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Technical Document Series



## A Technical Note on Spatial Aggregation for Independent Cities and Counties in Virginia

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# A Technical Note on Spatial Aggregation for Independent Cities and Counties in Virginia

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## **Abstract**

This document provides an overview of two approaches to treat Virginia's independent cities in county-level data sets. Then, issues of spatial aggregation and geographical division change are introduced respectively. A Python function for spatial aggregation is also provided. Although this document focuses on independent cities and counties in Virginia, it can be extended into other regions for spatial aggregation.

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# 1 Introduction

When regional economists, geographers and urban planners regularly use county or county equivalent as the basic geographical unit for regional economic analysis in the U.S., an issue of whether to regard independent cities as county equivalents might arise. Independent cities, by definition, do not politically belong to any county. Among all the forty-one independent cities in the U.S., thirty-eight of them come from the state of Virginia. The remaining three are Baltimore, Maryland; St. Louis, Missouri; and Carson City, Nevada, all of which are treated as county equivalents for the purpose of collecting, processing, analyzing and reporting statistical information.

However, unlike these three cities, independent cities in Virginia are not always regarded as county equivalents and may be aggregated with their surrounding counties. As such, this document focuses on the spatial aggregation issue of these independent cities, identifies the impact of geographical division changes over time and demonstrates a Python function for spatial aggregation.

## 2 Independent Cities in Virginia

Generally, independent cities in Virginia and their surrounding counties are treated with either of the two approaches. First, some statistical agencies like the U.S. Census Bureau have separate records for Virginia's independent cities and their surrounding counties. For instance, Charlottesville (FIPS<sup>1</sup> code: 51540) and its surrounding county, Albemarle County (FIPS code: 51003), have different records in the Census tables.

Second, other agencies like the U.S. Bureau of Economic Analysis (BEA) aggregate some of Virginia's independent cities with their surrounding counties because of strong socioeconomic connections. In this case, Albemarle County (FIPS code: 51003) and Charlottesville (FIPS code: 51540) are combined to form an "Albemarle + Charlottesville" (FIPS code: 51901) region in the BEA regional tables. However, note that not all independent cities in Virginia are aggregated with their surrounding counties. One example comes from Alexandria (FIPS code: 51510) that does not aggregate with

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<sup>1</sup>FIPS stands for Federal Information Processing Standards.

any county and keeps its status. Moreover, in some cases, more than one independent city are aggregated with their surrounding county. For example, Falls Church (FIPS code: 51610), Fairfax City (FIPS code: 51600) and Fairfax County (FIPS code: 51059) are spatially aggregated into one region.

These two approaches have been used by statistical agencies, and for the purpose of brevity, the results of these two approaches are termed as *disaggregated* and *aggregated* formats in this document. Table 1 enumerates some county-level data sources in these two formats<sup>2</sup>.

Table 1: Spatial Aggregation Formats and Data Source Examples

Format	Data Source Examples
Disaggregated	<ul style="list-style-type: none"> <li>• American Community Survey (ACS) from Census Bureau</li> <li>• County Business Patterns (CBP) from Census Bureau</li> <li>• Quarterly Census of Employment and Wages (QCEW) from Bureau of Labor Statistics (BLS)</li> </ul>
Aggregated	<ul style="list-style-type: none"> <li>• Appalachian Regional Commission (ARC)</li> <li>• Bureau of Economic Analysis (BEA) Regional Accounts</li> </ul>

### 3 Geographical Division Changes

While the definition of the U.S. counties has been stable, some counties or county equivalents, including independent cities, have been created or deleted since the 1980s. In the case of Virginia, three geographical division changes have been made:

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<sup>2</sup>For further references see the descriptions of these datasets: American Community Survey, County Business Patterns, Quarterly Census of Employment and Wages, Appalachian Regional Commission and Bureau of Economic Analysis

- The city of South Boston, VA (FIPS code: 51780) was incorporated into Halifax, VA (FIPS code: 51083) in 1994.
- Clifton Forge, VA (FIPS code: 51560) has been merged with Alleghany, VA (FIPS code: 51005) since 2001.
- Bedford City, VA (FIPS code: 51515) changed its town status and was added to Bedford County, VA (FIPS code: 51019) in 2013.

Because of these changes, the total number of counties and county equivalents in both disaggregated and aggregated formats vary in different periods of time. Currently, there are 95 counties and 38 independent cities in disaggregated format; in other words, a total of 133 counties or county equivalents in Virginia. By comparison, in aggregated format, the total number of counties or county equivalents is 105, including 72 counties, 10 independent cities and 23 combinations of independent cities and surrounding counties. Table 2 lists these combinations.

## 4 A Python Function for Spatial Aggregation

```
def aggF (r, disaggregated_format):  
    # Input variable :  
    # r: the row aggregation scheme.  
    # disaggregated_format: the original disaggregated matrix  
    # Output variable :  
    # aggregated_format: the aggregated matrix  
    # Reference :  
    # Stair (2013): An Aggregation Matrix MatLab Function.  
    import numpy as np  
    row=np.array(r).flatten()  
    col=np.array(range(len(r))).flatten()  
    data=np.array([1]*len(r)).flatten()  
    from scipy.sparse import coo_matrix  
    s = coo_matrix((data, (row, col)), shape=(max(row)+1, len(row)))  
    s = s.toarray()  
    aggregated_format=np.dot(s, disaggregated_format)  
    return (aggregated_format)
```

## 5 Conclusion

In this document, several spatial aggregation-related issues in Virginia are visited. Future regional analysis can benefit from this document in a number of ways. For instance, before undertaking regional analysis, it is essential to know whether independent cities have been aggregated with their surrounding counties in data sets; otherwise, the analysis would miss certain parts of the whole region or involve double counting errors, resulting in inaccurate analysis. It should also be noted that geographical division changes over time can affect spatial aggregation results of geographical datasets, especially when dealing with time-series data sets. Some smaller regions recently might have been incorporated into larger areas. To this end, attention should be paid to these geographical division changes.

Moreover, unlike sectoral aggregation in input-output tables (Stair, 2013), not all data sets can be spatially aggregated. Population density, for example, cannot be aggregated directly; rather, population and region size should be aggregated respectively, and then their ratio calculated. In addition, although this document focuses on Virginia's independent cities, it can be extended to other spatial aggregation issues like defining functional economic regions (Farmer and Fotheringham, 2011) and metropolitan statistical areas (MSAs).

## References

- Farmer, C. J. and Fotheringham, A. S. (2011). Network-based functional regions. *Environment and Planning A*, 43(11):2723–2741.
- Stair, C. (2013). An aggregation matrix matlab function. Technical report, Regional Research Institute, West Virginia University.

Table 2: Aggregated County Equivalentents in Virginia

FIPS code	County composition with FIPS code in parentheses
51901	Albemarle (51003), Charlottesville (51540)
<b>51903</b>	<b>Alleghany (51005), Covington (51580)</b>
51907	Augusta (51015), Staunton (51790), Waynesboro (51820)
51911	Campbell (51031), Lynchburg (51680)
<b>51913</b>	<b>Carroll (51035), Galax (51640)</b>
51918	Dinwiddie (51053), Colonial Heights (51570), Petersburg (51730)
51919	Fairfax (51059), Fairfax City (51600), Falls Church (51610)
51921	Frederick (51069), Winchester (51840)
51923	Greensville (51081), Emporia (51595)
<b>51929</b>	<b>Henry (51089), Martinsville (51690)</b>
51931	James City (51095), Williamsburg (51830)
51933	Montgomery (51121), Radford (51750)
51939	Pittsylvania (51143), Danville (51590)
51941	Prince George (51149), Hopewell (51670)
51942	Prince William (51153), Manassas (51683), Manassas Park (51685)
51944	Roanoke (51161), Salem (51775)
<b>51945</b>	<b>Rockbridge (51163), Buena Vista (51530), Lexington (51678)</b>
51947	Rockingham (51165), Harrisonburg (51660)
51949	Southampton (51175), Franklin (51620)
51951	Spotsylvania (51177), Fredericksburg (51630)
<b>51953</b>	<b>Washington (51191), Bristol (51520)</b>
<b>51955</b>	<b>Wise (51195) , Norton (51720)</b>
51958	York (51199) , Poquoson (51735)

[Note: Appalachian regions are in bold.]