



BANK OF CANADA
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Bank of Canada Quarterly Research Update

2025Q1

This quarterly newsletter features the latest research publications by Bank of Canada economists. The report includes papers appearing in external publications and staff working papers published on the Bank of Canada's website.

PUBLISHED PAPERS

In-Press

Amor Aniss Benmoussa & Reinhard Ellwanger & Stephen Snudden, “Carpe Diem: Can Daily Oil Prices Improve Model-Based Forecasts of the Real Price of Crude Oil?”, *International Journal of Forecasting*, March 2025 (online version)

Efrem Castelnovo & Kerem Tuzcuoglu & Luis Uzeda, “Sectoral Uncertainty: A Hierarchical-Volatility Approach”, *Journal of Business & Economic Statistics*, March 2025 (online version)

Pablo Castro & Ajit Desai & Han Du & Rodney Garratt & Francisco Rivadeneyra, “Estimating Policy Functions in Payment Systems Using Reinforcement Learning”, *ACM Transactions on Economics and Computation*, Vol. 13(1), February 2025

Y.-H. Henry Chen & Hossein Jebeli & Craig Johnston & Sergey Paltsev & Marie-Christine Tremblay, “Impacts of Border Carbon Adjustments on the Canadian Economy”, *Energy Economics*, Vol. 141, January 2025

Michael B. Devereux & Wei Dong & Ben Tomlin, “Trade Flows and Exchange Rates: Importers, Exporters and Products”, *Journal of International Economics*, Vol. 154, March 2025

Reinhard Ellwanger, “The Tail Risk Premium in the Oil Market”, *Energy Economics*, Vol. 141, January 2025

Joep Lustenhouwer & Isabelle Salle, “Learning to be Rational in the Presence of News: A Lab Investigation”, *European Economic Review*, Vol. 172, February 2025

Blake Debruin Martos & Rodrigo Sekkel & Henry Stern & Xu Zhang, “Is Anyone Surprised? the High-Frequency Impact of U.S. and Domestic Macro Data Announcements on Canadian Asset Prices”, *Economics Letters*, Vol. 248, March 2025

James Younker, “Calculating Effective Degrees of Freedom for Forecast Combinations and Ensemble Models”, *Economics Letters*, Vol. 247, February 2025

Forthcoming

Gregor Boehl & **Cars Hommes**, “Rational vs. Irrational Beliefs in a Complex World”, *Journal of Economic Behavior & Organization*

Elizabeth Caucutt & Lance Lochner & Joseph Mullins & **Youngmin Park**, “Child Skill Production: Accounting for Parental and Market-Based Time and Goods Investments”, *Journal of Political Economy*

Tony Chernis & Niko Hauzenberger & Florian Huber & Gary Koop & James Mitchell, “Predictive Density Combination Using a Tree-Based Synthesis Function”, *International Economic Review*

Thibaut Duprey & **Kerem Tuzcuoglu**, “High-Frequency Effects of Macroprudential Policy Announcements”, *Economics Letters*

Reinhard Ellwanger & Stephen Snudden, “Putting VAR Forecasts of the Real Price of Crude Oil to the Test”, *Finance Research Letters*

Joao Granja & **Nuno Paixao**, “Bank Consolidation and Uniform Pricing”, *Journal of Financial Economics*

Igor Livshits & **Youngmin Park**, “Democratic Political Economy of Financial Regulation”, *International Economic Review*

STAFF WORKING PAPERS

Christian Friedrich & Hanno Friedrich & **Nick Lawrence** & Javier Cortes Orihuela & **Phoebe Tian**, “The International Exposure of the Canadian Banking System”, Bank of Canada Staff Working Paper 2025-1

Michael Brolley & **David Cimon**, “Non-Bank Dealing and Liquidity Bifurcation in Fixed-Income Markets”, Bank of Canada Staff Working Paper 2025-2

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Stéphane Surprenant, “Quantile VARs and Macroeconomic Risk Forecasting”, Bank of Canada Staff Working Paper 2025-4

Olena Kostyshyna & Isabelle Salle & Hung Truong, “Anchored Inflation Expectations: What Recent Data Reveal”, Bank of Canada Staff Working Paper 2025-5

Joaquín Saldain, “High-Cost Consumer Credit: Desperation, Temptation and Default”, Bank of Canada Staff Working Paper 2025-6

Alex Chernoff & Allen Head & Beverly Lapham, “Markups, Pass-Through, and Firm Heterogeneity with Sequentially Mixed Search”, Bank of Canada Staff Working Paper 2025-7

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Zhentong Lu & Kenichi Shimizu, “Estimating Discrete Choice Demand Models with Sparse Market-Product Shocks”, Bank of Canada Staff Working Paper 2025-10

Lu Han, “The Mutable Geography of Firms’ International Trade”, Bank of Canada Staff Working Paper 2025-11

Phoebe Tian & Yu Zhu, “Liquidation Mechanisms and Price Impacts in DeFi”, Bank of Canada Staff Working Paper 2025-12

STAFF DISCUSSION PAPERS

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Sebastian Hernandez & **Badr Omrane** & David Pereyra & Vera Roberts & Helena Wang, “Tech Reluctance: Fostering Empathy for Canadians Facing Challenges with Digital Systems”, Bank of Canada Staff Discussion Paper 2025-2

Justin-Damien Guénette & Lin Shao, “Assessing the Impact of Demographic Composition on Productivity”, Bank of Canada Staff Discussion Paper 2025-3

Daniela Balutel & Marie-Hélène Felt & Doina Rusu, “[Canadian Bitcoin Ownership in 2023: Key Takeaways](#)”, Bank of Canada Staff Discussion Paper 2025-4

David Cimon & Jean-Philippe Dion & Jean-Sébastien Fontaine & Jabir Sandhu, “[Will Asset Managers Dash for Cash? Implications for Central Banks](#)”, Bank of Canada Staff Discussion Paper 2025-5

Jack Mandin, “[Risk-Free Uncollateralized Lending in Decentralized Markets: An Introduction to Flash Loans](#)”, Bank of Canada Staff Discussion Paper 2025-6

ABSTRACTS

Papers In-Press

[Carpe Diem: Can Daily Oil Prices Improve Model-Based Forecasts of the Real Price of Crude Oil?](#)

This paper proposes techniques to include information from the underlying nominal daily series in model-based forecasts of average real series. We apply these approaches to forecasts of the real price of crude oil. Models utilizing information from daily prices yield large forecast improvements and, in some cases, almost halve the forecast error compared to current specifications. We demonstrate for the first time that model-based forecasts of the real price of crude oil can outperform the traditional random walk forecast, which is the end-of-month no-change forecast, at short forecast horizons.

[Sectoral Uncertainty: A Hierarchical-Volatility Approach](#)

We propose a new empirical framework to estimate sectoral uncertainty from data-rich environments. We jointly decompose the conditional variance of economic time series into a common, a sector-specific, and an idiosyncratic component. By specifying a hierarchical-factor structure to stochastic volatility modeling, our framework combines both dimension reduction and flexibility. To estimate the model, we develop an efficient Markov Chain Monte Carlo algorithm based on precision sampling techniques. We apply our framework to a large dataset of disaggregated industrial production series for the U.S. economy. Our findings suggest that: (i) uncertainty is heterogeneous at a sectoral level; and (ii) durable goods uncertainty may drive some business cycle effects typically attributed to aggregate uncertainty.

[Estimating Policy Functions in Payment Systems Using Reinforcement Learning](#)

This paper uses reinforcement learning (RL) to approximate the policy rules of banks participating in a high-value payment system (HVPS). The objective of the RL agents is to learn a policy function for the choice of amount of liquidity provided to the system at the beginning of the day and the rate at which to pay intraday payments. Individual choices have complex strategic effects precluding a closed form solution of the optimal policy, except in simple cases. We show that in a stylized two-agent setting, RL agents learn the optimal policy that minimizes the cost of processing their individual payments—without complete knowledge of the environment. We further

demonstrate that in more complex settings, both agents learn to reduce the cost of processing their payments and effectively respond to liquidity-delay trade-off. Our results show the potential of RL to solve liquidity management problems in HVPS and provide new tools to assist policymakers in their mandates of ensuring safety and improving the efficiency of payment systems.

Impacts of Border Carbon Adjustments on the Canadian Economy

This paper examines how border carbon adjustments (BCAs) may address the consequences of uncoordinated global climate action, focusing on the economic impacts for Canada. We investigate these impacts under different BCA design features and by considering a coalition of countries and regions that adopt BCAs. We find that when Canada is within a coalition of BCA-implementing countries including the United States, BCA measures in the form of import tariffs reduce Canada's carbon leakage and boost domestic and foreign competitiveness. We show that these results may change if Canada imposes BCAs on a different set of sectors than the rest of the coalition or includes export rebates and free emissions allowances to firms. When Canada remains in the coalition while the United States does not, we show that Canada's carbon leakage increases, domestic competitiveness weakens, and foreign competitiveness improves.

Trade Flows and Exchange Rates: Importers, Exporters and Products

Using highly-disaggregated transaction-level trade data, we document the importance of new firm-level trade partner relationships and the addition of new products to existing relationships in driving aggregate trade flows. Moreover, we find that these margins are sensitive to movements in the exchange rate and that larger firms are substantially more responsive in terms of both the number of trade partners and products. These findings are then rationalized in a model of international trade with endogenous matching between heterogeneous importers and exporters. Simulations of the model highlight: (1) a new channel through which exchange rates influence short-run trade flows; and (2) the importance of firm heterogeneity—on both sides of trade transactions—in the adjustment process.

The Tail Risk Premium in the Oil Market

This paper studies tail risk and its option-implied risk compensation in the crude oil market. We identify economically large premia for upside and downside tail risks that significantly forecast crude oil futures returns. These premia are also reflected in the convenience yield for

physical oil, which amplifies the predictive power for spot returns. Oil tail risk premia are not spanned by aggregate uncertainty measures, suggesting that shifts in market-specific risk attitudes contribute to commodity price volatility and return predictability.

Learning to be Rational in the Presence of News: A Lab Investigation

We conduct a laboratory experiment in a micro-founded macroeconomic model where participants receive public announcements about future government spending shocks, and are tasked with repeatedly forecasting output over a given horizon. By eliciting several-period-ahead predictions, we can investigate forecast revisions in relation to these announcements. We find that subjects learn the magnitude of the effect of the shocks on output, albeit not with perfect accuracy. We find micro-level evidence that they persistently underreact to the announcements in a way consistent with sticky information, but find little support for fully backward-looking expectations. We rationalize the experimental data with a Bayesian updating model, which provides a particularly good description of the behaviors in longer-horizon environments and among attentive, experienced, and effortful subjects.

Is Anyone Surprised? the High-Frequency Impact of U.S. and Domestic Macro Data Announcements on Canadian Asset Prices

We show how Canadian interest rates, the CAD/USD spot exchange rate, and stock market returns react to both U.S. and domestic macro announcements using almost two decades of detailed high-frequency data. We find that Canadian macro announcements invoke greater responses in short-term yields, whereas U.S. macro announcements play an increasingly important role in the yield movements of longer-term assets. While U.S. macro announcements are relatively more important to explain changes in Canadian stock market returns, domestic macro announcements have a larger impact on the CAD/USD spot exchange rate. We discuss the significance of our results for understanding the factors that influence Canadian financial markets.

Calculating Effective Degrees of Freedom for Forecast Combinations and Ensemble Models

Forecast combinations, also known as ensemble models, routinely require practitioners to select a model from a massive number of potential candidates. Ten explanatory variables can be grouped into 2^{1078} forecast combinations, and the number of possibilities increases further to $2^{(1078+2^{1078})}$ if we allow for forecast

combinations of forecast combinations. This paper derives a calculation for the effective degrees of freedom of a forecast combination under a set of general conditions for linear models. It also supports this calculation with simulations. The result allows users to perform several other computations, including the F-test and various information criteria. These computations are particularly useful when there are too many candidate models to evaluate out of sample. Furthermore, computing effective degrees of freedom shows that the complexity cost of a forecast combination is driven by the parameters in the weighting scheme and the weighted average of parameters in the auxiliary models as opposed to the number of auxiliary models. This identification of complexity cost contributions can help practitioners make informed choices about forecast combination design.

Forthcoming Papers

[Rational vs. Irrational Beliefs in a Complex World](#)

How do rational and boundedly rational agents interact in a competitive asset market? To answer this question, we build a highly nonlinear asset pricing model where agents hold heterogeneous beliefs. Our model features fully rational forward looking agents versus boundedly rational backward looking agents whose market shares evolve endogenously. This gives rise to chaotic model dynamics which are characterized by complex bubble and crash dynamics, even without any exogenous fluctuations. We show that computational methods can be applied to numerically analyze models combining agents forming rational expectations and agents forming extrapolative expectations, with the possibility of transition between one type of behavior and the other. Not only do we find that boundedly rational agents remain in the market, but document that their effect on price dynamics is even amplified by the behavior of fully rational agents. In their interaction, trend-extrapolators amplify small deviations from fundamentals, while rational agents eventually anticipate market crashes after large bubbles and drive prices back to the fundamental.

[Child Skill Production: Accounting for Parental and Market-Based Time and Goods Investments](#)

Families invest parental time, home goods/services, and market-based child care in their children. We study these investments, focusing on two issues: the role of parental human capital and the substitutability of inputs in the skill production process. We develop a

relative demand estimation strategy that uses intratemporal optimality to estimate the substitutability and relative productivity of different inputs. This approach assumes that families are knowledgeable about these features of the skill production technology, but it does not require data on skills and easily addresses measurement error in inputs. We show how relative demand restrictions can simplify and improve estimation of the dynamics of skill production when incorporating panel data on skill measures. Combining data on relative demand and skill dynamics further allows researchers to test whether beliefs about skill production align with the true technology. Using data from the Child Development Supplement of the PSID, we estimate the skill production technology for American children ages 5–12, finding moderately strong complementarity between inputs. We estimate little effect of parental education on the child production technology: more-educated parents invest more because they have higher incomes and stronger preferences for children’s skills. Counterfactual simulations show that the degree of input complementarity we estimate has important implications for policies that subsidize specific inputs or provide free child care.

Predictive Density Combination Using a Tree-Based Synthesis Function

Bayesian predictive synthesis (BPS) provides a method for combining multiple predictive distributions based on agent/expert opinion analysis theory and encompasses a range of existing density forecast pooling methods. The key ingredient in BPS is a “synthesis” function. This is typically specified parametrically as a dynamic linear regression. In this paper, we develop a nonparametric treatment of the synthesis function using regression trees. We show the advantages of our tree-based approach in two macroeconomic forecasting applications. The first uses density forecasts for GDP growth from the euro area’s Survey of Professional Forecasters. The second combines density forecasts of US inflation produced by many regression models involving different predictors. Both applications demonstrate the benefits – in terms of improved forecast accuracy and interpretability – of modeling the synthesis function nonparametrically.

High-Frequency Effects of Macroprudential Policy Announcements

We investigate high-frequency impacts of macroprudential policy announcements using novel Canadian daily data. Lender-side tightening announcements reduce large banks’ perceived systemic risks but decrease bank stock prices. Borrower-side tightening

announcements increase mortgage rate spreads and real estate investment stock prices.

Putting VAR Forecasts of the Real Price of Crude Oil to the Test

This study reevaluates crude oil price forecasts from state-of-the-art VAR models (Baumeister et al., 2022). Unlike Baumeister et al., who use the average-price no-change forecast, we employ the end-of-period no-change forecast, corresponding to the traditional random walk hypothesis. VAR forecasts do not significantly outperform the random walk for horizons under one year. The average-price benchmark systematically biases the Diebold–Mariano test statistic, affecting inference on forecast improvements up to 18 months. Similar biases are observed for alternative forecast criteria. The fact that naive benchmark choice alters inference even at extended horizons is relevant for all forecasts targeting averaged series.

Bank Consolidation and Uniform Pricing

We evaluate how bank mergers affect consumer welfare when banks set deposit rates with a high degree of uniformity across their branch networks. First, we document that merger-induced changes to local market concentration are only weakly correlated with pricing decisions. Second, we develop a structural model of the banking sector to simulate equilibrium post-merger deposit rates with and without uniform pricing. The simulated deposit rates from the model with uniform pricing best match the observed changes in deposit rates following bank mergers. We use the model to evaluate antitrust decisions that force acquirers to divest branches in order to contain local market concentration levels. Our counterfactual exercises suggest that forced divestitures sometimes improve consumer welfare but can also impose consumer welfare losses when antitrust regulators do not consider that uniform pricing practices might lead to better deposit rates at acquired branches after a merger.

Democratic Political Economy of Financial Regulation

This paper offers a simple theory of inefficiently lax financial regulation arising as an outcome of a democratic political process. Lax financial regulation encourages some banks to issue risky residential mortgages. In the event of an adverse aggregate housing shock, these banks fail. When banks do not fully internalize the losses from such failures (due to limited liability), they offer mortgages at less than actuarially fair interest rates. This opens the door to homeownership for young, low net-worth individuals. In turn, the additional demand from these new home-buyers drives up house

prices. This leads to a non-trivial distribution of gains and losses from lax regulation among households. On the one hand, renters and individuals with large non-housing wealth suffer from the fragility of the banking system. On the other hand, some young middle-wealth households are able to get a mortgage and buy a house, and current (old) homeowners benefit from the increase in the price of their houses. When these latter two groups, who benefit from the lax regulation, constitute a majority of the voting population, then regulatory failure can be an outcome of the democratic political process. We find empirical support for this mechanism in the voting patterns in U.S. Congress, where members from districts with higher homeownership rates or lower income inequality (larger middle class) tended to vote for lax mortgage regulation prior to the Great Financial Crisis.

Staff Working Papers

[The International Exposure of the Canadian Banking System](#)

In 2023, the share of Canadian banks' foreign assets and liabilities amounted to around 50%. While Canadian banks engage domestically mostly with households and non-financial corporations, their most common counterparties abroad are non-bank financial institutions.

[Non-Bank Dealing and Liquidity Bifurcation in Fixed-Income Markets](#)

Non-bank financial institutions, such as principal-trading firms and hedge funds, increasingly compete with bank-owned dealers in fixed-income markets. Some market participants worry that if non-bank financial institutions push out established bank dealers, liquidity will become unreliable during times of stress. We model non-bank entry and state-dependent liquidity provision. Non-bank participants improve liquidity more during normal times than in stress, leading to a bifurcation of liquidity. In the cross-section, their entry improves liquidity for large and previously unserved small clients; however, banks may no longer provide reliable liquidity to marginal clients. Central bank lending may limit harmful bifurcation during times of stress if that lending is predictable and at sufficiently favourable terms.

[Differentiable, Filter Free Bayesian Estimation of DSGE Models Using Mixture Density Networks](#)

I develop a methodology for Bayesian estimation of globally solved, non-linear macroeconomic models. A novel feature of my method is

the use of a mixture density network to approximate the distribution of initial states. I use the methodology to estimate a medium-scale, two-agent New Keynesian model with irreversible investment and a zero lower bound on nominal interest rates. Using simulated data, I show that the method is able to recover the “true” parameters when using the mixture density network approximation of the initial state distribution. This contrasts with the case when the initial states are set to their steady-state values.

Quantile VARs and Macroeconomic Risk Forecasting

Recent rises in macroeconomic volatility have prompted the introduction of quantile vector autoregression (QVAR) models to forecast macroeconomic risk. This paper provides an extensive evaluation of the predictive performance of QVAR models in a pseudo-out-of-sample experiment spanning 112 monthly US variables over 40 years, with horizons of 1 to 12 months. We compare QVAR with three parametric benchmarks: a Gaussian VAR, a generalized autoregressive conditional heteroskedasticity VAR and a VAR with stochastic volatility. QVAR frequently, significantly and quantitatively improves upon the benchmarks and almost never performs significantly worse. Forecasting improvements are concentrated in the labour market and interest and exchange rates. Augmenting the QVAR model with factors estimated by principal components or quantile factors significantly enhances macroeconomic risk forecasting in some cases, mostly in the labour market. Generally, QVAR and the augmented models perform equally well. We conclude that both are adequate tools for modeling macroeconomic risks.

Anchored Inflation Expectations: What Recent Data Reveal

We analyze micro-level data from the Canadian Survey of Consumer Expectations through the lens of a heterogeneous-expectations model to study the state-dependent risk of inflation expectations unanchoring in low- and high-inflation environments. In our model, agents are either trend-chasing or mean-reverting forecasters of inflation. We interpret the degree of mean reversion in inflation expectations as a measure of anchoring, which varies over time with the share of agents using each approach. We find that during the post-pandemic inflation spike, trend-chasing expectations surged, resulting in a heightened risk of unanchoring expectations and entrenching above-target inflation. Furthermore, forming trend-chasing inflation expectations is associated with higher expectations for other key economic variables — such as interest rates, wages,

and house prices — and a restraint in household spending. We provide additional new insights into household expectation formation, documenting that forecasting behaviors, attention, and noise in beliefs vary across socio-demographic groups and correlate with views about monetary policy.

High-Cost Consumer Credit: Desperation, Temptation and Default

I study the welfare consequences of regulations on high-cost consumer credit in the United States. I estimate a heterogeneous-agents model with uninsurable idiosyncratic risk, risk-based pricing of loans, and preference heterogeneity including households with self-control issues. I find that one-third of high-cost borrowers suffer from self-control issues. Noncontingent regulatory borrowing limits have distributional consequences within households with self-control issues. High-income households benefit from restrictions on borrowing because they face loose price schedules from lenders that allow them to overborrow. Low-income households face tight individually targeted loan price schedules that limit households' borrowing capacity so that borrowing restrictions cannot improve welfare over them.

Markups, Pass-Through, and Firm Heterogeneity with Sequentially Mixed Search

We study the determination of market power at the firm and industry levels when heterogeneous firms compete for sales to ex ante homogeneous buyers in a market with both directed and random search and free entry of firms that differ in productivity. Search and the distribution of productivity across active firms generate distributions of equilibrium prices and markups that we relate to variation in the elasticity of demand at the firm level. With directed search at the outset, a shock that raises the matching rate for buyers improves conditions for them and tends to lower markups. Random matching follows sequentially, and the same shock can lower the productivity threshold for operation, pushing up prices and markups for all firms. The net effect on market power can be ambiguous depending on the forces driving matching rates. The distributions of prices and markups respond in equilibrium to changes in common and firm-specific costs, consumption utility, and fixed costs of both entry and operation. We characterize the differential pass-through of these changes to prices and markups at both the firm and market levels.

Breaking Down the US Employment Multiplier Using Micro-Level Data

We use restricted data from the Quarterly Census of Employment and Wages to link the universe of US establishments with the universe of contractors in the Federal Procurement Data System. Leveraging detailed institutional knowledge of federal acquisitions, we construct a new dataset of unanticipated contracts and examine their effects on employment growth. We find positive, significant and persistent effects on firms with fewer than 150 employees. Using loan data from the US Federal Reserve (Y14-Q), we show that small firms expand their credit and receive lower interest rates after winning unanticipated contracts. At the regional level, we estimate a cost-per-job of US\$57,000 per year using unanticipated contracts—an order of magnitude lower than previous estimates based on all defense contracts. Lastly, we leverage the restricted census data to decompose the employment multiplier into a direct effect on contractors of 55% and an indirect effect on noncontractors of 45%.

The Prudential Toolkit with Shadow Banking

Several countries now require banks or money market funds to impose state-contingent costs on short-term creditors to absorb financial stress. We study these requirements as part of the broader prudential toolkit using a model with five key ingredients: banks may face an aggregate stress state with high withdrawals; a fire-sale externality motivates a mix of non-contingent and state-contingent regulation; banks may use shadow technologies to circumvent regulation; parameters of the shadow technologies may be private information; and bailouts may occur. We characterize the optimal policy for various combinations of these ingredients and demonstrate that the threat of shadow activities constrains state-contingent regulation more than non-contingent regulation, especially when imperfect information and limited commitment coexist. The planner triggers shadow activities with positive probability under imperfect information, and shadow activities that deplete resources in the stress state elicit larger bailouts under limited commitment, rendering the requirement of state-contingent costs a weak instrument.

Estimating Discrete Choice Demand Models with Sparse Market-Product Shocks

We propose a new approach to estimating the random coefficient logit demand model for differentiated products when the vector of market-product-level shocks is sparse. Assuming sparsity, we establish nonparametric identification of the distribution of random

coefficients and demand shocks under mild conditions. Then we develop a Bayesian estimation procedure, which exploits the sparsity structure using shrinkage priors, to conduct inference about the model parameters and counterfactual quantities. Compared with the standard BLP (Berry, Levinsohn, and Pakes 1995) method, our approach does not require demand inversion or instrumental variables (IVs), and thus provides a compelling alternative when IVs are not available or their validity is questionable. Monte Carlo simulations validate our theoretical findings and demonstrate the effectiveness of our approach, while empirical applications reveal evidence of sparse demand shocks in well-known datasets.

The Mutable Geography of Firms' International Trade

Exporters frequently change their set of destination markets. This paper proposes a new approach to identifying the underlying drivers of changes in exporters' market decisions over time. The approach exploits information on the price and quantity of the changes in firms' continuing markets, to uncover the microshocks that drive firms' market changes. Applying the method to customs data from China (2000-2006) and the UK (2010-2016), I find consistent results showing that most firm- and firm-product-level market changes are driven by demand-related shocks, with a nontrivial proportion of these changes being correlated across markets.

Liquidation Mechanisms and Price Impacts in DeFi

This paper examines the price impacts of liquidations in decentralized finance (DeFi) lending and how they vary with fixed-spread and auction-based liquidation mechanisms. Using a theoretical framework, we show that the impact of these mechanisms depends on the liquidator participation cost, which determines the level of competition. Auctions mitigate the price impact of liquidations when the participation cost is low, but amplify them when it is high. Empirical analysis of Ethereum blockchain data shows that auction-based liquidations lead to smaller price drops by increasing competition, which raises collateral prices and reduces liquidation volumes. These findings underscore the importance of liquidation design in promoting market stability and mitigating fire-sale risks in DeFi lending.

Staff Discussion Papers

Privacy-Enhancing Technologies for CBDC Solutions

With the rapid digitization of financial transactions, central banks have given considerable focus in recent years to the research and development of central bank digital currencies (CBDCs). While CBDCs could offer several advantages, there are concerns about end-user privacy. Traditional methods of protecting confidentiality in banking and financial systems have primarily relied on data encryption and access control techniques. However, these techniques alone are inadequate, especially in cases where data are shared across different entities because privacy in such situations is typically governed by legal frameworks. Privacy-enhancing technologies (PETs) can offer robust protection for data throughout their lifecycle, whether stored, in transit or during processing, and ensure privacy is maintained even when data are extensively shared or analyzed. This study explores the use of PETs in the design of CBDC systems, potentially paving the way for solutions that better safeguard end-user privacy and meet rigorous data protection standards. While PETs promise significant advancements in privacy protection, they present some challenges in implementation. They can introduce performance overheads and add complexity to systems, and their effectiveness and applicability are currently limited due to their early stage of development. As these technologies evolve, it is crucial for organizations to carefully consider these factors to fully leverage PET benefits while managing associated challenges. This paper provides a comprehensive overview of how PETs can transform privacy design in financial systems and the implications of their broader adoption.

Tech Reluctance: Fostering Empathy for Canadians Facing Challenges with Digital Systems

Designing inclusive and user-friendly digital payment systems is crucial to eliminate barriers faced by users. This research focuses on fostering empathy for and identifying the needs of users who exhibit behaviours that indicate they encounter accessibility or usability barriers in digital systems. Specifically, we examine two types of users based on two common behaviours: users who rely on others to perform tasks and those who avoid interacting with technology.

The Bank of Canada partnered with the Inclusive Design Research Centre at OCAD University to gain a deeper understanding of these groups. Co-design sessions with end users were used to identify

scenarios when cooperative efforts are needed, system features that facilitate supported banking and pain points customers and their support people encounter.

The findings show that individuals in the two groups avoid systems they expect lack usability. Addressing these issues through standard accessibility practices, live assistance and thoughtful interface design can enhance user interaction and trust. For accessibility issues that cannot realistically be eliminated, technology that enhances cooperative relationships and allows account owners to control information sharing is key.

Assessing the Impact of Demographic Composition on Productivity

We examine how demographic factors influence potential output, focusing on how the age distribution of the working-age population and the old-age dependency ratio affect aggregate productivity. Following Feyrer (2007), we emphasize that the contribution to aggregate productivity varies by age group, with middle-aged individuals (aged 40 to 49) being the most productive. Our analysis shows that changes in demographic composition could explain some of the productivity trends observed in China and the United States over the past few decades. This demonstrates why it is important to incorporate the impact of demographic composition when estimating potential output. In particular, demographic factors are expected to narrow the differential in trend labour productivity (TLP) growth between China and the United States by nearly 1 percentage point between 2024 and 2030. On average, TLP growth in China could be reduced by 0.8 percentage points, while that in the United States could rise by 0.1 percentage point. Moreover, demographic factors in Canada portray a similar story to that of the United States. After averaging about 1 percentage point per year from 2010 to 2019, demographic headwinds are expected to dissipate fully through the 2020s, which could signal an upside risk to Canadian TLP growth.

Canadian Bitcoin Ownership in 2023: Key Takeaways

We provide an update on cryptoasset ownership in Canada using data from the Bitcoin Omnibus Survey (BTCOS) conducted in late 2023. Bitcoin ownership remained stable at around 10% in 2023 and continues to be concentrated among men, younger individuals and those with higher income and levels of education. The use of Bitcoin for payments remains limited, with most owners viewing it primarily as an investment. Despite growing awareness of alternative

cryptocurrencies, Bitcoin remains the dominant holding among Canadians, with a median value of Can\$500.

Will Asset Managers Dash for Cash? Implications for Central Banks

In times of stress, if the potential demand from asset managers for market liquidity approaches or exceeds dealers' ability to intermediate, it could lead to a precautionary but disruptive dash for cash and may lead central banks to intervene. If the likelihood of such a dash for cash increases in the future, central banks may wish to consider enhancing their tool kits to provide asset managers with greater access to cash-like assets, regardless of dealers' capacity to intermediate, while managing moral hazard and asset managers' expectations of support from central banks in a crisis. We explore ways for central bank to use new facilities that make it easier for asset managers to convert existing assets to cash as well as possible ways to introduce new assets with liquidity that central banks would guarantee.

Risk-Free Uncollateralized Lending in Decentralized Markets: An Introduction to Flash Loans

A flash loan is a special type of uncollateralized loan with zero default risk that is native to blockchain ecosystems. Since its inception in 2018, the technology has seen significant adoption across decentralized finance markets, having facilitated over US\$2 trillion in lending activity in 2024 on Ethereum-Virtual-Machine-compatible (EVM-compatible) blockchains. Despite their high levels of adoption, flash loans are not well understood by academics and central bank researchers. I provide a detailed description of flash loans, document their usage across major EVM-compatible blockchains, present key findings from the data, and provide the necessary background and context to motivate further research on the topic. Key results show that flash loans expand access to liquidity and are used by highly sophisticated actors for many practical applications.

UPCOMING EVENTS

Giancarlo Corsetti (European University Institute)

Organizer: INT Seminar Series

Date: 1 April 2025

Romina Ruprecht (Federal Reserve Board)

Organizer: BAP Seminar Series

Date: 1 April 2025

Toni Ahnert (European Central Bank)

Organizer: EFR Seminar Series

Date: 8 April 2025

Jake Orchard (Federal Reserve Board)

Organizer: INT Seminar Series

Date: 11 April 2025

Michele Dathan (Federal Reserve Board)

Organizer: FMD Seminar Series

Date: 15 April 2025

Ping McLemore (Federal Reserve Bank of Richmond)

Organizer: FSD Seminar Series

Date: 15 April 2025

Joao Ritto (University of Toronto)

Organizer: FSD Seminar Series

Date: 22 April 2025

Thomas Drechsel (University of Maryland)

Organizer: CEA Seminar Series

Date: 25 April 2025