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Effects of Introducing a CO_2 Tax: The Case of Poland

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Abstract. Actions to reduce CO_2 emissions are one of the main priorities of the European Union's climate policy. The paper presents a CGE-based analysis of the effects of introducing a CO_2 tax in Poland. Two scenarios are considered: in the first, the tax applies only to sectors with the highest emission intensity, while in the second it is extended to all sectors of the economy. The results indicate that industrial sectors based on fossil fuels - electricity, gas and heat production and supply (Section D) and transport (Section H) - are in the most adverse position, whereas low-emission industries have the potential to expand their output. Overall, the introduction of a CO_2 tax is expected to reduce GDP by 1.63%.

Keywords: CO_2 emissions, CO_2 tax, CGE model.

JEL Classification: Q58, C68, Q54.

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1. INTRODUCTION

The European Union's climate policy is primarily based on instruments designed to reduce greenhouse gas emissions. Their adoption stems from the Paris Agreement, signed on December 12, 2015. This legally binding international treaty was adopted by 196 countries at the UN Climate Change Conference (COP21) and entered into force on November 4, 2016.

The aim of this paper is to assess the economic effects of introducing a CO_2 tax in Poland using a Computable General Equilibrium (CGE) model. The working hypothesis is that such a tax will reduce GDP, while at the same time creating incentives for the development of low-emission sectors. The research methodology combines CGE modelling with statistical analysis of CO_2 emissions and energy consumption, drawing on data from international databases (GTAP, EORA, Ember, Energy Institute). Two policy scenarios are considered: in the first, the tax applies only to the most carbon-intensive sectors, while in the second it is extended to all sectors of the economy.

According to the literature, a reduction in CO_2 emissions can be achieved through the following basic instruments (De Mooij et al., 2012):

- carbon tax,
- cap-and-trade system,
- excise tax on individual fuels (e.g. coal), electricity or vehicles,
- energy efficiency standards,
- emission standards,
- incentives for renewable fuels,
- "feebates" schemes,
- regulatory combinations.

Carbon taxes should be imposed at the beginning of the fossil fuel supply chain in proportion to the carbon content of energy sources. They may also be levied on the amount of CO_2 emitted by major industrial installations.

Alternatively, cap-and-trade policies can be used to reduce emissions by requiring companies to hold allowances for each tonne (potential or actual) of CO_2 emissions. The government limits the number of allowances and facilitates trade among the companies covered by the system, making it possible to determine the market price of allowances. These schemes can also be applied either at the initial stage of determining the carbon content of fuels or at the point of emission.

Another instrument is an excise tax on individual fuels (e.g., coal, electricity) or vehicles. Energy efficiency standards may also be introduced, applying not only to vehicles but also to other goods. For vehicles, these rules should specify minimum requirements for average fuel consumption (in kilometres per litre) or maximum permissible average CO_2 emissions per kilometre. In an ideal case, emissions trading would enable specialized producers of large vehicles that fail to meet the standards to purchase credits from other entities. Such standards can also be applied to improve the energy efficiency in new buildings, household appliances, and other durable goods that use electricity.

Emission standards for the energy sector impose a maximum allowable level of CO_2 emissions per kilowatt hour (kWh), averaged across all types of power plants. Flexibility can again be ensured by allowing generators with high emissions to purchase allowances from lower-emission generators if they fail to meet the standard.

Finally, policies promoting renewable energy production (renewable fuel incentives) include portfolio standards for renewable energy (minimum share of renewable energy in a producer's fuel mix), subsidies for renewable energy generation, and guaranteed prices for renewable electricity production.

Fees for new vehicle sales would be prorated to reflect the difference between their CO_2 emissions per kilometre and the reference point, with corresponding rebates (or subsidies) for vehicles whose CO_2 emissions per kilometre are lower than the reference point. Similarly, in the electricity sector, fees per kWh impose a charge on generators in proportion to the difference between their average CO_2 emissions per kWh and the benchmark, along with a discount for generators whose CO_2 emissions per kWh are below this level.

The two most frequently used instruments aimed at reducing CO_2 emissions are taxes and tradable CO_2 emission certificates. The effectiveness of these instruments, as well as the relative advantages of one over the other, remains a matter of debate. CO_2 taxes can reduce energy intensity and energy demand by encouraging technological improvements, new equipment, and investments in the countries where the taxes are implemented. According to a World Bank report (World Bank, 2016), CO_2 prices can play a key role in implementing the provisions of the Paris

Agreement, and carbon pricing can serve as a tool supporting cooperation between countries and regions in reducing greenhouse gas emissions.

Currently, the basic tool for regulating and controlling greenhouse gas emissions in the European Union is the European Union Emissions Trading System (EU ETS). Thirty-one countries participate in the EU ETS - all EU Member States plus Liechtenstein, Norway, and Iceland. This system covers CO_2 emissions mainly from energy and industrial plants, as well as from intra-European aviation. This means that emissions from large energy-producing installations, energy-intensive industrial plants, and all flights between participating Member States are included in the EU ETS. This accounts for approximately 45% of total greenhouse gas emissions in the European Union. Moreover, tradable emission allowances for greenhouse gases are listed in the Kyoto Protocol of 1997 as one of the key mechanisms for the sustainable reduction of these gases.

The EU ETS, introduced in 2005, is the world's largest carbon emissions reduction market. The main idea is that each Member State receives an allocation of free allowances for CO_2 emissions in the form of the so-called EUA certificates (European Union Allowances), which are transferred to enterprises with high energy consumption and CO_2 emissions. One EUA certificate entitles its holder to emit one tonne of CO_2 into the atmosphere. By emitting CO_2, enterprises gradually redeem the EUA certificates they received. The EU ETS is based on the "cap-and-trade" principle described earlier. The EU sets a limit on the amount of CO_2 that can be emitted.

The penalty for CO_2 emissions without appropriate certificates is EUR 100 per tonne of CO_2. Therefore, to avoid this penalty, companies emitting large amounts of CO_2 purchase additional EUA certificates on the stock exchange. If a company introduces modernization and achieves lower emissions than expected, it can sell its excess certificates on the market. The price of certificates reached EUR 100 per tonne of CO_2 in 2023. Figure 1 presents the historical market prices of CO_2 emission allowances.

Figure 1.
Prices of CO_2 emission allowances

Note. Source: Trading Economics, Carbon. https://tradingeconomics.com/commodity/carbon (accessed January, 18, 2024).

Participation in the EU ETS is compulsory for power plants and large heat producers. There are currently approximately 11,000 installation operators in Europe subject to mandatory participation in the EU ETS. All power plants with a capacity of at least 20 MW are obliged to participate in the system. Plants in energy-intensive industries, such as steel mills, cement plants, and refineries, must exceed the specified production thresholds for these sectors to be subject to the obligation to trade emission allowances.

Since 2013, the chemical and aluminium industries have also been covered by the EU ETS. From that time, other greenhouse gases besides CO_2 have been included in trading, such as nitrous oxide (N_2O) and perfluorinated hydrocarbons (PFCs), which are much more harmful to the environment. Air transport is also subject to CO_2 emission obligations, with trading of allowances for aviation included since 2012. This currently applies to all aircraft operators conducting flights within or between EU ETS Member States.

From 2024, maritime transport is also planned to be included in the system. Moreover, a completely new, separate ETS is to come into force in 2027, covering emissions from buildings, road transport, and other sectors (EU ETS 2).

Planned activities within the EU also include the introduction of the so-called border tax, based on the CBAM (Carbon Border Adjustment Mechanism) principle. Due to the high costs of operating in the CO_2 certificate compliance zone, some companies are relocating production to regions of the world where such certificates are not required. The term *carbon leakage* - the phenomenon whereby production or investment is transferred from the EU to other countries with lower emissions-reduction ambitions, or where EU products are replaced by more carbon-intensive imports - has already been described in the literature (Pyrka & Lizak, 2009; Cygler et al., 2016). Some authors point out that this tax may cause more harm than benefits (Böhringer et al., 2014).

To limit this practice, the EU plans to introduce a border tax that would be levied on energy-intensive goods at the EU border. Several different mechanisms are being considered, but the idea is that the tax would correspond to the difference between the emission price of a tonne of CO_2 in the country of production and the emission price in the EU. It is worth emphasizing that the border tax is not an alternative to emission certificates.

To summarize, the CO_2 tax and emission certificates are currently the two basic climate policy instruments aimed at reducing greenhouse gas emissions. These instruments establish different mechanisms for determining the emission price. In the case of a CO_2 tax, the price of emissions is set directly by the legislator. In the case of the cap-and-trade system, the price is determined indirectly on market principles after the legislator sets the emission limit. According to some authors, using both of these instruments can achieve similar results (Goulder & Schein, 2013). Despite their differences, both instruments provide incentives to reduce emissions, and the burden on economic sectors and households is comparable. When it comes to the international competitiveness of enterprises, this depends on the mechanisms of international trade adjustment and the ways of subsidizing energy-intensive sectors of the economy.

Taking into account that ultimately all certificates will become payable, and that the CO_2 emission tax is, in a sense, an equivalent instrument in terms of the burden on energy-intensive branches of the economy, this study focuses on analyzing the impact of a CO_2 tax of EUR 40 per tonne and its effects on the Polish economy, using a Computable General Equilibrium (CGE) model. The disaggregation of the economy is carried out at the section level, in accordance with the Polish Classification of Activities.

2. REVIEW OF THE LITERATURE

Over the last two decades, there has been a significant increase in the number of articles devoted to the application of Computable General Equilibrium models in the analysis of environmental problems. Numerous studies in many countries have simulated the effects of CO_2 taxes using CGE models. A comprehensive review of publications on the use of CGE models to study environmental issues is provided by Kangxin et al. (2023). The authors examined 1,002 studies published between 2001 and 2021 by researchers from 51 countries, focusing on policy analyses of low-emission strategies. They indicate that the main areas of research include climate goals, CO_2 emission prices, and energy policy. In addition, CGE analyses primarily focus on the economic impact of reducing CO_2 emissions, with growing attention to social and environmental consequences.

For example, Yang et al. (2014) used a CGE model to assess the impact of a carbon tax on the Chinese economy. The authors found that it was possible to reduce CO_2 emissions by 3% through the application of a tax of 50 yuan per tonne of CO_2, and noted that the limited effectiveness of carbon taxes was associated with the inflexibility of energy demand. Similarly, Allan et al. (2014) employed a CGE model to demonstrate that a USD 50 per tonne CO_2 tax in Scotland could reduce emissions by 37% by 2020. Pereira et al. (2016) simulated the reduction of CO_2 emissions in Portugal and showed that the 2030 reduction target could be achieved by gradually increasing tax rates over time, provided that tax revenues were used to promote greater energy efficiency. Garcia Benavente (2016) applied a CGE model to the Chilean economy and found that a tax of USD 26 per tonne of CO_2 could reduce emissions by 20% over four years, leading to a 2% decline in GDP. The study also showed structural changes in electricity generation: fossil fuel consumption fell by 11%, renewable energy use rose by 43%, and electricity prices increased by 8% as indirect effects.

One main conclusion can be drawn from the reviewed articles: the introduction of a CO_2 emission tax leads to a reduction in emissions but, at the same time, results in a lower level of GDP.

In Poland, according to the KOBIZE report (2019), approximately 81.34% of greenhouse gas emissions are due to CO_2 and 11.94% to CH_4; therefore, most studies focus on CO_2 emissions. Gadomski and Kruś (2016), using a two-criteria optimization model (maximizing consumption and minimizing CO_2 emissions), concluded that the required reduction in CO_2 emissions disrupts current economic growth, but after some time, as technology evolves, the economy returns to growth along a new equilibrium path. Kiuila (2018) conducted research using a hybrid CGE model for Poland, showing that phasing out coal requires a focus on biomass, nuclear, and wind energy. Kiuila and Lewczuk (2021), in turn, pointed out that CO_2 emission permits are equivalent to taxation if there are no transaction costs. If transaction costs are present, emissions trading becomes a more expensive instrument.

An interesting study analyzing the effects of introducing the previously mentioned border tax on greenhouse gas emissions (Border Tax Adjustment), in the context of tightening EU climate policy until 2030, is a report prepared by the Center for Climate and Energy Analysis in Warsaw (Pyrka et al., 2020). The analysis presented in the report is based on calculations using a CGE model. The report examines changes in prices, volumes of imports and exports, GDP, and budget revenues of Poland and other EU countries, as well as reductions in global CO_2 emissions after the introduction of the border tax.

The main conclusions of the analysis indicate that the implementation of a border tax on emissions would result in higher prices of imported products from non-EU countries in sectors covered by the tax, accompanied by a simultaneous decline in the value of imports. With large drops in imports from sectors covered by the tax, the remaining sectors of the economy would see an increase (on average approx. 0.3%), resulting, among others, from the substitution of taxed products. This study fits into the broader trend of research on the economic effects of introducing a CO_2 emissions tax

3. METHODOLOGY AND DATA

The impact of introducing a CO_2 tax in Poland was assessed using a Computable General Equilibrium model, appropriately calibrated to the objectives of the study. As has been shown, CGE models are widely used in research on the economic effects of changes in climate policy, including the introduction or modification of taxes on greenhouse gas emissions. CGE models express economic relationships in mathematical terms and allow for predictions of changes in various variables resulting from policy interventions. These models enable the analysis of the effects of different policy decisions, taking into account the main linkages between sectors and between domestic and international production of goods and services.

The effects of introducing a CO_2 tax in the present study are analysed using the standard CGE model GTAP (Global Trade Analysis Project). The GTAP model is a multi-regional, multi-sectoral CGE framework developed by the Center for Global Trade Analysis. It was founded in 1992 by Professor Thomas W. Hertel and is located within the Department of Agricultural Economics at Purdue University.

The basic GTAP system of equations includes two types of equations. The first group concerns national accounts relationships that express the balance of revenues and expenditures for every agent in the economy. The second group consists of behavioral equations based on microeconomic theory. These equations determine the behavior of agents (producers and consumers) who optimize their decisions in the economy. The GTAP model also provides users with a wide range of options for model closure, i.e., the division of variables into exogenous and endogenous. All these features of the GTAP model justify its choice as an analytical tool.

The basic assumptions of this model are as follows: (i) constant returns to scale, (ii) perfect competition, (iii) the Armington assumption (domestic and imported goods are imperfect substitutes), and (iv) separate consideration of the value of goods and transport costs in the calculations. The theoretical framework of the GTAP model was first presented by Hertel (1997) and later updated by Corong et al. (2019).

Along with the GTAP model, a database is provided on which the model is calibrated. For this study, the GTAP database (version 9) was used, containing data on global economic activity for 140 countries and 57 industries (Aguiar et al., 2016). Among the available methods, the multi-stage Gragg procedure was applied to solve the model. Although Johansen's one-step solution method is the fastest and computationally simplest, it is only a good approximation for small shocks. Because the GTAP model is a non-linear system and the simulated changes are not small (especially in the case of energy-intensive sectors), linearization would not provide accurate results. Gragg's method, which is a variant of Euler's method, was therefore the better choice.

The regional aggregation of the GTAP database was carried out to include Poland separately in comparison with other regions of the world. In addition, sectoral aggregation of data was performed, reducing 57 sectors of the economy to 15 sections. Since preliminary data analysis showed that land and pipeline transport differ significantly from air transport in terms of emissions, Section H - Transport and Storage was divided into two parts: Transport1 (land transport and pipelines) and Transport2 (water and air transport). A detailed description of the economic sectors and the aggregation map is provided in Annex 1.

To assess the emission intensity and energy intensity of individual branches of the Polish economy, data from the EORA database were used. This database includes, among others, data on CO_2 emissions (Gg) and energy consumption (TJ) for world economies, disaggregated by industry. The most up-to-date data available are from 2015. These data were also aggregated to the section level.

Additionally, data from *Ember - Yearly Electricity Data* (2023), *Ember - European Electricity Review* (2022), and the *Energy Institute - Statistical Review of World Energy* (2023) were used for the preliminary analysis.

During the simulations, it was assumed that the CO_2 emission tax would amount to EUR 40 per tonne and that the tax burden would be proportional to the amount of emissions in a given section. The shock was defined as an additional CO_2 tax of EUR 30 per tonne, increasing the effective carbon price from EUR 10 to EUR 40 per tonne. It was converted into USD at the prevailing exchange rate, resulting in a value of USD 33.33 per tonne.

The tax rate was set at EUR 40 per tonne for two reasons. Firstly, the model calibration data are from 2015, when the price of emission allowances was approximately EUR 10 per tonne. Between 2015 and 2021, certificate prices gradually increased to EUR 40 per tonne. In the model, it was assumed that for industries previously covered by ETS certificates, the price would rise from EUR 10 to EUR 40 per tonne. Secondly, the initially estimated level of taxation for sectors to be included in the EU ETS 2 was also set at EUR 40 per tonne.

The CO_2 tax is paid by producers; therefore, it increases production costs in individual industries. The resulting price increases are transmitted to other industries, and ultimately the effects are borne by consumers.

Two scenarios were adopted:

- Scenario I - in this scenario, the tax applies only to the two sections with the largest CO_2 emissions, i.e., Section D - Energy production and supply (electricity, gas, etc.), water and air transport (subsection Transport2). This scenario can be interpreted as an analysis of the impact of changes in EUA certificate prices on the Polish economy that occurred between 2015 and 2021.
- Scenario II - in the second scenario, the tax applies to all sections. With some approximation, this scenario can be interpreted as an analysis of the impact on the Polish economy of changes in EUA certificate prices between 2015 and 2021, assuming that the EU ETS 2 system had been introduced at the same time.

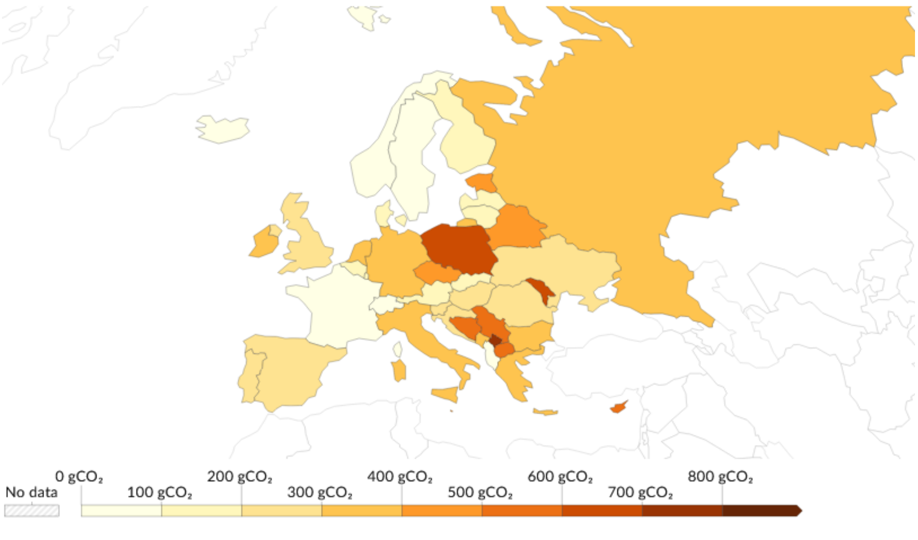
In both cases, the size of the tax burden for individual sections is calculated on the basis of CO_2 emissions in a given section.

4. PRELIMINARY ANALYSIS

The European Union (EU-27) accounts for 7.3% of global CO_2 emissions and ranks third in the world (after China with 32.9% and the United States with 12.6%). Germany is the largest emitter within the European Union. In 2021, seven German and three Polish industrial plants were among the ten largest CO_2 emitters in Europe. The top position on this list has been held consistently for 17 years by the coal-fired power plant in Bełchatów. Activities related to electricity generation are typically the largest sources of CO_2 emissions.

Poland does not compare favorably to other EU countries in terms of the CO_2 emission intensity of electricity production. Figure 2 presents the CO_2 emission intensity for electricity generation in EU countries in 2022. CO_2 emission intensity is expressed in grams of carbon dioxide equivalent (gCO_2e) emitted per kWh of electricity produced.

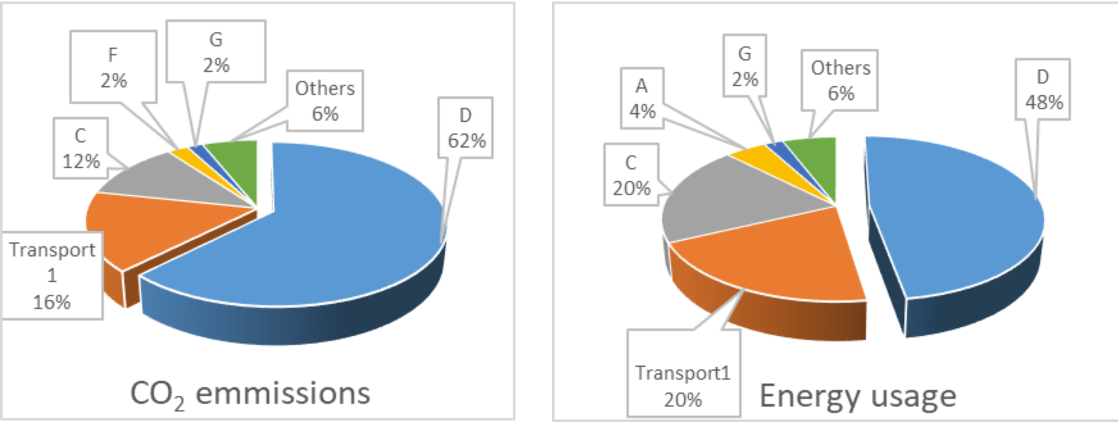
Figure 2.
CO_2 emission intensity



Note. Source: Ember - Yearly Electricity Data (2023); Ember - European Electricity Review (2022); Energy Institute - Statistical Review of World Energy (2023). *Our World in Data*. https://ourworldindata.org/grapher/carbon-intensity-electricity?time=2022&region=Europe.

Preliminary analysis of data for Poland shows that 62% of CO_2 emissions come from Section D (generation and supply of electricity, gas, etc.), 16% from land and pipeline transport, and 12% from the industrial sector (Section C). Similarly, in terms of energy consumption, the most energy-intensive sectors are Section D (48%), land and pipeline transport (Transport1 subsection) (20%), and Section C (Manufacturing) (20%). These results are presented in Figure 3.

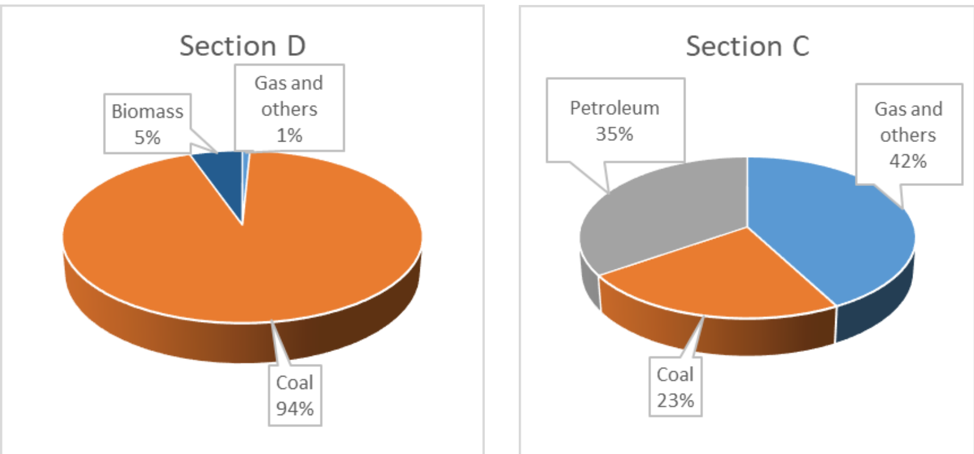
Figure 3.
CO_2 emissions and energy consumption by sections in 2015



Note. Source: EORA database (2015).

Section D consumes 48% of the energy in the country, while land and pipeline transport account for 20%. The main source of energy for Section D is coal (94%), and for transport petroleum (93%). For comparison, the industrial sector (Section C) consumes 20% of domestic energy, of which 42% comes from gas, 35% from petroleum, and 23% from coal. The energy sources for Sections D and C are presented in Figure 4.

Figure 4.
Basic energy sources for Sections C and D in 2015



Note. Source: EORA database (2015).

Table 1 presents production, CO_2 emissions, and energy consumption for each section of the Polish economy in 2015, as well as CO_2 emissions in tonnes per thousand USD of production.

Table 1.
Summary of data for Poland

Section	Production (million USD)	CO_2 emissions (Gg)	Energy consumption (TJ)	CO_2 emissions per production (tonnes per thousand USD)
Section A - Agriculture, forestry, hunting and fishing	27755	2305	157155	8.3
Section B - Mining and quarrying	6448	1044	21622	16.2
Section C - Manufactoring	161462	32979	690308	20.4
Section D - Generation and supply of electricity, gas, etc.	16453	178100	1666568	1082.5
Section E - Water supply, sewage and waste management, and remediation activities	4787	407	5246	8.5
Section F - Construction	44299	6515	27781	14.7
Section G - Wholesale and retail trade; repair of motor vehicles, including motorcycles	55608	4933	72372	8.9
Transport1 - Land transport and pipelines	13097	45347	12336	346.2
Transport2 - Water and air transport	1444	816	1024	565
Section I - Accommodation and catering services	7584	595	8571	7.8
Section J - Information and communication	10209	980	14444	9.6
Section K - Financial and insurance activities	35730	3008	43932	8.4
Section M - Professional, scientific and technical activities	25986	4901	32824	18.9
Section N - Administrative and support service activities	5272	601	8874	11.4
Section O - Public administration and defense; compulsory social security	9548	750	11562	7.9
Section P - Education	5768	455	6958	7.9
Section Q - Health care and social assistance	7565	614	9268	8.1
Section R - Arts, entertainment and recreation	6436	538	7864	8.4
Section S - Other service activities	2875	238	3436	8.3
Section T - Households with employees	557	47	616	8.4

Note. Source: Own calculations based on EORA data.

The sectoral aggregation of the EORA database was performed to match the section level of NACE Rev.2 (A-T classification). This allows for consistent comparison across sectors of the Polish economy.

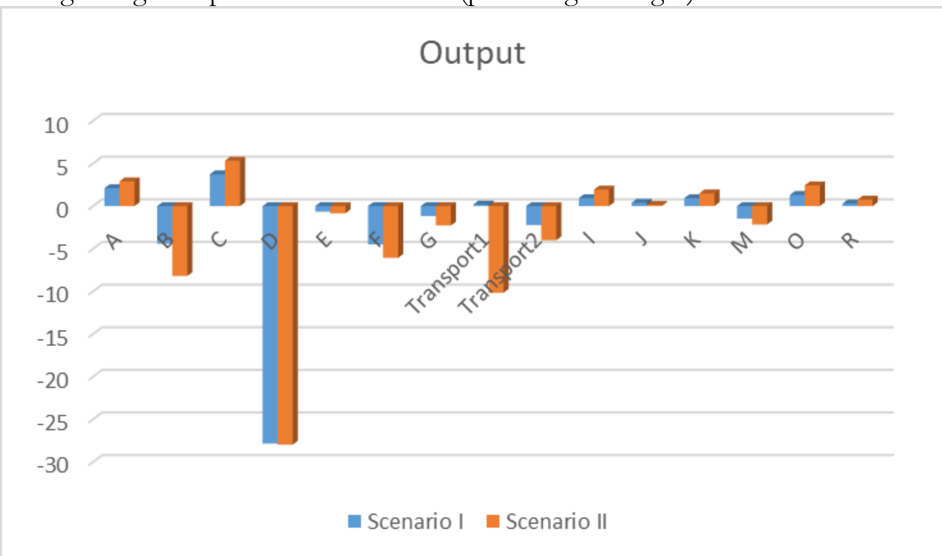
As expected, Section D and Transport1 subsection exhibit the highest emission intensity per unit of production. These results were used to define the level of taxation in the simulation analysis. It was assumed that, in the first scenario, the tax applies only to Section D and Transport1, while in the second scenario, it applies to all sections according to their CO_2 emissions per unit of production.

5. RESULTS AND CONCLUSIONS

The simulation results for Scenarios I and II are presented as percentage changes for all sections in the following variables: global production (output), exports, imports, prices, and domestic sales, as well as at the aggregated level: GDP, capital goods production, and the so-called Equivalent Variation. The latter is a measure of the change in social welfare caused by price changes and is available in the GTAP model.

The introduction of a tax on CO_2 emissions reduces the output of industries with the highest CO_2 emissions - including electricity and heat generation, transport, the refining industry, construction, trade, and professional services - in both scenarios. Large declines of almost 30% are expected in Section D. Slight positive changes are recorded in Sections A, C, I, J, K, O, and R (Figure 5).

Figure 5.
Changes in global production in Poland (percentage changes)

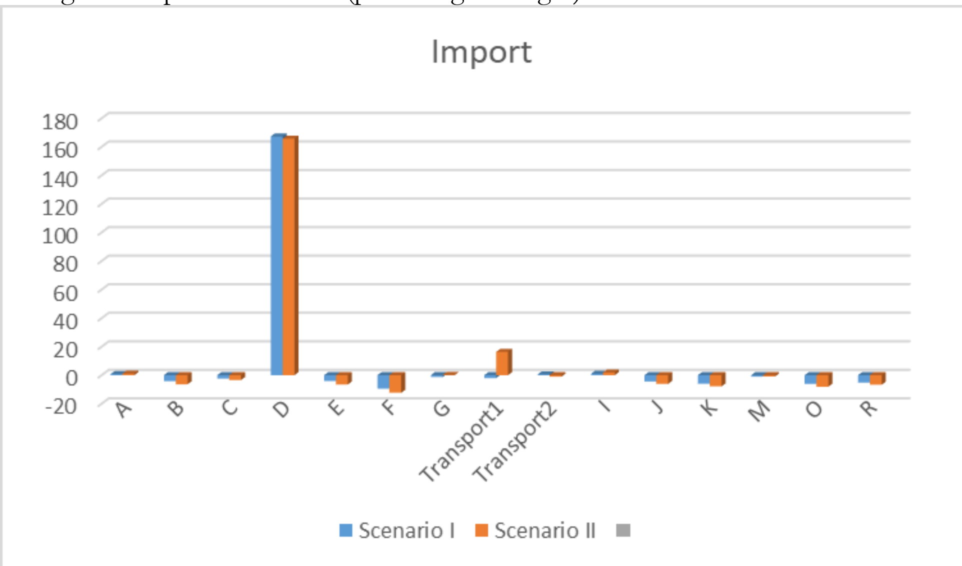


Note. Source: own calculations

In the case of a tax applied only to Section D and Transport2 (Scenario I), the negative impact is stronger in these sections, as well as in Sections B and F. Under Scenario II, the reactions of Section F (construction) and Section B (mining and quarrying) are stronger.

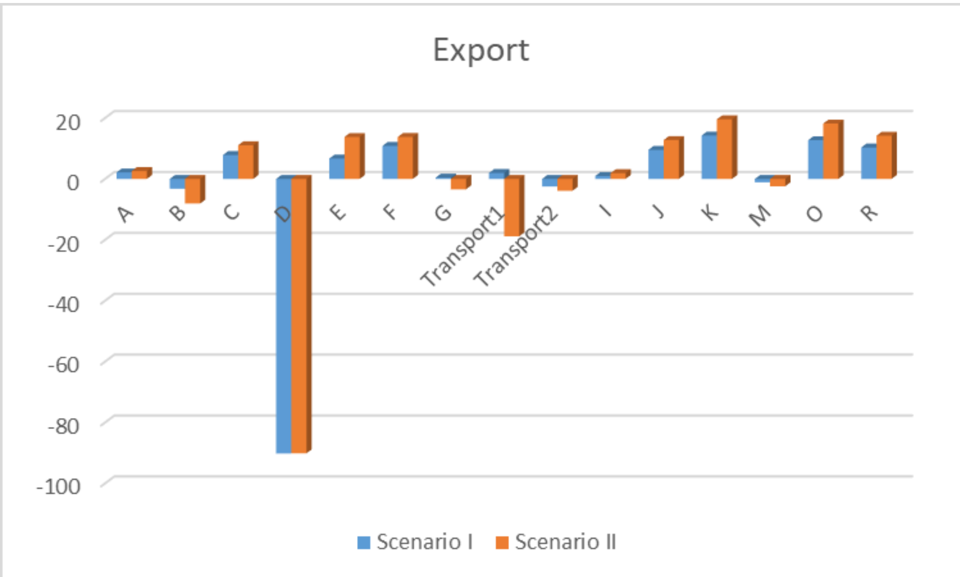
Changes in imports and exports, shown in Figures 6 and 7 respectively, indicate - as expected - an increase in imports and a decrease in exports for Section D and land transport (Transport1 subsection). In the case of Section D, these changes are substantial: imports are expected to rise by approximately 160%, while exports decline by approximately 80%.

Figure 6.
Changes in imports in Poland (percentage changes)



Note. Source: own calculations

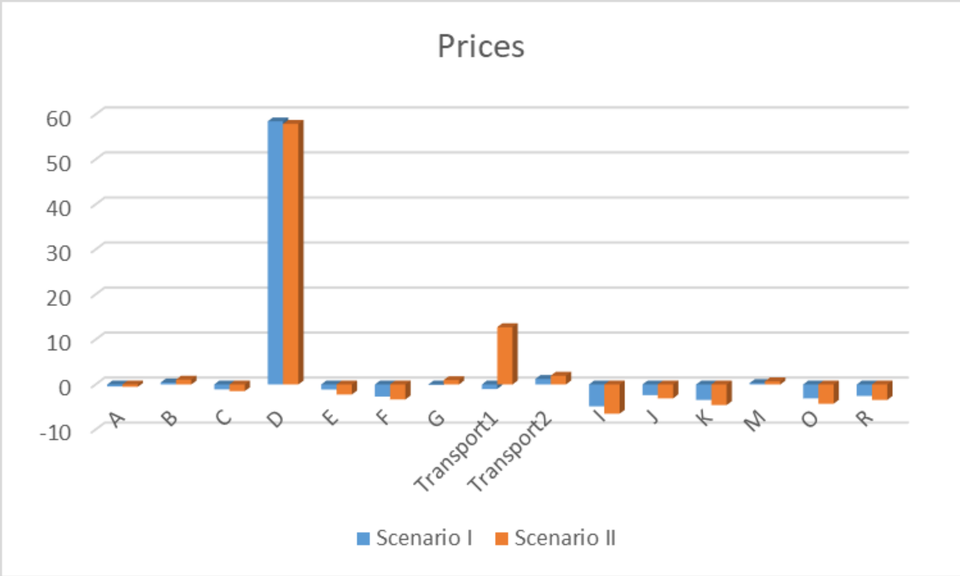
Figure 7.
Changes in exports in Poland (percentage changes)



Note. Source: own calculations

Such large changes may result from the definition of the shock in the model, as the analysis covered only changes in Poland rather than in the entire EU. Therefore, these results should be treated with caution. The introduction of a tax on CO_2 emissions leads to an increase in prices, primarily in the sections with the highest emissions and the highest tax burden. These effects are presented in Figure 7.

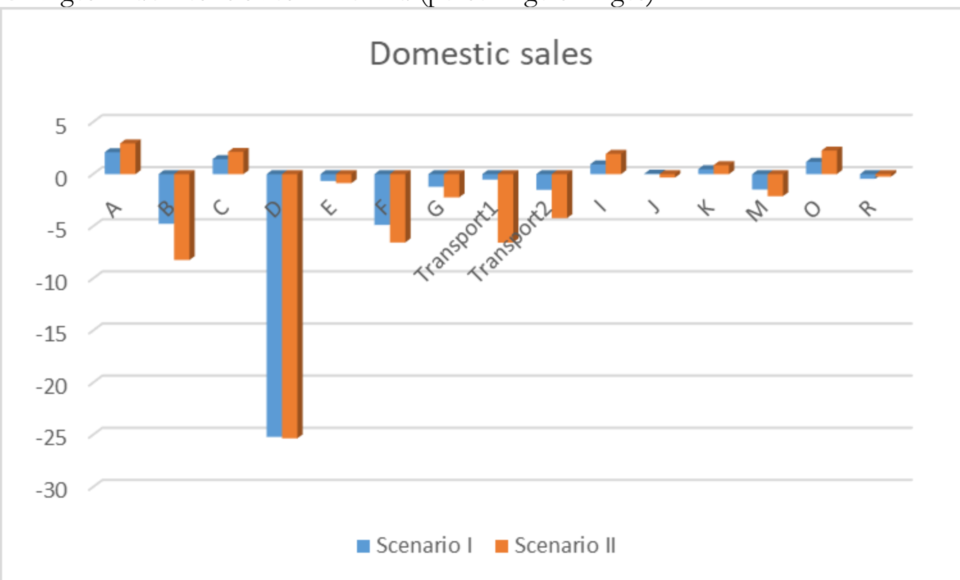
Figure 8.
Changes in prices in Poland (percentage changes)



Note. Source: own calculations

Changes in sales of domestic production, presented in Figure 9, demonstrate that sales in high-emission industries decrease significantly. These include Sections D, B, F, H (Transport1 and Transport2 subsections), G, and M.

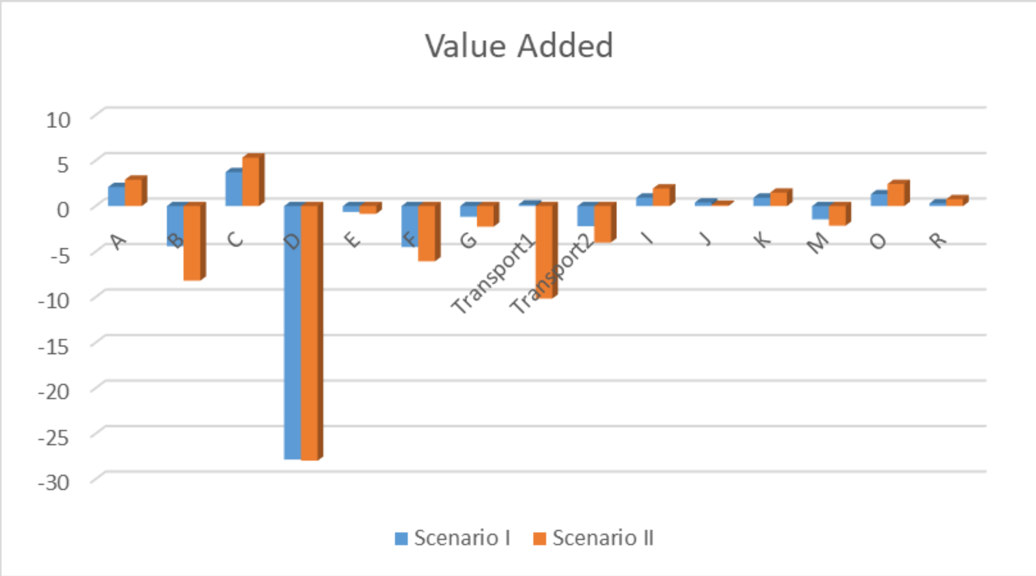
Figure 9.
Changes in domestic sales in Poland (percentage changes)



Note. Source: own calculations

Similarly, the value added generated by these sections decreases (Figure 10).

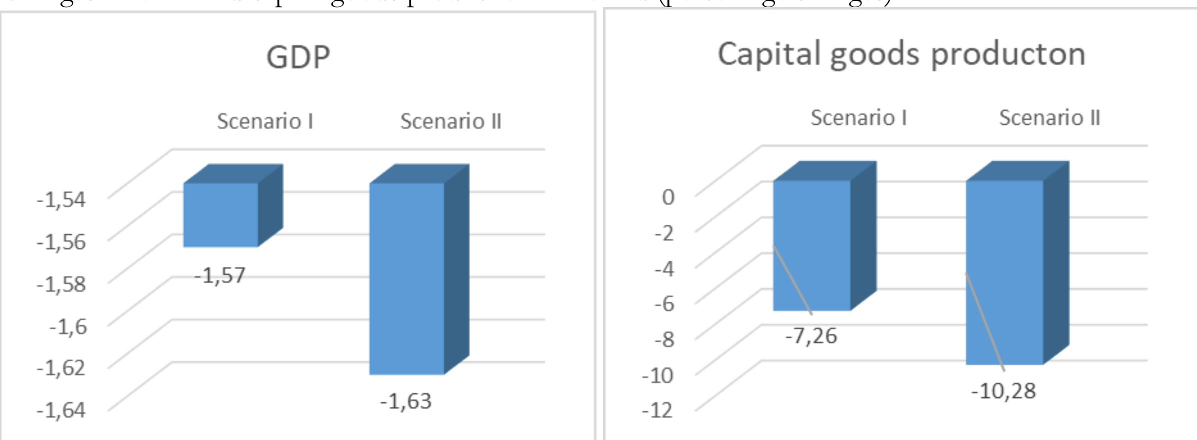
Figure 10.
Changes in value added in Poland (percentage changes)



Note. Source: own calculations

Calculations from the CGE model indicate that in both scenarios GDP declines; in the first scenario, the expected decline is about 1.57%, and in the second scenario about 1.63%. The production of capital goods also decreases, by approximately 7.26% in the first scenario and by approximately 10.28% in the second (Figure 11).

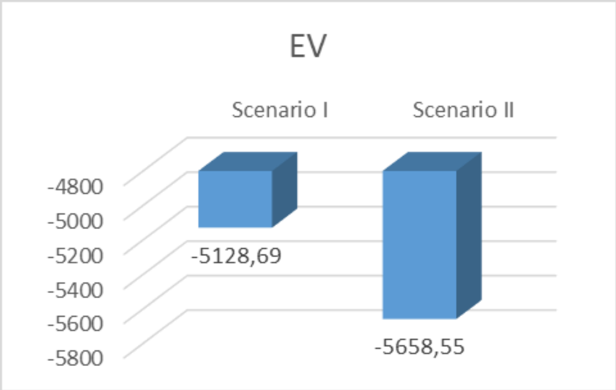
Figure 11.
Changes in GDP and capital goods production in Poland (percentage changes)



Note. Source: own calculations

Additionally, Figure 12 presents the calculation results for Equivalent Variation (EV) in both scenarios.

Figure 12.
Changes in social welfare (Equivalent Variation, EV) in Poland (million USD)



Note. Source: own calculations

The effects of introducing a CO_2 emissions tax are negative for society due to rising prices. Equivalent Variation (EV) indicates the impact on consumer income resulting from the price changes caused by the introduction of the tax.

5.1. Main conclusions

The introduction of a CO_2 tax of EUR 40 per tonne results in a general reduction in domestic production, a significant increase in imports, and a decline in exports in Section D. In both scenarios, production decreases in the sectors with the highest energy consumption: by approximately 25% in Section D and by about 9% in land and pipeline transport. The expected decline in real GDP is 1.57% in the first scenario and 1.63% in the second. As expected, extending the policy to tax a larger number of industries also generates higher costs for the economy, as a greater share of overall carbon dioxide emissions becomes subject to taxation.

The price reaction is heterogeneous: prices are expected to increase in the most carbon-intensive sectors and to decline in others. This may result from changes in production and consumption shifting toward goods that require less energy input. In both scenarios, GDP and EV decline, along with output in sectors producing capital goods.

5.2. Summary

A tax rate equivalent to a CO_2 emission fee of EUR 40 per tonne may result in a decline in GDP of 1.57-1.63%. The sectors in the most adverse situation are those based on fossil fuels, while sectors with the lowest energy consumption are expected to expand their output. The results suggest that with the policy of taxing CO_2 emissions, Poland should transition to a low-emission economy if it aims to maintain its economic competitiveness.

It is important to note that the proposed research approach has certain limitations. The first concerns the model itself: this is the standard static GTAP model, which does not capture the dynamic effects of introducing taxes. However, for the purposes of our analysis - where the tax is introduced as a one-off and permanent measure - this model appears to be an appropriate tool. Some results, particularly those related to exports and imports, may be slightly overstated because the tax shocks were applied to Poland alone. Moreover, this approach does not account for the effects of a border tax, which aims to prevent imports of goods from countries where a CO_2 tax is not applied. Shifts in production to such countries may reduce the price competitiveness of Polish and EU producers in markets outside the EU.

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