

I am a job market candidate at the Vancouver School of Economics, the University of British Columbia. My research interest includes topics on dynamic structural models in oligopolistic competition, biased belief in dynamic games, agents' choice models and finite mixture models.

### Job Market Paper

My job market paper, *"Building up Trust in a Dynamic Game: A study on Collusive Price-fixing in the Chilean Pharmaceutical Retail Industry"*, discusses firms' coordination issues when initiating collusion. By understanding the economics behind the initiation of collusion, the government can tailor policies to prevent collusion from emerging. The paper is the first to model the firms' initiation problem. The work contributes to understanding the firms' learning-to-coordination process. From empirical researches, we observe that firms exhibit post-cartel tacit collusion. The observations indicate that once firms build up trust, the market is vulnerable to collusion. Literature in collusion focuses on the *implementation* but overlooks the *initiation* of collusion. This paper provides a tractable model that considers firms' *incentive problems* and *coordination problems* separately. The *incentive problems* refers to whether there exists a sustainable collusive equilibrium. The *coordination problems* refers to firms' uncertainty about multiple sub-game perfect equilibria. This model relaxes the rational expectations by estimating firm-specific "conduct parameters" that disentangle firms' information acquisition processes from firms' strategic interactions. Firms gradually build up the trust and learn other firms' "true" probability to cooperate. The price-fixing cartels in the retail industry often involve multi-market contact. With multi-market contact, the gradualism in the initiation of collusion takes the form of diffusion among markets: firms are more likely to collude on a given market if they have already conspired on one market. Identifying the belief parameters relies on two exclusion restrictions: (1) one firm's lagged pricing decision affects his payoff through adjustment costs while other firms' lagged pricing decisions do not. (2) The profits on a given market are not affected by the market outcomes in other markets. The framework with nonequilibrium belief represents the data observed better than the rational expectation model.

### Research Papers

In joint work with Hiro Kasahara, *"Using Euler Equation to Estimate Non-Finite-Dependent Dynamic Discrete Choice Model with Unobserved Heterogeneity"*, we propose an estimator for dynamic discrete choice models with unobserved heterogeneity. In the dynamic discrete choice analysis, controlling for unobserved heterogeneity is an important issue, and finite mixture models provide flexible ways to account for it. The previous discussion of incorporating the finite mixture model in the dynamic discrete choice model focuses on a class of models where the difference in future value terms depends on a few conditional choice probabilities(finite dependence property). In models that do not exhibit finite dependence property, it is computationally costly to estimate finite mixture models with the expectation-maximization(EM) algorithm. Arcidiacono and Ellickson 2011 discuss the finite mixture in dynamic discrete choice with finite dependence property. My joint work with Hiro Kasahara adopts the EM algorithm to incorporate unobserved heterogeneity for a broader range of the dynamic discrete choice model that does not require the finite dependence property. Following the Euler Equation(EE) representation of dynamic discrete decision problems, we provide an alternative conditional choice probability (CCP) value function representation. This representation relies only on the CCP of one action. Contrasting to the Hotz-Miller CCP representation that relies on all the conditional choice probabilities, this characterization avoids the matrix inversion in each EM iteration. The matrix inversion can be computed outside the EM iterations and therefore this characterization is computationally attractive. The characterization provides an unbiased estimator for models with and without finite dependence property. We illustrate the computational gains with Monte Carlo simulations.

The above proceedings focus on dynamic choice models. In joint work with Hiro Kasahara, *"Testing the Number of Components in Finite Mixture Normal Regression Model with Panel Data"*, we develop a test for the number of components in the finite mixture normal panel regression model. We implement the test by considering the sequential likelihood-ratio test of the null hypothesis of a  $m_0$ -component model against an alternative of  $(m_0 + 1)$ -component model. The finite normal mixture models suffer from three major issues, the infinite Fisher Information matrix, the unbounded likelihood ratio and

the loss of strong identifiability. We reparameterize the parameters in the direction orthogonal to the zeros under the null hypothesis following Kasahara and Shimotsu (2012). The likelihood ratio test statistic can be approximated by a local quadratic expansion of squares and products of the reparameterized parameters. We show mathematically the finite mixture normal panel regression models suffer from unbounded likelihood and singular Fisher Information matrix. To account for the infinite information matrix and the unbounded likelihood issue, we obtain the data-driven penalty function via computational experiments to attend to the unbounded likelihood ratio. We apply the test to random coefficient Cobb-Douglas production function estimation following the framework of Gandhi, Navarro, and Rivers (2016) and Kasahara and Shimotsu (2015). The empirical findings suggest evidence of heterogeneous production technology beyond the Hicks-neutral technology factor.

### Work in progress

I am interested in extending the Euler-Equation estimator of the dynamic discrete choice to more generalized models. One work in progress, *"Dynamic Decision Models with Continuous-Discrete Mix Choices"*, generalizes the Euler equation expression to estimate the dynamic choice problems where agents make both discrete and continuous choices. In dynamic decision problems, agents can make both discrete and continuous choices at the same time. The existence of both types of choices is natural under some circumstances. For example, empirical industrial organization literature examines firms' entry and investment decisions. The decision of entry is discrete, and the decision of investment is continuous. Blevins (2010) provides identification results of the class of dynamic discrete-and-continuous-choice models. We show the discrete-and-continuous model is equivalent to the agents' making decisions that map every possible state to an outcome simultaneously. With the property, the agent's future value can be represented as the discounted payoff from repeatedly taking an arbitrary action. The estimation technique is the first to account for the Dynamic decision models with discrete-continuous-mix choices.

The project, *"Dynamic Discrete Choice with Many Choices"*, applies the Euler Equation approach to dynamic discrete choice problems with large control spaces. Researchers compute the value function from the probability-weighted average of the continuation value in a model where an agent faces many choices. The estimator requires the conditional choice probabilities(CCPs) of many choices to be correctly estimated. The result derived in the Euler equation shows that value function admits the expression that is a function of the CCPs of an arbitrary function. The characterization requires a consistent estimation of a single CCP instead of all the CCPs.

The above proceedings focus on dynamic discrete choice models. I am interested in consumer preferences over durable goods. Another work in progress, titled *"Does the EV rebate program raise awareness on the environment: evidence based on China automobile market"*, identifies consumer preference change based on individual choice data. This project uses administrative vehicle registration data from one of China's major cities to identify consumers' preference over household vehicles' gas-efficient attributes over time. We propose to evaluate the long-run effect of electric vehicles(EV) adoption policy on the consumer's preference using administrative data from one major city in China. The data contains registration, transfer and disposal record from January 2010 to the present. The administrative data include the Vehicle Identification Number(VIN) of the registered vehicle, the household district information, the gender, and the consumer's date of birth. The identification relies on the relative preference of high displacement vehicles and low displacement vehicles. The Chinese tax structure creates a discontinuity in demand for the displacement attribute. The Chinese government imposes a 7.5% consumption tax for a vehicle with engine displacement below 1.6 litres and a 10% tax for those above 1.6 litres(Xiao2011; Xiao2014). The level of the difference between vehicle above 1.6-litre displacement compared to those below 1.6 litres conditional on rebate program for electric cars over time can explain whether the consumers' preference for environmentally friendly cars has changed.