

# Heterogeneity in Means and Variances

## Traditional Random Parameters Models:

$$\beta_n = b + \varphi_n$$

We have some mean  $b$  and add an error term to account for possible heterogeneity (and assume a distribution for  $\varphi_n$ )

### Problem:

- We are not sure how accurately our chosen distribution of  $\varphi_n$  can track the unobserved heterogeneity
- What if the degree of unobserved heterogeneity is actually some function of explanatory variables?

## Heterogeneity in the means:

We allow the mean of the parameter to be a function of explanatory variables so:

$$\beta_n = b + \Theta Z_n + \varphi_n$$

where:

- $b$  is the mean parameter,
- $Z_n$  is a vector of explanatory variables that influence the mean of  $\beta_n$ ,
- $\Theta$  is a vector of estimable parameters, and
- $\varphi_n$  is a randomly distributed term that captures unobserved heterogeneity across crashes.

## **Potential Problem:**

- We still might be limited because we inherently assume a common variance (one standard deviation) across the parameters.

## **Possible Solution:**

- Allow the variance to be a function of explanatory variables as well.

## Heterogeneity in the means and variances:

We allow the mean of the parameter to be a function of explanatory variables so:

$$\beta_{kn} = b + \Theta_{kn} Z_{kn} + \sigma_{kn} \text{EXP}(\omega_{kn} W_{kn}) \varphi_{kn}$$

where:

- $W_{kn}$  is a vector of explanatory variables that captures heterogeneity in the standard deviation  $\sigma_{kn}$
- $\omega_{kn}$  is the corresponding parameter vector, and
- All other terms as previously defined,

## **Recent Papers:**

Behnood, A., Mannerling, F., 2017. The effect of passengers on driver-injury severities in single-vehicle crashes: A random parameters heterogeneity-in-means approach. *Analytic Methods in Accident Research* 14, 41-53.

Seraneepakarn, P., et al., 2017. Occupant injury severities in hybrid-vehicle involved crashes: A random parameters approach with heterogeneity in means and variances. *Analytic Methods in Accident Research* 15, 41-55.

Behnood, A., Mannerling, F., 2017. Determinants of bicyclist injury severities in bicycle-vehicle crashes: A random parameters approach with heterogeneity in means and variances. *Analytic Methods in Accident Research* 16, 35-47.