Demand for Visits to Southwestern National Parks:

Efficient Estimation with Time-Invariant and Rarely Changing Variables and Park-Specific Fixed Effects

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Methods: Step 1

- **TSCS estimation of annual national park visits**
  - **42 SW parks**
  - **1979 – 2003**

- **Fixed Effects Vector Decomposition**
  - **Economic variables**
  - **Environmental / climate variables**

Methods: Step 2

- **Input output analysis**
  - **Maps visits to visitor spending, then local sales, income, and employment**
- **Comparative static simulations**
  - **Global warming effects**
  - **Reduce lake elevations**
  - **Carbon taxes**

Problems in TS-CS estimation

- Problems with TS-CS data
  - Panel heteroskedasticity
  - Contemporaneous correlation of errors
  - Autocorrelation
- FGLS underestimates variance of parameter estimates
  - Beck/Katz propose PCSE w/ AR(1) correction
  - What about unit effects?

Dilemma of Fixed Effects

$$Y_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{kit} + \sum_{m=1}^{M} \gamma_m Z_{mi} + \mu_i + \varepsilon_{it}$$

- Omitted variables bias if left out
- Can't use time-invariant variables
- Estimation of rare changing variables inefficient

Approaches to deal with FE

- Ignore them
- Omit time invariant variables
- Hanink / White: stepwise regression
- Random Effects
- Hausman-Taylor

Plumper & Troeger's Fixed Effects Vector Decomposition (FEVD)

- Extension of Hsiao
- 3-step estimator
- Allows
  - Inclusion of unit effects
  - Inclusion of time invariant variables
  - More efficient estimation of rarely changing variables
- For rarely changing variables, tradeoff between
  - (small) bias and
  - large variance of parameter estimates

Step 1: FE estimation

$$\ddot{Y}_{it} = Y_{it} - \overline{Y}_i$$

$$\ddot{X}_{kit} = X_{kit} - \overline{X}_{ki}$$

$$\ddot{\varepsilon}_{it} = \varepsilon_{it} - \overline{\varepsilon}_i$$

Estimate

$$\ddot{Y}_{it} = \sum_{k=1}^{K} \beta_k \ddot{X}_{kit} + \ddot{\varepsilon}_{it}$$

To get

$$\hat{\mu}_i = \overline{Y}_i - \sum_{k=1}^{K} \hat{\beta}_k^{FE} \overline{X}_{ki}$$

Step 2: FE

Part of FE explained by time invariant *Z*s

Estimate

$$\hat{\mu}_i = \omega + \sum_{m=1}^{M} \gamma_m Z_{mi} + \eta_i$$

unexplained

To get $$\hat{\eta}_i = \hat{\mu}_i - \hat{\omega} - \sum_{m=1}^{M} \hat{\gamma}_m Z_{mi}$$

Step 3

$$Y_{it} = \alpha + \sum_{k=1}^{K} \beta_k X_{kit} + \sum_{m=1}^{M} \gamma_m Z_{mi} + \delta \hat{\eta}_i + \varepsilon_{it}$$

- Include unexplained portion of 2^{nd} stage regression in final stage
- Include time-invariant & rarely changing variables
- PCSE & AR(1) correction

Plumper & Troeger Monte Carlo Results

- FEVD performs better than OLS, RE, & Hausman-Taylor when both time invariant and time variant variables correlated with unit effects
- FEVD ‘better’ than FE for rarely changing variables if ratio of between to within S.D. of variable high enough

Data

- 42 parks, 1979-2003
- Spatial demand variables
- Park attributes
- Environmental variables

Demand Variables

- Regional population
- Market Potential Index (distance from “where the money is”)
- Competing Destination Index (park location in relation to other parks)
- Gasoline price
- Real exchange rate (passenger fare weighted)

Recreational Visits to Top-10 Parks

Park	Recreation Visits
Lake Mead NRA	7,915,581
Grand Canyon NP	4,124,900
Zion NP	2,458,792
Glen Canyon NRA	1,876,984
Joshua Tree NP	1,283,346
Bryce Canyon NP	903,760
Canyon de Chelly NM	866,498
Arches NP	757,781
Saguaro NP	643,697
Montezuma Castle NM	637,024
Total (whole sample)	**26,958,392**

Park Attributes

- Size (acres)
- Age (date established)
- Designation (e.g. NP vs. NM or NHS)
- Concessional lodging
- Topographical variation

Environmental Variables

- January temperature
- July temperature
- January hours of sunshine
- July humidity
- Lake surface area (where relevant)
- Extreme drought variable (based on SPI)

Other control variables

- Dummy variables for large forest fires
- Dummy variables for changes in visitor counting procedures
- Variable for post-9/11 effect

Regression Results

- Adjusted R^2: 0.98395
- DW (original): 0.3746
- H0: panel homoskedasticity rejected
- H0: no contemporaneous correlation rejected
- H0: no autocorrelation rejected
- In previous literature, geographers run OLS

Regression Results

	Coefficient	Standard Error
LnGas	-0.2334165	0.0608322*
LnXRate	-0.3006279	0.0746176*
LnPop	1.059815	0.1217164*
Post911	-0.14437	0.0385546*
CDInex	13.56334	0.1375827*
MPIndex	4.98e-08	1.76e-09*
Estab	-.0204284	0.0003031*
TopoVar	.2600213	0.0095831*
Lodging	1.631734	0.0247951*
Area	9.12e-06	1.25e-07*
AreaSq	-6.69e-12	9.53e-14*

Regression Results

	Coefficient	Standard Error
NP	0.9814274	0.110322*
NHP	-0.5925199	0.0404904*
NHS	-0.2756065	0.0221629*
JanSun	-0.0408096	0.003303*
JanSunSq	0.000547	8.10e-06*
JulHum	0.0805317	0.0028882*
JulHumSq	-0.0010695	0.0000382*
Dry	-0.016727	0.0588642
Cerro	-0.2648594	0.0920546*
Tonto	-0.2973203	0.2154973
Eta (η)	1.005091	0.010786*

Regression Results

	Coefficient	Standard Error
JanTemp	0.4603223	0.0159172*
JanTempSq	-0.0049867	0.0002095*
JulTemp	-0.098604	0.0311719*
JulTempSq	0.0005051	0.0002095**
LnPowell	0.1157354	0.0040682*
LnLMNRA	0.4455426	0.0057047*

Comparative Statics: Warming

- Impact of 2°F July and 1°F increase
- Previous literature suggests positive effect
- Regression results map changes in temperature to changes in visits
- MGM2 (input-output) Model (Stynes et al.)
  - Visits to visitor spending
  - Visitor spending to changes in sales, personal income, and jobs

Visits to Local Economic Impacts

- Visits converted
  - to “party days”
  - by “visitor segment”
  - spending patterns differ by segment
- Assume
  - Exogenous shock affects all segments the same
  - No change share of each segment

Warming Results

Park	Visits % Change	– Change in – Visits	Party Days	Visitor Spending (million's)
Grand Canyon	6%	243,701	94,824	20.0
Glen Canyon	12%	233,107	175,849	13.5
Lake Mead	4%	349,022	106,505	10.6
Arches	16%	119,051	58,342	10.0
:				
Organ Pipe	-6%	(15,452)	(8,016)	-0.7
Joshua Tree NP	-2%	(20,279)	(9,491)	-0.8
Saguaro NP	-4%	(27,030)	(15,149)	-1.7
Total (All Parks)		1,603,095	768,256	80.5

Warming: Local Economic Impacts Including Multiplier Effects

Direct Effects		
Sales (millions)	Jobs	Income (millions)
66.5	1,671	24.5
Total Effects		
Sales (millions)	Jobs	Income (millions)
93.0	2,047	33.7

Comparative Statics: Reductions in Lake Levels from 1998 levels

	Glen Canyon NRA	Lake Mead NRA	Total
2003 Reductions in			
Visits	76,261	827,662	903,923
Party Days	57,529	252,562	310,092
Visitor Spending (millions)	4.4	25.1	29.5
Sales (millions)	5.1	24.3	29.4
Jobs	108	633	741
Income (millions)	1.8	8.6	10.4

Lake Reduction Scenarios

- Climate modeling suggests reductions in future lake levels
- Experiment with 3 scenarios
  - Level 1 Shortage
  - Power Pool
  - Powell Dead Pool
- Correspond (roughly) to those considered
  - In climate literature
  - BOR Interim Guidelines Final EIS

Lake Reduction Scenario Results

- Net effects of warming and lake reductions negative
- Goes negative faster for Mead
- Scientific uncertainty
  - How often will low elevations be reached?
  - How often will low elevations occur?
- Overall regional impacts still positive, even with sharp reductions in lake visits

Carbon tax experiment

- Carbon tax mapped to gas price increase
  - Elasticity of visits w.r.t. gas price -0.23
- Gas price increase to visits
- Visits to spending, then local sales, income and employment

Carbon tax experiment results

- $10 / ton of CO_2 tax reduces local employment by @300 jobs

- HR 1612 (Public Lands Service Corps Act) could be vehicle to counteract negative impacts of tax

Conclusions

- Warming has overall positive effect (as in past studies)
- Negative effects on low desert parks
- Negative lake level effects could counteract positive warming effects
- A few parks capture most of regional effects
- Pure population growth may have more impact than environmental, policy, or economic changes