Natural Capital as an Economic Public Product: An Empirical Analysis of Illinois Counties

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This paper addresses the question, "how do Illinois counties rank in terms of investments in natural capital". A statistical modeling of county capability suggests that metro counties not only invest in natural capital, but also benefit from the investment by attracting more STEM-qualified employees / entrepreneurs to the county who engage in innovative, R&D activities.
Keywords: Ecological systems, county capability, discriminant analysis.

1.0. Introduction

The term capital implies the following attributes[2]: (i) the concept is an asset which may be owned privately (for instance, physical capital such as an automobile) or collectively (for example, material cultural capital such as religious places of worship); (ii) the concept helps persons (and communities) to enhance their wellbeing; (iii) the concept could deteriorate in quality and quantity over time, and (iv) the concept's stock can be built through investment (for example, financial investments on physical capital) which has an opportunity cost (Dalziel et al 2017). The natural environment meets these criteria (Helm, 2015): the eco system is being damaged by humans and these impacts can be mitigated through well-designed investments. Who owns this problem? It depends on the geographical context of the analysis; for climate change mitigation, it is the global community; for green spaces in a specific geographical region such as the county, it is the local government that has the responsibility to invest and (co)produce natural capital as an economic public product.

An economic public product is one of the two categories of products that we consume, private consumption products and economic public (collective) consumption products. Collective consumption is plagued by free-rider problems (Dawes and Thaler, 1988), citizens do not want to pay for these public goods and services. To illustrate, consider a community with a population of 40,000 adults. The community is in need of street lighting which would cost $800,000, or $20 per adult. However, since street lighting is a public benefit for everyone in the community[3], it is unlikely to be funded by voluntary collaboration. One may think that her contribution of $20 is not going to make much of

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[2] Technically, it is the 'intension' part of the conceptual definition.
[3] It is 'non-excludable', not possible to prevent others from enjoying the service.

an impact on the $800,000 goal, but the extra $20 in personal spending would bring in a much larger benefit. This makes collective consumption products less attractive for profit-oriented businesses and provides a rationale for the local governments to levy taxes, for example, to fund the production and delivery of collective consumption products (Samuelson, 1954).

At the county level, investments in natural capital has economic development consequences; entrepreneurs will search out innovation opportunities in a domain such as the "green" domain (cf. the 'smart specialization concept'[4] in EU cohesion policy (OECD, 2012)). Finding ways to enhancing these entrepreneurial processes is crucial for identification and development of general purpose technologies[5].

How do Illinois counties rank in terms of investments in natural capital, an economic public good? Which county is ready (prepared) for 'smart specialization' in R&D? This paper addresses these and other related questions.

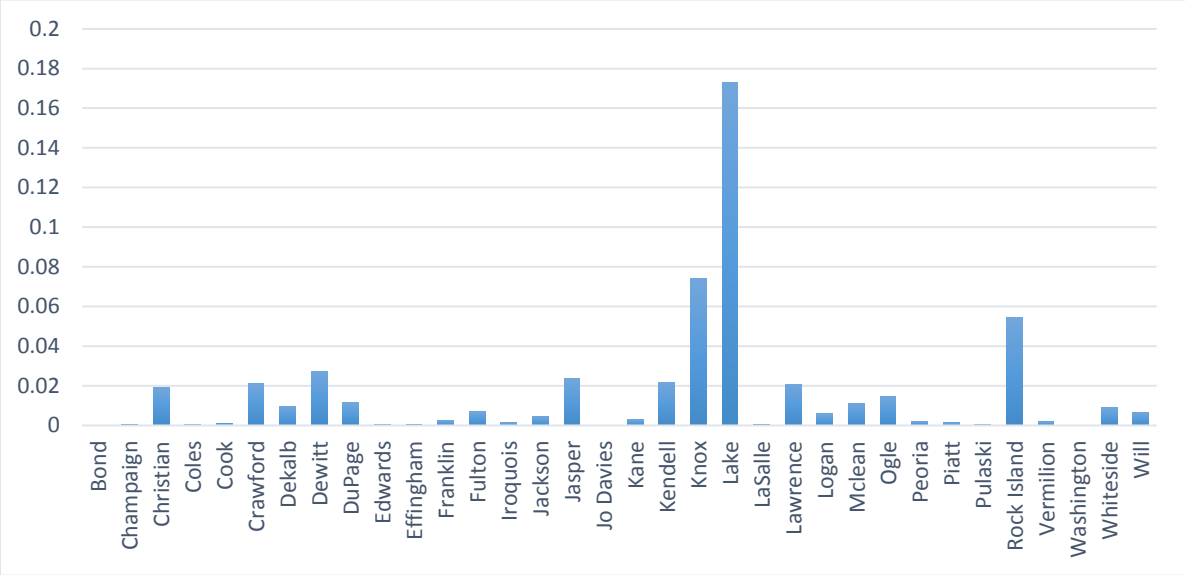
2.0. County Government and Economic Public Goods

The premise of this section is that public sector offers opportunities to enhance wellbeing of residents, beyond what they could attain from voluntary associations and market exchanges. The limits of voluntary organizations in enhancing personal wellbeing is highlighted by Olson (1965) in the form of an empirical generalization: the larger the voluntary group, the less it will further members' common interests[6]. Market economy tends to supply only products where the externalities[7] favor the firm. For negative externalities involving a large number of residents, government intervention is required.

Figure 1 shows counties' expenditure on natural capital for the 2017 fiscal year[8]. Only three counties report spending at least 5% of their total budget[9] on natural capital.

[4] Smart specialization is a concept for technological linkages between industrial sectors. Its origin lies with the European Union's Knowledge for Growth expert group (K4G, McCann and Ortega-Argiles, 2015).
[5] Examples of general purpose technologies (GPT) include electricity and computer.
[6] Personal reward is tied to a member's interest which is determined by the scope or number of activities the voluntary organization is engaged in; the larger the scope of activities, the lower the benefits for any member.
[7] Externalities are positive / negative impacts experienced by persons not directly involved in the consumption of a product (Baumol, 1972). For example, CKC (IL) 336 would benefit travelers from Macomb, IL to Quincy, IL by reducing travel times, but may negatively impact businesses in the US136 Macomb → Tennessee route.
[8] 2017 fiscal year for Illinois spans the July 1 2017 to June 30 2018 time period.
[9] We use the term budget to describe total county expenditure.

Figure 1: Spending on Natural Capital as a Proportion of Total Expenditure

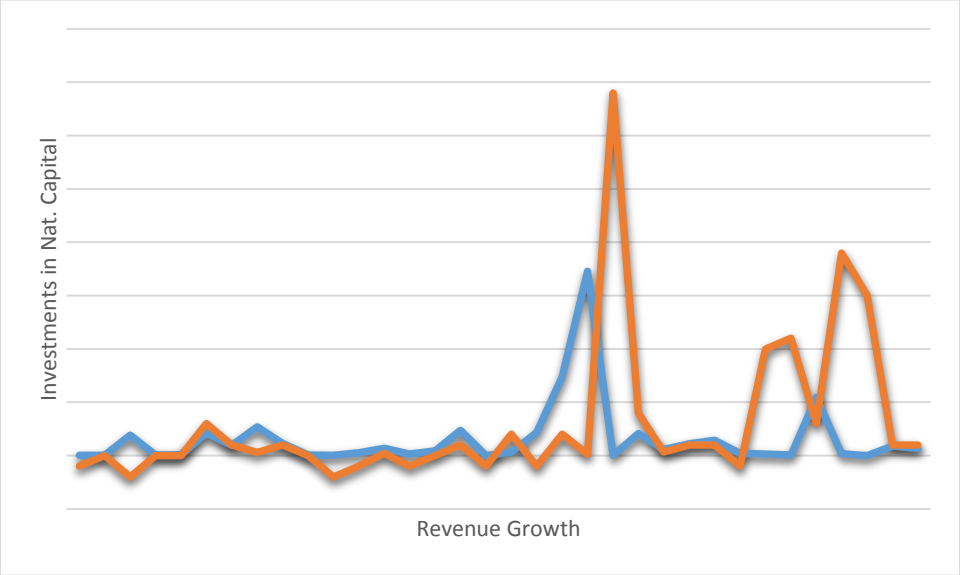


In all, 34 counties (33%) reported spending on natural capital. Appendix 1 ranks these counties in terms of proportion of total expenditure spent on ecological systems. As a measure of investment in natural capital, the rank orderings in Appendix 1 show that Lake, Knox, and Rock Island are leaders. Bond, Jo Davies, and Washington counties are laggards, they have the lowest investments in natural capital.

One logical explanation for little or no investments in natural capital is declining county revenues. Although the Pearson correlation between investments in natural capital and growth in revenues is $p = 0.27$, there is little statistical evidence that investments in natural capital is associated with growth in revenues (Figure 2[10]).

[10] The 0.27 correlation suggests that revenue growth explains approximately 7% of the variance in county investments in natural capital.

Figure 2: Investments in Natural Capital and Revenue Growth during 2012-2017



Note: The z value of the correlational relationship is 1.54, p ≤ 0.12

An indepth analysis of county revenue data suggests that less than one-third of total revenue is from federal and state governments (Appendix 2). Furthermore, a path-dependence analysis of sources of revenues for the county governments reveals that 'local revenue' is the only source of revenue growth; other sources registered zero growth[11].

This push towards independent financial existence of counties provides a context for the following analysis on distinctive contributions county governments can make to wellbeing.

3.0. County Government and Capabilities

A growing area of research in regional science is smart specialization (OECD, 2013; Foray, 2015). The smart specialization concept suggests that geographical regions such as counties should be helped to identify areas of research and development strengths based on their existing capabilities. Multi-attribute utility models such as AHP can be used in this investigation, but their implementation requires personal surveys of stakeholders (Athiyaman, 2019a). If the task demands a smart-specialization

[11] Growth in revenues, source-wise, were analyzed for the 2012-2017 time period. The median growth rates were: local taxes 2%, state, federal, and other sources: 0%.

assessment for all the counties in the nation or for a state such as Illinois, then resource constraints (including time) may require a statistical analysis of published county-level data on indicators related to research and development. This is the approach taken in this paper, we assess the ease of innovative activities in the counties (EASE), examine the (industry) sectoral correlates of EASE, and highlight the socio-economic and demographic profiles of the high/low EASE counties.

3.1. Methodology

To assess the innovative potential (ease of engaging in innovative activities, EASE) of a county two indicators were used: number of science and engineering graduates in the county (STEM), and number of patents issued to the county's entrepreneurs and industry. The American Community Survey (ACS) data were used to compile county-level STEM numbers[12]. The patent data were obtained from the US Patent and Trademark Office[13]. The standard scores of these variables for the counties were computed[14], summed and averaged, and the counties ranked[15].

Based on the reasoning that larger the industry the higher will be the ease of innovative activities in the industry, Pearson correlations were computed between EASE and NAICS two-digit (industry) sectoral employment numbers[16]. The statistical significance of the correlations were assessed using a *z* test.[17]

Finally, a median split of the EASE scores was used to categorize counties into two groups, high and low innovative regions, and a battery of socio-economic and demographic variables were used to identify the 'structure' of the high EASE counties (for example, they all have higher per capita income)[18].

4.0. Results and Discussion

Table 1 shows the EASE rankings of the top three counties and the three lowest ranking counties. Metro or non-metro classification seems to be a key factor that determines EASE group membership, metro counties have higher R&D readiness.

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[12] Table B15012.

[13] www.uspto.gov/web/offices/ac/ido/oeip/taf/countyall/usa_county_gd.htm

[14] A standardized variable has parameters μ = 0 and $\sigma^2 = 1$.

[15] Patent data used were the most recent available, the 2015 numbers.

[16] ACS Table DP3.

[17] The test is based on the results of the computation: $z = \frac{\sqrt{n}-3}{2} \times ln\frac{(1+r)}{(1-r)}$

[18] The profile variables considered include: population, GDP, employment in NAICS 2-digit sectors, health, infrastructure and air quality indices (Athiyaman, 2019b).

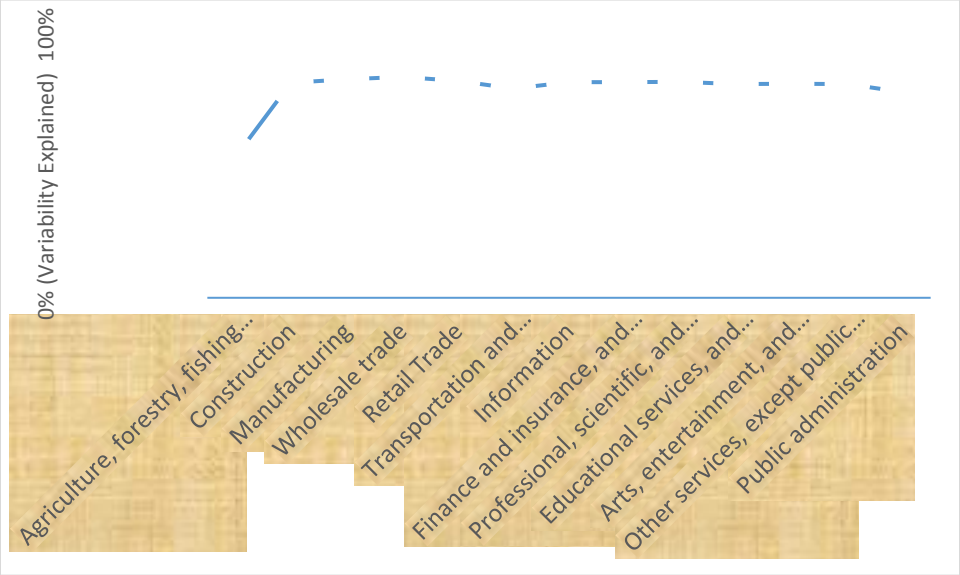
Table 1: EASE Rankings of Counties

County	Score (sum of z Scores)	Rank
Top Counties		
Cook County	8.92	1
Lake County	2.60	2
DuPage County	2.52	3
Low EASE Counties		
Alexander County	-0.225	101
Hardin County	-0.224	100
Pulaski County	-0.223	99

Correlations between EASE scores and sectoral employment numbers imply, that compared to the other industrial sectors, the natural resources sector (NAICS 11: agriculture, forestry, fishing and hunting, and mining) has the lowest number of STEM-qualified employees and minimal number of patents[19]. Manufacturing exhibits the highest association with EASE. Information sector and professional, scientific, and management services are also benefitting from the innovative opportunities provided by the regions (Figure 3).

[19] One reason for this could be the low wages in the sector (Athiyaman, 2019c), STEM specialists may find the sector unattractive for employment and R&D.

Figure 3: Variability in EASE Explained by Sectoral Employment Numbers



Note: R^2 is the metric plotted.

In exploring the phenomenon of EASE at Illinois counties, it is assumed that it is influenced by quality of life factors and real GDP. A linear discriminant of the form $Y = a_1x_1 + \cdots + a_6x_6$ that will discriminate between the high and low EASE counties was calibrated[20]. The parameters were chosen to maximize the ratio:

$$\frac{Variance\ between\ means\ on\ the\ discriminant\ axis}{variance\ within\ group\ on\ the\ discriminant\ axis}$$

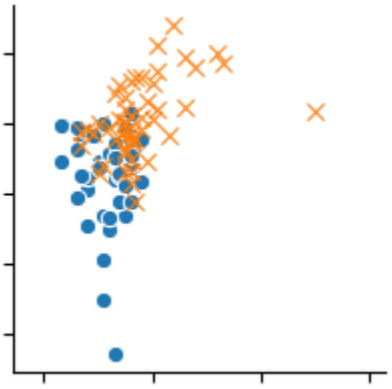
The calibrated discriminant function shows that infrastructure (Internet penetration) and air quality are the salient discriminator between high and low EASE counties. The discriminant function predicts the low/high classification with 78% accuracy (Table 2 and Figure 4).

Table 2: Structural Influences on EASE

Structural Determinants:	Group Means:
Internet Penetration	High EASE = 20.511
Air Quality	Low Ease = 11.934

[20] Quality of life factors and real GDP were assigned variable labels: x1 = life expectancy, x2 = physicians per 1000 population, x3 = internet penetration, x4 = air quality, x5 = population, and x6 = real GDP. See (Athiyaman, 2019b) for operational definitions of the variables. .

Figure 4: High and Low EASE Counties: Distribution on Infrastructure and Air Quality Variables



Note: Circle represents low EASE counties

Here are the implications for county governments wanting to improve their standings on the EASE measure:

(i) To attract more STEM qualified employees and to increase R&D in the county improve the county's infrastructure, specifically Internet connectivity;
(ii) Invest in natural capital to enhance air quality, and
(iii) Pay a living wage in natural resources sector to increase its innovative activities.

5.0. Conclusion

This paper is an attempt to show that investment in natural capital is required to enhance wellbeing. Empirical analysis shows that only 33% of Illinois counties invest in natural capital. Given that county revenue is contingent on the innovative capacity of the county, a linear discriminant analysis was conducted to identify structural dimensions of R&D intensive counties. The results point to the need for counties to invest in natural capital to attract STEM-qualified employees and entrepreneurs to engage in innovation.

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Appendix 1: Expenditures on Economic Public Goods, Fiscal Year 2017[21]

County	Gen Govt	Public Safety	Corrections	Judiciary	Transportation and Public Works	Social Services	Housing	Natural Capital	Total Expenditure ($)	Rank
Bond	24.04%	22.89%	0.00%	9.23%	15.78%	25.72%	0.00%	0.02%	$ 12,064,045.00	32
Champaign	28.33%	7.28%	10.56%	10.02%	5.29%	26.32%	0.00%	0.03%	$ 112,455,748.00	30
Christian	16.88%	19.44%	4.96%	13.16%	28.07%	10.13%	0.00%	1.92%	$ 13,923,105.00	9
Coles	9.65%	4.16%	1.37%	1.76%	3.72%	2.74%	0.09%	0.06%	$ 87,613,923.00	27
Cook	10.58%	0.00%	8.72%	14.18%	1.27%	36.56%	0.00%	0.08%	$ 5,782,446,750.00	25
Crawford	20.91%	18.56%	7.45%	8.21%	23.39%	11.46%	0.00%	2.11%	$ 11,417,140.00	7
Dekalb	16.88%	10.45%	6.61%	8.10%	7.85%	23.26%	0.00%	0.96%	$ 94,007,032.00	13
Dewitt	38.93%	18.84%	2.55%	7.22%	18.49%	6.89%	0.00%	2.70%	$ 11,120,524.00	4
DuPage	16.63%	11.58%	2.22%	7.95%	8.59%	20.86%	1.51%	1.15%	$ 476,102,757.00	11
Edwards	36.75%	20.70%	0.00%	15.70%	18.38%	8.42%	0.00%	0.05%	$ 2,827,119.00	28
Effingham	36.30%	23.46%	0.00%	0.00%	15.43%	14.49%	0.00%	0.03%	$ 18,063,691.00	31
Franklin	41.38%	28.08%	0.00%	8.32%	14.03%	0.31%	0.00%	0.27%	$ 18,504,550.00	20
Fulton	34.68%	12.09%	3.65%	8.53%	10.62%	28.16%	0.00%	0.69%	$ 26,933,473.00	15
Iroquois	22.33%	15.77%	0.00%	8.44%	35.56%	6.35%	0.00%	0.16%	$ 14,950,779.00	23
Jackson	26.88%	13.68%	9.57%	12.32%	13.88%	21.44%	0.00%	0.45%	$ 37,100,915.00	18
Jasper	18.21%	22.58%	0.44%	7.16%	23.64%	17.85%	0.00%	2.36%	$ 9,179,343.00	5
Jo Davies	31.40%	24.60%	0.00%	8.87%	25.28%	9.07%	0.00%	0.00%	$ 15,243,539.00	34
Kane	27.54%	12.33%	9.04%	10.91%	9.25%	5.20%	1.93%	0.32%	$ 224,705,652.00	19
Kendell	19.08%	21.90%	7.72%	10.67%	15.59%	9.01%	0.00%	2.17%	$ 62,033,727.00	6
Knox	10.26%	14.31%	4.30%	8.14%	7.82%	43.64%	0.00%	7.41%	$ 42,355,772.00	2
Lake	16.17%	9.19%	5.77%	7.89%	3.74%	14.06%	0.00%	17.28%	$ 569,751,293.00	1
LaSalle	8.31%	1.48%	1.92%	2.44%	1.74%	4.08%	0.00%	0.03%	$ 327,192,712.00	29
Lawrence	16.40%	20.33%	0.00%	9.60%	21.29%	14.84%	0.00%	2.08%	$ 7,205,452.00	8
Logan	25.05%	25.50%	0.00%	13.58%	12.55%	16.61%	0.00%	0.58%	$ 15,591,829.00	17
Mclean	27.52%	11.95%	0.00%	16.66%	4.98%	15.95%	0.00%	1.10%	$ 108,514,184.00	12
Ogle	19.84%	18.19%	6.43%	14.44%	9.39%	7.54%	0.00%	1.44%	$ 30,625,390.00	10
Peoria	25.92%	13.49%	9.62%	11.28%	8.82%	18.84%	0.00%	0.21%	$ 113,867,441.00	21
Piatt	14.39%	11.95%	0.00%	3.65%	12.66%	54.45%	0.00%	0.15%	$ 21,629,085.00	24
Pulaski	11.37%	5.90%	43.65%	4.04%	6.05%	2.44%	0.00%	0.07%	$ 15,337,782.00	26
Rock Island	27.11%	8.46%	8.09%	8.90%	3.38%	30.36%	0.00%	5.45%	$ 93,442,614.00	3
Vermilion	6.51%	12.08%	1.00%	3.22%	3.56%	2.54%	0.00%	0.20%	$ 120,850,876.00	22
Washington	9.78%	3.72%	1.30%	1.32%	3.53%	3.66%	0.00%	0.02%	$ 40,396,159.00	33
Whiteside	19.13%	12.06%	5.13%	10.90%	10.64%	39.27%	0.00%	0.89%	$ 31,993,971.00	14
Will	16.10%	15.79%	8.42%	12.50%	4.09%	14.01%	0.00%	0.67%	$ 410,289,845.00	16

[21] Only counties with spending on natural capital are shown. Data are from the Illinois Comptroller's Office.

Appendix 2: Sources of Revenue, 2017[22]

County	Total. Rev	Local Rev.	State. Rev	Fed. Rev.	Other Rev[23].
Adams	32370158	9154959	11973733	340220	10901246
Alexander	21517961	3222168	5319767	1908956	11067070
Bond	12376166	3286676	3766080	442302	4881108
Boone	29437879	13141798	7441213	8201	8846667
Brown	12612617	1400385	9995818		1216414
Bureau	18546573	5992472	5501008	669953	6383140
Calhoun	4279065	1267227	1708338	282308	1021192
Carroll	7703291	3241425	2532686	172252	1756928
Cass	12479187	2650294	5484216	1898714	2445963
Champaign	110329306	37582591	25902841	13346933	33496941
Christian	13830184	3905858	6154773	174961	3594592
Clark	12566152	3969209	4838388	723188	3035367
Clay	7697368	2682487	4024305		990576
Clinton	16497407	7027124	4658452	355987	4455844
Coles	86709229	8325958	5876545	942778	71563948
Cook	5928330505	2217264993	237033157	1046188907	2427843448
Crawford	11628763	4748428	4258326	202177	2419832
Cumberland	18473861	1352565	2098791	126847	14895658
Dekalb	74477531	23336312	9440709	3129059	38571451
Dewitt	11391459	4782574	3283980		3324905
Douglas	10111711	4277146	3433741	361390	2039434
DuPage	468637353	98502331	169469580	30749530	169915912
Edgar	39914705	4059997	5887773	347681	29619254
Edwards	2984493	1207693	1090223		686577
Effingham	17597866	4145626	9199567	732395	3520278
Fayette	59890115	2197304	3564303	516417	53612091
Ford	8449019	3353769	3221724		1873526
Franklin	17238466	4285100	5824194	51523	7077649
Fulton	28140338	7975924	7960377	1269116	10934921
Gallatin	3095565	950565	1616566	17346	511088
Greene	6596277	2149621	1635987	600628	2210041
Grundy	37140789	17560520	6837119	817373	11925777
Hamilton	5334360	907144	2655013	56930	1715273
Hancock	13572087	3731216	4199219	532642	5109010
Hardin		0	0		0
Henderson	5107755	2102898	838167	105532	2061158
Henry	34190317	8580745	8007232	592997	17009343
Iroquois	16364562	4987597	7832266		3544699
Jackson	36404077	12306184	8656264	1733378	13708251
Jasper	10114733	3906324	3931917	314831	1961661
Jefferson	18277285	6436402	6828893	248380	4763610

[22] Data are from the Illinois Comptroller's office. Units = $.
[23] Includes licenses and permits, fines, charges for services, and interests (see Local Government Warehouse, Illinois Comptroller's Office)

Jersey	11302870	4001721	3268488	218716	3813945
Jo Davies	15023323	7433197	4864193	369326	2356607
Johnson	7754913	2520866	3576338		1657709
Kane	235600210	92478616	71587155	9858819	61675620
Kankakee	63758616	20042349	12294177	8298842	23123248
Kendell	60605473	26160759	22419388	2711526	9313800
Knox	42814898	10385056	8368126	2050673	22011043
Lake	524190645	215259124	83563141	55848248	169520132
LaSalle	328321451	29257251	13869866	1907346	283286988
Lawrence	7803399	1960339	2812694	128572	2901794
Lee	20979739	7284056	6402931		7292752
Livingston	26132398	8165994	7567345	625626	9773433
Logan	14488622	4528792	4481062	1024574	4454194
Macon	66724241	23173287	21227445	1040548	21282961
Macoupin	20433754	4427373	5743355	3009952	7253074
Madison		0	0		0
Marion		0	0		0
Marshall	6784511	2763866	2446811	85996	1487838
Mason	10677961	3463572	3586806	292078	3335505
Massac	23663853	17359623	2628541	23073	3652616
McDonough	22854415	5805937	4636769	596848	11814861
McHenry	215449769	101307333	40637843	10736104	62768489
Mclean	98737568	35055966	24846077	3776701	35058824
Menard	14508310	3433287	2046631		9028392
Mercer	11398094	3967334	3361361	11968	4057431
Monroe	101338206	79786543	4096320		17455343
Montgomery	15736799	6032345	3110857	740496	5853101
Morgan	68546641	5721630	7645275	21331	55158405
Moultrie	8811228	3239386	3925876	87718	1558248
Ogle	31663444	13027595	7395095	507578	10733176
Peoria	112887106	38241369	26930378	1317847	46397512
Perry	12011161	3648882	4245281	557061	3559937
Piatt	19774998	4031320	4574820	126397	11042461
Pike	44855163	3612022	2664066	1718230	36860845
Pope	3282688	819539	1640002	450000	373147
Pulaski	13089343	1503525	1376171		10209647
Putnam	4223138	1614294	1761933	86391	760520
Randolph	17700641	4243081	11005741	318879	2132940
Richland	7069098	2328478	3181073		1559547
Rock Island	94006628	36123892	11743714	9613470	36525552
Saline	12692756	3439769	3214289	600	6038098
Sangamon	89577899	30181326	25137895	11540835	22717843
Schuyler	5081601	1584726	1202862	54801	2239212
Scott	13274005	1124529	971797		11177679
Shelby	14143849	4441272	6960718	852804	1889055
Stark	3513787	1316287	1699667	3847	493986
St. Claire	151943419	38012863	29981134	26149315	57800107
Stephenson	34017325	10823228	5224926		17969171
Tazewell	54765138	20352016	15627557	2305331	16480234
Union	11927241	3230997	4486041	16659	4193544

Vermilion	127790116	14934922	15718441	752118	96384635
Wabash	12133969	6668897	1657617	354584	3452871
Warren	8457892	3015579	2630409	592987	2218917
Washington	47347661	36896673	2136547	157098	8157343
Wayne	9002202	2528978	4847983		1625241
White	8873419	1829341	3678801	140871	3224406
Whiteside	32630409	10593164	7284081	3373451	11379713
Will	363121959	160930841	72945229	20801083	108444806
Williamson	43988565	18960665	12804087	1461222	10762591
Winnebago	181176196	68652254	36876233	10786385	64861324
Woodford	17664414	5339494	7505346	482236	4337338
MEDIAN PROPORTION		**0.32**	**0.29**	**0.02**	**0.32**