

RESEARCH STATEMENT

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My current research encompasses four areas, each of which contributes to advancing our understanding of various aspects of economic behavior and market outcomes.

The first area of my research revolves around the development of models and methodologies that enable us to study the dynamic behavior of individuals and firms. This entails creating frameworks that capture the intricacies of decision-making processes over time, as well as designing empirical applications to explore real-world phenomena using these methodological advancements.

A second focal point of my research lies in the empirical applications of dynamic network games. Here, I delve into understanding how networks evolve and influence strategic interactions among economic agents. By examining the dynamics of network formation and behavior, I aim to uncover insights into the complex interplay between network structures and economic outcomes.

In a parallel line of inquiry, my research investigates firms' informational and behavioral biases and their impact on market dynamics. By examining the presence of biases, both in information processing and decision-making, I seek to shed light on their implications for market efficiency and welfare. This line of research provides valuable insights into the role of cognitive and behavioral factors in shaping economic outcomes.

Lastly, I explore the geographic diffusion of credit and the role played by banks' local market power. By analyzing the distribution and availability of credit across different geographic areas, I aim to uncover how factors such as branch networks, market concentration, and regulatory policies influence credit access and financial outcomes at the local level.

Collectively, my research endeavors have made significant contributions to these areas of study. By developing innovative models, employing advanced methodologies, and conducting empirical analyses, I strive to enhance our understanding of dynamic behavior, network effects, biases, and geographic diffusion of credit. Through these research pursuits, I aim to generate valuable insights that can inform policymakers, practitioners, and researchers, ultimately contributing to a deeper comprehension of economic phenomena and the development of effective strategies for addressing economic challenges.

1. IDENTIFICATION AND ESTIMATION OF DYNAMIC STRUCTURAL MODELS

My contributions to the literature of dynamic structural models revolve around tackling three fundamental challenges: the curse of dimensionality in model solution and estimation,

identification problems, and incorporating unobserved heterogeneity to discern genuine dynamics from spurious ones.

a. Dealing with the curse of dimensionality

Nested Pseudo Likelihood estimation

In [AMira-2002], we propose and apply a novel method for estimating single-agent dynamic discrete choice structural models called the Nested Pseudo Likelihood (NPL) method. This approach eliminates the need for repeatedly solving the dynamic programming problem, resulting in significant computational savings compared to alternative methods. The algorithm converges to provide the maximum likelihood estimator. In [AMira-2007], we extend the NPL method to estimate dynamic games. This extension retains similar computational and statistical properties as observed in single-agent models and effectively addresses the challenge of multiple equilibria in dynamic games. The NPL method has garnered considerable attention in the literature and has been employed in a growing number of empirical applications. However, in the case of dynamic games, the fixed-point algorithm proposed in [AMira-2007] does not exhibit contraction properties, which has led to reported convergence problems in several applications. In [AMarcoux-2021], we undertake a comprehensive study of this convergence issue. We characterize the nature of the problem and propose a new algorithm, namely the spectral method, which demonstrates favorable convergence properties for computing the NPL estimator.

Euler equations in dynamic discrete choice models.

A significant challenge in structurally estimating dynamic models is the curse of dimensionality, particularly regarding the dimension of the state space. In models where the decision variable is continuous, Euler equations can mitigate the curse of dimensionality in estimation. These equations avoid the computation of present values and instead utilize conditions that incorporate agents' payoffs at two (or a few) consecutive periods.

Traditionally, it was believed that Euler equations did not exist for dynamic discrete choice models. However, in [AMagesan-2013], we derive marginal conditions of optimality for a broad class of dynamic discrete choice structural models. These conditions allow for the estimation of structural parameters in these models without the need to solve for approximate value functions. This result extends the GMM-Euler equation approach proposed by Hansen and Singleton (1982) for estimating dynamic continuous decision models to the realm of discrete choice models.

In [AMagesan-2021], we further demonstrate that the advantages of the Euler equations approach in discrete choice models extend beyond structural parameter estimation. They also apply to model solution and the evaluation of counterfactual experiments. We define an Euler fixed-point mapping

and show that it exhibits stronger contraction properties compared to both the standard value function operator and the relative value function operator. Solving the dynamic programming problem by iterating through the Euler operator yields substantial computational savings compared to iterations involving value functions, relative value functions, or policy functions. These alternative approaches typically require a significantly larger number of iterations or involve costly valuation steps at each iteration.

b. Unobserved heterogeneity in structural dynamic discrete choice models

Fixed effects and structural dynamic discrete choice models

A pervasive challenge in microeconometrics is disentangling the contributions of true dynamics and spurious dynamics to the observed time persistence in agents' decisions. True dynamics refer to the genuine causal effect of past decisions on current decisions—the *hand of the past*, as described by James Heckman. Spurious dynamics arise from serially correlated unobservables that impact both past and current decisions. When working with short panels, this identification problem is connected to two well-known econometric issues: the incidental parameters problem and the initial conditions problem. The former arises when including individual dummies to control for unobserved heterogeneity, leading to inconsistent estimates of the structural parameters that capture true dynamics. The latter occurs when the distribution of persistent unobservables lacks nonparametric identification, leading to potentially significant biases in estimating true dynamics. Traditionally, empirical applications of dynamic discrete choice structural models have tackled this identification problem by employing Random Effects models that assume a parametric distribution for the unobserved heterogeneity. However, it is widely acknowledged that this approach can be highly sensitive to misspecification of its parametric assumptions. Furthermore, it was commonly believed that robust methods used in reduced-form models—such as the sufficient statistics - conditional maximum likelihood method (CML)—could not be applied to dynamic structural models involving forward-looking agents.

Contrary to this common belief, in [AGL-2021], we utilize a CML approach to demonstrate the identification of structural parameters in a class of single-agent dynamic discrete choice structural models. This class encompasses state dependence, duration dependence, and a nonparametrically specified Fixed Effects structure for unobserved heterogeneity. Additionally, in [ACarro-2021] we establish the identification of Average Marginal Effects in this model class, representing counterfactual causal effects integrated over the distribution of unobserved heterogeneity, despite the non-identification of the distribution itself.

In [A-2023], I apply these identification results to a dynamic demand model for differentiated products. The model encompasses various sources of dynamics, such as product durability or storability, habit formation, and consumer switching costs. A notable benefit of the CML approach

in dynamic structural models is that the sufficient statistics controlling for unobserved heterogeneity also eliminate continuation values in agents' intertemporal payoff function. Consequently, similar to the Euler equations approach, this estimation method avoids the need for present value computation, alleviating the curse of dimensionality. This feature proves particularly advantageous when studying demand and supply for differentiated products, as the dimension of the price vector makes present value calculations impractical. In [AGM-2022], we explore the identification of dynamic games in the presence of fixed effects structures for market and firm unobserved heterogeneity.

c. Identification of structural models

Entry cost, fixed cost, and scrap value in entry/exit models

In [ASuzuki-2014], we uncover a fundamental identification problem in the structural estimation of dynamic oligopoly models concerning market entry and exit. We find that three components of a firm's profit function—the fixed cost of an incumbent firm, the entry cost of a new entrant, and the scrap value of an exiting firm—are not separately identified using data on firms' entry and exit decisions. We thoroughly examine the implications of this result on the model's ability to identify the effects of various comparative static exercises and counterfactual public policies.

Despite the non-separate identification of the three primitives, we demonstrate that a significant class of counterfactual experiments can still be identified. Specifically, experiments involving additive changes in any component of the profit function can be effectively identified. However, we also reveal that a class of economically relevant counterfactual experiments remains unidentified. This includes experiments that modify the transition probability of the state variables or the time-discount factor.

To illustrate the consequences of ignoring the non-identification of these counterfactuals, we present a numerical example highlighting sizable biases that can even alter the sign of estimated effects. This research has raised awareness of this crucial identification issue and has been cited in numerous empirical applications. Furthermore, it has stimulated the development of a new methodological approach focused on the partial identification of counterfactual experiments in dynamic structural models.

Unobserved heterogeneity and multiple equilibria

In [AMira-2019], we delve into the identification of discrete games of incomplete information by considering two types of unobservables that are common knowledge to the players: payoff-relevant unobservables and non-payoff-relevant variables that influence the selection between multiple equilibria. Our study demonstrates that by imposing standard exclusion restrictions,

which involve observable variables affecting the payoff of a player but not those of other players, we can achieve nonparametric identification of both the payoff function and the distribution of the two types of unobserved heterogeneity.

This research sheds light on the identification challenges associated with discrete games of incomplete information and highlights the crucial role played by exclusion restrictions in enabling the identification of key model parameters and unobserved heterogeneity distributions.

2. EMPIRICAL APPLICATIONS OF DYNAMIC NETWORK GAMES

Dynamic network competition in the airline industry

In [AHo-2012], we present a dynamic game of network competition among airlines in the US airline industry. Our model incorporates data on quantities, prices, and entry and exit decisions from all airline companies operating on routes between the 55 largest cities in the United States. By estimating this model, we examine the various factors—demand, costs, and strategic considerations—that contribute to the adoption of hub-and-spoke networks within the industry.

Our empirical findings shed light on the primary drivers behind the adoption of hub-and-spoke networks. Notably, we discover that the sunk cost of entry on a given route significantly decreases as the number of cities connected by an airline from the origin and destination airports of the route increases. This finding underscores the importance of economies of scale in explaining the prevalence of hub-and-spoke networks. Additionally, we identify the entry deterrence motive as the second most influential factor in the adoption of hub-and-spoke networks.

This paper represents the pioneering empirical application that endogenizes airlines' networks, making it a noteworthy contribution to the expanding literature on empirical models of competition within the airline industry. As a result, it has garnered significant attention from scholars and researchers exploring competition dynamics in this industry.

Dynamic competition between retail chain networks

In [AVicentini-2016], we introduce a dynamic game of spatial competition among multi-store retailers. This model captures the interplay between firms as they compete in terms of pricing and make decisions regarding store openings and closures based on factors such as demand and cost conditions, the presence of competitors at various locations, and location-specific shocks.

To analyze this dynamic game, we develop an algorithm that approximates a Markov Perfect Equilibrium, which provides insights into the optimal strategies of the competing firms over time. Furthermore, we propose a robust procedure for estimating the parameters of the model using

panel data encompassing information on the number of stores, prices, and quantities across multiple geographic locations within a city.

By applying our model and estimation procedure to real-world data, we can gain a better understanding of the dynamics of spatial competition among multi-store retailers. This research contributes to the literature on market competition and provides valuable insights for firms operating in this context.

COVID diffusion in a dynamic network of production and social interactions

In [\[AGLM-2021\]](#), we present a dynamic model that aims to evaluate the economic and public health effects of the diffusion of COVID-19. Our framework integrates a Susceptible-Infectious-Recovered (SIR) epidemiological model, which captures the spread of the virus, with a dynamic game of network production and social interactions.

Within our model, the economy is composed of three types of geographic locations: homes, workplaces, and consumption places. Each individual has their own set of locations where they conduct their daily activities. The combination of these individual sets determines the overall production and social network of the economy.

On a daily basis, individuals make decisions regarding whether to work and consume in physical locations (outside) or remotely (from home) without physical interactions. Working and consuming outside is associated with higher productivity and generates positive externalities due to complementarities. However, in the presence of a virus, working outside also facilitates infection and the spread of the virus, leading to negative externalities.

Crucially, individuals in our model are forward-looking, taking into account the potential health risks and economic consequences of their choices. To assess the impact of various counterfactual public policies, we calibrate the model and conduct numerical experiments. These experiments allow us to evaluate the health and economic effects of policies such as subsidies for working from home, testing strategies, herd immunity, and changes in the network structure.

Through these numerical experiments, we observe substantial differences in the propagation of the virus and its economic impact under different policy scenarios. By quantifying the effects of these policies on both public health and the economy, our research provides valuable insights that can inform policymakers and help guide decision-making during the ongoing COVID-19 pandemic.

In [\[AGLM-2021\]](#), we employ granular cell-phone data on individual mobility decisions before, during, and after the COVID-19 pandemic to estimate the structural parameters of our dynamic network model. By leveraging this detailed dataset, we gain valuable insights into individuals' mobility patterns and behaviors in response to the evolving circumstances.

Once we estimate the structural parameters of the model, we leverage its flexibility and realism to conduct various policy experiments. These experiments allow us to simulate and evaluate the potential outcomes and impacts of different policy interventions. By systematically altering specific aspects of the model, such as policy measures or behavioral assumptions, we can assess their effects on individual mobility, virus diffusion, and economic outcomes.

3. FIRMS' BIASED BELIEFS AND COMPETITION

Firms' decisions are heavily influenced by their expectations regarding future demand, costs, and the strategies of their competitors. Notably, firms vary in their ability to gather and process information, resulting in divergent beliefs about the future. The heterogeneity in these beliefs holds significant implications for market outcomes, efficiency, and overall welfare. While economists have long acknowledged the importance of firms' heterogeneity in expectation formation and the potential existence of biased or non-equilibrium beliefs, the prevailing approach has typically assumed rational expectations.

In this research program, I develop models, identification techniques, and estimation methods that allow for the presence of biased beliefs among firms concerning future demand, costs, or competitors' decisions.

Identifying firms' beliefs in dynamic oligopoly games

In [AMagesan-2020] and [A-2022], we establish the separate identification of firms' beliefs and firms' costs. In these papers, we address the identification challenge by utilizing data on firms' choices and adopting a revealed preference and beliefs framework. Specifically, we leverage an exclusion restriction commonly observed in competition models: an observable variable that affects a firm's cost but lacks a direct impact on other firms' profits in the market. Examples of such variables include firm-specific input prices and predetermined factors like the firm's capital stock or its incumbency status at previous periods. In [AMagesan-2020], we illustrate our identification strategy, we apply it to a dynamic game of store location conducted by retail chains.

By incorporating these identification techniques, we gain valuable insights into firms' beliefs and their influence on market dynamics. This research program contributes to a deeper understanding of the role of beliefs in shaping firms' decisions and market outcomes, challenging the assumption of rational expectations and shedding light on the potential implications of biased or non-equilibrium beliefs in economic settings.

Identifying agents' preferences and beliefs in laboratory experiments

In [AXie-2021], our research focuses on the identification of players' preferences and beliefs in discrete choice games using experimental data. To achieve this, we conduct an experiment involving a series of games with varying matrices of monetary payoffs. Our objective is to identify players' preferences, specifically their utility of money, and their beliefs regarding the expected behavior of their opponents. Importantly, we aim to accomplish this without imposing equilibrium restrictions or parametric assumptions on utility and belief functions.

We demonstrate that the hypothesis of unbiased or rational beliefs can be tested, provided that the set of games in the experiment generates variation in the monetary payoffs of other players while keeping the own monetary payoff constant. By considering this variation, we establish conditions for the full identification of utility and belief functions at the individual level, without imposing restrictions on players' heterogeneity in preferences or beliefs.

To validate our approach, we apply our method to data from two experiments: a matching pennies game and a public good game. By analyzing these datasets, we are able to identify players' preferences and beliefs in a rigorous and nonparametric manner.

This research contributes to the understanding of how individuals form preferences and beliefs in strategic decision-making situations, providing valuable insights into the dynamics of discrete choice games.

Managerial skills and decentralization of decision-making in retail chains

In [AGuiton-2022], our research focuses on examining the effects of decentralizing decision-making in multi-establishment firms. To investigate this, we utilize a comprehensive dataset obtained from the Liquor Control Board of Ontario (LCBO) and evaluate the impact of granting store managers the authority to control inventory replenishment decisions for their respective stores. By analyzing two years of daily data, we estimate a separate dynamic structural model of inventory management for each store manager within the retail chain.

Our findings reveal a significant level of heterogeneity across the inventory decisions made by the 634 store managers in the retail chain. We identify that a considerable portion of this heterogeneity stems from the diverse perceptions of inventory holding costs held by the managers. Through conducting counterfactual experiments based on the estimated model, we explore the implications of a centralized inventory management system. The results demonstrate that eliminating the heterogeneous skills of store managers would lead to a substantial reduction in ordering and storage costs. On average, this reduction amounts to 23%, with a corresponding decrease of 3.7% for the median store.

However, we also observe a negative impact on profits resulting from the delayed information about demand in a centralized system. Consequently, the net effect of the trade-off between cost reduction and profit decline is relatively modest. Specifically, we find that implementing a centralized inventory system would result in a mere 2% increase in annual profit for LCBO. We further discuss the implications of this trade-off and explore the potential for a more efficient inventory system that combines elements of both centralization and decentralization.

By shedding light on the effects of decentralized decision-making in multi-establishment firms, our research provides insights into the optimization of inventory management systems. These findings contribute to the ongoing discussions surrounding the design of efficient and effective decision-making structures within organizations.

4. BANK COMPETITION AND THE GEOGRAPHIC DIFFUSION OF CREDIT

In [\[ACW-2021\]](#), our research delves into the issue of geographic dispersion in the distribution of depositors, borrowers, and banks, which can hinder the flow of funding to areas with high loan demand and subsequently limit credit access. We aim to provide empirical evidence of this geographic imbalance of deposits and loans while developing a methodology to examine the factors contributing to this imbalance. Specifically, we investigate the role of branch networks, market power, and scope economies using bank-county-year level data.

To assess the extent of the geographic imbalance, we introduce a novel measure (*imbalanced index*) tailored for this purpose. Additionally, we employ a structural model of bank competition that allows for interconnections across locations and between deposit and loan markets. Through estimation and analysis, we uncover the impact of branch networks and competition on the flow of credit.

By conducting counterfactual experiments, we explore the potential effects of various factors on the geographic imbalance. Our findings highlight the significant contributions of branch networks and competition in shaping the flow of credit. However, it is important to note that these factors tend to favor larger and wealthier markets.

The insights gained from our research shed light on the challenges associated with geographic dispersion in the financial system. By better understanding the factors influencing the distribution of deposits and loans, policymakers and industry stakeholders can devise strategies to promote a more balanced and accessible credit market. Ultimately, our work aims to contribute to the ongoing discussions surrounding the equitable provision of financial services across geographic regions.

In [\[ACW-2016\]](#), our research focuses on examining the effects of the 1994 Riegle-Neal Act (RN) in the United States, which removed restrictions on branch-network expansion for banks.

Specifically, we investigate the impact of this regulatory change on banks' geographic risk diversification (GRD).

To measure banks' geographic risk, we employ a factor model that allows us to assess the level of risk diversification achieved by banks. Our analysis reveals that the implementation of RN expanded the possibilities for GRD, particularly in smaller states. However, we observe that only certain large banks took advantage of these opportunities.

Using our measure of geographic risk and an empirical model of branch-network choice, we are able to identify the preferences of banks toward GRD separately from other factors that might limit their network expansion. By conducting counterfactual analyses, we gain insights into the potential impact of various factors on banks' value and decision-making processes.

Our findings indicate that while geographic risk has a negative effect on bank value, this impact is offset by several mitigating factors. Specifically, we observe that economies of density/scale, costs associated with reallocation/merging, and concerns related to local market power play a significant role in counterbalancing the negative effects of risk on bank value.

Through our research, we contribute to the understanding of the implications of regulatory changes on banks' risk diversification strategies. By elucidating the factors influencing banks' decisions regarding geographic risk, our work provides valuable insights for policymakers and industry stakeholders. Ultimately, our aim is to enhance the knowledge surrounding the impact of regulatory reforms on the financial sector's risk management practices and overall stability.

List of Cited Publications and Working Papers (in inverse chronological order)

[A-2023] Aguirregabiria, V. (2023): “Dynamic Demand for Differentiated Products with Fixed-Effects Unobserved Heterogeneity,” *Econometrics Journal*. Forthcoming.

[AGuiton-2022] Aguirregabiria, V., and F. Guiton (2022): “Decentralized Decision-Making in Retail Chains: Evidence from Inventory Management,” manuscript, University of Toronto.

[AGLM-2022] Aguirregabiria, V., J. Gu, Y. Luo, and P. Mira (2022): “Estimation of a Structural Model of Spatial and Time Diffusion of Covid-19 using Cellphone Mobility Data,” manuscript, University of Toronto.

[AGM-2020] Aguirregabiria, V., J. Gu, and P. Mira (2020): “Identification of Structural Parameters in Dynamic Discrete Choice Games with Fixed Effects Unobserved Heterogeneity,” manuscript, University of Toronto.

[ACarro-2022] Aguirregabiria, V., and J. Carro (2022): “Identification of Average Marginal Effects in Fixed Effects Dynamic Discrete Choice Models,” manuscript, University of Toronto.

[AMagesan-2021] Aguirregabiria, V., and A. Magesan (2021): “Solution and Estimation of Dynamic Discrete Structural Models Using an Euler-Equations Mapping,” manuscript, University of Toronto.

[AMarcoux-2021] Aguirregabiria, V., and M. Marcoux (2021): “Imposing Equilibrium Restrictions in the Estimation of Dynamic Discrete Games,” *Quantitative Economics*, 12(4), 1223-1271.

[AGL-2021] Aguirregabiria, V., J. Gu, and Y. Luo (2021): “Sufficient Statistics for Unobserved Heterogeneity in Structural Dynamic Logit Models,” *Journal of Econometrics*, 223(2), 280-311.

[AGLM-2021] Aguirregabiria, V., J. Gu, Y. Luo, and P. Mira (2021): “Diffusion of COVID-19 in Social and Production Networks: Simulation Evidence from A Dynamic Model,” *Annals of Economics and Statistics*, 142, 179-210.

[A-2021] Aguirregabiria, V. (2021): “Identification of Firms’ Beliefs in Structural Models of Competition.” *Canadian Journal of Economics*, 54(1), 5-33.

[AXie-2021] Aguirregabiria, V., and E. Xie (2021): “Identification of Non-Equilibrium Beliefs in Games of Incomplete Information Using Experimental Data,” *Journal of Econometric Methods*, 10(1), 1-26.

[ACW-2020] Aguirregabiria, V., R. Clark, and H. Wang (2020): “The Geographic Flow of Bank Funding: Branch Networks and Local-Market Competition,” manuscript, University of Toronto.

[AMagesan-2020] Aguirregabiria, V., and A. Magesan (2020): “Estimation of Dynamic Discrete Games when Players’ Beliefs are not in Equilibrium,” *The Review of Economic Studies*, 87(2), 582–625.

[AMira-2019] Aguirregabiria, V., and P. Mira (2019): “Identification of Games of Incomplete Information with Multiple Equilibria and Unobserved Heterogeneity,” *Quantitative Economics*, 10(4), 1659-1701.

[AVicentini-2019] Aguirregabiria, V., and G. Vicentini (2016): “Dynamic Spatial Competition between Multi-Store Firms,” *Journal of Industrial Economics*, 64(4), 710-754.

[ACW-2019] Aguirregabiria, V., R. Clark, and H. Wang (2016): “Diversification of Geographic Risk in Retail Bank Networks: Evidence from Bank Expansion after the Riegle-Neal Act,” *RAND Journal of Economics*, 47(3), 529-572.

[ASuzuki-2014] Aguirregabiria, V., and J. Suzuki (2014): “Identification and Counterfactuals in Dynamic Models of Market Entry and Exit,” *Quantitative Marketing and Economics*, 12, 267-304.

[AMagesan-2013] Aguirregabiria, V., and A. Magesan (2013): “Euler Equations for Estimation of Dynamic Discrete Choice Structural Models,” *Advances in Econometrics*, Volume 31, *Structural Microeconometrics*, E. Choo and M. Shum, eds., 3-44.

[AHo-2012] Aguirregabiria, V., and CY. Ho (2012): “A Dynamic Oligopoly Game of the US Airline Industry: Estimation and Policy Experiments,” *Journal of Econometrics*, 168, 156-173.

[AMira-2007] Aguirregabiria, V., and P. Mira (2007): “Sequential Estimation of Dynamic Discrete Games,” *Econometrica*, 75(1), 1-53.

[AMira-2002] Aguirregabiria, V., and P. Mira (2002): “Swapping the Nested Fixed Point Algorithm: A Class of Estimators for Discrete Markov Decision Models,” *Econometrica*, 70, 1519-1543.