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Before implementing carbon taxes in developing countries: Egypt as a case study

Abstract: Carbon taxing is an efficient instrument that is implemented by several countries to reduce CO_2 emissions. Taxed products and services that result in emitting CO_2 in their processes will be replaced by more sustainable alternatives. Carbon taxing is associated with concerns about high energy prices that can negatively affect households and businesses. Egypt, one of the low middle-income developing countries, depends on fossil fuels to supply more than 93% of its total energy supply. In this paper, an analysis is carried out to assess the effects of a suggested carbon tax on the major carbon emitting sectors; power generation, transport and industry. The results show that the power generation sector can absorb and benefit from a suggested tax at a rate of USD 5 per ton of emitted CO_2. The transport sector, which relies heavily on subsidized liquid fuels, needs an urgent reform program to remove these subsidies, which costs the country about 10 billion USD annually, and after that, the carbon tax can be introduced. The industry sector may be affected negatively by the suggested tax, due to competitiveness with non-taxed imported products. On the other hand, this tax can help this sector to be prepared to compete when exporting its products to foreign markets that apply carbon taxes. In conclusion, developing countries like Egypt need a well-planned carbon

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tax program that can make revenues, remove subsidies, and prepare local industries for fair competitiveness in the global market.

Keywords: carbon tax, developing countries, CO_2 emissions, Egypt

1. Introduction to carbon taxing

1.1. Carbon taxing and the social cost of carbon

Carbon taxation is a fee imposed on CO_2 emissions resulting from the burning of fossil fuels. All activities that depend on burning of the fossil fuels such as thermal power generation, transport, heating processes in industries, the burning of wastes, and so on will see an increase in the price of their activities due to this new environmental tax. The tax is designed under the principle of "polluters pay" (UN 2022). Increasing the prices of goods and services resulting from carbon -emitting processes will shift consumption and production away from these activities towards more sustainable alternatives. Carbon taxing motivates emitters to invest in cleaner technology or switch to more efficient practices (Lilliestam et al. 2021).

The Social Cost of Carbon (SCC) is an estimate, in dollars, of the socio-economic cost resulting from emitting one additional ton of CO_2 into the atmosphere. The SCC reflects the cost of emissions that the public pays for, such as health problems due to air pollution caused by the burning of fossil fuel and increased levels of CO_2 emissions, in addition to other economic losses caused by climate change such as loss of households, property, land, crops, and jobs. Traditional estimates of the SCC were around 50 USD per ton of emitted CO_2 (USD/tCO_2), whereas more recent estimates are around USD 185/tCO_2 (Liu et al. 2022; Rennert et al. 2022).

From the socio-economic perspective, the carbon tax should be set equal to the SCC. From the environmental perspective, carbon taxing should be set to result in net zero emissions by 2050 (Dominioni 2022). For example, if the cost of 1 kWh of electricity generated from the fossil fuel power plant is USD 0.08 and the cost of 1 kWh of electricity generated from renewables is 0.10$, most of the consumers will choose the cheaper cost. However, if we add to the cost of the electricity generated from the fossil fuel power plant a carbon tax of USD 0.02/kWh or higher to include or "internalize" the SCC, then most consumers will be enthusiastic to have their electricity supply generated from renewables.

To achieve the goals of the Paris Agreement (PA) and stay well below 2ºC, the carbon tax should be in the range of \$50–100/tCO_2 by 2030 (with an average of \$75/tCO_2), whereas the current global average carbon tax is only \$7/tCO_2 (UNDP 2021). Narrowing this gap between the current rate and the required rate is difficult, given governments' concerns about the competitiveness impacts and relative implementation in other countries.

1.2. Carbon tax/Emission Trading System (ETS)

There are mainly two types of carbon taxing instruments: carbon tax and Emission Trading Systems (ETS). Carbon tax sets a price on CO_2 emissions in USD/tCO_2 or on the carbon content of fossil fuels in USD/unit of fuel. Finland, which was the world's first country to implement a carbon tax in 1990, has a carbon tax rate that reached USD 85/tCO_2 in 2022. Poland, which was the second country to implement a carbon tax, has the lowest tax rate of less than USD 0.1/tCO_2, and which has remained unchanged for more than thirty years. Uruguay, which is the latest country to apply a carbon tax, had the highest carbon tax rate worldwide at USD 137/tCO_2, as shown in Figure 1 (Köppl and Schratzenstaller 2022).

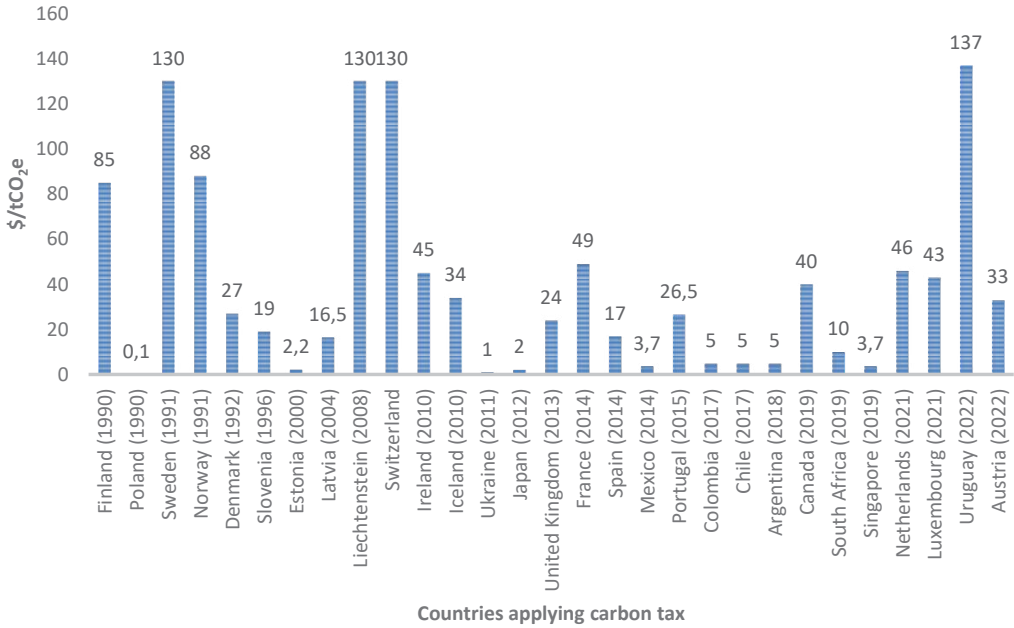

Fig. 1. Countries applying carbon tax (compiled from Köppl and Schratzenstaller 2022)

Rys. 1. Kraje stosujące podatek węglowy

In the ETS or cap-and-trade system, the government sets a maximum limit (cap) on emissions for various emitters (for example a 5% decrease in emission compared to the previous year), and allows emitters with low emissions to sell their extra allowances to larger emitters in a market-based trading system. Companies exceeding their allowances must buy new credits to increase their cap. The cap ensures that the required emission reductions will take place to keep the emitters within their pre-allocated carbon budget. The most well-known ETS is the European Union's (EU) ETS (ICAP 2022; IEA 2020).

Carbon taxes are recommended for developing countries due to its ease of implementation, fixed price, and the potential to raise significant revenues. ETSs provide more certainty over emission levels but it requires a complex monitoring, reporting and verification system. A net-zero target is a cap to be applied by 2050 (Parry et al. 2022; Stavins 2022).

1.3. Cross-border carbon pricing

In the absence of a global agreement, some countries have unilaterally adopted a carbon taxing system. This extra tax forces domestic producers to raise their cost of production. When the carbon taxing is not imposed on producers outside that country, this can reduce the competitiveness of domestic producers in comparison to foreign producers. This means that a polluting activity is reduced in countries where environmental standards are higher but increased in places with lower or no standards. This is known as "carbon leakage". Carbon leakage is characterized by the relocation of the domestic industry to a country with no/lower carbon tax. Some governments apply border carbon adjustment (BCA) or carbon border adjustment mechanisms (CBAM) as a tool to deal with carbon leakage. CBAM is a charge on embodied carbon in products imported from countries with no/low carbon pricing into a country with fair carbon tax. the EU have decided that CBAMs are to take action in 2026 (Parry et al. 2021).

1.4. Revenues of carbon pricing

In addition to decreasing emissions, there is an opportunity to collect revenues from applying carbon taxing. These revenues can be used for public investments in a green transition. In 2021, revenues from carbon pricing instruments worldwide resulted in a record 84 billion USD, with a global average price of USD 7/tCO_2. Such revenues highlight carbon taxing potential to finance investments in deep de-carbonization (World Bank 2022).

Imposing an environmental tax could produce a "double dividend" or two-fold benefits: first, a reduction in polluting emissions, and second, an increase in gross domestic product (GDP) and economic efficiency through the use of environmental tax revenues (Ghazouani et al. 2020). There is disagreement on how to spend the revenue. The most effective policy is returning part of the revenues to the most affected households and businesses within a compensation scheme and using the remaining revenues to finance environmental projects (Prasad 2022).

1.5. Carbon taxation co-benefits

Besides its impact on climate change mitigation, carbon taxation provides several co-benefits. For example, many pollutants are emitted during fossil fuel combustion such as fine particulate matter (PM2.5), sulfur dioxide (SO_2), and nitrogen oxides (NO_x); therefore, a carbon tax that targets emission reduction would lead to lower air pollution and increased public health. This co-benefit may even outweigh the climate benefits of carbon taxation. Furthermore, fuel taxes reduce overall vehicle use, lowering congestion and road accidents. Using carbon tax revenues to invest in development projects can increase the social benefit obtained from carbon taxes (Semmler et al. 2021).

1.6. Challenges to carbon taxation

1.6.1. Fossil fuel subsidies

Governments subsidized fossil fuels by approximately 6 Trillion USD in 2021 (Parry et al. 2021). Carbon subsidies are adding fuel to the fire of the climate crisis. Eliminating fossil fuel subsidies would greatly reduce global carbon emissions and would reduce the health risks of air pollution. Setting fossil fuel prices that reflect their true cost would cut global CO_2 emissions by over a third (Parry et al. 2021).

1.6.2. Fossil fuel producers

Net zero emissions would require leaving more than half of today's fossil fuel reserves un-extracted by 2050. Countries depending on exports of fossil fuels would lose a major source of foreign currency revenues. This could lead to the "Green Paradox": the anticipation of a collapse in the value of fossil fuel reserves may result in increased production, decreased prices, increased consumption and related increased emissions in the short run, thereby accelerating global warming (Rufael and Weldemeskel 2021).

1.6.3. Public acceptance

There may be strong public opposition to carbon pricing due to its increasing energy costs. This was observed in 2018, in France, when the "gilets jaunes" or (yellow vests) protests forced the government to suspend its proposal to escalate the existing carbon tax. The effectiveness of a carbon tax depends on its "acceptability" by the public. Public acceptability of carbon taxation depends on transparency in providing information about carbon taxation and its revenue use. To

be publicly accepted, the revenues of the carbon taxes can be used to compensate low-income households and fund climate projects (Maestre-Andrés et al. 2021).

2. Carbon taxation in developing countries

2.1. Carbon taxation in developed/developing countries

According to the World Bank, the term 'developing' refers to low-income and middle--income countries (World Bank 2020). Many poor countries account for a relatively small share of global emissions. South America accounts for 3% of the global CO_2 emissions and Africa accounts for 4%. Thus, they are not the countries where carbon taxing is most needed. Despite this, the economic rationale for carbon taxation applies everywhere: the contribution of each ton of CO_2 emitted into the atmosphere to climate change does not depend on where in the world it occurs. Carbon taxation have been implemented in thirty-nine developed countries and eight middle-income countries, and none of the lower-income countries, as shown in Table 1 (Koh et al. 2021). Another eight middle-income countries intend to implement carbon pricing.

Table 1. Carbon taxing in developing countries (compiled from Koh et al. 2021)

Tabela 1. Opodatkowanie emisji dwutlenku węgla w krajach rozwijających się

Country	Year of implementation	Carbon tax [USD/tCO_2]
Bulgaria	2007	EU ETS
Ukraine	2011	< 1
Kazakhstan	2013	ETS
China (pilot)	2013	ETS
Mexico	2014	3.7
Colombia	2017	5
Argentina	2018	6
South Africa	2019	10

2.2. Risks of carbon taxation to developing countries

Implementing carbon pricing in the developing countries has been associated with several risks, including high energy prices hurting households and reducing the industrial competitiveness of the economy. Firms will attempt to pass the additional costs on to their customers, resulting in higher prices for products and services. Households may suffer higher energy costs, fuel prices, transportation costs and general inflation of goods and services (Koh et al. 2021; World Bank 2020).

Increasing the cost of fuel and energy is often a risky political decision. One reason why carbon taxes have proven difficult to implement in developing countries is that they can aggregate poverty by increasing prices of basic goods and services such as food, energy and transport. Many developing countries not only do not apply carbon taxes but also subsidize fossil fuels for political and social reasons (Price 2020; UN 2021).

2.3. Benefits of carbon taxation to developing countries

There are good reasons for developing countries to seriously consider carbon taxes. Without a carbon tax, individuals and companies may now make investments in technologies that would later be wasted. For example, power companies may invest in new power plants that use fossil fuels. These will later either need to be scrapped, wasting the investment, or will lock countries into a higher emissions pathway over the medium term. A carbon tax now provides a strong signal that should help to avoid these "lock-in" effects. In addition, carbon taxes offer an important revenue source for financing environmental projects (Muhammad 2022).

3. Case study: Egypt

3.1. Country context

After a couple of years of political and economic instability after the 2011 and 2013 revolutions, the new government started reform programs in the energy sector in 2014 that were aimed at energy security and decreasing emissions.

In 2015, Egypt signed the Paris Agreement (PA) for decreasing emissions of CO_2 due to human activities, in order to limit the increase in the average global temperature to well below 2°C (hopefully 1.5°C). Egypt's share in the global CO_2 emissions is approximately 250 million tons annually (0.7% of the global emissions). The main causes for such emissions in Egypt are electricity generation, transportation and industry. De-carbonizing these sectors is the most effective way for Egypt to achieve its sustainable development goals.

In 2015, Egypt submitted its first intended nationally determined contributions (NDCs) and issued its sustainable development goals (SDGs) towards 2030, known as Egypt Vision 2030. In 2016, Egypt adopted its Integrated Sustainable Energy Strategy (ISES) with targets of supplying the increasing demand, diversifying the energy mix, and decreasing CO_2 emissions from burning fossil fuels (Abdallah and El-Shennawy 2020).

Before hosting CoP27, Egypt submitted an update to its NDCs in June 2022. In its updated NDC, Egypt has set several sectorial emission reduction targets to be achieved by 2030, as compared with a business-as-usual (BAU) scenario relative to the baseline of 2015. The country has not adopted a net zero target, nor has it set out a pathway to achieve it. These targets are lower than expected and are conditional on international financing support of 196 Billion USD for mitigation actions and 50 Billion USD for adaptation actions (Egypt 2022; CAT 2022).

Egypt made it clear in its updated NDCs that although Egypt is not one of the major emitters, it wants to contribute to the global efforts of the climate action. Egypt, as one of the developing, low-middle income countries, has limited resources to adopt the required pathways for energy transition to zero emissions. Egypt welcomes international support from the developed, richer and historical emitters (as part of their responsibilities according to Paris Agreement pledges). Unless Egypt receives the above-mentioned financial support, Egypt will continue to emit on a BaU scenario to achieve its economic growth targets, taking into consideration its new discoveries of natural gas and its infrastructure of refineries for liquid fuels, pipelines, fueling stations and liquefying gas facilities (Simões and Stanicek 2022).

Table 2 shows some economic indicators for Egypt (CAPMAS 2023; Central Bank of Egypt 2023; World Bank Group 2022). Table 3 shows some indicators related to Egypt's emissions (EIA 2022; BP 2022; Ritchie and Roser 2022).

Table 2. Egypt's relevant economic indicators compiled from (CAPMAS 2023; Central Bank of Egypt 2023; World Bank Group 2022)

Tabela 2. Zestawione odpowiednie wskaźniki ekonomiczne Egiptu

Population inside the country	104 million people (January 2023)
World bank classification	Lower middle-income country
Gross domestic product (GDP)	USD 404 billion
GDP per capita	USD 3900
Currency exchange rate	USD 1 = EGP 31 (L.E.) (May 2023)
External debts	USD 155 billion (February 2023)
National foreign currencies reserves	USD 33.45 billion (February 2023)
Government debt to GDP	87.2%
Inflation rate	25.8%
Corporate tax rate	22.5%
Personal income tax rate	25%
Population living below the poverty line	30%

Table 3. Egypt's relevant energy and emissions indicators compiled from (EIA 2022; BP 2022; Ritchie and Roser 2022)

Tabela 3. Skompilowane odpowiednie wskaźniki zużycia energii i emisji w Egipcie

Primary energy consumption (PEC) Natural Gas Oil Coal Hydro Wind Solar	3.8 EJ (2021) 58.7% 33.7% 1.3% 3.6% 1.9% 0.8%
GHG emissions (including CO_2, methane and fluorinated gases emissions)	350 $MtCO_{2e}$
CO_2 emissions Emissions from power plants Emissions from transport Emissions from industry Emissions from agriculture Emissions from wastes Emissions from construction Emissions from gas leakage & flaring Emissions from other fuels	250 $MtCO_2$ 32% 22% 16% 9% 9% 5% 4% 3%
CO_2 emissions per capita	2.47 kg
Global share of CO_2 emissions	0.68%
Rank among world emitters	26^{th}
Gasoline annual consumption Gasoline annual local production	6.7 million tons 5.7 million tons (net importer)
Diesel annual consumption Diesel annual local production	12 million tons 8.8 million tons (net importer)
Natural gas annual consumption Natural gas annual local production	61.8 billion m^3 per year 67.8 billion m^3 per year (net exporter)

4. Assessment of possible application of carbon taxes in Egypt

From Table 3, we can see that Egypt relies on fossil fuel (93.7%) to supply its energy needs, and 6.3% from hydropower and renewables. We can also see that 70% of all CO_2 emissions are from power generation, transportation and industry. Now, if any intended carbon tax might be applied in the near future, it will be applied on these three sectors, covering 175 $MtCO_2$.

In their economic analysis of the application of a carbon tax in Egypt (Elshennawy and Willenbockel 2021) suggested that a carbon tax in Egypt may start with USD 4/tCO_2 and that can be increased annually by USD 4/tCO_2 to reach USD 20/tCO_2 after five years and then stops at

that rate. In this scenario, the revenues of the carbon tax begin with 700 Million USD in the first year and increase gradually until it reaches 3.5 Billion USD after five years of implementation, given that the emissions from the aforementioned sectors will remain unchanged. The revenues will represent around 1% of the total GDP in Egypt. The expected revenues can be used to finance environmental projects. For example, we can build projects like the iconic solar photo voltaic (PV) Benban project in Egypt with a capacity of 1.5 GW each year from the carbon tax revenues. It can also be used to compensate households and small businesses who will be most affected by the new tax.

The authors of this paper suggest applying a carbon tax with a fixed rate of USD 5/tCO_2. Such carbon tax can be easily implemented without public opposition. Note that the global average of carbon taxes is USD 7/tCO_2. In the next subsections, we assess the application of a suggested carbon tax on of the targeted sectors.

4.1. Carbon tax & power generation sector in Egypt

According to the latest report of the Egyptian Electricity Holding Company (EEHC) for the state of electricity in Egypt up to 30-6-2021, the total capacity of generation plants in Egypt was approximately 59 giga watts (GW), of which 53 GW were fossil-fueled (thermal) power plants, and 6 GW were from hydro and renewable power plants (EEHC 2022).

The number of fossil-fueled (thermal) power plants in Egypt is sixty-three. Sixty power plants are owned by the government through the EEHC. Only three power plants are owned by the private sector with generating capacities of 2 GW. The main fuel used to power these sixty-three plants the natural gas (98%), followed by heavy diesel oil (2%). No coal is used in the power plants. The amount of natural gas consumed in the thermal power plants during the fiscal year 2020/2021 was approximately 38,000 million m^3, in addition to 600 kilo tons of heavy fuel oil (EEHC 2022). Given that the emission factor of natural gas is 2.2 kg CO_2/m^3, and that of the heavy fuel oil is 3.17 kg CO_2/kg, the total emissions from the thermal power plants in Egypt was approximately 85 million tons of CO_2 during the fiscal year 2020/2021.

The total energy generated from electricity in Egypt during the fiscal year 2020/2021 was 204,000 GWh, of which 180,000 GWh (88%) were from thermal power plants and 24,000 GWh (12%) were from hydropower and renewables. The emission rate from the total generating plants was 367 tons of CO_2/GWh, and for the thermal plants, the rate (without hydro or renewables) was 420 tons CO_2/GWh (EEHC 2022). Multiplying the emission rate from the thermal power plants (420 tons CO_2/GWh) with the amount of generated energy from thermal plants (180,000 GWh) results in 75 Million tons of CO_2 annually.

We can have an average value between these two values to get an average of approximately 80 million tons of CO_2. This average is equal to the value given in Table 3, which estimates the emissions from the power plants by 32% of the total CO_2 emissions in Egypt (250 million tons annually).

The electricity tariff in Egypt varies according to the users, as shown in Table 4. These tariffs are based on the price of the natural gas that is used as a fuel in the power stations. This price is currently USD 3 per million British thermal unit (MBtu).

1 MBtu is equivalent to approximately 26~28 m^3 of natural gas. This means that the price of natural gas (for power plants in Egypt) is approximately USD 0.11/m^3 of natural gas. Since 38,000 million m^3 are used to generate 180,000 GWh of thermal energy, then to generate 1 kWh of thermal energy, we need 0.2 m^3 of natural gas at a price of USD 0.022/kWh. Given that the emission factor of natural gas is 2.2 kg CO_2/m^3 of natural gas, the carbon tax on 1 m^3 of natural gas or 1 kWh of electricity is as shown in Table 5. This means that after implementing a carbon tax of 5 or 10 or USD 20/tCO_2, the price of the kWh generated from thermal power plants will increase as shown in Table 6.

Table 4. Electrical energy prices in Egypt (compiled from EEHC 2022)

Tabela 4. Ceny energii elektrycznej w Egipcie

Customer	Price
Industry	USD 0.04 /kWh
Residential / commercial low consumption (< 100 kWh / month) mid consumption (100 : 650 kWh / month) high consumption (> 650 kWh / month)	 USD 0.02 /kWh USD 0.04 /kWh USD 0.05 /kWh

Table 5. Scenarios for carbon tax on electricity

Tabela 5. Scenariusze podatku węglowego od energii elektrycznej

Carbon tax rate	USD 5/tCO_2	USD 10/tCO_2	USD 20/tCO_2
Carbon tax/1 m^3 of natural gas	USD 0.55	USD 0.011	USD 0.022
Carbon tax/1 kWh of electricity	USD 0.0011	USD 0.0022	USD 0.0044

Table 6. Electricity prices after implementing carbon taxes

Tabela 6. Ceny energii elektrycznej po wprowadzeniu podatków węglowych

Customer	Current price [USD/kWh]	Price after carbon tax of USD 5/tCO_2	Price after carbon tax of USD 10/tCO_2	Price after carbon tax of USD 20/tCO_2
Industry	0.04	0.0411	0.0422	0.0444
Residential/commercial low consumption mid consumption high consumption	 0.02 0.04 0.05	 0.0211 0.0411 0.0511	 0.0222 0.0422 0.0522	 0.0244 0.0444 0.0544

4.2. Carbon tax & transport in Egypt

The transport sector is the second largest emitter in Egypt after the power generation sector. Its share is approximately 22% of Egypt CO_2 emissions, with annual emissions of 55 million tons of CO_2. In its updated NDCs (2022), Egypt plans to decrease emissions from the transport sector by 7% of what they would be in a BaU scenario by 2030, relative to the 2015 base year. Road transport is by far the largest contributor in the transport sector in Egypt, which means the strategy will focus on encouraging a low carbon shift towards mass transit services, improving road infrastructure, and bringing greener fuel to mass transport.

According to the Central Agency for Public Mobilization and Statistics (CAPMAS) in Egypt, the number of motor vehicles in Egypt was approximately 11 million at the end of 2021. Of these vehicles, 50% (5.5 millions) were passenger cars, including ~350,000 taxis, in addition to 2.6 million motorcycles. These two types of motor vehicles use gasoline fuel (all types). Other motor vehicles included 180,000 buses (public transport, schools, tourism, private usage), 1.3 million trucks, 100,000 road trains, and 300,000 rickshaws (tuktuks). These types use diesel fuel (CAPMAS 2022). The prices of liquid fuel products in Egypt are shown in Table 7.

Table 7. Prices of liquid fuels (compiled from MoP 2023, Global Petrol Prices 2023)

Tabela 7. Ceny paliw płynnych

Fuel Type	Price in Egypt	Average global price
Gasoline 95	USD 0.37/liter	USD 1.31/liter
Gasoline 92	USD 0.33 /liter	
Gasoline 80	USD 0.28/liter	
Diesel fuel	USD 0.27/liter	USD 1.24/liter

As of May 2023, the average price of gasoline 95 around the world was USD 1.31 /liter. However, there is substantial difference in the prices among countries. As a general rule, richer countries have higher prices while poorer countries and the countries that produce and export oil have significantly lower prices. Although Egypt is a net importer of petroleum, Egypt is ranked as the seventh cheapest country in gasoline prices (Global Petrol Prices 2023).

The main problem in Egypt concerning liquid fuels is not with gasoline, it is mainly with light diesel oil. Almost all public (and private) transport buses, trucks for transporting food, goods and livestock between cities are mainly fueled by diesel. Moreover, several diesel generators are used in agricultural areas to supply electricity to rural areas. A slight increase in the prices of diesel results in an aggregate increase in all of the supply chain. As of May 2023, the average price of diesel around the world is USD 1.24/liter. Egypt is ranked as the sixth cheapest country with regard to diesel prices (Global Petrol Prices 2023). This means that the liquid fuel prices are heavily subsidized in Egypt. Now, we need a two-step action: first, we have to remove subsidies; and, second, we can then apply carbon taxes.

According to the American Petroleum Institute (API), and as a rule of thumb, the minimum price for 1 liter of gasoline may be calculated as 1.7 times the price of 1 liter of crude oil. This 70% overhead is attributed to refining costs (30%), transportation and distribution costs (20%), margins and taxes (20%). A barrel of crude oil that costs USD 80 (May 2023) contains 160 liters, this means that the price of 1 liter is USD 0.5. Therefore, the minimum price of 1 liter of gasoline will be $1.7 \cdot 0.5$ = USD 0.85. The minimum price for 1 liter of diesel may be calculated as twice the price of 1 liter of crude oil (API 2023). Large and bold steps of removing liquid fuel subsidies are required in Egypt in order to increase the prices of liquid fuels from USD 0.37, 0.33, 0.28 and 0.27 per liter to the range of USD 0.85/liter. Egypt consumes about 18.7 million tons of liquid oil annually. The average price of the liquid fuels is in the range of USD 0.3/liter, whereas the minimum (fair) price should be USD 0.85/liter. A subsidy removal program can result in huge revenues (10 billion USD annually, or 2.5% of GDP). This can also result in strong public oppositions. A carbon tax would be negligible compared to the revenues of removing subsidies.

4.3. Carbon tax & industry in Egypt

The industry and manufacturing sector is the third largest emitter in Egypt after the power generation and transport sectors with 16% emissions (40 million tons of CO_2). Egypt's updated NDC does not include specific emissions reduction targets for the industry sector. The NDC includes improving energy efficiency across all industries, with a focus on iron and steel, fertilizers and ceramic industries. Fertilizers, for example, will see a transition to low-carbon production by replacing feedstock with green hydrogen and green ammonia. The manufacturing of construction materials – including cement, red brick, paint and steel – is a major contributor of CO_2 emissions. The main pollutant in cement is the production of clinker, which releases CO_2. The government is looking to enforce a low carbon roadmap that will improve energy efficiency, introduce a partial shift to alternative fuels, and lower clinker content in cement. The prices of natural gas varies according to the industry, as shown in Table 8 (Gas Regulatory Authority 2023).

Table 8. Natural gas prices for industry (Gas Regulatory Authority 2023)

Tabela 8. Ceny gazu ziemnego dla przemysłu

Industry	Natural gas price
Cement	USD 12/MBtu
Fertilizers	USD 5.75/MBtu for non-nitrogenous fertilizers According to a price equation for nitrogenous fertilizers, with a minimum of USD 4.5/MBtu
Iron & Steel	USD 5.75/MBtu
All other industries	USD 4.75/MBtu

During the fuel crisis in Egypt a decade ago, there was a shortage in natural gas, and many cement factories switched to coal instead of natural gas. Coal is completely imported in Egypt at prices of USD 170/ton. Egypt currently enjoys being self-sufficient with regard to natural gas and, moreover, it exports all the surplus natural gas quantities through its liquefying facilities. Switching back from the dirtiest fossil fuel, coal, to the cleanest one natural gas, is not a cost -effective decision, given the long term contracts and the costly infrastructure for the imported coal. In addition, exaggerated prices of natural gas to the cement industry may make the decision unfeasible. It is worth noting that the price of natural gas to the cement industry had increased from USD 5.75/MBtu to USD 12/MBtu since Oct. 2022. This more-than-double price caused a huge increase in the prices of cement and other construction materials and lead to exaggerated prices in the real estate market. The average prices of natural gas worldwide ranges around USD 3/MBtu, with some temporary surges reaching USD 6/MBtu. We can see that the prices of the natural gas for industry in Egypt are exceeding fair prices and an additional carbon tax affects the ability of these industries to compete both domestically and abroad.

Another challenge to the industry in Egypt comes from the cross border adjustment mechanism (CBAM). This is the mechanism that the EU established to "enforce" trade partners outside the EU to apply carbon taxing to their products. Otherwise, the EU would apply carbon taxes (similar to the rates inside the EU) when these products just pass the EU borders. In its initial phase, the CBAM will cover five sectors: aluminum, cement, electricity, fertilizers, and iron & steel. Countries that rely on carbon-intensive exports to the EU will be impacted by the CBAM. While countries such as USA, China and India have tools to deal with such mechanisms, losses in developing countries like Ukraine, Egypt, Mozambique and Turkey will range between USD 1 billion to USD 5 billion, which are significant relative to their GDP (Xiaobei et al. 2022). The EU is aiming to include all goods covered by the EU ETS, which include crude oil and petroleum products, polymers, organic and inorganic chemicals, industrial gases, synthetic rubber and non-ferrous metals. This could hurt – the EU is a key trading partner for Egypt and is the largest overseas customer for the local fertilizer and metal industries (Magacho et al. 2022). In 2021, 60% of Egypt's fertilizers, aluminum, and iron and steel exports went to Europe. The financial impact is that these industries could lose 5~10% of export revenues. In the absence of a local carbon tax, Egyptian producers will likely save their more polluting products for the local market. Overland and Sabyrbekov (2022) put Egypt among the ten countries most likely to be negatively affected by the CBAM, due to the high carbon content of its products and the limited solutions available due to lower level of technological innovation. Egyptian industries are required to shift to a de-carbonized future, or alternatively, to become involved in some carbon taxing system. They can be the main drivers for the government to apply carbon taxing system. A carbon taxing system for such industries begins by first decreasing the costs of fuel to these industries to be in line with other corresponding industries in foreign countries. A flat rate of USD 3/MBtu of natural gas is common worldwide (except for the current situation in Europe due to the Russian -Ukrainian war), and we can then apply a suitable carbon tax.

5. Results and discussions

Egypt, a low-middle income developing country, with a relatively weak economy, an energy situation that depends heavily on fossil fuels, and emitting approximately 0.7% of the world's CO_2 emissions, has to consider the following considerations regarding carbon taxes:

- The country can apply carbon tax to the power generation sector. This sector is centralized by the government and collecting taxes would be easy through the sixty-three thermal power stations that use fossil fuel, mainly natural gas (98%). A suggested carbon tax of USD 5/tCO_2 emissions will result in internalizing or passing on a maximum increase in the price of electricity by 22% to residential and commercial customers with the lowest consumption (and who are currently subsidized), an increase of 11% to the industrial customers and residential/commercial customers with the mid consumption, and finally an increase of 8.8% to the residential/commercial customers with the highest consumption. These increases could be absorbed by the customers, especially after three years of fixing the electricity prices in Egypt due to the COVID pandemic and then due to the Russian-Ukrainian war. The emissions from the electricity sector represent about 32% of the national emissions, with approximately 80 Million tons of CO_2. The revenues from these taxes (400 Million USD) could be used to finance a new environmental project each year such as a PV solar system on every school.The transport sector relies heavily on liquid fuels. The 11 million motor vehicles in Egypt emit about 22% of the country's CO_2 emissions (55 million tons of CO_2). Liquid fuels are heavily subsidized in Egypt. A quick and effective subsidy removal program is required before considering applying any carbon tax. A subsidy removal program can result in annual revenues of 10 Billion USD, a huge figure that accounts to approximately 2.5% of Egypt's GDP, and can effectively enhance the weak economic situation of the country, on the condition that that the reform program would be well-planned to alleviate any political or social oppositions.
- The industry sector in Egypt is currently facing and will continue to face several challenges. The current prices for electrical energy are fair but the prices for the natural gas are high compared to the world's average. There is no opportunity to increase the prices through a carbon tax. The upcoming challenge comes from applying the CBAM to the products that are exported to the EU from other countries, including Egypt. This mechanism will impose carbon taxes on these products similar to that applied within the EU. This will limit the competitiveness of the highly carbon-intensive Egyptian products exported to the EU and will cause economic losses to these industries, unless a well-planned Egyptian carbon tax is applied, which can enhance the exporting industries to transit to a cleaner production.

Conclusions

Egypt, like most of the developing countries, needs intensive international support to mobilize technology and financing in order to get out from the hydrocarbon (fossil fuel) lock-in and move towards a greener energy transition. A well-designed carbon tax program is needed that targets the major CO_2 sector emitters in Egypt as follows:

- In the electricity generation sector, the application of a fixed carbon tax at a USD 5/tCO_2 that can make an annual revenue of USD 400 million, which can be used to finance green projects.
- In the transport sector, starting with the removal of subsidies on liquid fuels, which can save USD 10 billion to the country's economy annually.
- In the industry sector, decrease natural gas prices to USD 3/MBtu and the application of a carbon tax program to prepare local industries for fair competitiveness in the global market.

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Przed wdrożeniem podatku węglowego w krajach rozwijających się: Egipt jako studium przypadku

Streszczenie

Opodatkowanie emisji dwutlenku węgla jest skutecznym instrumentem wdrażanym przez kilka krajów w celu ograniczenia emisji CO_2. Opodatkowane produkty i usługi, które prowadzą do emisji CO_2 w swoich działaniach, zostaną zastąpione bardziej zrównoważonymi alternatywami. Opodatkowanie emisji dwutlenku węgla wiąże się z obawami o wysokie ceny energii, które mogą mieć negatywny wpływ na gospodarstwa domowe i przedsiębiorstwa. Egipt, jeden z krajów rozwijających się o niskim średnim dochodzie, jest uzależniony od paliw kopalnych, które dostarczają ponad 93% całkowitej energii. W niniejszym artykule przeprowadzono analizę mającą na celu ocenę wpływu proponowanego podatku węglowego na główne sektory emitujące dwutlenek węgla: energetykę, transport i przemysł. Sektor transportu, który w dużej mierze opiera się na subsydiowanych paliwach płynnych, wymaga pilnego programu reform w celu usunięcia tych dotacji, co kosztuje kraj około 10 mld USD rocznie, a następnie można wprowadzić podatek węglowy. Sugerowany podatek może mieć negatywny wpływ na sektor przemysłowy ze względu na konkurencyjność w stosunku do nieopodatkowanych produktów importowanych. Z drugiej strony, podatek ten może pomóc temu sektorowi przygotować się do konkurowania przy eksporcie swoich produktów na rynki zagraniczne, które stosują podatki węglowe. Podsumowując, kraje rozwijające się, takie jak Egipt, potrzebują dobrze zaplanowanego programu podatku węglowego, który może generować przychody, usuwać subsydia i przygotowywać lokalne branże do uczciwej konkurencyjności na rynku globalnym.

Słowa kluczowe: podatek węglowy, kraje rozwijające się, emisje CO_2, Egipt