The Impact of International Trade on Environment from the Perspective of Global South

A Game Theoretic Approach

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Abstract: The expansion of global trade raises questions on the impact of trade on the environment, inversely; a change in the natural environment can also modify trade patterns. This paper brings in light the impact of global integration in terms of trade on environment. One potential benefit of trade is that it allows the developing countries to adopt the new technologies from the developed countries which might potentially reduce emissions and improve the environment. When poor, developing countries are competing with each other to survive in the global market, they may not have an incentive to give away their comparative advantage of low cost of production. Being myopic, they may not adopt the new technologies of production from the West, which are environment saving but expensive. Their payoffs are not just dependent on their action (here, for instance, how much to pollute) but also on other player's actions. Therefore, a game theoretic approach seems appropriate for this setting which is the theme of this paper. The paper uses Evolutionary Stable Strategies to show the conjecture by taking a particular payoff matrix according to the assumptions. A different assumption may change the result. The paper also questions on how much of the burden of environment protection should lie on the developing countries given the First World had exploited the environment when it was there chance of growth.

INTRODUCTION

"Beggars are not choosers".

The idiom can fit well into the economic policy structure of the less developed and developing part of the world called the global south which seeks to integrate with the global north. The expansion of global trade raises questions on the impact of trade on the environment. Inversely, a change in the natural environment can also modify trade patterns. Environmental problems need a cooperative solution, for instance, reduction of the impact of climate change requires cooperation at the global level whereas the solution for Punjab's stubble burning problem requires coordination at the national level. There are undoubtedly numerous benefits of coordination, but they do not come without cost. The first difficulty arise in terms of finding an optimal share of the costs by the participating parties, as environment is a non-rival commodity there is a positive externality for those who are not participating and also the current generation is sharing the costs and benefits with the future generation which is not physically present to bargain for themselves.

The problems exacerbate in the presence of a well-integrated world. Even though the world is becoming a global village, the members are all not on an equal footing. They have different situations and priorities, their payoffs are not just dependent on their action (here, for instance, how much to pollute) but also on other person's actions. Therefore, a game theoretic approach seems appropriate for this setting which is the theme of this paper. One potential benefit of trade is that it allows the developing countries to adopt the new technologies from the developed countries which might potentially reduce emissions and improve the environment. The paper tries to analyze why this might not be the case. Also, since developed countries can strategically export emissions to the poor and developing countries, the situation might get worse for them.

I. HOW MUCH SHOULD DEVELOPING COUNTRIES PAY

This section focuses on the emission of carbon dioxide, an important greenhouse gas (GHG), but a similar result can be found for other GHGs. CO_2 absorbs the thermal radiation which traps heat and creates a greenhouse effect. Without GHGs our earth would be too cold. CO_2 emissions have primarily been driven by burning of fuel. Since the Industrial Revolution, there has been a rapid increase in the emission of CO_2. This led to a disturbance in the global carbon cycle resulting in a warming impact. Global warming has a potential physical and health ramifications.

Consequently, there is an increase in sea-level, disruption in the water system, changed crop pattern and extreme weather events such as droughts, storm, floods, and heatwaves. Although CO_2 emissions are attributed to energy production, there are other important sources, such as transportation and agriculture. The Intergovernmental Panel on Climate Change (IPCC) reported that the agriculture, forestry, and land use (AFOLU) sector was responsible for about 25 percent of global greenhouse gas emissions.

Historically, CO_2 emissions as an energy driver had been fundamental in economic growth. We find a strong positive correlation between per-capita CO_2 emission and GDP. This relation not only holds at a cross-section level but is also present over time. Figure1 shows the relationship between per-capita CO_2 emission for 201 countries and GDP per capita for the year 2014[1]. The correlation comes out to be 0.825.

[1] Data for Figure1 and 2 is taken from data published by OWID based on the Global Carbon Project, and population estimates by Gapminder and UN

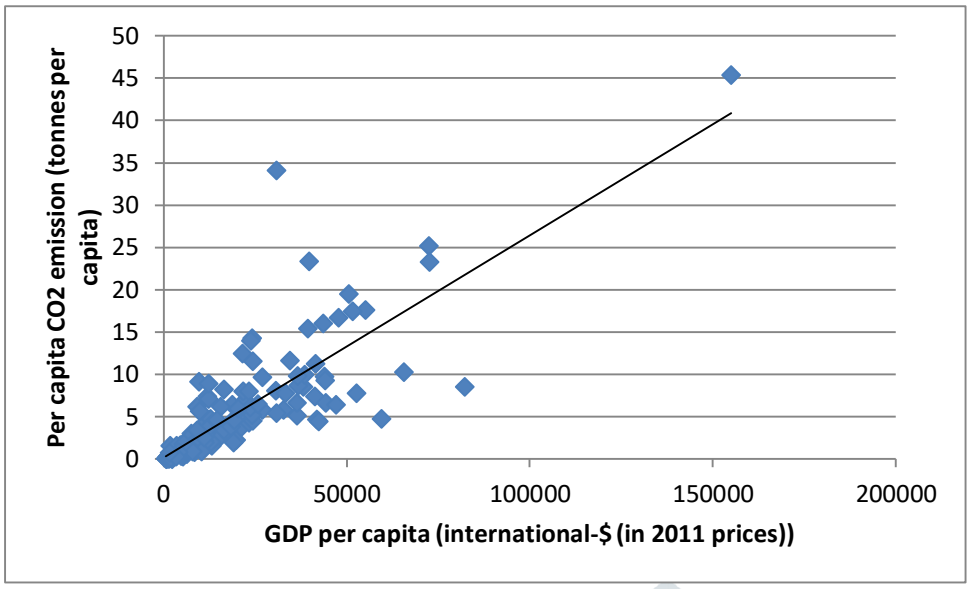

Figure 1: Plot of per-capita CO_2 emission against per-capita GDP for 201 countries (2014)

On the other hand, Figure2 shows the time series plot for CO_2 emission per capita for various countries of the global north and south for a period from 1970-2016. The emissions have been rising for both the sets but the emissions from the global north or developed part of the world are at a much higher level for the entire period under consideration, and the similar pattern can be observed for the period before it.

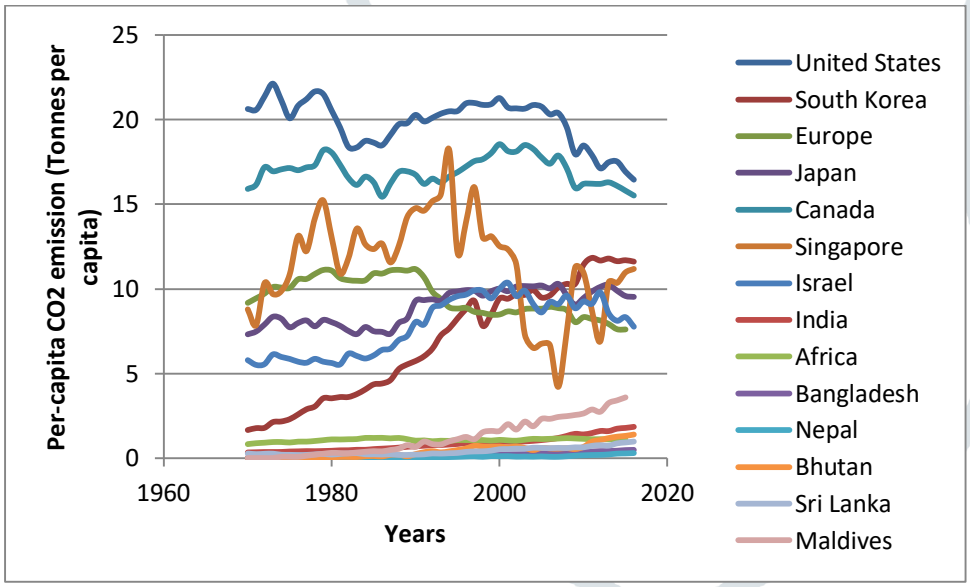

Figure 2: Time series plot of per-capita $\mathbf{CO_2}$ emission of different countries (1970-2016)

CO_2 emissions are typically reported as emissions within the geographical boundary of a country. This method does not account for the emissions which may be exported or imported in the form of internationally traded goods. Net emissions transferred, defined as CO_2 embedded in exported good subtracted from that embedded in imported goods tackles the problem. Figure3 shows a map with net emissions transferred as a percent of domestic emissions. The countries marked in red are net importers, and the countries in blue are net exporters of emissions.

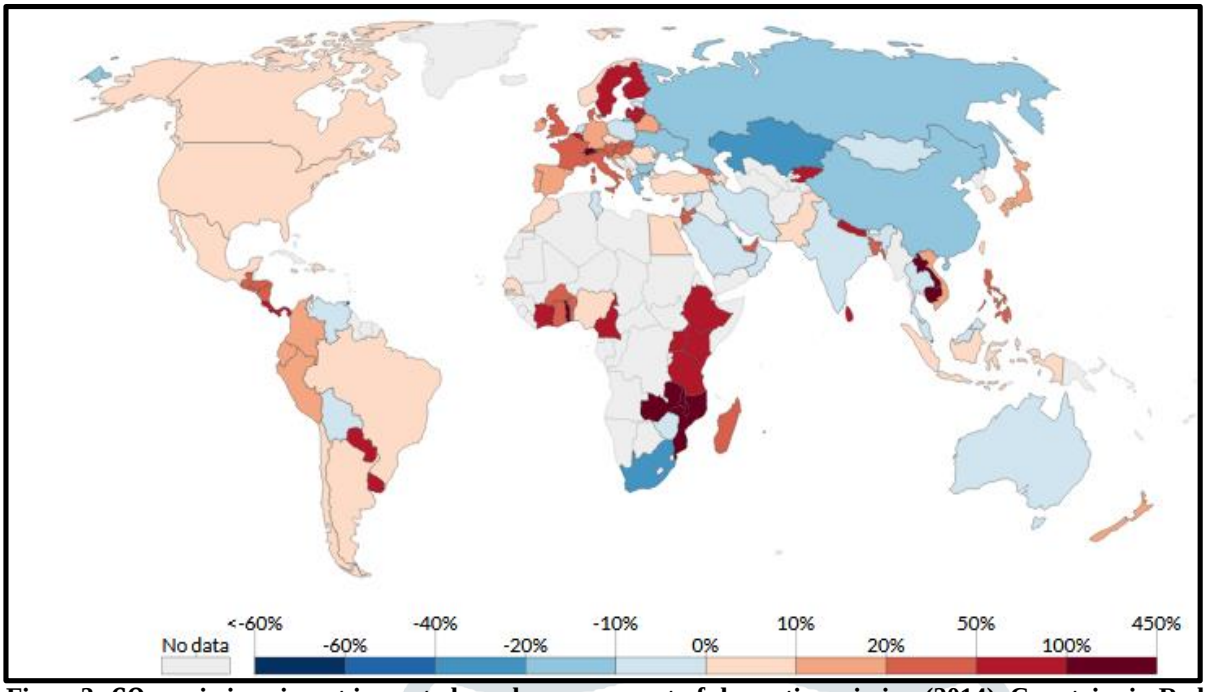

Figure3: CO_2 emissions in net imported goods as a percent of domestic emission (2014). Countries in Red as net importers and in blue as net exporter
Source: Peters et al. Global Carbon Project (http://www.globalcarbonproject.org/carbonbudget/16/data.htm)

From the figure, we see that there are large exports from Asia and Eastern Europe to North America and Western Europe. Data gathered by Peters et al. (2012) and Global Carbon Project, for consumption-based reporting, showed that in 2014 the annual CO_2 emissions for the UK would increase by 38 percent, for the USA it would increase by 7 percent. On the other hand, for developing countries like India, it would decrease by 13 percent and South Africa the emissions would fall by 29 percent. This indicates that many of the developed countries are not only emitting at a much higher per-capita level but also importing goods from developing countries, the production of which requires a higher emission, i.e., they are exporting pollution by importing goods whose production involves high environmental impacts.

These findings raise questions on how developing countries be compensated for the emissions. The ill-effects of climate change are rampant and cannot be ignored. To prevent further warming UN members have set a target of limiting average warming to 2 degrees Celsius above pre-industrial temperatures. This target can be achieved by reducing the emissions by all the countries. Even though the per-capita emissions from developing countries are increasing and that in developed countries are falling, yet the levels are much higher in the latter. What matters for the environment is the absolute emission that takes place, so, should the developing and poor countries be given their fair chance to emit if it is required for development and a considerable reduction be expected from those countries who had it enough already? Also, since it is clear from figure3 that developed countries through their imports are exporting carbon emissions to the developing countries, should these countries be compensated for the environmental damage the trade leads to? On the other hand, if the victims are over-compensated, it might also lead to a higher victim activity, in the form of higher emissions? There is no perfect answer to the questions, though it requires an extensive study to prevent further environmental damage and exploitation of the Global South.

II. THE EFFECT OF TRADE ON GLOBAL SOUTH: A GAME THEORETIC APPROACH

The expansion in world trade has raised issues about the relationship between trade and the environment. The question of whether trade is good or bad for the environment does not have a direct answer. It is clear from figure 3 that production of goods that are imported and exported have environmental effects. A potential solution to the above-mentioned problem can be to change the development process, by the introduction of green technology, which increases output and growth by reducing or at least, not increasing the emissions. This is an ideal growth path. The new technology will be beneficial only if all the countries simultaneously adopt it. It is an expensive strategy for the developing and poor countries to shift to a different process of production, as they also have to keep prices competitive to survive international competition.

The paper tries to analyze the conjecture by taking a simplified view of the world by assuming only one developed country which is involved in trade with the developing countries. These countries have to compete with each other to export their goods to the developed country which leads to an increase in income and development in the exporting country. The theory of comparative advantage by David Ricardo says that the trading partners gain from trade by specializing in the goods they can produce relatively efficiently. Developing and poor countries have the advantage of producing goods at a lower price due to cheap labor and technology. In the World Trade Organization, countries are allowed to take into account the environmental impacts of products which are traded, but they do not take into account the impact of the production process being undertaken. The process by which a product is produced cannot be accepted as a cause for trade restrictions. A country can impose controls only if the product itself is harmful (Harris, 2004).

To analyze this view the paper uses Evolutionary stable strategies which are relevant in game theory and behavioral ecology. ESS is a Nash equilibrium that is "evolutionarily" stable; once it is fixed in a population, an alternative (mutant) strategy, which is initially rare cannot successfully invade the system.

2.1 RESEARCH METHODOLOGY

The paper uses a solution called "Evolutionary Stable Strategies" (ESS) given by Maynard Smith (1972). The Nash equilibrium is a traditional and widely accepted solution concept in game theory. It takes as given that it is common knowledge amongst players that they know the structure of the game and try to predict the moves of the other players to maximize their payoffs. Whereas in ESS, it is presumed that the players' strategies are biologically encoded and heritable. They are hardwired to play a particular strategy, and it is then evaluated if that strategy survives if initially, a small proportion of the population deviates from it. ESS is a refined solution concept as every ESS is a NE, but some NE is not ESS.

Definition of ESS (Smith, 1972)

In a two player symmetric game, a pure strategy $\hat{s}$ is ES (in pure strategies) if there exists a small mutation size $\varepsilon_0 > 0$, such that for all mutation size $\varepsilon < \varepsilon_0$ hardwired to play some other strategy $\grave{s}$, the following inequality holds:

$$(1-\varepsilon)\,[U(\hat{s},\hat{s})] + \varepsilon\,[U(\hat{s},\grave{s})] > (1-\varepsilon)\,[U(\grave{s},\hat{s})] + \varepsilon\,[U(\grave{s},\grave{s})]$$

This implies that equilibrium is ES if a certain percent of individuals (mutants) deviate from the equilibrium but they die out over time and the original equilibrium prevails. In other words, expected payoff of individuals following the norm should be higher than expected payoff of individuals following the other strategy.

We can have large population of individuals with hardwired strategies, and we can pick two individuals at random and make them play the symmetric game. The player adopting the strategy yielding higher payoff will survive whereas the player whose strategy yields a lower payoff will lose and will die out. We can represent the situation of the simplistic world in our model in the form of the given normal form representation taking two developing countries having two actions.

2.2 THEORATICAL FRAMEWORK

Let us assume that there is an increasing awareness about the harmful effects on the environment throughout the world. The developed country involves a lot of research and development and comes up with a new technological process which reduces emissions during production or other activities. Trade then involves an export of the new and expensive technology from the developed country and an export of cheap goods from the developing countries which are also competing with each other and would like to keep prices as low as possible. Developing countries have an option to produce with their traditional technology or else invest in the new technology before producing and then compete in the international market. Let us assume that the traditional technology is homogenous in all the countries and produce same amount of emissions. The results that follow depend on the particular assumptions taken in the theoretical framework.

Given below is the representation of the situation as a static, complete information game.

Players: Two developing countries

Actions: {Produce with traditional technology, Produce with new technology}

Payoffs: The first best outcome for a country is when it produces with its traditional technology, and the other country adopts the new technology, as it free-rides on environmental benefits from the other country and also since it can under-cut the other country and can export to the developed country at a cheaper rate and gain the benefits. The second best outcome is when all the countries adopt the new technology and then compete with each other in the market. The gains from improvement in the environment can outweigh the cost of the new technology. Also, since the cost for all the developing countries will increase simultaneously, everyone will compete in the same manner as before. The third best outcome is when all the countries are producing with traditional technology and compete in the market, their cost structure does not change and they are in the same situation prior to the introduction of the green technology. The worst outcome would be when only the given country adopts the new technology and the other countries produce using the traditional process as the cost for the country adopting the technology will rise and it loses its comparative advantage.

The payoffs of countries according to the above mentioned assumptions can be given by the following payoff matrix

COUNTRY 2

		Trad Tech.	New Tech.
	Trad. Tech.	1, 1	3, 0
COUNTRY 1	New Tech.	0, 3	2, 2

When country 1 uses traditional technology and 2 uses new technology, the payoff of country 1 is 3 which is highest. When both the countries use the new technology and compete in the market they get a payoff of 2. When both the countries simultaneously do not adopt the new and compete with each they get a payoff of 1, which is less 2 of the previous case, which shows adopting the new technology, has benefits for both of them. The worst scenario for country 1 is when only it adopts the new technology and not the other as it loses its comparative advantage. The same analysis holds for country 2 as the matrix is symmetric.

First we see whether the strategy of using traditional technology evolutionary stable or not. Let a small proportion ε of the population deviate and adopting the new technology. For the strategy of continuing with the traditional technology to be ES, the expected payoff of the incumbents should be higher than that of the mutants for the small mutant size ε, i.e.

- $(1-\varepsilon)\ 1 + \varepsilon\ 3 > (1-\varepsilon)\ 0 + \varepsilon\ 2$
- $(1-\varepsilon)\ 1 + \varepsilon\ 3 > \varepsilon\ 2$
- $(1-\varepsilon)\ 1 + \varepsilon > 0$
- $1 > 0$

The inequality holds for any mutation size ε. Hence, the strategy of continuing with the traditional technology is ES. If only a small proportion of countries try to adopt the new technology, they will not be able to survive the competition and finally be wiped off.

On the other hand, the strategy to adopt the new technology will be ES if:

- $(1-\varepsilon)\ 2 + \varepsilon\ 0 > (1-\varepsilon)\ 3 + \varepsilon\ 1$
- $(1-\varepsilon)\ 2 > 3 - 2\ \varepsilon$
- $2 > 3$

This inequality is always false; hence the strategy of adopting the new technology is not evolutionary stable. From the above analysis we find that continuing with the traditional technology is ESS. It is a strategy that survives if a small proportion of the population deviates from it.

INFERENCE

This approach shows that the developing countries will not evolve naturally to adopt the new technology which leads to a better environment. The prime reason for this can be that, developing countries, with limited resources and development opportunities, do not give environmental problems the highest priority. For them, development at the least cost is more important. And given they also have to compete with other countries to be able to trade with developed countries, adopting a new technology increases their cost and they lose their comparative advantage. Hence, they indulge in cheap, potentially environment damaging techniques of production to keep the prices of their products low in the international market. Given the WTO mandate that the process of production is not of vital importance but the products, allows them to take up this process. These countries have a myopic outlook, and for a temporary gain they give up a larger gain because if all the countries adopt the better technology, they will achieve a higher payoff of 2, whereas, using the traditional production process gives them a payoff of 1.

The result of the above analysis will change when let's say the benefit to the country by producing using traditional technology reduces when the other country has adopted the new technology. One of the ways it can be achieved is when the products of the country are not allowed to trade in the international market which is produced using traditional technology. Also, since it will increase the costs of import for the developed country, they might have vested interests in overlooking the process of production.

POTENTIAL SOLUTION

Trade is said to be advantageous because the poor and developing countries can import better technologies from the developed countries which can lead to a reduction in emissions and improve the environment. This might not be able to give the desired results if the countries are myopic and are competing with other countries in the international market. The new technology can be effectively used if all the countries adopt it at the same time; hence the problem requires a cooperative solution at a large scale. In other words, it requires a Big Push. The actions can be coordinated by an external world-wide organization which monitors the historical emissions by all the countries and then decides how much should each country be permitted. To give further incentives, these technologies should be available at a subsidized rate, and there should be a more pronounced international recognition if a country which uses 100 percent green technology.

CONCLUSION

The paper tried to bring in light a conjecture that there can be potential environmental repercussions of trade. Developed countries can strategically export emissions to the developing countries which can be seen empirically through consumption-based reporting. The paper focuses on the emission of carbon dioxide, but similar results can be found for other gases too. Even though one benefit of trade is in terms of exporting high level of technologies from developed to developing countries, this might also not work in case the developing countries are myopic and try to maximize short-term gains. The environmental problem requires a coordinated solution at a large scale. There is a need for an unbiased international organization which takes into consideration that

emissions are necessary for the initial development and efficiently balance the emissions throughout the world. The developing countries should also not be allowed to emit at increasing rates since it will ultimately damage the environment which harms everyone. The development process should eventually be transformed into one which uses greener technology, and the cost of adoption should not be subsidized for the poor countries. Environment is a public good; if all the individuals take advantage of it, they should be equally responsible for its maintenance. Presently, trade might hurt the global south in terms of environment, but if coordinated efficiently it can prove to be effective in controlling the environmental problems.

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