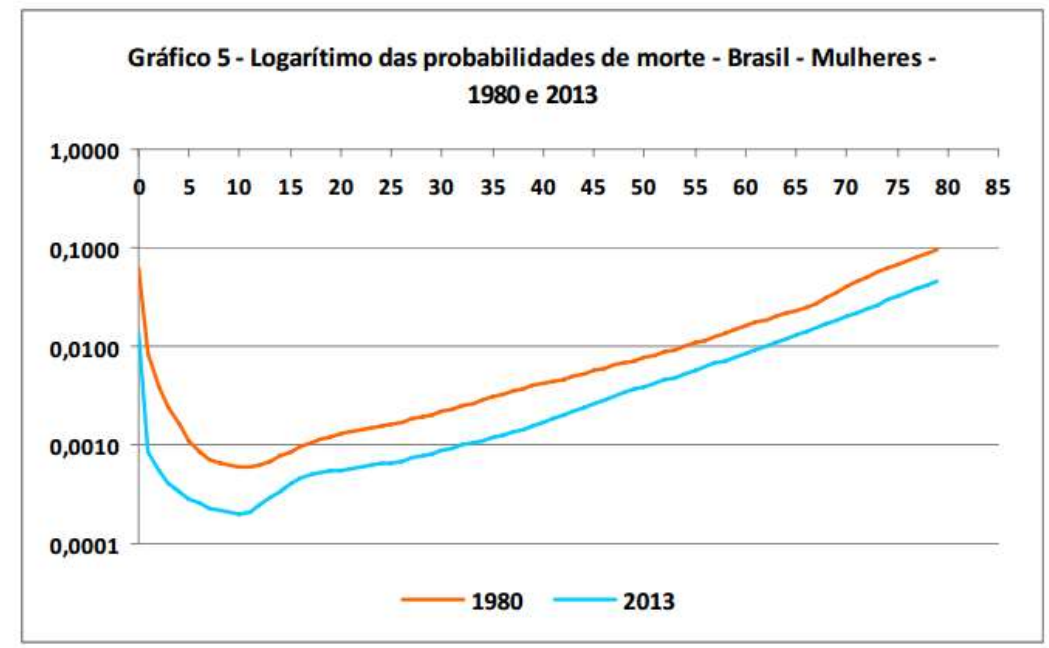
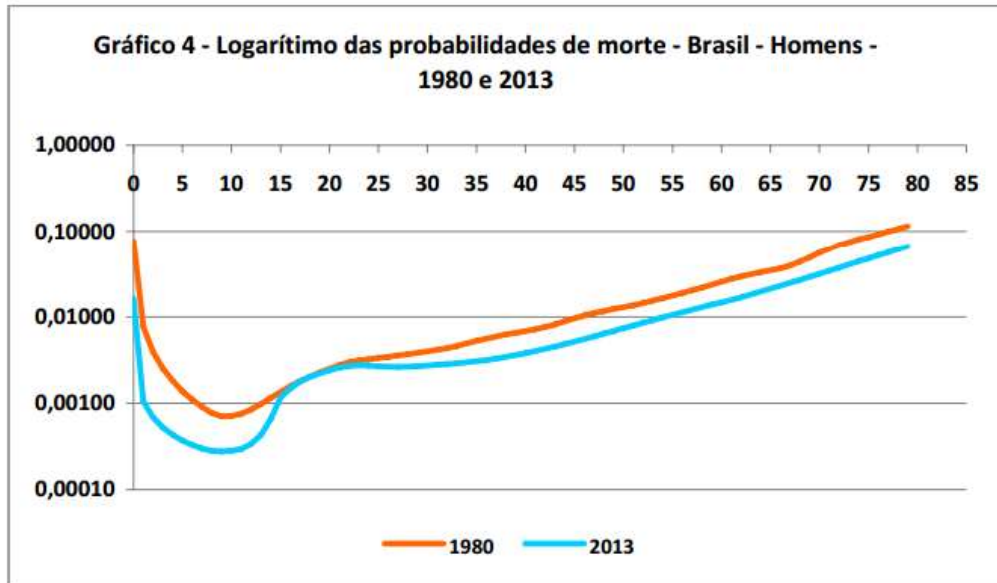


Spatial Error Regression Model of Life Expectancy in Brazil

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May, 2015

Introduction to Life Expectancy

- ▶ How long a member of a population can expect to live on average
- ▶ Brazilian Government legally obligated to give estimates every year based on 10 year census data
- ▶ Mean LE in 2010 = 73.089, SD = 2.68047
- ▶ Up from 62.71 years in 1980



Introduction to Municipalities of Brazil

- ▶ Microregions in Brazil
- ▶ N = 5570
- ▶ Census data from 2010 Available at Municipal Level

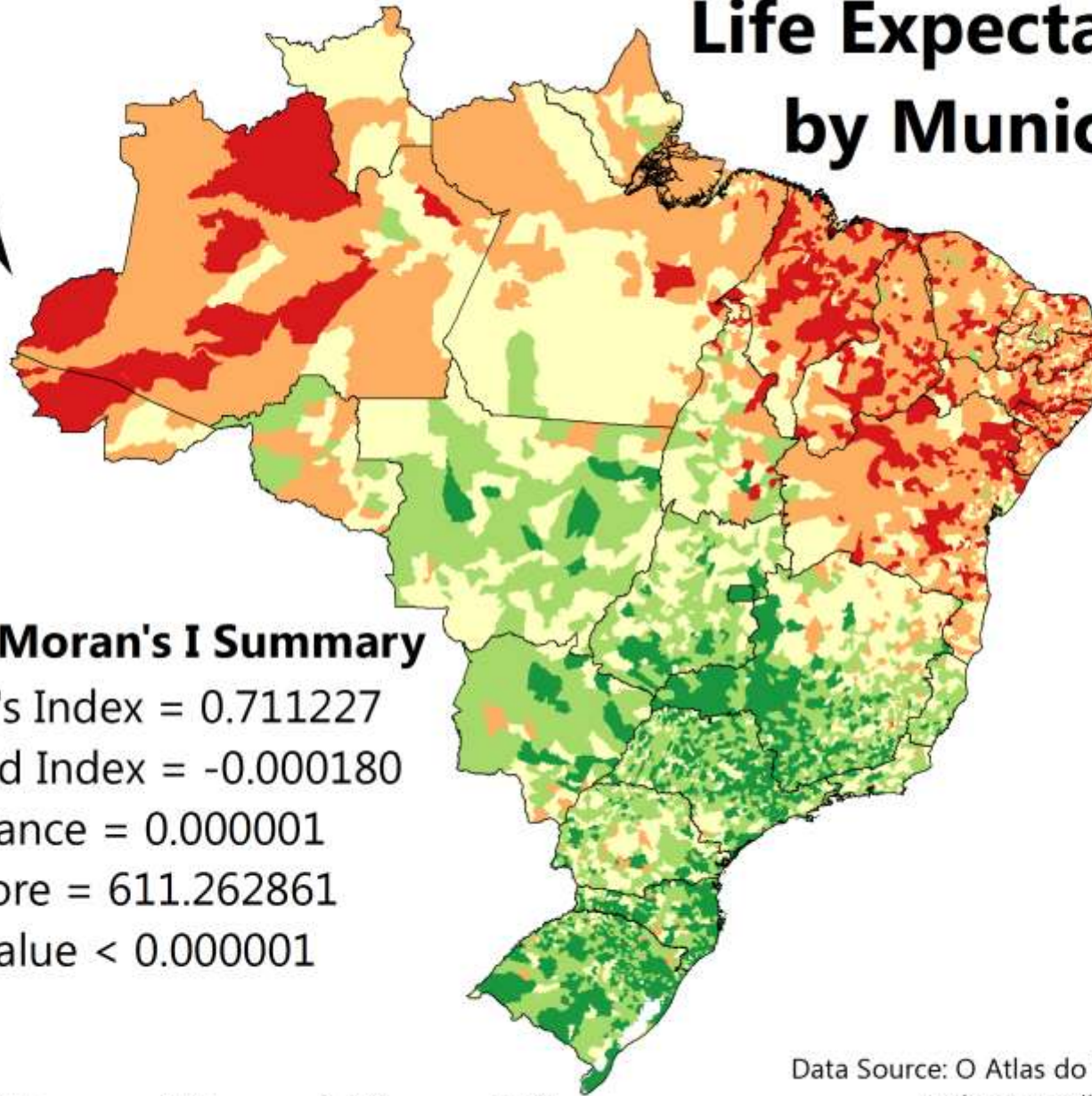
% de empregadores - 18 anos ou mais (1991)
% de empregadores - 18 anos ou mais (2000)
% de empregadores - 18 anos ou mais (2010)
Esperança de vida ao nascer (1991)
Esperança de vida ao nascer (2000)
Esperança de vida ao nascer (2010)
População total (1991)
População total (2000)
População total (2010)
População rural (1991)
População rural (2000)
População rural (2010)
População rural (2010)%
População urbana (1991)
População urbana (2000)
População urbana (2010)
Mortalidade infantil (1991)
Mortalidade infantil (2000)
Mortalidade infantil (2010)

IDHM (1991)
IDHM (2000)
IDHM (2010)
IDHM Renda (1991)
IDHM Renda (2000)
IDHM Renda (2010)
IDHM Longevidade (1991)
IDHM Longevidade (2000)
IDHM Longevidade (2010)
IDHM Educação (1991)
IDHM Educação (2000)
IDHM Educação (2010)
Razão de dependência (1991)
Razão de dependência (2000)
Razão de dependência (2010)
População residente masculina (1991)
População residente masculina (2000)
População residente masculina (2010)
População residente feminina (1991)

População residente feminina (2000)
População residente feminina (2010)
proporcao feminina 2010
Mulheres chefes de família e com filhos menores de 15 anos (1991)
Mulheres chefes de família e com filhos menores de 15 anos (2000)
Mulheres chefes de família e com filhos menores de 15 anos (2010)
% de 18 a 24 anos na escola (1991)
% de 18 a 24 anos na escola (2000)
% de 18 a 24 anos na escola (2010)
Renda per capita (1991)
Renda per capita (2000)
Renda per capita (2010)
% de extremamente pobres (1991)
% de extremamente pobres (2000)
% de extremamente pobres (2010)
% de pobres (1991)
% de pobres (2000)
% de pobres (2010)
% de vulneráveis à pobreza (1991)

Life Expectancy in Brazil by Municipality, 2010

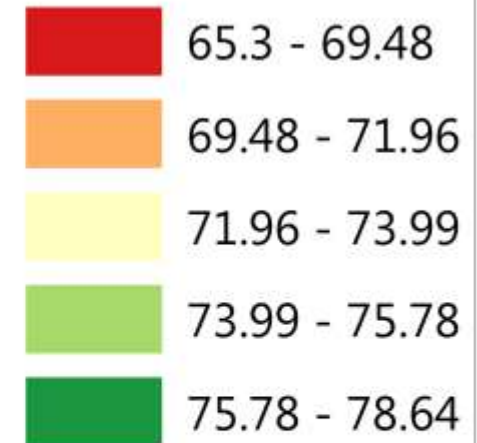
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Global Moran's I Summary

Moran's Index = 0.711227
Expected Index = -0.000180
Variance = 0.000001
z-score = 611.262861
p-value < 0.000001

Life Expectancy (Years)

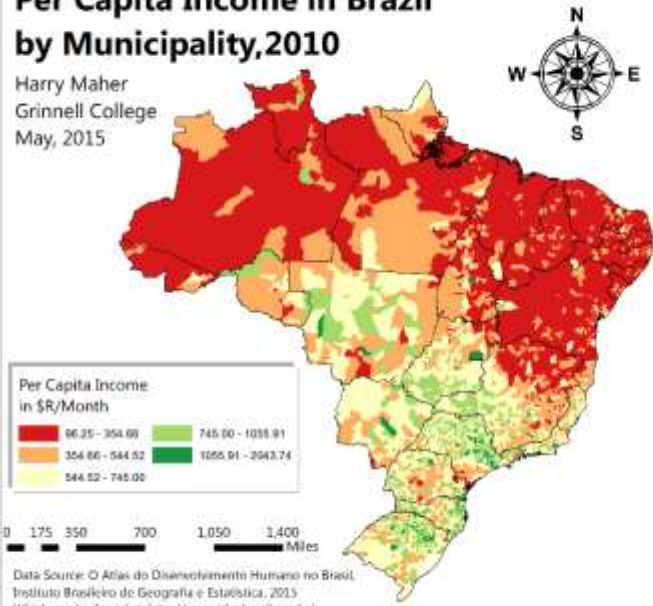


0 212.5 425 850 1,275 1,700
Miles

Data Source: O Atlas do Desenvolvimento Humano no Brasil,
Instituto Brasileiro de Geografia e Estatística, 2015
Which can be found at: <http://www.atlasbrasil.org.br/>

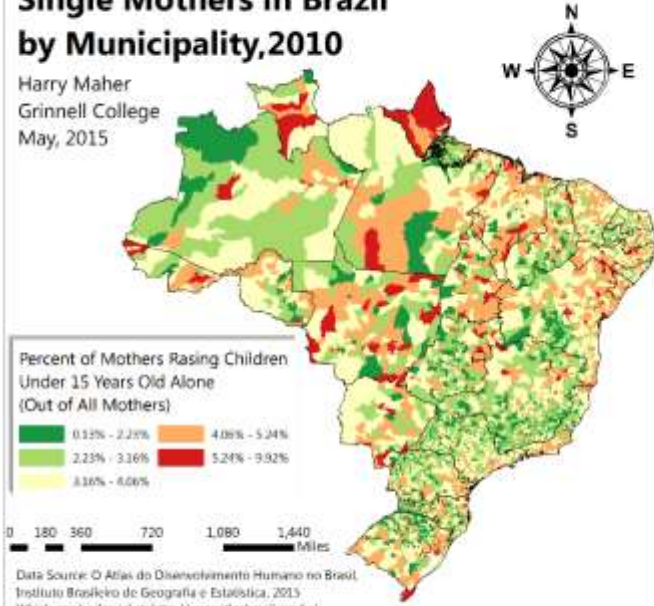
Per Capita Income in Brazil by Municipality, 2010

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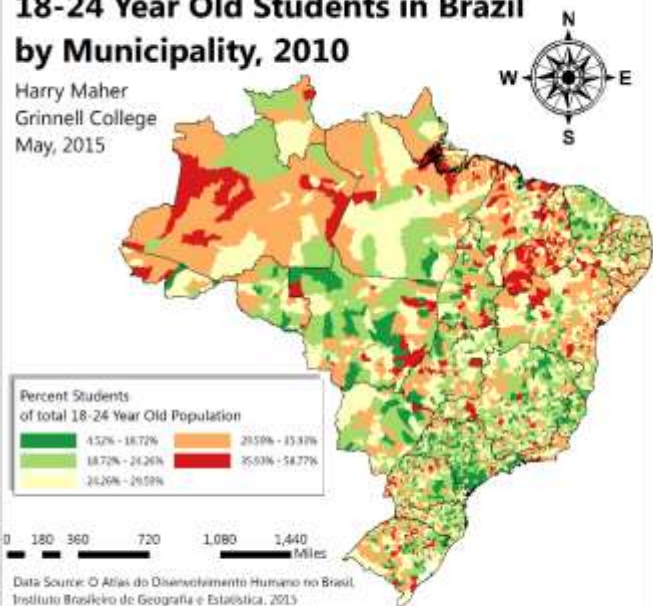
Single Mothers in Brazil by Municipality, 2010

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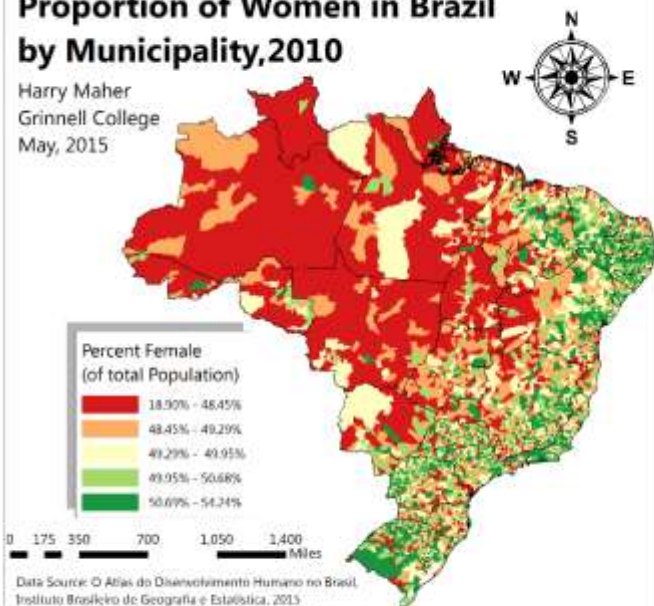
18-24 Year Old Students in Brazil by Municipality, 2010

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Proportion of Women in Brazil by Municipality, 2010

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METHODS

The background features abstract, overlapping geometric shapes in various shades of green, ranging from light lime to dark forest green. These shapes are primarily located on the right side of the frame, creating a dynamic, layered effect. The rest of the background is plain white.

OLS (Linear) Regression Model 1

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.801 ^a	.641	.641	1.60678

a. Predictors: (Constant), Per Capita Monthly Salary 2010, Percent of 18-24 year-olds in School (2010), Proportion of female heads of household with children under 15, Proportion Female

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	25629.766	4	6407.442	2481.839	.000 ^b
	Residual	14354.426	5560	2.582		
	Total	39984.192	5564			

a. Dependent Variable: Life Expectancy, 2010

b. Predictors: (Constant), Per Capita Monthly Salary 2010, Percent of 18-24 year-olds in School (2010), Proportion of female heads of household with children under 15, Proportion Female

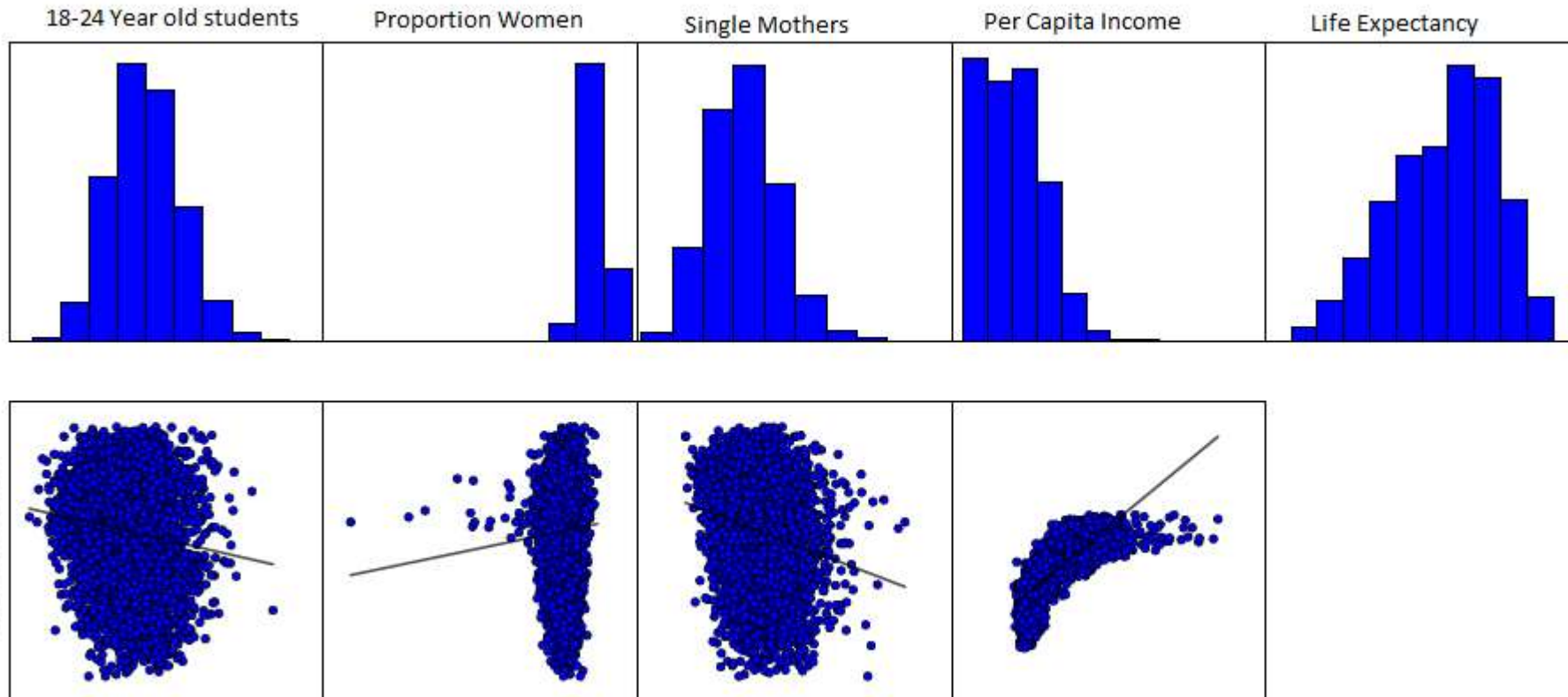
Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	75.035	.692		108.467	.000		
	Proportion Female	-9.060	1.461	-.053	-6.203	.000	.883	1.132
	Proportion of female heads of household with children under 15	-14.099	1.950	-.060	-7.229	.000	.941	1.063
	Percent of 18-24 year-olds in School (2010)	-.048	.003	-.121	-14.547	.000	.940	1.064
	Per Capita Monthly Salary 2010	.009	.000	.784	94.427	.000	.936	1.069

a. Dependent Variable: Life Expectancy, 2010

Problem

Variable Distributions and Relationships



So, Ran again using log(PCI)

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.840 ^a	.705	.705	1.45681

a. Predictors: (Constant), LoggedPCI, Percent of 18-24 year-olds in School (2010), Proportion of female heads of household with children under 15, Proportion Female

b. Dependent Variable: Life Expectancy, 2010

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28184.304	4	7046.076	3320.047	.000 ^b
	Residual	11799.888	5560	2.122		
	Total	39984.192	5564			

a. Dependent Variable: Life Expectancy, 2010

b. Predictors: (Constant), LoggedPCI, Percent of 18-24 year-olds in School (2010), Proportion of female heads of household with children under 15, Proportion Female

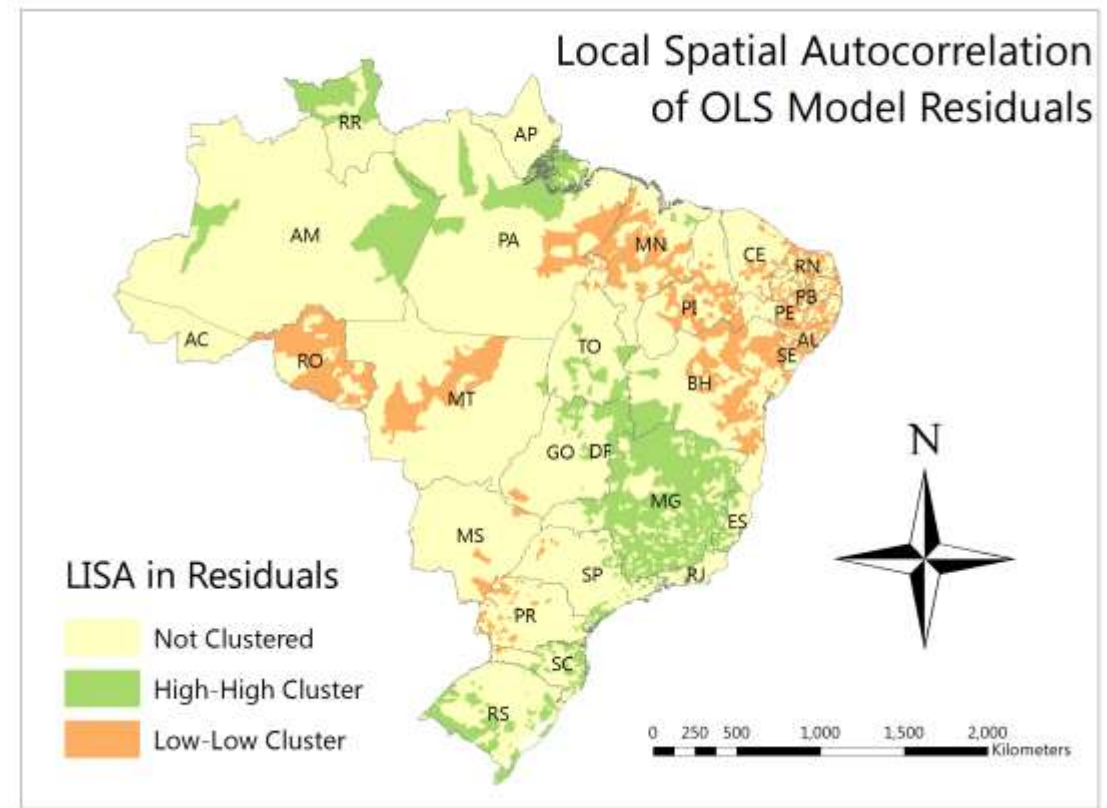
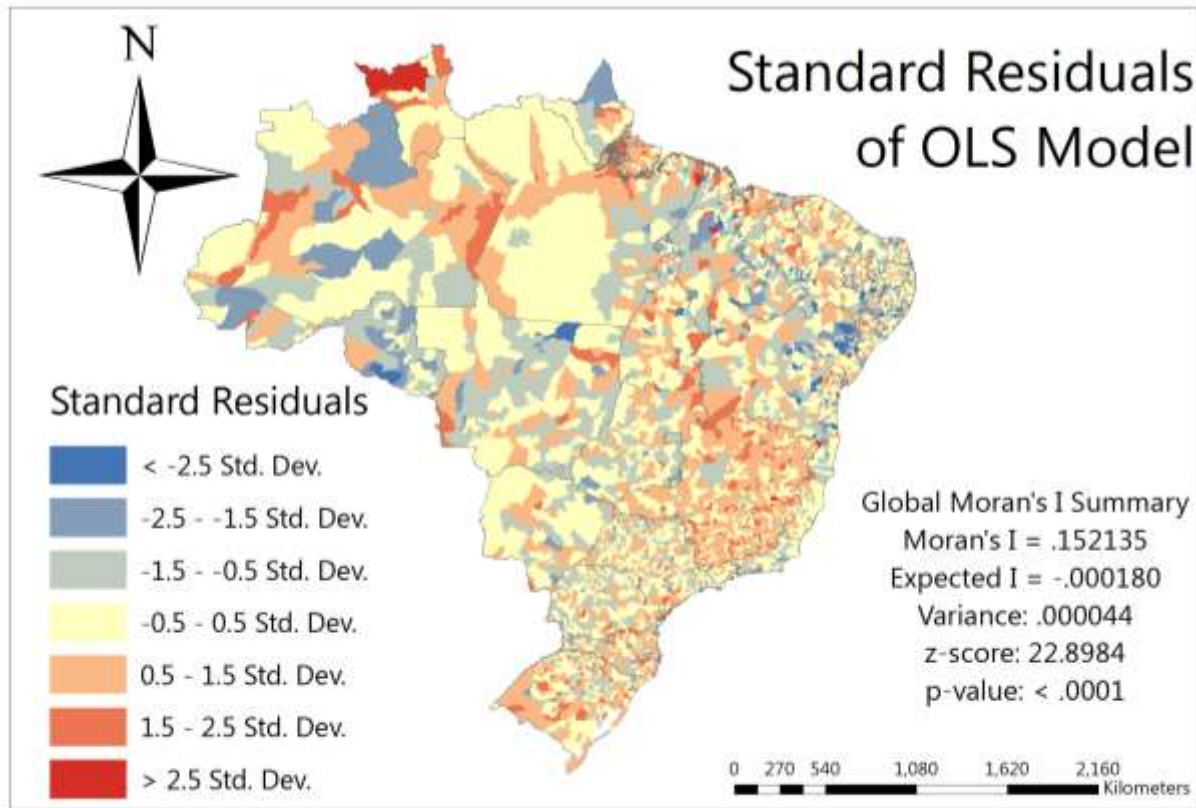
Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	51.767	.637		81.314	.000		
	Proportion Female	-9.728	1.323	-.057	-7.355	.000	.886	1.129
	Proportion of female heads of household with children under 15	-10.355	1.772	-.044	-5.845	.000	.938	1.067
	Percent of 18-24 year-olds in School (2010)	-.018	.003	-.046	-6.131	.000	.927	1.079
	LoggedPCI	4.436	.040	.831	109.775	.000	.927	1.078

a. Dependent Variable: Life Expectancy, 2010

Life Expectancy = 51.767 +
 proportion female (-9.728) +
 proportion single moms (-10.355)
 + percent 18-24 in school (-.018)
 + ln(PCI)(4.436)

Spatial Autocorrelation in OLS Model



Can we improve the model with Geographically Weighted/ Spatial Lag/Error Models? Which to use?

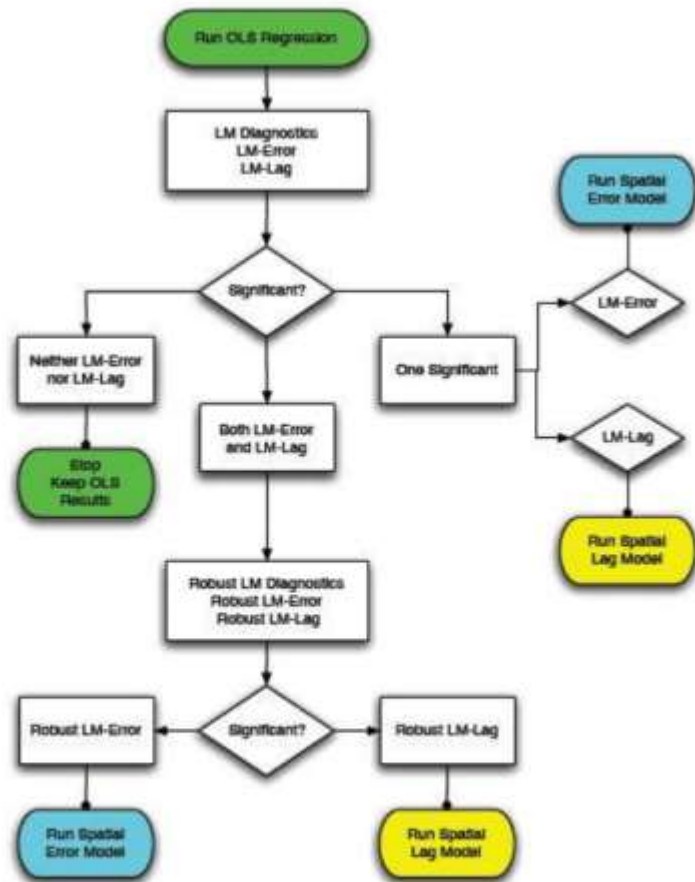


Figure 23.24: Spatial regression decision process.

- **Geographically Weighted Model** - constructs a separate equation for every feature in the dataset incorporating the dependent and explanatory variables of features falling within the bandwidth of each target feature
- **Spatial lag model:** y_i influences y_j - or life expectancy in Jasper County influences Poweshiek County. Also, Tobler's 1st law.
- **Spatial error model:** "observations are related due to unmeasured factors that, for some unknown reason, are correlated across the distances among the observations." (Ward & Gleditsch, 2007)
 - In other words, the model is missing something like SUS coverage, dengue/yellow fever/malaria or other health factors that vary regionally

(Findings) Final Model: Spatial Error Model

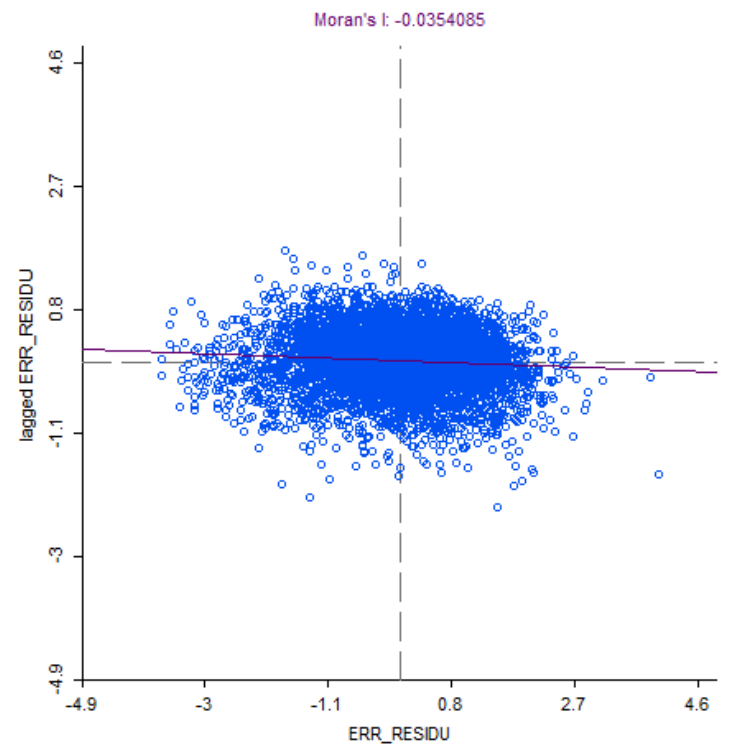
$$R^2 = 0.747292$$

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT:	52.90804	0.6796764	77.84299	0.0000000
18-24 Year Old Students:	-0.006463592	0.003146995	-2.053893	0.0399859
Proportion Female:	-6.311388	1.450869	-4.350074	0.0000136
Single Mothers:	-4.838864	1.814225	-2.667179	0.0076492
Log(PCI):	3.885839	0.05873287	66.16123	0.0000000
LAMBDA:	0.4838049	0.01642824	29.44958	0.0000000

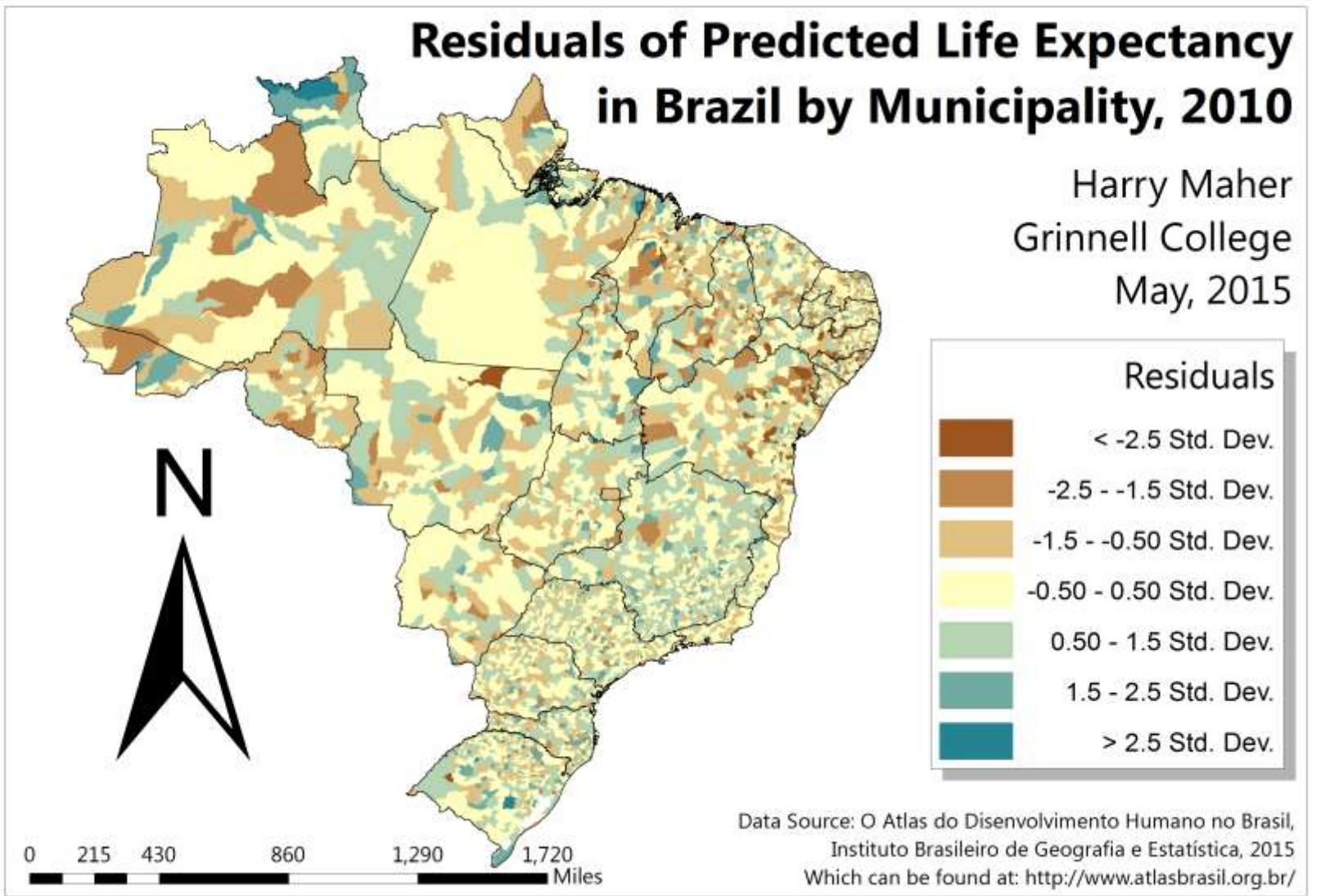
Findings

Final Model:

Moran's I = $-.0354$

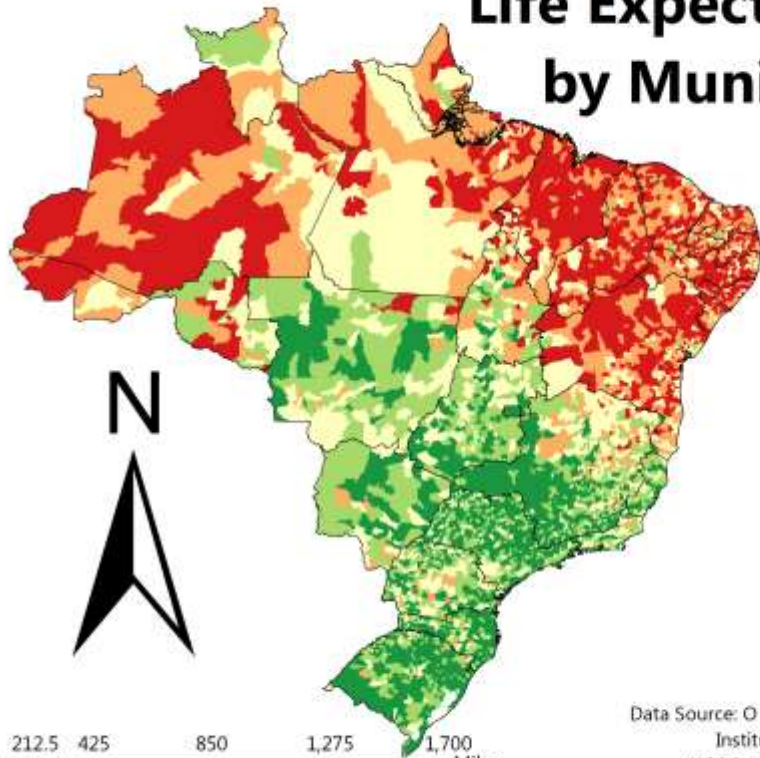


#obs	R ²	const a	std-err a	t-stat a	p-value a	slope b	std-err b	t-stat b	p-value b
5565	0.00569	0.0102	0.00628	1.62	0.105	-0.0354	0.00628	-5.64	$1.77e-008$

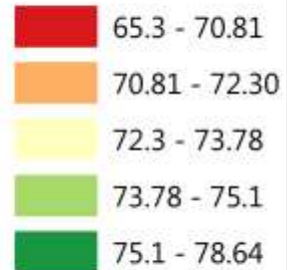


Life Expectancy in Brazil by Municipality, 2010

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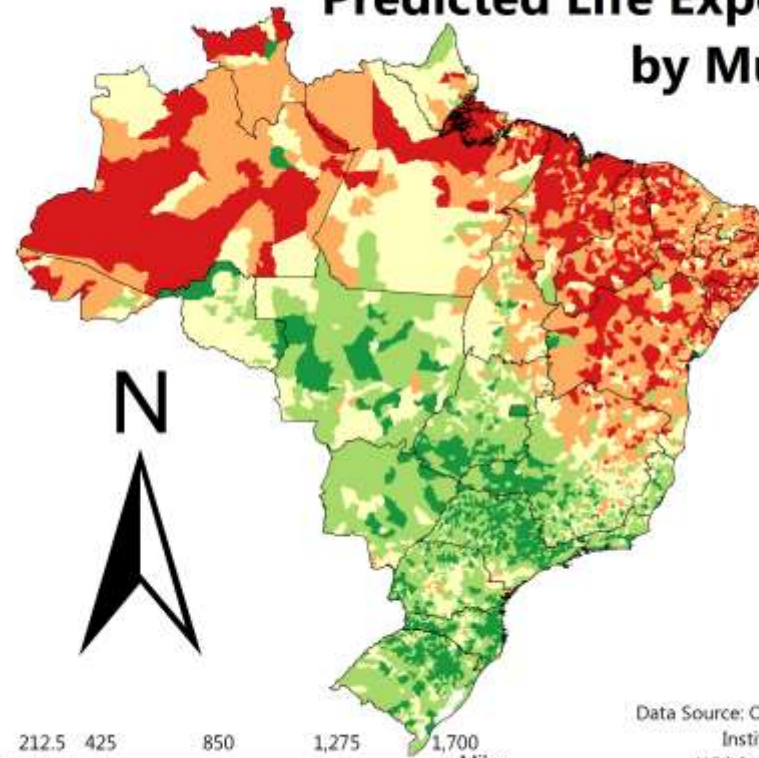
Life Expectancy (Years)



Data Source: O Atlas do Desenvolvimento Humano no Brasil,
Instituto Brasileiro de Geografia e Estatística, 2015
Which can be found at: <http://www.atlasbrasil.org.br/>

Predicted Life Expectancy in Brazil by Municipality, 2010

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Predicted Life Expectancy (Years)



Data Source: O Atlas do Desenvolvimento Humano no Brasil,
Instituto Brasileiro de Geografia e Estatística, 2015
Which can be found at: <http://www.atlasbrasil.org.br/>

Discussion & Conclusions

- ▶ The model was good without SE model also
 - ▶ PCI - Significantly correlates with health outcomes (Lynch & Kaplan, 1998).
 - ▶ Single mothers - Children at increased risk of accidental injury & asthma (Dawson, 1991)
 - ▶ Women live longer, so where there are more of them, there is increased L.E. - Although within the model this seems to be interacting with other variables to reduce life expectancy. (IBGE, 2013)
 - ▶ Students aged 18-24 - Unclear if we're looking at university towns
- ▶ Potential spatial variables should be put in the model to improve it to make up for this spatial error
 - ▶ Looking at SUS (Public Healthcare) coverage
 - Minas Gerais was earliest to start predecessor programs, is established (Brant, 2004).
 - Rondônia historically and currently underserved (Matos, 2007; O Globo, 2015)
 - ▶ Dengue, Yellow Fever, Malaria - Can these be another geographic variable (I found Dengue, but that alone was not significant)
- ▶ S.E. model improved the model to $R^2 = 0.7473$ from .705

MAPA DA SAÚDE

Government Propaganda ("Health Map")

- ▶ Left: "This is a cool health map. There are a lot of health centers to care for people. And how does it compare to other countries?"
- ▶ Right: "I don't know, but my teacher says that the Brazilian system is one of the few that recognizes health as a right for any person"



Dengue in Brazil Over Time

- ▶ Finding the data took forever, but didn't help model.
 - ▶ So I made a visualization of Dengue rates over time, but I couldn't save it, so here's a bunch of screenshots: <\\storage\gis\sst295\maherhar\project\Pictures-2015-05-06\Pictures>
- ▶ Method:
 - ▶ Coordinates of dengue municipalities w/
 - ▶ Estimated population w/ 2000-2010 population data to get a rate of dengue/person
 - ▶ Changed coordinates to equal area projected coordinate system
 - ▶ Transformed coordinates so they would have same impact scale as years across 8 years

References

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