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Economic "Causality" Among Chattanooga and its Regional Neighbors

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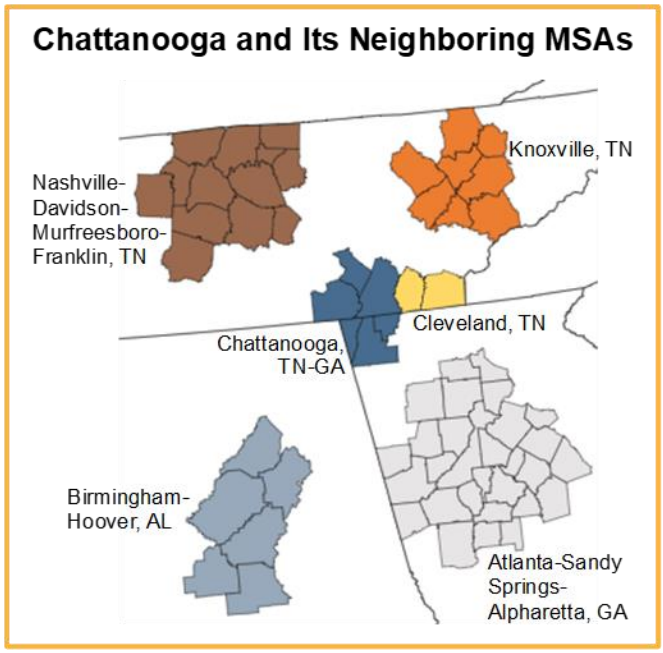
Summary

Chattanooga is situated at the literal crossroads between Atlanta, Birmingham, Knoxville, and Nashville, whose combined employment growth rate over the past 10 years was nearly double the national average. A full understanding of the Chattanooga metro economy requires an understanding of how it interacts with these large metro areas in its booming region. This paper tries to untangle the interregional links by testing for Granger-causality, or predictability, between metro areas within the region. It finds that higher growth in the Atlanta, Knoxville, and Nashville metro areas tends to be followed by higher growth in the Chattanooga metro area. The signs and magnitudes of these effects are useful for forecasting the near future of the Chattanooga labor market.

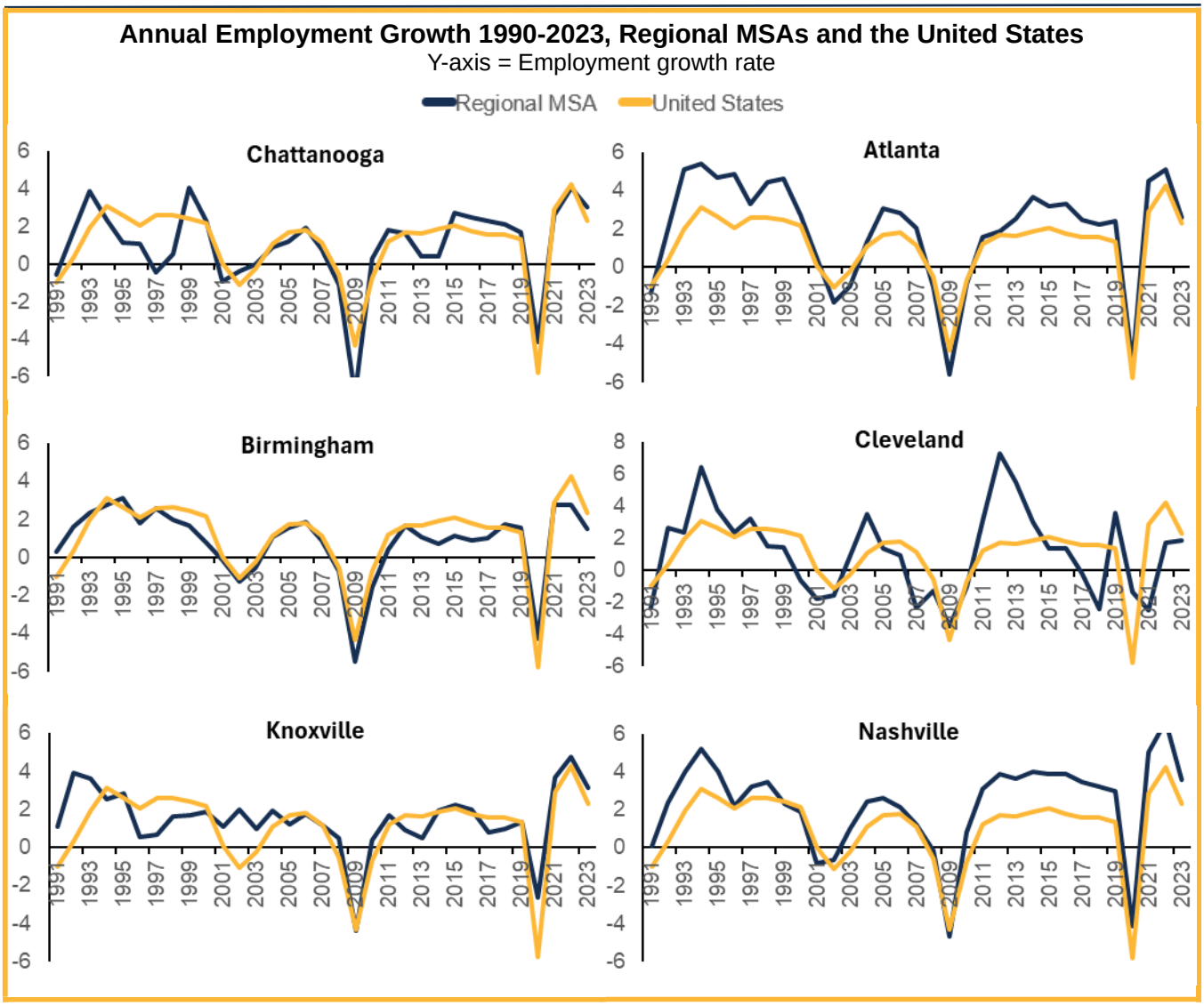
Introduction

The Chattanooga, TN, Metropolitan Statistical Area (MSA) is a mid-sized metro area in a region that has been growing above the national average for some time. Geographically, Chattanooga sits at the center of a square whose corners are larger MSAs that are directly accessible to Chattanooga and each other via interstate highways. Given its proximity to these relatively booming metro areas, Chattanooga's economy cannot be understood fully without understanding how it relates to the MSAs in its region. This paper takes a step in that direction by looking at whether employment growth in Chattanooga can be predicted by past growth in its regional neighbors, and vice versa. Such predictability would be consistent with causal links between the economies of the regional MSAs. True causality is difficult to prove empirically, but economists often test for a special type of causality—Granger causality—which is when changes in one data series are followed predictably by changes in a second data series.[i]

Throughout this paper, employment growth is measured by the percentage change in annual nonfarm payroll employment (the number of jobs), which is provided by the Bureau of Labor Statistics and is available for metro areas for 1990-2023.[ii] In addition to the Chattanooga MSA, the analysis includes the MSAs of Atlanta-Sandy Springs-Roswell, GA; Birmingham-Hoover, AL; Cleveland, TN; Knoxville, TN; and Nashville-Davidson-Murfreesboro-Franklin, TN. For convenience, the MSAs will be referred to using only the name of their principal cities.[iii]



The charts below show employment growth for each MSA alongside that of the United States as a whole. Note that although there is a strong tendency for the MSAs to move with the nation, there can be significant deviations. Roughly speaking, it is the job of regional economics to understand and explain how and why these deviations occur and why they differ across areas. Economists have found that differences in education, industries, taxes, agglomeration economies, and economic freedom can all affect differences in growth. Geography, location, and intraregional links can also matter and, as described above, Chattanooga is a prime example of a locale whose economic fortunes might be tied to those of its regional neighbors.



Positive links between MSAs can arise if, for example, one is a supplier of intermediate inputs (Nashville producing auto parts for Chattanooga auto manufacturers), or a supplier of recreational activity (Nashville residents going to Chattanooga for outdoor activities). Negative links might arise if MSAs compete over a resource that is particularly scarce (manufacturers in Nashville and Chattanooga both require experienced engineers). If the positive links are dominant, then neighboring MSAs are regional partners. If negative links are dominant, they are regional competitors. The present analysis will be able to determine whether MSAs are regional partners or competitors by providing the signs and magnitudes of their links.

Modeling and Testing for Regional Granger-Causality

My model of regionally interrelated employment growth assumes that the national economy is the main driver of current growth in local economies, but that the local economies interact with each other such that

each might affect each others' future growth. More specifically, the region can be described by a vector auto regression (VAR) model in which the six MSA's current growth rates are linearly related to the current growth rate for the rest of the country, the previous two-years of its own growth, and the previous two years of the other five MSAs' growth.[iv] The model includes a trend variable and a dummy for 2020 to capture the effects of the COVID recession in the second quarter and the rapid employment recovery of the third and fourth quarters.

The full set of estimation results is available in Appendix 1, but there are two key points:[v] First, growth in five of the MSAs is strongly related to growth in the rest of the country, whereas the estimated coefficient for Cleveland is statistically significant but is less than half of those for the other MSAs. Second, most of the variation in growth is explained by variations in national growth, but the regional effects can still be large. To illustrate this, the table compares the goodness of fit (R^2) for each equation with and without the other MSA effects in the model. Generally speaking, the larger the MSA the less is explained by adding the other regional MSAs to the model. Chattanooga, Cleveland, and Knoxville experience the largest increases in model fit when their interaction with the other MSA is considered.

Goodness of Fit (R^2) With and Without Regional MSAs

	Full Model	No Other MSA Variables
Chattanooga	0.915	0.773
Atlanta	0.979	0.945
Birmingham	0.976	0.939
Cleveland	0.675	0.521
Knoxville	0.864	0.703
Nashville	0.961	0.927

Once estimates are obtained, the test for Granger-causality is straightforward: If the lags of one MSA's growth are statistically significant in another MSA's equation, then growth in the first is said to cause (or predict) growth in the second. The table shows the results for all of the tests for Granger causality, which compare the results with and without the respective MSA for each equation. It also indicates whether all other MSAs as a whole show evidence of Granger-causality. As you can see, the results indicate that employment growth in Chattanooga is Granger-caused by growth in each of its regional neighbors: If growth in Atlanta, Birmingham, Cleveland, Knoxville, or Nashville rises in a given year, we would expect that future growth in Chattanooga would differ, holding growth in the other MSAs constant. As indicated by the results in Appendix 1, these marginal effects are clearly positive only for growth in Nashville. Other MSAs in the region do not appear to be as affected at the margin as much as Chattanooga is. Birmingham and Atlanta are MSAs with the next most statistically significant links with other MSAs, with four and three instances of Granger causality, respectively. Growth in Cleveland and Knoxville is Granger-caused by only

Tests for Granger Causality

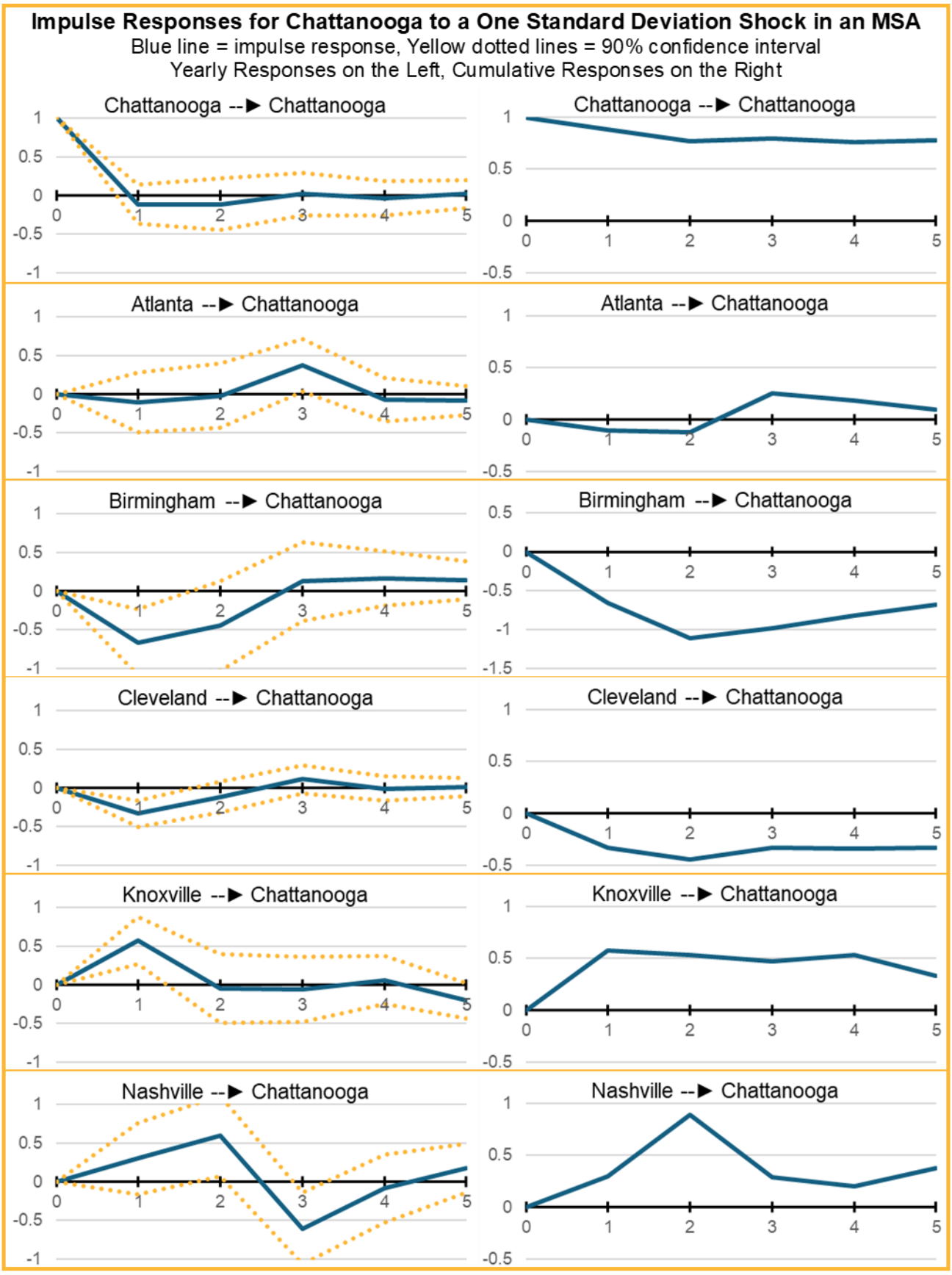
Equation	Excluded MSAs	Prob > χ^2	Equation	Excluded MSAs	Prob > χ^2
Chattanooga	Atlanta	0.007 *	Atlanta	Chattanooga	0.458
Chattanooga	Birmingham	0.012 *	Atlanta	Birmingham	0.793
Chattanooga	Cleveland	0.000 *	Atlanta	Cleveland	0.079 †
Chattanooga	Knoxville	0.001 *	Atlanta	Knoxville	0.002 *
Chattanooga	Nashville	0.000 *	Atlanta	Nashville	0.000 *
Chattanooga	All other MSAs	0.000 *	Atlanta	All other MSAs	0.000 *
Birmingham	Chattanooga	0.004 *	Cleveland	Chattanooga	0.962
Birmingham	Atlanta	0.003 *	Cleveland	Atlanta	0.161
Birmingham	Cleveland	0.008 *	Cleveland	Birmingham	0.719
Birmingham	Knoxville	0.661	Cleveland	Knoxville	0.379
Birmingham	Nashville	0.020 *	Cleveland	Nashville	0.094 †
Birmingham	All other MSAs	0.000 *	Cleveland	All other MSAs	0.144
Knoxville	Chattanooga	0.021 *	Nashville	Chattanooga	0.682
Knoxville	Atlanta	0.631	Nashville	Atlanta	0.279
Knoxville	Birmingham	0.340	Nashville	Birmingham	0.212
Knoxville	Cleveland	0.495	Nashville	Cleveland	0.959
Knoxville	Nashville	0.514	Nashville	Knoxville	0.483
Knoxville	All other MSAs	0.000 *	Nashville	All other MSAs	0.002 *

The null hypothesis is that the results using the full equation are statistically the same as when variables are excluded. A "*" or "†" indicate that the null is rejected at the 5 percent or 10 percent level, respectively (i.e., that growth in the excluded MSA "causes" growth in the equation's MSA).

one of the other MSAs, while growth in Nashville is Granger-caused by none of the others individually, although it is caused by them collectively.

Interregional Responses to Growth Shocks

To obtain the total effects of growth in one MSA on the future growth in the others, the entire system of six equations needs to be considered. That is, a shock to growth in Nashville will spread through the other MSAs and back, then out to the other MSAs and back again, and so on, dissipating over time. A growth shock is a one-time unexpected change in one of the MSA's growth rates and is analogous to a helicopter drop of money or resources into a local economy. For our purposes it is an analytical concept to help understand how the MSAs are interrelated, but examples of real-life growth shocks include localized natural disasters or resource discoveries. The total effects of these shocks are captured by impulse responses, which show what is expected to happen over time in all of the MSAs as the shock propagates through them.[vi] The figures show the impulse responses for Chattanooga for five years after shocks occuring in year 0. The figure on the left is the yearly response to the shock, while the figure on the right is the cumulative response. The yearly impulse responses for the other five MSAs are provided by Appendix 2.


Impulse Responses for Chattanooga to a One Standard Deviation Shock in an MSA
Blue line = impulse response, Yellow dotted lines = 90% confidence interval
Yearly Responses on the Left, Cumulative Responses on the Right
Chattanooga --► Chattanooga
Chattanooga --► Chattanooga
Atlanta --► Chattanooga
Atlanta --► Chattanooga
Birmingham --► Chattanooga
Birmingham --► Chattanooga
Cleveland --► Chattanooga
Cleveland --► Chattanooga
Knoxville --► Chattanooga
Knoxville --► Chattanooga
Nashville --► Chattanooga
Nashville --► Chattanooga

A shock in any of the regional MSAs is followed at some point by a statistically significant response in Chattanooga: Atlanta, Knoxville, and Nashville are Chattanooga's regional partners, whereas Birmingham and Cleveland are its regional competitors. According to the point estimates:

- A shock in Chattanooga has an immediate effect that tapers off until the cumulative effect is about 80 percent the size of the shock.
- A shock in Atlanta has very small negative effects on Chattanooga's growth except for the third year, when it has a large postive effect. Perhaps Chattanooga's direct ties to Atlanta are relatively weak, but that Chattanooga eventually benefits from the driving force that Atlanta has on the economy of the South East.
- Birmingham is a regional competitor to Chattanooga in that a shock in Birmingham has large negative effects on Chattanooga growth in the first and second year after it occurs, although the later effect is not statitically significant. The negative effects dissipate beyond that, but the cumulative effect is large and negative by the fifth year.
- A shock in Cleveland has a relatively small negative effect on Chattanooga in the year or two after the shock occurs. One explanation is that, given that their labor markets overlap, a positive shock in Cleveland can move jobs from Chattanooga easily because workers would not have to change where they live.
- A shock in Knoxville has a large and statistically significant effect on Chattanooga in the next year, so it is a regional partner of Chattanooga. The effects of the shock are maintained for several years.
- A shock in Nashville tends to be followed by two years of significant additional growth in Chattanooga. Much of these positive effects are reversed when Chattanooga's growth rate is reduced in the third year after the shock. Perhaps as the main engine of the state economy good things happening in Nashville are followed by immediate benefits in Chattanooga, but that Nashville's rapid growth eventually leads to a reallocation of productive resources within the state.

It should be reiterated that the dominant determinants of movements in the growth rates of the six regional MSAs is the national economy. In that sense, all of these MSAs are partners that rise and fall with the national business cycle. This paper focused on particular intra-regional links that occur over time and are indicated by consistent patterns of sequential changes to growth rates. Such patterns are consistent with causal links, but it could be that the MSAs are being affected by some common factor, but that it affects them at different times. Either way, such links are evidence of predictive power that can be helpful in projecting or forecasting local economic growth both formally and informally.

Endnotes

[i] Nobel-prize winning economist Clive Granger developed this test of causality in a paper published in 1969.
[ii] As of the time this paper was written, the hadn't yet released 2023 annual average employment for MSAs because the December levels were preliminary. I calculated my own annual average using the preliminary numbers.
[iii] Although the Cleveland MSA is very small, it is included because it is part of the Chattanooga–Cleveland–Dalton, TN-GA-AL, Combined Statistical Area, indicating that Chattanooga and Cleveland have somewhat overlapping labor markets.
[iv] The statistically preferred specification allows for current growth to be related to growth for the prior two years.
[v] The equations are estimated as a system of Seemingly Unrelated Regressions (SUR). Ordinary Least Squares (OLS) applied to each equation independently would provide consistent but inefficient results because the error terms are related across equations. That is, the estimated coefficients would be the same using SUR or OLS, but the standard errors would differ.
[vi] Cholesky ordering is meant to be according to 'how exogenous' the MSAs are, which I determined by the frequency of Granger-causality, using size as a tiebreaker. Thus, the order was Cleveland, Nashville, Knoxville, Atlanta, Birmingham, and Chattanooga.

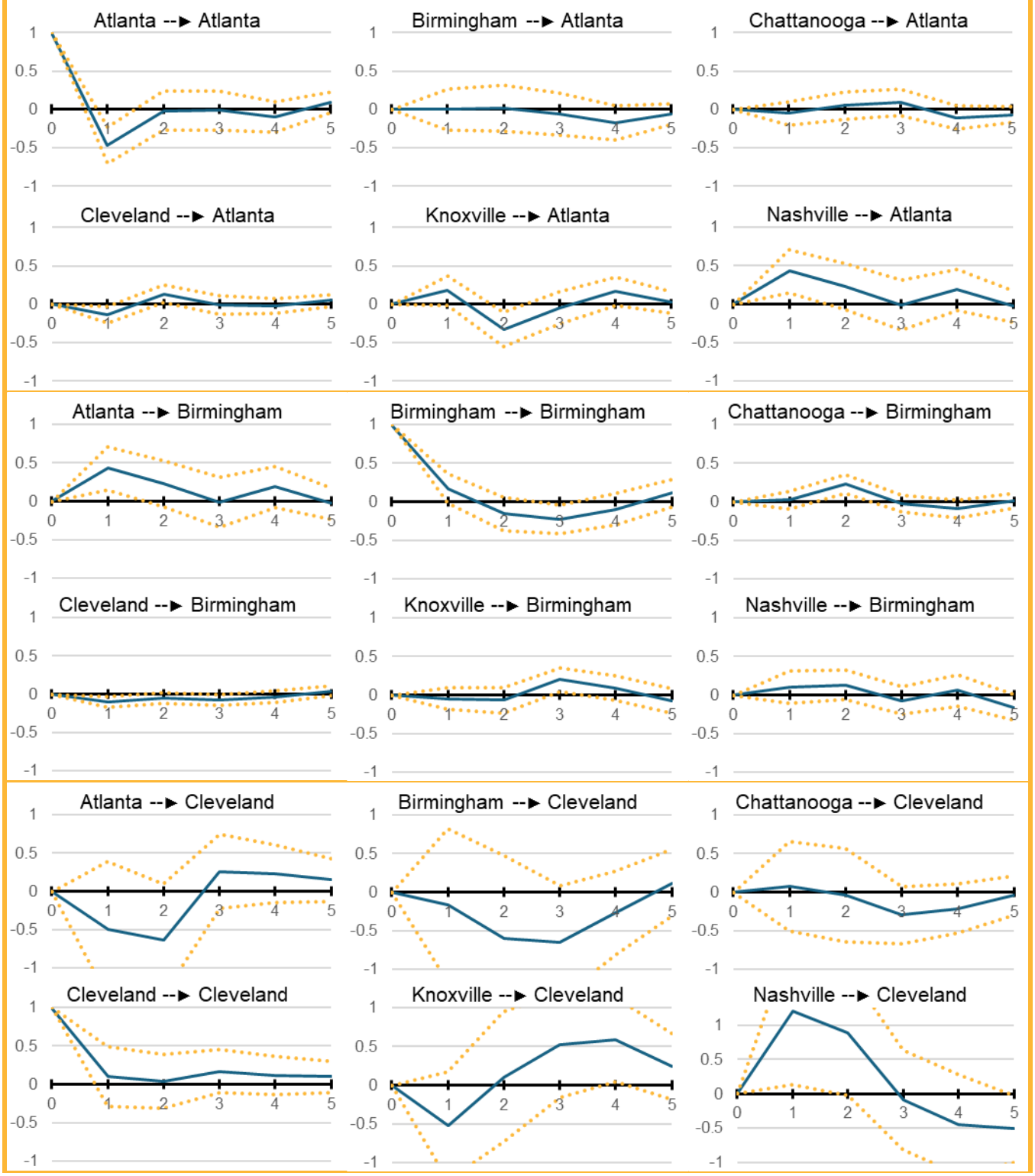
Appendix 1: Seemingly Unrelated Regression (SUR) Results for Six-Equation VAR Model

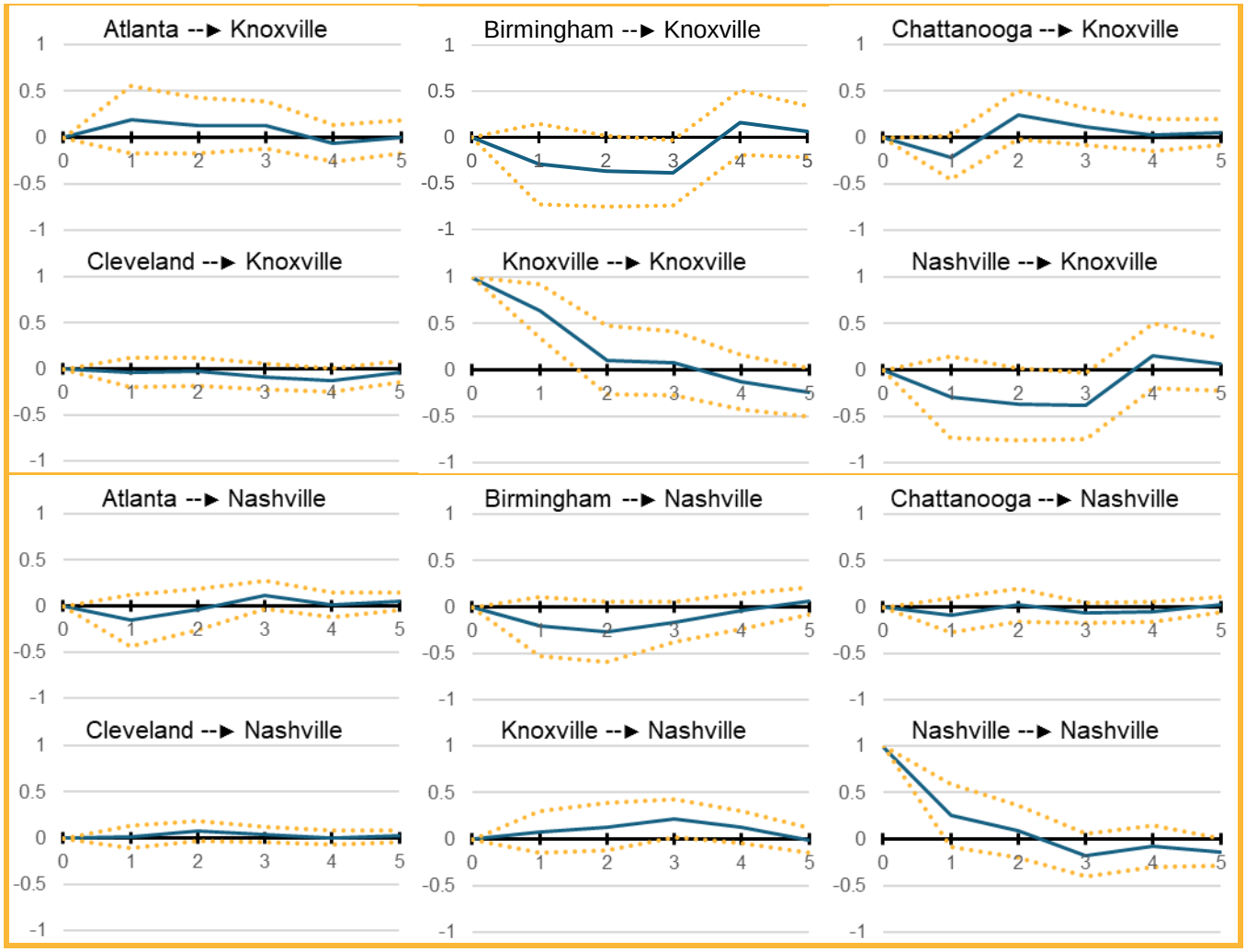
Equation	Chattanooga (t)		Atlanta (t)		Birmingham (t)		Cleveland (t)		Knoxville (t)		Nashville (t)	
Variable (lag)	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat	Coeff.	*t*-stat
Chattanooga (t-1)	-0.11	-0.73	-0.05	-0.53	0.02	0.35	0.08	0.23	-0.21	-1.47	-0.09	-0.79
Chattanooga (t-2)	0.06	0.41	0.11	1.17	0.23	3.30	-0.06	-0.17	0.35	2.46	0.05	0.43
Atlanta (t-1)	-0.10	-0.45	-0.47	-3.25	-0.26	-2.45	-0.50	-0.92	0.19	0.88	-0.15	-0.91
Atlanta (t-2)	-0.48	-2.99	-0.28	-2.78	-0.15	-1.98	-0.56	-1.50	-0.08	-0.53	-0.14	-1.15
Birmingham (t-1)	-0.66	-2.53	0.00	0.00	0.17	1.45	-0.17	-0.28	-0.35	-1.40	-0.21	-1.08
Birmingham (t-2)	-0.20	-0.70	0.12	0.65	-0.18	-1.38	-0.43	-0.64	0.01	0.02	-0.21	-0.98
Cleveland (t-1)	-0.33	-3.28	-0.14	-2.18	-0.10	-2.17	0.11	0.46	-0.04	-0.41	0.02	0.23
Cleveland (t-2)	-0.18	-2.06	0.07	1.29	-0.05	-1.31	-0.07	-0.35	-0.07	-0.90	0.01	0.08
Knoxville (t-1)	0.58	3.13	0.18	1.57	-0.05	-0.54	-0.53	-1.23	0.64	3.66	0.08	0.60
Knoxville (t-2)	-0.56	-2.71	-0.44	-3.43	-0.06	-0.60	0.43	0.90	-0.22	-1.15	0.14	0.89
Nashville (t-1)	0.30	1.07	0.43	2.49	0.10	0.81	1.20	1.85	-0.29	-1.10	0.26	1.26
Nashville (t-2)	1.23	4.73	0.55	3.43	0.30	2.51	0.50	0.83	-0.04	-0.18	0.13	0.71
Rest of the U.S. (t)	1.32	11.97	1.49	22.02	1.17	23.27	0.46	1.79	1.03	9.88	1.29	16.01
Time (t)	-0.10	-3.10	-0.11	-5.43	-0.06	-4.01	-0.16	-2.11	0.01	0.37	0.01	0.53
COVID (t)	4.76	3.86	4.28	5.65	3.42	6.10	1.78	0.62	3.06	2.64	2.60	2.89
Intercept	0.20	0.37	1.72	5.22	0.44	1.80	2.20	1.78	0.14	0.27	0.29	0.75
R squared	0.915		0.979		0.976		0.675		0.864		0.961	

The first 12 dependent variables are the lagged growth rates for the six MSAs. The variable "Rest of the U.S." refers to the growth rate for the United States excluding the six MSAs. "Time" is a time trend and "COVID" is a dummy variable for 2020.

Appendix 2: Impulse Responses to a One Standard Deviation Shock in an MSA

Blue line = impulse response, Yellow dotted lines = 90% confidence interval
The first MSA is the source of the impulse (shock) and the second is where the response occurs.

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