## Appendix 1

MATLAB source code for frequency histogram and filled area Graph
%% imports the F value in EXCEL into MATLAB area(F)%fill area map
grid on %% hist (F, 3221) % frequency histogram grid on Hist (F, 2400) grid on :
plot(x,y11,x,y21,x,y31,x,y41,x,y51) grid on xlabel ('FIPS-Combined'); ylabel ('Absolute Quantity Feature');
legend('Heroin','non-synthetic opioids ','synthetic opioids', 'opioids', 'Total Drug Reports County').

## Appendix 2

Partial results of SPSS principal component analysis
Component Matrix

| | **Component** | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| GEO.id2 | | -0.052 | | |
| | 0.0148 | | 7 0.4878 | 0.724 |
| year | | | | -0.201 |
| | 0.0044 | 0.4794 | 0.4037 | 9 |
| School Enrollment-Elementary School (Grades 1-8) | | -0.025 | | 2 |
| | 0.2717 | 0.0009 | -0.002 | |
| | | -0.029 | -0.009 | |
| School Enrollment -College Or Graduate School | | -0.03 | | |
| | 0.2654 | 7-<br>0.0113 | 0.009 | |
| Educational Attainment - Less Than 12th Grade, No Diploma | | -0.029 | -0.083 | |
| | 0.2574 | 1 | 2 0.0249 | |
| Educational Attainment - High School Graduate (Includes Equivalency) | | | | |
| | 0.2615 | 0.0449 | -0.139<br>0.1233 | |
| Educational Attainment - Associate's Degree - 0.084 | | | | |
| | 0.2637 | 0.0575 | 1 | 0.0786 |
| Educational Attainment - University Degree Or Above | | -0.04 | | -0.045 |
| | 0.2681 | 9 | 0.07 | 7 |
| Veteran Status - Civilian Population 18 Years And Over | | -0.007 | -0.026 | |
| | 0.2733 | 1 | 5 | 0.0239 |
| Residence 1 Year Ago - Same House | 0.273 | -0.012 | -0.016 | 0.0199 |
| Residence 1 Year Ago - Different House In The U.S. | | -0.045 | | |
| | | 0.2662 | 7 8 | 0.0119 |
| World Region Of Birth Of Foreign Born - Europe | | | -0.086 | -0.061 |
| | | 0.2525 | 6 0.0558 | 7 |
| World Region Of Birth Of Foreign Born - Asia | | | -0.199 | -0.29 |
| | | 0.2102 | 1 0.3866 | 4 |
| World Region Of Birth Of Foreign Born -Latin America | | | | -0.288 |
| | | 0.2009 | -0.211<br>0.4112 | 4 |
| | | | -0.083 | |

| | | | | |
|---|---|---|---|---|
| Language Spoken At Home - English Only | 0.27 | 0.022 | | 2<br>0.0676 |
| | | | -0.267 | |
| Heroin | 0.2179 | 0.2039 | | 5<br>0.1243 |
| | | | -0.291 | -0.035 |
| synthetic opioid | 0.1131 | 0.3928 | 2 | 8 |
| Heroin ratio | 0.0623 | 0.4353 | 0.2127 | 0.3481 |
| synthetic opioid ratio | 0.0096 | 0.5282 | 0.1683 | -0.309<br>3 |

## Appendix 3

Matlab program for gray correlation analysis a= vv%vv is the 460*9 matrix of opioid use, usage trends and population data of all aspects for i=[1:8] % standardization of benefit indicators a(i,:)=(a(i,:)-min(a(i,:)))/(max(a(i,:))-min(a(i,:)))); end [m, n]=size(a); can kao=max(a')' % find the value of the reference sequence t=repmat (can kao,[1,n])-a; % find the difference between the reference sequence and each sequence m min=min(min(t)); % calculates the minimum difference m max=max(max(t)); % calculates the maximum difference rho=0.5; % resolution coefficient xishu=(m min+rho*m max)./(t+rho*m max) % Calculate the grey correlation coefficient guanliandu=mean(x ishu) % take equal weight and calculate relevance [gsort, ind]=sort(guanliandu, 'descend') % sorts the relevance by big to small.

## Appendix 4

**Preliminary screening of the second question variable**

For ease of explanation, the variables in Table A are replaced with the 2010 code in the second question data, and the last four columns in the first column are the variables of the first question.

| variable | Abbreviation County code year | |
|---|---|---|
| HC01_VC75 | School Enrollment | 1 |
| HC01_VC78 | Primary school enrollment rate | 2 |
| HC01_VC79 | High school enrollment rate | 3 |
| HC01_VC80 | ³University enrollment rate | 4 |
| HC01_VC84 | Educational Attainment | 5 |
| HC01_VC85 | | |
| HC01_VC86 | Education (<Grade 12) | 6 |
| HC01_VC87 | Education (high school graduates) | 7 |
| HC01_VC89 | Education (University but no degree) | 8 |
| HC01_VC88 | | |
| HC01_VC90 | Education (³University) | 9 |
| HC01_VC91 | | |
| HC01_VC98 | Veterans (³18 years old) | 10 |
| HC01_VC117 | RESIDENCE 1 year ago | 11 |
| HC01_VC118 | residence 1 year-same house | 12 |
| HC01_VC119 | residence 1 year-diffierent house | 13 |
| HC01_VC156 | World birthplace | 14 |
| HC01_VC157 | European born population | 15 |
| HC01_VC158 | Asian born population | 16 |
| HC01_VC161 | Latin American birth population | 17 |
| HC01_VC167 | Language - English only | 18 |
| Heroin | Number of cases in Heroin | 19 |
| synthetic opioid | Number of synthetic opioid cases | 20 |

| | | |
|---|---|---|
| Heroin ratio | Proportion (% of heroin cases) | 21 |
| synthetic opioid ratio | Proportion (% of synthetic opioid cases) | 22 |

**Appendix 5**

Matlab results of grey correlation analysis（part)

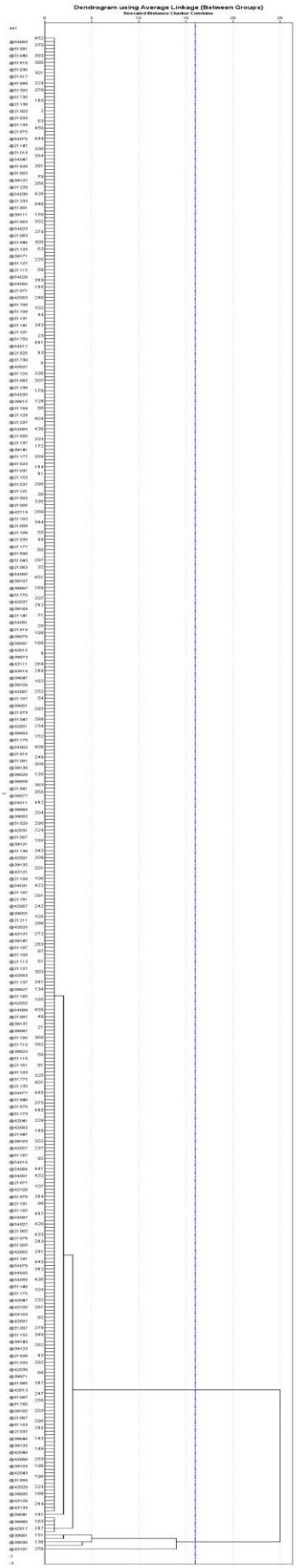
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **xishu =** | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1 | | | | | | | |
| 0.9598 | 0.9594 | 0.9759 | 0.9598 | 0.9692 | 0.9884 | 0.9919 | 0.9599 |
| 1 | | | | | | | |
| 0.9188 | 0.9187 | 0.9521 | 0.9194 | 0.9371 | 0.9778 | 0.9866 | 0.9197 |
| 1 | | | | | | | |
| 0.927 | 0.9269 | 0.955 | 0.9279 | 0.9458 | 0.9762 | 0.9857 | 0.9279 |
| 1 | | | | | | | |
| 0.7711 | 0.7693 | 0.8557 | 0.7711 | 0.8147 | 0.9304 | 0.9521 | 0.7796 |
| 1 | | | | | | | |
| 0.9261 | 0.9259 | 0.9542 | 0.9267 | 0.9429 | 0.9794 | 0.9857 | 0.9263 |
| 1 | | | | | | | |
| 0.8202 | 0.82 | 0.8839 | 0.8219 | 0.8626 | 0.9411 | 0.9602 | 0.823 |
| 1 | | | | | | | |
| 0.9447 | 0.9445 | 0.9681 | 0.9453 | 0.9569 | 0.9842 | 0.9889 | 0.9453 |
| 1 | | | | | | | |
| 0.7178 | 0.717 | 0.8112 | 0.7192 | 0.776 | 0.9022 | 0.9331 | 0.7233 |
| 1 | | | | | | | |
| 0.6414 | 0.6409 | 0.7608 | 0.6441 | 0.7116 | 0.8617 | 0.9083 | 0.6497 |
| 1 | | | | | | | |
| 0.9464 | 0.9462 | 0.9648 | 0.9469 | 0.9588 | 0.9857 | 0.9905 | 0.947 |
| 1 | | | | | | | |
| 0.7673 | 0.7666 | 0.8546 | 0.7684 | 0.8137 | 0.928 | 0.9527 | 0.772 |
| 1 | | | | | | | |
| 0.922 | 0.9215 | 0.951 | 0.9227 | 0.9385 | 0.9789 | 0.9864 | 0.9226 |
| 1 | | | | | | | |
| 0.8142 | 0.8139 | 0.8794 | 0.8156 | 0.8558 | 0.9415 | 0.958 | 0.8184 |
| 1 | | | | | | | |

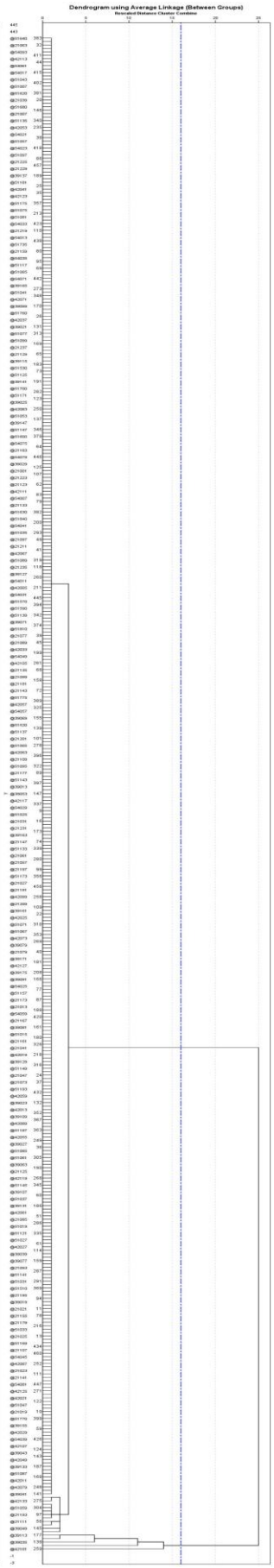
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.9705 | 0.9705 | 0.9826 | 0.9709 | 0.9768 | 0.9924 | 0.9947 | 0.9706 |
| 1 | | | | | | | |
| 0.9501 | 0.9501 | 0.9706 | 0.9508 | 0.9624 | 0.985 | 0.9895 | 0.9506 |
| 1 | | | | | | | |
| 0.8815 | 0.8813 | 0.9276 | 0.8826 | 0.9088 | 0.9653 | 0.9757 | 0.8832 |
| 1 | | | | | | | |
| 0.9816 | 0.9815 | 0.9895 | 0.9817 | 0.9852 | 0.9956 | 0.9969 | 0.9816 |
| 1 | | | | | | | |
| 0.5937 | 0.5922 | 0.7236 | 0.5955 | 0.668 | 0.8408 | 0.8914 | 0.6035 |
| 1 | | | | | | | |
| 0.9809 | 0.9809 | 0.9889 | 0.9811 | 0.9849 | 0.9949 | 0.9965 | 0.981 |
| 1 | | | | | | | |
| 0.9565 | 0.9564 | 0.9726 | 0.9568 | 0.9673 | 0.9873 | 0.9908 | 0.9566 |
| 1 | | | | | | | |
| 0.9 | 0.8999 | 0.9397 | 0.9012 | 0.9237 | 0.9697 | 0.98 | 0.9011 |
| 1 | | | | | | | |
| 0.9815 | 0.9815 | 0.988 | 0.9816 | 0.985 | 0.9959 | 0.9973 | 0.9816 |
| 1 | | | | | | | |
| 0.9489 | 0.9488 | 0.9708 | 0.949 | 0.9592 | 0.9878 | 0.9915 | 0.9492 |
| 1 | | | | | | | |
| 0.9759 | 0.9759 | 0.9861 | 0.9763 | 0.9816 | 0.9934 | 0.9953 | 0.9763 |
| 1 | | | | | | | |
| 0.9557 | 0.9556 | 0.9729 | 0.956 | 0.9663 | 0.987 | 0.991 | 0.9558 |
| 1 | | | | | | | |
| 0.9312 | 0.9311 | 0.9546 | 0.9319 | 0.9472 | 0.9801 | 0.9869 | 0.9318 |
| 1 | | | | | | | |
| 0.9647 | 0.9646 | 0.9788 | 0.9651 | 0.9729 | 0.9899 | 0.9929 | 0.9648 |
| 1 | | | | | | | |
| 0.8251 | 0.8247 | 0.8868 | 0.8262 | 0.8715 | 0.9346 | 0.968 | 0.8308 |
| 1 | | | | | | | |
| 0.9488 | 0.9487 | 0.969 | 0.9492 | 0.961 | 0.9857 | 0.99 | 0.9493 |
| 1 | | | | | | | |
| 0.9581 | 0.9581 | 0.9749 | 0.9586 | 0.9693 | 0.9874 | 0.9912 | 0.9584 |
| 1 | | | | | | | |
| 0.8638 | 0.8634 | 0.9156 | 0.8648 | 0.8927 | 0.9605 | 0.9736 | 0.8653 |
| 1 | | | | | | | |
| 0.909 | 0.9087 | 0.9421 | 0.9097 | 0.9291 | 0.9749 | 0.983 | 0.9095 |
| 1 | | | | | | | |
| 0.9282 | 0.9279 | 0.9568 | 0.9287 | 0.945 | 0.9794 | 0.9858 | 0.929 |
| 1 | | | | | | | |
| 0.909 | 0.9085 | 0.9437 | 0.9095 | 0.9303 | 0.9732 | 0.9827 | 0.9094 |
| 1 | | | | | | | |
| 0.9324 | 0.9322 | 0.9585 | 0.9329 | 0.9501 | 0.9787 | 0.9869 | 0.9331 |
| 1 | | | | | | | |
| 0.941 | 0.9407 | 0.9637 | 0.9417 | 0.9557 | 0.9818 | 0.9871 | 0.9417 |
| 1 | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.6731 | 0.6724 | 0.7818 | 0.675 | 0.7349 | 0.8844 | 0.9218 | 0.6772 |
| 1 | | | | | | | |
| 0.5875 | 0.5872 | 0.7156 | 0.59 | 0.6589 | 0.8429 | 0.8934 | 0.5999 |
| 1 | | | | | | | |
| 0.7895 | 0.7889 | 0.8707 | 0.7909 | 0.8274 | 0.9367 | 0.9571 | 0.7914 |
| 1 | | | | | | | |
| 0.8931 | 0.893 | 0.9348 | 0.8943 | 0.9163 | 0.9694 | 0.9789 | 0.8947 |
| 1 | | | | | | | |
| 0.9349 | 0.9348 | 0.958 | 0.9356 | 0.9522 | 0.98 | 0.9858 | 0.9369 |
| 1 | | | | | | | |
| 0.9643 | 0.9643 | 0.9791 | 0.9647 | 0.9731 | 0.9899 | 0.993 | 0.9646 |
| 1 | | | | | | | |
| 0.9833 | 0.9832 | 0.9898 | 0.9835 | 0.987 | 0.9954 | 0.9969 | 0.9832 |
| 1 | | | | | | | |
| 0.7769 | 0.7765 | 0.8487 | 0.7786 | 0.8291 | 0.9225 | 0.9423 | 0.7879 |
| 1 | | | | | | | |
| 0.6008 | 0.6006 | 0.7103 | 0.6034 | 0.6767 | 0.8403 | 0.888 | 0.625 |
| 1 | | | | | | | |
| 0.9515 | 0.9515 | 0.9717 | 0.9521 | 0.9638 | 0.9852 | 0.9925 | 0.952 |
| 1 | | | | | | | |
| 0.9037 | 0.9036 | 0.9403 | 0.9043 | 0.9207 | 0.9757 | 0.9844 | 0.9064 |
| 1 | | | | | | | |
| 0.951 | 0.951 | 0.9696 | 0.9516 | 0.9638 | 0.9832 | 0.9918 | 0.9516 |
| 1 | | | | | | | |
| 0.9194 | 0.9193 | 0.9511 | 0.92 | 0.9409 | 0.9732 | 0.9878 | 0.9211 |
| 1 | | | | | | | |
| 0.8984 | 0.8982 | 0.9383 | 0.8994 | 0.9201 | 0.9702 | 0.9811 | 0.8994 |
| 1 | | | | | | | |
| 0.7589 | 0.7589 | 0.844 | 0.761 | 0.8079 | 0.9223 | 0.9516 | 0.7704 |
| 1 | | | | | | | |
| 0.7407 | 0.7401 | 0.8338 | 0.7429 | 0.7901 | 0.9153 | 0.9422 | 0.7552 |
| 1 | | | | | | | |
| 0.5795 | 0.5787 | 0.6909 | 0.582 | 0.6576 | 0.8283 | 0.887 | 0.6051 |
| 1 | | | | | | | |
| 0.9609 | 0.9608 | 0.9781 | 0.9612 | 0.9687 | 0.9907 | 0.9937 | 0.9612 |
| 1 | | | | | | | |
| 0.7342 | 0.734 | 0.8259 | 0.7363 | 0.7899 | 0.906 | 0.9411 | 0.7435 |
| 1 | | | | | | | |
| 0.8509 | 0.8506 | 0.9076 | 0.852 | 0.8766 | 0.9603 | 0.9737 | 0.8518 |
| 1 | | | | | | | |
| 0.9898 | 0.9898 | 0.9923 | 0.9898 | 0.9905 | 0.9987 | 0.9997 | 0.9901 |
| 1 | | | | | | | |
| 0.8351 | 0.8349 | 0.8961 | 0.8364 | 0.8674 | 0.9504 | 0.9655 | 0.8397 |
| 1 | | | | | | | |
| 0.9813 | 0.9813 | 0.9893 | 0.9814 | 0.9852 | 0.9953 | 0.9967 | 0.9814 |
| 1 | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.9531 | 0.953 | 0.9714 | 0.9537 | 0.9628 | 0.9877 | 0.9927 | 0.9534 |
| 1 | | | | | | | |
| 0.9434 | 0.9433 | 0.9646 | 0.944 | 0.9551 | 0.9852 | 0.9911 | 0.9439 |
| 1 | | | | | | | |
| 0.8972 | 0.8971 | 0.9365 | 0.898 | 0.9249 | 0.964 | 0.9839 | 0.8987 |
| 1 | | | | | | | |
| 0.9452 | 0.9452 | 0.9684 | 0.946 | 0.956 | 0.9857 | 0.9905 | 0.9455 |
| 1 | | | | | | | |
| 0.9687 | 0.9687 | 0.9809 | 0.9691 | 0.9748 | 0.9918 | 0.9942 | 0.9694 |
| 1 | | | | | | | |
| 0.783 | 0.7825 | 0.8616 | 0.784 | 0.8266 | 0.9331 | 0.958 | 0.7918 |
| 1 | | | | | | | |
| 0.5937 | 0.5933 | 0.7066 | 0.5971 | 0.6607 | 0.8353 | 0.8862 | 0.6054 |
| 1 | | | | | | | |
| 0.8964 | 0.8963 | 0.9384 | 0.8974 | 0.9174 | 0.972 | 0.9818 | 0.8976 |
| 1 | | | | | | | |
| 0.8501 | 0.8497 | 0.905 | 0.8514 | 0.8807 | 0.9543 | 0.969 | 0.8549 |
| 1 | | | | | | | |
| 0.6828 | 0.6827 | 0.7823 | 0.6856 | 0.7434 | 0.8859 | 0.9227 | 0.708 |
| 1 | | | | | | | |
| 0.9784 | 0.9784 | 0.9874 | 0.9787 | 0.9828 | 0.9949 | 0.9966 | 0.9786 |
| 1 | | | | | | | |
| 0.991 | 0.991 | 0.9949 | 0.9911 | 0.9925 | 0.998 | 0.9987 | 0.991 |
| 1 | | | | | | | |
| 0.9884 | 0.9884 | 0.9931 | 0.9885 | 0.9907 | 0.9973 | 0.9982 | 0.9884 |
| 1 | | | | | | | |
| 0.969 | 0.969 | 0.9809 | 0.9693 | 0.9763 | 0.991 | 0.9949 | 0.9692 |
| 1 | | | | | | | |
| 0.949 | 0.949 | 0.9698 | 0.9494 | 0.9605 | 0.9866 | 0.9908 | 0.9493 |
| 1 | | | | | | | |
| 0.9887 | 0.9887 | 0.994 | 0.9888 | 0.9907 | 0.9974 | 0.9982 | 0.9887 |
| 1 | | | | | | | |
| 0.9795 | 0.9795 | 0.9878 | 0.9798 | 0.9835 | 0.9949 | 0.9966 | 0.9796 |
| 1 | | | | | | | |
| 0.9925 | 0.9925 | 0.9958 | 0.9925 | 0.994 | 0.9981 | 0.9987 | 0.9925 |
| 1 | | | | | | | |
| 0.8994 | 0.8992 | 0.9415 | 0.9005 | 0.9209 | 0.973 | 0.9818 | 0.9002 |
| 1 | | | | | | | |
| 0.9715 | 0.9715 | 0.9836 | 0.9718 | 0.9773 | 0.9928 | 0.9951 | 0.9716 |
| 1 | | | | | | | |
| guanliandu = | 0.9219 | 0.9218 | 0.949 | | NaN | 0.9383 | 0.9737 |
| 0.9825 | 0.9249 | 1 | | | | | |
| gsort = | NaN | 1 | 0.9825 | | 0.9737 | 0.949 | 0.9383 |
| 0.9249 | 0.9219 | 0.9218 | | | | | |
| ind =4 9 | 7 | 6 | 3 | 5 | 8 | 1 | 2 |

**Appendix 6**
System clustering results
Heroin clustering map& Synthetic opioid clustering map


Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine


Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine