Identifying the Drivers of GHG Emissions

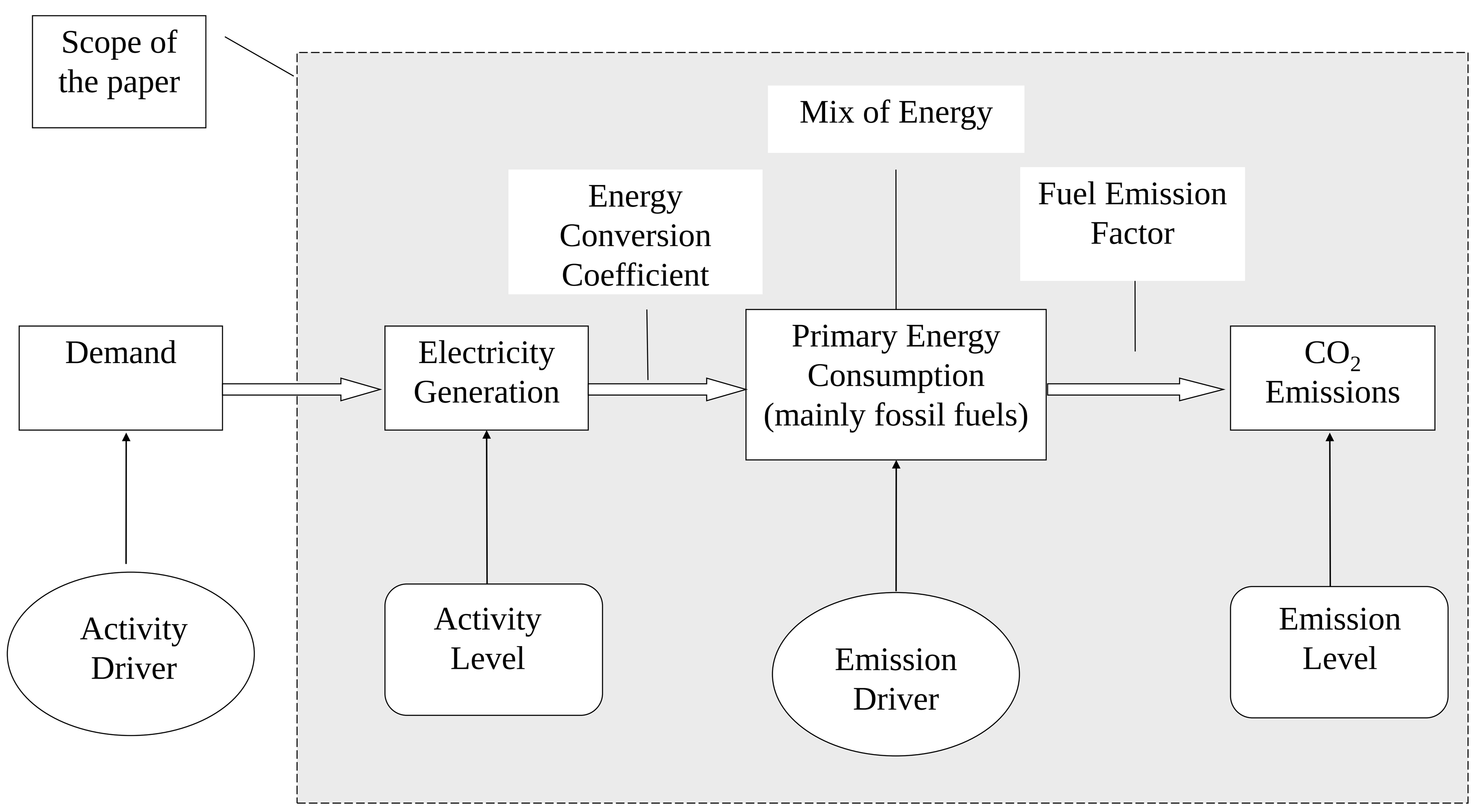
Jie Zhou

University of Southern California

ABSTRACT

The paper presented an approach to identify the key drivers of Greenhouse Gas (GHG) emissions from electricity generation, and quantitatively measure the significance of the drivers by using index number decomposition method. Identifying and measuring the drivers are important in the spatial comparisons of GHG emissions. The indexes developed by the approach can serve as a useful indicator to aggregate local information thus useful in comparison. CO_2 emissions from electricity generation in California and Pennsylvania were used as a case study to illustrate the approach. The results indicated that the differences in electricity generation structure by fuel type and the differences in the fuel CO_2 emission factors were the major positive and the major negative drivers of the differences in CO_2 emission from electricity generation between the two states, respectively.

FRAMEWORK AND METHODS



Quantifying the drivers – Index number decomposition

Multiplicative Approach:

$$C_{PA} / C_{CA} = C_s / C_0 = (\Sigma_i\, s^s_i \times f^s_i \times e^s_i) / (\Sigma_i\, s^0_i \times f^0_i \times e^0_i)$$
$$= S(s^0, s^s, f^0, f^s, e^0, e^f) \times F(s^0, s^s, f^0, f^s, e^0, e^f) \times E(s^0, s^s, f^0, f^s, e^0, e^f) \times R$$

Additive Approach:

$$C_{PA} - C_{CA} = C_s - C_0 = (\Sigma_i\, s^s_i \times f^s_i \times e^s_i) - (\Sigma_i\, s^0_i \times f^0_i \times e^0_i)$$
$$= S(s^0, s^s, f^0, f^s, e^0, e^f) + F(s^0, s^s, f^0, f^s, e^0, e^f) + E(s^0, s^s, f^0, f^s, e^0, e^f) + R$$

In which,

C: Emission of CO_2 per unit electricity generation within the state.

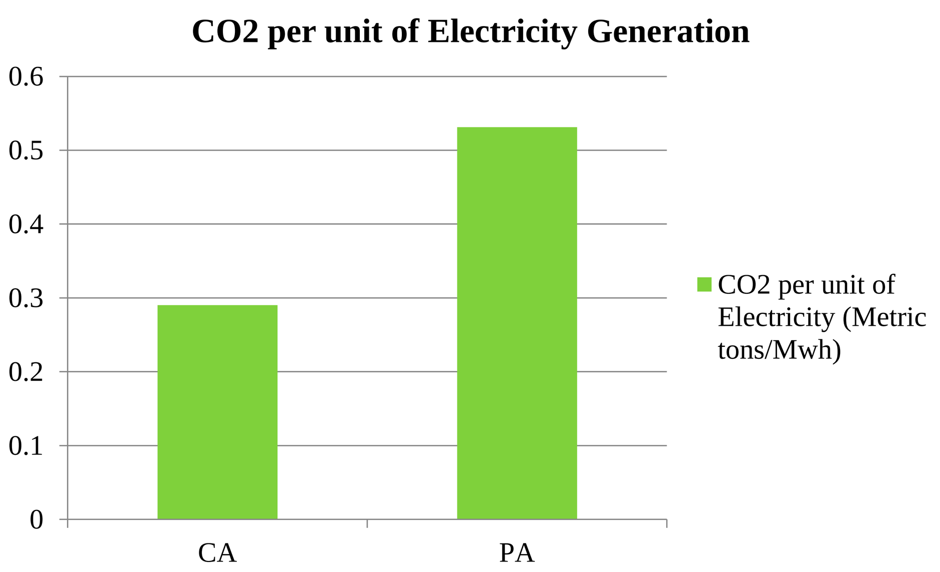
S: Structure of electricity generation by fuel type

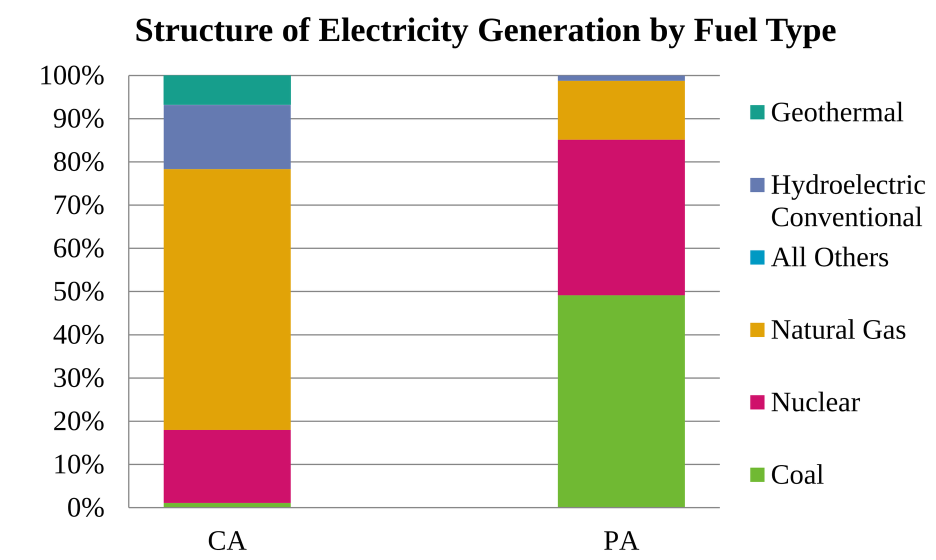
F: Fuel consumption per unit of electricity or energy conversion efficiency by fuel type

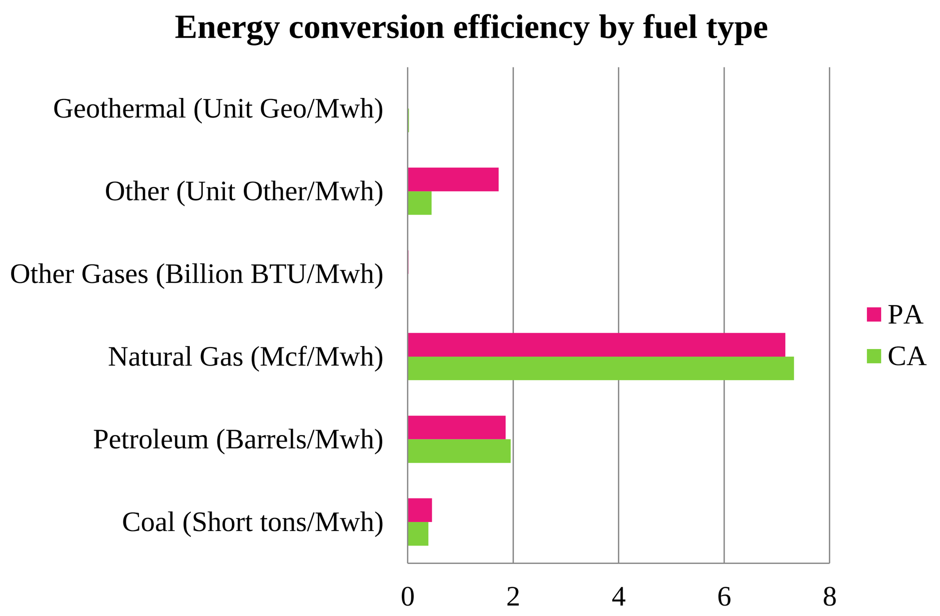
E: Fuel emission factor in electricity generation

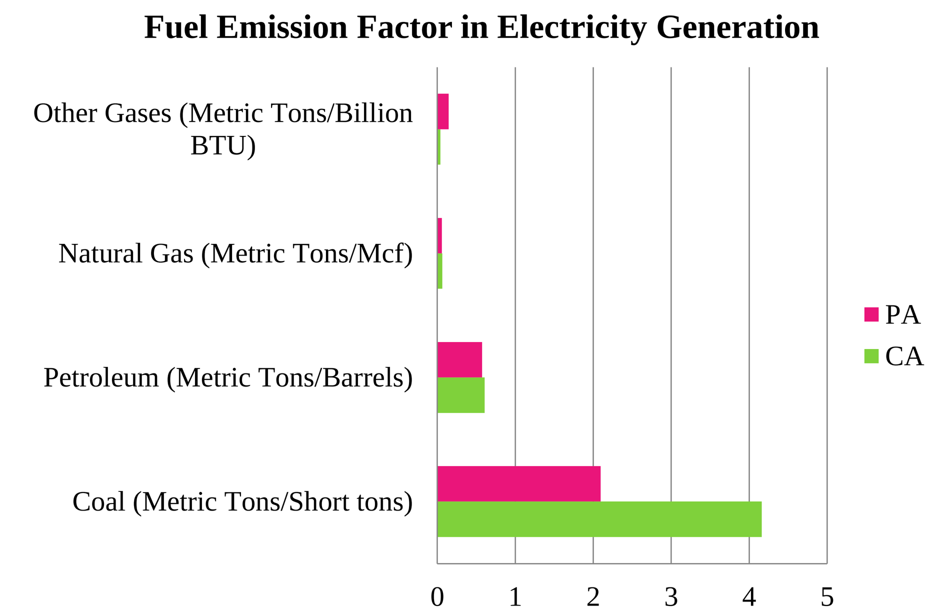
R: Decomposition residual. For complete decomposition, R=1 in multiplicative approach, R=0 in additive approach

CASE STUDY



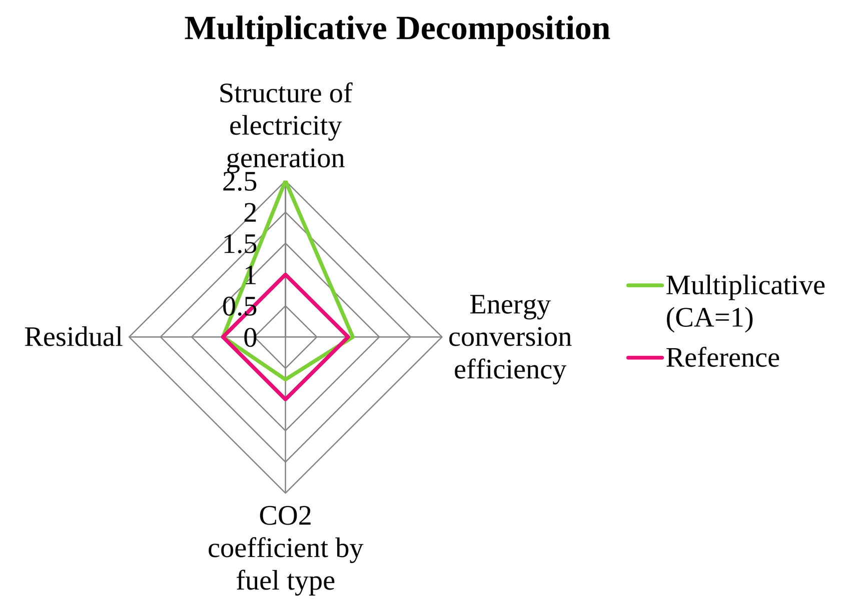


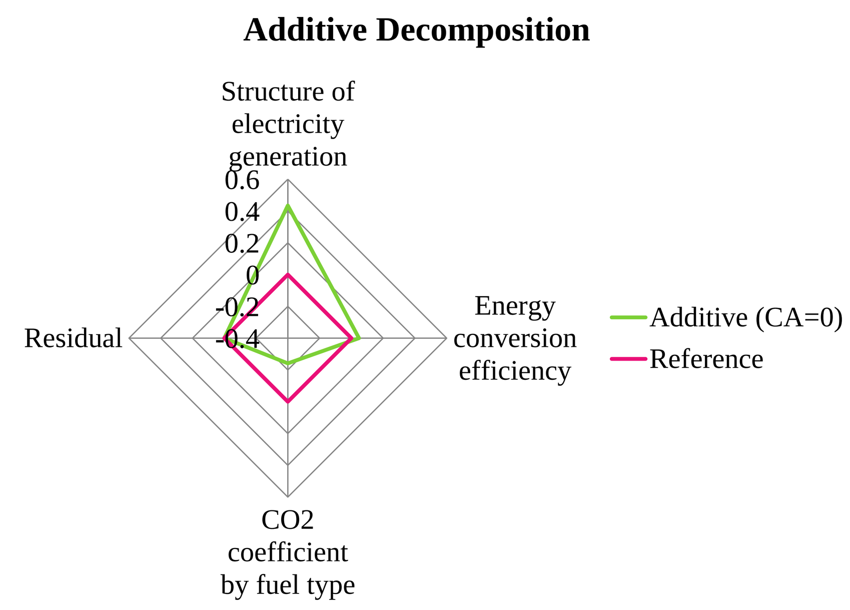




CASE STUDY (CON.)

Decomposition Results





	Total	Structure of electricity generation	Energy conversion efficiency	CO_2 coefficient by fuel type	Residual
CA vs. PA					
Multiplicative	1.83	2.50	1.08	0.68	1.00
Additive	0.24	0.44	0.05	-0.24	0.00
PA vs. CA					
Multiplicative	0.55	0.40	0.93	1.47	1.00
Additive	-0.24	-0.44	-0.05	0.24	0.00

CONCLUSION

Identifying and quantifying drivers of the spatial differences in GHG emissions may help policy makers and planners to target efforts on reducing GHG emissions in certain areas. Efforts have been made in quantifying carbon inventories and emissions over space, but methods to measure the significance of drivers are relatively under-developed for various reasons.

Index number decomposition is an approach for separating multi-factor effects and does not require large dataset. Fisher Ideal Index (FII) decomposition is one of the index number decomposition approaches considered to have good explanatory power and be easy to use. After applying the three-factor FII decomposition on the CO_2 per unit of electricity generation in California and Pennsylvania, we found that the electricity generation structure by fuel type was the major positive driver of the CO_2 emission differences between the two states. If we consider structural differences in electricity generation alone, the level of CO_2 per unit of electricity generation in PA would be 2.5 times the CA level. The CO_2 coefficient by fuel type was the major negative driver, which, if considered alone, would drive Pennsylvania's CO_2 per unit of electricity generation to be 0.68 times the CA level.

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Any questions or interests regarding the paper, please contact: Jie Zhou, jiezhou@usc.edu