Regional Growth Report

1998-2016

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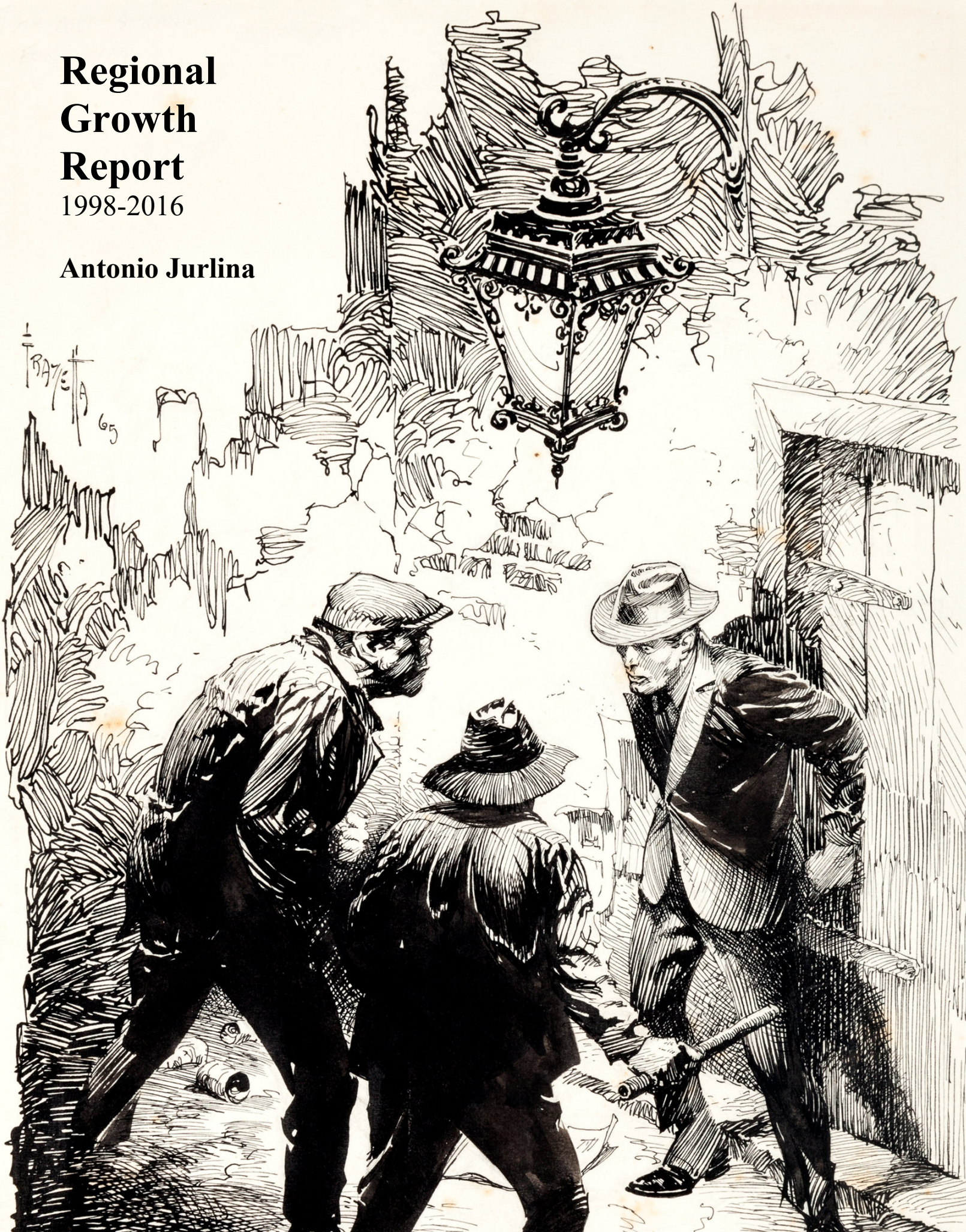

ECO 527

Regional Economics: Modeling

Prof. Andrew Crawley

This paper is going to analyze growth across four regions (A-D). This is going to be done with a Cobb-Douglas estimation of labor and capital impacts on output. The economic base is described, and multipliers are presented, along with a shift-share analysis, to pinpoint the industries largely responsible for regional growth. It starts by outlining important issues with the approach taken. The reader needs to be familiarized with these so as not to be misled by the results. Additionally, the paper presents the data and results on a per-region basis. Following this, it will cover the downsides of using these techniques and conclude with recommendations for future analyses.

Cobb-Douglas

Using the work of Cobb and Douglas (1928), supplemented with the findings of Solow (1957), output (*Y*) is modeled as a function of labor, capital, and technology, presuming constant returns to scale.

1. $\ln(Y_i) = \alpha_0 + \alpha_1 A_i + \alpha_2 \ln(\mathrm{K_i}) + \alpha_3 \ln(L_i)$
2. $\ln(\mathrm{y_i}) = \alpha_0 + \alpha_1 A_i + \alpha_2 \ln(\mathrm{k_i})$

In these two specifications, *Y* represents *GDP*, A represents technology, *K* represents capital, *L* represents labor, *y* represents output-to-labor ratio, *k* represents capital-to-labor ratio and *i* stands for region.

Both specifications have been tested for heteroskedasticity, presenting no relevant issues. (see Table 3, Figures 6-9). However, given that a Cobb-Douglas specification uses correlated variables it seemed prudent to verify for multicollinearity issues. This has been explored by others (Doll, 1974; Enaami et al., 2011) and it is a known issue with this approach. As expected, the variance inflation factor is indeed large (Table 3 and Figure 5), especially for Equation 1. This makes sense, given that labor and capital are separated and correlated, whereas in Equation 2, they are combined into a single ratio and this issue is not detected. These values indicate that the reader should be careful when interpreting estimates for Regions A and C, as they are most likely to be biased/inaccurate. However, the combined explanatory power of the variables should still hold.

Data spans the period between *1998* and *2016*, indexed so that *1998=100*. Figures 1 and 2 present relationships between the variables across two model specifications. Table 1 shows all of the estimates, across both models. In the first model specification, as noted, estimates for Regions A and C are quite unreliable. However, estimates for Regions B and D are more robust. First, the sum of their estimates is around 1.1, indicating increasing returns to scale. It is possible that this is indeed true, or that the model shows slight misalignment with real world outcomes. It is unclear which is the correct interpretation. Furthermore, in Region B, output increases by *64%* for every *1%* increase in labor usage, and it increases *44%* for every *1%* increase in capital usage, on average. In Region D, output increases by *55%* for every *1%* increase in labor usage, and it increases *56%* for every *1%* increase in capital usage, on average. In both regions, the effect of technological change is a *0.1%* increase in output for each unit of technological progress, on average.

When it comes to the per capita model, Regions A and C are dubious, again. With per-capita output decreasing by *170* and *124* percent for each *1%* increase in the capital-labor ratio, it is difficult to take these numbers at face value. Capital deepening is expected to have a positive effect on per-capita output. This is what estimates for Regions B and D indeed show. With per-capita output increasing by *30* and *41* percent respectively, capital deepening has the expected effect. Across all regions, technology once more has the same effect, indicating robust results,

except for Region A, where it seems to have an unexpected sign. Again, these issues can be contributed to the general unreliability of the estimates across Regions A and C.

Across all regions, capital-to-labor ratio is decreasing (see Figure 4), indicating a general upward trend in capital broadening through labor inflows. However, per-capita output is fairly stagnant across all regions except region C. Figure 2 indicates Region C to be the wealthiest among them. Still, it is difficult to ascertain whether labor is actually moving from the (relatively) poorer regions to the wealthier one. The whole picture is, unfortunately, incomplete. Is the labor leaving Regions A, B, and D for some unspecified Region H or is it actually ending up in Region C? In the period between *1998* and *2016*, employment numbers have actually gone up (see Tables 6 and 7) across all regions and it would require more data to detect the actual reasons behind labor redistributions across industries and for encompassing regions.

Economic-Base and Multipliers

In determining the economic base (the export-oriented industry), two approaches were used. First, an ad-hoc approach was based around three industries as exporters: manufacturing, mining (quarrying, oil, and gas extraction included), and finance (insurance included). First two are assumed to be the primary exporting industries given the wide consumer base they satisfy. Finance and insurance are assumed to be exporting industries given the service-based orientation of the U.S. economy in general and the need for financial intermediaries across various aspects of it. Second, exporting industries were classified as those with a location quotient greater than *1*. This would indicate an industry regionally more concentrated than on the national level. In both cases, the regional economic base multipliers were calculated in two ways, for a total of four multiplier values across various methods:

3. $m = \frac{\Delta T_i}{\Delta B_i}$
4. $T_i = intercept + mB_i$

In these two specifications, *T* represents total regional employment, *B* represents the economic base (exporting industries classified according to the LQ approach or the ad-hoc approach) and *i* stands for region. Results are presented in Figure 16 and Table 2. In subsequent discussion, the multiplier (*m*) represents the total change in local economic activity stemming from change in the economic base, that is

5. $\Delta T_i = m\Delta B_i$

In Region A, the multiplier varies between *5.91* and *19.4* for the LQ approach and *-4.96* and *-3.56* for the ad-hoc approach. In Region B, the multiplier varies between *7.31* and *7.56* for the LQ approach and *-66.9* and *-3.68* for the ad-hoc approach. In Region C, the multiplier varies between *6.67* and *8.16* for the LQ approach and *27.31* and *73.99* for the ad-hoc approach. Finally, in Region D, the multiplier varies between *9.66* and *15.73* for the LQ approach and *14.51* and *19.27* for the ad-hoc approach. The lower bound for each region's multiplier comes from Equation 4 OLS approach and the upper bound comes from Equation 3 approach.

The ad-hoc approach produces multipliers with much higher absolute values and seems to be less reliable in general. The whole approach rests on having a good sense which industry is a strong exporter in the region. This is mostly flawed given that the author is not aware of what Regions A-D actually refer to, so the assumptions were based on U.S. national trends. These results are

most likely wrong, and more consideration should be given to the LQ approach, specifically the OLS results.

Growth Potential

Regions A and C have experienced an employment decrease due to local effects while all regions (including A and C) have experienced substantial employment increases due to national effects and some minor increases due to industrial effects (Figures 10-14, Tables 4-5). Overall, the employment trends seem to be positive at first glance. However, several effects need to be noted. As seen in Tables 4 and 5, large industries across these regions seem to be growing less concentrated locally. Furthermore, the ones experiencing largest decline due to industrial effects across all regions are manufacturing, retail trade and government enterprises (Figures 10-13). Government aside, these are major indicators of upcoming shifts that haven't been felt yet given that local and national shares seem to have remained positive. Worse even, retail trade is one of the larger employers across these regions and it keeps declining (Tables 4-5). Additionally, other large employers are health services, government, accommodation and food services, professional, scientific and technical services and finance.

Important to note, largest employers are still fairly well regionally concentrated (Tables 4-5). The downside is their service-oriented, closed-loop nature, vulnerable to exogenous shocks. With retail trade declining, health care and government remain the largest employers across these regions. One of the upsides is the relatively strong presence of the professional, scientific and technical services sector and the finance and insurance sector. Both of these are among the higher concentrated ones with solid employment numbers. Going forward, these sectors could be supported in order to produce regional growth. Moreover, the declining industries need to be addressed as well. Many, like retail trade, are not likely to return, and this part of the labor force will be in need of retraining soon. These are some issues that can be addressed before they become a more pressing problem. Finally, the service-based nature of each region's economic make-up is likely to leave the regions vulnerable to exogenous supply shocks. Whether the regions, or the nation as a whole should address this issue is unclear, however, it must not be brushed aside.

Limitations

Most limitations have been noted already, both for Cobb-Douglas production function and the approach to choosing an adequate method of measuring the regional export base. In the case of multipliers, the issue really lies with the amount of data available, usually a cost-based problem and not much the author can do about. However, Cobb-Douglas approach itself is somewhat limited. By original design, there are only two inputs, labor and capital, augmented by technical change. While labor is much easier to define, capital seems to subsume much and categories are quite hard to draw between raw materials, building and equipment (and labor used to produce them!). The embedded expectation of constant returns to scale is questionable as well, given that both decreasing and increasing returns are an actuality. Finally, the issue of multicollinearity is ever-present and has been, more recently, addressed through the use of partial least squares models, which are beyond the aim of this project.

Nevertheless, mathematical simplicity of the model allows for easy extraction of elasticity measurements. Also, it allows for determination of output shares of labor and capital across many industries, especially manufacturing ones. On a well selected scale, the Cobb-Douglas function can aid in the empirical studies of industrial output shares.

References

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2. Doll, J. P. (1974). On Exact Multicollinearity and the Estimation of the Cobb-Douglas Production Function. *American Journal of Agricultural Economics*, *56*(3), 556–563. https://doi.org/10.2307/1238608

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4. Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics*, *39*(3), 312–320. JSTOR. https://doi.org/10.2307/1926047

Table 1. Model Estimates

	$\ln(Y) = \alpha_0 + \alpha_1 A + \alpha_2 \ln(K) + \alpha_3 \ln(L)$				$\ln(y) = \alpha_0 + \alpha_1 A + \alpha_2 \ln(k)$			
region	A	B	C	D	A	B	C	D
intercept	-8.21	-0.35	1.98	-0.60	0.19	0.02	-0.12	-0.14
	(3.02)	(1.65)	(1.20)	(0.84)	(0.08)	(0.08)	(0.03)	(0.07)
technology	-0.003	0.001	0.001	0.001	-0.001	0.001	0.001	0.002
	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)
labor	4.03	0.64	3.42	0.55				
	(0.77)	(0.64)	(0.72)	(0.19)				
capital	-1.19	0.44	-2.88	0.56				
	(0.63)	(0.44)	(0.97)	(0.32)				
capital/labor					-1.70	0.31	-1.24	0.41
					(0.72)	(0.36)	(0.27)	(0.17)
R^2	0.80	0.71	0.99	0.93	0.31	0.05	0.91	0.43

Table 2. Multipliers (with standard errors)

	$T = \alpha_0 + mB$				$m = \frac{\Delta T}{\Delta B}$			
region	A	B	C	D	A	B	C	D
ad-hoc	-3.56	-3.68	27.31	14.51	-4.96	-66.90	73.99	19.27
	(0.80)	(1.84)	(8.06)	(1.49)	(0.39)	(0.46)	(1.67)	(0.47)
lq	5.91	7.56	6.67	9.66	19.40	7.31	8.16	15.74
	(1.97)	(0.94)	(0.52)	(2.12)	(0.44)	(0.42)	(0.12)	(0.84)

Table 3. Variance Inflation Factor and Heteroskedasticity tests

	$\ln(Y) = \alpha_0 + \alpha_1 A + \alpha_2 \ln(K) + \alpha_3 \ln(L)$				$\ln(y) = \alpha_0 + \alpha_1 A + \alpha_2 \ln(k)$			
region	A	B	C	D	A	B	C	D
technology	16.77	2.36	1.94	2.09	10.58	2.12	1.75	1.22
labor	17.12	8.05	207.39	6.22				
capital	1.96	5.93	210.26	7.20				
capital/labor					10.58	2.12	1.75	1.22
Breusch-Pagan (p-value)	0.31	0.33	0.20	0.08	0.15	0.19	0.07	0.25

Figure 1. GDP versus independent variables

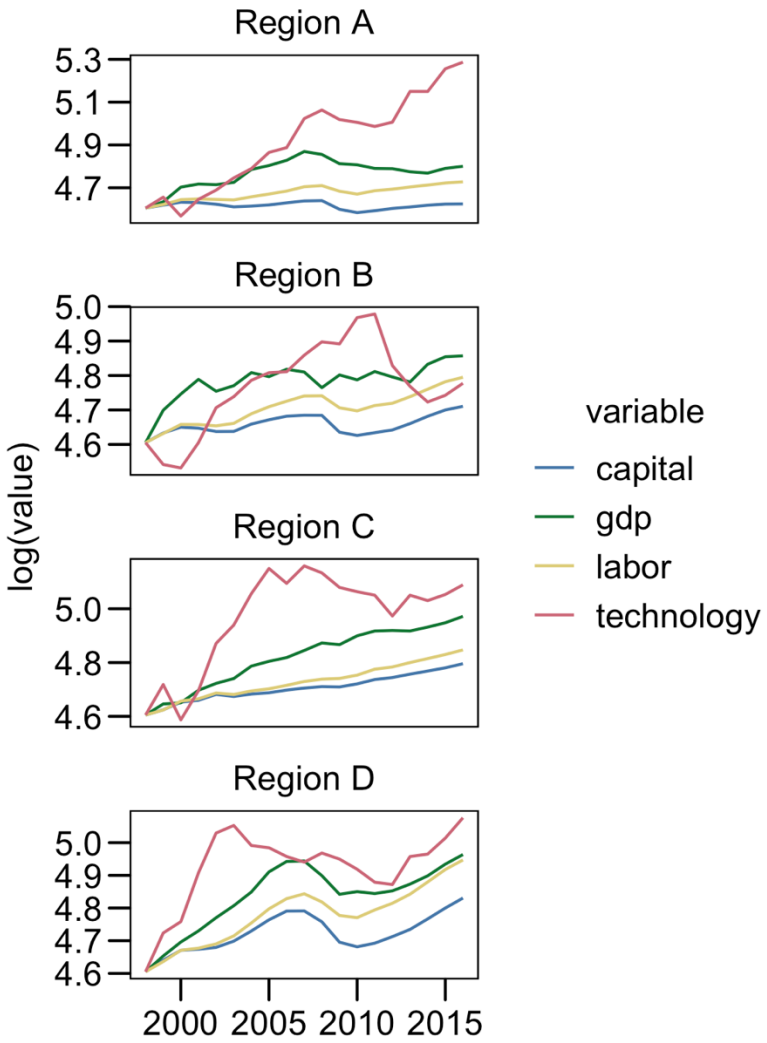


Figure 2. GDP per capita versus capital-labor ratio

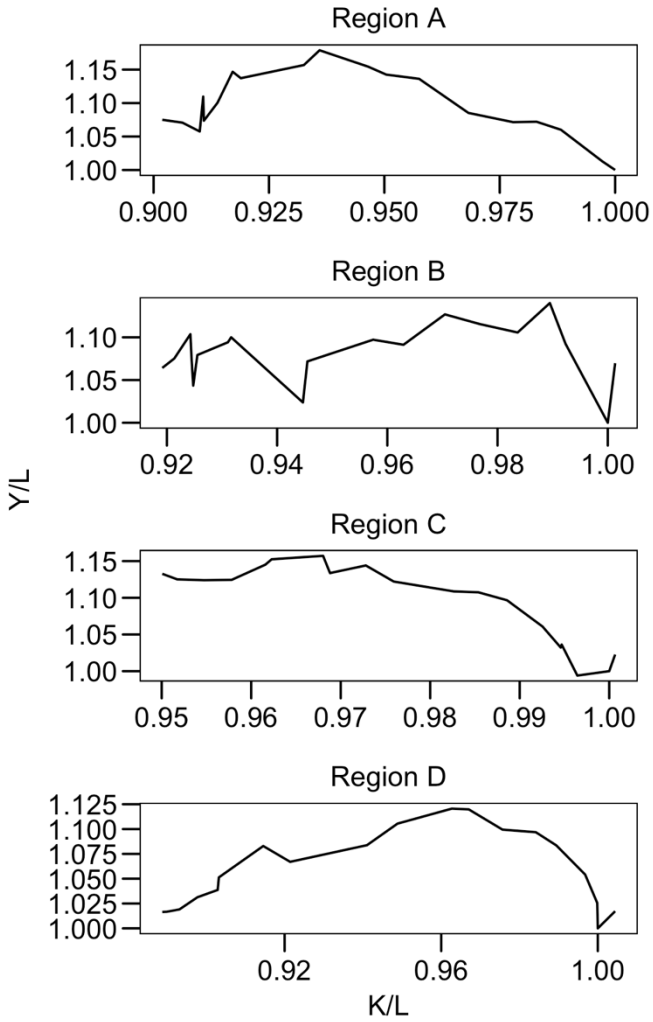


Figure 3. GDP per capita over time

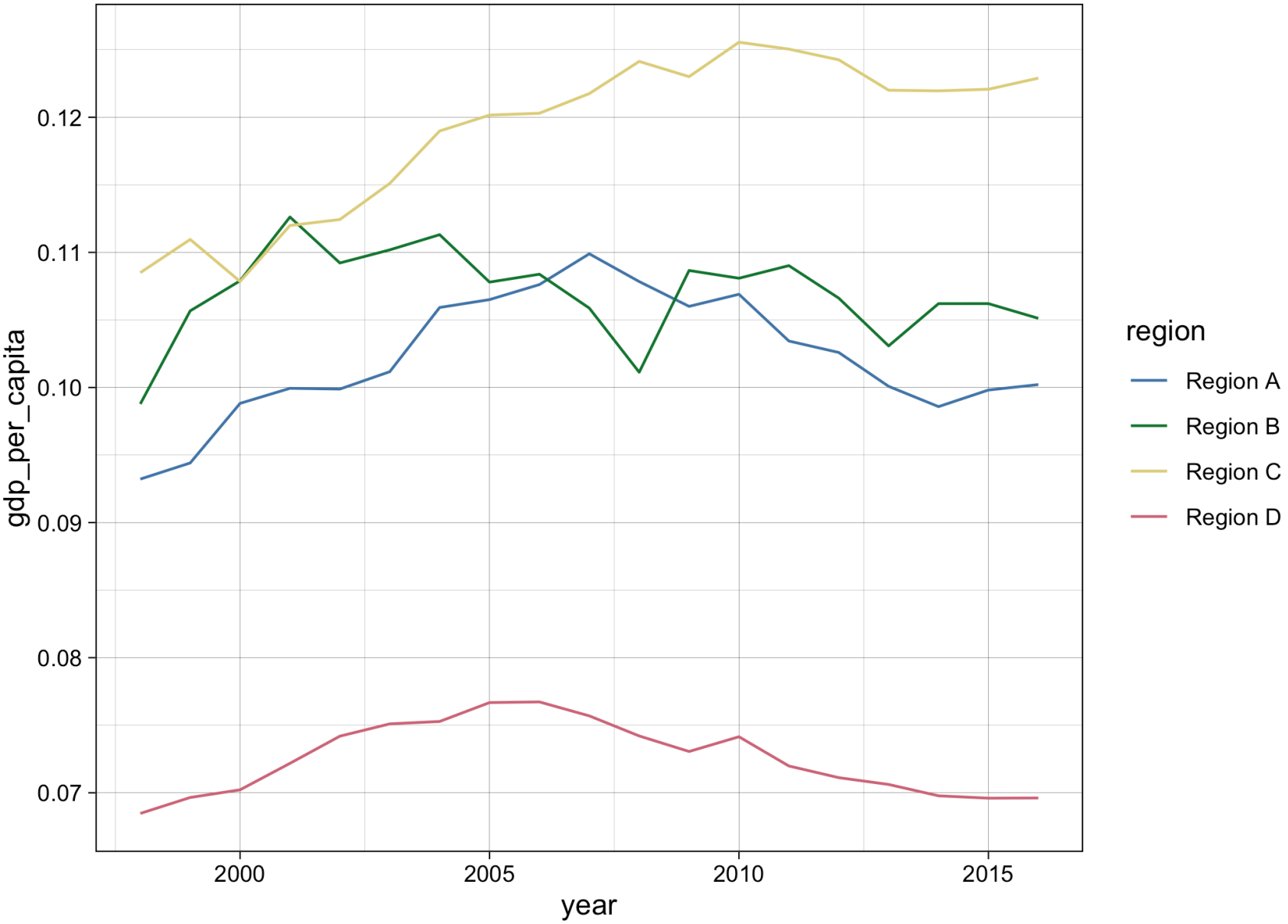
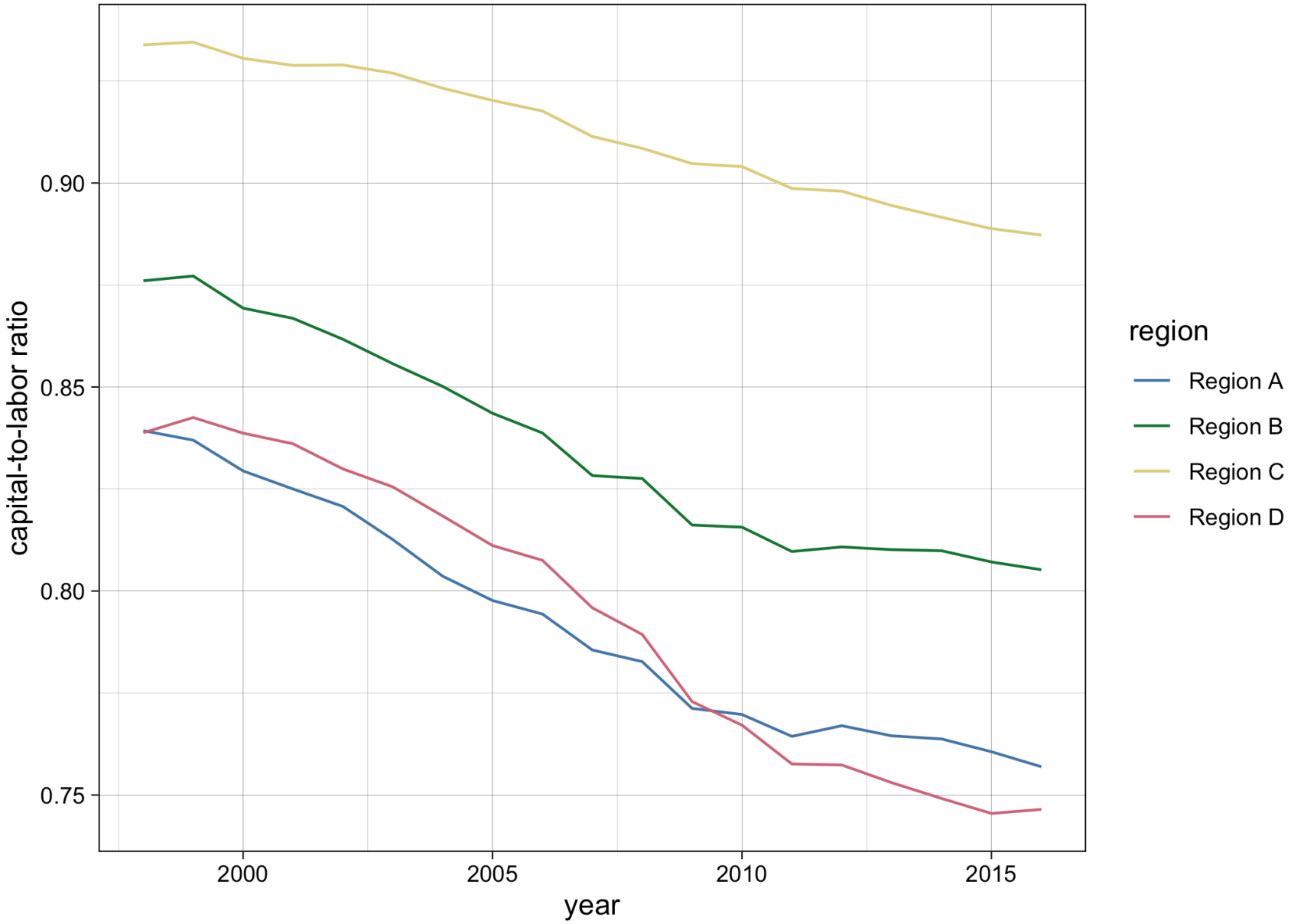


Figure 4. Capital-labor ratio over time



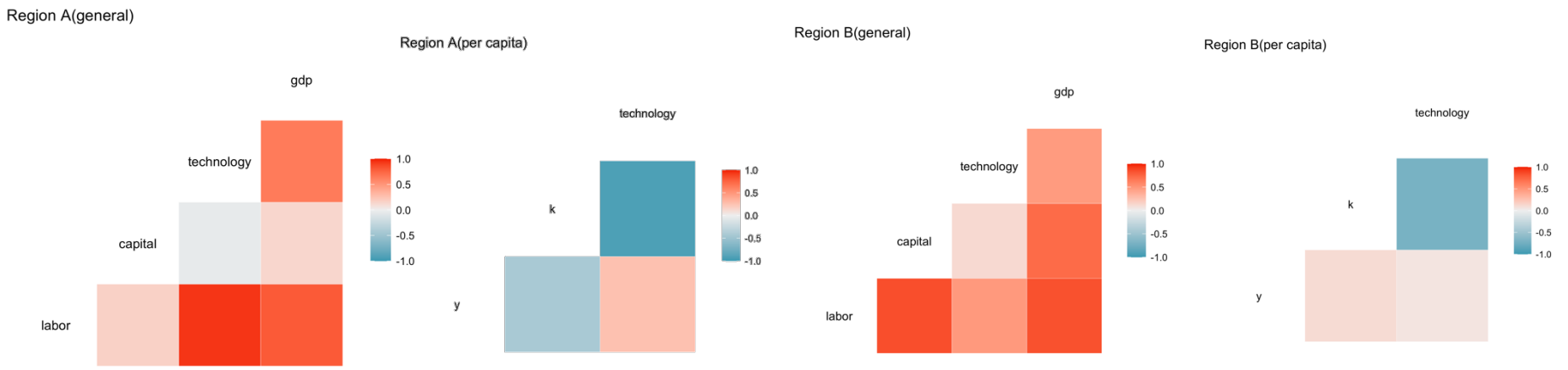
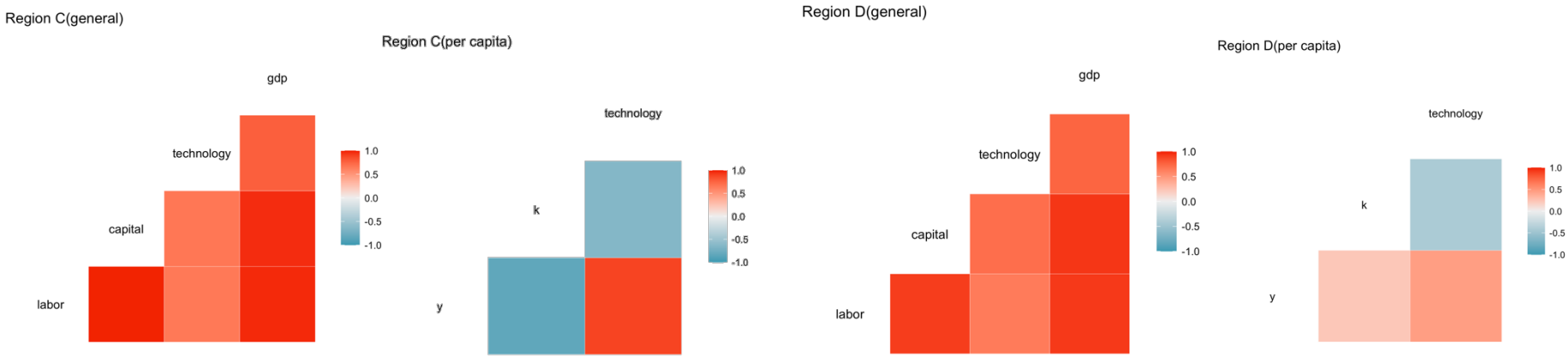


Figure 5. Correlation matrices



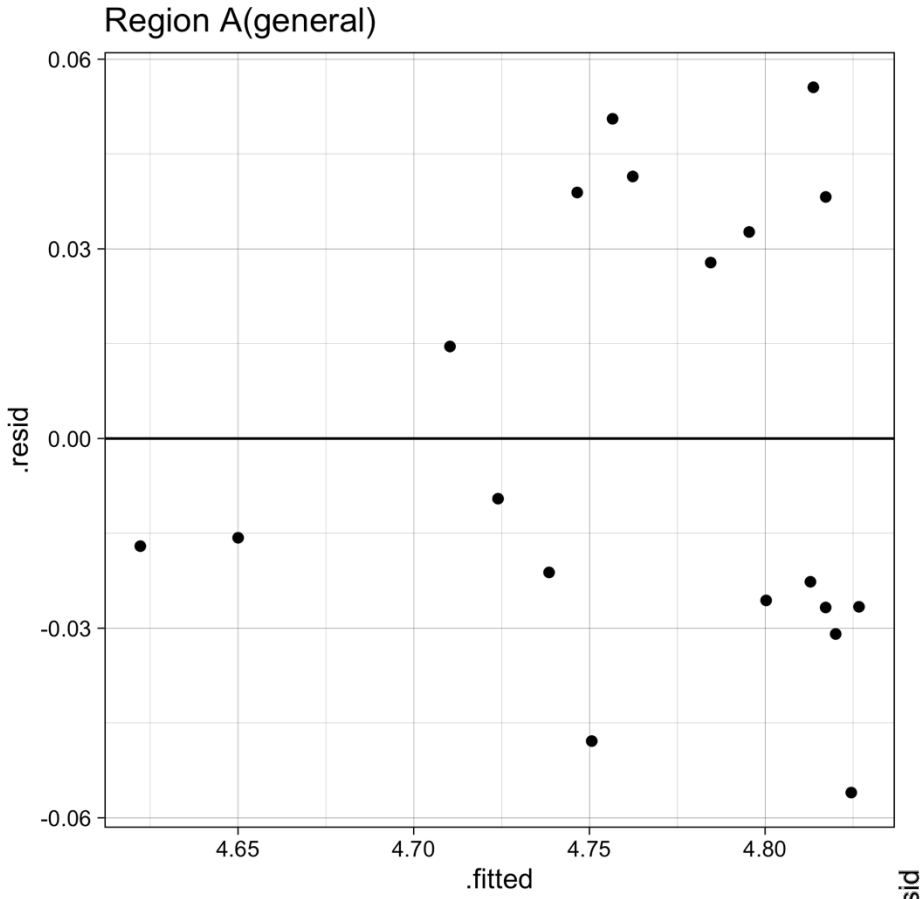
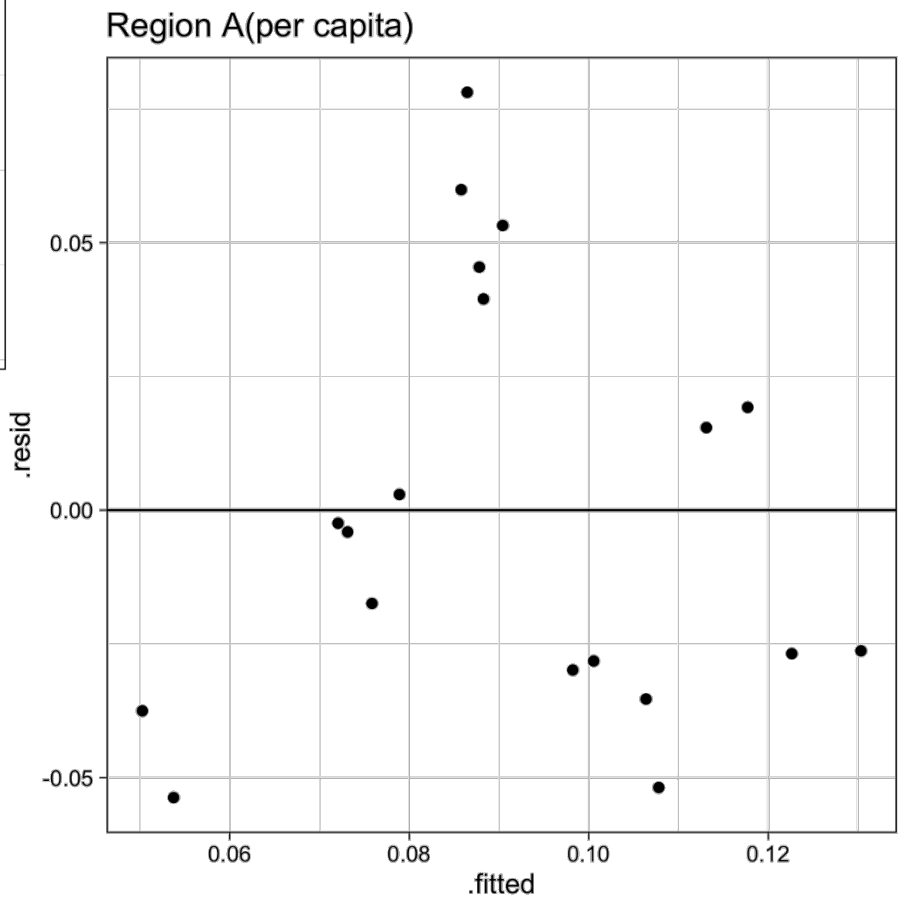


Figure 6. Residual vs. fitted – Region A models



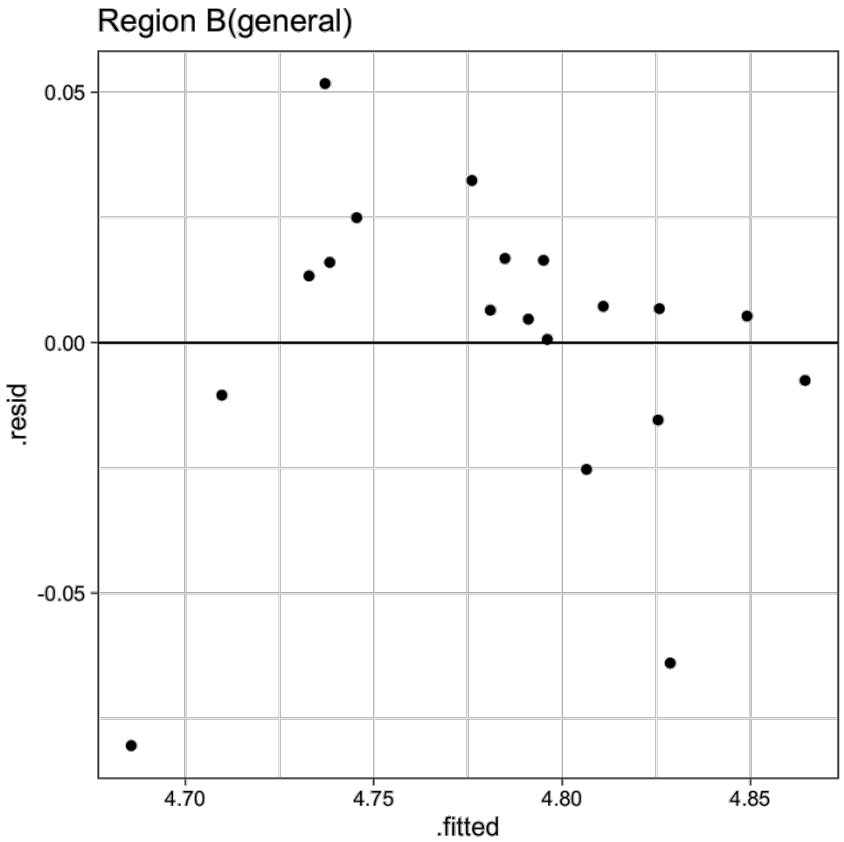
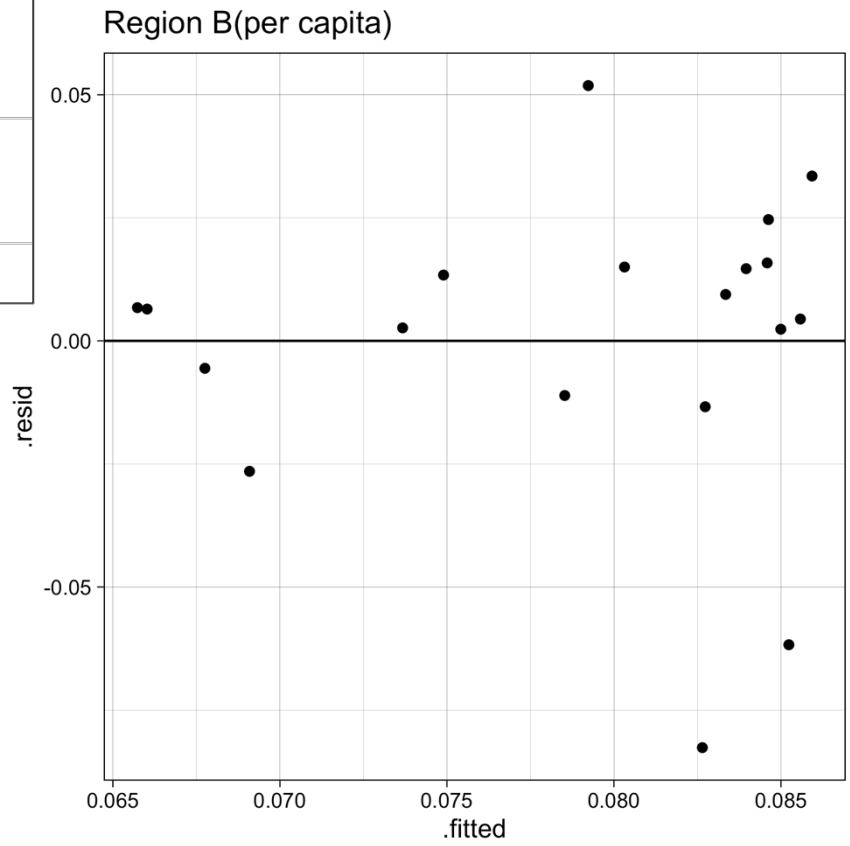


Figure 7. Residual vs. fitted – Region B models



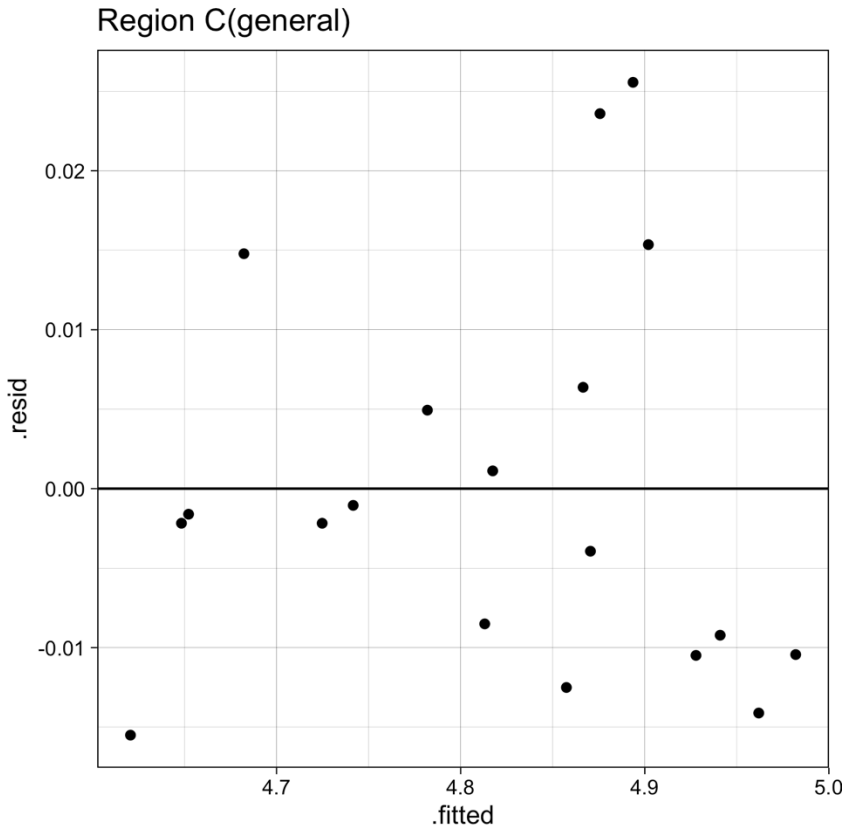
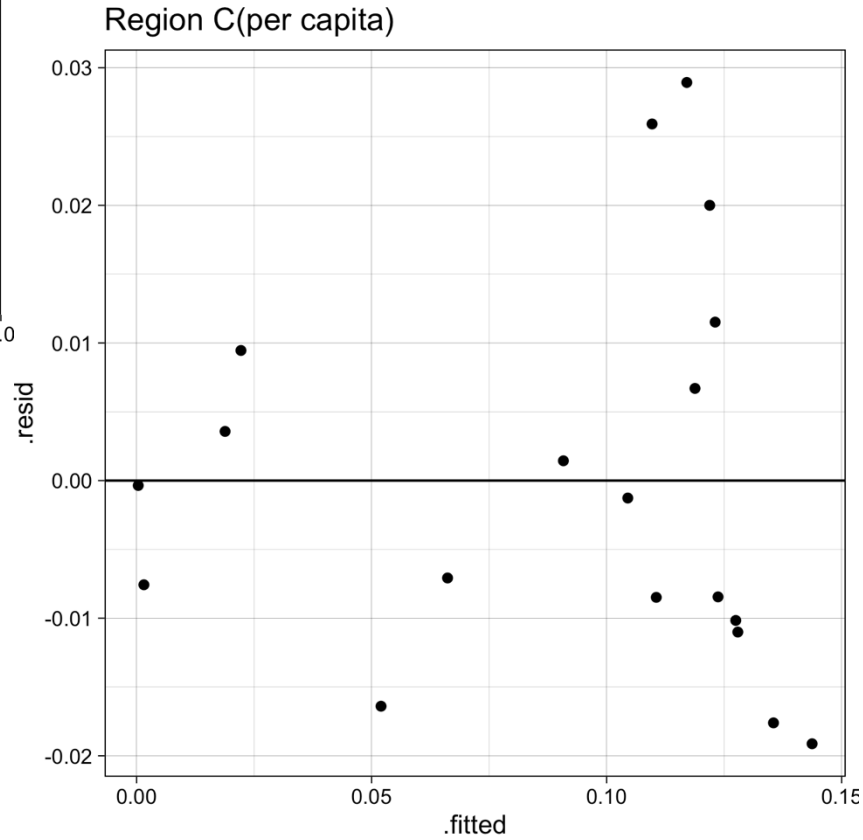


Figure 8. Residual vs. fitted – Region C models



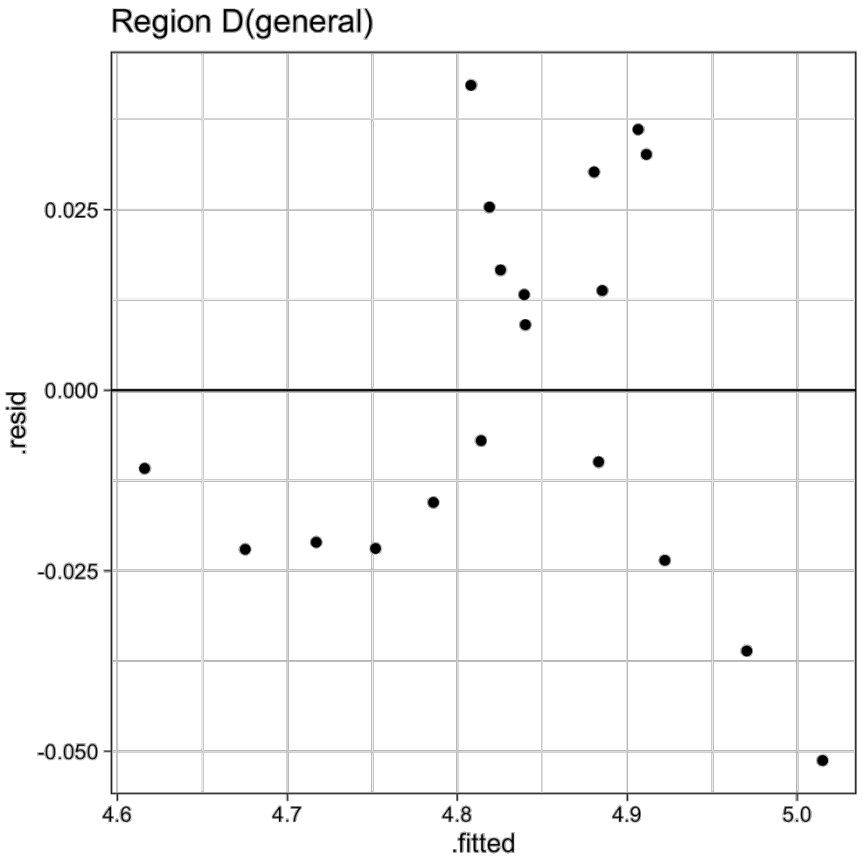
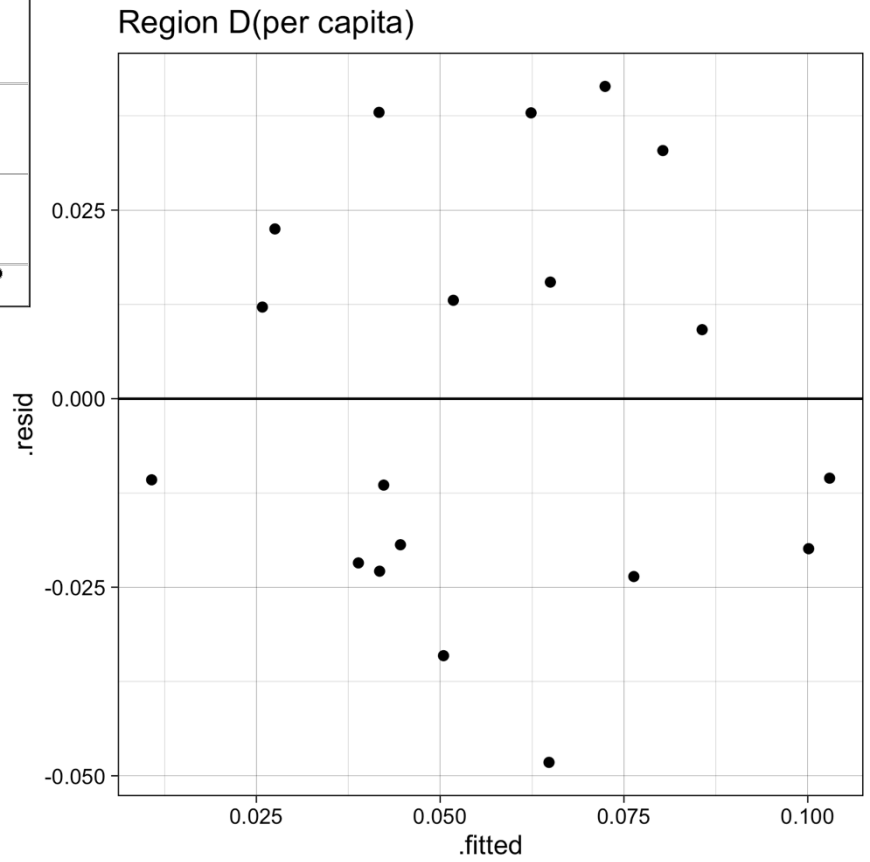


Figure 9. Residual vs. fitted – Region D models



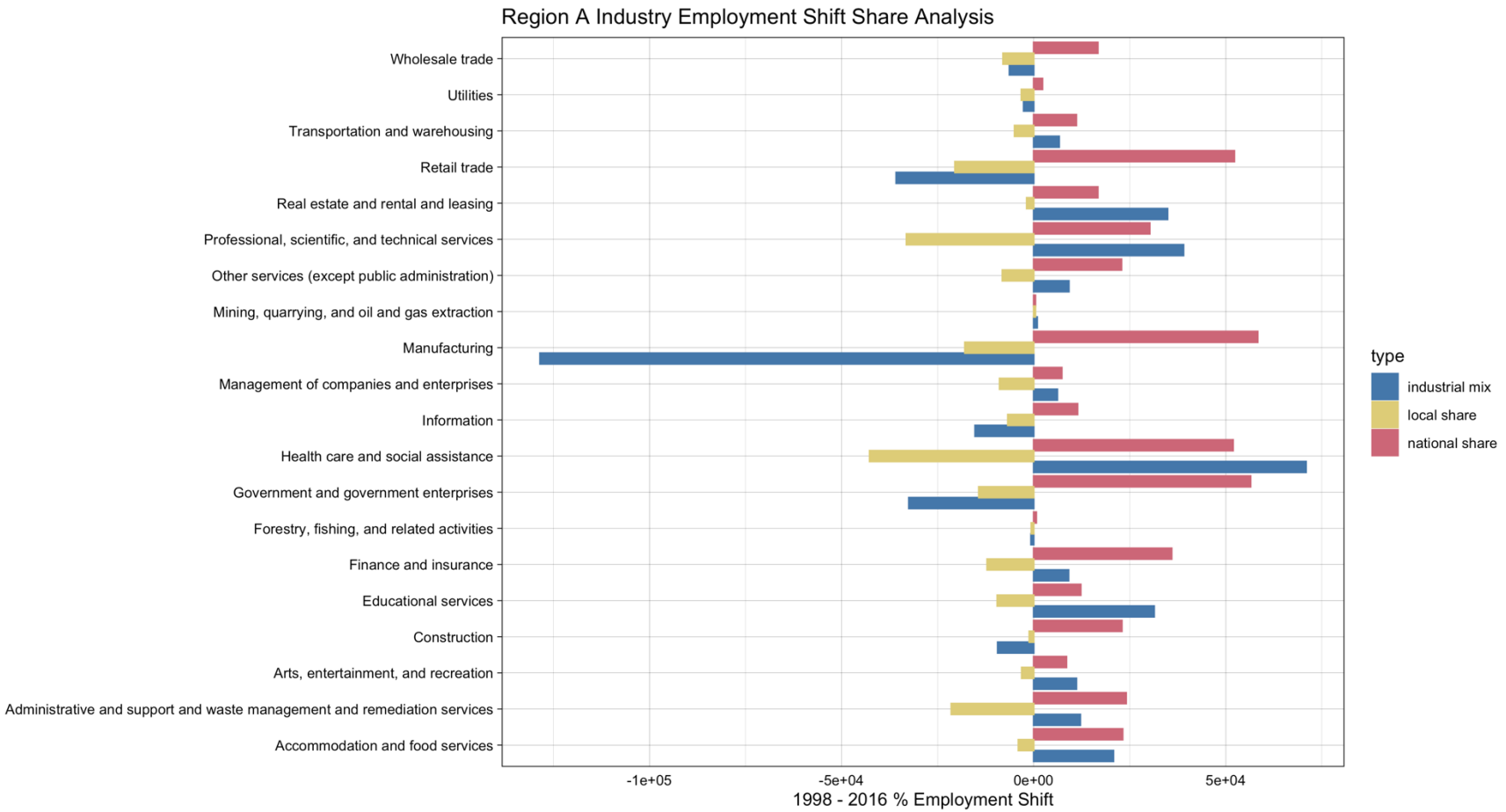


Figure 10. Region A Shift Share Analysis

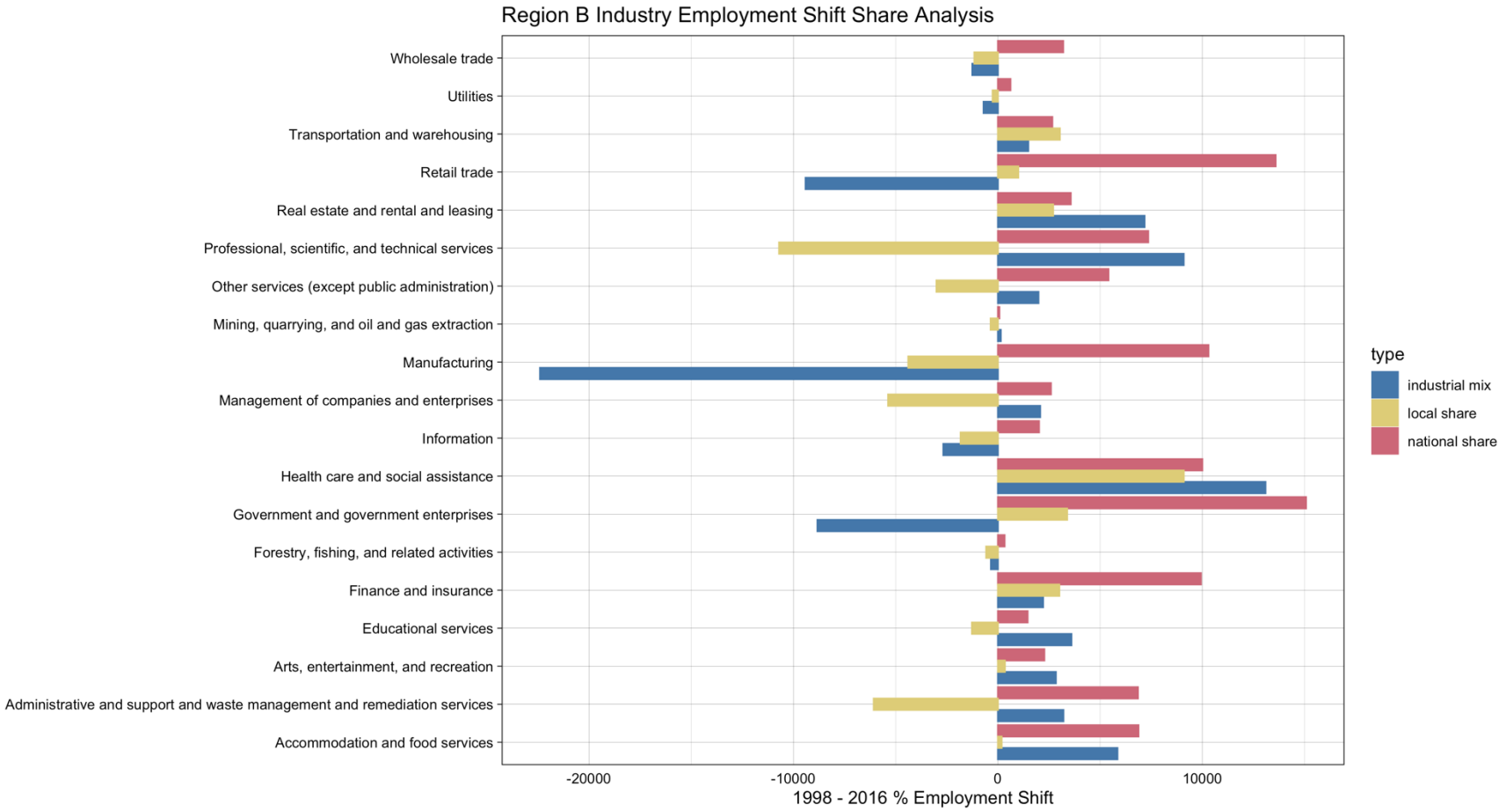


Figure 11. Region B Shift Share Analysis

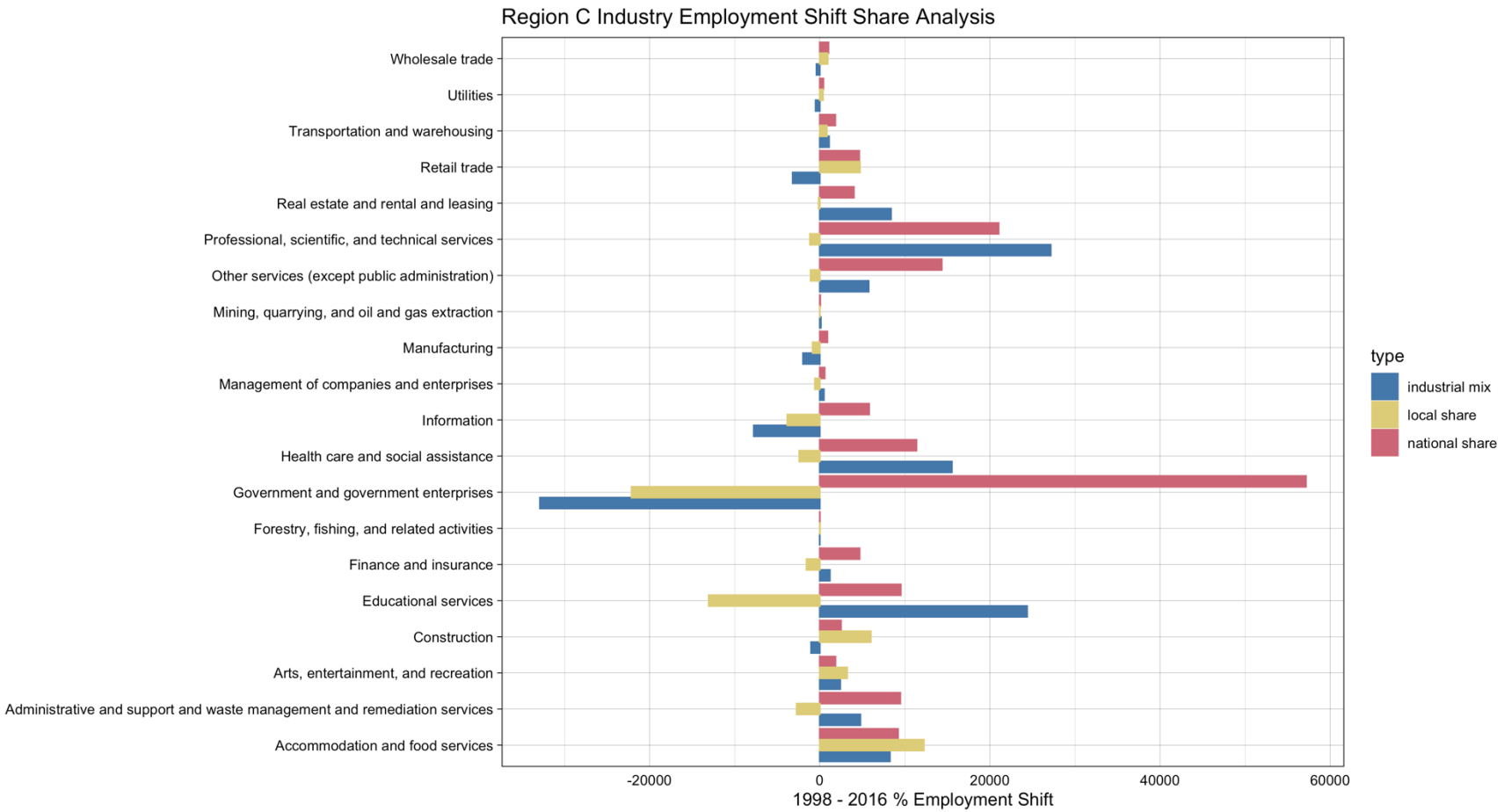


Figure 12. Region C Shift Share Analysis

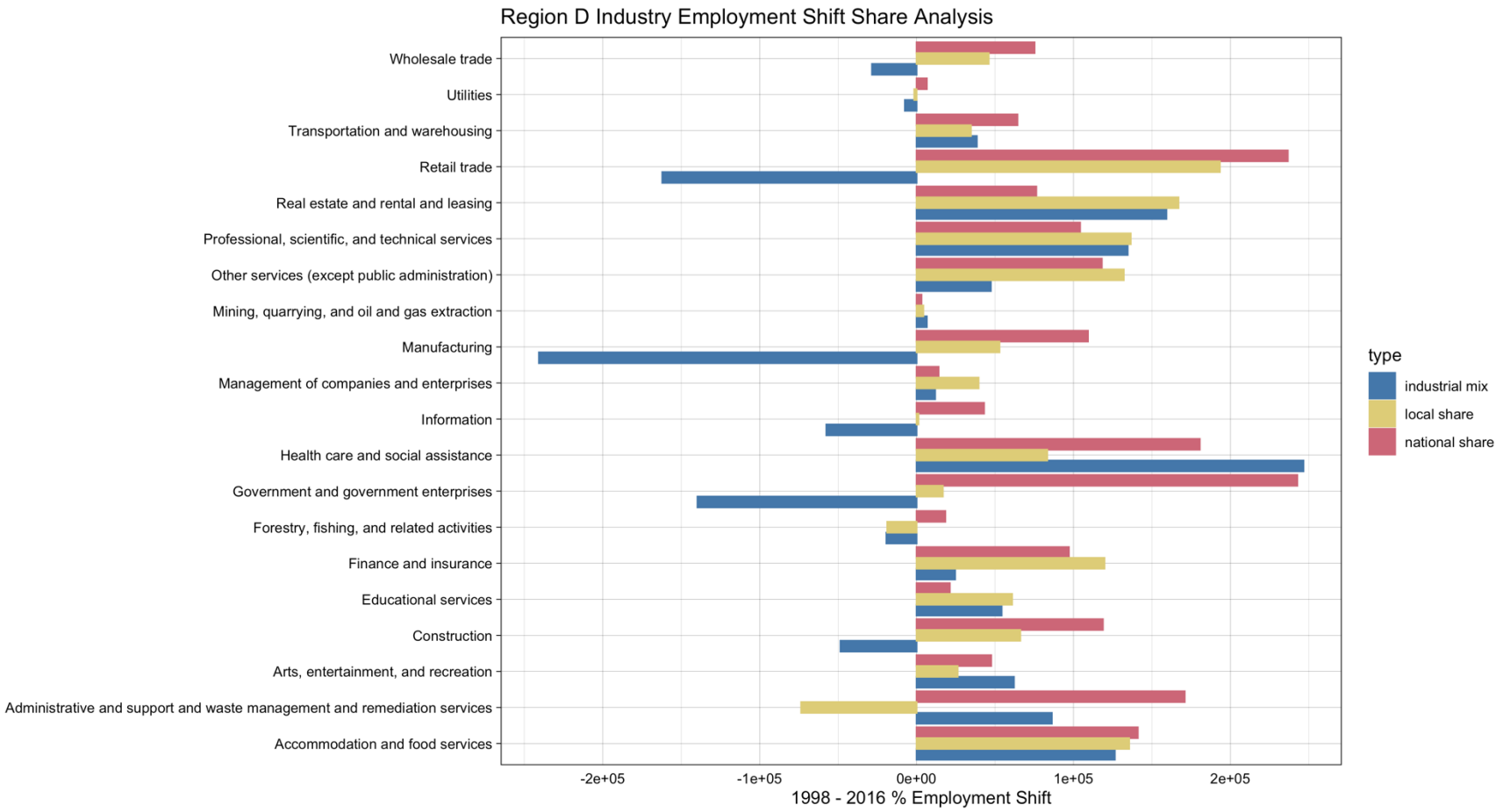


Figure 13. Region D Shift Share Analysis

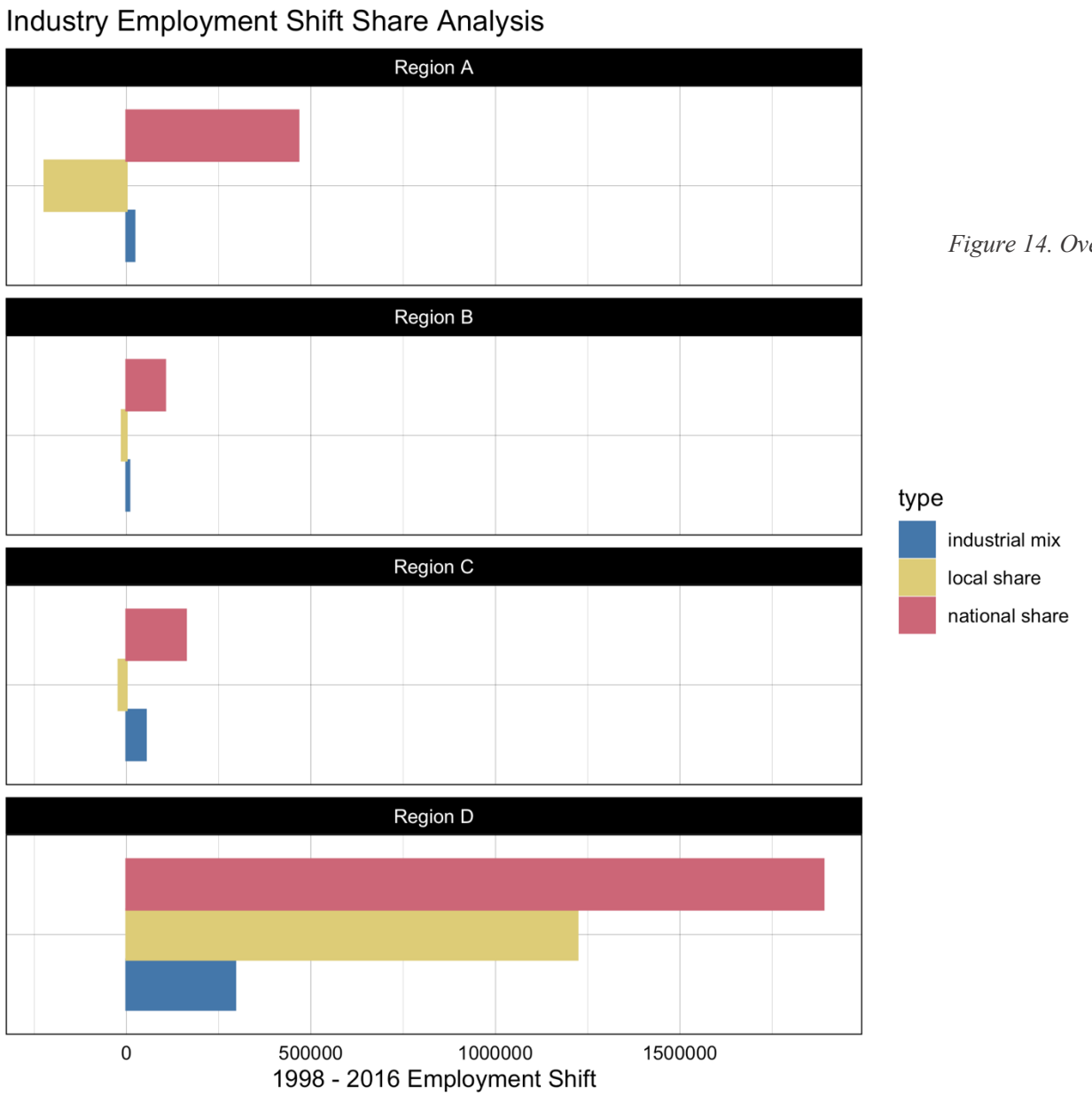


Figure 14. Overall Shift Share Analysis

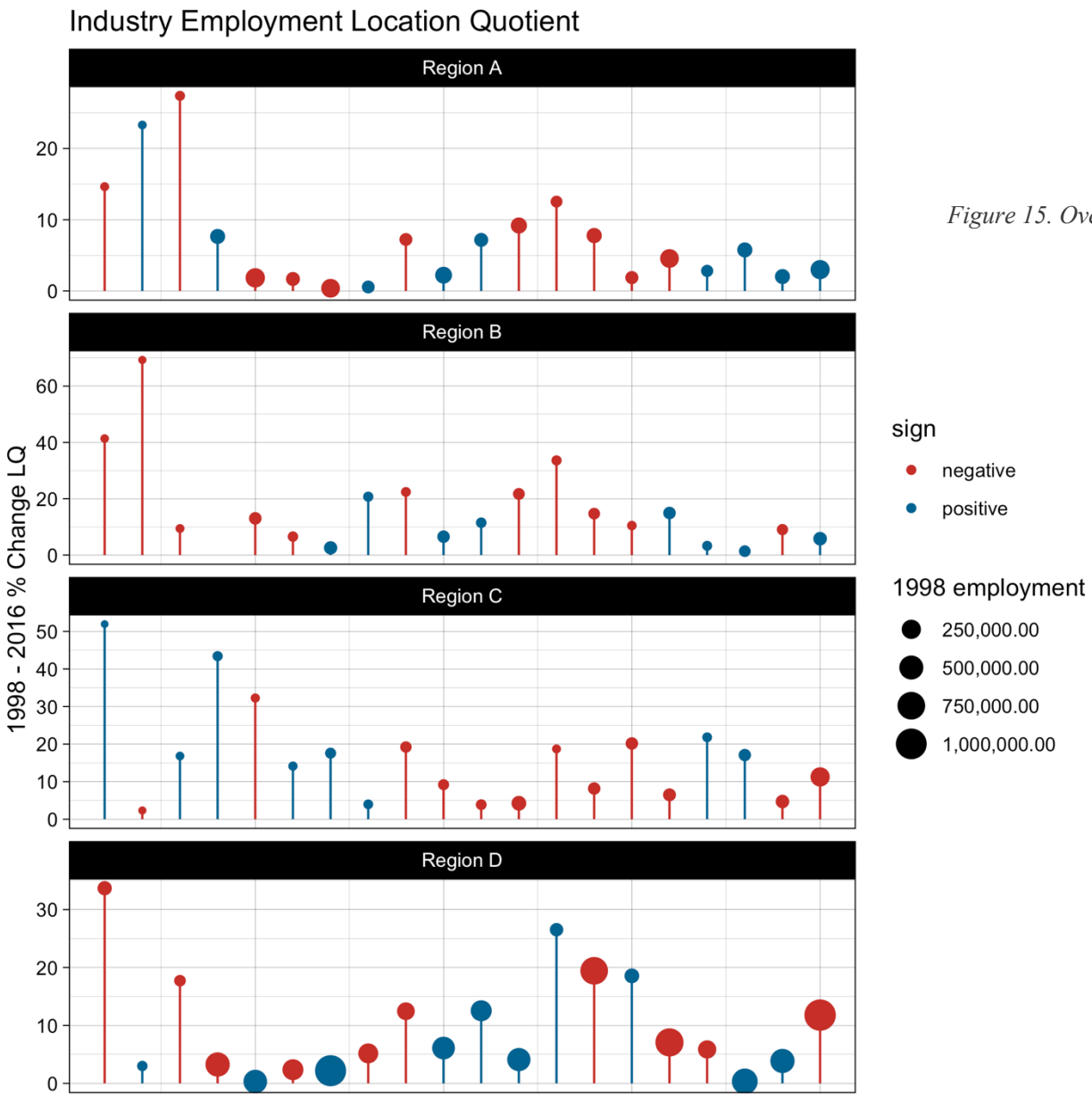


Figure 15. Overall Change in LQs

Table 4. Top Industries by 2016 % Region Employment

Region	Industry	1998 LQ	2016 LQ	1998 % Employment	2016 % Employment	Growth rate	Birch Index	National share	Industrial mix	Local share
Region A	Health care and social assistance	1.2	↑ 1.2	11.2	↑ 13.4	35.4	108463.1	51898.8	70899.2	-42712.0
Region A	Government and government enterprises	0.9	↑ 0.9	12.1	↓ 11.1	3.9	10051.4	56453.6	-32492.1	-14290.5
Region A	Retail trade	1.0	↑ 1	11.2	↓ 9.8	-1.8	-3970.2	52238.2	-35789.9	-20490.3
Region A	Finance and insurance	1.6	↑ 1.6	7.7	↑ 8.3	21.0	39792.4	35912.6	9085.3	-12117.9
Region A	Professional, scientific, and technical services	1.1	↓ 1	6.5	↑ 7.3	27.4	45985.1	30206.0	39003.7	-33123.7
Region B	Health care and social assistance	1.0	↑ 1.1	9.6	↑ 13.8	75.7	56547.4	9999.1	13087.7	9092.2
Region B	Government and government enterprises	1.0	↑ 1	14.5	↓ 13.6	15.0	11077.8	15072.7	-8829.9	3387.2
Region B	Retail trade	1.1	↑ 1.1	13.0	↓ 11.6	9.0	5635.3	13584.8	-9410.8	998.0
Region B	Finance and insurance	1.8	↑ 1.9	9.5	↑ 10.6	35.9	20584.5	9932.1	2211.7	3004.3
Region B	Accommodation and food services	1.0	↑ 1	6.6	↑ 7.8	44.2	18603.0	6875.4	5846.4	182.3
Region C	Government and government enterprises	2.5	↓ 2.2	35.6	↓ 28.2	0.9	2155.3	57150.9	-32893.5	-22120.5
Region C	Professional, scientific, and technical services	2.3	↓ 2.2	13.1	↑ 15.6	51.4	71167.3	21023.7	27146.9	-1150.6
Region C	Other services (except public administration)	1.6	↓ 1.5	8.9	↑ 9.2	30.4	24802.1	14338.5	5749.8	-1075.3
Region C	Health care and social assistance	0.8	↓ 0.7	7.1	↑ 8.3	49.5	36590.2	11366.5	15527.8	-2412.3
Region C	Accommodation and food services	0.9	↑ 1	5.7	↑ 7.8	74.1	51651.1	9199.1	8244.2	12229.7
Region D	Retail trade	1.1	↑ 1.1	12.5	↓ 11.2	26.0	337427.6	236625.2	-162118.7	193315.6
Region D	Health care and social assistance	1.0	↑ 1	9.6	↑ 11.1	64.9	841765.1	180519.4	246608.3	83271.2
Region D	Government and government enterprises	0.9	↓ 0.8	12.8	↓ 10.1	11.3	133304.8	242681.6	-139676.5	16733.8
Region D	Accommodation and food services	1.2	↑ 1.2	7.5	↑ 8.7	65.6	667175.7	141003.0	126366.6	135498.5
Region D	Administrative and support and waste management and remediation services	1.6	↓ 1.3	9.0	↓ 8	24.7	228784.0	170899.5	86198.7	-73570.1

Table 5. Top Industries by 2016 LQ

Region	Industry	1998 LQ	2016 LQ	1998 % Employment	2016 % Employment	Growth rate	Birch Index	National share	Industrial mix	Local share
Region A	Finance and insurance	1.6	↑ 1.6	7.7	↑ 8.3	21.0	39792.4	35912.6	9085.3	-12117.9
Region A	Educational services	1.6	↓ 1.5	2.6	↑ 3.8	64.0	55965.9	12251.9	31356.3	-9476.3
Region A	Health care and social assistance	1.2	↑ 1.2	11.2	↑ 13.4	35.4	108463.1	51898.8	70899.2	-42712.0
Region A	Management of companies and enterprises	1.4	↓ 1.2	1.6	↑ 1.6	14.4	5260.2	7316.2	6160.4	-8879.6
Region A	Manufacturing	1.1	↑ 1.1	12.5	↓ 7.2	-34.7	-57532.1	58309.4	-128496.2	-17904.2
Region A	Real estate and rental and leasing	1.1	↑ 1.1	3.6	↑ 5.3	68.4	83712.5	16695.5	34840.5	-1819.1
Region B	Finance and insurance	1.8	↑ 1.9	9.5	↑ 10.6	35.9	20584.5	9932.1	2211.7	3004.3
Region B	Management of companies and enterprises	2.1	↓ 1.4	2.5	↓ 1.9	-6.4	-661.7	2595.5	2069.8	-5372.3
Region B	Utilities	1.4	↓ 1.3	0.6	↓ 0.4	-13.2	-300.3	615.8	-701.9	-259.9
Region B	Arts, entertainment, and recreation	1.1	↑ 1.2	2.2	↑ 2.8	56.5	8526.2	2270.5	2835.5	342.9
Region B	Health care and social assistance	1.0	↑ 1.1	9.6	↑ 13.8	75.7	56547.4	9999.1	13087.7	9092.2
Region B	Real estate and rental and leasing	1.0	↑ 1.1	3.4	↑ 5.3	88.7	25368.6	3565.0	7173.3	2703.7
Region B	Retail trade	1.1	↑ 1.1	13.0	↓ 11.6	9.0	5635.3	13584.8	-9410.8	998.0
Region C	Educational services	3.6	↓ 2.8	5.9	↑ 7	50.3	31316.8	9524.2	24375.4	-13056.6
Region C	Government and government enterprises	2.5	↓ 2.2	35.6	↓ 28.2	0.9	2155.3	57150.9	-32893.5	-22120.5
Region C	Professional, scientific, and technical services	2.3	↓ 2.2	13.1	↑ 15.6	51.4	71167.3	21023.7	27146.9	-1150.6
Region C	Other services (except public administration)	1.6	↓ 1.5	8.9	↑ 9.2	30.4	24802.1	14338.5	5749.8	-1075.3
Region C	Information	1.5	↓ 1.2	3.6	↓ 2.2	-22.8	-4449.0	5801.6	-7756.5	-3809.1
Region D	Administrative and support and waste management and remediation services	1.6	↓ 1.3	9.0	↓ 8	24.7	228784.0	170899.5	86198.7	-73570.1
Region D	Arts, entertainment, and recreation	1.4	↓ 1.3	2.5	↑ 2.9	65.5	224793.1	47572.3	62061.8	26156.9
Region D	Real estate and rental and leasing	1.2	↑ 1.3	4.0	↑ 6.3	121.1	889872.2	76301.1	159226.5	166922.4
Region D	Accommodation and food services	1.2	↑ 1.2	7.5	↑ 8.7	65.6	667175.7	141003.0	126366.6	135498.5
Region D	Other services (except public administration)	1.1	↑ 1.2	6.3	↑ 7	57.9	469618.2	118069.5	47346.5	132080.0

Table 6. Employment Change across Regions

Region	1998	2016
Region A	2027062	↑ 2291818
Region B	442565	↑ 541577
Region C	698383	↑ 889431
Region D	8225233	↑ 11630025

Table 7. Growth Rate and Birch Index across Regions

Region	Growth rate	Birch Index
Region A	18.85127	21937.208
Region B	17.34438	8848.537
Region C	37.16824	14857.214
Region D	49.04471	287985.851

Figure 16. OLS Multiplier Estimates