4

Firms, International Trade, and the Environment in Pakistan

Theresa Thompson Chaudhry[1] and Nida Jamil[2]

Abstract

According to the World Trade Organization (WTO, 2021), international trade—including the production and transportation of manufactured goods—accounts for 20 to 30 percent of global greenhouse gas (GHG) emissions. This study examines the relationship between firms, international trade, and the environment, focusing specifically on Pakistan. Beyond transportation, international trade influences emissions through production via various channels, such as scale, technique, and composition effects. Although some of these channels have the potential to reduce emissions, the overall effect has often resulted in a net increase. Using firm-level data from Punjab, we investigate the impact of two significant trade policy changes on emissions from production in Pakistan's textile sector: the termination of the Multi-fibre Arrangement (MFA) in 2005 and the Pakistan-China Free Trade Agreement (FTA) in 2006. Emission levels and intensity were higher in the post-2005 period, particularly for the spinning sector. However, emission levels and intensity were lower for exporters to destinations other than China during the same period. Notably, emission levels and intensity peaked in 2005 compared to 2000 and 2010. While Pakistan's reliance on fossil fuels has been reduced due to hydroelectric power generation, the country still faces electricity shortages. Payments to power plants and petroleum imports to fuel them have strained government budgets and foreign exchange reserves. Renewable energy sources, such as solar power, offer significant potential to reduce the environmental footprint of Pakistan's exports. In an upcoming randomized controlled trial (RCT), we aim to explore the role of information provision in incentivizing small and medium firms in the textile and food & beverage processing sectors to adopt solar energy.

[1] Professor, Faculty of Economics and Co-Director, Innovation and Technology Center, Lahore School of Economics.
[2] Early Career Researcher, School of Economics, University of Edinburgh.

Introduction

International trade plays a pivotal role in the global economy, but its environmental impact is increasingly being scrutinized. According to the World Trade Organization (WTO), international trade, which encompasses the production and transportation of manufactured goods, is responsible for 20-30% of global greenhouse gas (GHG) emissions (WTO, 2021). This significant contribution highlights the critical intersection between economic globalization and environmental sustainability.

Certain industrial sectors stand out as major contributors to greenhouse gas emissions. The most emissions-intensive industries encompass energy production, basic metals manufacturing, coal and petroleum products, computer and electrical equipment production, chemical manufacturing, and pharmaceuticals. The complexity of global value chains has worsened transportation-related emissions. As companies source intermediate inputs from increasingly diverse and distant locations, the carbon footprint of international trade grows.

A meta-analysis by Afesorgbor and Demena (2021) estimated that the trade-openness-emissions elasticity ranges from 0.02 to 0.06, with a more pronounced impact in developed economies. Research covering the years 1991 to 2014 indicated that trade openness incrementally increased $CO2$ emissions across nearly 49 studied countries (Sun et al., 2019). Regional variations are particularly noteworthy: the Middle East and Africa exhibited the highest trade-emission elasticities, Southeast Asian countries demonstrated significant emissions correlations, and Europe uniquely experienced a reduction in pollution levels. Additionally, export diversification has been associated with higher $CO2$ emissions (Can et al., 2020).

Researchers have identified three primary channels through which trade influences environmental emissions, as outlined by Barrows and Ollivier (2018). The scale effect refers to the increase in emissions resulting from heightened production to meet foreign demand. As international markets expand, manufacturers ramp up production, consequently raising their overall greenhouse gas output. The technological effect presents a potential pathway to emissions reduction. International trade can facilitate the spread of cleaner technologies, enabling firms to lower their emissions per unit of production. Firms that specialize in core competencies tend to exhibit lower emissions intensity. The composition effect introduces a more nuanced dynamic, where changes in firms' product mix can either increase or decrease emissions intensity. These mechanisms highlight the complexity of understanding trade's environmental impact.

Developing countries present a particularly complex emissions narrative, and China serves as a compelling case study. During its World Trade Organization (WTO) accession, Chinese exporters achieved remarkable progress in reducing emissions intensity. Rodrigue et al. (2022) found that exporting lowered SO_2 intensity by over one-third, primarily through strategic energy sourcing, refined product scope, and modernized capital infrastructure. Pei et al. (2020) noted that the export intensity of Chinese firms is linked to lower SO_2 emissions intensity, although Lin & He (2022) reported mixed results.

India provides another illuminating example. Increased exports were correlated with decreased emissions intensity, driven more by product mix and pricing strategies than by technological improvements (Barrows, 2015, Ch. 1). Barrows and Ollivier (2021) noted that foreign demand heightened the emissions growth rate of Indian exporters due to the scale effect, although technological improvements partially mitigated this impact. However, policy changes such as the termination of the Multi-Fibre Agreement exposed the fragility of these emissions reductions (Barrows, 2015, Ch. 2).

Institutional frameworks significantly influence emissions variations across countries (Shapiro, 2023). Strong institutional mechanisms can favor clean industries, potentially redirect "dirty" industries to regions with more lenient environmental regulations, and influence trade policies that might inadvertently subsidize carbon emissions through the import of "dirty" inputs at lower tariffs (Shapiro, 2021).

The European Union is leading the way with aggressive regulatory mechanisms to address emissions. The Carbon Border Adjustment Mechanism (CBAM) establishes a transitional period from 2023 to 2026, during which importers must report the greenhouse gas content of their goods. Starting in 2026, purchases of mandatory certificates will be required for goods with embedded emissions, affecting industries such as cement, iron, steel, aluminum, fertilizers, electricity, and hydrogen. According to a report by Baker McKenzie (2024), the Corporate Sustainability Due Diligence Directive (CS3D) requires large companies to implement comprehensive due diligence policies, ensuring they identify and mitigate environmental and social risks throughout their operations and value chains.

These emerging regulations have profound implications for Pakistan if they are ultimately (as expected) imposed on textiles. As the world's seventh-largest textile exporter, comprising 60% of Pakistan’s total exports and 46% of its manufacturing output, the country would encounter significant challenges in adapting to new international environmental standards.

While trade provides opportunities for technological innovation and economic growth, it also presents significant environmental challenges. Collaborative, nuanced approaches that balance economic development with environmental sustainability will be essential in navigating this complex landscape.

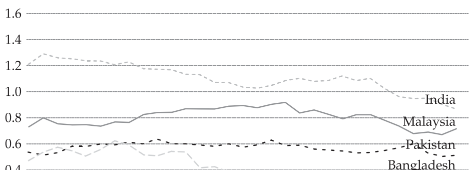
Empirical Analysis of the Trends in the Emissions of Textile Manufacturers in Punjab

Emissions are a function of the type and quantity of fuel firms use (Barrows & Ollivier, 2021). Therefore, the energy efficiency of production is a primary determinant of CO_2 emissions. NEPRA (2023) documents that over 60 percent of Pakistan's electricity comes from non-renewable thermal sources. However, Pakistan's CO_2 emissions per US$ of GDP are roughly in the middle of the pack when compared to countries such as Bangladesh, India, Malaysia, and Nigeria (Figure 1). This is likely due to Pakistan's reliance on hydroelectric power, which has reduced its dependence on fossil fuels (Figures 2-4).

Two significant events impacting textile sector exports occurred around 2005: the termination of the Multi-fibre Arrangement on January 1, 2005, and the implementation of the Pakistan-China Free-Trade Agreement in 2006.

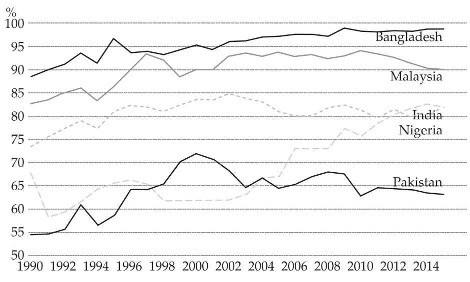
Adopted in 1974, the MFA imposed quotas on the amount of textiles and clothing that developing nations could export to developed countries, aiming to protect domestic industries in those countries. When the MFA agreement ended in 2005, the USA and Europe lifted their quota restrictions on textile and apparel imports from developing nations. Removing quotas was expected to alter trade patterns, providing Pakistan greater access to major markets like the US and EU. However, the benefits of lifting the MFA restrictions in Pakistan were somewhat diminished by various factors, including intense competition from other nations, particularly China. Consequently, Pakistan's market share in the US and EU fell (Whalley, 2006).

Figure 1: CO_2 emissions (kg per 2015 US$ of GDP)



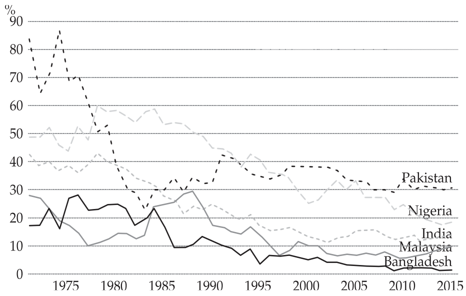
https://data.worldbank.org/indicator/EN.ATM.CO2E.KD.GD?end=2020&locations=PK-IN-NG-BD-MY&start=1990&view=chart

Figure 2: Electricity production from oil, gas and coal sources (% of total)



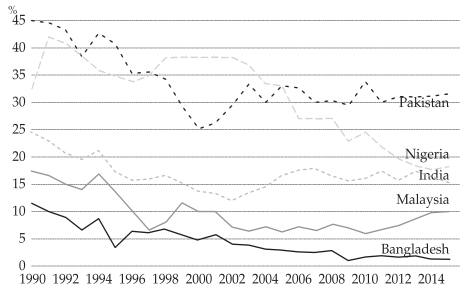
https://data.worldbank.org/indicator/EG.ELC.FOSL.ZS?end=2015&locations=PK-IN-NG-BD-MY&start=1990&view=chart

Figure 3: Electricity production from hydroelectric sources (% of total)



https://data.worldbank.org/indicator/EG.ELC.HYRO.ZS?locations=PK-IN-NG-BD-MY

Figure 4: Renewable electricity output (% of total electricity output)



https://data.worldbank.org/indicator/EG.ELC.RNEW.ZS?end=2015&locations=PK-IN-NG-BD-MY&start=1990&view=chart

At about the same time, Pakistan and China entered into a Free Trade Agreement (FTA), where both countries lowered their tariff rates. While the trade balance favored China, Pakistan's exports to China still grew by 13.6% per year between 2003-2018 (World Bank, 2020). Although tariffs fell across all segments, China's concessions to Pakistan were more significant in low-value-added sectors such as spinning and less generous in higher-value-added clothing and garments. Consequently, only the spinning segment experienced a substantial increase in exports to China.

Therefore, Pakistan's textile industry experienced two major external demand shocks in 2005-06, with contrasting outcomes. We empirically analyze the effects of these changes on the emissions of textile manufacturers, considering the timing of these changes and the firms' export destinations. We use data on the textile sector from the CMI for Punjab; details can be found in Jamil et al. (2022).

We consider the overall net effect of these two important agreements on firm-level emissions over time in equation 1a:

$$Y_{ft} = \alpha_0 + \alpha_t + \alpha_s + \alpha_{st} + \gamma_1 Post\_2005 + \theta \boldsymbol{C}_{ft} + \varepsilon_{ft} \quad (1a)$$

where Y_{ft} is log emissions or emissions per unit (i.e. emissions intensity) of firm f at time t, respectively, and the coefficient on *Post_2005* measures the ex-post changes following the trade policy changes due to the end of the MFA and the beginning of the Pak-China FTA period. α_t are year-fixed effects; α_s are segment-fixed effects, and α_{st} are segment-year fixed effects. $\boldsymbol{C}$ are controls for firm f at time t, which include firm average productivity, quality, and number of products produced, firm inputs, and dummies for missing data by year. We find that emissions and emissions intensity increased following the end of the MFA and Pakistan-China Free-Trade Agreement, driven by the spinning sector (Table 1).

Table 1: Total Emissions and Emissions Intensity (Emissions per unit) by Sector, Post-2005

	Industry	Spinning	Clothing	Finishing	Interior
Total emissions					
Post 2005	0.768***	1.388***	0.147	0.295	0.666
	(0.127)	(0.225)	(0.221)	(0.243)	(0.425)
Emissions per unit					
Post 2005	1.789***	3.108***	0.372	-0.207	0.666
	(0.189)	(0.266)	(0.303)	(0.379)	(0.846)
N	1428	715	352	209	132

Controls include firm average productivity, quality, and number of products produced, firm inputs and segment fixed effects.

Next, we consider how the trends in emissions following the end of the MFA and the beginning of the FTA period differ by export destination, where we separate firms exporting to China from firms exporting to other destinations in equation 1b:

$$Y_{ft} = \alpha_0 + \alpha_t + \alpha_s + \alpha_{st} + \gamma_1 Post\_2005 + \gamma_2 Post\_2005 * Exporter\_China + \gamma_3 Post\_2005 * Exporter\_Other\_Dest + \gamma_4 Exporter\_China + \gamma_5 Exporter\_Other\_Dest + \theta \boldsymbol{C}_{ft} + \varepsilon_{ft} \quad (1b)$$

Exporters to China had higher emission intensity, but the trend did not accelerate post-FTA (Table 2). However, exporters to other destinations saw decreased emissions and emissions intensity in the post-MFA period.

Table 2: Emissions and Emissions Intensity by Export Destination, Post-2005

	Emissions	Emissions Per Unit
Post 2005	0.811***	1.914***
	(0.134)	(0.197)
China* Post2005	0.058	-0.412
	(0.193)	(0.400)
Other destinations * Post 2005	-0.248*	-0.465*
	(0.124)	(0.218)
China	0.182	0.652*
	(0.155)	(0.360)
Other Destinations	0.047	0.121
	(0.102)	(0.193)

N=1,428

Controls include firm average productivity, quality, and number of products produced, firm inputs and segment fixed effects.

We can explore the trends in greater detail by separately considering the effects in 2005 and 2010 compared to the base year, 2000. In this context, we replace the post-2005 indicator with dummy variables for 2005 and 2010. The results presented in Table 3 tell a similar story to that in Table 1; however, when disaggregated by year, there was a notable increase in emissions intensity in 2005 (compared to 2000) that did not occur in sectors other than spinning in 2010. Emissions and emissions intensity were higher in both 2005 and 2010 compared to the base year, 2000; however, neither reached the levels seen in 2010 as they did in 2005 (Tables 3-4). The decrease in emissions intensity for non-China exporters overall (as shown in Table 2) was, in fact, consistent throughout the post-MFA period, with negative and significant coefficients on the interaction terms of exporters to other destinations for both 2005 and 2010 (Table 4).

Table 3: Total Emissions and Emissions Intensity by Sector, 2005 and 2010

	Industry	Spinning	Clothing	Finishing	Interior
Total Emissions					
Year 2005	0.846***	1.451***	0.199	0.387	1.010*
	(0.129)	(0.226)	(0.227)	(0.272)	(0.431)
Year 2010	0.615***	1.213***	0.080	0.259	0.174
	(0.136)	(0.242)	(0.248)	(0.252)	(0.440)
Emissions per unit					
Year 2005	1.969***	2.965***	0.930**	0.876**	1.666*
	(0.188)	(0.262)	(0.301)	(0.434)	(0.793)
Year 2010	1.437***	3.501***	-0.361	-0.622	-0.762
	(0.203)	(0.274)	(0.336)	(0.369)	(0.778)
N	1428	715	352	209	132

Controls include firm average productivity, quality, and number of products produced, firm inputs and segment fixed effects.

Table 4: Emissions and Emission Intensity by Export Destination, 2005 and 2010

	Emissions	Emissions Per Unit
Year 2005	0.898***	2.059***
	(0.139)	(0.198)
Year 2010	0.639***	1.564***
	(0.143)	(0.214)
China*Year 2005	0.158	0.057
	(0.268)	(0.456)
Other Destinations*Year 2005	-0.304*	-0.448*
	(0.144)	(0.240)
China* Year 2010	0.046	-0.562
	(0.207)	(0.415)
Other Destinations * Year 2010	-0.200	-0.500*
	(0.147)	(0.242)

	Emissions	Emissions Per Unit
China	0.186	0.655*
	(0.157)	(0.362)
Other Destinations	0.046	0.116
	(0.102)	(0.194)

N=1428
Controls include firm average productivity, quality, and number of products produced, firm inputs and segment fixed effects.

Promoting investment in solar energy across firms in Pakistan: the role of information provision

Pakistan's ongoing electricity shortages and dependence on fossil fuels present major challenges. Xin et al. (2022) estimate an increasing energy gap of 5,000 to 8,000 MW for the country. The financial burden on government budgets and foreign exchange reserves due to payments to power plants and oil imports highlights the urgent need for sustainable solutions. Instead of depending on fossil fuels to close this gap, Pakistan has a valuable opportunity to shift toward renewable energy production.

A transition to renewable energy would help Pakistan not only meet its growing energy demand and reduce carbon emissions but also mitigate the high cost of grid electricity, which significantly constrains the competitiveness of local firms (Bacon, 2019). While some exporting firms, especially in the innovation-driven, export-oriented Sialkot region (known for soccer balls and surgical instruments), have started adopting solar energy to comply with global environmental standards set by their branded customers, most small to medium enterprises lag behind.

A brief phone survey conducted in 2023 of about 500 companies in the targeted sectors revealed that only 16 percent had installed solar power systems. Among those without solar, more than half had considered or were actively considering it. However, cost concerns posed a significant barrier for those contemplating solar. For firms not considering solar, reasons included high installation costs, satisfaction with grid electricity, or low electricity demand.

Despite the significant depreciation of the PKR, local solar installers estimate that the payback period for solar energy has dropped to about 1.5 to 2 years as of August 2024, partly due to the declining cost of imported solar cells. However, only a small percentage of firms, especially small and medium-sized businesses, have embraced solar energy. This gap may stem from insufficient information or biased perceptions among business owners, causing them to underestimate the advantages and overestimate the costs of transitioning to solar power.

Several factors contribute to this situation. Fluctuating panel prices, currency depreciation, import controls, and increased government taxes on panels, inverters, and cables have affected the cost and availability of solar energy systems. Additionally, a common misconception is that solar energy systems require a substantial upfront investment in batteries or are incompatible with other energy sources, such as generators and grid electricity. In reality, batteries are only necessary if one wishes to entirely replace electricity from the grid. Supplementing one's grid electricity usage with solar energy is significantly more affordable, and electricity from solar panels can be integrated with the grid and generators.

Chaudhry and other co-authors plan to collect primary data on solar energy investment beliefs and intentions from a sample of 400 small and medium manufacturing enterprise owners in the textile and food/beverage processing sectors of Punjab. Through our survey measures, we will assess respondents' beliefs about future electricity costs, the benefits of solar energy sources, the perceived level of solar energy uptake in the community, the perceived prerequisites, maintenance costs, the reliability and life expectancy of the panels, and the ease or difficulty of integrating solar energy into their current energy mix. We will survey firms about their intentions to invest in solar energy in the short- and long-term and identify perceived hindrances such as the integration of solar with other energy sources, financing, and physical requirements. Additionally, the survey will collect data on control variables such as risk tolerance and time preferences.

The second part of the survey features an embedded randomized information experiment. Respondents watch videos of a peer firm discussing the benefits of investing in solar energy and various framings of affordable financing. The primary outcomes measured post-treatment will be the intention to invest in solar and interest in contacting a solar provider. Secondary outcomes will include the beliefs that influence the primary outcomes, such as attitudes toward solar and perceived behavioral control.

According to our 2023 survey, 85% of firms have received information about solar energy through "word-of-mouth" or other firms. Therefore, we believe that our video treatment has the potential to influence firms to consider adopting solar energy, as suggested by our phone survey. Our study aims to address the following questions:

- Can information be an effective means for policymakers to promote manufacturers' adoption of solar energy in a developing country?
- Are there information gaps regarding the costs and benefits of solar? If so, how substantial are these gaps?
- Can these gaps be bridged through information from peer firms?
- Are firms constrained by behavioral control problems, such as trialability and ease (or difficulty) of finance, installation, integration, and maintenance?

The study contributes to the literature on informational experiments that influence economic expectations and decision-making, particularly in the context of renewable energy adoption by firms in developing countries. The study also has policy implications for promoting green and inclusive growth, reducing carbon emissions, and enhancing energy security in Pakistan and similar settings.

Conclusions

Using firm-level data for Punjab, we examined the impact of two significant trade policy changes on emissions from Pakistan's textile sector: the termination of the Multi-fibre Arrangement (MFA) in 2005 and the Pakistan-China Free Trade Agreement (FTA) in 2006. Emission levels and emission intensity were higher in the post-2005 period, especially for the spinning sector. However, emission levels and intensity were lower for exporters to destinations other than China in the same period. Emission levels and emission intensity peaked in 2005 compared to 2000 and 2010.

A field experiment with an embedded informational intervention will be conducted in late 2024 through early 2025. This study aims to understand the constraints faced by small and medium firms in adopting solar energy. Our exploratory study will not only help identify and measure the relative role of structural and informational barriers preventing business owners from investing in solar energy but also provide a first critical step in assessing the impact of information provision on intended solar energy purchasing behavior. The study also has policy implications for promoting green and inclusive growth, reducing carbon emissions, and enhancing energy security in Pakistan.

References

Afesorgbor, S. K., & Demena, B. A. (2021). Trade Openness and Environmental Emissions: Evidence from a Meta-Analysis. *Environmental and Resource Economics*, *81*(2), 287–321. https://doi.org/10.1007/s10640-021-00627-0

Bacon, R. (2019, May 6). *Learning from Power Sector Reform: The Case of Pakistan*. Social Science Research Network. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3383813

Baker McKenzie. (2024). *European Union: The new Corporate Sustainability Due Diligence Directive has been provisionally agreed, what does this mean for companies? | Insight*. Baker McKenzie. https://www.bakermckenzie.com/en/insight/publications/2024/01/corporate-sustainability-due-diligence-directive

Barrows, G. (2015) *Essays on Technology and the Environment from an International Perspective.* University of California Berkeley. https://escholarship.org/uc/item/0nj2q50r

Barrows, G., & Ollivier, H. (2018). Cleaner firms or cleaner products? How product mix shapes emission intensity from manufacturing. *Journal of Environmental Economics and Management*, *88*, 134–158. https://doi.org/10.1016/j.jeem.2017.10.008

Barrows, G., & Ollivier, H. (2021). Foreign demand, developing country exports, and CO2 emissions: Firm-level evidence from India. *Journal of Development Economics*, *149*, 102587.

Can, M., Dogan, B., & Saboori, B. (2020). Does trade matter for environmental degradation in developing countries? New evidence in the context of export product diversification. *Environmental Science and Pollution Research*, *27*(13), 14702–14710. https://doi.org/10.1007/s11356-020-08000-2

Jamil, N., Chaudhry, T. T., & Chaudhry, A. (2022). Trading textiles along the new silk route: The impact on Pakistani firms of gaining market access to China. *Journal of Development Economics*, *158*, 102935. https://doi.org/10.1016/j.jdeveco.2022.102935

Lin, Xi & He, L.-Y. (2022). The More the Merrier? Evidence from Firm-Level Exports and Environmental Performance in China. *Environmental and Resource Economics*, *84*(1), 125–172. https://doi.org/10.1007/s10640-022-00717-7

NEPRA. (2023). *STATE OF INDUSTRY REPORT 2023*. Nepra.org.pk. https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202023.pdf

Pei, J., Sturm, B., & Yu, A. (2020). Are exporters more environmentally friendly? A re-appraisal that uses China's micro-data. *The World Economy*, *44*(5), 1402–1427. https://doi.org/10.1111/twec.13024

Rodrigue, J., Sheng, D., & Tan, Y. (2022). Exporting, Abatement, and Firm-Level Emissions: Evidence from China's Accession to the WTO. *Review of Economics and Statistics, 106*(4), 1-45.

Shapiro, J. S. (2021). The Environmental Bias of Trade Policy*. *The Quarterly Journal of Economics*, *136*(2), 831–886. https://doi.org/10.1093/qje/qjaa042

Shapiro, J. S. (2023). Institutions, Comparative Advantage, and the Environment. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4596068

Sun, H., Attuquaye Clottey, S., Geng, Y., Fang, K., & Clifford Kofi Amissah, J. (2019). Trade Openness and Carbon Emissions: Evidence from Belt and Road Countries. *Sustainability*, *11*(9), 2682. https://doi.org/10.3390/su11092682

Whalley, J. (2006). The Post Mfa Performance of Developing Asia. *NBER Working Paper No. w12178*.

World Bank. (2020). *The Pakistan- China Economic Corridor and the Growth of Trade.* Washington, D.C. . Retrieved from http://documents.worldbank.org/curated/en/674251583850888285/The-China-Pakistan-Economic-Corridor-and-the-Growth-of-Trade

World Trade Organization. (2021). *Trade and Climate Change Information Brief N°4 Carbon Content of International Trade 1*. World Trade Organization. https://www.wto.org/english/news_e/news21_e/clim_03nov21-4_e.pdf

Xin, Y., Bin Dost, M. K., Akram, H., & Watto, W. A. (2022). Analyzing Pakistan's Renewable Energy Potential: A Review of the Country's Energy Policy, Its Challenges, and Recommendations. *Sustainability*, *14*(23), 16123. https://doi.org/10.3390/su142316123