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Employment Cycle Co-Movements and Economic Integration Between Milwaukee and Chicago

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Abstract

Chicago's expanding global role depends on the city serving as the center of a large, integrated economic region—which includes its northern neighbor of Milwaukee. This study uses monthly data to create series of employment cycles, before applying time-series tools to address comovements and economic integration. We find that the two MSAs are in the same phase of the employment cycle for about two-thirds of quarters. Cross-correlation functions show that Milwaukee and Chicago are more synchronized with each other than they are with smaller MSAs in their states, but less synchronized than New York and Philadelphia. Rolling correlations between Milwaukee and Chicago are higher during recessions and are lower during booms; perhaps the cities have different drivers of growth. Forecast Error Variance Decompositions confirm that Milwaukee has less of an impact on Chicago's economy than vice-versa, but that New York has twice the effect on Philadelphia than Chicago has on Milwaukee. We therefore conclude that Milwaukee and Chicago are fairly integrated, but that this degree is still comparatively low.

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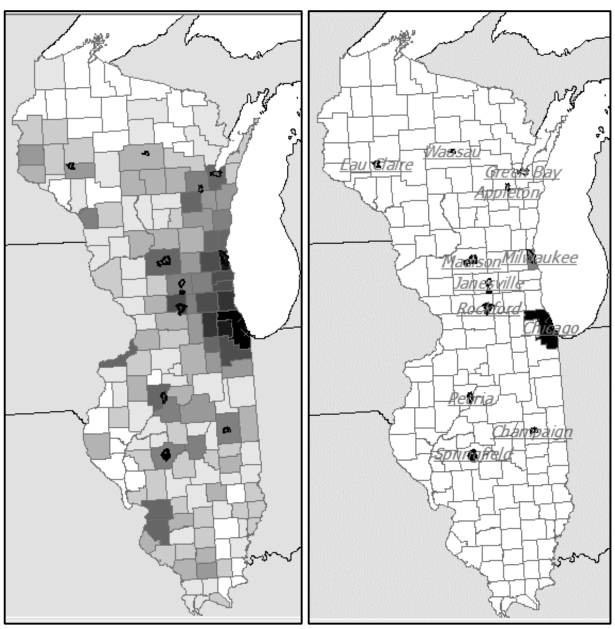
1. Introduction

As U.S. cities such as Chicago strive for "global city" status, they will continue to depend on their surrounding regions as an economic base and a source of influence. But, as these regions grow, they stand to swallow other, smaller, cities in neighboring states that have grown used to a degree of independence from their larger neighbors. Successful cooperation between neighboring yet independent metro areas depends on the degree of economic integration; high levels of integration portend that two metro areas within a larger agglomeration might augment each other's strengths, while a lack of economic unification might weaken the region's global role.

As Duranton and Puga (2004) outline in detail, urban agglomerations form as a result of three major processes that can be explained using standard microeconomic theory. These processes include the "sharing" of fixed and indivisible production inputs (a concept that is related to economies of scale), as well as risk; improving the probability of finding a higher-quality match in labor and other markets; and the diffusion of knowledge. Any convergence between the two Midwestern cities discussed in this study may be the result of these processes—or may help increase the potential for further gains from agglomeration. Figure 1 shows that population density in Wisconsin and Illinois is highest in the Chicago-Milwaukee "mega-region" and lower near some of the medium-sized cities analyzed here.

Figure 1. Population Density and Major Cities In Wisconsin and Illinois.



Source: U.S. Census Bureau, American Community Survey, 2013.

This study uses time-series, macroeconomic methods to examine the degree of interconnection between the Chicago metropolitan area and that of Milwaukee, which lies roughly 90 miles (145km) to its north and just outside Chicago's traditional suburban fringe. But, continued growth in the region, if augmented by improved transportation connections, might link the two areas into a single mega-region. In fact, the Organization for Economic Cooperation and Development (OECD) published a study in 2012 examining Chicago's "tri-state" metropolitan area (comprised of 14 countries in Illinois, Indiana, and Wisconsin), and also discussed an expanded, 21-county region that includes Milwaukee. Throughout the report, improved cooperation among leaders in a fragmented region was called for.

In our analysis we focus on measuring economic integration. Using methods that have also been applied to other U.S. cities, as well as to member states of the European Union, we find that Milwaukee and Chicago are more integrated with each other than they are with their smaller, neighboring cities, but not to the degree to which a comparison pair of New York and Philadelphia are interconnected. In addition, we find that comovements between Milwaukee and Chicago are stronger during recessions than during booms.

Previous studies use a number of time-series methods to ascertain the degree of interconnection among measures of economic activity in various states, regions, and metropolitan areas. Some, such as Barrios and de Lucio's (2003) analysis of Spain and Portugal, or Hegerty's (2010) study of Central European links to the European Union, examine international connections. Other studies, such as Carlino and Mills (1993) and Loewy and Papell (1996) investigate regional convergence in the United States using ARIMA modeling and stationarity tests, respectively. Dobkins and Ioannides (2001) examine the role of distance in influencing neighbors' urban growth rates.

Most recently, two rigorous analyses have examined employment cycles in numerous U.S. city pairs, using advanced econometric techniques. Owyang *et al.* (2013) use a Markov-switching approach to estimate city-level employment cycles for 58 American cities, before mapping the group's periods of economic contraction. The authors then address whether similarities in cyclical movements are attributable more to geographic proximity or similarities in industrial structure, and find that most evidence points to the former. Wall (2013) focuses on a set of city pairs that lie within same metro area (for example, Dallas-Fort Worth in Texas). While the regions overlap, the authors surmise that beneficial agglomeration effects decay rapidly over distance. Similarly to the previous paper, the author applies a Markov-switching model (in which expansions and contractions have different time-series properties). He also draws "phase maps" of city employment contractions and calculates the share of "concordances" where two cities simultaneously experience expansions or contractions. The author by definition would not consider Milwaukee to be part of the same metro area as Chicago, but he does pair Chicago with Gary, Indiana and with Lake County, Illinois. The study finds most cycles to be more strongly connected between city pairs than among non-neighboring cities, but that this effect might be due to being located within the same state rather than to other economic factors. Chicago, however, appears to be more closely connected to non-neighbors than to its immediate region.

This study applies a set of macroeconomic, time-series methods to examine connections between the employment cycles of Milwaukee and Chicago, and to compare them to other regional and national pairs. Our paper proceeds as follows. Section II outlines the empirical methodology. Section III provides the results. Section IV concludes.

2. Methodology

Monthly, deseasonalized, time series of metro-area employment for Milwaukee, Chicago, a set of comparison cities, and the United States are taken from the Bureau of Labor Statistics (BLS) and used in this study. We take the natural logs of each city series, before deseasonalizing each using the Hodrick-Prescott filter (with λ = 14,400)[1]. We also calculate the difference

[1] While the H-P filter is sometimes criticized for its time-series properties, no alternative filter (such as the Band-Pass filter) has been shown to be uniformly superior. As a result, the H-P filter is often used in this type of study.

between each city series and the U.S. series, and then conduct a number of complementary analyses on our cycle and "difference" series.

First, following Owyang *et al.* (2013) or Hegerty (2015), we construct "phase maps" of a subset of these cities' employment cycles. We do so by averaging the three monthly values within each quarter to create a quarterly series, which helps smooth out monthly fluctuations. We then show a quarterly grid where black spaces represent recessions (falling employment) and white spaces represent growth. This allows us to see easily whether Milwaukee and Chicago, as well as the entire United States and other cities in Wisconsin and Illlinois, go into and out of recession at roughly the same time. We can also calculate the percentages of quarters during which employment in two regions are both rising or both falling—known as periods of "concordance"—to create a metric of employment-cycle integration. Because common national cycles might easily drive events in both major cities, we also create maps analyzing changes—and any differences in patterns—using our measures of business-cycle deviations.

Next, for both log employment and our log-difference series, we calculate cross-correlation functions (CCFs) for all cities' employment-cycle pairs. As explained by Bahmani-Oskooee and Hegerty (2010), a CCF shows the correlation between a series X during one time period and another series Y a number of periods into the past and future. If the CCF's highest value is at concurrent values of X and Y, we can say that the two cycles are synchronized. Otherwise, it is possible that one series "lags" or "leads" its partner series and that the two are out of phase. The CCF is calculated as follows:

$$\rho_{t+k} = \frac{\sum\left(X_t - \bar{X}\right)\left(Y_{t+k} - \bar{Y}\right)}{\sqrt{\sum\left(X_t - \bar{X}\right)^2 \sum\left(Y_{t+k} - \bar{Y}\right)^2}} \qquad (1).$$

Here, k represents the number of leads and lags up to a maximum of six months.

We continue our study by calculating rolling correlations (over 24-month) windows between Milwaukee and Chicago employment cycles. We apply nonparametric methods, namely Kendall's τ and Spearman's ρ. Both are similar in spirit to standard parametric correlations, but are less sensitive to outliers and other issues. As explained in detail in Hollander and Wolfe (1999), they are calculated using paired rankings among observations rather than deviations from the mean. Kendall's τ, in particular, assess concordant and discordant pairs in two time series. Correlation between the two cities' cycles, as well as their deviations from the U.S. cycle, will allow us to see during which time periods integration is closest.

Finally, we employ Forecast Error Variance Decompositions (FEVDs) to estimate the contribution of various shocks to the variance of employment in our two cities of interest. Here, we use the Cholesky ordering U.S. → Chicago→ Milwaukee in a trivariate specification.[2] By way of comparison, we also repeat this analysis for the New York-Philadelphia pair because both are a similar distance apart, are in different states, and are unequal in size. As an additional specification we include all four cities within a single VAR. At the suggestion of a conference discussant, we also consider the city pair of Boston, MA (population 650,000) and Providence, RI (population 180,000), which lie about 50 miles apart. We can then see which factors are strongest in driving employment cycles in Chicago and Milwaukee.

[2] Alternative Cholesky orderings were also used; their results are generally the same as the ones presented here.

3. Results

We begin by plotting metro-area employment cycles, for five Illinois MSAs and seven Wisconsin MSAs, in Figure 2. As expected, employment declines for all areas during the 2008 recessions and the 1991 and 2000 downturns. By the same token, employment cycles tend to peak during the mid- and late-1990s and the mid-2000s. Smaller cities appear to have more volatile monthly movements, but this is likely due to data aggregation and rounding issues.

Figure 2. Monthly Employment Cycles, 1990-2015.

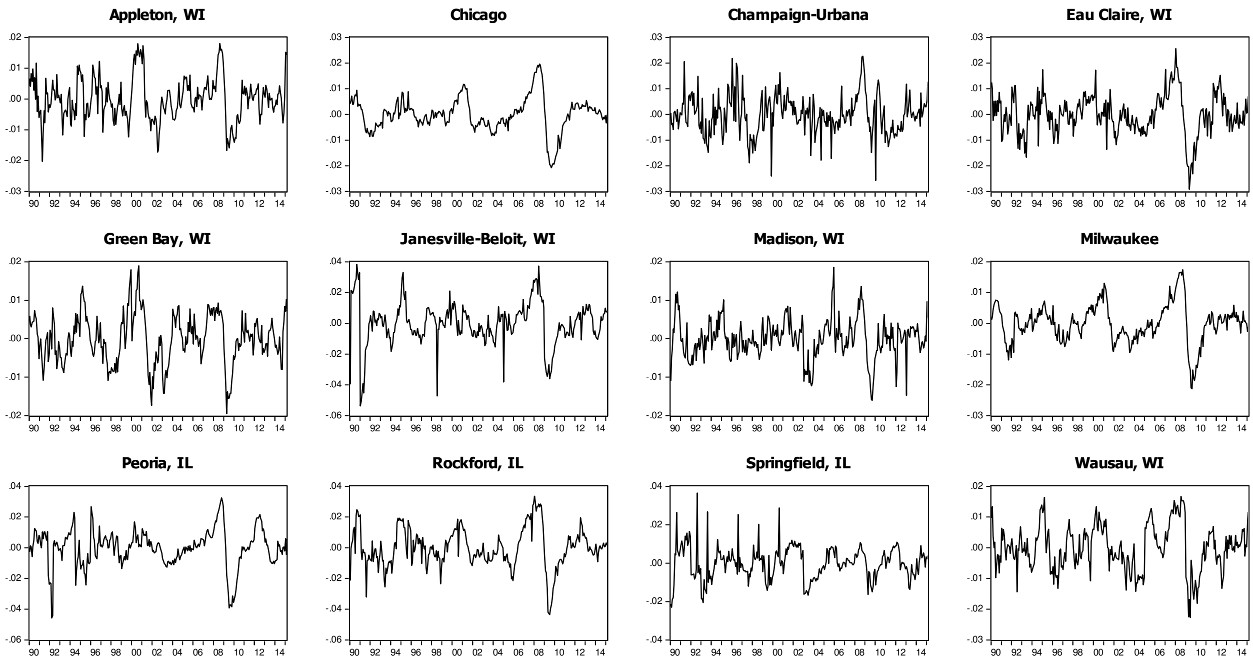


Figure 3 shows our phase diagrams, depicted for a subset that includes only the largest cities, outside of the Milwaukee-Chicago area. These diagrams represent recessions as dark cells and periods of zero or positive growth as white cells. While the official U.S. recession periods are clearly reflected for all cities, there are also contractions during other periods. In particular, there is evidence of general patterns in the business cycles, but Rockford and Madison often seem different from the rest. Perhaps this is due to the cities' functional roles, the former serving as a manufacturing center and the latter as a seat of education and state government. Table 1 gives the percentage of quarters during which given pairs' business cycles are in the same phase. These two city pairs have the lowest share of "concordances" in this case. Perhaps most interesting, Milwaukee and Chicago appear to be more "in phase" during recessions than during other periods, and have a relatively high share of business-cycle concordances. This finding will be explored in further detail below.

Table 1. Percentage of Quarters During Which Employment Cycles are "Concordant."

Chicago/ Milwaukee	Chicago/ U.S.	Chicago/ Rockford	Milwaukee/ U.S.	Milwaukee/ Green Bay	Milwaukee/ Madison
63.6	67.7	55.6	65.7	66.7	56.6

Figure 3. Business-Cycle Contractions (in Black) by Quarter.

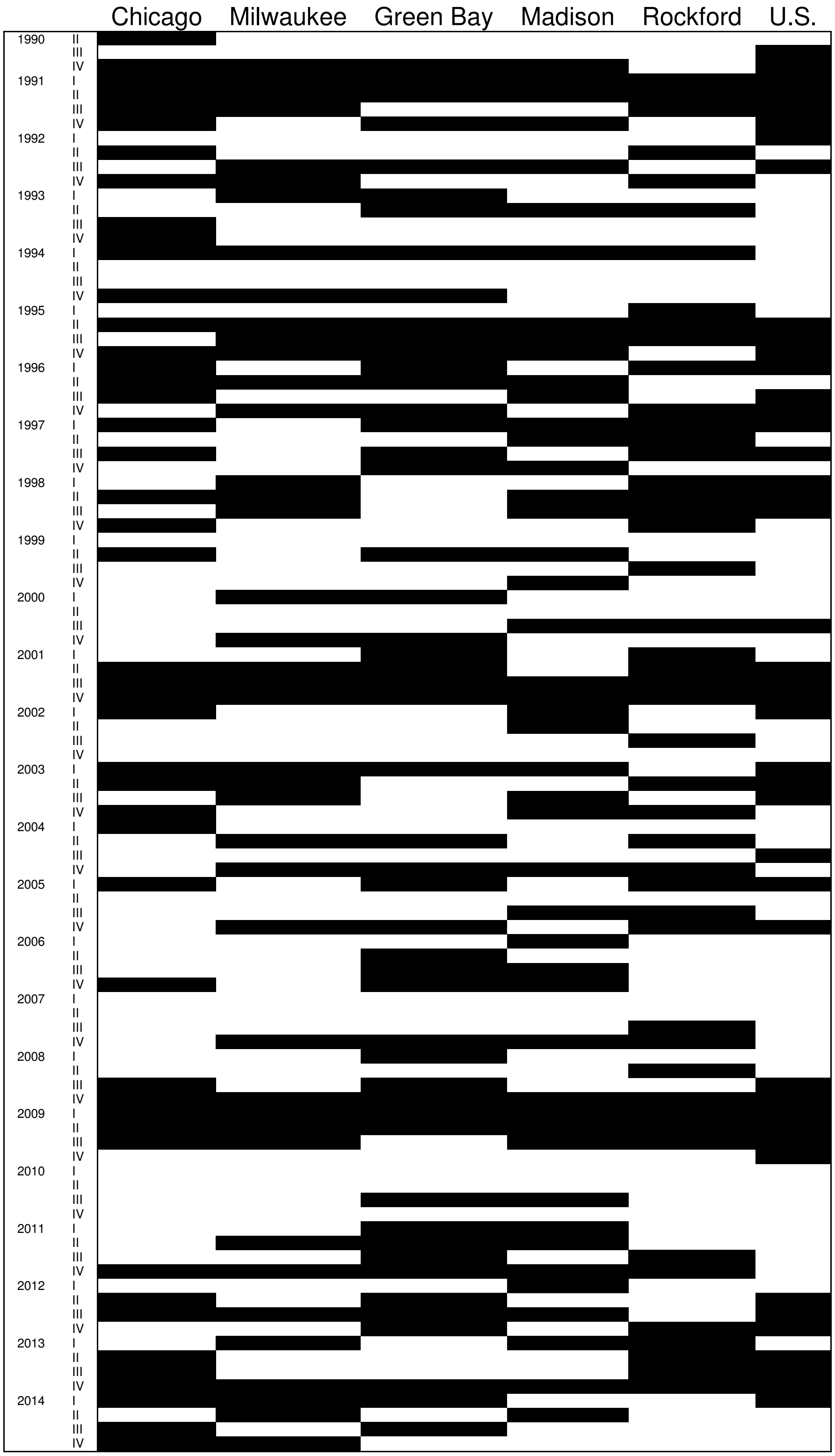


Table 2 provides the cross-correlation function values for all city pairs, as well as for the city pairs' differences from the U.S. cycle. Most pairs appear to be synchronized, with the exceptions of Rockford (difference series), which leads Chicago's (U.S.-difference) cycle by four months. Eau Claire leads Milwaukee by three months. This is likely due to differences in industrial structure; orders might take time to place, and production levels do not change immediately. And, as noted by Hegerty (2015), Madison and Milwaukee have low correlations

Table 2. Monthly Business-Cycle Cross-Correlations.

	Cycles MKE Chgo (+i)	MKE U.S .(+i)	Chgo U.S. (+i)	Peoria Chgo (+i)	Rkfrd Chgo (+i)	Sprfld Chgo (+i)	Apltn MKE (+i)	EC MKE (+i)	GB MKE (+i)	Jnsvl MKE (+i)	Mdsn MKE (+i)	Waus MKE (+i)
6	0.635	0.607	0.594	0.346	0.613	0.084	0.319	0.632	0.524	0.527	0.241	0.510
5	0.711	0.678	0.676	0.416	0.679	0.106	0.407	0.650	0.568	0.581	0.306	0.556
4	0.772	0.742	0.750	0.483	0.731	0.137	0.474	0.659	0.607	0.620	0.380	0.595
3	0.825	0.798	0.818	0.551	0.762	0.181	0.529	**0.662**	0.618	0.650	0.440	0.619
2	0.860	0.844	0.873	0.596	0.765	0.214	0.569	0.629	**0.638**	**0.654**	0.497	**0.635**
1	0.879	0.876	0.916	0.637	**0.765**	0.241	0.585	0.588	0.633	0.645	0.529	0.631
0	**0.889**	**0.894**	**0.944**	**0.675**	0.765	**0.283**	**0.601**	0.554	0.626	0.615	**0.594**	0.617
-1	0.856	0.886	0.942	0.675	0.738	0.281	0.547	0.485	0.546	0.543	0.578	0.582
-2	0.815	0.860	0.923	0.661	0.688	0.272	0.510	0.419	0.477	0.470	0.545	0.545
-3	0.753	0.815	0.891	0.638	0.621	0.267	0.471	0.338	0.399	0.396	0.508	0.477
-4	0.683	0.754	0.842	0.610	0.543	0.262	0.422	0.264	0.310	0.319	0.446	0.432
-5	0.598	0.680	0.782	0.562	0.465	0.256	0.389	0.195	0.233	0.234	0.370	0.396
-6	0.504	0.595	0.710	0.498	0.400	0.247	0.318	0.128	0.163	0.164	0.295	0.358

	Differences from National Cycle Milwaukee Chicago (+i)	New York Philadelphia (+i)	Rockford Chicago (+i)	Providence Boston (+i)	Green Bay Milwaukee (+i)	Madison Milwaukee(+i)
6	0.030	0.269	0.305	0.206	0.138	0.007
5	0.100	0.246	0.333	0.241	0.132	-0.019
4	0.147	0.193	**0.347**	0.291	0.159	0.000
3	0.200	0.200	0.290	0.327	0.138	0.021
2	0.234	0.250	0.176	0.345	0.170	0.072
1	0.243	0.300	0.109	0.340	0.182	0.091
0	**0.286**	**0.394**	0.084	**0.370**	**0.227**	**0.215**
-1	0.192	0.297	0.043	0.301	0.125	0.172
-2	0.152	0.242	-0.016	0.245	0.084	0.131
-3	0.075	0.234	-0.095	0.175	0.048	0.110
-4	0.046	0.204	-0.164	0.098	-0.007	0.062
-5	-0.013	0.216	-0.219	0.031	-0.022	0.010
-6	-0.055	0.259	-0.200	-0.019	-0.015	-0.015

Bold = Highest correlation value.

overall. For the smaller cities, while Appleton's employment cycle is synced with Milwaukee's, those of the industrial centers of Green Bay, Janesville-Beloit, and Wausau lead Milwaukee slightly. Springfield—which, as Illinois' state capital, might be more resistant to external shocks—is synchronized but with a low correlation coefficient. Milwaukee and Chicago exhibit higher correlations than other Midwestern city pairs, but the correlations are higher for New York and Philadelphia (and Boston and Providence). This leads us to believe that the two large cities are relatively integrated within the region, but not when compared to other cities nationally.

These correlations differ over time (and by business-cycle phase) as well. Figure 4 shows the nonparametric correlation measures, over rolling 24-month windows. While the correlation values are somewhat lower when national effects are removed, the patterns are virtually identical. Both the Kendall and the Spearman statistics show that correlations were lowest during the boom period of the late 1990s, and were highest during the recent recession. In other words,

Figure 4. Rolling Spearman's ρ and Kendall's τ Statistics for Chicago and Milwaukee (24-Month Windows).

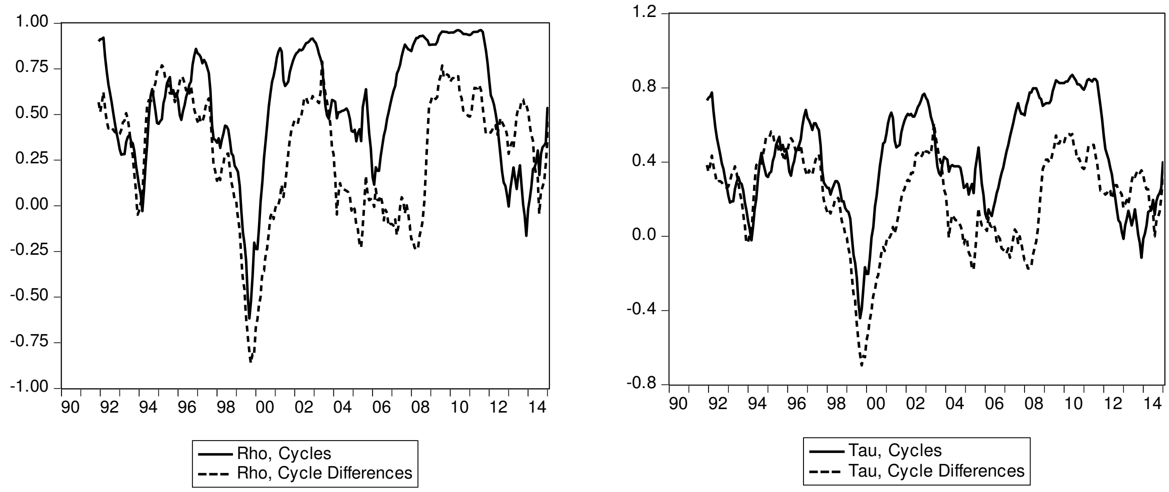
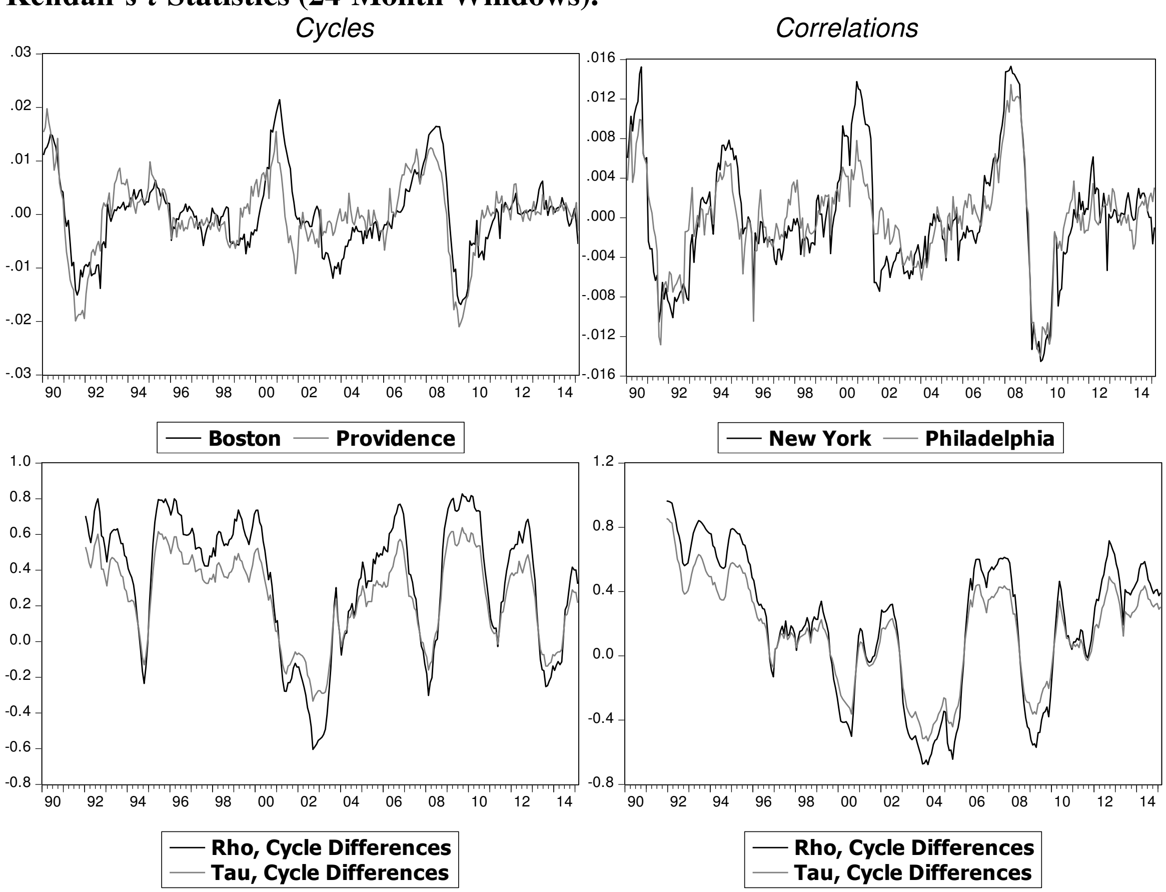


Figure 5. Monthly Employment Cycles for Other City Pairs, and Rolling Spearman's ρ and Kendall's τ Statistics (24-Month Windows).



integration is highest during recessions, but lower during booms. The same pattern does not hold for New York and Philadelphia's deviations from the national cycle, however, which are depicted in Figure 5. For those two cities, correlations are lowest around 2001, and also during the mid 1990s and late 2007-early 2008. Perhaps financial events in New York take time to propagate. Or, the two city pairs might not be entirely similar in their economic behavior. Boston and Providence appear to follow a pattern that does not closely follow their Northeastern neighbors. The two MSAs correlations, for example, are high during the run-up to the 2008 crisis and negative shortly afterward. This suggests that city groups might not be highly integrated with other groups, even within the same U.S. region.

Table 3. Forecast Error Variance Decompositions.

Trivariate Specifications

Chicago Horizon	USCYC	CHICYC	MKECYC	Milwaukee Horizon	USCYC	CHICYC	MKECYC
1	22.552	77.448	0.000	1	7.904	4.810	87.286
3	48.505	51.125	0.370	3	31.698	3.408	64.894
6	73.687	24.767	1.546	6	56.895	2.072	41.033
9	82.169	16.136	1.695	9	67.425	2.451	30.124
12	85.080	13.319	1.601	12	71.702	2.913	25.386

New York Horizon	USCYC	NYCCYC	PHLCYC	Philadelphia Horizon	USCYC	NYCCYC	PHLCYC
1	25.869	74.131	0.000	1	27.223	14.941	57.836
3	53.609	45.059	1.332	3	49.205	10.943	39.853
6	68.738	29.006	2.256	6	65.205	7.931	26.864
9	74.829	22.771	2.400	9	72.101	6.401	21.499
12	77.860	19.786	2.354	12	75.506	5.622	18.873

Boston Horizon	USCYC	BOSCYC	PRVCYC	Providence Horizon	USCYC	BOSCYC	PRVCYC
1	19.496	80.504	0.000	1	23.158	5.884	70.958
3	32.555	67.113	0.331	3	36.870	5.158	57.972
6	45.453	50.907	3.640	6	40.799	3.368	55.833
9	51.124	38.901	9.975	9	40.123	2.579	57.298
12	52.459	31.275	16.266	12	38.603	2.412	58.985

Five-variable Specification

Chicago Horizon	USCYC	NYCCYC	PHLCYC	CHICYC	MKECYC
1	27.404	2.933	0.835	68.829	0.000
3	46.436	1.664	0.467	50.801	0.633
6	64.842	1.059	0.422	32.833	0.844
9	71.915	0.889	0.535	26.013	0.648
12	74.491	1.016	0.682	23.302	0.509

Milwaukee Horizon	USCYC	NYCCYC	PHLCYC	CHICYC	MKECYC
1	13.987	0.132	0.035	5.124	80.721
3	26.443	0.504	0.074	3.027	69.951
6	40.993	1.128	0.085	3.603	54.191
9	49.354	1.587	0.098	5.237	43.724
12	54.194	1.893	0.194	6.584	37.135

Lastly, we calculate FEVDs for shocks in the Milwaukee and Chicago cycles. These are provided at a number of horizons in Table 3. The trivariate specifications show that Chicago's cycle is influenced most by the U.S. cycle. At three months, 48.5 percent of the forecast error can be attributed to national cycles, with 51.25 percent due to the city's own cycles, and less than one percent attributable to Milwaukee. The small city's small influence grows somewhat; at 12 months the figures are 85.08%, 13.32%, and 1.60% respectively. As might be expected, Chicago has more of an impact on Milwaukee, but its overall role is rather small. At a three-month horizon, nearly two thirds of the forecast error is due to Milwaukee's own shocks, with 32 percent due to national cycles and 3.5 percent due to Chicago employment cycles. At 12 months, these figures are fairly persistent, at 71.7%, 25.34%, and 2.91%. Including New York and Philadelphia in a five-variable specification shows New York's impact on Chicago to be double that of Milwaukee (at 12 months), but Chicago's impact on its smaller neighbor increases after the six-month horizon. While other cities do indeed have effects on the Midwest, local effects appear to be stronger.

Perhaps Northeastern cities behave differently from Western ones. The trivariate specification shows that however, has a much larger impact on Philadelphia's employment cycle, (nearly 11 percent at three months and six percent at 12 months) than Chicago has on Milwaukee. Philadelphia also contributes a larger share to New York's variance than Milwaukee does to Chicago. Providence's contribution to Boston appears to be greater than the other way around. These findings are clearly worthy of further analysis, particularly regarding the specific linkages (and how they differ) between the Milwaukee-Chicago and other similar pairs.

4. Conclusion

As a city that strives for status as a global player—vying to attract international investment as well as high-profile events such as the 2012 NATO summit and (unsuccessfully) the 2016 Summer Olympics—Chicago depends on its role as the center of a large, integrated economic region. But while the political structure of the three-state, 21-county region has been criticized as fractious, economic connections are worthy of further analysis. We conduct such a study, focusing on macroeconomic connections between the Chicago MSA and that of Milwaukee, which lies on the northern fringe of the extended "mega-region."

Using monthly data to create series of employment cycles for the two metropolitan areas, we apply a number of time-series tools to address the degree of economic integration between them. First, we examine quarters during with these two MSAs, as well as the United States employment cycle and those of smaller cities in Wisconsin and Illinois in our study, are in recession or expanding. Milwaukee and Chicago generally move together; the two regions are in the same phase of the employment cycle for 63.6 percent of the quarters, which is a higher share of concordances than for the Chicago/Rockford pair and lower than the proportion for Milwaukee and Green Bay.

Secondly, we generate cross-correlation functions for a number of employment-cycle pairs. Milwaukee and Chicago appear to be somewhat synchronized, while Chicago/Rockford and Milwaukee/Green Bay are less so. Controlling for the "common" U.S. cycle, we find the two large cities to be more synchronized with each other than they are with the smaller MSAs in their respective states. But, the overall correlations are lower than for the New York/Philadelphia pair.

Two nonparametric, rolling measures of correlation uncover an important finding: These values are highest during recessions and are lower during booms. This is particularly apparent during the late 1990s and around the time of the 2008 crisis. This leads us to believe that Milwaukee and Chicago have different drivers of growth and thus fairly independent economies. Finally, while Forecast Error Variance Decompositions confirm that Milwaukee has less of an impact on Chicago's economy than vice-versa, we also find that New York has twice the relative effect on Philadelphia than Chicago has on its smaller neighbor.

We therefore conclude that Milwaukee and Chicago are fairly integrated—particularly in comparison to other Midwestern cities—but that this degree is still comparatively low. Growth periods diverge, however, and our comparison pair of New York and Philadelphia exhibit closer connections than Chicago and Milwaukee. Policymakers who wish to boost the global role of the "mega-region" should examine ways to bring these macroeconomic cycles into closer harmony.

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