discounting accounts for time preferences and CO2 deprecation.

$$\tau_t^s = Y_t \bar{\gamma}_t \left(\frac{\varphi_L}{1-\beta} + \frac{(1-\varphi_L)\varphi_0}{1-(1-\varphi)\beta} \right) \tag{4}$$

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Creating Opportunities