IIRA'S PERFORMANCE METRICS: INSIGHTS FROM AGGREGATE DATA

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BACKGROUND

The Illinois Institute for Rural Affairs (IIRA) produces annual performance metrics for benchmarking and planning purposes (see Appendix 1). These are aggregate metrics such as number of community-development programs implemented during the year. Recently, the author attended a meeting in which an attendee commented that "IIRA staff travel thousands of miles every year to infuse a feeling of *personal touch* (of IIRA products) for the clients". Assuming that clients prefer face-to-face meetings over virtual ones, we address the question, "how to gain insights into the means and variances of miles traveled by each of the IIRA programs using the annual, aggregate performance-metrics data". The methodology presented in this paper should be of interest to IIRA management wanting to streamline IIRA's annual performance metrics.

THE MODEL

We focus on two of the most salient IIRA activities: conference presentations, and the MAPPING programs. As mentioned earlier, our interest is on estimating the means and variances of the miles traveled to deliver each of the two activities to clients. The model, therefore, is

$$y = \beta_1 x_1 + \beta_2 x_2 \qquad (1)$$

Where y = total miles traveled;
x_1 = number of conference presentations
x_2 = number of MAPPING programs
β_1 = average miles travelled for conference presentations
β_2 = average miles travelled for MAPPING programs

If the miles travelled for conference presentations have a mean $\overline{\beta_1}$ and variance σ_1^2, then $E(\beta_1) = \overline{\beta_1}$, and Var. $(\beta_1) = \sigma_1^2 / x_1$. Similarly, if the miles travelled for MAPPING programs have a mean $\overline{\beta_2}$ and variance σ_2^2, then $E(\beta_2) = \overline{\beta_2}$, and Var. $(\beta_2) = \sigma_2^2 / x_2$.

To estimate this model from data in Appendix 1, we proceed as follows. We equate β_1 to $\overline{\beta_1} + u_1$, where $E(u_1) = 0$, $V(u_1) = \sigma_1^2 / x_1$. Similarly, $\beta_2 = \overline{\beta_2} + u_2$, where $E(u_2) = 0$, $V(u_2) = \sigma_2^2 / x_2$. Then, we rewrite Eq. 1 as:

$$y = \bar{\beta}_1 x_1 + \bar{\beta}_2 x_2 + w \qquad (2)$$

where $w = u_1 x_1 + u_2 x_2$. Hence, $E(w) = 0$, $V(w) = x_1\sigma_1^2 + x_2\sigma_2^2 = \sigma_2^2(x_1 + x_2\lambda)$; where $\lambda = \frac{\sigma_2^2}{\sigma_1^2}$.

Model calibration starts with least-squares estimates of EQ 2. Let **r** be the vector of estimated residuals. Then **r** = **Mw**, where M = $\mathbf{I}-\mathbf{X}(\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'$. Algebraically, $r_t = m_{t1}w_1 + \ldots + m_{tn}w_n$, where m_{t1} to m_{tn} comprise the t^{th} row of **M**. Since $E(w_j) = 0$ for all j, we have $E(r_t) = 0$.

$\text{Var}(r_t) = \text{E}(r_t^2) = \sum_{j=1}^{n} m_{tj}^2 \; Var(w_j) = \sum_{j=1}^{n} m_{tj}^2 \; \sum_{i=1}^{k} m_{tj}^2 \, x_{ij}^2 \, \sigma_i^2$

Simply put, $E(\dot{\boldsymbol{r}}) = \dot{\boldsymbol{M}}\dot{\boldsymbol{X}}\dot{\boldsymbol{\sigma}}$ (3)

Where $\dot{\boldsymbol{r}}$ = vector with elements r_t^2;

$\dot{\boldsymbol{M}}$ = matrix **M** with each element replaced by its square;

$\dot{\boldsymbol{X}}$ = matrix **X** with each element replaced by its square, and

$\dot{\boldsymbol{\sigma}}$ = vector with elements σ_j^2.

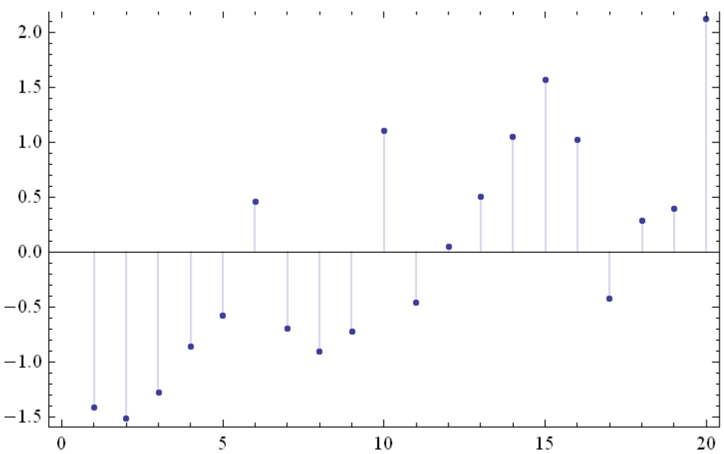
Note that the least-square estimates of $\dot{\boldsymbol{\sigma}}$ in EQ 3 can be used to derive the deflator:

$$\sqrt{\sigma_2^2 \; (x_1 + \; x_2 \; (\lambda)}$$

RESULTS

The initial least-squares estimates to derive residuals highlighted the need for model calibration using Generalized Least Squares (Figure 1). Specifically, the residuals exhibit a cyclical positive-negative pattern, and the predictive power of the model is a low 0.13.

Figure 1: Results of Least-Squares Estimates: $\boldsymbol{y = \bar{\beta}_1 x_1 + \bar{\beta}_2 x_2 + w}$ **(R^2 = .13)**



ANOVA Table:

	DF	SS	MS	F- Statistic	P- Value
b1	1	$1.378863508639516 \times 10^{10}$	$1.378863508639516 \times 10^{10}$	4.795840249423348	0.04276190585022132
b2	1	$2.036025750000839 \times 10^{8}$	$2.036025750000839 \times 10^{8}$	0.07081523428196805	0.7933540786568141
Error	17	$4.887710688380475 \times 10^{10}$	$2.875123934341456 \times 10^{9}$		
Total	19	$6.28693445452 \times 10^{10}$			

To estimate, σ_{xi}^2, the residuals were regressed on the variables in the matrix $\mathbf{Z} = \dot{\boldsymbol{M}}\dot{\boldsymbol{X}}$. The results were, σ_{x1}^2 = 104, 882, and σ_{x2}^2 = 372499. Finally, the GLS model was implemented with the deflator:

$$\sqrt{\sigma_2^2 \ = \ 372499\ (x_1 + \ x_2\ (\lambda = 3.57204))}$$

Appendix 2 shows the deflated data matrix. Table 1 shows the results of the GLS estimation which, as expected, provides better predictions than ordinary least squares. The residuals of GLS are also white noise.

Table 1: Results of GLS Estimates: $y = \dfrac{\bar{\beta}_1 x_1 + \bar{\beta}_2 x_2}{\sqrt{\sigma_2^2 = 372499\ (x_1 + x_2\ (\lambda{=}3.57204)}}$

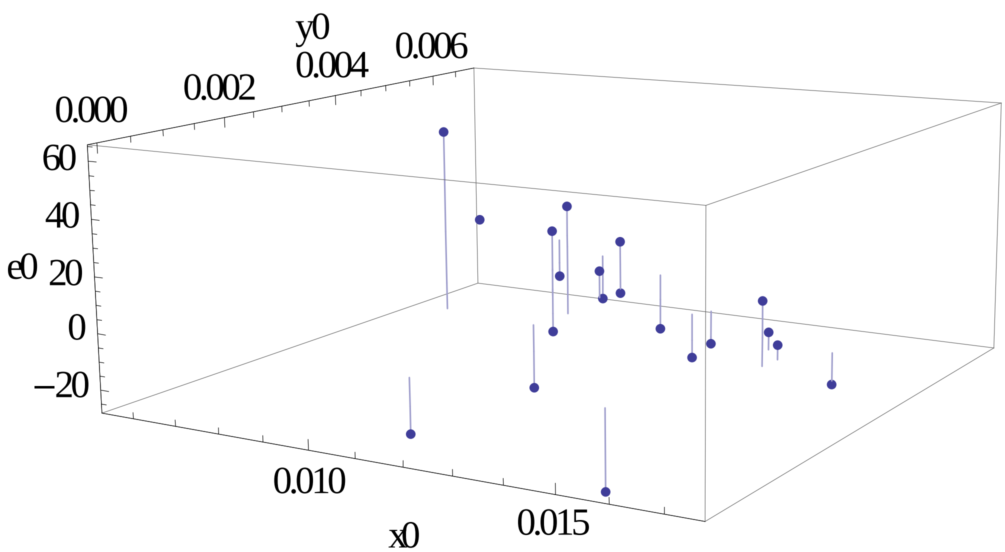
(i) ANOVA Table

	DF	SS	MS	F-Statistic	P-Value
$\beta_{\text{Conference}}$	1	54864.28896076929	54864.28896076929	95.56627056200342	$1.264585993753515 \times 10^{-8}$
β_{Mapping}	1	390.0210447568097	390.0210447568097	0.6793646175703923	0.42059385610985567
Error	18	10333.742182113509	574.0967878951949		
"Total"	20	65588.05218763961			

(ii) Parameter Estimates (R^2 = 0.83)

	Estimate	Standard Error	t-Statistic	P-Value
$\beta_{\text{Conference}}$	3631.6834413118318	695.0584697263163	5.225004225532033	0.000057196162881668344
β_{Mapping}	1909.463618578061	2316.647335357211	0.8242357778999775	0.4205938561098588

(iii) List Plot of Residuals



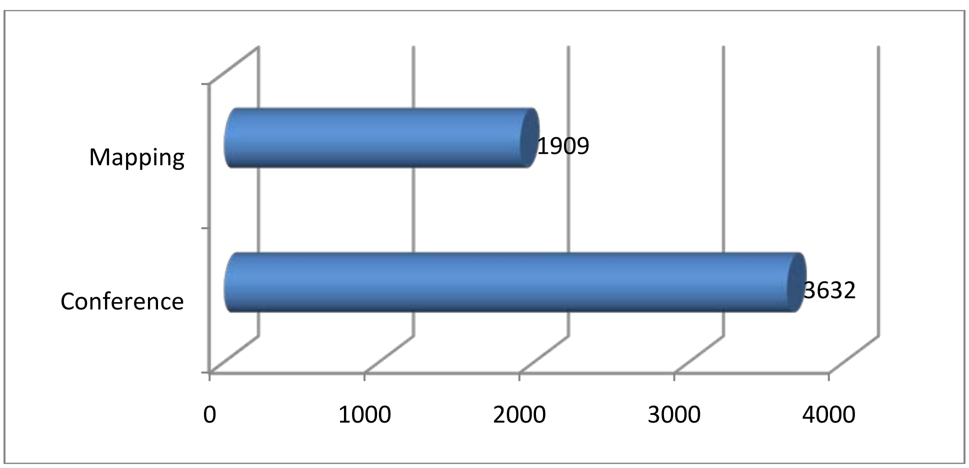
DISCUSSION

To assess performance against its mission of enhancing quality of life for rural residents, for the last 20 years IIRA has been listing the number of programs or activities it has implemented in communities, and adds up the miles its personnel have travelled to accomplish or execute these programs. As a measurement system, these metrics appear clear and simple: they highlight the efforts of IIRA (miles travelled) to assist in the (economic) developmental efforts of communities. However, it could trigger misperceptions among stakeholders about the importance IIRA places on its activities.

To elaborate, consider how a stakeholder could make sense of the metrics. First, she would standardize them across a dimension; for example, compute average miles traveled across programs listed in the activities section of the metrics; then, edit out all that is common across programs (for instance, MAPPING and other programs have averaged similar miles so they are the same), and base her performance assessment of IIRA on differences (for example, "conferences" required more miles so it seems that IIRA is focusing on conference presentations to assist community development). This reasoning is based on the information-processing theory of consumer behavior (see for example, East 1997). A consequence of this misperception would be the stakeholder's tendency to assume that future IIRA activities would be a linear extrapolation of the present; that is, more conference presentations. I believe that this is not the image that the IIRA management wants to project among its stakeholders.

To understand the "real" information embedded in the miles-and-programs metrics, we utilized the GLS estimates of number-of-miles-travelled for conference presentations, and mapping programs (Figure 2). As shown in Figure 2, on average, conference presentations require more miles of travel. In contrast, MAPPING programs tend to be implemented in communities closer to the IIRA's headquarters in Macomb, IL. These results validate our earlier findings that the geographical markets for IIRA programs are the nearby counties such as Adams, McDonough, and Warren (Athiyaman, 2011).

Figure 2: Average Miles Travelled to Deliver IIRA Activities (n=20 years)



Note: MAPPING coefficient doesn't differ from zero (see Table 1)

CONCLUSION

Our empirical analysis reveals a hidden-flaw in the miles-and-programs metrics: it is likely to create misperceptions about the relevance of various IIRA programs for community development. It is time that IIRA management evaluates the benefits of broadcasting the miles-and-program metrics to IIRA stakeholders.

REFERENCES

Athiyaman, A. (Forthcoming). Customer insights for community-economic-development agencies (EDAs): The time series behavior of programs, *Journal of Economics Education and Research*. Also available online at: www.instituteintelligence.com.

East, R. (1997). *Consumer Behavior*, London, UK: MacMillan.

Appendix 1: IIRA Metrics

INSTITUTE MANAGEMENT INDICATORS

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	1990-2009
INPUTS																					
Faculty & Staff:																					
Full-Time	9	11	11	12	13	17	17	18	17	20	21	21	22	26	27	28	29	34	36	37	-
Part-Time	-	-	-	1	3	3	3	2	3	4	4	4	6	2	1	1	1	0	1	1	-
Peace Corps Fellows	-	-	-	-	3	4	7	9	7	19	17	14	20	20	25	20	16	11	13	18	205
Student Workers	5	7	15	11	16	17	8	7	8	15	13	3	3	4	4	2	0	2	2	9	-
Grants	5	3	4	6	8	10	12	11	12	20	26	35	37	36	44	46	46	31	43	48	483
Indirect Cost Dollars (000's)																		180.2	192.2	174.2	547
Appropriated Dollars (000's)	250.0	229.7	226.4	226.2	256.3	330.6	440.9	535.2	569.6	885.3	942.7	1,008.6	1,092.6	1,117.3	1,140.7	1,123.8	1,379.7	1,411.2	1,643.8	1,615.1	16,426
Grant Dollars (000's)	479.6	497.6	498.0	569.3	634.9	652.8	763.4	694.1	731.8	1,046.2	1,227.2	1,163.0	1,791.0	1,953.0	1,636.0	1,974.0	1,873.1	2,959.5	2,280.8	1,952.6	25,378
Total Dollars (000's)	729.6	727.3	724.4	795.5	891.2	983.4	1,204.3	1,229.3	1,301.4	1,931.5	2,169.9	2,171.6	2,883.6	3,070.3	2,776.7	3,097.8	3,252.8	4,370.7	3,924.6	3,567.7	41,804
Calls to the Toll Free Number	601	1,287	1,932	3,282	3,653	3,649	4,164	3,786	3,388	3,255	3,484	2,467	3,595	2,538	2,766	2,560	2,440	2,345	2,288	1,633	55,113
Hits to Web Pages (000's)	-	-	-	-	-	-	-	-	-	-	-	-	37	130.5	266.4	160.5	540.8	594.1	938.0	2,050.5	4,718
Miles Traveled (000's)	31.3	51.1	52.8	75.4	84.6	105.2	92.5	99.4	116.8	193.1	135.7	138.5	157.6	175.0	205.5	215.7	166.3	184.0	188.9	203.5	2,673
ACTIVITIES																					
Conference Presentations	15	26	25	27	26	17	31	37	39	33	41	33	31	27	28	42	50	44	44	19	635
MAPPING Programs	-	-	5	10	20	21	18	16	10	12	11	12	10	9	7	5	8	6	7	5	192
Mailings (000's)	10.4	9.5	10.6	21.9	41.4	48.3	53.2	39.8	40.8	44.3	40.3	29.2	26.2	34.0	20.1	23.2	25.7	25.8	25.7	19.2	590
Service on Boards/Committees																					
Surveys	2	1	7	5	7	6	16	9	12	27	9	11	11	19	10	8	11	18	49	45	283
Teaching - No. of Students	260	205	185	175	140	236	352	271	274	378	273	547	576	454	786	719	521	156	139	130	6,777
Training Programs	-	7	13	7	10	16	17	18	13	54	26	45	98	95	125	92	97	130	156	90	1,109

PRODUCTS																					
Books (hard bound)	-	1	1	-	-	1	2	-	1	-	2	-	2	0	3	0	0	1	1	1	16
Book Chapters, Monographs and Articles	24	20	21	18	10	15	22	15	16	20	22	18	17	12	10	11	14	28	32	20	365
Rural Research Reports	3	10	10	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	6	187
Professional / Trade Publications	-	10	13	12	8	7	10	12	15	16	8	11	9	5	5	7	22	9	2	11	192
OUTCOMES																					
Conference/Training Participants	1,383	1,508	2,487	4,956	3,809	4,388	4,039	4,479	4,252	3,341	2,697	4,275	4,414	4,347	6,540	5,879	7,473	7,728	6,452	2,665	87,112
Faculty/Staff Awards	1	1	1	5	1	3	3	3	3	2	5	5	4	2	2	5	7	7	5	1	66
Trained ED Practitioners (Peace Corps Fellows)	-	-	-	-	-	-	2	2	1	5	8	4	3	6	5	3	5	5	1	2	52
% of Grants Received	100%	100%	80%	100%	91%	100%	91%	100%	89%	100%	94%	87%	96%	94%	95%	94%	86%	97%	68%	86%	92%

Appendix 2: Data Matrix (GLS Model)

Note: Data are for 20 years (1990 to 2009);
Column 3 is the dependent variable: Miles travelled;
Columns 1 and 2 pertain to conferences and mapping respectively.

0.011993379393517259	0.	24.997400890594903
0.015790017693040444	0.	31.028599383570093
0.011825208031151333	0.0023650416062302665	24.967744236972926
0.010557357015648371	0.0039101322280179155	29.499601581058364
0.008156404503363511	0.006274157310279624	26.532156433710476
0.005488081081375681	0.006779394276993488	33.948301084493245
0.009833736222265422	0.0057099113548637935	29.35148210237984
0.011808135307457744	0.00510622067349524	31.71282177032638
0.013971430702403203	0.003582418128821334	41.82938879755655
0.011732499697152482	0.004266363526237266	68.65289974303468
0.014169104231281378	0.0038014669888803694	46.886948252942396
0.011732499697152482	0.004266363526237266	49.22636895660714
0.01175244513176404	0.0037911113328271094	59.76042527275357
0.010871469912280062	0.003623823304093354	70.46323091292633
0.011909634422974926	0.0029774086057437316	87.40820978290526
0.016810324800091966	0.0020012291428680913	86.32902276504372
0.01746706946964145	0.002794731115142632	58.09547305602746
0.016844288607838494	0.002296948446523431	70.43975236005188
0.016402518951764828	0.002609491651417132	70.41899613609947
0.00969104531516896	0.0025502750829392	103.79619587562543