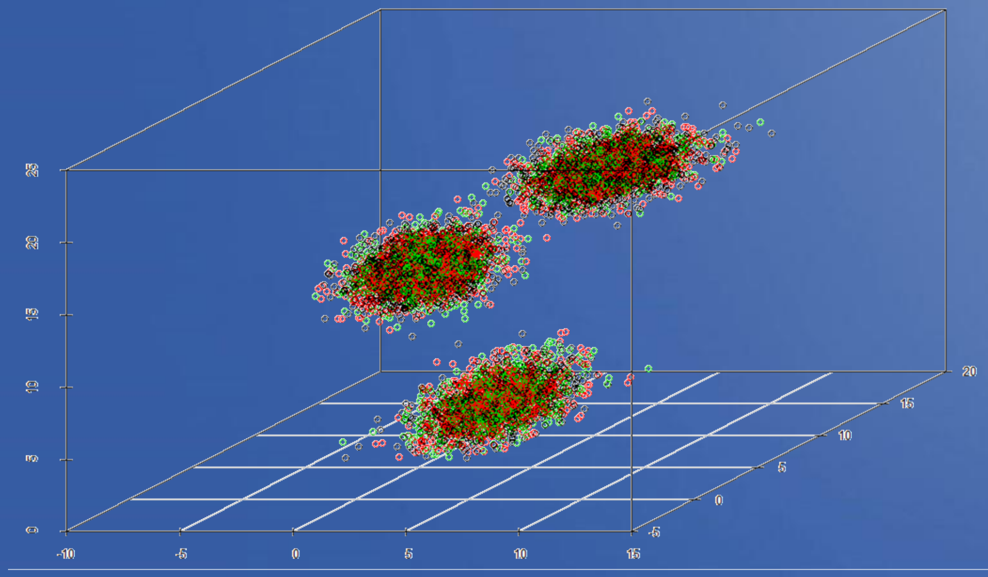
The Effect of Survey Measurement Error on Clustering Algorithms



ITSEW 2019
International Total Survey Error Workshop

Utrecht University

VU VRIJE UNIVERSITEIT AMSTERDAM

Paulina Pankowska and Dr Daniel Oberski

Presentation outline

- Background
  - ✓ Clustering algorithms: GMM and DBSCAN
  - ✓ (Survey) measurement error
  - ✓ Measurement error & clustering

- Our research
  - ✓ Testing the sensitivity of clustering results to measurement error- a simulation study

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Clustering / cluster analysis

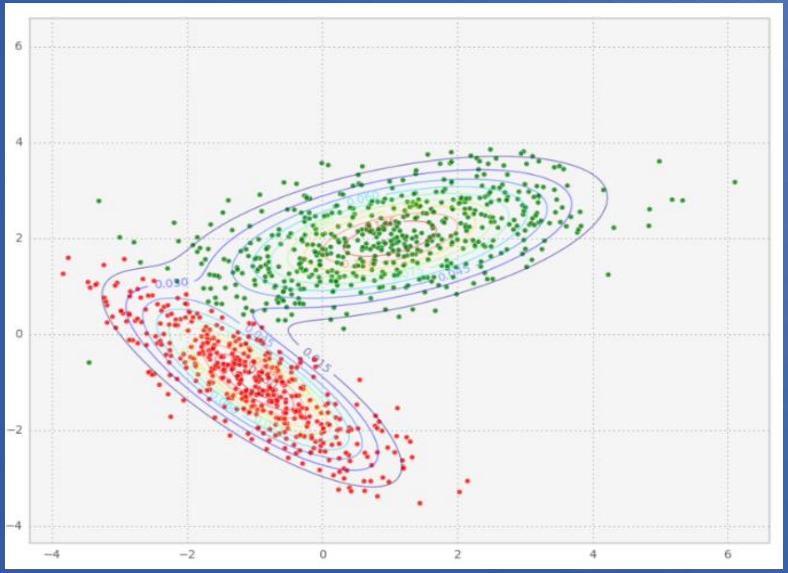
- A process classifying observations into groups (i.e. clusters) such that similar ones belong to the same group and dissimilar to different groups

- An unsupervised learning problem (unlabeled data/ no predefined classes)

- Has a wide range of applications (e.g. marketing, insurance and banking- fraud detection, adaptive survey designs)

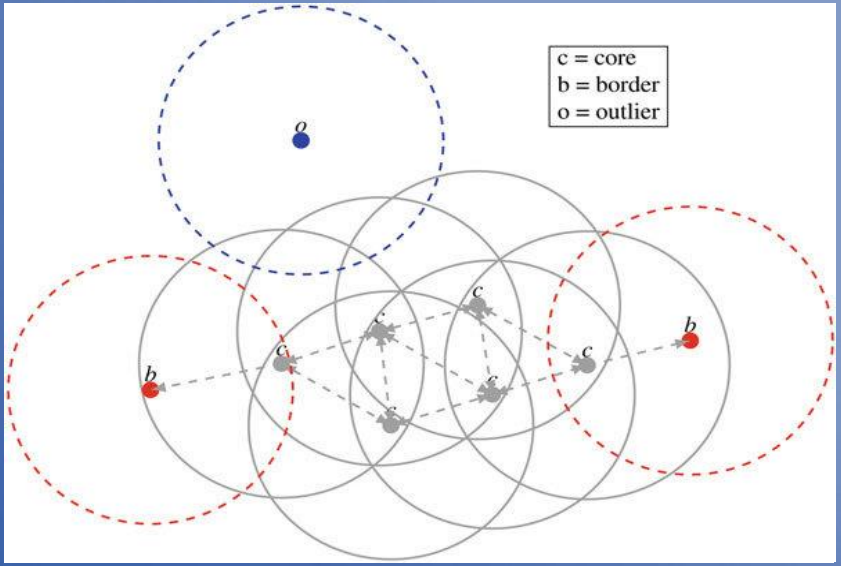
GMM and DBSCAN

Gaussian Mixture Models (GMM)



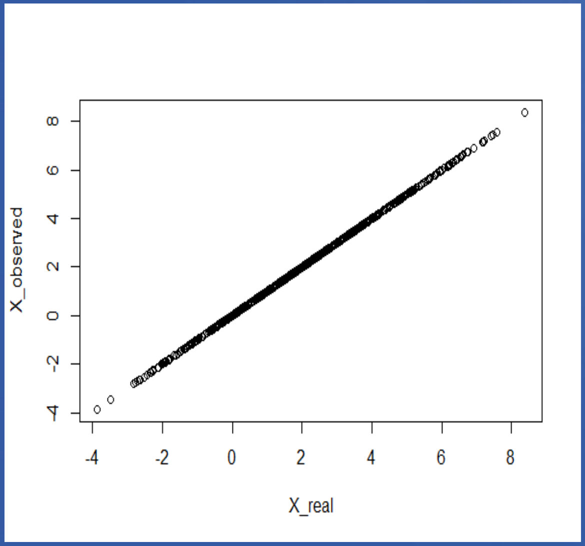
Source: http://www.nehalemlabs.net/prototype/blog/2014/04/03/quick-introduction-to-gaussian-mixture-models-with-python/

Density-based spatial clustering of applications with noise (DBSCAN)

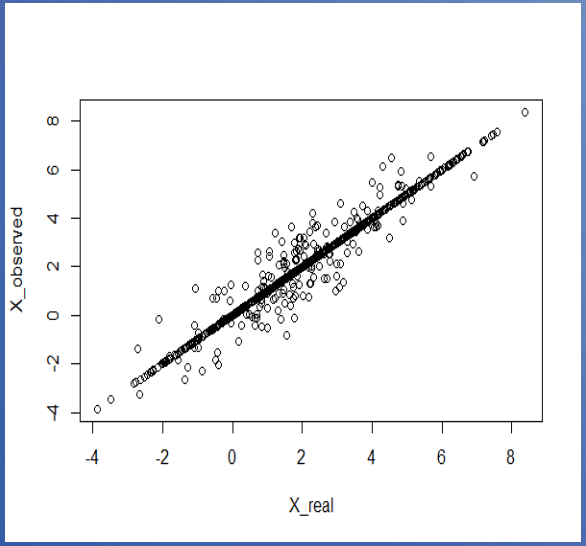


Source: Izzo et al. (2016)

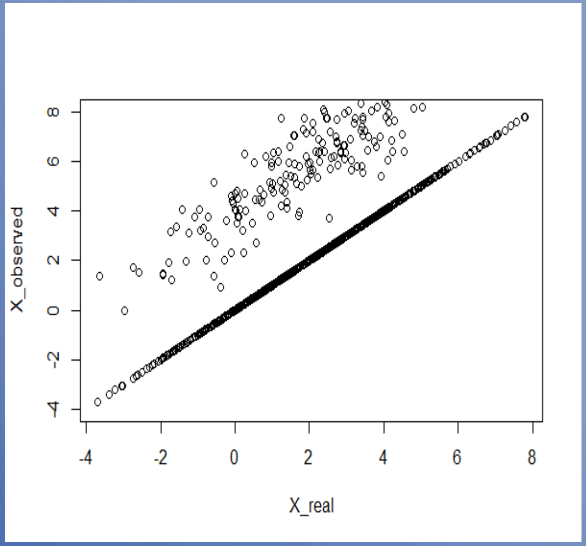
(Survey) measurement error



No measurement error



Random measurement error



Systematic measurement error

Our analysis- simulation setup

- Simulate a 3-dimensional dataset from a mixture of three multivariate Gaussian distributions (N = 1,000)

- Introduce measurement error based on 24 conditions:

Error type		Var's with error		Error rate		Magnitude
1. Random 2. Systematic	X	1. One 2. All (three)	X	1. 0.2 2. 0.4	X	1. Low 2. Medium 3. High

- Compare clustering results for 'original' data and datasets with error:

  ✓Number of clusters

  ✓Cluster similarity of (i) 'raw' clustering results and (ii) merged/ stable clusters (adjusted Rand index)

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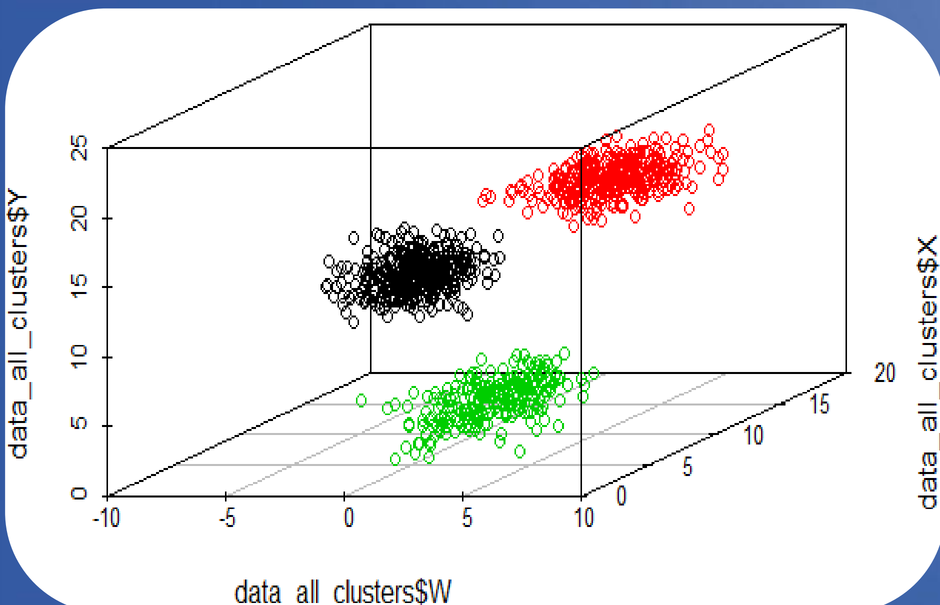
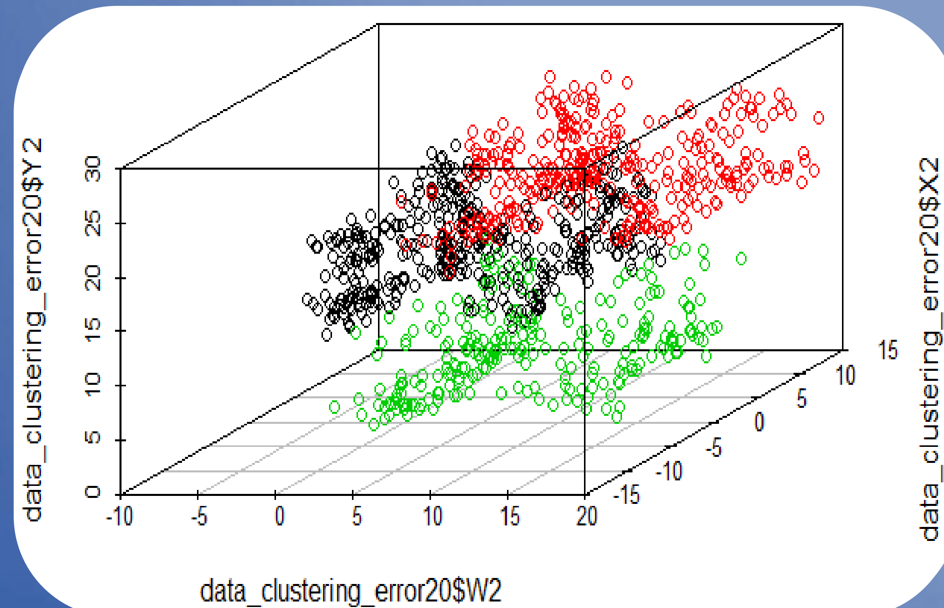
Our analysis- visualization of the data

Simulated dataset ('original data')



Dataset with systematic measurement error (3 var)



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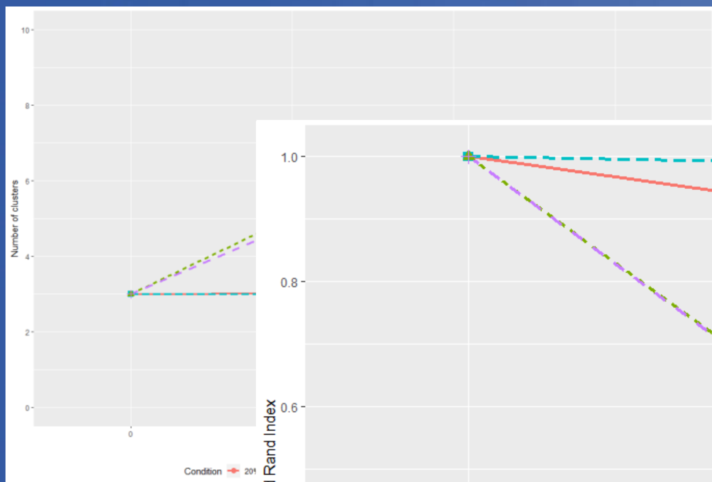
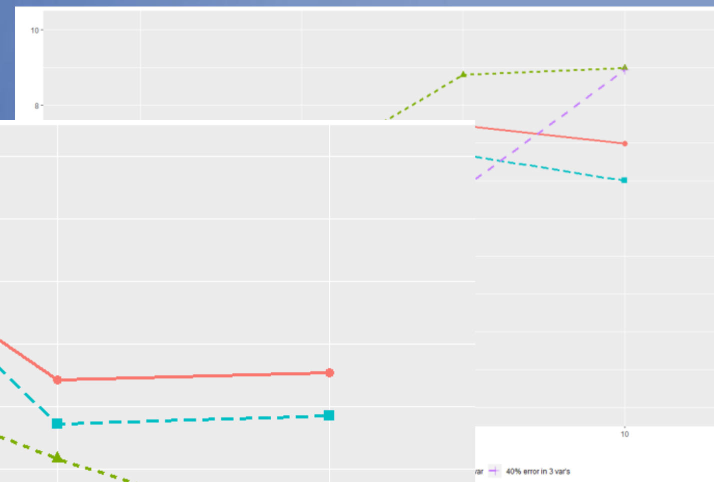
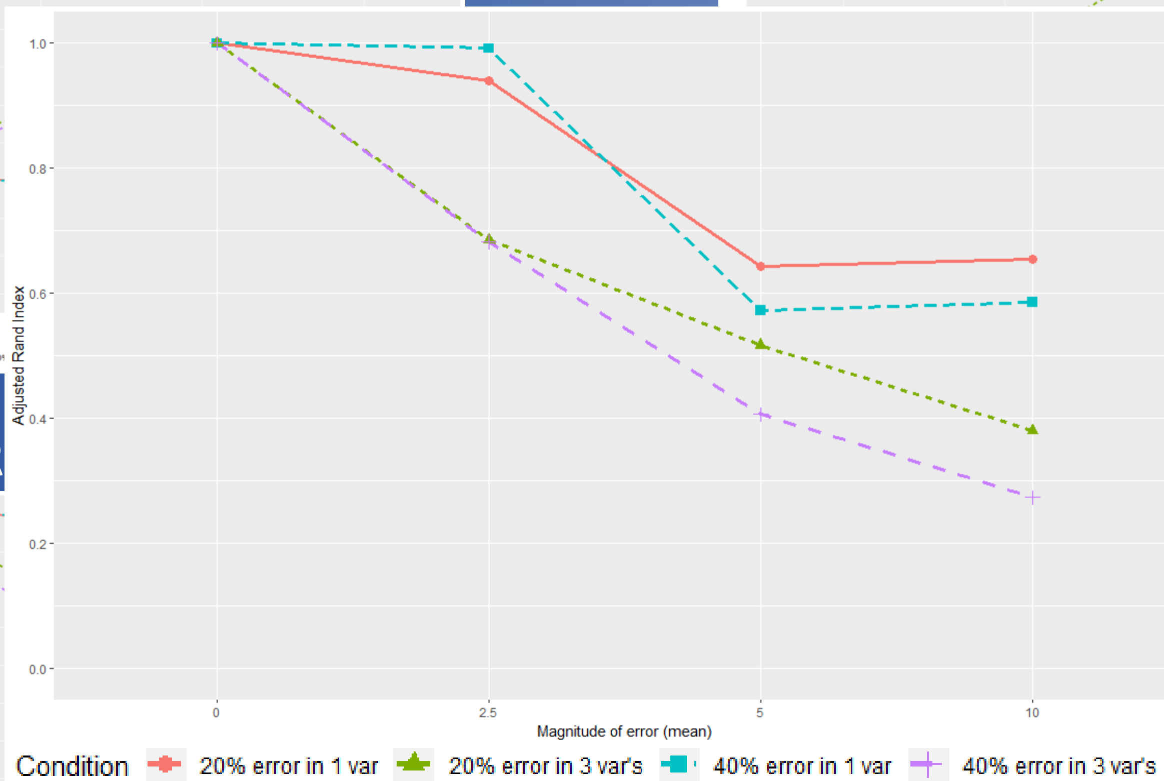
GMM Results: components

- Number of clusters







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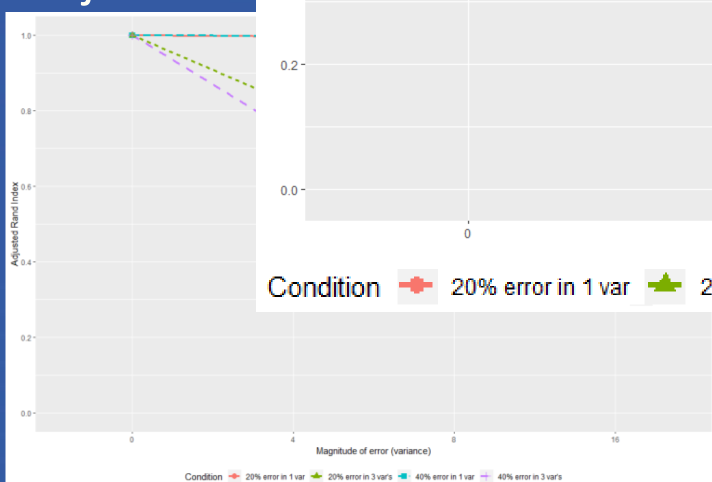
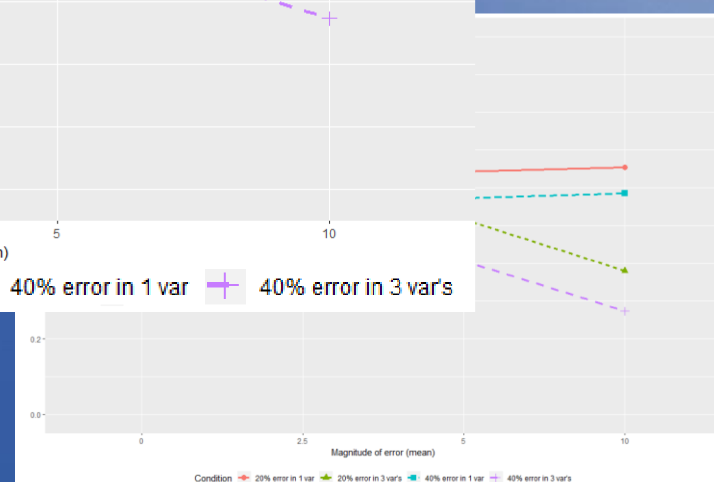
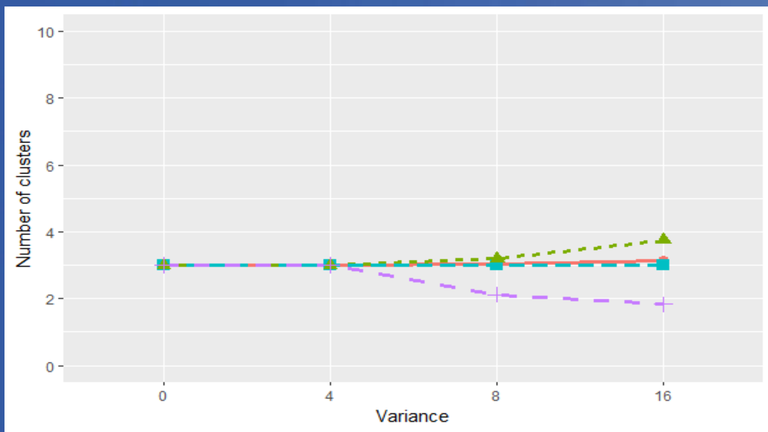
- Adjusted R



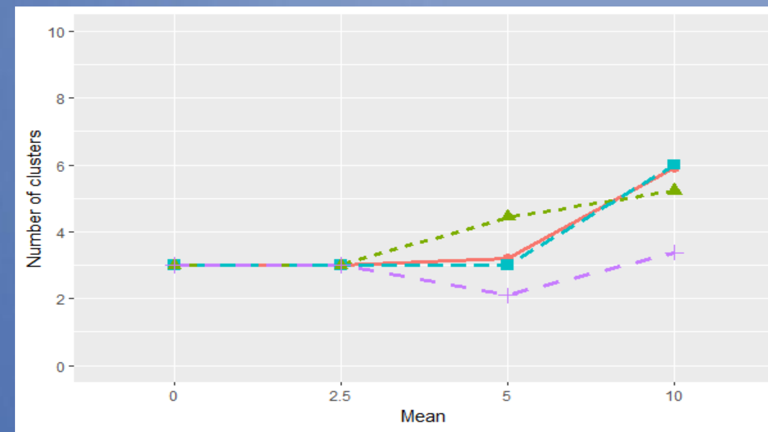


GMM Results: (merged) clusters

- Number of clusters

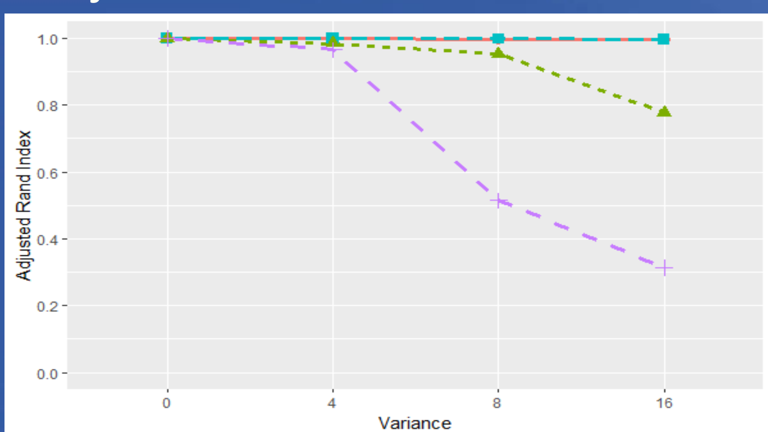


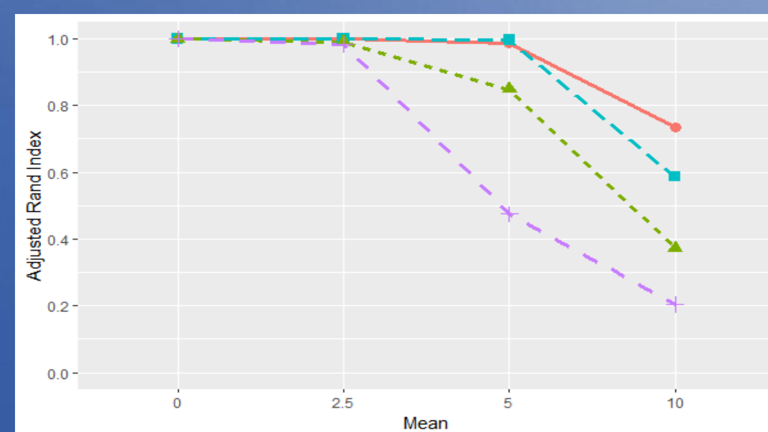
Random error



Systematic error

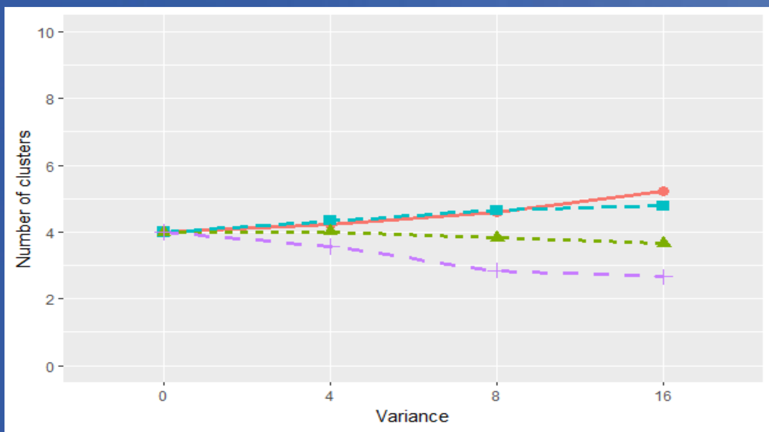
- Adjusted Rand index



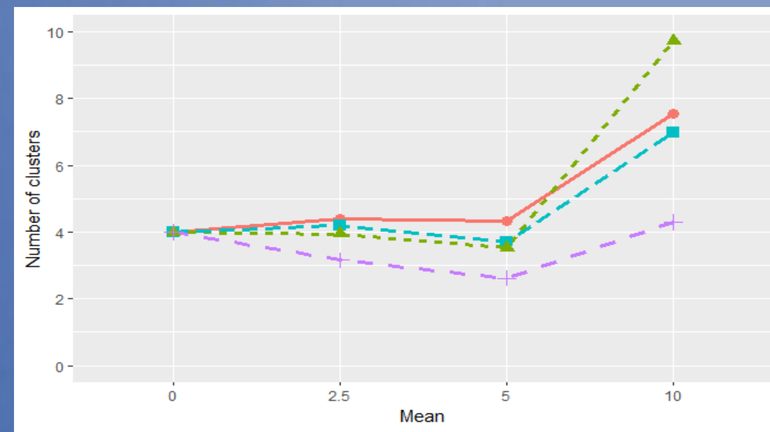


DBSCAN Results: all clusters

- Number of clusters

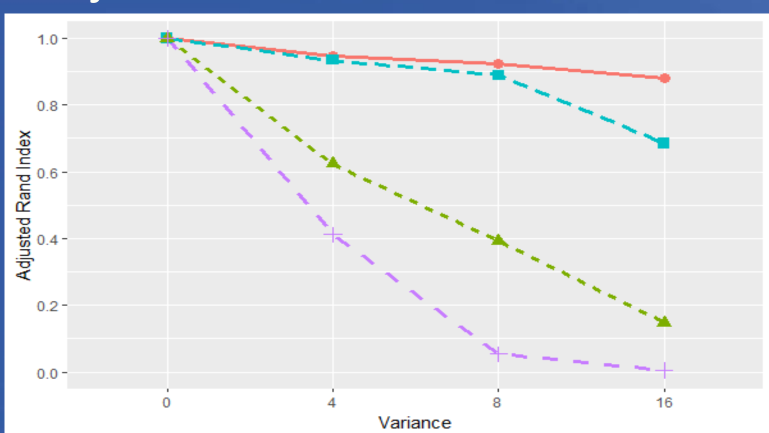


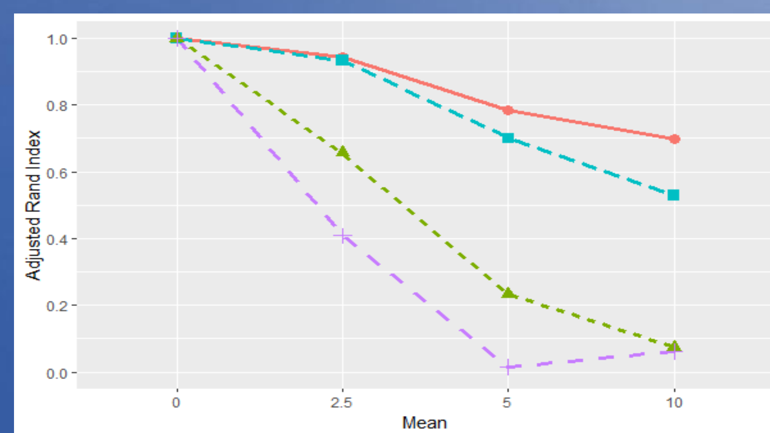
Random error



Systematic error

- Adjusted Rand index

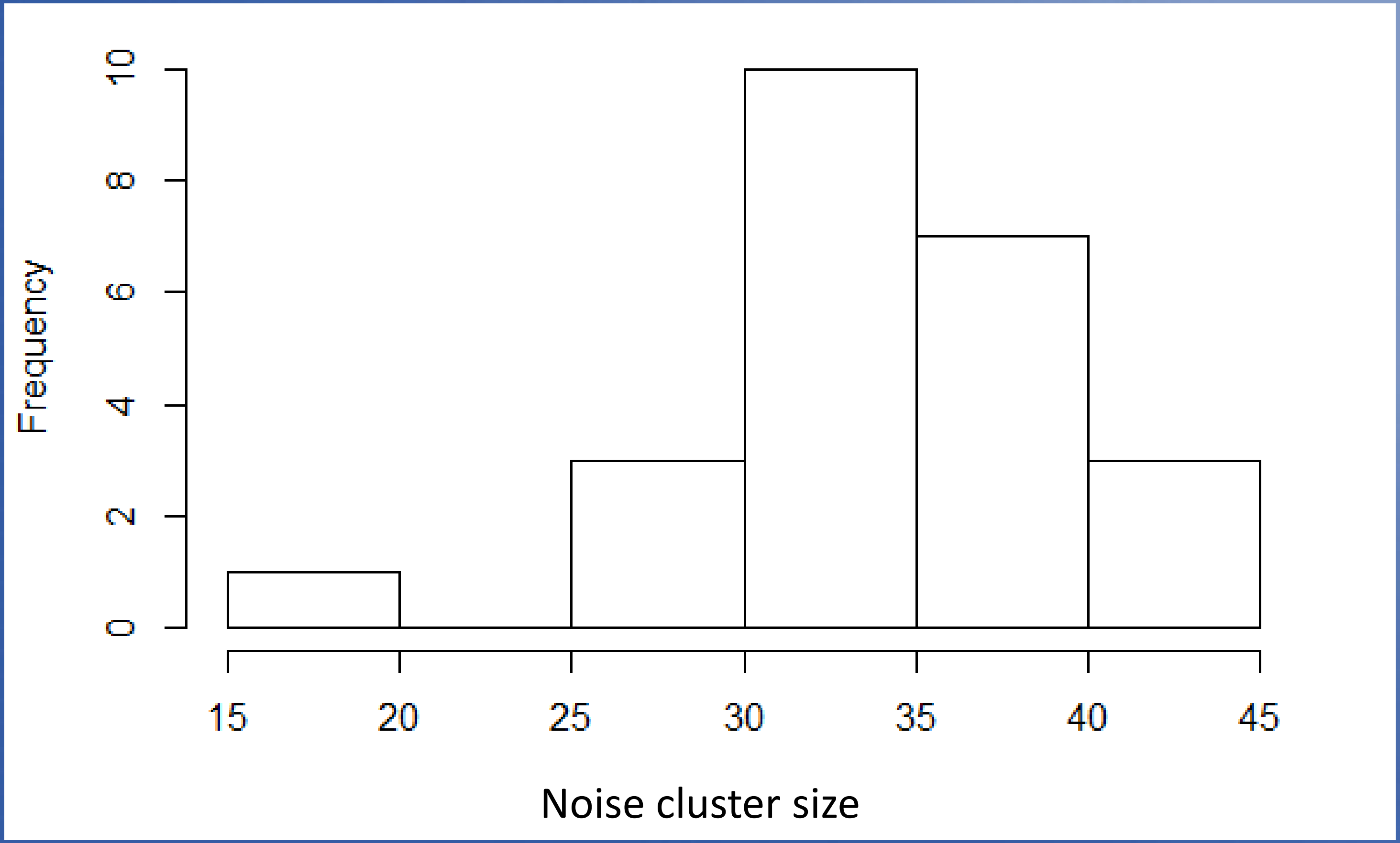




Condition: 20% error in 1 var; 20% error in 3 var's; 40% error in 1 var; 40% error in 3 var's

DBSCAN Results: size of noise cluster

- **Original noise cluster size: 32**



Summary and conclusions

- **GMM is less sensitive to measurement error than DBSCAN**
  - ✓ In particular when GMM components are merged into clusters
  - ✓ Only looking at stable DBSCAN clusters does not help
  - ✓ The noise cluster in DBSCAN does not capture measurement error
- **Measurement error has very strong biasing effects when**
  - ✓ It is systematic as opposed to random
  - ✓ It affects all (three) variables rather than only one
  - ✓ The magnitude is high
  - ✓ Error rate does not appear to matter much

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Questions about next steps

1. Should we try other clustering algorithms and/or other techniques to extract and compare clusters?
   - If so, which ones?

2. Should we also correct for measurement error in this paper (i.e. using latent variable modelling)?

3. Would a real-life data application be interesting?

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Thank you!

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