Time-varying Group Unobserved Heterogeneity in Finance

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SETTINGS

$$
\begin{aligned}
y_{it} &= \underbrace{\alpha_i}_{\substack{\text{time inv.}\\ \text{FE}}} + \underbrace{x_{it}}_{\substack{\text{var. of}\\ \text{interest}}} \overbrace{\beta}^{\substack{\text{param. of}\\ \text{interest}}} + \underbrace{W_{it}'\gamma}_{\substack{\text{observ.}\\ \text{confounders}}} + \underbrace{(\epsilon_{it} + \sum_{k=1}^{\overbrace{K}^{\substack{\text{time-var.}\\ \text{unobs. het.}}}} \zeta_{itk})}_{\substack{\text{unobserv.}\\ \text{confounders}}} \\
&= \alpha_i + x_{it}\beta + W_{it}'\gamma + \tilde{\epsilon}_{it}
\end{aligned}
$$

Omitted Variable Bias: if $E(x_{it}\tilde{\epsilon}_{it}) \neq 0$

- Financial constraints (Farre-Mensa and Ljungqvist, 2015), Investment opportunities (Robertson and Whited, 2012), Time-varying management quality (Bloom et al. 2017)
- Group structure among firms with similar moral hazard, asymmetric information, and contract enforcement cost

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Current Practices - Two-way Fixed Effect Models

Top 3 Finance Journals (2017 – 2018)

359/389 papers use fixed effect models (assumes homogeneity with λ_t, time fixed effect)

- 95 use one-way fixed effect (e.g., firm or time)
- 264 use two-way fixed effect (e.g., firm and time)
- Assumes unobserved heterogeneity is time-invariant or homogenous across individual units

Top 3 Accounting Journals (2019 – 2021)

343/358 papers use fixed effect models

- 41 use one-way fixed effect (e.g., firm or time)
- 302 use two-way fixed effect (e.g., firm and time)

Current Practices - Interacted Fixed Effect Models

81 (Fin) and 69 (Acc) papers use interacted fixed effect (e.g. Industry $\times$ Year)

- Assumes unobserved heterogeneity has a group structure
- Requires one to pre-specify group membership of individual units

How should I pre-specify the grouping?

PROBLEM

Key: Correctly identify exact group membership that captures heterogeneity $\Longrightarrow$ interact group and time dummies

Challenge:

- Determinants of group structure vary across applications and some are unobservable
- Challenging to use a single/few observables to capture all relevant group level heterogeneity

How to obtain correct and data-driven group memberships?

IN THIS PAPER, WE...

Discuss a new class of models, "group fixed effect" (GFE) models

- Excellent asymptotic and finite sample properties of the "super-consistency" group membership estimation.
- Consistent and unbiased estimates of β under TFE and IFE DGPs
- New Hausman-type specification test to choose among TFE, IFE and GFE if there are concerns about efficiency loss
- New methodology with a two-stage least squares GFE to address the joint endogeneity issue from unobserved heterogeneity and simultaneity bias faced by most empirical finance papers
- Empirical relevance and economic importance
- Guidance and user-written functions in statistical package.

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PROPOSED SOLUTION

Grouped fixed effects (GFE, Bonhomme and Manresa 2015)

$$y_{it} = \alpha_i + \lambda_{g_i,t} + X_{it}'\beta + \epsilon_{it}, \quad g_i = 1, \ldots, G.$$

Match DGP of stylized facts:

(1) Time fixed effects to differ across groups

▸ Group Membership

(2) Unknown group memberships

Two types of parameters to estimate

- standard regression parameters β and $\lambda_{g_i,t}$ for all g and t
- group membership parameter g_i for all i

DETAILS YOU CAN FIND IN THE PAPER

- How to determine the number of groups for GFE?
- Finite sample properties of GFE across different DGPs?
- How to choose between TFE and GFE in practice?
- How to handle endogenous explanatory variables?
- Standard error estimates of various methods
- Show effectiveness in estimating group membership via a natural experiment
- Show economic importance through replicating a published paper on corporate innovation

AN EXPERIMENT - GROUPING EFFECTIVENESS

Whether and how group membership estimates of GFE make sense in practice?

Challenges - Verifying correctness of group membership is difficult using empirical data given that group membership is latent

We use a natural experiment!

- Sales growth and various firm variables are affected by natural disasters - Barrot and Sauvagnat (2016, QJE)
- Natural disasters = market-wide events

  $\Longrightarrow$ Firms respond differently depending on whether a firm is located in disaster region, magnitude of effect, customers and suppliers, hedging procedures, etc.
- Regress sales growth using GFE w/o natural disaster info. and check if GFE group estimates coincide with variations in severity of natural disasters

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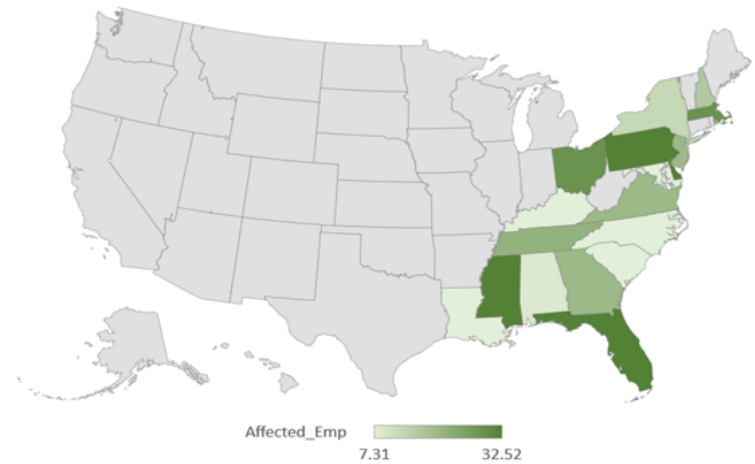
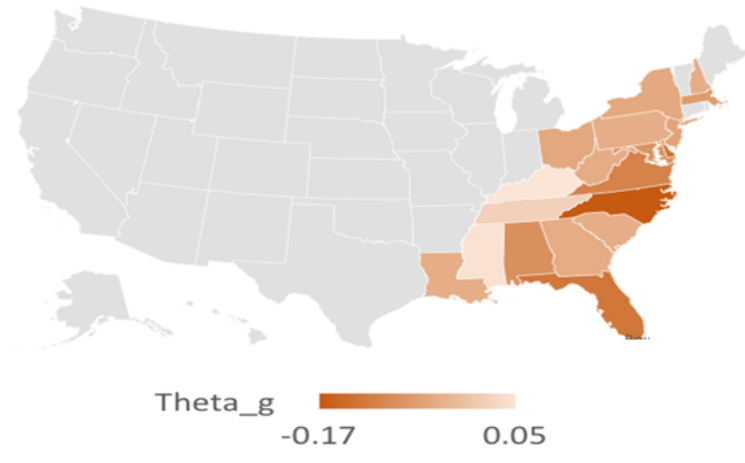
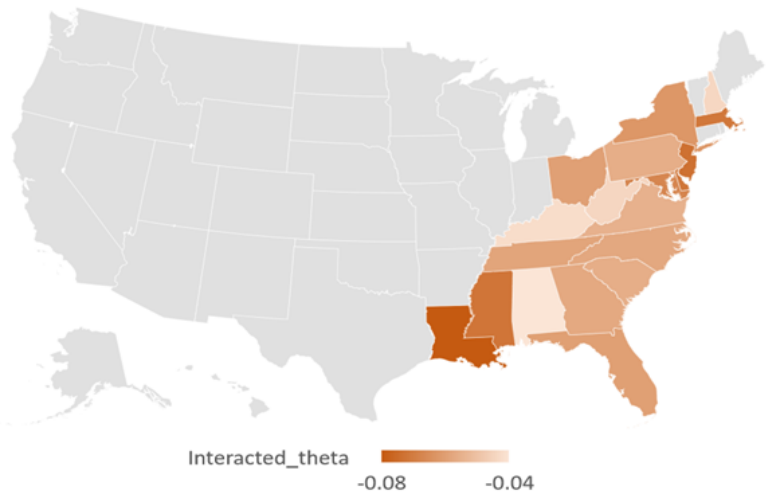
Natural Disasters and Employment 2004

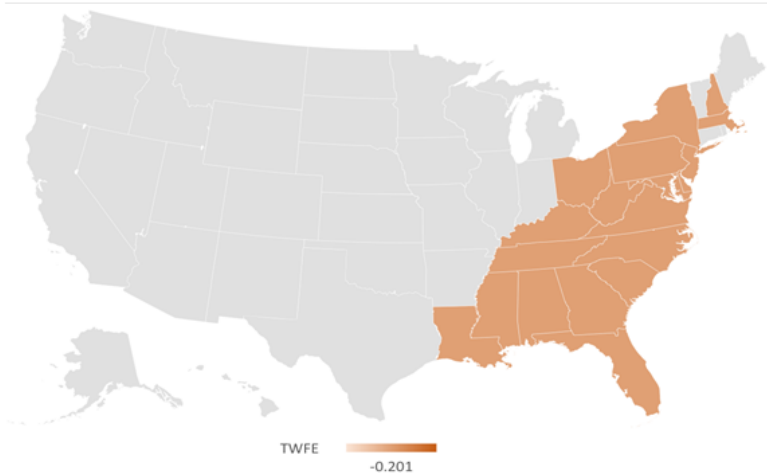
FEs from: $\ln(\text{Sales growth})_{i,t} = \alpha_i + \theta_{g_{i,t}} + X'_{i,t-1}\beta + \epsilon_{i,t},\ g_i \in \{1, ..., G\}$

Data from SHELDUS (Spatial Hazard and Loss Database for the United States)









Regression estimates show that only GFE estimates are negatively and significantly related to affected employment

ECONOMIC IMPORTANCE

Investigate how pilot CEO influence corporate innovation (Sunder et al., 2017, JFE)

- Innovation outcome across firms with pilot and non-pilot CEOs
- CEOs with hobby of flying airplanes is associated with significantly better innovation outcomes
- Pilot CEOs: Sensation seeking drives risky R&D investments $\rightarrow$ Pat. citations $\uparrow$
- They use two way fixed effects models (industry and year)

No significant difference between pilot and non-pilot CEOs across firms using GFE. Firms with less financial constraints are more likely to hire pilot CEOs.

Conclusion

- Discuss a methodology that allows researchers not have to take a stance about group membership in accounting for unobserved group heterogeneity at a small cost of efficiency loss
- Provide a model specification test to help empiricists to decide between the tradeoffs of heterogeneity bias and efficiency loss
- Propose novel 2SLS-GFE estimation to account for two sources of endogeneity jointly (unobserved heterogeneity and simultaneity bias)
- Provide guidance and user-written functions on how to use GFE
- Email me for a revised version of the paper - w.tham@unsw.edu.au

ALGORITHM

1. Let $g^{(0)}$ be an initial value of grouping. Set $s = 0$.
2. For the given $g^{(s)}$, compute:

$$(\theta^{(s+1)}, \beta^{(s+1)}) = \arg\min_{\beta,\theta} \sum_{i=1}^{N}\sum_{t=1}^{T}(\dot{y}_{it} - \dot{X}'_{it}\beta - \theta_{g_i^{(s)},t})^2.$$

   estimates coefficient parameters for a given group structure as in usual least squares problem

3. Compute for all $i \in \{1, \ldots, N\}$:

$$g_i^{(s+1)} = \arg\min_{g\in\{1,\ldots,G\}} \sum_{t=1}^{T}(\dot{y}_{it} - \dot{X}'_{it}\beta^{(s+1)} - \theta_{g_i,t}^{(s+1)})^2.$$

   finds optimal group, min. SSR over time for each unit, based on estimated coef. param. from previous step, i.e., in step $s+1$, firm i is classified in group g if its time-series SSR computed using estimated coef. param. $\theta_{g,t}^{(s+1)}$ is less than that computed using $\theta_{g',t}^{(s+1)}$ for any $g' \neq g$

4. Set $s = s + 1$ and go to Step 2 (until numerical convergence).

▸ GFE Estimation

TIME VARYING GROUP MEMBERSHIPS

- Current specification: g_i does not change over time
- Time-varying group structure can be incorporated by imposing a larger number of groups

TABLE: Time-varying group memberships

$t = 1$	$t = 2$	GFE Group
1	1	1
2	⋮	⋮
⋮	300	300
⋮	g_{12}	G_1
499		
500	301	301
	302	⋮
g_{11}	⋮	500
	⋮	
501	⋮	G_2
502	⋮	
⋮	⋮	501
⋮	999	⋮
999	1000	1000
1000		
	g_{22}	G_3
g_{21}		

GFE Properties