

An aerial photograph of a rural landscape with rolling hills and patchwork fields. A network of white lines connects various points across the landscape, with some points highlighted in blue, purple, and yellow. The network is denser in some areas and sparser in others, suggesting a complex system. The background is a bright blue sky with scattered white clouds.

A New Framework for Regional Economic Development

Resiliency as Adaptation in a Complex System: Multiple Concepts and Multiple Measures

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STATSAMERICA

Outline

- What would researchers, policymakers and practitioners – in common – want to know about regions adapting to shocks?
 - In literature, one sees an increasing reference to the complex adaptive system framework
- High-level overview of key concepts and complex adaptive systems
 - Our measure for industry transformation aligns with the CAS attribute of emergence
- Propose different concepts and measures
- Phase transition concepts & markers:
 - **Risk, Recovery and Restructuring**

Outline, continued

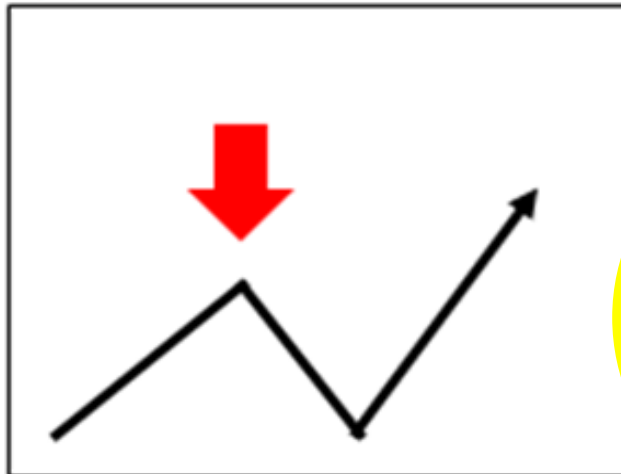
- Consider labor churn as a signal for regional economic transformation
- Propose two metrics that would be of interest to those studying regional resiliency and adaptation
- Question the need for the counterfactual
- Discuss next steps in exploring a conceptualization and measure of resiliency that does not require a counterfactual and does provide information about the complex industrial adaptations regions undergo after an economic shock

Does this experience undercut how resilience is measured?

Longer-term response to the Great Recession (global financial crisis), U.S. counties

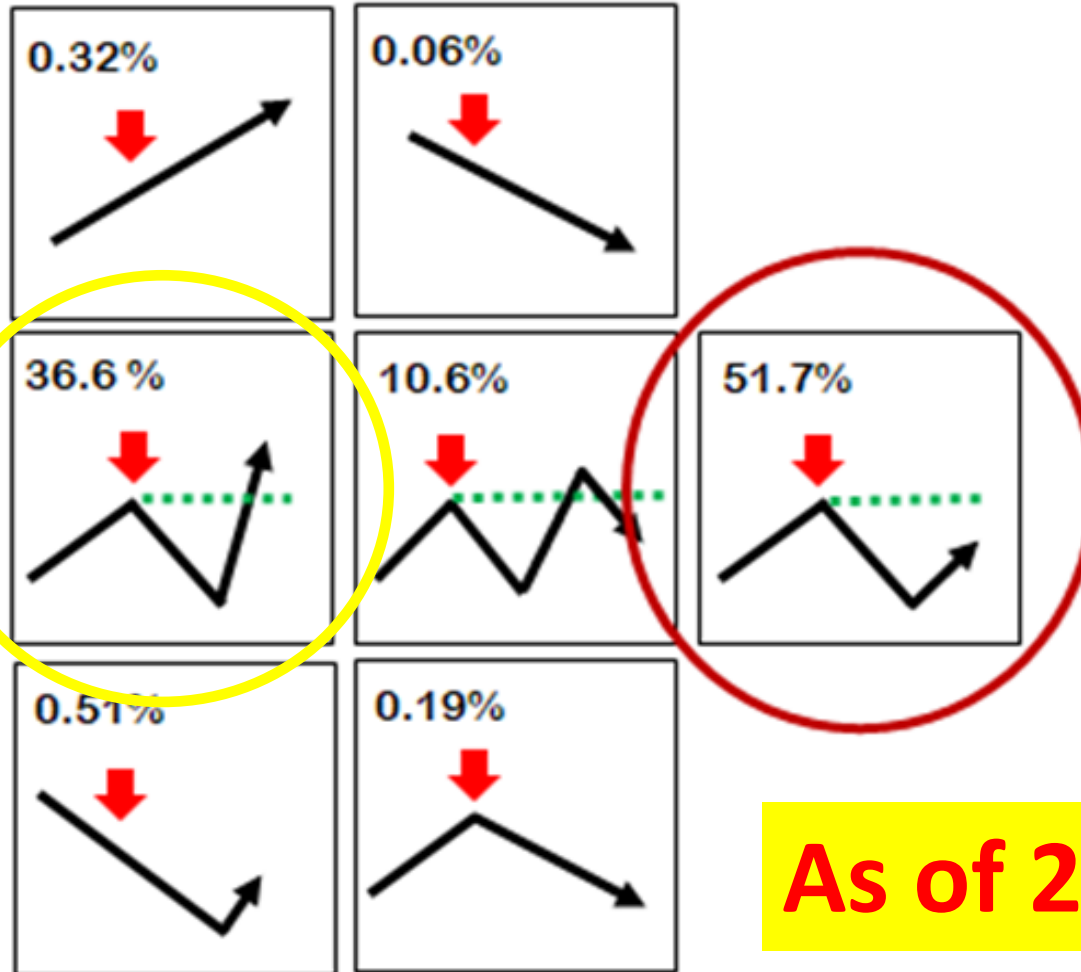
U.S. in the Aggregate

(3,139 counties)



Data source: US Department of Labor Statistics, Quarterly Census of Employment and Wages, Jan 2000 – June 2017

Analysis: Stephan J. Goetz and Yicheol Han
Dept. of AESE, NERCRD
Penn State University



As of 2016

Big Ideas

- Few U.S. regions experienced the stylized recession and recovery templates
- What is resiliency anyway?
 - Resisting? Absorbing? Adapting? TRANSFORMING?
- Are we measuring the right phenomena?
 - Are there false signals for resiliency?
 - Can a region be resilient and **Shrinking Smartly**?
- May we defenestrate the idea of the counterfactual?

Analytical Frameworks for Resiliency

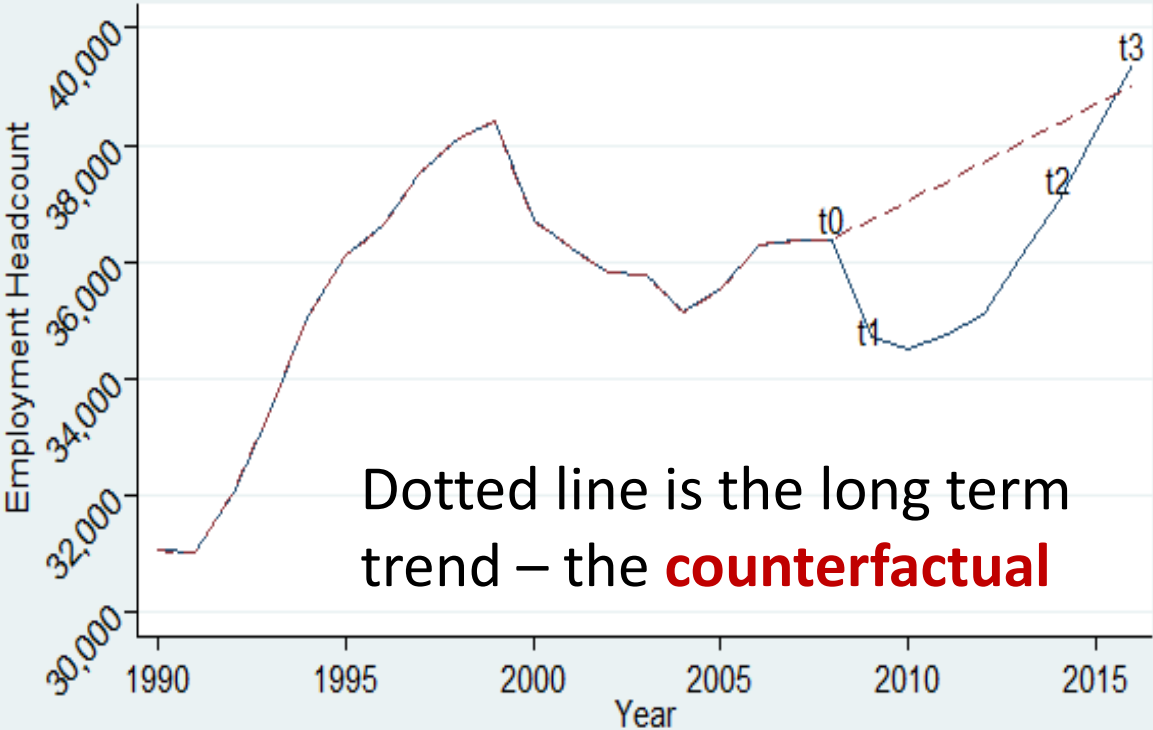
- Analytical frameworks generally fall into three categories (Martin, 2012):
- **Engineering** resilience
 - Holling’s (1973) notion of engineering resilience with that of **self-correcting mechanisms**
 - Not associated with “hardening” or immunization
 - Hysteresis may include a scenario where a shock causes multiple subsequent equilibria and/or permanently redirect an economy’s path away from sustainable growth
- **Ecological** resilience
- **Evolutionary** resilience
- Does resilience imply returning to an upward-sloping expected trend?
- Is a “slow burn” evidence of resilience? Better than “augur in”!
- Is smart shrinkage evidence of resilience?

Do Framework Matter?

- “Plucking Model” of business fluctuations
 - Serves as a general framework for a region’s response to a recessionary shock with something of an idealized long-term employment growth trend that is upward sloping
 - Martin focuses on hysteresis, the phenomena of a shock knocking region off its (former) expected trend
- Han & Goetz (2015) implement this framework for U.S. counties by comparing the actual employment level against a counterfactual employment level
 - expected trend is estimated using a compound growth rate of the **three previous years** leading up to peak employment
 - Three transition phase markers - shock, drop, and rebound
 - Spoiler alert, elsewhere we proposed four transition phase markers – peak, drop, return-to-**peak** and return-to-**trend**
- Other than this work, not much for the U.S. context

Plucking Model versus Hysteresis

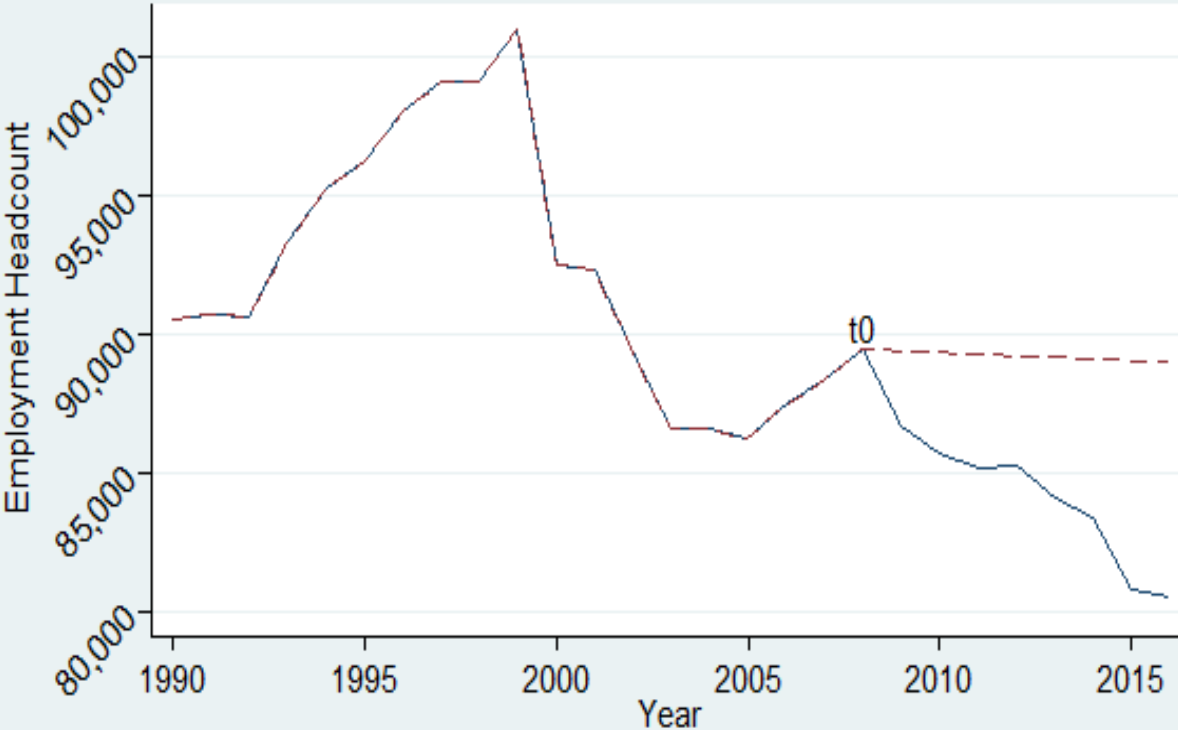
Floyd County, IN
CAGR from 1990-2008 (local peak)



— Actual Employment - - - - CAGR Employment, 1990 to t0

Pop = 76,723

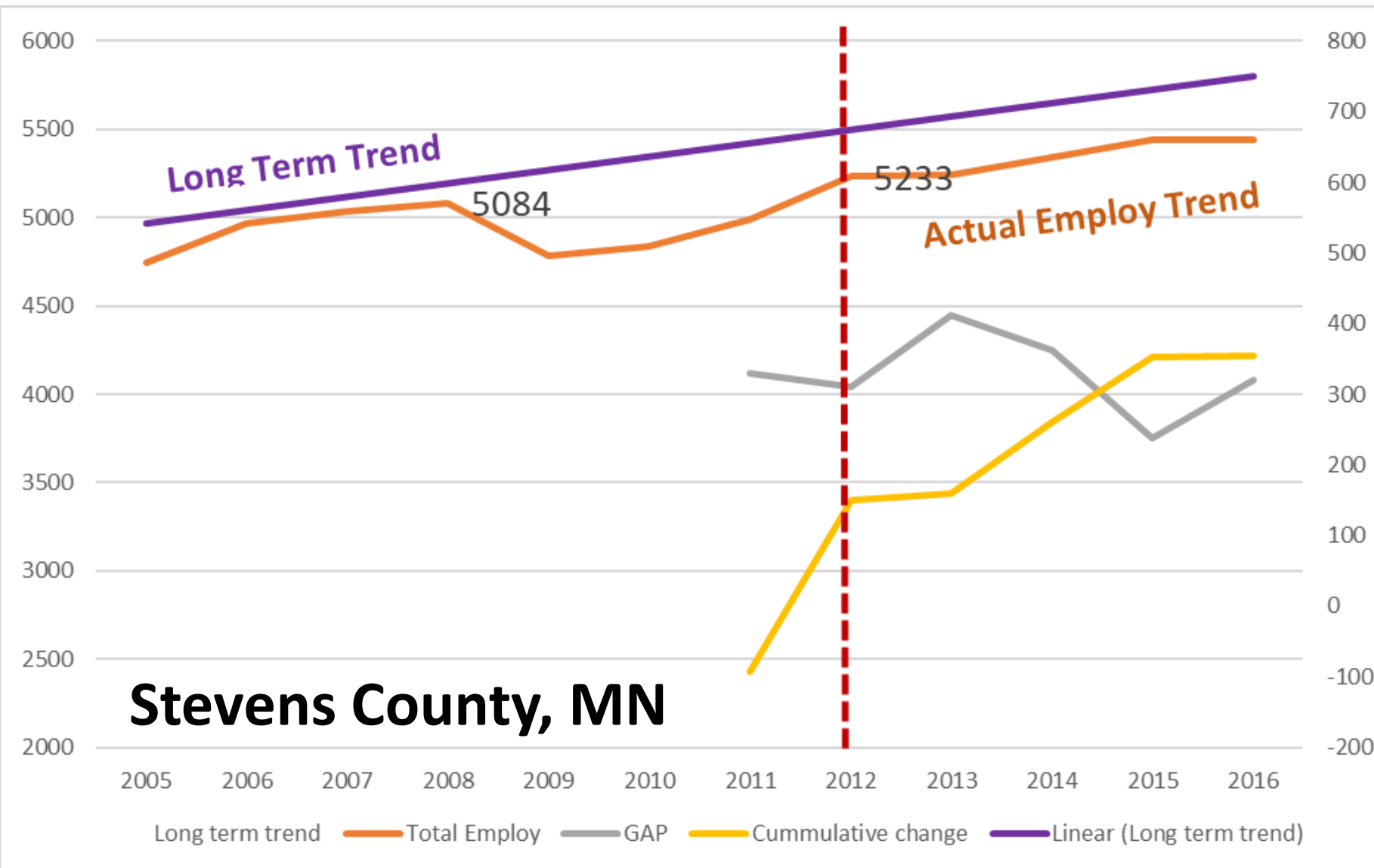
Kanawha County, WV
CAGR from 1990-2008 (local peak)



— Actual Employment - - - - CAGR Employment, 1990 to t0

Pop = 186,097

Is recovering to LTT feasible? Often observed?



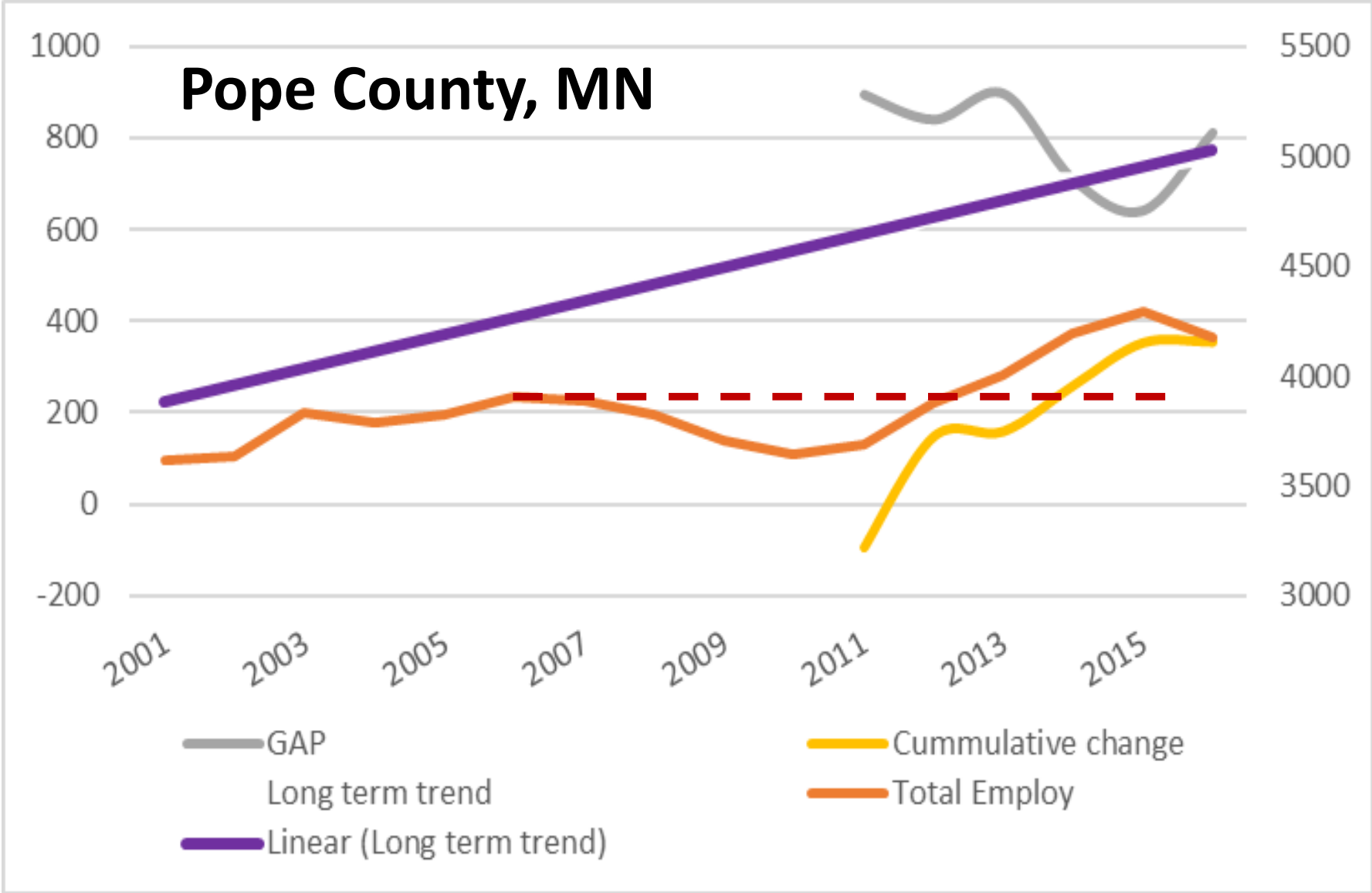
LTT based on linear 1990 to 2016

Trend versus actual shows persistent gap (gray line)

Similar experience in Houston, San Diego, etc.

Return to Peak but not trend, at least not yet

Returns to peak but doesn't close the GAP



Trend versus actual shows persistent gap (gray line, left axis)

The experiences do not fit the template!

Do Frameworks Matter?

- *Ecological* and *Evolutionary* based on **transformation**
- **Can we measure transformation? *You bet!***
- Martin, Sunley, Gardiner & Tyler (2016) used Lilien and Krugman (dissimilarity) indexes to measure industry structure change
- If a regional performance improves, is it, **by definition**, resilient?
- Can there be a “**false signal**” for resilience? Does any positive change do?
- What appears clear in the resilience adaptation literature is that ***how* regions change** is different from ***that* regions change**

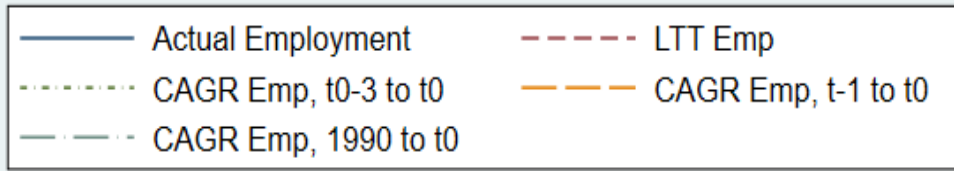
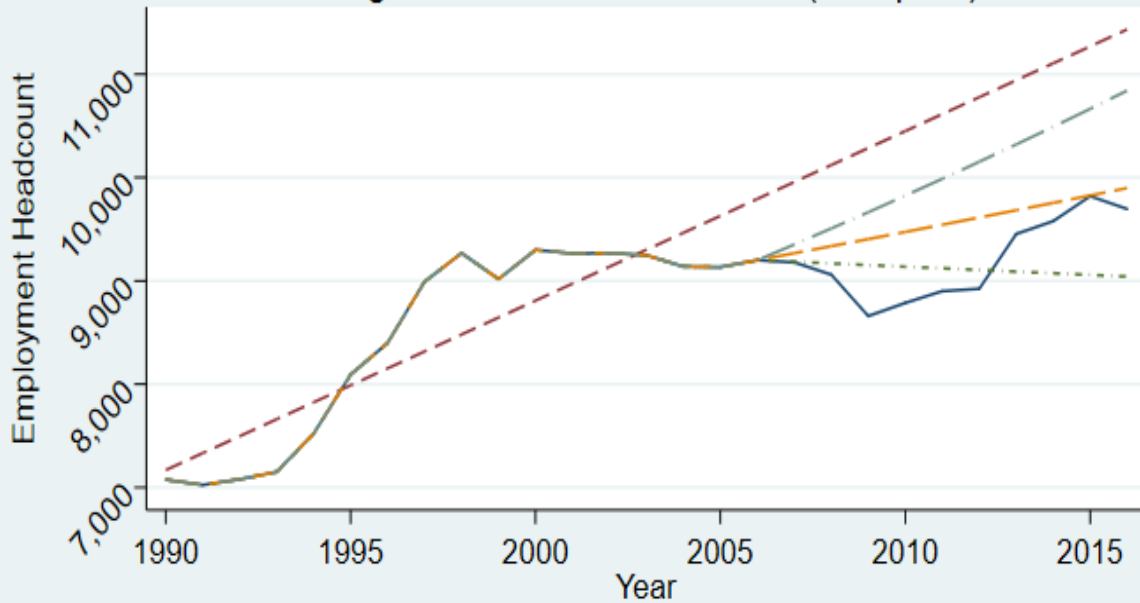
The Counterfactual

- Currently, measuring economic resilience depends on defining the counterfactual scenario
- Assumptions: linear versus compounding growth rate
 - Starting point or ending point
 - Duration/length of time series
 - Regional reference points or a national benchmark?
- A region is considered “resilient” depending on these choices
- You tell me the counterfactual assumptions and I’ll tell you...

Which Counterfactual Again?

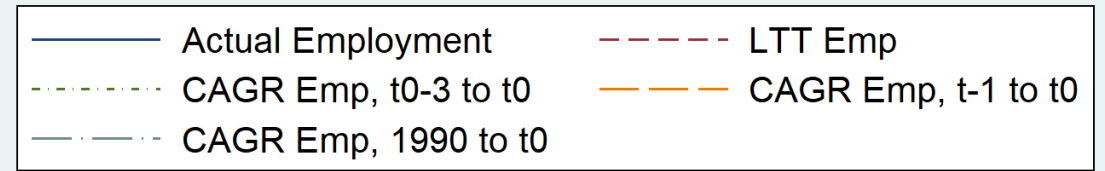
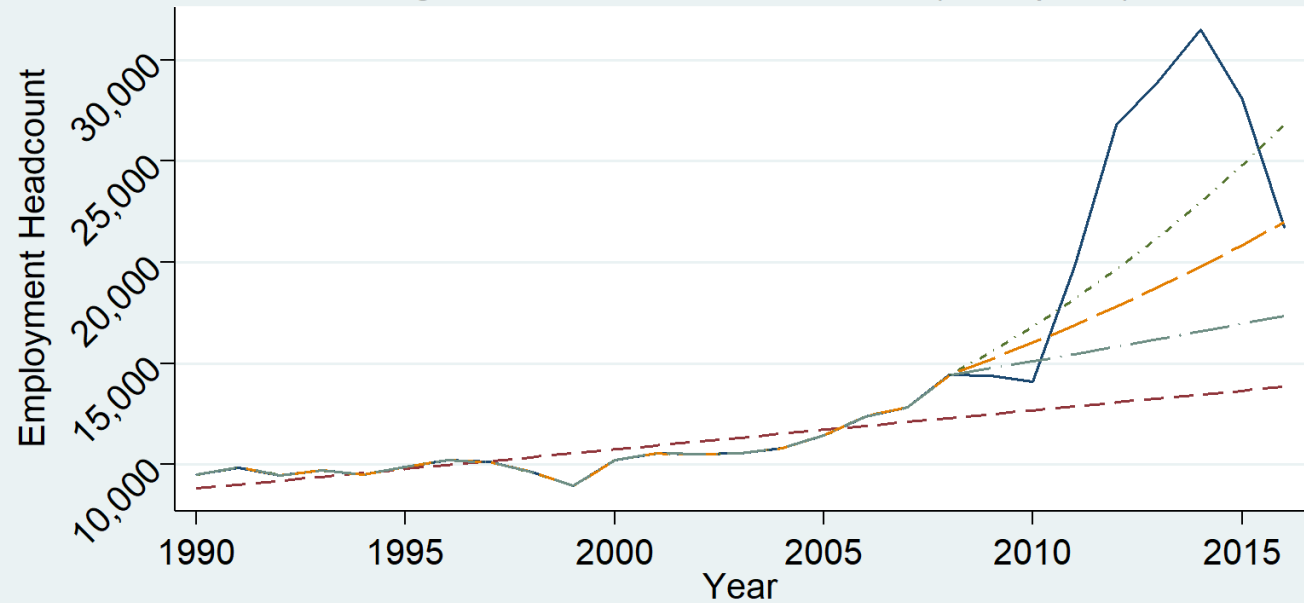
CAGR? Or Linear Long-term Trend? Which period is the most relevant?

Washington County, MO
Long-term trend from 1990-2006 (local peak)



Pop = 25,002

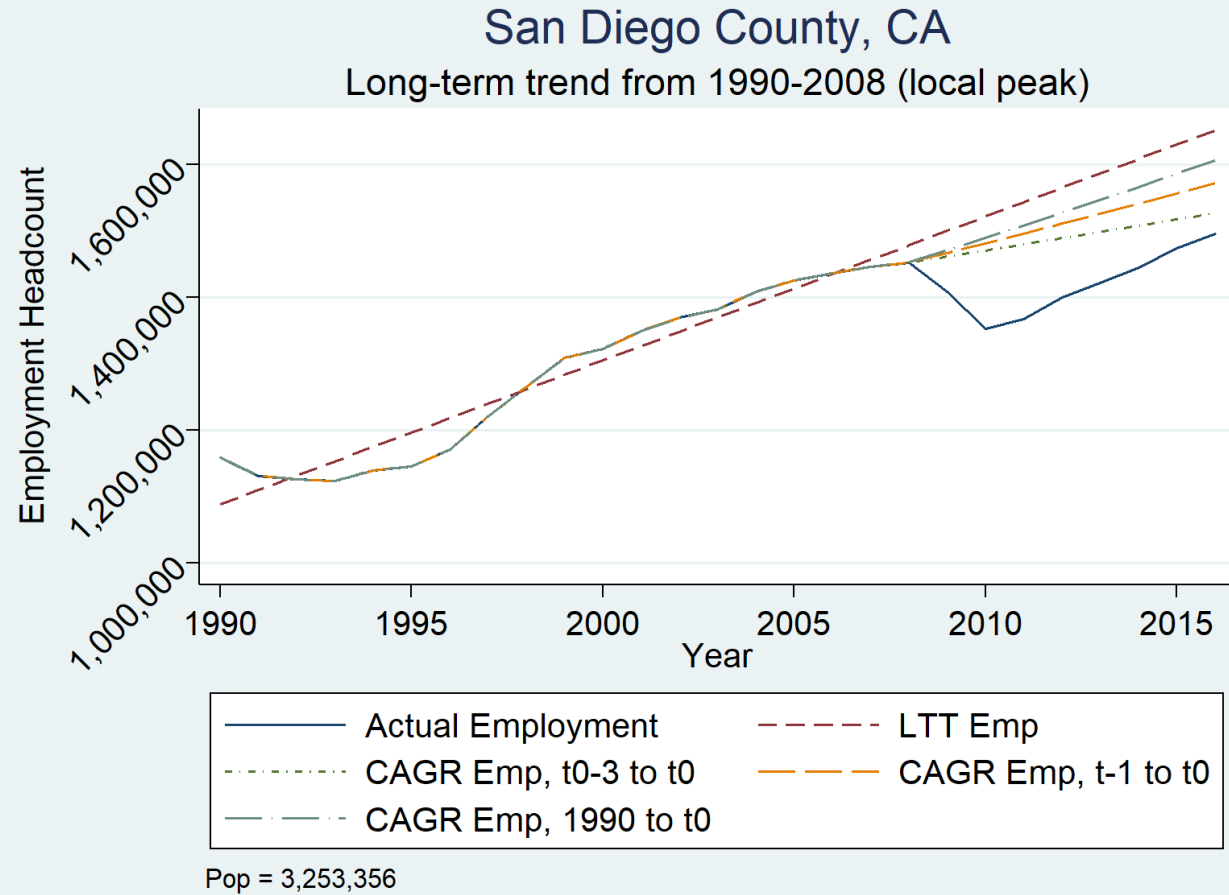
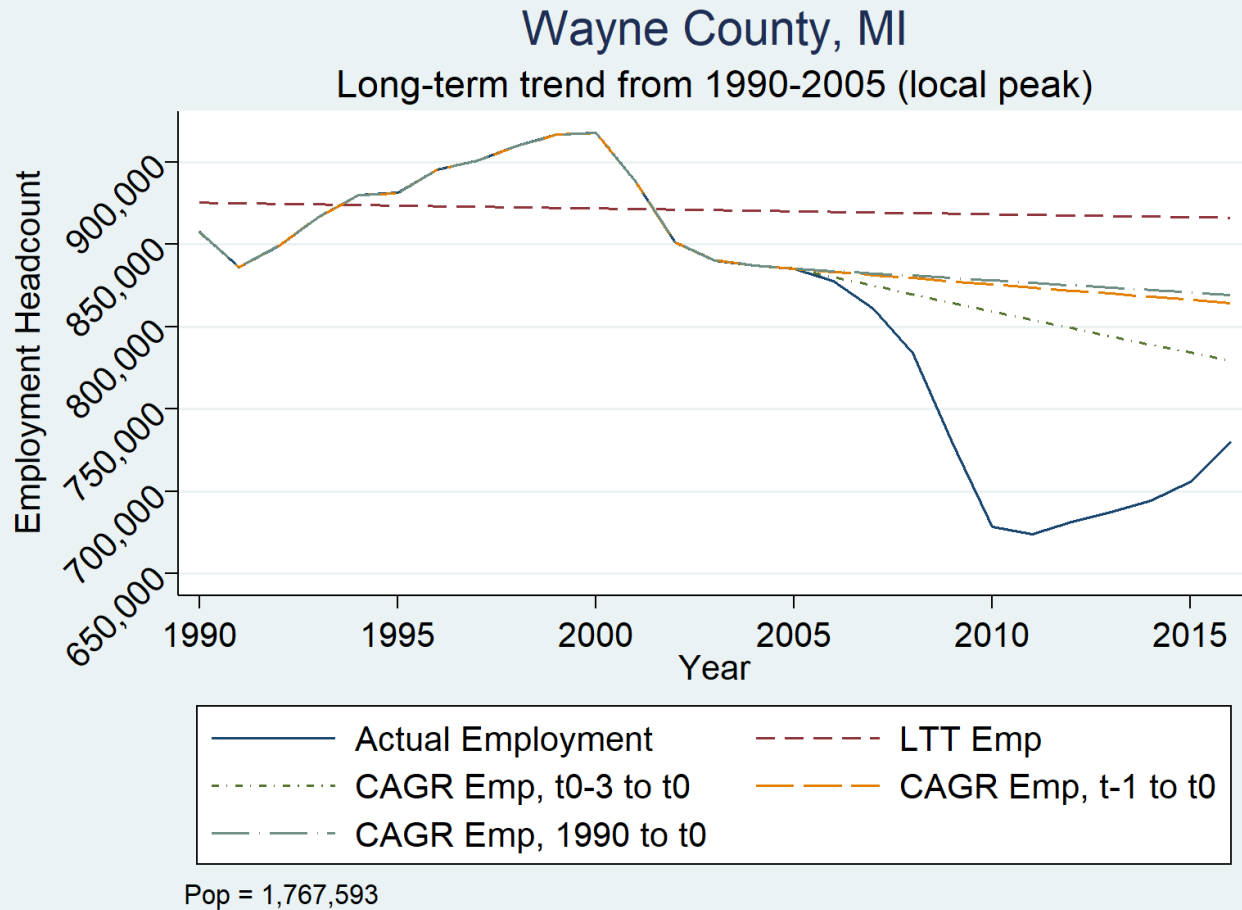
Williams County, ND
Long-term trend from 1990-2008 (local peak)



Pop = 31,643

Which Counterfactual?

CAGR (AAR)? Or Linear Long-term Trend? Which period is the most relevant?





Brief overview for the complex adaptive system inductees

FROM THE “*THAT*” TO THE “*HOW*”

Complex Adaptive System Attributes

- **Self-organizing**
- **Dynamic**
- **Non-linear**
- **History/memory**
- **Open**
- **Exhibit *emergence***
- Emergence is the “behavior” of a system or collection of systems that cannot be accounted for, or explained at, the “agent” level
- Agents – the individual actors alone – and their actions important
- Their actions influence the behavior of the complex systems
- London Millennium Bridge -> agents compensating for the swaying bridge made the sway worse as they tried to balance themselves
- Agent behavior different than systems behavior

Agents in the CAS Framework

- Agents in the regional economy are dissimilar individuals who may or may not organize into some group or structure
- Agents respond to incentives and environmental forces
- Complex systems theory is a framework that explains how **rules govern** agent interaction within a system
- Those interactions result in emergence – system level behaviors
- System level behaviors change with time but are dependent upon past transition phases (or are in some degree, path-dependent)
 - Have “memory” like expressway traffic
- Show non-linear patterns

On Complexity, Maladaptation and Hemoglobin

- Adaptive systems are complex
- Complex systems are not necessarily adaptive
- A complex system may change in a manner that compromises the *ability to persist* → *maladaptation*
- Appraising adaptation depends on the scale/size of the component
- A person's cells, organs and body may adapt to living at high altitude by changing their structure and metabolism
- Given many levels of interacting sub-systems, how measure whether, or the degree, the **system as a whole has adapted?**
- For altitude adaptation => test the hemoglobin

Finding Regional Hemoglobin

- Complex systems theory is a scientific framework that explains how **system rules** are manifest in **emergence** (\approx structural change)
- Emergence will help guide **place-specific theories** and the practice of regional, and especially rural, economic development
- Economics is a theory heavy discipline, but just the same, theories and data concepts tend to grow together
- Testing a **theory** requires data and **scientists/economists** have needed theory to categorize and define what data to collect
- Emergence, an attribute of CAS, is shown by agent, organizational and social behavior that is continuously re-constructed

Finding Regional Hemoglobin

- Adaptation/transformation over time is a hallmark of emergent systems, akin to evolutionary systems
- For regional economic development, a signal for emergence, or adaptive change, is the re-balancing/churn of industry employment
- **Balanced labor churn is evidence of adaptation**
- In complex adaptive regions, some industries wax while others wane
- Rebalancing – some industries shed jobs while other industries absorb them – is a diagnostic metric for adaptation

New concepts and measures for resiliency

THINKING UNCONVENTIONALLY

Two Diagnostic Transformation Metrics

1) The proportion of the industry contribution to employment change after the trough to the last year of available data in the employment time series (2016 in this case)

- May be used year-to-year and, when combined with the recessionary **drop** (peak to trough) measure, can be used to determine the return-to-peak **phase transition marker**
- It is scale independent, so provides a view into how robust or anemic the regional industrial metabolism is relative to other regions

2) The skew of the cumulative industry contribution to employment change to signal balance, hysteresis and/or resilience false flags

Data and Method

- “QCEW-Complete” fills in the missing values that are particularly prevalent for lesser-populated counties (much like the CBP dataset developed by the Upjohn except ours includes agriculture and government)
- Annual in periodicity for both convenience and necessity:
 - less erratic than quarterly or semi-annual data
 - allows decomposition to industries
- Aggregate the county-level QCEW-Complete by 3-digit NAICS and did our best defining local and traded using Porter’s CMP 6-digit traded/local assignments

Cumulative Change by County & Industry

First, we find the absolute “drop” in employment during the Great Recession for all the industries in each county by summing the year-over-year changes in employment between the county’s peak and trough years.

$$GRtemp_d_{ig} = \left| \sum_{t=t_0 \dots t_1}^{i=1 \dots 71} emp_{igt} - emp_{igt-1} \right|$$

emp_{igt} = employment in industry i in county g in year t

emp_{igt-1} = employment in industry i in county g in year $t - 1$

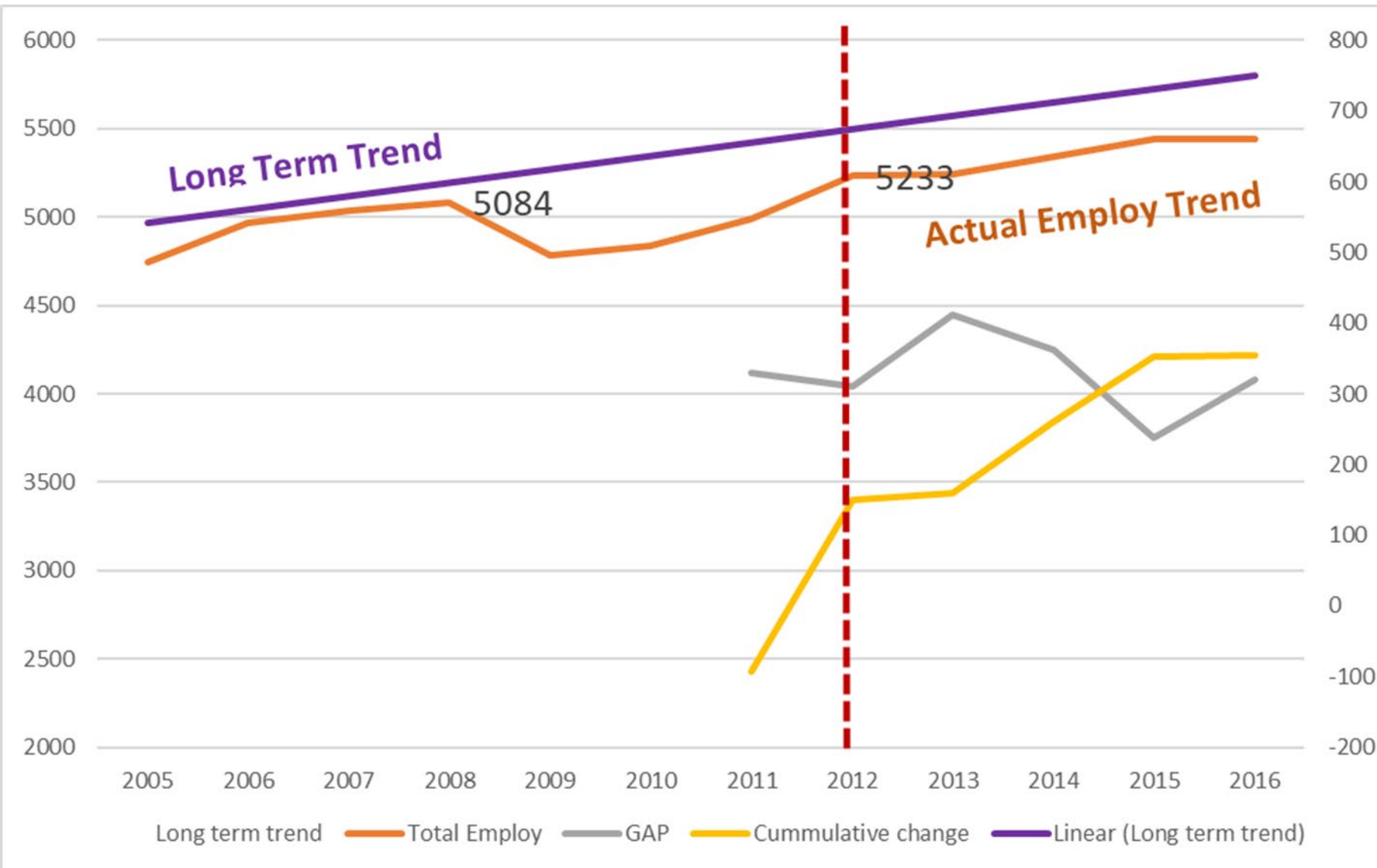
Next, we find the “cumulative rebound” in total employment by summing the year-over-year (total) employment changes from the region’s trough to the last year available, 2016.

$$RGemp_d_{ig} = \sum_{t=t_1 \dots t_{2016}}^{i=1 \dots 71} emp_{igt} - emp_{igt-1}$$

Finally, we calculate the contribution to the total aggregate employment bounce-back measure by estimating the bounce back proportion within the region/county by dividing by total employment.

$$empbb_{ig} = RGemp_d_{ig} / GRtemp_d_g$$

According to the counterfactual...



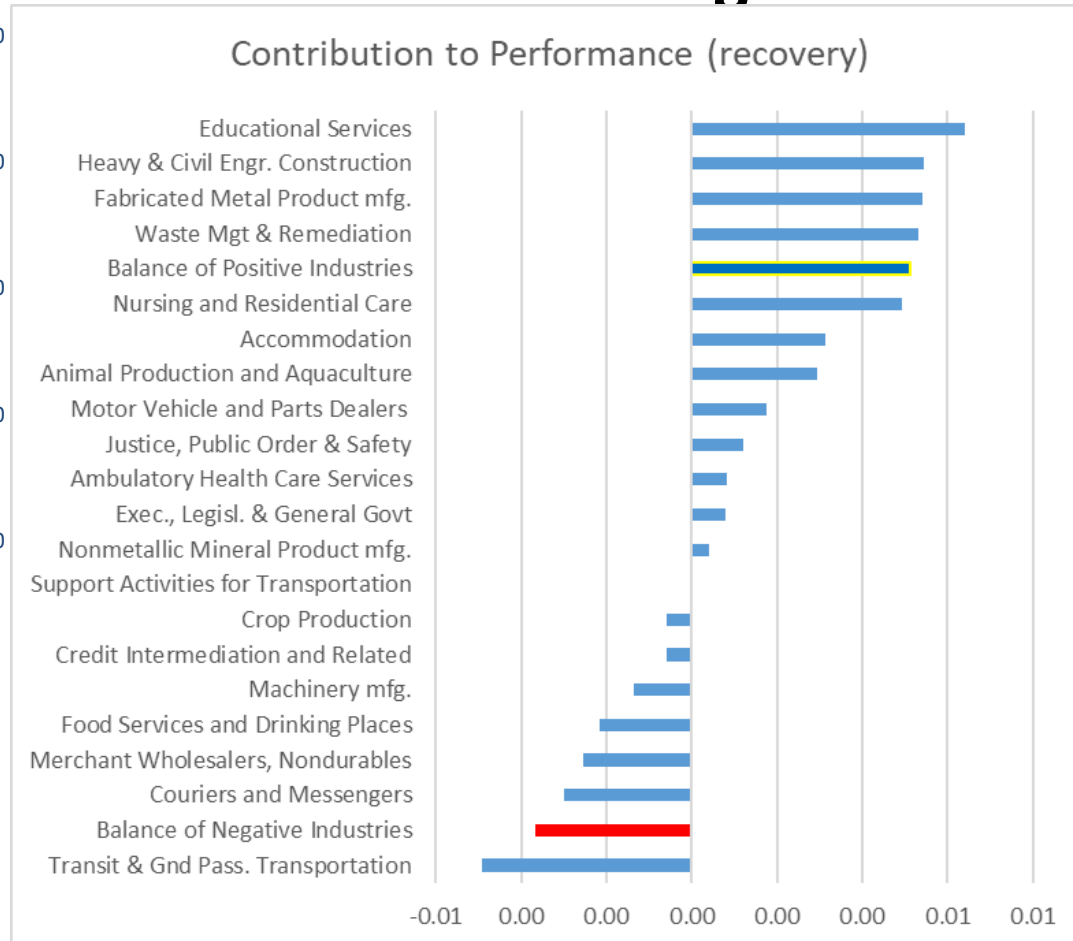
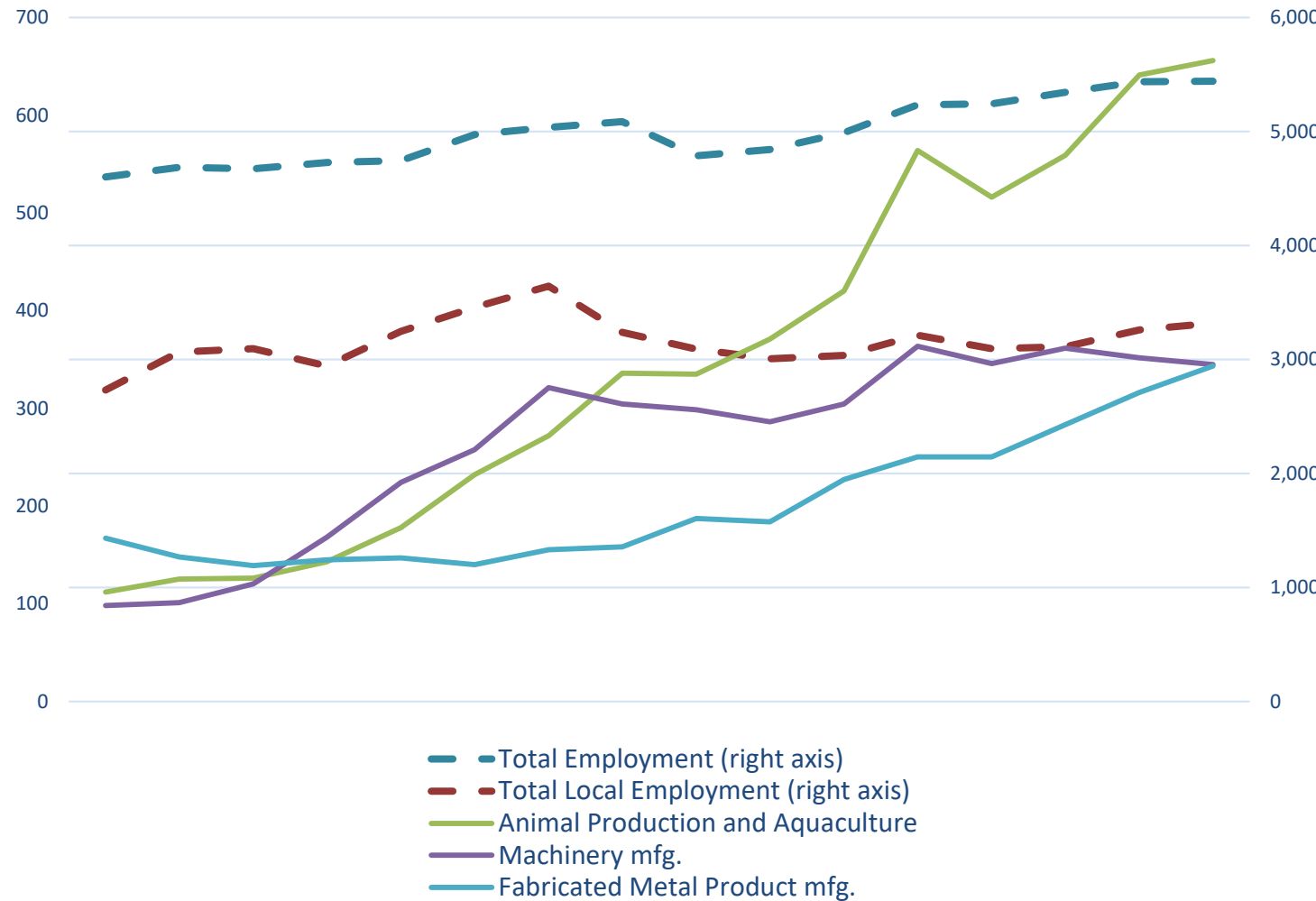
...AND, using only the recovery to the counterfactual long-term trend employment line as the phase transition marker...

Stevens County MN is not resilient

According to the counterfactual...

**...Stevens Co. is not resilient ...
... but it is growing and ...
transforming**

Stevens County, MN
Total Employment and Top 3 Traded



Example of Labor Churn and Contribution to Performance by Industry (CMP definition and aggregation)

Industry Name	Employment Headcount in Peak Year (2008)	Headcount Drop from Peak to Trough (2009)	Return-to-Peak Years	Return-to-Peak Measure	2011	2012	2013	2014	2015	2016	Cumulative Delta Total	Contribution to Performance
Stevens County, MN Aggregate Statistics	5084	298	3	0.03	(93)	149	160	260	353	354	354	0.070
Transit & Gnd Pass. Transportation	211	211		-0.90	(58)	(32)	(21)	(5)	(10)	(25)	(25)	-0.005
Balance of Negative Industries												-0.004
Food Services and Drinking Places	419	140	3	0.12	16	26	(100)	(32)	(21)	(11)	(11)	-0.002
Support Activities for Transportation	79	79		-1.00	24	20	(34)	(44)	(22)	0	0	0.000
Exec., Legisl. & General Govt	158	73		-0.35	(4)	11	(18)	(19)	0	4	4	0.001
Credit Intermediation and Related	92	51		-0.30	(4)	(11)	(9)	(11)	10	(3)	(3)	-0.001
Merchant Wholesalers, Nondurables	162	45		-0.28	5	0	(5)	(2)	(3)	(13)	(13)	-0.003
Justice, Public Order & Safety	165	75		-0.34	(8)	7	(12)	(1)	(3)	6	6	0.001
Ambulatory Health Care Services	96	94	2	1.45	49	(7)	(94)	(50)	(11)	4	4	0.001
Crop Production	103	102		-0.42	10	12	26	(14)	(1)	(3)	(3)	-0.001
Machinery mfg.	304	35	3	0.19	18	59	(18)	16	(10)	(7)	(7)	-0.001
Couriers and Messengers	35	5	1	0.25	7	22	20	15	(8)	(15)	(15)	-0.003
Motor Vehicle and Parts Dealers	93	15	4	0.14	6	5	14	6	23	9	9	0.002
Educational Services	552	136	3	0.06	19	71	(46)	15	(6)	33	33	0.006
Accommodation	25	17	6	1.65	(0)	(0)	5	18	28	16	16	0.003
Heavy & Civil Engr. Construction	292	44	3	0.13	12	38	(28)	15	12	28	28	0.005
Nonmetallic Mineral Product mfg.	108	61	3	0.28	(1)	19	(1)	9	(1)	2	2	0.000
Fabricated Metal Product mfg.	158	29	2	0.44	43	23	0	33	33	28	28	0.005
Nursing and Residential Care	281	135	6	0.43	(4)	(19)	89	(20)	118	25	25	0.005
Balance of Positive Industries												0.005
Waste Mgt & Remediation	5	2	1	0.13	6	5	50	106	53	27	27	0.005
Animal Production and Aquaculture	336	1	1	0.10	49	144	(48)	43	82	15	15	0.003
County Resiliency Gap: Long-Term Trend Employment minus Actual Employment					493	478	582	536	414	499		

What Resiliency Measures are Relevant?

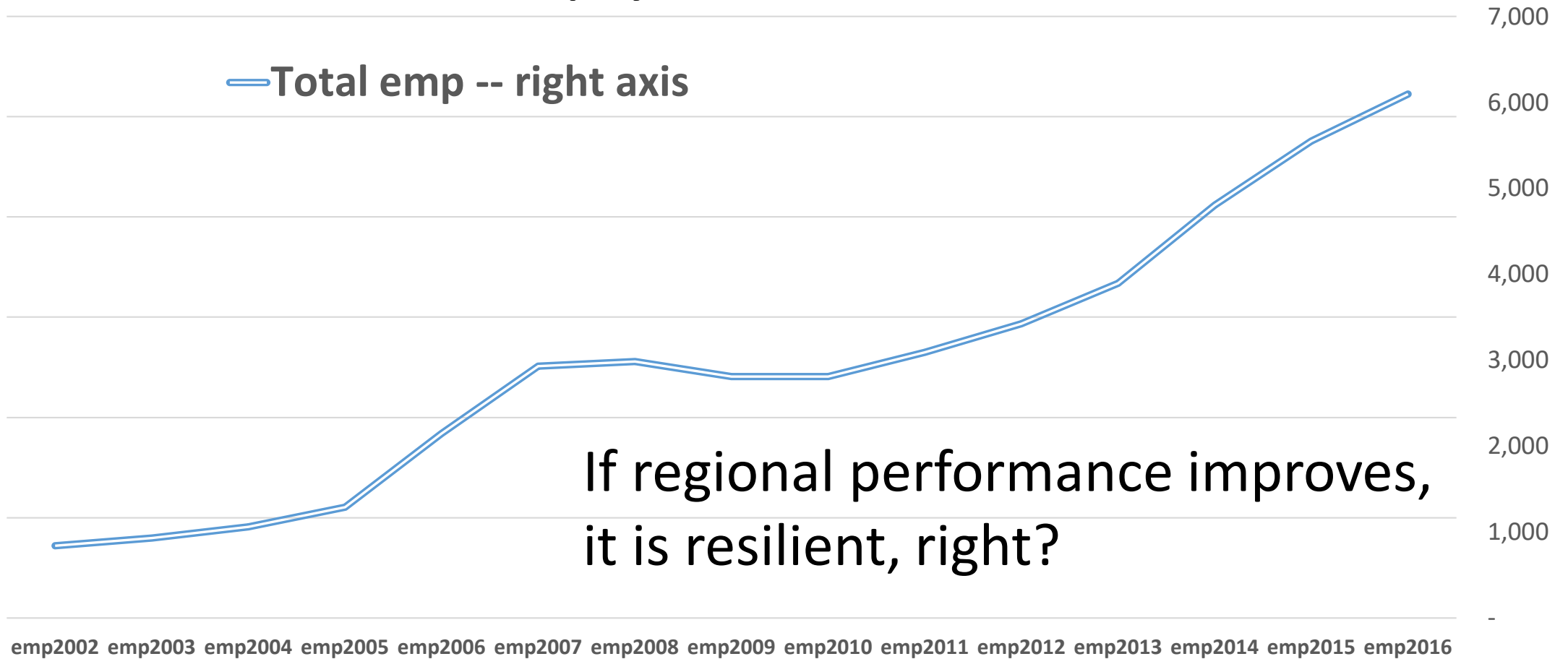
- Vulnerability?
- Speed of recovery?
- Evidence of restructuring to adapt to a ‘new world’?
 - EMERGENCY!
- What measures are practical? Or “what can we do about *that*” from a policy or economic development perspective?

We'll get to the broad view, but for now, let's focus on the more challenging concepts and measures

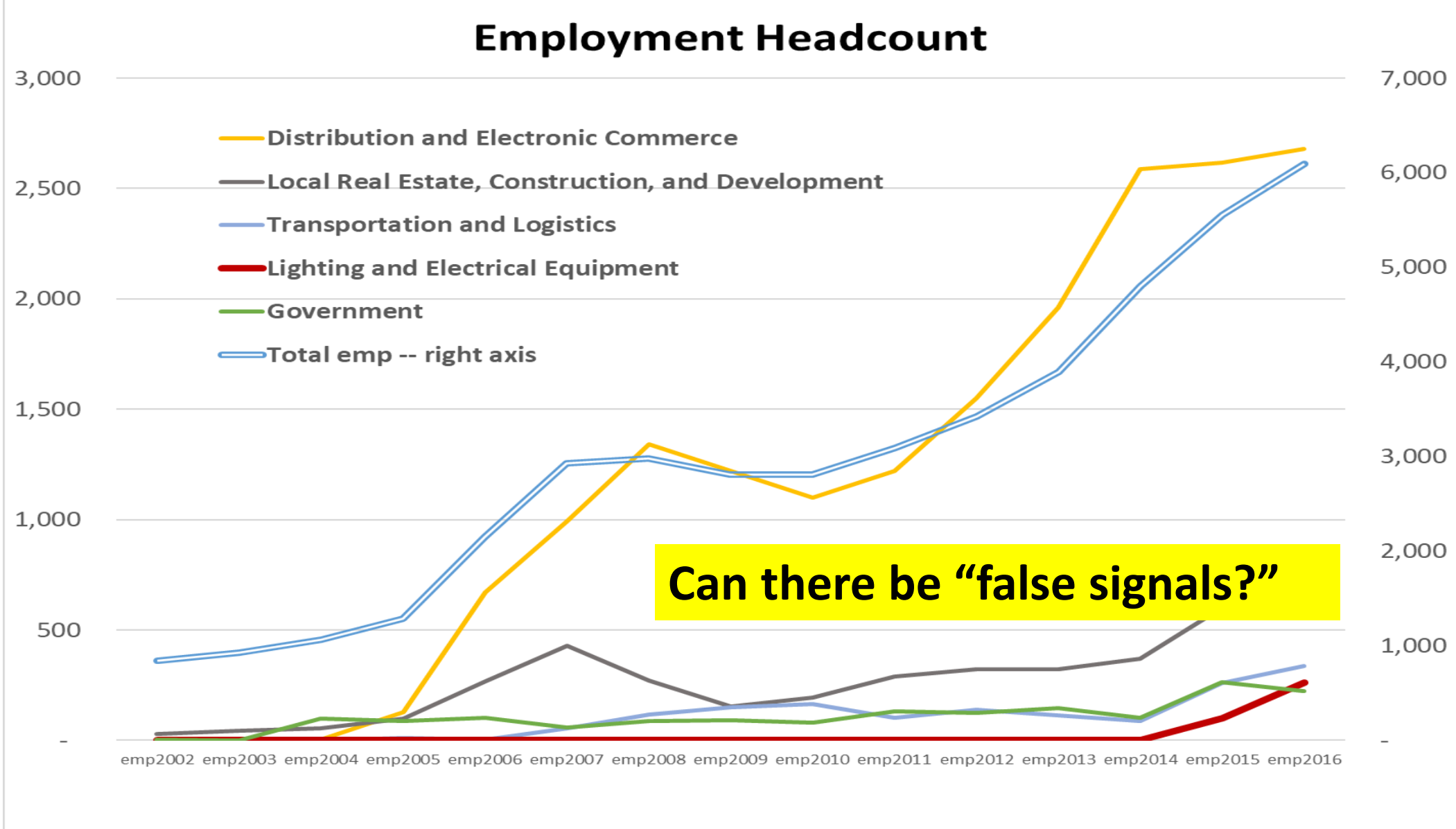
RESILIENCE DIAGNOSTICS FOR REGIONS AS COMPLEX ADAPTIVE SYSTEMS

Is this county resilient?

Employment Headcount



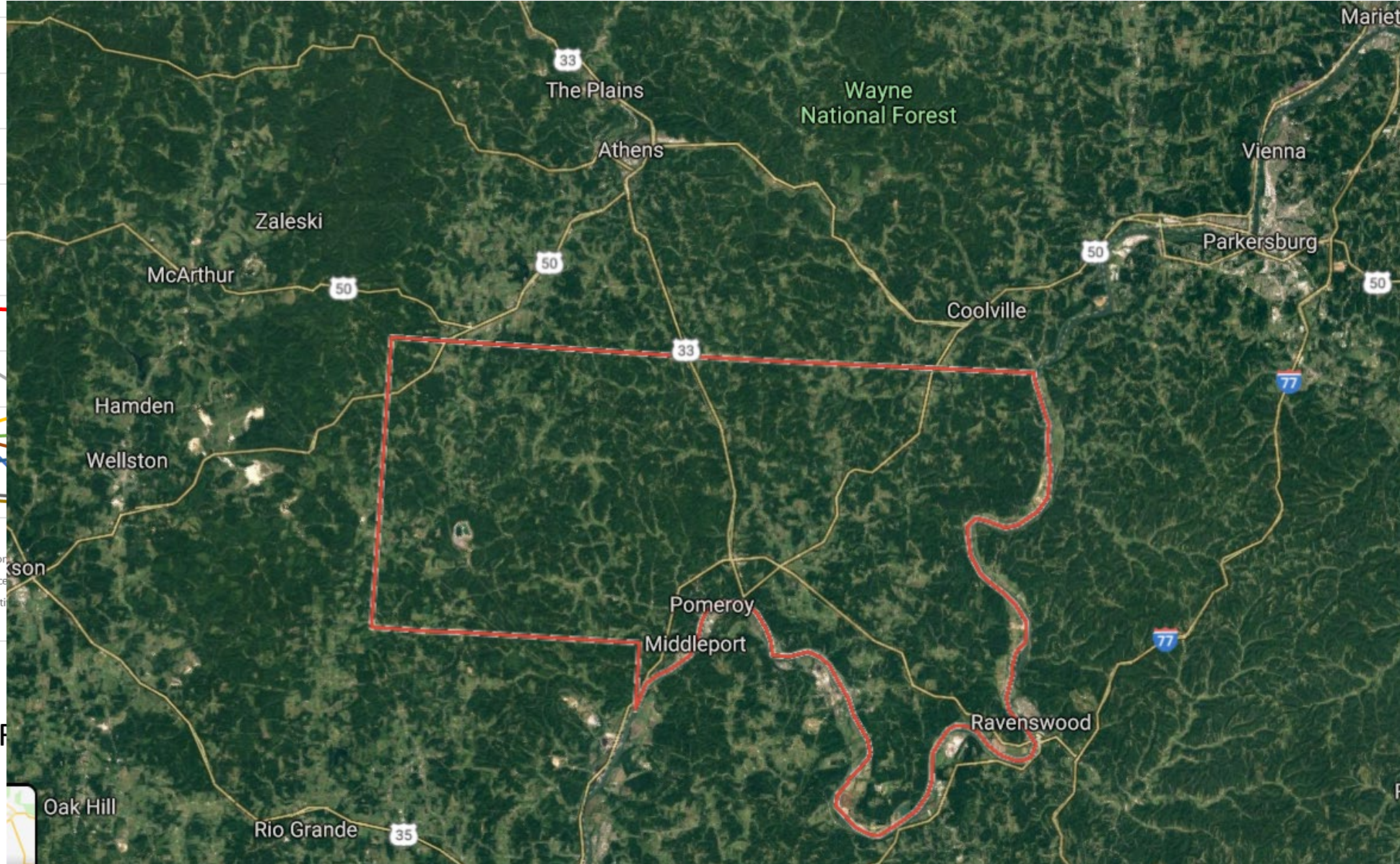
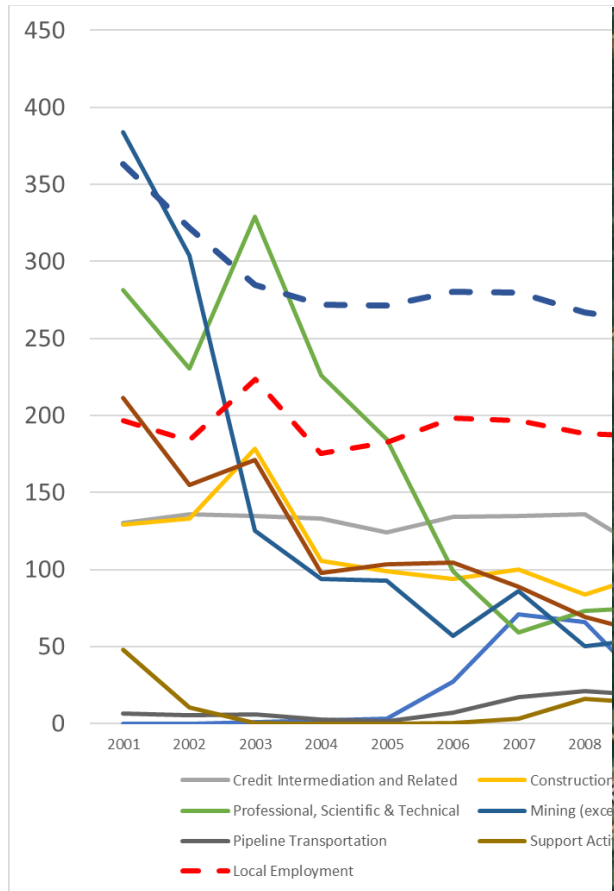
Is Storey County, NV resilient? Or Lucky?



There is something wrong with the general framework and measures: they don't capture all or even any of the important internal dynamics evident in complex systems

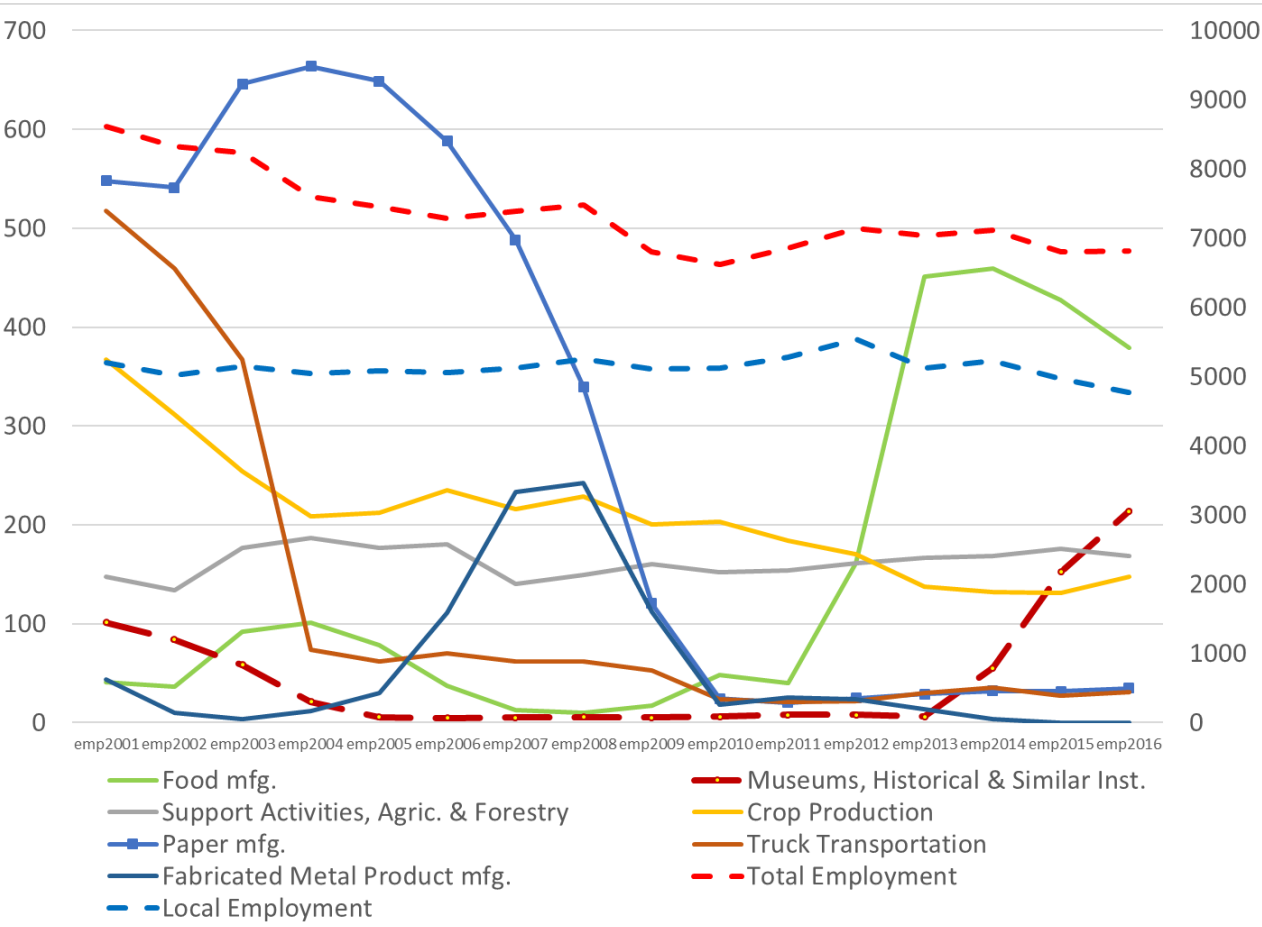
**ARE THERE PHENOMENA SUCH AS
SMART SHRINKAGE OR INTELLIGENT DECLINE
OR PATHWAY TO LOW ENTROPY?**

Resilient Shrinkage? – Meigs Co, OH



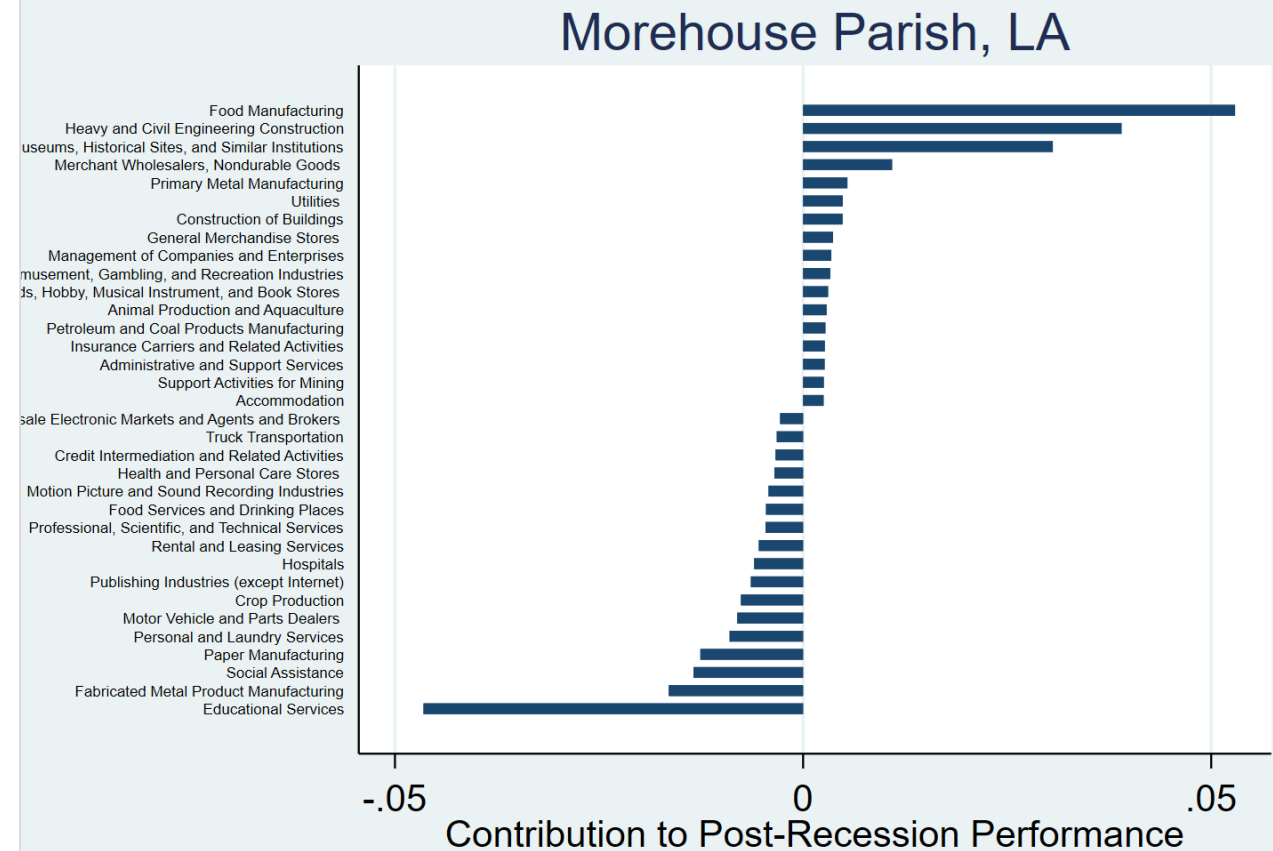
Emp_r: - 0.017 (AAP)
Skew: 1.09

Resilient Shrinkage? – Morehouse Parish, LA



Emp_r: - **0.015** (AAR)
Skew: 1.49

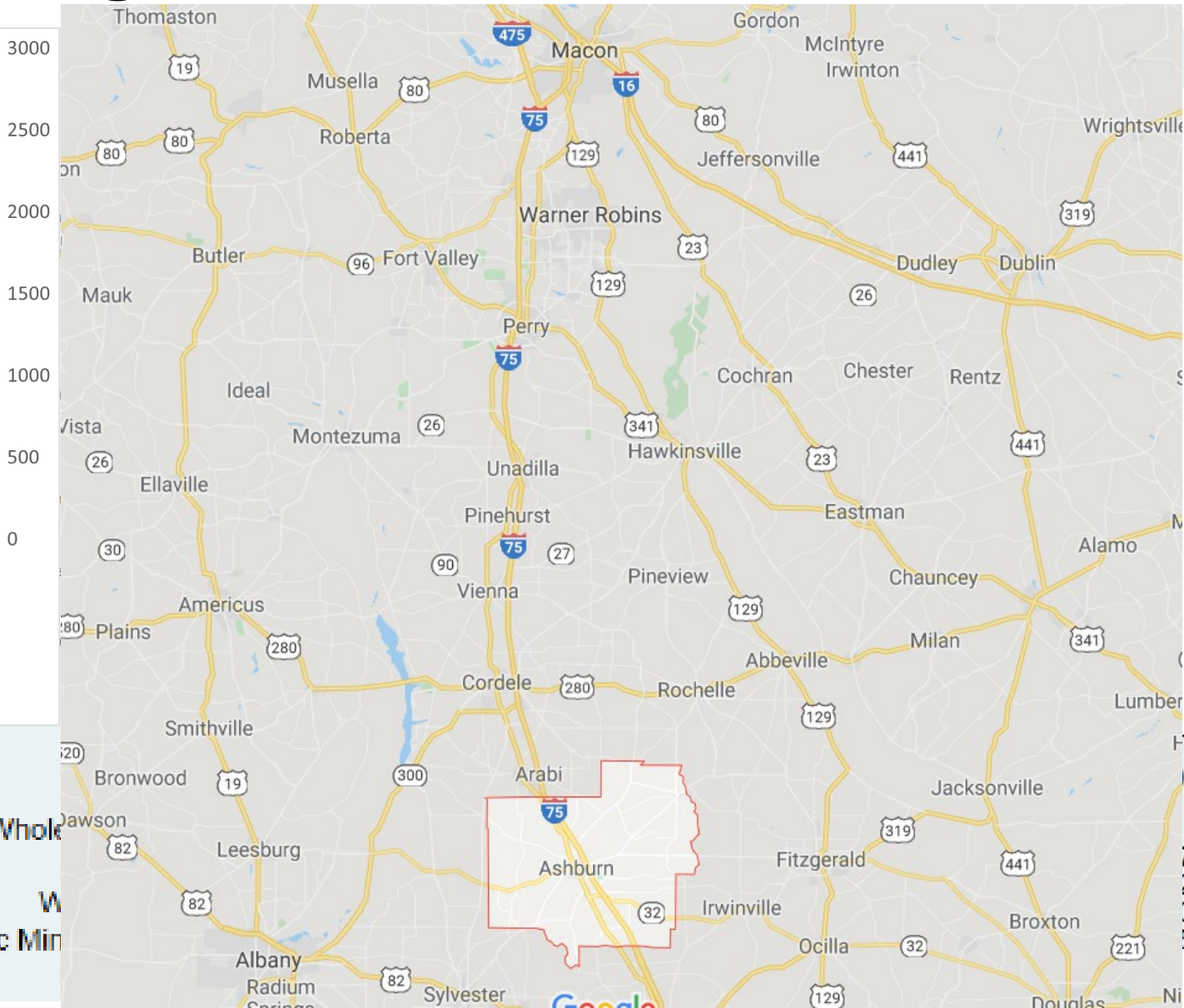
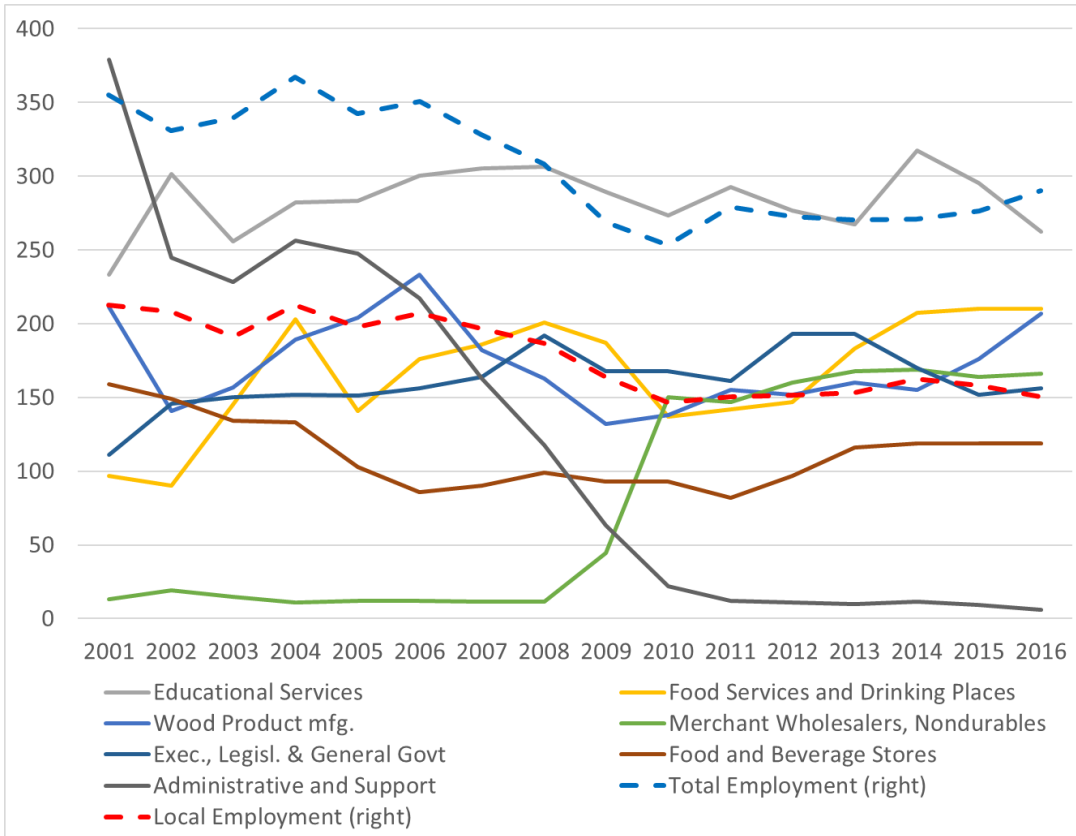
Bad Luck then Good Luck?



Food Manufacturing
Heavy and Civil Engineering Construction
Museums, Historical Sites, and Similar Institutions
Merchant Wholesalers, Nondurable Goods

Skew = 1.496
Employment Growth = -0.0145
cntr_perf_g = 0.012
2016 Population = 26,739

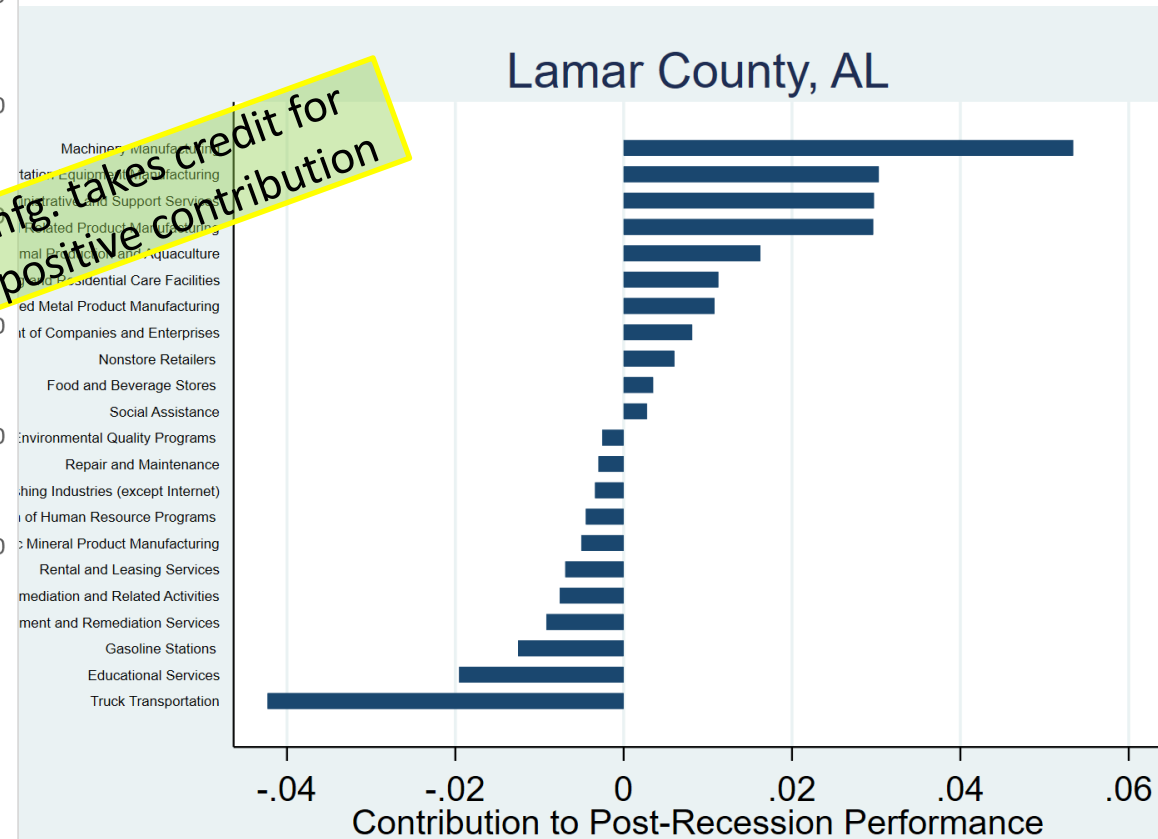
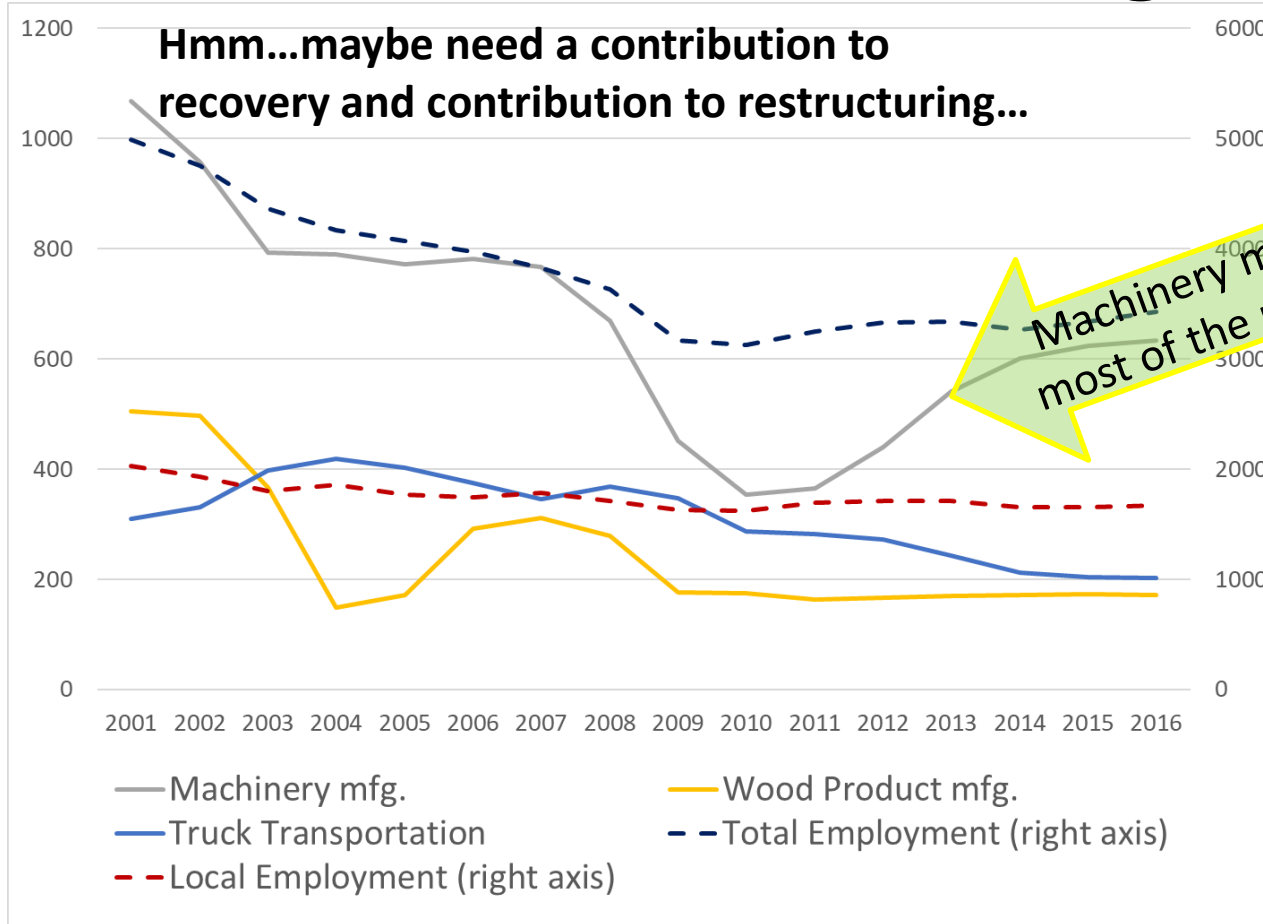
Resilient Shrinkage? – Turner Co, GA



Emp_r: - 0.013 (AAR)
Skew: 1.87

Merchant Wholesalers, Nondurables
Nonmetallic Mineral Products

Resilient Shrinkage? – Lamar Co, AL

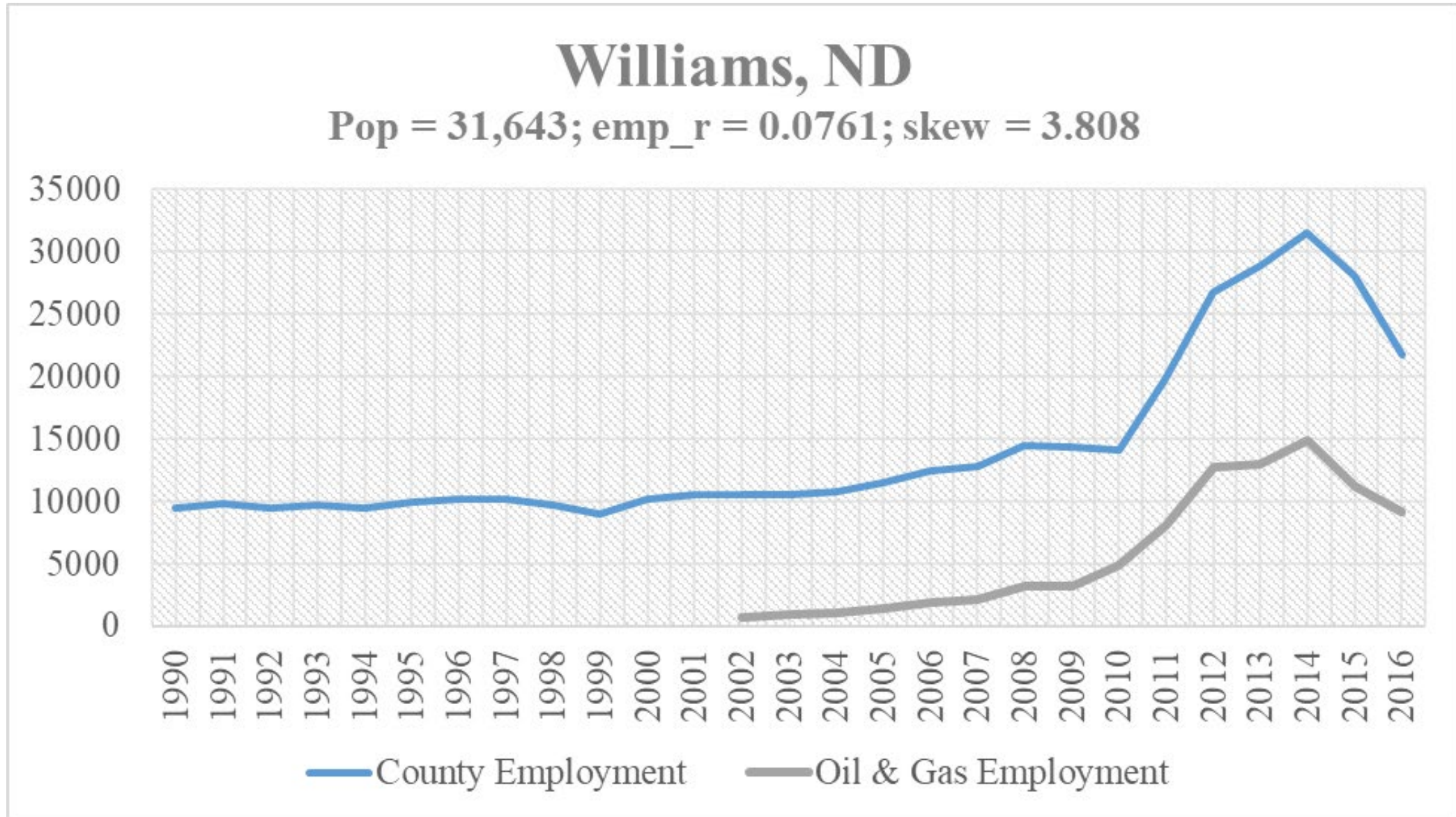


Skew = 1.575
 Employment Growth = -0.024
 cntr_perf_g = 0.096
 2016 Population = 14,066

Emp_r: - **0.024** (AAR)
 Skew: 1.57

- Machinery Manufacturing
- Transportation Equipment Manufacturing
- Administrative and Support Services
- Furniture and Related Product Manufacturing

Method can help identify false flags



EMPIRICAL EXPLORATION AND NEXT STEPS

	Full Sample of Counties, all sizes			Small Counties, population 1 to 15 K		
	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable	emp_r_1016	emp_r_1016	emp_r_1016	emp_r_1016	emp_r_1016	emp_r_1016
edbach	0.000313*** (0.0000539)		0.000383*** (0.0000516)	0.000269* (0.000158)		0.000288* (0.000156)
edhs	0.00000262 (0.0000377)	0.0000704* (0.0000360)		0.0000728 (0.0000722)	0.0000792 (0.0000714)	
d_krug_index_1016	0.000100 (0.000725)	0.00125* (0.000723)	0.000850 (0.000718)	0.00651*** (0.00181)	0.00681*** (0.00181)	0.00679*** (0.00181)
skew_cntr	0.000229*** (0.0000692)	0.000220*** (0.0000688)	0.000211*** (0.0000681)	0.000176 (0.000201)	0.000203 (0.000200)	0.000179 (0.000200)
sk_nrntmmb	-0.000177*** (0.0000498)	-0.000136*** (0.0000485)	-0.000209*** (0.0000489)	-0.000173* (0.0000888)	-0.000143* (0.0000859)	-0.000169* (0.0000874)
cntr_perf_g	0.000506*** (0.0000187)	0.000536*** (0.0000178)	0.000500*** (0.0000184)	0.000548*** (0.0000382)	0.000551*** (0.0000374)	0.000537*** (0.0000381)
ln_popest16	0.00168*** (0.000239)	0.00241*** (0.000223)	0.00181*** (0.000231)	0.00254* (0.00132)	0.00177 (0.00129)	0.00242* (0.00129)
d_trd_prop_emp_0916	0.00970*** (0.00120)	0.00817*** (0.00121)	0.00772*** (0.00120)	0.00410* (0.00213)	0.00340 (0.00213)	0.00333 (0.00212)
lcl_prop_emp2016		-0.0209*** (0.00248)	-0.0234*** (0.00248)		-0.0161*** (0.00548)	-0.0163*** (0.00547)
_cons	-0.0117*** (0.00360)	-0.00685* (0.00365)	0.00317 (0.00305)	-0.0301** (0.0133)	-0.00956 (0.0139)	-0.0120 (0.0138)
N	2708	2708	2708	671	671	671
adj. R-sq	0.344	0.353	0.365	0.272	0.278	0.280
	* p<.10	** p<.05	*** p<.01	Standard errors in parentheses		

Variables of interest show expected relationships with employment growth for both the full sample and the small county sample

More winners than losers -- positive cntr_perf_g – employment goes up! DUH!

Positive relationship for skew in the large sample, but not statistically significant for the smaller county dataset.

Skew also measures extremes. High skew in small counties => FDI?

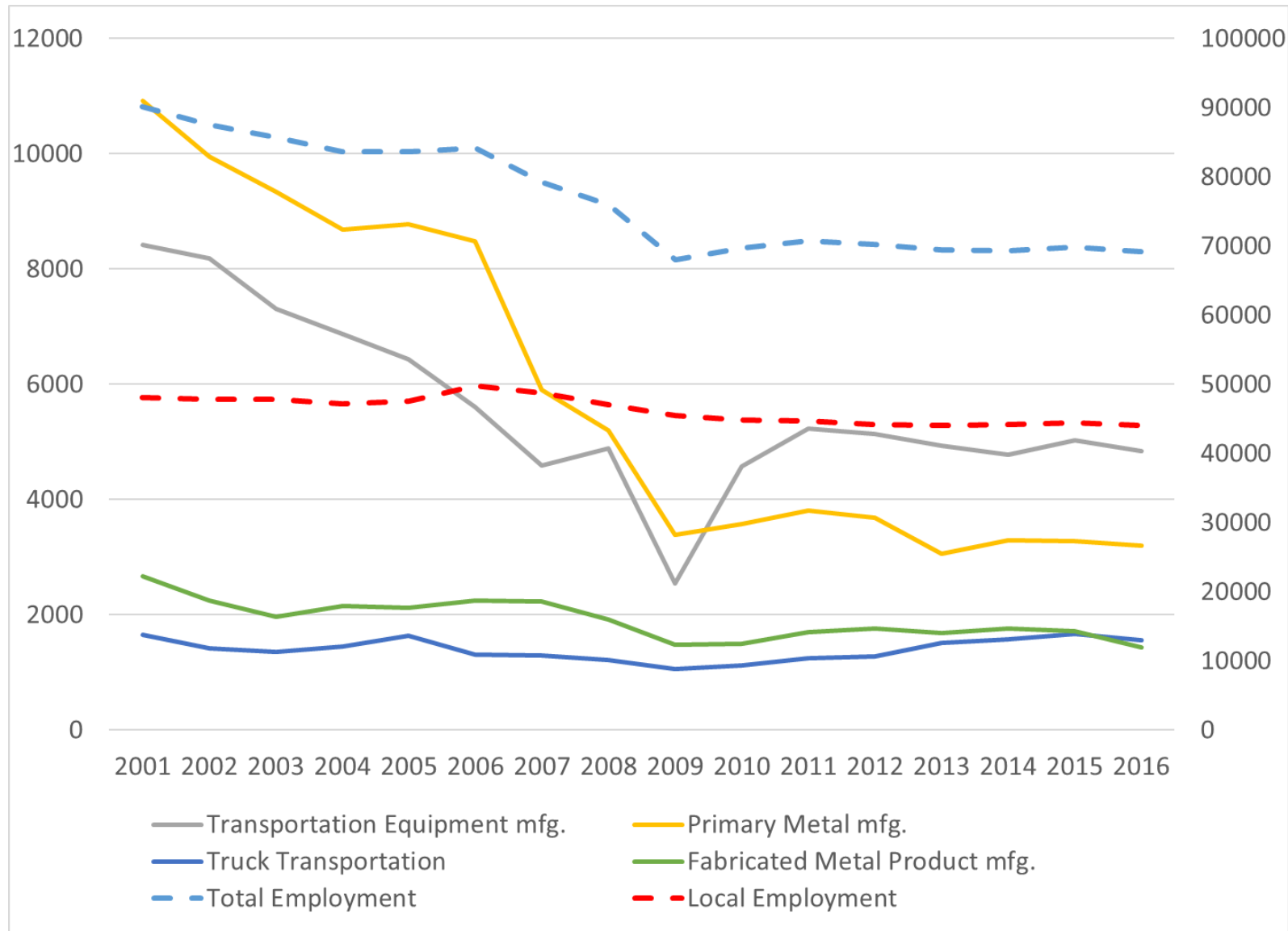
Change in Krugman dissimilarity index 2010-16 is a better general measure than is skew for structural change for smaller less diverse counties

Is this picking up diversification?

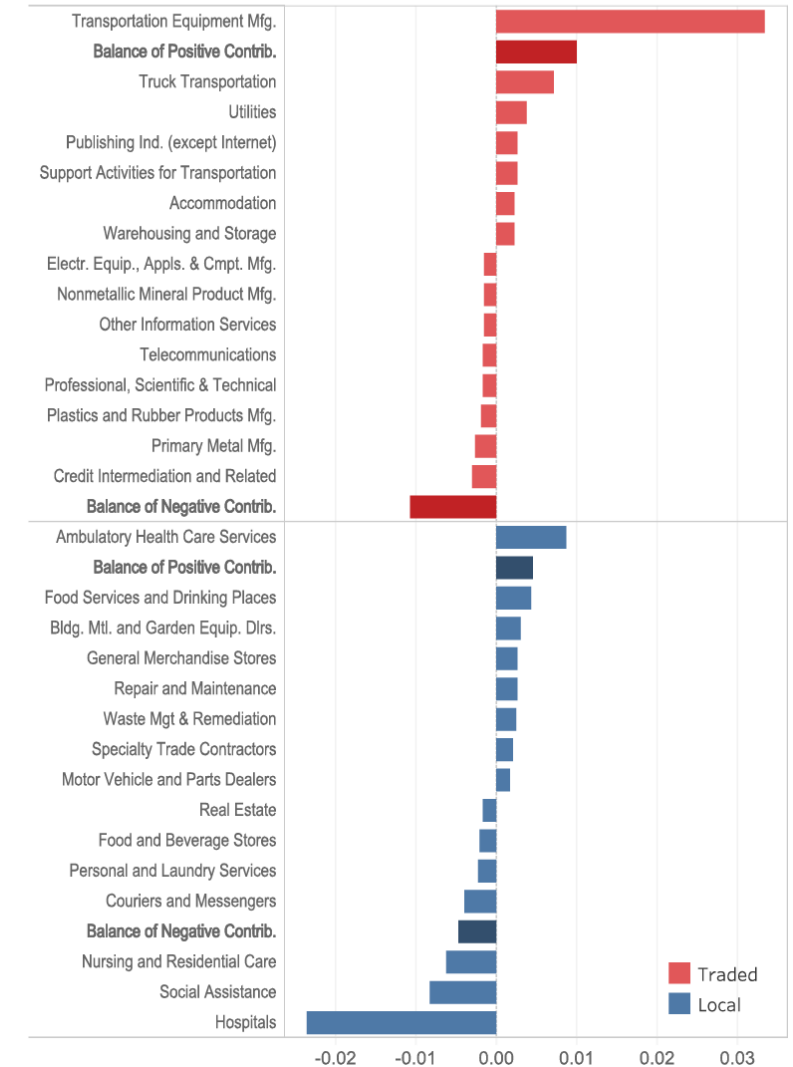
Next Steps

- Sharpen the identification of phase transition markers
- Firm up criteria for false flags
- Determine sensitivity for scale
- Controls for skew based on scale and industry diversity
- Test for effects of industry relatedness, traded and non-traded
- Link changes in industry employment with income dynamics, average wage and income distribution
 - “contribution to regional income”
- Extend to occupations: skill & knowledge domains, education
- Assess labor churn regarding regional demographics & cultural norms

Trumbull County, Ohio (Youngstown MSA)



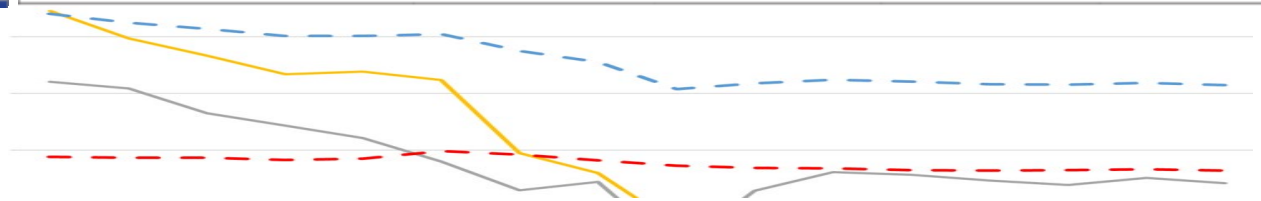
Industry Contribution to Regional Restructuring and Employment Growth



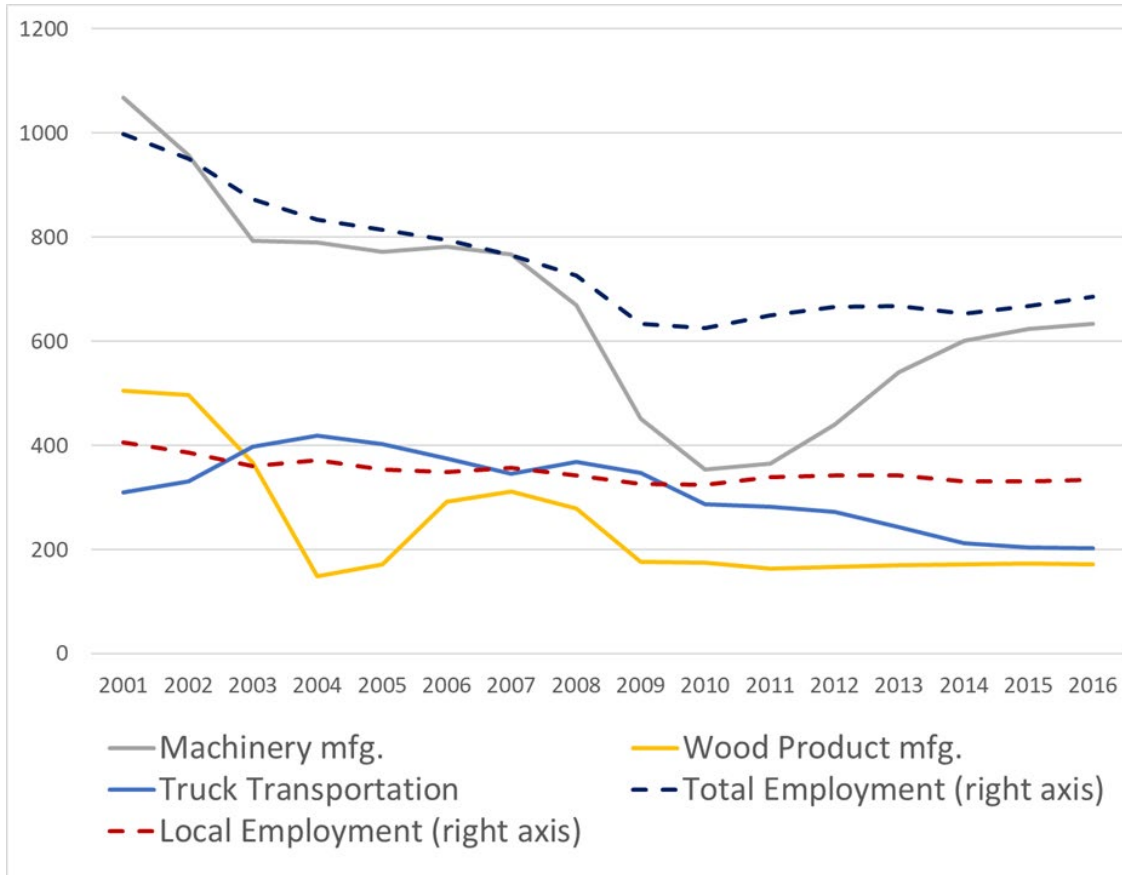
Trumbull County, Ohio (Youngstown MSA)

Resilience Metrics: Risk, Recovery and Restructuring				
Sensitivity to Shock	Beta ^[1]	R-sq ^[2]	P-value ^[2]	Quality ^[2]
	1.256	0.588	<0.001	Excellent
Recovery Quickness	RTP - Region ^[3]	RTP - U.S.	Year - Region	Year - U.S.
	-0.254	0.009	n/a	2011
Restructuring	Empl Contr ^[4]	Skew ^[5]	Inc Contr ^[5]	
	0.017	2.47	0.149	
Economic Performance				
	2002-16	2008-16	2012-16	
Empl growth, AAR ^[6]	-0.016	-0.004	-0.003	
Shannon Index, change ^[7]	0.022	0.003	0.009	
Krugman Index, change ^[8]	-0.046	-0.078	-0.195	
	2002	2008	2012	2016
Traded empl % ^[9a]	45.4%	38.0%	37.2%	36.4%
Local empl % ^[9b]	54.6%	62.0%	62.8%	63.6%
Shannon [0 to 1] ^[10]	0.777	0.792	0.788	0.794
Krugman [0 to 2] ^[11]	0.562	0.491	0.474	0.452
Base year similarity [0 to 1] ^[12]	n/a	0.152	0.160	0.221

Demographics and Income				
	2002	2008	2012	2016
Population	222,063	210,575	207,399	204,908
Salad Days % ^[13]	26.1%	23.6%	22.4%	21.7%
HS Attainment % ^[14]		86.1%	87.5%	88.9%
Bachelor's attainment % ^[15]		11%	11.4%	12.1%
Ed Attainment Index ^[16]		0.346	0.395	0.394
Net migration ^[17]			-0.012	-0.014
Dependency (retirement) ^[18]	1.675	1.861	1.882	1.877
Dependency (supplements) ^[19]	1.365	1.5	1.476	1.533
Per-capita personal income ^[20]	\$26,140	\$31,651	\$34,708	\$38,343
GDP per-capita ^[21]	\$33,633	\$30,861	\$32,632	\$33,970
Self-employment rate ^[22]		0.087	0.080	0.077
Gini Index ^[23]		0.420	0.418	0.442
Dominant Regional Clusters (Growth Clusters with LO > 1.5) ²⁴				
Automotive				
Metalworking Technology				
Local Industrial Products & Services				



Relevant for practitioners and policy makers?

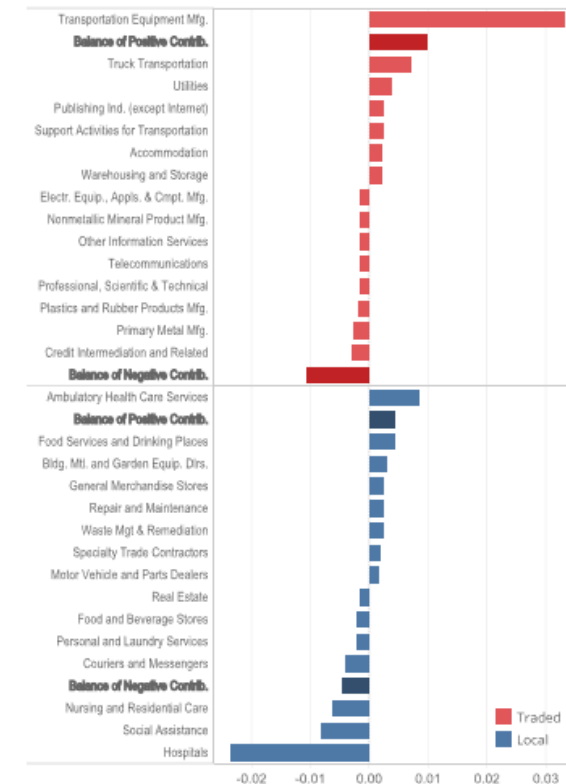


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Metalworking Technology				
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Total and local industry employment are dashed lines—right axis – and the top traded industries as solid lines—left axis.

The bar chart below depicts the general nature and scale of the region's job churn with those industries – both traded and local– that gained or lost jobs.

Industry Contribution to Regional Restructuring and Employment Growth



Slapesheets available in the poster session!

Give us feedback at:

<http://www.statsamerica.org/r3>

Key Takeaways

- Counterfactual is problematic in both experience and practice
- The core of (most) resilience frameworks is **transformation**
- Key CAS attribute is **emergence**
- Using the “Contribution to Performance” measure proposed here aligns with the **emergence** concept and signals **transformation**
- We apply CAS theory, economic theory and data concepts and measurement to regional economic development and resilience
 - **Risk=>beta; Recovery=>return-to-peak; Restructuring=>adaptation**
- **Most important literal takeaway: Resiliency summary sheets!**