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The Effect of Nuclear Power on Carbon Intensity

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Introduction

The world is currently facing one of the biggest threats to the environment in its history: the warming of the Earth's surface due to climate change. One major contributor is the release of greenhouse gases, such as carbon dioxide, into the atmosphere by humans. To reduce these emissions, countries are making a concerted effort to invest in more sustainable energy sources. Nuclear power is one green energy source that can potentially support the transition to lower carbon emissions. Nuclear power plants release no carbon emissions during the generation of electricity. The only emissions are a result of maintenance, such as mining and refining of the uranium ore used (4). Nuclear power plants also produce at the highest capacity factor of any energy source and with a relatively low level of radioactivity (3). However, there is controversy surrounding nuclear energy and its perception by the public. One factor is the well-known reactor meltdowns at Three Mile Island, Chernobyl, and Fukushima. Another is nuclear waste, despite it being recyclable.

To better understand nuclear power's relationship with overall carbon emissions, this project explores the effect electricity by nuclear power generation has on carbon intensity (kg per PPP \$ of GDP) in different levels of electricity.

Methods

Data for nuclear power generation was collected by the included countries' data collection agencies and compiled by the U.S. Energy Information Administration (1). Data for carbon intensity was collected by Climate Watch (2). 5 countries were chosen from the highest, median, and lowest nuclear generation outputs from 2018 and separated by those levels: Argentina, Armenia, Belgium, Bulgaria, Canada, China, Czechia, Finland, France, Netherlands, Pakistan, Slovenia, Switzerland, Ukraine, and the United States. Several countries were excluded due to lack of data: Russia, South Korea, Taiwan, and Iran. The nuclear generation and carbon intensity for the included countries were examined from 1990-2018.

Results

Electricity by nuclear power generation was a significant predictor of carbon intensity in the countries examined for the high (ANOVA on LM, $F = 58.726$, $df = 2/135$, $p < 0.05$) and medium (ANOVA on LM, $F = 142.38$, $df = 4/140$, $p < 0.05$) levels. However, it was not a significant predictor of carbon intensity in the countries examined for the low level (ANOVA on LM, $F = 5143$, $df = 10/129$, $p > 0.05$).

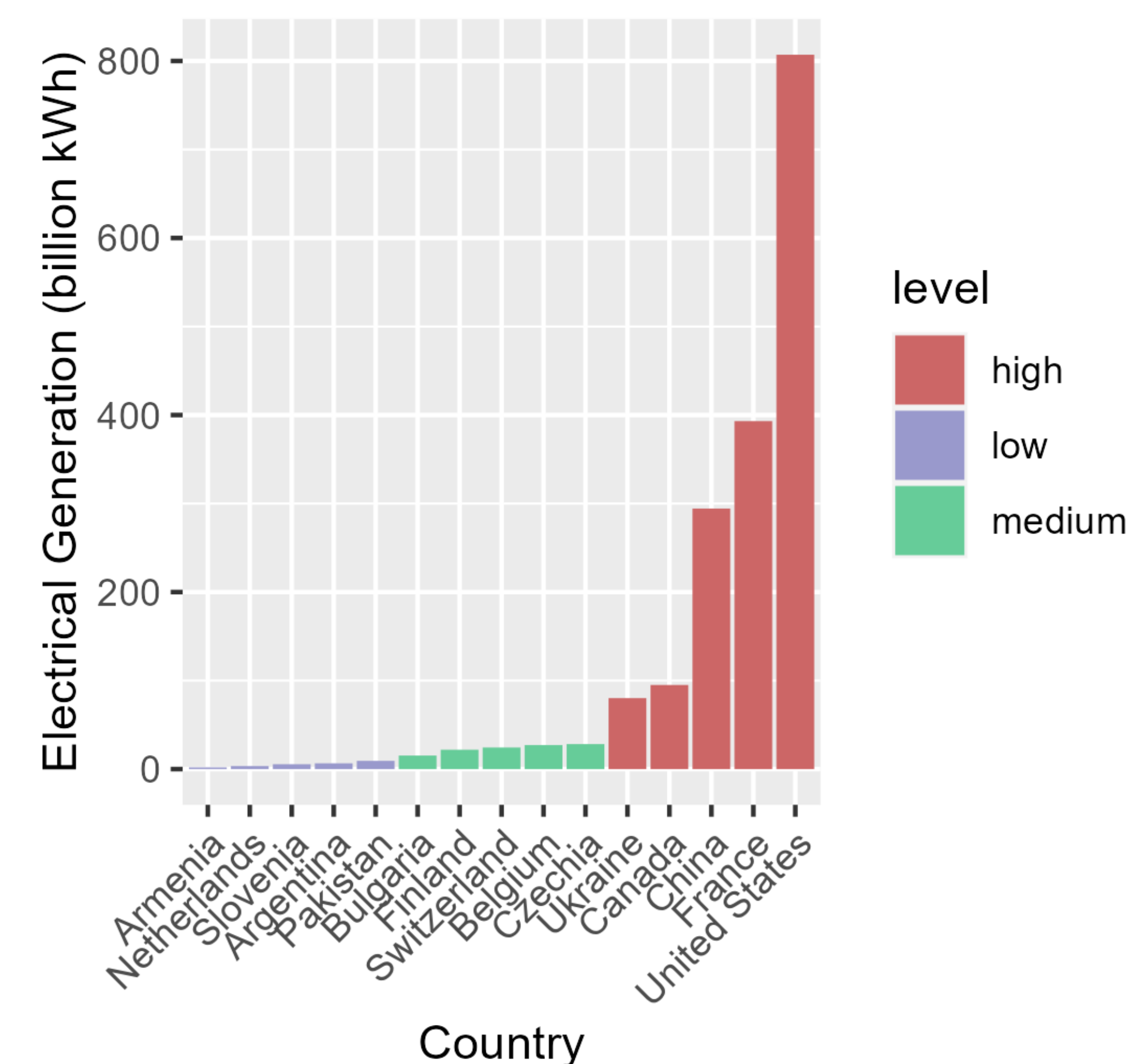


Fig 1. Electrical generation by nuclear power in 2018 across 15 countries of high, medium, and low levels

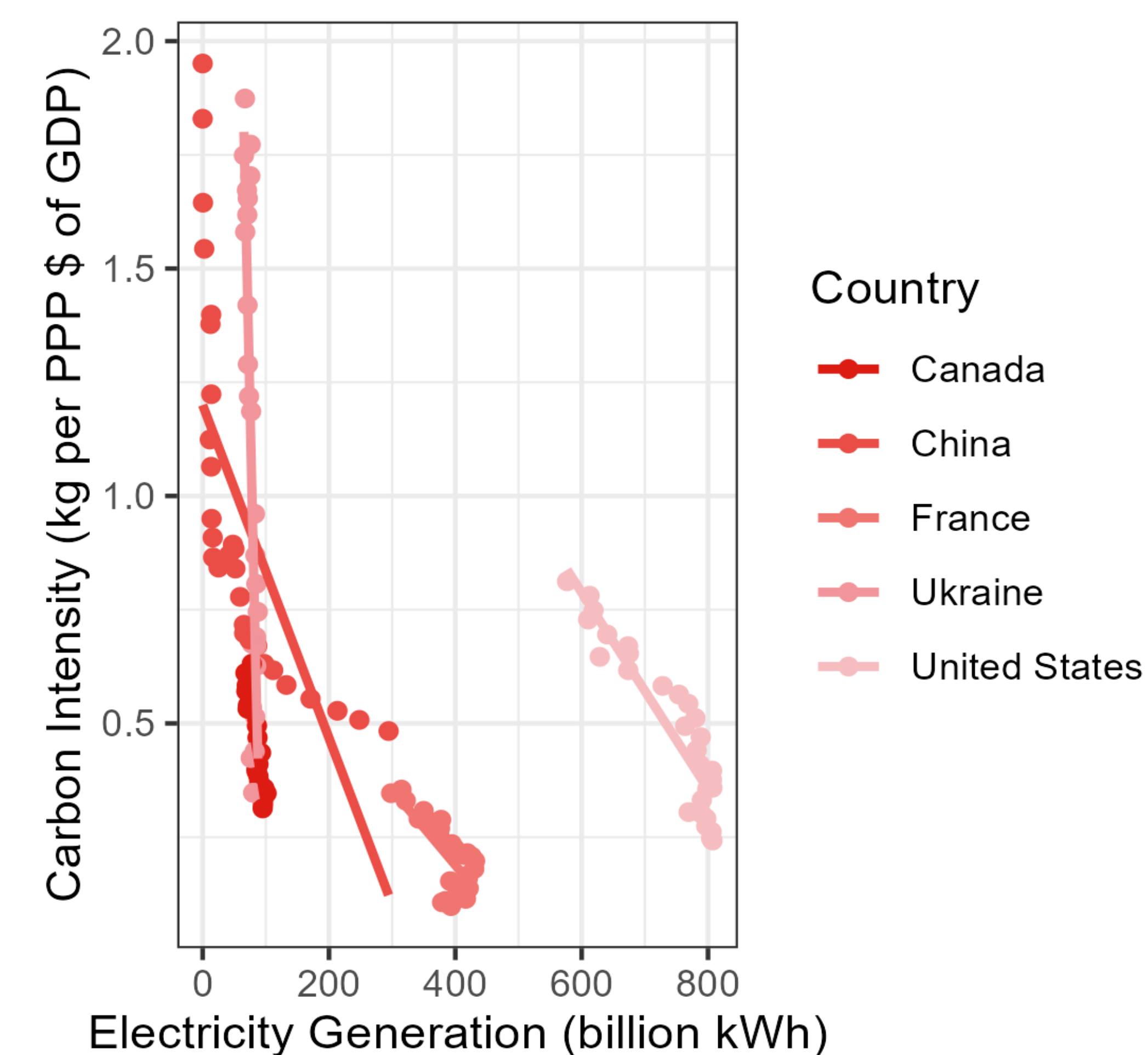


Fig 2. Carbon intensity over electrical generation by nuclear power in countries in the high level

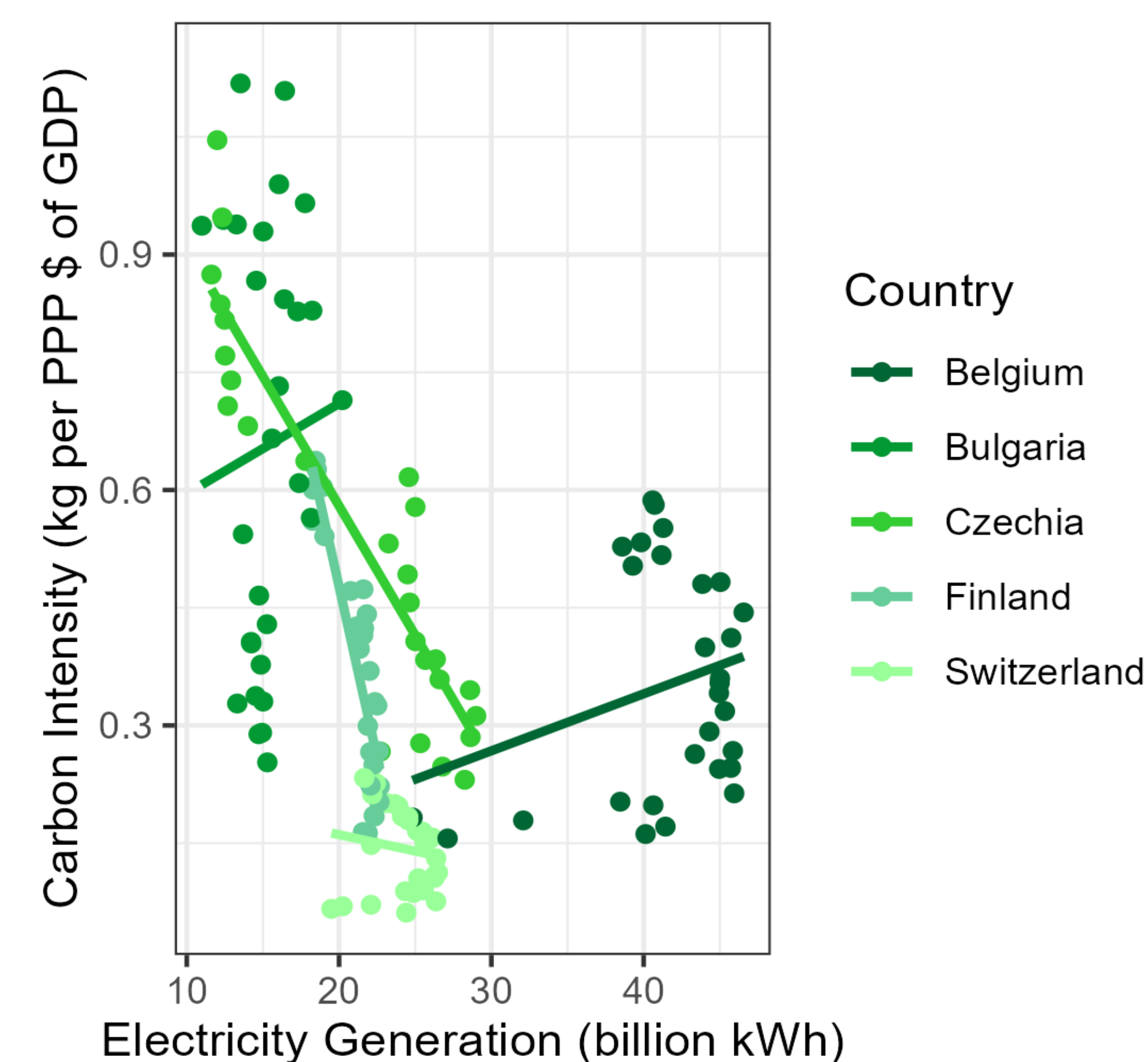


Fig. 3 Carbon Intensity over electrical generation by nuclear power in countries in the medium level

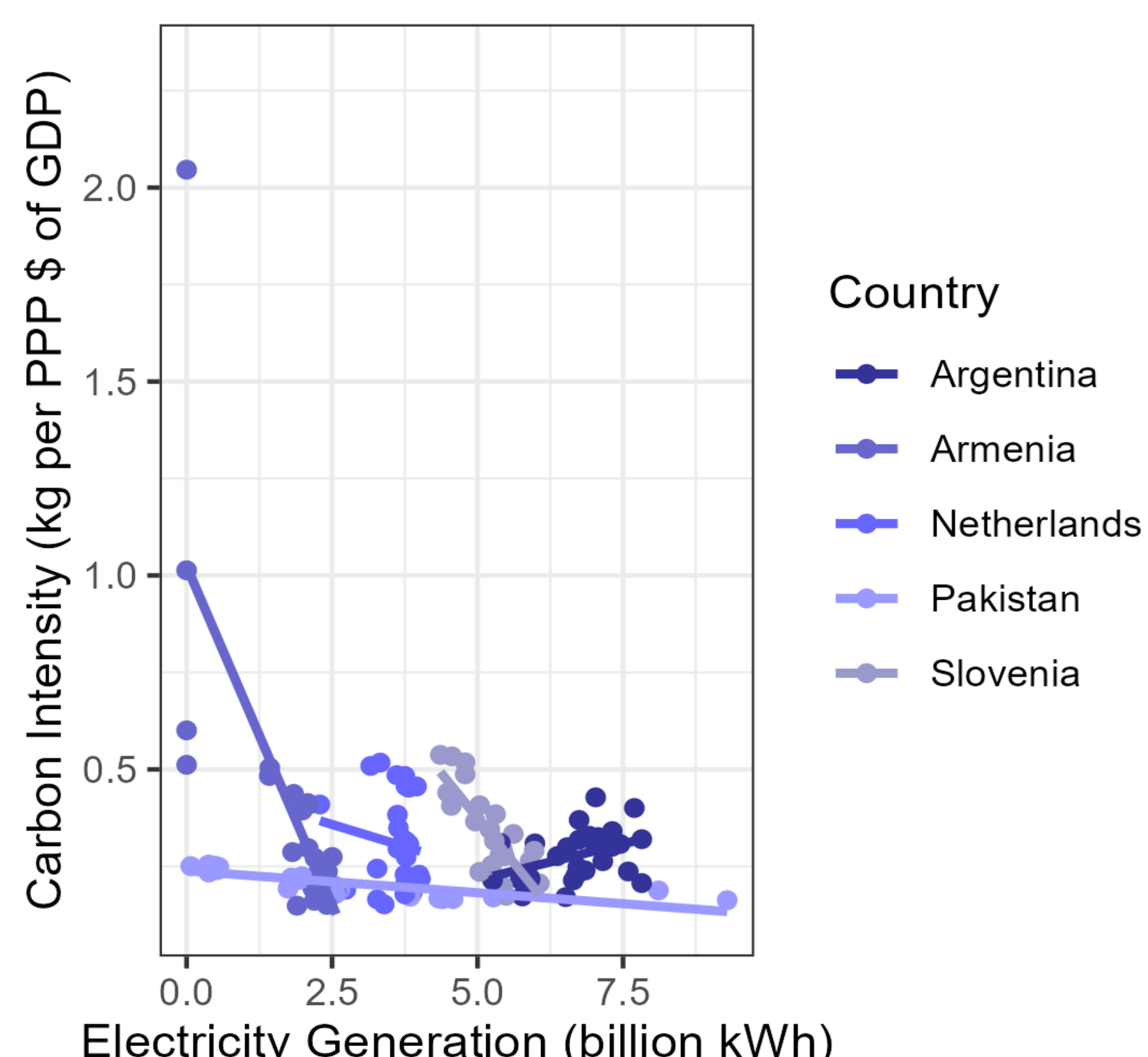


Fig. 4 Carbon Intensity over electrical generation by nuclear power in countries in the low level

Conclusion

There is a potential correlation between electricity generation by nuclear power and carbon intensity. This was evident in the medium and high levels of nuclear generation, but it was not in the low level. One reason for this could be that countries need to reach a minimum threshold of nuclear output for carbon emissions to decrease. However, the inconsistency across all levels could mean that base nuclear power generation is not an effective indicator of reduction in carbon emissions. In future research, the percentage of overall electrical generation by nuclear power compared to other energy sources may show a stronger correlation. Only looking at nuclear generation output does not include a country's reliance on it as an energy source. Analyzing nuclear power as a percentage of total power usage could support the notion that nuclear power is the future of green energy.

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