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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

Jason Allen & Robert Clark & Brent Hickman & Eric Richert, “Resolving Failed Banks: Uncertainty, Multiple Bidding, and Auction Design”, *Review of Economic Studies*, Vol. 91(3): 1201-1242, May 2024

Scott Cameron & Babak Hamidzadeh, “Preserving Paradata for Accountability of Semi-Autonomous AI Agents in Dynamic Environments: An Archival Perspective”, *Telematics and Informatics Reports*, Vol. 14, June 2024

Christoph Carnehl & **Andre Stenzel** & Peter Schmidt, “Pricing for the Stars: Dynamic Pricing in the Presence of Rating Systems”, *Management Science*, Vol. 70(3), May 2024

Tony Chernis, “Combining Large Numbers of Density Predictions with Bayesian Predictive Synthesis”, *Studies in Nonlinear Dynamics and Econometrics*, Vol. 28(2): 293-317, April 2024

Bruno Feunou, “Generalized Autoregressive Positive-Valued Processes”, *Journal of Business & Economic Statistics*, Vol. 42(2): 786-800, 2024

Xing Gu & Rogemar Mamon & **Thibaut Duprey**, “Interfacing Learning Methods for Anomaly Detection in Multi-Country Financial Stress Indicators”, *Knowledge-Based Systems*, Vol. 294, June 2024

Myrna Hennequin & **Cars Hommes**, “Managing Bubbles in Experimental Asset Markets with Monetary Policy”, *Journal of Money, Credit and Banking*, Vol. 56(3): 429-454, April 2024

Martin Kuncil & **Alexander Ueberfeldt**, “Monetary Policy and the Persistent Aggregate Effects of Wealth Redistribution”, *Journal of Monetary Economics*, Vol. 144, May 2024

Cesaire Meh & Vincenzo Quadrini & **Yaz Terajima**, “Limited Nominal Indexation of Optimal Financial Contracts”, *Journal of the European Economic Association*, Vol. 22(2): 575-616, April 2024

Andrea Ugolini & Juan C. Reboredo & **Javier Ojea-Ferreiro**, “Is Climate Transition Risk Priced into Corporate Credit Risk? Evidence from Credit Default Swaps”, *Research in International Business and Finance*, Vol. 70, June 2024

Andrea Ugolini & Juan C. Reboredo & **Javier Ojea-Ferreiro**, “Tail Risks of Energy Transition Metal Prices for Commodity Prices”, *Resources Policy*, Vol. 93, June 2024

Forthcoming

Jason Allen & Robert Clark & Jean-Francois Houde & **Shaoteng Li** & Anna V. Trubnikova, “The Role of Intermediaries in Selection Markets: Evidence from Mortgage Lending”, *Review of Financial Studies*

Matteo Cacciatore & **Stefano Gnocchi** & **Daniela Hauser**, “Time Use and Macroeconomic Uncertainty”, *Review of Economics and Statistics*

Jing Cynthia Wu & **Yinxi Xie** & Ji Zhang, “The Role of International Financial Integration in Monetary Policy Transmission”, *IMF Economic Review*

Tatjana Dahlhaus & Tatevik Sekhposyan, “Survey-Based Monetary Policy Uncertainty and Its Asymmetric Effects”, *Journal of Money, Credit and Banking*

Tatjana Dahlhaus & Luca Gambetti, “Noisy Monetary Policy Announcements”, *Journal of Applied Econometrics*

Ajit Desai & **Francisco Rivadeneyra** & **Danica Marsden** & **Vladimir Skavysh**, “Improving the Efficiency of Payments Systems Using Quantum Computing”, *Management Science*

Jean-Sébastien Fontaine & **Sermin Gungor** & René Garcia, “Intermediary Leverage Shocks and Funding Conditions”, *Journal of Finance*

Wenting Song & Samuel Stern, “Firm Inattention and the Efficacy of Monetary Policy: A Text-Based Approach”, *Review of Economic Studies*

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Chinara Azizova & **Jonathan Witmer** & **Xu Zhang**, “[Assessing the Impact of the Bank of Canada’s Government Bond Purchases](#)”, Bank of Canada Staff Discussion Paper 2024-5

Skylar Brooks, “[Central Bank Liquidity Policy in Modern Times](#)”, Bank of Canada Staff Discussion Paper 2024-6

ABSTRACTS

In-Press Published Papers

Resolving Failed Banks: Uncertainty, Multiple Bidding, and Auction Design

The FDIC resolves insolvent banks with scoring auctions. Although the structure of the scoring rule is known to bidders, they are uncertain about how the FDIC trades off different bid components. Scoring-rule uncertainty motivates bidders to submit multiple bids for the same failed bank. To evaluate the effects of uncertainty and multiple bidding for FDIC costs, we develop a methodology for analysing multidimensional bidding when the auctioneer's scoring weights are unknown to bidders. We estimate private valuations for failed-bank assets during the great financial crisis and compute counterfactuals in the absence of scoring uncertainty. Our findings imply a substantial reduction in FDIC resolution costs of between 29.8% (\$8.2 billion) and 44.6% (\$12.3 billion). These savings can reduce policy-driven banking-sector distortions, since FDIC resolution costs are covered either through special levies on banks or through loans from the US Treasury. Our analyses also shed new light on optimal bid portfolio choice in combinatorial auctions.

Preserving Paradata for Accountability of Semi-Autonomous AI Agents in Dynamic Environments: An Archival Perspective

This paper proposes the category of real-time artificial intelligence (AI) systems as applications of computerized control systems in dynamic, time-constrained contexts normally managed by human intelligence. Noting the accountability challenges which these systems introduce, the paper posits the need for robust documentation and records capacities within these systems. The paper surveys four real-time AI systems with significant records needs: autonomous vehicles, online content targeting systems, mixed-reality tools for surgical contexts, and digital twin systems in airport facilities management. The paper identifies paradata, or the data leading up to an output in a system's operation, as a key data category necessitating preservation for full transparency in the records generated by these systems. Paradata is defined as "information about the procedure(s) and tools used to create and process information resources, along with information about the persons carrying out those procedures." Paradata uncovers opaque technological processes underlying the production of other datasets and at a granular level must be identified and preserved to delineate

the boundaries between human and system agency in semi-autonomous systems. With a basis in control theory, the paper finally offers a framework for assessing the functions of real-time AI systems' operations and their documentation and records needs.

Pricing for the Stars: Dynamic Pricing in the Presence of Rating Systems

Maintaining good ratings increases the profits of sellers on online platforms. We analyze the role of strategic pricing for ratings management in a setting where a monopolist sells a good of unknown quality. Higher prices reduce the value for money, which on average worsens reviews. However, higher prices also induce only those consumers with a strong taste for the product to purchase, which on average improves reviews. Our model flexibly parametrizes the two effects. This parametrization can rationalize the observed heterogeneity in the relationship between reviews and prices. Based on an analytic characterization of the optimal dynamic pricing strategy, we study a platform's choice of the sensitivity of its rating system to incoming reviews. The optimal sensitivity depends on the effect of prices on reviews and on how the platform weighs consumers and sellers in its objective. Although sellers always benefit from more sensitivity, consumers may suffer from higher prices and from slower learning from reviews due to endogenously emerging price and rating cycles.

Combining Large Numbers of Density Predictions with Bayesian Predictive Synthesis

Bayesian Predictive Synthesis is a flexible method of combining density predictions. The flexibility comes from the ability to choose an arbitrary synthesis function to combine predictions. I study choice of synthesis function when combining large numbers of predictions – a common occurrence in macroeconomics. Estimating combination weights with many predictions is difficult, so I consider shrinkage priors and factor modelling techniques to address this problem. These techniques provide an interesting contrast between the sparse weights implied by shrinkage priors and dense weights of factor modelling techniques. I find that the sparse weights of shrinkage priors perform well across exercises.

Generalized Autoregressive Positive-Valued Processes

We introduce generalized autoregressive positive-valued (GARP) processes, a class of autoregressive and moving-average processes that extends the class of existing autoregressive positive-valued

(ARP) processes in one important dimension: each conditional moment dynamic is driven by a different and identifiable moving average of the variable of interest. The article provides ergodicity conditions for GARP processes and derives closed-form conditional and unconditional moments. The article also presents estimation and inference methods, illustrated by an application to European option pricing where the daily realized variance follows a GARP dynamic. Our results show that using GARP processes reduces pricing errors by substantially more than using ARP processes.

Interfacing Learning Methods for Anomaly Detection in Multi-Country Financial Stress Indicators

This paper presents a novel ensemble supervised learning classification model designed for the early detection of financial stability anomalies. In particular, we utilise the time series of Financial Stress Indices (FSI) across multiple countries in developing an early-warning system. The innovation of this model lies in its unique integration of stochastic process modelling, hidden Markov models (HMM), random forest (RF), and XGBoost algorithms. This results to a comprehensive approach that can capture the dynamics of FSIs and forecast potential crisis episodes. The model's strength arises from the synthesis of the Ornstein–Uhlenbeck (OU) processes and HMM online recursive filters, forming a robust framework. Additionally, a feature selection module based on RF and a final classifier using XGBoost enhance the out-of-sample predictive performance. Our comparative analyses with five alternative models underscore the strong predictive power of the proposed model. A tailored feature-importance analysis highlights the substantial impact of the HMM features, emphasising their crucial role in the model's effectiveness. Furthermore, the inclusion of two projected anomaly-warning signals enhances the model's ability to predict extreme events, benefitting financial stability and public policy research.

Managing Bubbles in Experimental Asset Markets with Monetary Policy

We study the effect of a “leaning against the wind” monetary policy on asset price bubbles in a learning-to-forecast experiment, where prices are driven by the expectations of market participants. We find that a strong interest rate response is successful in preventing or deflating large price bubbles, while a weak response is not. Giving information about the interest rate changes and communicating the goal of the policy increases coordination of expectations and has a stabilizing effect. When the steady-state fundamental price is unknown and the

interest rate rule is based on a proxy instead, the policy is less effective.

Monetary Policy and the Persistent Aggregate Effects of Wealth Redistribution

Monetary easing redistributes from savers, some of whom are retired and not adjusting labor supply, to borrowers who reduce their labor supply. This results in persistently lower aggregate labor and output. Hence the interaction of labor supply heterogeneity with heterogeneity in net nominal positions of households creates a monetary policy trade-off whereby short-term economic stimulus is followed by lower output over the medium term. The policy trade-off is stronger in economies with more nominal household debt and a larger wealth share of retired households but weakened by a more aggressive monetary policy stance and under price-level targeting.

Limited Nominal Indexation of Optimal Financial Contracts

When financial contracts are not fully enforceable and firms observe their own nominal sales before the observation of the aggregate nominal price, the optimal financial contract is not fully indexed to inflation. Because of the limited nominal indexation, which is endogenous in the model, unanticipated inflation affects aggregate investment and future economic activity. The macroeconomic volatility induced by price uncertainty, however, is not monotone: It first increases and then decreases with nominal price uncertainty. We also show that the degree of nominal indexation declines with real idiosyncratic volatility and the impact of an inflation shock decreases with nominal indexation. Using firm-level data from Canada, we find that both predictions are supported by the data.

Is Climate Transition Risk Priced into Corporate Credit Risk? Evidence from Credit Default Swaps

We study whether climate transition risk is reflected in the credit default swap (CDS) spreads of European firms. Using information on the vulnerability of a firm's value to the transition to a low-carbon economy, we construct a climate transition risk (CTR) factor, and report how this factor shifts the term structure of the CDS spreads of more but not of less vulnerable firms. Considering the CTR factor, we find that different climate transition policies have asymmetric and significant economic impacts on the credit risk of more vulnerable firms, and negligible effects on less vulnerable firms.

Tail Risks of Energy Transition Metal Prices for Commodity Prices

Energy transition requires huge amounts of critical metals —called energy transition metals (ETMs)— to deploy clean energy technologies. The growing demand for ETMs and uncertainties regarding the path to net-zero emissions could cause ETM price oscillations, with potential effects on the prices of other commodities. We explore whether upward and downward movements in ETM prices have a neutral effect on the level and volatility of energy and non-energy commodity prices. By characterizing the conditional dependence between ETM and commodity prices, we document that, except for natural gas, extreme ETM price changes have a non-neutral effect on commodity prices, although this effect vanishes for non-extreme price movements. The implications of this evidence for investors operating in commodity markets are evaluated in terms of commodity risk-adjusted returns, commodity tail risk, and liquidity needs for trading in commodity futures contracts.

Forthcoming Published Papers

The Role of Intermediaries in Selection Markets: Evidence from Mortgage Lending

We study the role of brokers in selection markets. We find broker-clients in the Canadian mortgage market are observationally different from branch-clients. They finance larger loans with more leverage and longer amortization. We build and estimate a model of mortgage demand to disentangle three possible explanations for these riskier product choices: (i) selection on observables, (ii) unobserved borrower preferences for riskier loans, and (iii) a causal effect of brokers. Although we find that brokers influence product choices, the main reason borrowers choose high-leverage products is unobserved preferences. Borrowers prefer larger loans and brokers facilitate qualification for them.

Time Use and Macroeconomic Uncertainty

We estimate the effects of economic uncertainty on time use and discuss its macroeconomic implications. Using data from the American Time Use Survey, we first infer cyclical variation in home production and leisure time. We then document that higher uncertainty increases housework and reduces market hours worked, with modest effects on leisure. Finally, we propose a model of housework with time-varying uncertainty that quantitatively accounts for these results. We use the model to demonstrate that substitution between market and non-market work provides an additional

insurance margin to households, weakening precautionary savings and labor supply. However, time-use reallocation also lowers aggregate demand, ultimately amplifying the contractionary effects of uncertainty. Policies that reallocate time use toward housework (e.g., lockdown restrictions) amplify the recessionary effects of uncertainty and can result in aggregate dynamics consistent with a supply-side shock.

The Role of International Financial Integration in Monetary Policy Transmission

Motivated by empirical evidence, we propose an open-economy New Keynesian model with financial integration that allows financial intermediaries to hold foreign long-term bonds. We find financial integration features an amplification for a domestic monetary policy shock and a negative spillover for a foreign shock. These results hold for conventional and unconventional monetary policies. Among various aspects of financial integration, the bond duration plays a major role, and our results cannot be replicated by a standard model of perfect risk sharing between households. Finally, we observe an important interaction between financial integration and trade openness, and demonstrate trade alone does not have an economically meaningful impact on monetary policy transmission.

Survey-Based Monetary Policy Uncertainty and Its Asymmetric Effects

We present empirical evidence revealing a notable asymmetry in the evolution of expectations regarding the federal funds rate. Specifically, our findings indicate that these expectations are more firmly anchored during periods of monetary tightening than episodes of monetary easing. Furthermore, we observe a gradual improvement in this anchoring phenomenon over time. We show that macroeconomic fundamentals cannot entirely explain this behavior. We then map the observed asymmetry of the forecast errors to interest rate and monetary policy uncertainty measures. We explore the macroeconomic consequences of monetary policy uncertainty. Our analysis reveals that these effects are not linear and depend on whether the economy is undergoing monetary easing or tightening. In monetary easing regimes, heightened uncertainty surrounding monetary policy tends to have a recessionary impact. Conversely, monetary policy uncertainty does not exert significant economic effects in periods of monetary tightening.

Noisy Monetary Policy Announcements

We address two main questions. First, do monetary policy announcements contain noise? Second, if yes, what are the effects of policy noise on the economy? The answer to the first question is “yes.” The answer to the second is “small,” except on federal funds rate expectations. In sum, we find that the bulk of fluctuations in the path factor are driven by noise. The results are obtained using dynamic rotations to identify the monetary policy shock in a VAR estimated with US data. Finally, we show that announcements about future tightening are mainly interpreted as Delphic over our sample period.

Improving the Efficiency of Payments Systems Using Quantum Computing

High-value payment systems (HVPSs) are typically liquidity-intensive because payment requests are indivisible and settled on a gross basis. The state of the art solutions to this problem involve algorithms that seek netting sets and some ad-hoc reordering of the payments submitted to the system. Finding the optimal order, however, is an NP-hard combinatorial optimization problem, which quantum algorithms may be able to tackle at meaningful scales. We develop an algorithm and run it on a hybrid quantum annealing solver to find an ordering of payments that reduces the amount of system liquidity necessary without substantially increasing payment delay. Despite the limitations in size and speed of today’s quantum computers, our algorithm provides quantifiable efficiency improvements when applied to the Canadian HVPS using a 30-day sample of transaction data. By reordering batches of 70 payments, we achieve an average of C\$240 million in daily liquidity savings, with a settlement delay of approximately 90 seconds. For a few days in the sample, the liquidity savings exceed C\$1 billion. We compare our quantum reordering results to reordering performed using classical computing and to algorithms currently used in HVPS. Solving the reordering problem with quantum computing provides more reliable and consistent solutions than classical computing and to current algorithms in HVPS, particularly under time constraints.

Intermediary Leverage Shocks and Funding Conditions

The aggregate leverage of broker-dealers responds to demand and supply disturbances that have opposite effects on financial markets. Leverage supply shocks that relax broker-dealers’ funding constraints raise leverage, improve liquidity, increase returns and carry a positive

price of risk. Leverage demand shocks also raise leverage but worsen liquidity, reduce returns and carry a negative price of risk. Disentangling demand-and supply-like shocks resolves existing puzzles around the price of leverage risk and yields consistent evidence across many markets of a central role for intermediation frictions and dealers' aggregate leverage in asset pricing.

Firm Inattention and the Efficacy of Monetary Policy: A Text-Based Approach

This paper provides empirical evidence of the importance of firm attention to macroeconomic dynamics. We construct a text-based measure of attention to macroeconomic news and document that attention is polarized across firms and countercyclical. Differences in attention lead to asymmetric responses to monetary policy: expansionary monetary shocks raise market values of attentive firms more than those of inattentive firms, and contractionary shocks lower values of attentive firms by less. Attention also mitigates the effects of macroeconomic uncertainty on firm performance. In a quantitative rational inattention model that is calibrated with this new text-based measure, inattention drives monetary non-neutrality. As average attention varies over the business cycle, so does the efficacy of monetary policy.

Staff Working Papers

Unintended Consequences of the Home Affordable Refinance Program

We study the unintended effects of the Home Affordable Refinance Program (HARP) on mortgage borrowers. Originally designed to help financially distressed borrowers refinance after the 2008–09 global financial crisis, HARP inadvertently amplified the market power of incumbent lenders by introducing a cost differential between incumbents and their competitors. To assess the welfare implications of this cost advantage, we develop and estimate a structural model of dynamic refinancing decisions with lenders' offers arising from a search and negotiation process. Our findings reveal that although the cost asymmetry was rectified by a 2013 policy, it still resulted in a welfare loss exceeding the impact of search frictions.

U.S. Macroeconomic News and Low-Frequency Changes in Small Open Economies' Bond Yields

This paper investigates the importance of U.S. macroeconomic news in driving low-frequency fluctuations in the term structure of interest

rates in Canada, Sweden and the United Kingdom. We follow two complementary approaches: First, we apply a regression-based framework that aggregates the impact of daily macroeconomic news on bond yields to a lower quarterly frequency. Next, we estimate a macro-finance affine term structure model linking the daily news to lower-frequency changes in bond yields and their expectations and term premia. Both approaches show that U.S. macroeconomic news is an important source of lower-frequency quarterly fluctuations in bond yields in these small open economies—even more important than the respective countries' domestic macroeconomic news. Furthermore, the macro-finance model shows that U.S. macroeconomic news is particularly important to explain low-frequency changes in the expectation components of the nominal, real and break-even inflation rates.

Parallel Tempering for DSGE Estimation

In this paper, I develop a population-based Markov chain Monte Carlo (MCMC) algorithm known as parallel tempering to estimate dynamic stochastic general equilibrium (DSGE) models. Parallel tempering approximates the posterior distribution of interest using a family of Markov chains with tempered posteriors. At each iteration, two randomly selected chains in the ensemble are proposed to swap parameter vectors, after which each chain mutates via Metropolis-Hastings. The algorithm results in a fast-mixing MCMC, particularly well suited for problems with irregular posterior distributions. Also, due to its global nature, the algorithm can be initialized directly from the prior distributions. I provide two empirical examples with complex posteriors: a New Keynesian model with equilibrium indeterminacy and the Smets-Wouters model with more diffuse prior distributions. In both examples, parallel tempering overcomes the inherent estimation challenge, providing extremely consistent estimates across different runs of the algorithm with large effective sample sizes. I provide code compatible with Dynare mod files, making this routine straightforward for DSGE practitioners to implement.

Endogenous Credibility and Wage-Price Spirals

Elevated inflation can threaten the credibility of central banks and increase the risk that inflation expectations do not remain anchored. Wage-price spirals might develop in such an environment, and high inflation could become entrenched. We quantitatively assess the risks of a wage-price spiral occurring in Canada over history by using a medium-scale dynamic stochastic general equilibrium model

enhanced with heterogenous expectation and learning. This mechanism generates time-varying propagation of inflationary shocks that improves forecasting performance of inflation and wage growth. Central bank credibility is endogenous in our model and depends on several notions of the learning mechanism. Weaker credibility and a higher risk of inflation expectations not remaining anchored increase the risk of a wage-price spiral.

Finding a Needle in a Haystack: A Machine Learning Framework for Anomaly Detection in Payment Systems

We propose a flexible machine learning (ML) framework for real-time transaction monitoring in high-value payment systems (HVPS), which are a central piece of a country's financial infrastructure. This framework can be used by system operators and overseers to detect anomalous transactions, which—if caused by a cyber attack or an operational outage and left undetected—could have serious implications for the HVPS, its participants and the financial system more broadly. Given the substantial volume of payments settled each day and the scarcity of actual anomalous transactions in HVPS, detecting anomalies resembles an attempt to find a needle in a haystack. Therefore, our framework uses a layered approach. In the first layer, a supervised ML algorithm is used to identify and separate “typical” payments from “unusual” payments. In the second layer, only the unusual payments are run through an unsupervised ML algorithm for anomaly detection. We test this framework using artificially manipulated transactions and payments data from the Canadian HVPS. The ML algorithm employed in the first layer achieves a detection rate of 93%, marking a significant improvement over commonly used econometric models. Moreover, the ML algorithm used in the second layer marks the artificially manipulated transactions as nearly twice as suspicious as the original transactions, proving its effectiveness.

The Macroeconomic Implications of Coholding

In the United States, 30% of households are coholders who simultaneously borrow on credit cards and hold liquid assets. This generates a rich distribution of gross wealth positions that underpins the distribution of net wealth often used to calibrate macroeconomic models. We show that, beyond their role in constructing net wealth, gross positions in liquid assets and liquid debt are important in determining how households consume, save, and repay debt in response to positive income shocks. We build a quantitative model that generates the coholding observed in the data and matches

observed marginal propensities to consume, save, and repay debt. The model highlights that fiscal transfers are more effective in stimulating demand if targeted at households with low gross positions instead of low net liquid wealth, while debt relief is less effective overall in the short run but achieves large consumption gains in the long run.

Digital Payments in Firm Networks: Theory of Adoption and Quantum Algorithm

We build a network formation game of firms with trade flows to study the adoption and usage of a new digital currency as an alternative to correspondent banking. We document endogenous heterogeneity and inefficiency in adoption outcomes and explain why higher usage may correspond to lower adoption. Next, we frame the model as a quadratic unconstrained binary optimization (QUBO) problem and apply it to data. Method-wise, QUBO presents an extension to the potential function approach and makes broadly defined network games applicable and empirically feasible, as we demonstrate with a quantum computer.

Financial Intermediation and Fire Sales with Liquidity Risk Pricing

We provide a theory of fire sales in which potential buyers are subject to liquidity shocks and frictions that limit their ability to resell assets. The model predictions align with some stylized facts about the large sales of corporate bonds and Treasury securities during the COVID-19 economic crisis. The equilibrium is constrained efficient under weak conditions that apply if one interprets the key agents in the model as money market funds or mutual funds. Thus, as viewed through the lens of the model, the liquidity requirements proposed by the U. S. Securities and Exchange Commission for these intermediaries could hurt the economy.

Decomposing Systemic Risk: The Roles of Contagion and Common Exposures

We estimate a structural model derived from the balance sheet identity to evaluate the effects of contagion and common exposure on banks' capital, which varies endogenously as a function of assets and liabilities. Through a regression approach inspired by the literature on structural vector autoregression, we infer the interdependence of banks' financial conditions. In this model, contagion can occur through direct exposures, fire sales, and market-based sentiment, while common exposures result from portfolio overlaps. We apply this model to granular balance sheet and interbank exposure data of the

Canadian banking market. First, we document that contagion varies over time, with the highest levels around the Great Financial Crisis in 2008 and somewhat lower levels for the pandemic period. Second, we find that since the introduction of Basel III, the relative importance of risks has changed, hinting that sources of systemic risk have changed structurally. Our new framework complements traditional stress-testing exercises focused on single institutions by providing a holistic view of risk transmission.

Markups and Inflation in Oligopolistic Markets: Evidence from Wholesale Price Data

We study how the interaction of market power and nominal price rigidity influences inflation dynamics. We formulate a tractable model of oligopolistic competition and sticky prices and derive closed-form expressions for the pass-through of idiosyncratic and common cost shocks to firms' prices. Using unpublished micro data for Canadian wholesale firms, we estimate that the pass-through of idiosyncratic costs is incomplete at 70% and independent of the degree of sector-price-stickiness. The pass-through of common costs declines with price stickiness, from nearly complete in flexible-price sectors to below 70% in sectors with the stickiest prices. An increase in the degree of sector or firm market power reduces the pass-through of both types of cost shocks. These estimates imply a degree of strategic complementarity that lowers the slope of the New Keynesian Phillips curve by 30% in a one-sector model and by 74% in a multi-sector model.

Saving After Retirement and Preferences for Residual Wealth

We use administrative data for Norway to estimate an incomplete-market life cycle model of retired singles and couples with a bequest motive, health-dependent utility, and uncertain longevity and health. We allow the parameters of the bequest utility to differ between households with and without offspring. Our estimates imply a very strong utility of residual wealth (bequest motive), in line with the estimates by Lockwood (2018). The bequest motive accounts for approximately three-quarters of aggregate wealth at age 85. More surprisingly, we estimate similar utility of residual wealth for households with and without offspring. that the utility of residual wealth represents forces beyond an altruistic bequest motive.

The Role of Beliefs in Entering and Exiting the Bitcoin Market

Cryptoassets, such as Bitcoin, represent a new type of financial technology that has grown substantially in recent years in terms of

market size. Previous research has documented the characteristics and motivations of early Bitcoin adopters, but less work has been done studying those who choose to exit the Bitcoin market. We develop a theoretical model of both entry and exit to the Bitcoin market, the dynamics of which are driven by agents' beliefs about Bitcoin's survival. We connect the model to micro-level data from Canada, allowing us to empirically test the role of beliefs in transitioning to past ownership. Using a control function approach with appropriate exclusion restrictions, we estimate the effects of beliefs while controlling both for selection into or out of Bitcoin ownership and for possible simultaneity. We find evidence that beliefs are significant predictors of exit, while the size and direction of these effects differ across time and ownership status.

Demand for Canadian Banknotes from International Travel: Indirect Evidence from the COVID-19 Pandemic

Recent trends suggest that domestic demand alone may not be enough to explain the increase in overall demand for Canadian banknotes (Engert et al., 2019). Estimating foreign cash demand is difficult due to data availability issues and confounding factors that simultaneously affect domestic demand. In this paper, I provide a quantitative causal estimate of banknote demand from international visitors to Canada by exploiting the exogenous shock from COVID-19 international travel restrictions, which led to an unprecedented drop in cross-border travel. To identify international visitor demand shocks from contemporaneous domestic demand shocks due to the pandemic, I apply a difference-in-differences strategy, taking advantage of foreign traveler demand's distinct regional patterns and data from the Bank of Canada's Bank Note Distribution System. I find that each international visitor brought on average \$165 worth of hundred-dollar notes with them to Canada prior to the pandemic. Under plausible assumptions, total holdings by international visitors constitute roughly 10% of total \$100 CAD notes in circulation at the end of 2019.

Non-Parametric Identification and Testing of Quantal Response Equilibrium

We study the falsifiability and identification of Quantal Response Equilibrium (QRE) when each player's utility and error distribution are relaxed to be unknown non-parametric functions. Using variations of players' choices across a series of games, we first show that both the utility function and the distribution of errors are non-parametrically over-identified. This result further suggests a straightforward testing

procedure for QRE that achieves the desired type-1 error and maintains a small type-2 error. To apply this methodology, we conduct an experimental study of the matching pennies game. Our non-parametric estimates strongly reject the conventional logit choice probability. Moreover, when the utility and the error distribution are sufficiently flexible and heterogeneous, the quantal response hypothesis cannot be rejected for 70% of participants. However, strong assumptions such as risk neutrality, logistically distributed errors and homogeneity lead to substantially higher rejection rates.

Staff Discussion Papers

The Neutral Interest Rate: Past, Present and Future

The decline in safe real interest rates over the past three decades has reignited discussions on the neutral real interest rate, known as R . *We review insights from the literature on R , addressing its determinants and estimation methods, as well as the factors influencing its decline and its future trajectory. While there is a consensus that R^* has declined, alternative estimation approaches can yield substantially different point estimates over time. The estimated neutral range is large and uncertain, especially in real-time and when comparing estimates based on macroeconomic data with those inferred from financial data. Evidence suggests that factors such as increased longevity, declining fertility rates and scarcity of safe assets, as well as income inequality, contribute to lowering R . Existing evidence also suggests the COVID-19 pandemic did not substantially impact R . Going forward, there is an upside risk that some pre-existing trends might weaken or reverse.*

Survey of Indigenous Firms: A Snapshot of Wages, Prices and Financing in the Indigenous Business Sector in Canada

Attempts to measure and track the Indigenous economy in Canada are limited by data availability and quality. Also, little is known about the business environment on reserves. Filling these information gaps is important to ensure that policy-makers and Indigenous leaders can make well-informed decisions that benefit the long-term prosperity of Indigenous communities. To help narrow these knowledge gaps, the Bank of Canada partnered with the Canadian Council for Aboriginal Business and Global Affairs Canada to conduct a large-scale, national survey of Indigenous-owned firms between May and September 2021. This paper reports findings from the survey results, including Indigenous-owned firms' main sources of financing and their expectations about wages, prices and inflation. These results are

compared with those from other Canadian business surveys such as the Bank's quarterly Business Outlook Survey (BOS) to better understand the unique conditions and challenges Indigenous businesses face. Overall, we find that, compared with the average small business in Canada, Indigenous firms were significantly less likely to use financial institutions as main sources of financing. Indigenous businesses also had stronger inflation expectations and weaker wage-growth expectations, on average, than non-Indigenous firms in Canada, based on results from the BOS during the same time frame. The relatively high inflation expectations partly reflect the large share of Indigenous firms located in rural areas compared with the total business population in Canada. Indigenous firms in rural locations tended to expect higher inflation and higher price increases than their counterparts in urban areas.

Assessing the Impact of the Bank of Canada's Government Bond Purchases

We provide an overview of the Bank's GBPP and discuss the theories for how QE transmits to financial markets and the macroeconomy. We also discuss the challenges inherent in estimating QE's impact. As a result of these challenges, the overall impact of QE is uncertain.

Central Bank Liquidity Policy in Modern Times

Central banks play a crucial role in promoting financial stability. They act as financial system stabilizers through their capacity to create liquidity and channel it to financial institutions and markets in times of stress—a role that has evolved and expanded substantially over the past 15 years. This paper provides a stylized discussion of recent policy developments in this area and what they mean for debates and decisions about the design of central bank liquidity policy. Across several policy dimensions, the paper outlines broad changes since the 2008–09 global financial crisis and highlights some of the key challenges, choices and considerations facing the designers of central bank liquidity tools today.

UPCOMING EVENTS

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