Handling High Dimensional Variables

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Discussion Topic

- The problem
- Techniques for handling high dimensions
- Comparisons of different techniques
- Conclusions

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The Problem

- High dimensional variables: variable with many units or levels
- Examples
  - ZIP code
  - Vehicle classification
  - Workers compensation classes
- Complication
  - Credibility at individual levels
  - Determining proper groupings

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Complications of High Dimensional Variables

- Credibility at individual levels
  - Models convergence errors
  - Results that do not make sense
- Examples
  - Thousands of ZIP codes
  - Thousands of model year/make/model/series combinations

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Techniques for Handling High Dimensional Variables

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Techniques for Handling High Dimensional Variables

- Groupings
  - Simple
  - May not be immediately obvious
  - May not be practical
- Curve fits
  - Great for continuous variables
- **Clustering using target variable** *
- **Clustering/Segmentation analysis based on inputs**
- **Use characteristics of variable level is model**
- **Principal Components**

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Clustering Using Target Variable

- Combine levels of high dimensional variable by similarity in target variable
- For levels without credible experience, combine with credibility complement
  - Proximity - ZIP
  - Similar type – Make/model
  - NCCI loss costs – Worker's Compensation Class
- Put cluster back into predictive model

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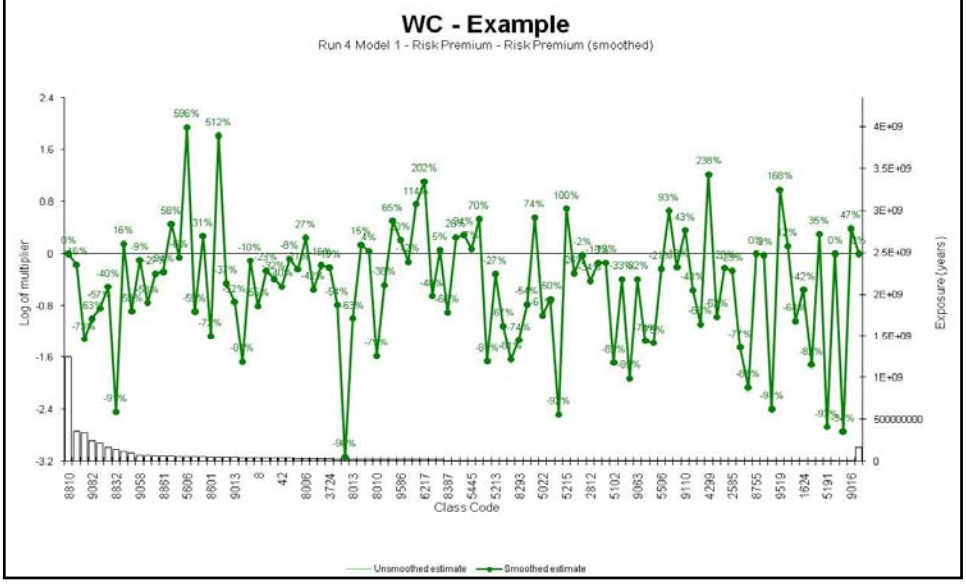
Worker's Compensation Class



WC Class Analysis

NCCI Class Code	Class Description	Revised Company Exposure ($00)	2004 NCCI Loss Cost	Proposed Loss Cost	Change from Current
7228	Trucking: Local Hauling Only	66,891	9.81	6.68	-32%
7380	Commercial Drivers	95,217	5.48	7.39	35%
7382	Bus Company	12,658	5.41	6.04	12%
8006	Gasoline Station	52,068	3.78	5.39	42%
8385	Bus Company	10,496	3.47	4.32	25%
8387	Service Stations	32,628	3.20	1.83	-43%
8391	Automobile Body Repair Shop	118,611	4.01	2.64	-34%
8393	Automobile Body Repair	33,165	2.99	0.98	-67%
8748	Automobile Salespersons	96,971	1.75	2.36	35%
42	Landscape Gardening & Drivers	70,943	8.45	4.46	-47%
5190	Electrical Wiring - Within Buildings	206,541	3.60	2.51	-30%
5437	Carpentry - Interior	111,300	6.87	4.83	-30%
5474	Painting Or Paperhanging	113,721	6.65	4.36	-34%
5606	Contractor - Executive Supervisor	113,489	2.09	14.49	593%
9052	Hotel: All Other Employees	863,123	3.22	2.53	-21%
9058	Hotel: Restaurant Employees	167,039	2.15	2.34	9%
9082	Restaurant NOC	709,574	2.61	1.83	-30%
9083	Restaurant: Fast Food	139,396	2.45	3.36	37%
8017	Store: Retail NOC	280,356	2.40	2.74	14%
8033	Store: Meat, Grocery & Provision Stores	458,603	2.85	2.14	-25%
8601	Architect Or Engineer - Consulting	135,932	0.99	1.25	26%
8742	Salespersons, Collectors or Messengers	672,184	0.95	1.20	26%
8810	Clerical Office Employees NOC	2,628,543	0.55	0.74	34%
8820	Attorney - All Employees & Clerical	148,121	0.44	1.48	237%
8832	Physician & Clerical	342,051	0.63	0.39	-38%

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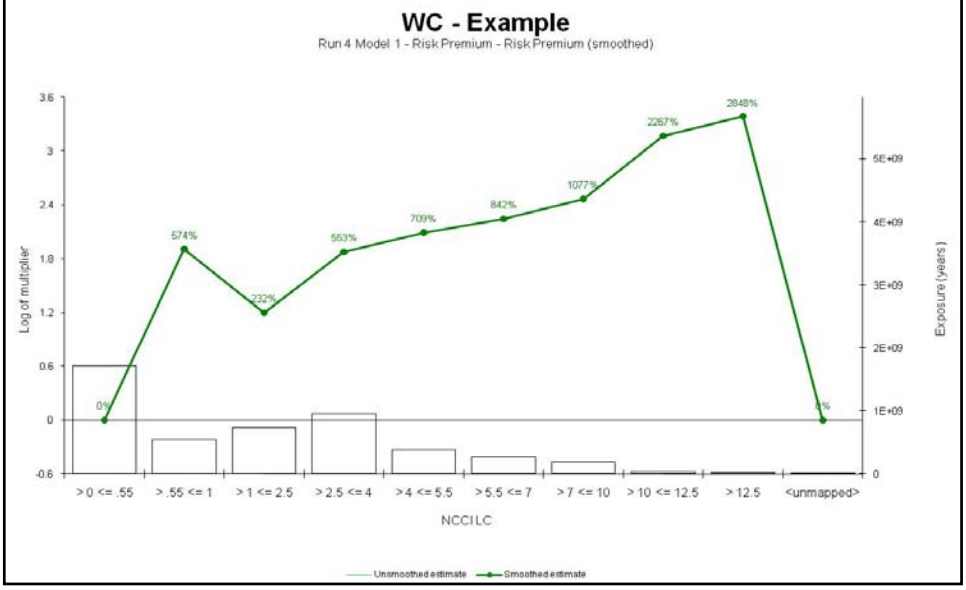
NCCI Loss Cost Indication



Clustering/Segmentation

- Unsupervised classification technique
- Groups data into set of discrete clusters or contiguous groups of cases
- Performs disjoint cluster analysis on the basis of Euclidean distances computed from one or more quantitative input variables and cluster seeds
- Objects in each cluster tend to be similar, objects in different clusters tend to be dissimilar
- Can be used as a dimension reduction technique

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Cluster/Segmentation Steps

- Begin with descriptive variables related to high dimensional variables
  - ZIP code: geo-demographic data
  - Make/Model: vehicle characteristics
- Levels of high dimensional variables with like descriptive variables will be in like clusters
- Assumes descriptive variables will be related to ultimate target (frequency, severity)

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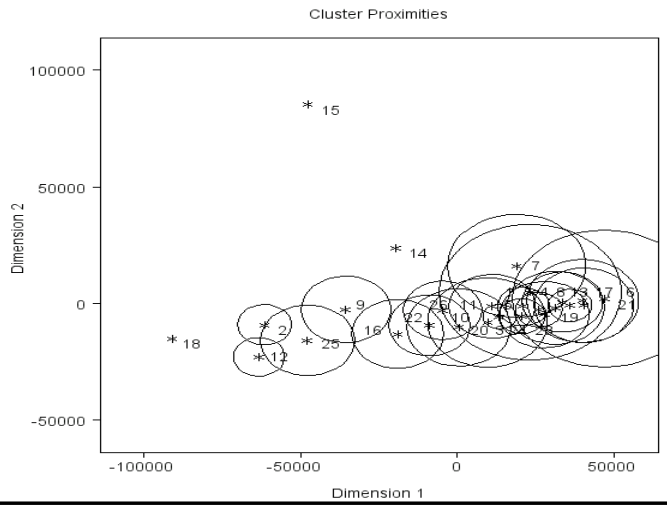
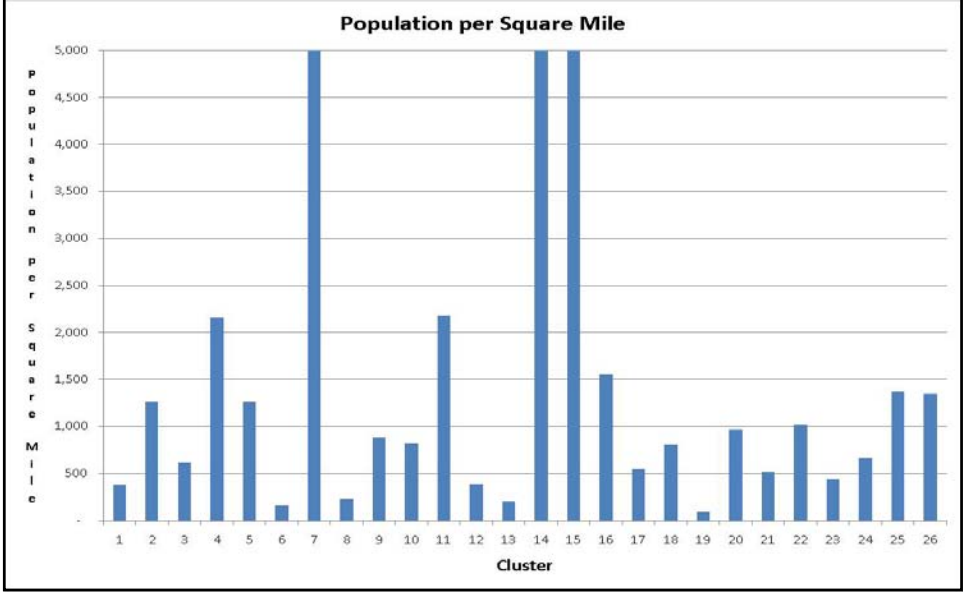
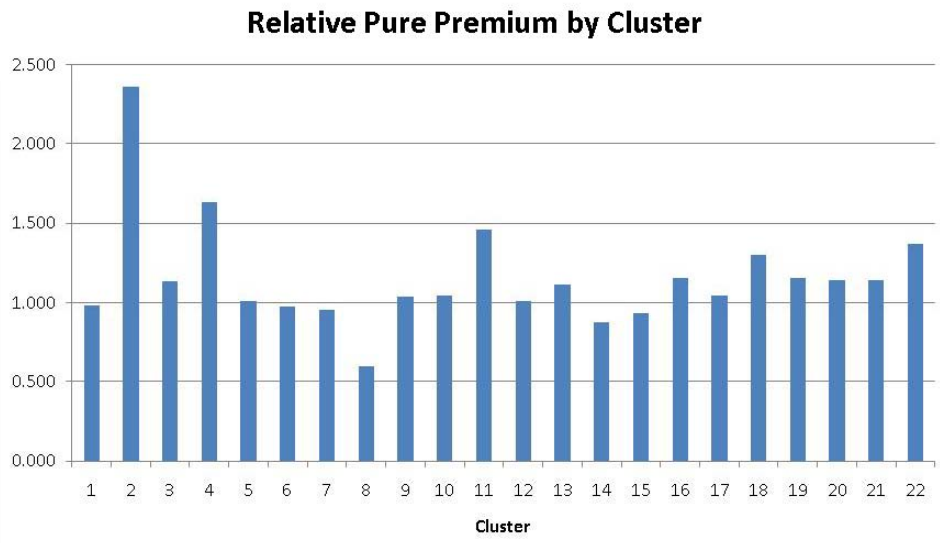
Cluster Proximity Map



Population per Square Mile by Cluster



Relative Pure Premium by Cluster



Use Variable Characteristics Directly

- Begin with descriptive variables related to high dimensional variables
  - ZIP code: geo-demographic data
  - Make/Model: vehicle characteristics
- Use descriptive variables in model development
- The resulting parameter estimates of descriptive variables can then be used in rating or can be grouped into new symbol/territory

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Vehicle Characteristic Data

- **Body**: style, number of doors, weight,
- **Engine**: cylinders, displacement,
- **Performance**: engine displacement, weight, performance, payload capacity
- **Additional**: ABS, anti-theft, base price, ESC
- **Crash test information**

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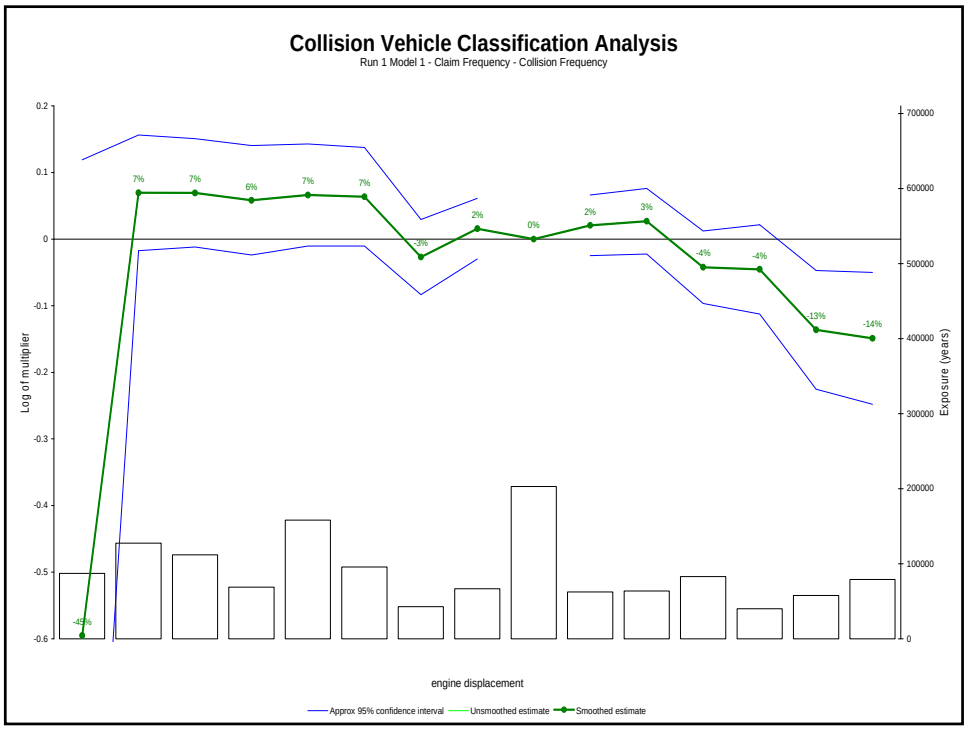
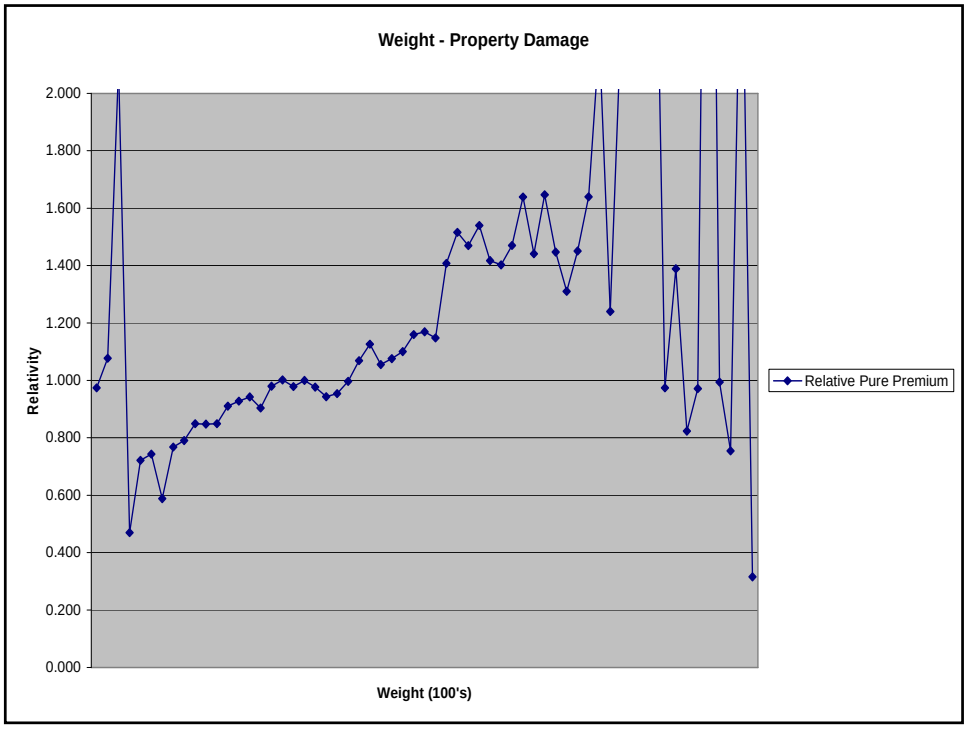
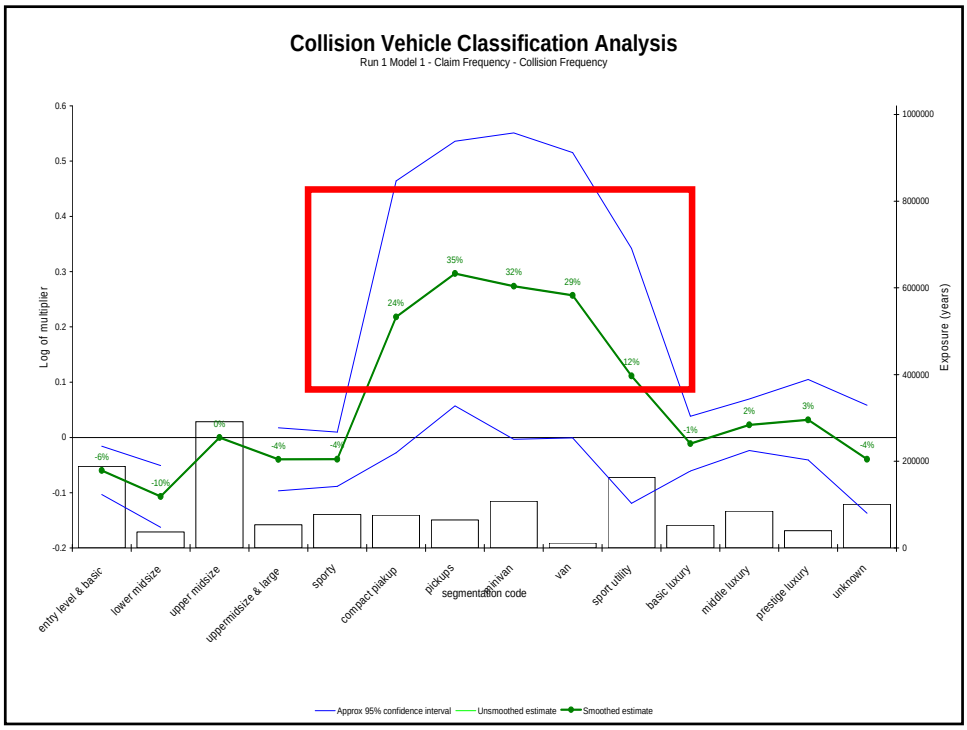



Weight - Property Damage
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Relativity
Weight (100's)
Relative Pure Premium


Collision Vehicle Classification Analysis
Run 1 Model 1 - Claim Frequency - Collision Frequency
Log of multiplier
Exposure (years)
segmentation code
entry level & basic
lower midsize
upper midsize
uppermidsize & large
sporty
compact pickup
pickups
minivan
van
sport utility
basic luxury
middle luxury
prestige luxury
unknown
-6%
-10%
0%
-4%
-4%
24%
35%
32%
29%
12%
-1%
2%
3%
-4%
Approx 95% confidence interval
Unsmoothed estimate
Smoothed estimate

Develop Vehicle Group

- Develop vehicle group
  - Calculate vehicle "relativity" for each risk
  - Group risks of similar loss potential
  - If desired, rename groups for ease of use
  - Append vehicle group to original database
  - Determine final relativities
- Implementation
  - Company specific symbols
  - Enhancement to current symbols
  - Series of additional rating factors

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Advantages of Using Vehicle Characteristics

- Competitive advantage
- Reflects a company's business
- More efficient use of vehicle data
- Removal of bias due to other characteristics
- Simplifies adjusting for prior years and introduction of new years
- Automatically handles new models
- Works for liability and physical damage

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Principal Components

- Mathematical transformation of input variables
- Calculated from the correlation matrix of the input variables
- Transforms a number of correlated variables into a smaller number of uncorrelated variables
- First component accounts for as much of variability as possible, second component accounts for as much of remaining variability as possible, etc.
- Can be used as a dimension reduction technique, creates a summarized version of the inputs to use in predictive models

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Principal Components

BL5

- First j principal components provide least squares solution to Y = XB + E
  - Y = n x p matrix of centered observed variables
  - X = n x j matrix of scores on first j principal components
  - B = j x p matrix of eigenvectors
- Eigenvectors are orthogonal
- Principal component scores are jointly uncorrelated

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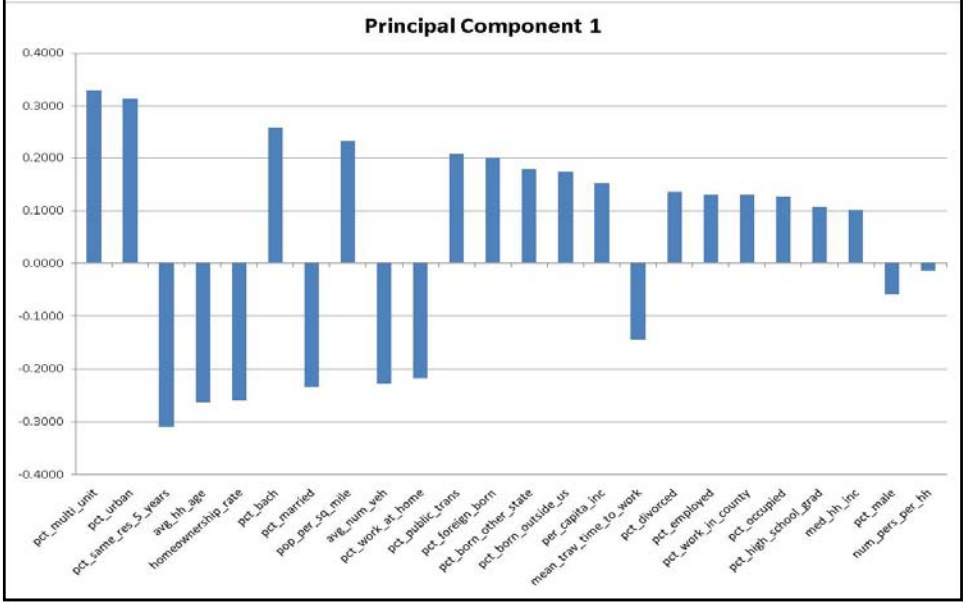
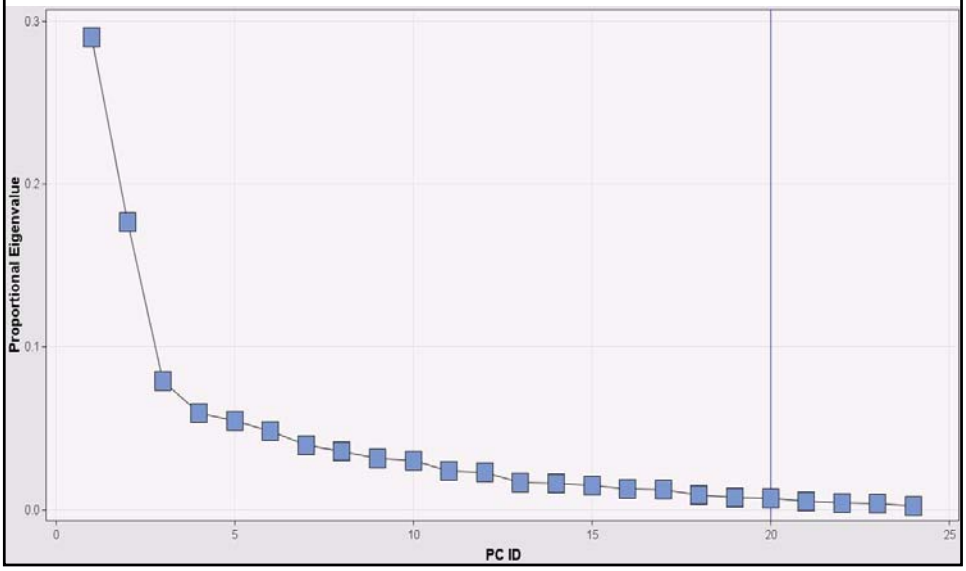
Boison, LeRoy, 3/12/2010

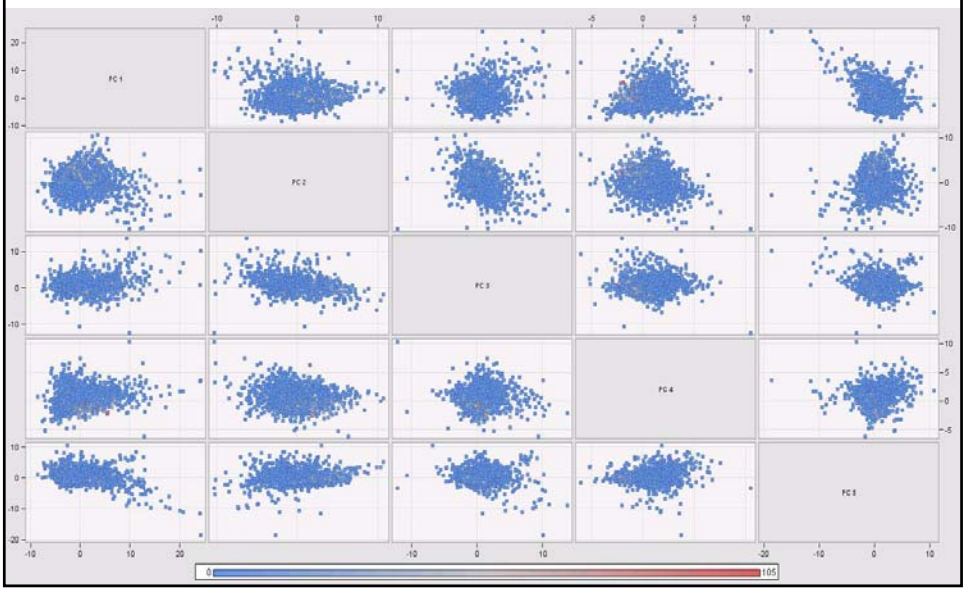
Principal Component 1 Eigenvectors



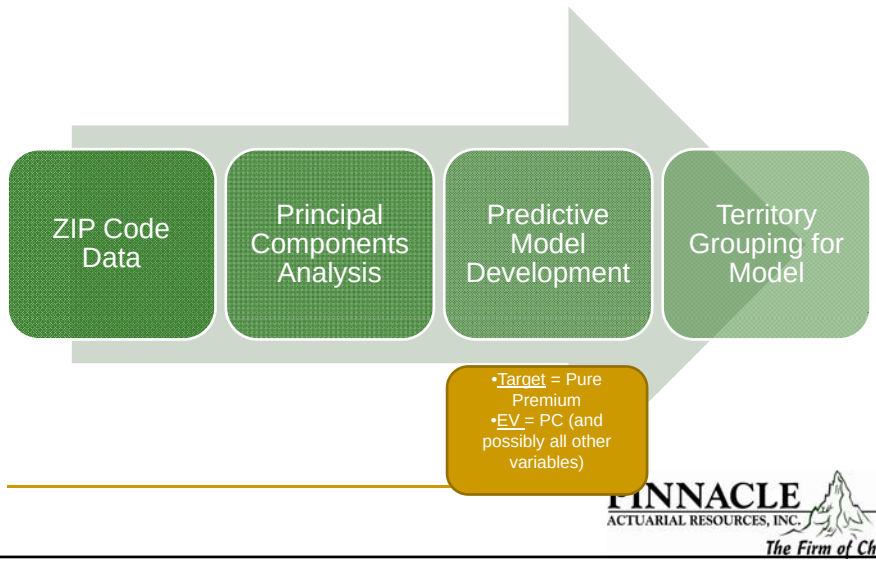
Correlation Matrix Proportional Eigenvalue Plot



Principal Components Matrix



Application of Principal Components



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Comparison of Results

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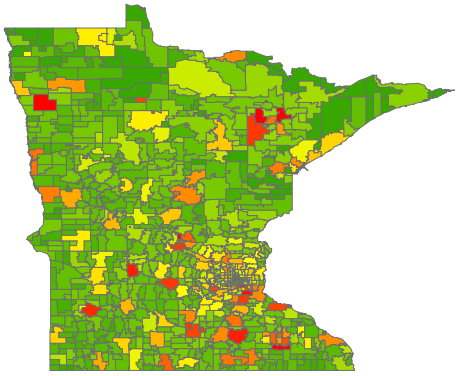
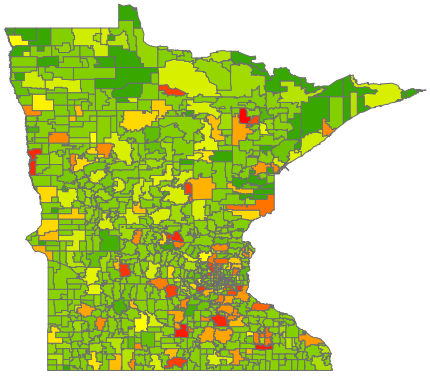
GLM



Principal Components



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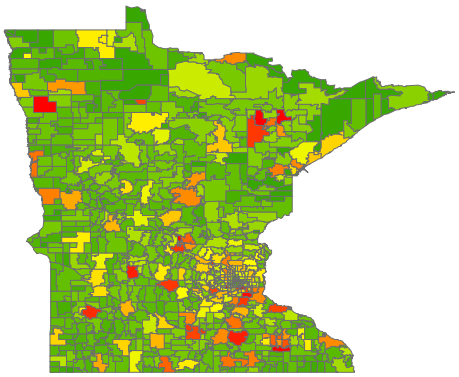
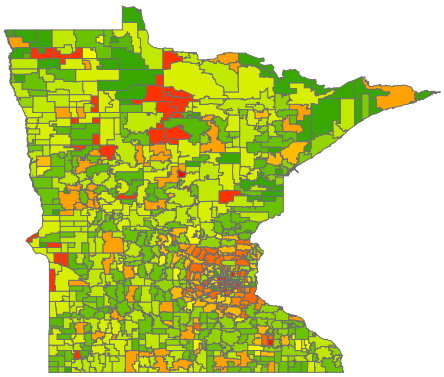
GLM

Clustering





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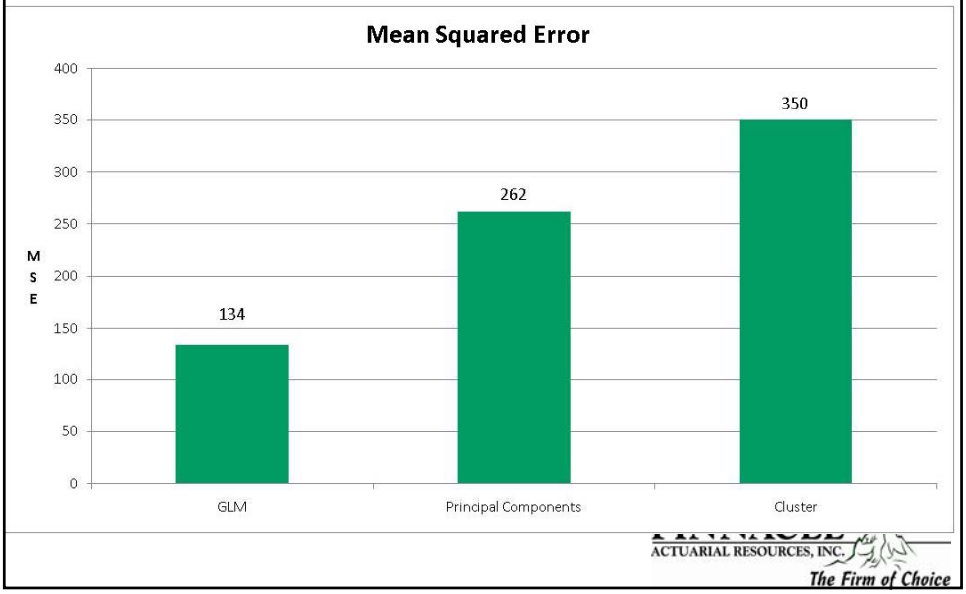
Mean Squared Error Comparison



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Conclusions

- Using input variable information directly is generally preferable when building predictive models
- There are many cases when this is not feasible
  - Unknown target
  - Input variable with too many levels
  - Too many input variables
- Techniques for handling high dimensional variables still result in models that produce predictive results

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