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# Estimating Heterogeneous Panel Data Models

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Lund  
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# Estimating Heterogeneous Panel Data Models



# Estimating Heterogeneous Panel Data Models

by Yousef Kaddoura



**LUND**  
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DOCTORAL DISSERTATION

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Abstract This Thesis deals with the development and application of new estimation methods of heterogeneous panel data models. In Paper I, a new estimator for heterogeneous panel data models with random interactive effects is proposed. The heterogeneity in this paper is viewed as heterogeneity over time, which is modeled by having the slope coefficients exhibit multiple structural breaks. The suggested estimator is suitable when the number of time periods, $T$ , is fixed, and only the number of cross-sectional units, $N$ , is large. To estimate the multiple structural breaks, I suggest minimizing a penalized objective function that induces structural breaks. In Paper II, I discuss the estimation of what I call “Coefficient-by-Coefficient” breaks. Existing econometric methods take an all-or-nothing approach when estimating structural breaks, in the sense that either all parameters shift together or not. However, we typically do not know which parameters are shifting and when. To address this, I suggest a penalized estimator that allows for the estimation of breaks in each component of the slope vector, providing further insight into what is breaking and when. In the same paper, I propose two estimators: one that accounts for homogeneous breaks and one for heterogeneous breaks. Heterogeneous breaks are breaks that vary across different groups. Hence, the considered heterogeneity is very general in the sense that the slope coefficient changes over time, but also over cross-sectional units. Paper III is concerned with the robustness of pooled estimators to random breaks in panel data models. The main point of this paper is to showcase that the least square estimator is not necessarily consistent under random breakpoints. In Paper IV we discuss the CCE estimator of Pesaran (2006). In this paper, we show that this estimator is more useful than commonly appreciated, in that it enables consistent and asymptotically normal estimation of interactive effects models with heterogeneous slope coefficients when only the number of cross-sectional units, $N$ , is large.		
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# Estimating Heterogeneous Panel Data Models

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*Dedicated to my Family*

# Contents

Acknowledgment	I
Introduction	1
Paper I	13
Paper II	59
Paper III	143
Paper IV	187

# Acknowledgements

I would like to begin this section by expressing my gratitude to God. I must acknowledge that, although I have worked hard, this achievement would not have been possible without His guidance. I encountered many challenges, and He supported me through them all. I am deeply thankful for His presence at every step of the way.

When I began my PhD journey, I was uncertain about the research area I should focus on. Initially, I thought I would concentrate on finance. However, just a few months into the PhD program, I decided to explore other fields. During this exploration, I met Joakim Westerlund, my PhD supervisor. It is no exaggeration to say that the thesis itself would not have been possible without Joakim's continuous support. After choosing Econometrics, I remember approaching Joakim with my first few ideas, which were not particularly impressive, but he always listened and showed interest. Once we embarked on our first project, Joakim treated me as a co-author rather than just a student. After a while, I began to send him many more ideas (slightly better than my first ones). Some days, I sent as many as six emails, each containing different concepts. Reflecting on this, it must have been challenging to manage a student like me, but Joakim supported me at every step. With that in mind, I would like to express my profound gratitude to my supervisor, friend, and mentor. Thank you, Joakim.

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# Introduction







# Introduction

## 1 Background

A panel data set is usually characterized by repeated observations (e.g., countries, individuals, firms) measured over multiple time periods (e.g., years, months, days). In recent years, we have seen a wide availability of such data sets, which has led to many empirical economic papers testing the significance of various economic relationships. An advantage of such a data set is the ability to pool the data, leading to more precise estimates. However, pooling the data might not always be the best practice as economic relationships are known to be highly heterogeneous. In other words, economic relationships could be different between different observations.

It is well-known that researchers frequently assume slope homogeneity in the empirical analysis of panel data. This assumption is often rejected in practice (see, for example, Wang et al. 2018). Researchers also typically preassume knowledge of the source of heterogeneity and then formulate hypotheses to test these effects. However, in many applications, the source of heterogeneity is unknown, necessitating methods for estimating latent heterogeneity.

In panel data models, heterogeneity in the slope parameters is typically understood as heterogeneity across different cross-sectional units. However, one can also estimate heterogeneity stemming from the time dimension, which is typically modeled as structural breaks. Moreover, it is also possible to have heterogeneity in both dimensions. More generally, we discuss these types of heterogeneity: random heterogeneity, latent groups, structural breaks, and a combination thereof. This thesis is dedicated to delving into these different types of heterogeneity and proposing various estimators in panel data models.

## 1.1 Random heterogeneity

Whenever tested, the homogeneous slope restriction is almost always rejected (see, for example, Pesaran et al., 1999, and Baltagi et al., 2000). Yet, in economics (and elsewhere), we are typically only interested in the average marginal effect. This idea of averaging the effects popularized modeling slope heterogeneity by assuming that the slope parameters follow a random coefficient model (see, for example, Pesaran, 2006). This assumption states that the slope parameters are heterogeneous only because of a random term with a mean of zero and a symmetric, non-negative covariance matrix. Because the mean of the random term is zero, the average of all cross-sectional estimates should be understood as an average effect. Hence, this shows the attractiveness of this assumption, which allows one to pool the data and estimate an average effect. To that end, many papers utilize this assumption to model slope heterogeneity in panel data models by interpreting the effects as average marginal effects. However, this “too good to be true” assumption can lead to biased and inconsistent estimates if one is not careful. This issue is discussed further in Paper III. On the other hand, when the estimates are consistent under this assumption, pooling the data is indeed the way to go. We discuss this in Paper IV in an interactive effects panel data model with heterogeneous slopes. If pooling is not possible, we would require an alternative method for estimating heterogeneous effects. One alternative would be to estimate latent group structures, which leads us to the next subsection.

## 1.2 Latent groups

Recently, there has been a surge of papers tackling the estimation of latent group structures. Estimating latent groups in a panel data model implies that cross-sectional units need to be arranged in different groups. The slope parameters are equal in each group, but different across groups. Further, the fact that the groups are unknown makes the estimation slightly more challenging but can result in more fruitful conclusions. For example, Bonhomme and Manresa (2015) have studied the relationship between income and democracy. They found that this relationship

is different across different countries. These countries can be grouped into four categories: high democracy, low democracy, early transition, and late transition. The slope parameters are equal for all countries in each group but are different across groups.

As discussed in the previous section, such an estimator can be considered more useful than a pooled one under the assumption of random heterogeneity in the slope parameters. The reason is that when assuming a random coefficient model, we force all cross-sections to have a common mean, implying that they are in the same group. On the other hand, allowing cross-sections to exhibit different slope behavior across groups allows the researcher to learn if there are any differences between the cross-sectional units. In Paper II, I discuss how one can estimate panel data models with latent group structures, but also with structural breaks.

### **1.3 Structural breaks**

Another way of viewing heterogeneity in panel data models is by viewing the parameters as possibly shifting over time. This is also important because there is strong evidence that the parameters of many macroeconomic models change over time, especially over longer horizons. One way of tackling such changes over time is modeling these shifts as structural breaks. When dealing with a panel data model with structural breaks, we need to estimate how many times the slope parameter has changed and when.

Dealing with structural breaks is an important step in most if not all, empirical economic research. This is particularly true in panel data comprised of many cross-sectional units, such as individuals, firms, or countries, which are all affected by major economic events. The worry is that if left unattended, existing breaks will manifest themselves as omitted variables, leading to inconsistent estimates of the slope coefficients of the model. It is, therefore, important to know if and when structural breaks have occurred. Of course, such knowledge is rarely available in practice, which means that it has to be inferred from the data.

In recent years, there have been many attempts to tackle the problem

of estimating multiple structural breaks. One way of estimating these breaks is by using regularization techniques. Historically, regularization techniques have been used for variable selection (see, for example, Tibshirani 1996). Recent papers have taken this as inspiration, utilizing regularization techniques to estimate the number of breaks and periods in panel data models. In Papers I and II, we propose new estimators for panel data models that employ such regularization techniques to estimate the breaks.

## 1.4 A combination

As I have already discussed, the source of heterogeneity in panel data models can stem from both the cross-sectional and time dimensions. Hence, in some applications, the parameters could be heterogeneous over cross-sections, but in others over time. However, this also raises the following question: What if we have heterogeneity across both dimensions? Take, for example, the application by Okui and Wang (2021). They study whether the relationship between income and democracy changes over time. This problem is similar to the one studied by Bonhomme and Manresa (2015) but with a major difference. The difference is that Okui and Wang (2021) allow for the breaks to be different across different groups. This means that if the relationship between income and democracy changed over time in a certain period in Sweden, that does not imply that this change should occur in another country. Hence, we have what is called “heterogeneous breaks,” implying that changes over time can be different for different individuals.

## 2 Contribution

We begin with Chapter Two. Recently, Qian and Su (2016) proposed a methodology that utilizes regularization techniques to estimate multiple structural breaks in panel data models. Their analysis requires a large number of time periods. Their model also incorporates cross-sectional fixed effects, implying the allowance for some form of unobserved heterogeneity in the error terms. However, in certain applications, the

number of time periods can be small, and fixed effects might not suffice as they only capture time-invariant effects. On the other hand, Li et al. (2016) suggest a similar regularization methodology that allows for interactive effects, which are more general than fixed effects, allowing for time-varying effects. However, their methodology relies on estimating principal components, which requires the number of periods to be large.

Given the above discussion, we suggest a new method that builds upon the “adaptive group fused” Lasso approach of Qian and Su (2016) and Li et al. (2016) to estimate multiple structural breaks in panel data models. The idea is to apply Lasso to cross-sectionally demeaned data. Demeaning does not affect the time-varying parameters and makes the resulting estimator robust to interactive effects, provided they satisfy a certain random coefficient condition. Another advantage of the suggested estimator is the structure of the breaks: there can be no breaks at all, and if breaks are present, the procedure does not make any assumptions about their number. Therefore, the procedure is valid even if some, or indeed all, regimes have a single observation, which is very useful for detecting a break as quickly as possible. Yet another advantage is that the procedure does not impose any conditions on the serial correlation properties of the data. Hence, the data can be stationary, as required in much of the previous literature, but it is not a necessity. We demonstrate that the suggested method consistently estimates the break and break dates and further showcase the finite sample properties in a Monte Carlo study.

Moving on to Chapter Three, we continue our discussion on structural breaks, focusing on a different issue: estimating breaks for each slope parameter. Existing econometric methods often adopt an all-or-nothing approach when estimating structural breaks, where either all parameters change or none do. However, when faced with an unknown set of parameters that undergo changes, identifying patterns of instability becomes challenging. Despite this, such knowledge is essential for both forecasting and policy analysis.

In this chapter, we introduce the concept of “coefficient-by-coefficient (CBC) breaks,” allowing each component of the parameter vector to have its own set of breaks. Unlike previous methods, where we estimate

a single number of breaks along with a single set of break dates, the idea of CBC breaks is more general as each parameter has its own set of breaks and break dates. Allowing parameters to shift together can make it challenging to pinpoint which parameters caused the break, especially when many controls are included in the model. Hence, understanding which components are shifting eases the interpretation of the results, which can be crucial in many applications. Additionally, shifting all parameters together unnecessarily can cause a loss of statistical power, affecting forecasting, prediction, and the significance levels of tests. For example, in a model with two parameters and two periods, if only the second parameter is breaking between periods 1 and 2, then we are forced to shift the first parameter too. On the other hand, by allowing each coefficient to have its own set of breaks, we avoid this unnecessary loss of power. This highlights the importance of CBC breaks: efficiency and added interpretability.

To estimate CBC breaks, we propose an approach that utilizes regularization techniques. More specifically, we suggest penalizing each parameter with a variation of the Lasso approach. Previous methods, such as those by Qian and Su (2016), utilize a similar approach but penalize the entire vector of parameters, inducing a shift in all parameters rather than in each parameter individually. Furthermore, we propose another estimator to estimate what we call “heterogeneous CBC breaks.” This estimator allows the breaks to potentially vary across different latent groups that we identify. The idea is that parameters can be the same within a group but different across groups. We apply a variation of the  $K$ -means algorithm, suggested by Bonhomme and Manresa (2015) and Okui and Wang (2021), to estimate breaks that vary across different groups. This allows our estimator to be very general, inducing heterogeneity across cross-sectional units and time periods.

In Chapter Four, we discuss the robustness to random breaks in panel data models. Empirical studies leveraging panel data often benefit significantly from pooling, despite the presence of heterogeneous parameters. The extensive information contained within large panel datasets enhances the understanding of economic phenomena, yet the potential for information overload is high without a mechanism for summarizing findings in a straightforward manner. This is particularly true when

the cross-sectional unit of observation is too granular to hold intrinsic interest. Pooling serves as a method for achieving this summarization. Consequently, the question arises: How do we justify pooling while at the same time not requiring homogeneous parameters? A plausible answer is to consider the parameters as randomly distributed. Such randomization strikes a balance between complete homogeneity and unrestricted heterogeneity. It permits the parameters to vary across the cross-section, with the assumption that this variability results from a random process, independent of the model's other random elements. This approach enables researchers focusing on the average parameter to proceed as if heterogeneity were non-existent. The underlying rationale, derived from linear models, suggests that pooling averages out the heterogeneity, thus facilitating the precise estimation of the average parameter (see, for example, Beck and Katz, 2007, or Wooldridge, 2019, for discussions).

In this chapter, we want to make a general point which is that randomization is not innocuous in the sense that estimators developed under the assumption of homogeneous parameters are not automatically valid under random parameters. We make this point by showing that the least squares breakpoint estimator is not necessarily consistent under random breakpoints. The reason why the least squares breakpoint estimator is not necessarily consistent is the non-linearity of the estimation problem, which invalidates the usual arguments for robustness to random heterogeneity in the linear case, a fact that seems to have been largely overlooked in the literature.

In the previous paragraph, we discussed that nonlinearity could lead to an inconsistent least squares estimator. In Chapter Five, we take a step back and look at linear panel models, this time allowing the slope parameters to have random heterogeneity in the cross-sectional dimension. We do this because pooling can be very attractive in the right setting. The idea behind this chapter is to show that the Common Correlated Effects (CCE) estimator, introduced by Pesaran (2006), is more useful than often appreciated. It enables consistent and asymptotically normal estimation of models with interactive effects and heterogeneous slope coefficients when the number of time periods is fixed and the number of cross-sectional units is large.



In a previous article, Westerlund et al. (2019) demonstrate that the CCE estimator can be applied effectively when the number of cross-sectional units is large, while the number of time periods remains small. However, their analysis relies on the assumption of homogeneous slopes—an assumption that, as we have discussed, is unlikely to hold in practice. Considering our context is a linear panel setting, we adopt a pooled estimator to determine an average marginal effect. This paper is the first to consider CCE estimation of a heterogeneous panel data model with random slope coefficients under the condition that the number of time periods is fixed and only the number of cross-sectional units is large.

## References

- Baltagi, B. H., J. M. Griffin and W. Xiong (2000). To Pool or Not to Pool: Homogeneous Versus Heterogenous Estimators Applied to Cigarette Demand. *Review of Economics and Statistics* **82**, 117–126.
- Beck, N., and J. N. Katz (2007). Random Coefficient Models for Time-Series-Cross-Section Data: Monte Carlo Experiments. *Political Analysis* **15**, 182–195.
- Bonhomme, S., and Manresa, E. (2015). Grouped patterns of heterogeneity in panel data. *Econometrica*, **83**, 1147–1184.
- Li D., Qian J., and Su L. (2016). Panel data models with interactive fixed effects and multiple structural breaks. *Journal of the American Statistical Association*, **111**, 1804–1819.
- Okui, R., and Wang, W. (2021). Heterogeneous structural breaks in panel data models. *Journal of Econometrics*, **220**, 447–473.
- Pesaran, H. M., Y. Shin and R. Smith (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *Journal of the American Statistical Association* **94**, 621–634.
- Pesaran, M. H. (2006). Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. *Econometrica* **74**, 967–1012.

- Qian, J., and Su, L. (2016). Shrinkage Estimation of Common Breaks in Panel Data Models via Adaptive Group Fused Lasso. *Journal of Econometrics*, **191**, 86–109.
- Tibshirani, R. (1996). Regression shrinkage and selection via the lasso. *Journal of the Royal Statistical Society Series B: Statistical Methodology*, **58**, 267–288.
- Wang, W., Philips, P.C.B., and Su, L. (2018). Homogeneity pursuit in panel data models: Theory and application. *Journal of Applied Econometrics*, **33**, 797–815.
- Westerlund, J., Y. Petrova and M. Norkute (2019). CCE in Fixed- $T$  Panels. *Journal of Applied Econometrics* **34**, 746–761.
- Wooldridge, J. M. (2019). Correlated Random Effects Models with Unbalanced Panels. *Journal of Econometrics* **211**, 137–150.



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