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Research article

Fossil energy use and carbon emissions: An easy-to-implement technical policy experiment

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Appendix A: Empirical Data

Hereafter the list of series employed throughout this work and the sources supplying them (last access on 08.11.2020).

A.1. ***Implicit Price Deflator*** [GDPDEF, index 2012=100, seasonally adjusted, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/GDPDEF);
A.2. ***Nominal Output*** [GDP, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/GDP);
A.3. ***Nominal Output*** [GDPA, billions of dollars, annual] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/GDPA);
A.4. ***Durable Goods*** [PCDG, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/PCDG);
A.5. ***Non-Durable Goods*** [PCND, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/PCND);
A.6. ***Services*** [PCESV, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/PCESV);
A.7. ***Fixed Private Investments*** [FPI, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/FPI);
A.8. ***Change in Private Inventories*** [CBI, billions of dollars, seasonally adjusted, annual rate, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/CBI);

A.9. ***Labor*** [HOANBS, index 2012=100, seasonally adjusted, quarterly] from Federal Reserve Economic Data (FRED). (https://fred.stlouisfed.org/series/HOANBS);

A.10. ***Fossil Energy Use*** [Total Fossil Fuels Consumption, quadrillion btu, monthly] from U.S. Energy Information Administration (EIA): *Table 1.3 Primary Energy Consumption by Source*. (https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T01.03&freq=m);

A.11. ***Gasoline and other energy goods (Household)*** [DGOERC, millions of dollars, annual] from U.S. Bureau of Economic Analysis (BEA): *Table 2.4.5. Personal Consumption Expenditures by Type of Product [T204205-A]*. (https://apps.bea.gov/national/Release/XLS/Survey/Section2All_xls.xlsx);

A.12. ***Electricity and Gas (Household)*** [DELGRC, millions of dollars, annual] from U.S. Bureau of Economic Analysis (BEA): *Table 2.4.5. Personal Consumption Expenditures by Type of Product [T204205-A]*. (https://apps.bea.gov/national/Release/XLS/Survey/Section2All_xls.xlsx);

A.13. ***Energy/Output*** [Energy expenditures as share of GDP, percent, annual] from U.S. Energy Information Administration (EIA): *Table 1.7 Primary Energy Consumption – Energy Expenditures and Carbon Dioxide Emissions Indicators*. (https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T01.07&freq=m);

A.14. ***Fossil Energy Price*** [DGOERG, index 2012 = 100, seasonally adjusted, quarterly] from U.S. Bureau of Economic Analysis (BEA): *Table 1.5.4. Price Indexes for Gross Domestic Product, Expanded Detail [T10504-Q]*. (https://apps.bea.gov/national/Release/XLS/Survey/Section1All_xls.xlsx);

A.15. ***CO_2 emissions*** [Total energy CO_2 emissions, million metric tons of co2, monthly] from U.S. Energy Information Administration (EIA): *Table 11.1 Carbon Dioxide Emissions from Energy Consumption by Source*. (https://www.eia.gov/totalenergy/data/browser/xls.php?tbl=T11.01&freq=m);

Appendix B: Some details concerning the calibration of climatic processes

B.1.: To derive the *e-folding* time implicit in Equation 25, $IRF_{CO_2}(t) = 1/e$ has been imposed and the corresponding value of t has been retrieved by numerically solving

$$1/e = 0.2173 + 0.2240e^{-\frac{t}{394.4}} + 0.2824e^{-\frac{t}{36.54}} + 0.2763e^{-\frac{t}{4.304}}$$

which supplies $t \approx 165$ years.

The permanence rate η is then computed as the difference between the total concentration of CO_2 and its fraction after n quarters, using the fact that $\eta = 1 - \frac{1}{(165 \cdot 4)} = 0.9985$. In other words, at each quarter, the approximate decay rate of $CO_2 = 0.0015$.

B.2: Let's define total CO_2 emissions M_t as the sum of domestic M_t^d and non-domestic M_t^{nd} emissions, that is, $M_t = M_t^d + M_t^{nd}$

$$S_t = S_0 + \delta^t M_0 + \delta^{t-1} M_1 + \ldots + \delta M_{t-1}$$
$$= S_0 + \sum_{i=1}^{t} \delta^{(t-i+1)} M_{i-1}$$

$$= S_0 + \delta M_{t-1} + \sum_{i=1}^{t-1} \delta^{(t-i+1)} M_{i-1}$$

$$= S_0 + (\delta S_0 - \delta S_0) + \delta M_{t-1} + \delta \sum_{i=1}^{t-1} \delta^{(t-i)} M_{i-1}$$

$$= S_0 - \delta S_0 + \delta M_{t-1} + \delta \left(S_0 + \sum_{i=1}^{t-1} \delta^{(t-i)} M_{i-1} \right)$$

$$= S_0 - \delta S_0 + \delta M_{t-1} + \delta S_{t-1}$$

Thus, renaming $\bar{S} = S_0$, it holds that

$$S_t = \bar{S} - \delta \bar{S} + \delta M_{t-1} + \delta S_{t-1} \rightarrow S_t - \bar{S} = \delta M_{t-1} + \delta (S_{t-1} - \bar{S}) \rightarrow V_t = \delta (M_{t-1} + V_{t-1})$$

where $V_t = S_t - \bar{S}$ represents the excess of CO_2 stock over the *pre-industrial* level.
Finally, shifting one period forward and splitting total emissions into their components, the following relation is obtained

$$V_{t+1} = \delta (M_t^d + M_t^{nd} + V_t)$$