

Appendix A1. Details on Empirical Strategy.

The LLDVE model can be explained as follows: let $Y_{i,t}$ be the dependent variable, where $i = 1, 2, \dots, N$ and $t = 1, 2, \dots, T$ are cross-sectional and time indices and $X_{i,t} = (X_{i,t,1}, X_{i,t,2}, \dots, X_{i,t,d})^T$ is a set of d independent variables; then the basic model can be written as

$$Y_{it} = f_i(t) + X_{it}^T \beta_t + \alpha_i + \epsilon_{it} \quad (4)$$

where we assume $f(t/T) = f_i(t/T)$ for all i is a cross-sectional specific trend function, $\beta_t = \beta(t/T) = (\beta_{t,1}, \dots, \beta_{t,d})^T$ is an unknown time-varying coefficient vector, α_i an unknown individual effect (where $\sum_{i=1}^N \alpha_i = 0$) and ϵ_{it} is assumed to be stationary for each i . The LLDVE technique estimates individual trend functions through fitted residuals, as prescribed by Phillips (2001), under some basic assumptions, namely that (i) $e_{i,t}$ satisfies martingale differences over time dimensions; (ii) $e_{i,t}$ are independent of $X_{i,t}$; (iii) $e_{i,t}$'s are cross-sectionally dependent for each i ; (iv) $X_{i,t}$ and α_i can be correlated. Using the above assumptions Eq.(4) can be written as

$$Y = f + B(X, \beta) + D\alpha + \epsilon \quad (5)$$

where $Y = (Y_1^T, Y_2^T, \dots, Y_N^T)^T$ with $Y_i = (Y_{i1}, Y_{i2}, \dots, Y_{iT})^T$, $\epsilon = (\epsilon_1^T, \epsilon_2^T, \dots, \epsilon_N^T)^T$ with $\epsilon_i = (\epsilon_{i1}, \epsilon_{i2}, \dots, \epsilon_{iT})^T$ for all $i = 1, 2, \dots, N$, $f = \bar{I}_N \otimes (f_1, f_2, \dots, f_T)^T$, $\alpha = (\alpha_1, \alpha_2, \dots, \alpha_N)^T$, $D = I_N \otimes \bar{I}_T$ and $B(X, \beta) = (X_{11}^T \beta_1, \dots, X_{1T}^T \beta_T, \dots, X_{N1}^T \beta_1, \dots, X_{NT}^T \beta_T)$, $\bar{I}_k$ is a $k \times 1$ vector of ones and $\otimes$ is the Kronecker product. Assuming $\sum_{i=1}^N \alpha_i = 0$ Eq. (4) can be re-written as

$$Y = f + B(X, \beta) + D_* \alpha_* + \epsilon \quad (6)$$

where $\alpha_* = (\alpha_2, \dots, \alpha_N)^T$ and $D_* = (-\bar{I}_{N-1}, I_{N-1})^T \otimes \bar{I}_T$. The final assumption, $\beta_t = (\beta_1(t/T), \beta_2(t/T), \dots, \beta_d(t/T))^T$ for $t = 1, 2, \dots, T$, provided an unknown smooth function τ with $\tau = t/T \in (0, 1]$ given $f_t = f(t/T)$

Appendix A2. Summary statistics, Tests for cross sectional dependence and unit root

Table A1: Summary Statistics

Statistics/variable	GDP	Spillover-1	Spillover-2	Employment	Carbon tax
Mean	597364.2151	60.42709767	1049.698499	8.693617877	0.012990795
Standard Deviation	790315.6512	79.76883963	1717.445912	10.39648124	0.031325441
Minimum	12090.63672	0.131541863	3.475237209	0.561121643	0
Maximum	3905024	353.6962028	7028.575194	43.23632813	0.322588
Skewness	1.879458212	2.240006378	2.255613958	1.633125903	6.145437325
Kurtosis	2.765778943	4.469985484	3.99915539	1.609510282	55.07559089

Variables in the period 1990-2017. We do not display values for lagged variables.

Table A2: Test for cross-sectional dependence

variable	CD	p-value	alpha	std.err
gdp	87.900	0.000	0.9836	0.0342
lagged gdp ¹⁸	87.900	0.000	1.005	0.3464
spillover 1	87.708	0.000	1.0057	0.2047
spillover 2	87.809	0.000	1.0057	0.05083
lagged emp	51.260	0.000	0.987	0.0332
carbon tax em.	87.856	0.000	1.0057	0.086

Table A3: Second generation panel unit root tests- CADF and CIPS.

Variables	CADF(+)	P-value	CIPS(*)
gdp	-2.120	0.032	-2.525
lagged gdp	-2.341	0.002	-3.221
spillover 1	-1.013	1.000	-5.060
spillover 2	-0.941	1.000	-3.169
lagged emp.	-1.632	0.722	-1.476
carbon tax em.	1.328	1.000	0.310

(+) Critical values CADF: -2.080 (cv10), -2.160 (cv5), -2.300 (cv1)

(*) Critical values CIPS: -2.04 (10%), -2.11(5%), -2.23 (1%)

Table A4: Second generation panel unit root tests- PANIC and PANICCA

Variables	<i>PANIC</i> **			
	ADF	P_a	P_b	PMSB
gdp	0.6899	0.8156	0.9106	1
lagged gdp	1	0.6026	0.6279	0.9687
spillover 1	0.6657	0.1168	0.1527	0.3799
spillover 2	0.5687	0.2905	0.3491	0.2499
lagged emp.	0.8192	0.7018	0.7435	0.9768
	<i>PANICCA</i> **			
	ADF	P_a	P_b	PMSB
gdp	0.593	0.6902	0.7529	0.9963
lagged gdp	0.0001	0.4646	0.4585	0.8796
spillover 1	0.9394	0.1845	0.1986	0.4552
spillover 2	0.6334	0.2115	0.2855	0.2584
lagged emp.	0.9849	0.7209	0.7694	0.9885

(**) p-values.

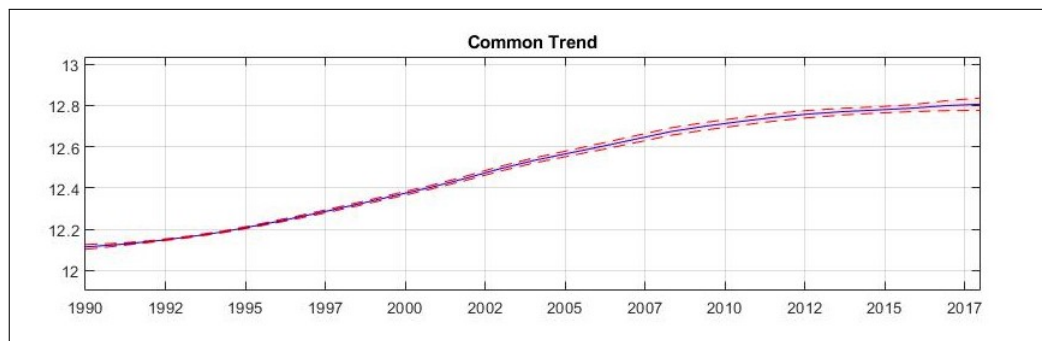


Figure A 1: LLDVE Panel Estimates - Common Trend.

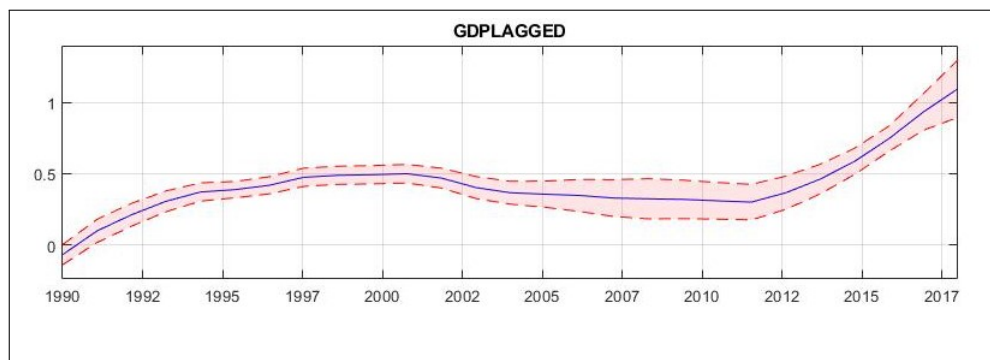


Figure A 2: LLDVE Panel Estimates - Lagged GDP.

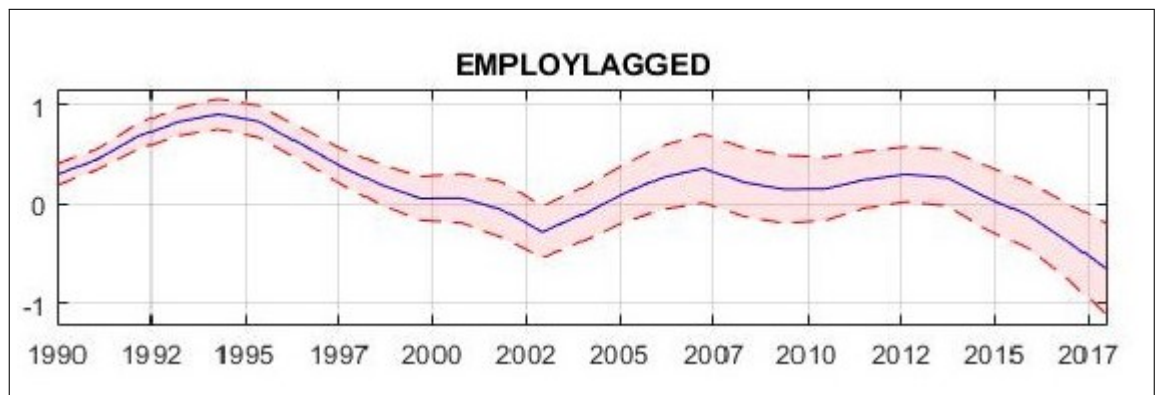


Figure A 3: LLDVE Panel Estimates - Lagged Employment.

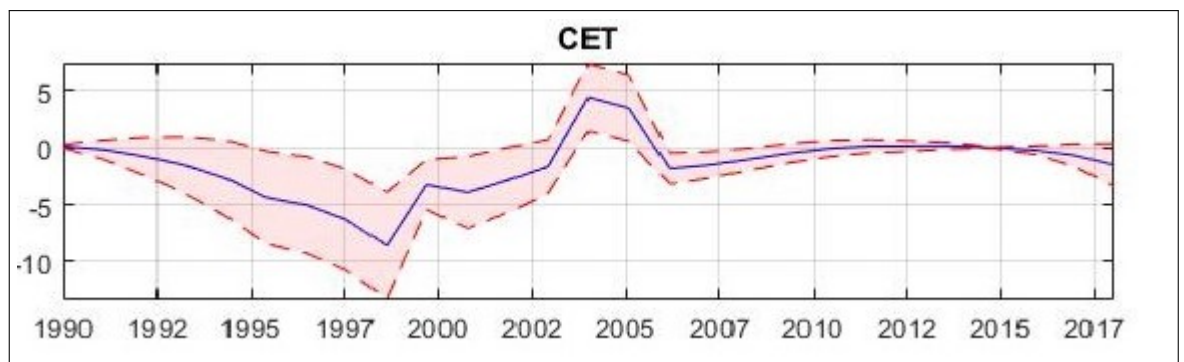


Figure A 4: LLDVE Panel Estimates - Carbon Tax Revenue.