Research Statement

The Macroeconomics of Microeconomic Frictions

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I am an applied (macro)economist working in macro-finance, monetary economics, spatial economics, and economics of technology. My research focuses on investigating microdata and developing quantitative models to understand and address emerging economic issues. I leverage the rich heterogeneity in various sources of newly available microdata and develop unique quantitative models to examine how micro-frictions impact aggregate dynamics. I refer to this program as *"The Macroeconomics of Microeconomic Frictions"*, the organizing theme of all my previous and ongoing research projects, which I discuss in more detail below:

- Macro-finance/monetary economics: Financial, investment, and pricing frictions.
- Spatial economics: Housing, migration, and family formation frictions.
- Economics of technology: Technology adoption and innovation frictions.

1 Macro-Finance/Monetary Economics

My first research topic is how various financial and real frictions affect firm decisions and their implications for the macroeconomy, as well as monetary and fiscal policies. More specifically, I study aggregate implications of such microeconomic frictions embedded in long-term debt contracts (maturity, covenants, callability), capital adjustments (fixed costs, irreversibility, durability), constrained firm growth, pricing technology, and inventory management.

1.1. Long-term Debt Contracts With various coauthors, I investigate corporate and aggregate implications of financial frictions embedded in defaultable long-term debt contracts. Unlike most macroeconomic models with financial frictions in the form of defaultable one-period debt or collateral constraints, most debt contracts in reality are written in the long term and often embed debt covenants and call options. Such a rich structure of long-term debt contracts brings non-trivial effects on corporate decisions and the aggregate economy.

I began my exploration with my classmate, Minjie Deng, currently at Simon Fraser University, in the first paper "Debt Maturity Heterogeneity and Investment Responses to Monetary Policy" (European Economic Review, 2022) [1], on the aggregate effects of the first attribute of long-term debt: Maturity choice and debt overhang. More specifically, we study how debt maturity choice/heterogeneity determines firm-level investment responses to conventional monetary policy shocks. Empirically, we document that firms that hold more long-term debt are less responsive to conventional monetary shocks. We then develop a quantitative heterogeneous firm model that incorporates investment, long-term and short-term debt, and default risk. The model provides a quantitative assessment of the debt overhang channel of monetary policy, such that firms with more long-term debt are more likely to default on their external debt and consequently are less responsive to investment in expansionary monetary shocks. The paper concludes that the effect of monetary policy on aggregate investment depends on the distribution of debt maturity.

With the experience of the above paper, I then joined with Aeimit Lakdawala at Wake Forest University and Timothy Moreland at the University of North Carolina–Greensboro, in the second paper "Monetary Policy and Firm Heterogeneity: The Role of Leverage Since the Financial Crisis" (Management Science, 2nd Round R&R) [2], on the aggregate effects of the second attribute of long-term debt: Maturity choice and debt dilution. Specifically, we demonstrate that stock prices of firms with high leverage were less responsive to monetary policy shocks in the pre-crisis period but have become more responsive since the crisis. These findings suggest that unconventional monetary policy may be transmitted differently through firms' debt positions. We then extend the above model to incorporate unconventional monetary policy, indicating the existence of a debt dilution channel of monetary policy. Debt dilution occurs when firms with more long-term debt are more likely to overissue additional long-term debt, thereby diluting the value of their existing outstanding debt. Since the crisis, unconventional monetary policy has had a disproportionately large impact on long-term interest rates, thereby strengthening the debt dilution channel that benefits firms with high leverage more. The paper concludes that policymakers should be particularly aware of the different roles of long-term debt positions in the transmission of unconventional monetary policy.

With a better understanding of both the debt overhang and debt dilution mechanisms, I further dive into long-term debt contracts with Wentao Zhou, now at Michigan State University, in the third paper "Debt Covenants as Macroeconomic Stabilizers" (Working Paper) [3], to understand the aggregate effects of the third attribute of long-term debt: Debt covenants. To prevent the dilution of existing debt, most creditors impose covenants that limit the maximum debt-to-earnings ratio for borrowing firms. In this paper, we embed debt covenants into a workhorse real business cycle model with defaultable long-term debt to study its macroeconomic implications.

In our model, creditors penalize firms when covenants are violated. We demonstrate an essential mechanism that debt covenants reduce debt dilution and default over business cycles. Furthermore, reduced debt dilution due to covenants also mitigates the debt overhang problem and boosts capital accumulation. Compared to counterfactual economies without covenants, the baseline economy with covenants experiences endogenous stabilization of macroeconomic shocks and higher levels of capital, output, and consumption.

Moving forward, I am actively exploring micro-frictions in long-term debt contracts and their aggregate implications, including debt callability and non-distress debt renegotiation. For instance, currently I am working with my colleague Murillo Campello at the University of Florida, Chi-Yang Tsou at the University of Manchester, and Wentao Zhou on a preliminary fourth paper "Call Back or Buy Back? A Liquidity Theory of Callable Bonds" (Work In Progress) [4], to understand the aggregate effects of the fourth attribute of long-term debt: Debt callability. We empirically document that over the past three decades, there has been a dramatic rise in the issuance of callable corporate debt, from approximately 30% to over 80%, which is at odds with the classic interest rate hedging mechanism, especially when interest rates have been decreasing during the same period. We propose a novel quantitative macro-finance model with an illiquid corporate bond market to explain this puzzle with a mechanism of liquidity risk hedging and quantify its aggregate implications. We are currently working on solving the quantitative model.

Overall, I am really excited about this entire agenda regarding how long-term debt contracts bring additional financial flexibility or introduce new financial frictions to the macroeconomy beyond our current understanding. I look forward to working on it much more.

1.2. Capital Adjustments With various coauthors, I investigate corporate and aggregate implications of real frictions embedded in capital adjustments. Unlike most macroeconomic models with smooth capital adjustments, most capital adjustments in reality are quite non-smooth and suffer non-convex costs beyond the quadratic adjustment costs. Such a non-smooth structure of capital adjustments has non-trivial effects on corporate decisions and the aggregate economy.

I began my exploration in the first paper "Lumpy Investment, Fluctuations in Volatility and Monetary Policy" (Review of Economic Studies, Reject and Resubmit) [5], with Wentao Zhou, on the essential roles of fixed costs and irreversibility in the investment channel of monetary policy during periods of elevated volatility. Given the lumpy nature of firm-level investment, we argue that elevated volatility leads to a decrease in extensive margin investment, resulting in less aggregate investment through nominal stimulus. We developed a heterogeneous firm New Keynesian model with fixed costs, irreversibility, and volatility shocks. The key idea in the model is that non-convex capital adjustment costs create a sizable extensive margin of investment, which is more sensitive to changes in both the interest rate and volatility than the intensive margin.

When volatility is high, firms tend to stay inactive at the extensive margin, so monetary stimulus motivates less investment at the extensive margin. The paper is undergoing major revisions both in the data and the model, and we anticipate updating it in the near future.[1]

With the experience of the above paper, I then further explore the essential roles of irreversibility with my former colleague Jonathan Adams, now at the Federal Reserve Bank of Kansas City, Cheng Chen at Clemson University, and my colleague Eugenio Rojas at the University of Florida in the third paper "Incomplete Information and Irreversible Investment" (Working Paper) [7]. Specifically, we examine how incomplete information impacts irreversible investment at both the firm and aggregate levels in a stylized continuous-time model of heterogeneous firms that face incomplete information and irreversible investment. The two frictions interact in rich and substantial ways. At the firm level, noisier information shrinks a firm's inaction region and reduces the elasticity of investment to productivity. In the aggregate, it increases steady-state capital, exacerbates capital misallocation, and mitigates the impact of productivity shocks on aggregate investment. More importantly, we test and quantify these predictions using Japanese administrative data, showing that the model has aggregate implications for understanding the essential roles of capital irreversibility when it interacts with incomplete information. The paper has been invited to submit to a top general interest journal and is undergoing minor revision in the quantification; we anticipate updating it in the near future.

Moving forward, I am actively exploring micro-frictions in capital adjustments and their aggregate implications, including capital durability, capital leasing, and consumer capital. For instance, currently I am working with Hui-Jun Chen at National Tsing Hua University, Spyridon Gkikopoulos at the University of Manchester, and Chi-Yang Tsou on an advanced fourth paper "The Macroeconomics of Capital Durability" (Work In Progress) [8], to understand the aggregate effects of capital durability under financial frictions and corporate tax policies. Specifically, we study the aggregate and distributional capital dynamics in a heterogeneous-firm investment model with idiosyncratic productivity shocks, financial frictions, tax policies, and capital durability, which is denoted by the speed of capital depreciation. Quantitatively, we demonstrate how financial frictions and tax policies jointly influence the distribution of capital durability. Specifically, more constrained firms opt for lower durability because durable capital is subject to lower depreciation deductions in corporate taxation. Consequently, durable capital has a larger share of tax benefits that are not realized immediately, and is less preferred by more constrained firms. We then jointly validate the roles of financial frictions and tax policies using exogenous variations in U.S. microdata. Taking the model to the data, we demonstrate that financial frictions lead

[1] In the process of writing this paper, I also noticed an interesting point on the classic setup of the random draw of the fixed capital adjustment costs and wrote a second paper on it. The results are presented in "A Note on Nonconvex Adjustment Costs in Lumpy Investment Models: Mean versus Variance" (Macroeconomic Dynamics) [6].

to substantial misallocation in capital durability, which also prolongs the persistence of recessions following financial shocks. Finally, we demonstrate that tax policies, such as accelerated depreciation on durable capital, can accelerate recovery from such recessions. We are currently wrapping up the paper and, hopefully, will have a draft to circulate in about a month or two.

Overall, I am really excited about this entire agenda regarding how frictional capital adjustments and capital heterogeneity affect the macroeconomy beyond our current understanding. I look forward to working on it much more and exploring other types of capital adjustments.

1.3. Constrained Firm Growth With various co-authors, I investigate the impact of various financial constraints (liquidity, collateral, and network) on firm growth and its corporate and aggregate implications for macroeconomic development, innovation, and the environment.

I began my exploration in the first paper "Short-term Finance, Long-term Effects" (Journal of Political Economy Macroeconomics, Revise and Resubmit) [9], with my former colleague Kenza Benhima at the University of Lausanne, Omar Chafik at the Arab Monetary Fund, and our former student Wenxia Tang, on the effect of short-term finance on firm growth and its aggregate implications in emerging economies. In theory, short-term finance promotes firm growth by enabling entrepreneurs to allocate their net worth more efficiently away from unproductive cash and towards productive capital. We build a quantitative model fitted to Moroccan data that replicates qualitatively and quantitatively the observational impacts of a loan guarantee program designed to relax short-term financial constraints. Fitting the model to the data also reveals that intertemporal distortions are large and that the costs of participating in the LGP are high. This implies that there are potentially large gains from increasing the guaranteed ratio and decreasing the participation costs. These two policies generate substantial growth and welfare gains, with the former generating relatively higher growth and the latter motivating relatively more participation.

In a second paper "Financial Frictions and Pollution Abatement Over the Life Cycle of Firms" (Working Paper) [10], joint with Po-Hsuan Hsu at National Tsing Hua University and Chi-Yang Tsou, I study how financial frictions shape the trade-off between growth-oriented capital investment and penalty-avoidance pollution abatement of heterogeneous firms and its aggregate implications for green finance policies. Using US firm-level data, we document significant differences in pollution abatement activities over the life cycle of firms. Under financial constraints, smaller and younger firms invest more in capital and engage less in pollution abatement. As they accumulate more net worth, their abatement activities accelerate, and their emission intensity decreases. Motivated by this evidence, we develop and quantify a heterogeneous firm model to study the dynamics among financial frictions, capital investment, and pollution abatement. In the model, smaller and younger firms prefer capital investment over pollution abatement because the returns from capital investment are higher than those from pollution abatement. Such low

returns on abatement expenditures stem from both a lack of collateralizability and an increasing return to scale in operating abatement activities. More importantly, we demonstrate that financial frictions render environmental regulation suboptimal at any level, reducing the aggregate welfare gain by 40%. Finally, we show that even without monitoring, green loan policies are considerably effective in reducing emission intensity. The paper is undergoing a minor revision due to the arrival of new data and is about ready to be submitted.

In a third paper "Financing Innovation with Innovation" (Working Paper) [11], joint with Minjie Deng, Zhiyuan Chen at Renmin University, and Zhiyuan's student Yunzhou Shang, I study how patent collateral could overcome financial frictions and facilitate innovation and economic growth. We document that Chinese firms are increasingly financing innovation using their innovation stock, measured by patents such that (1) In China, the total number and share of patents pledged as collateral have been rising steadily, (2) Chinese firms employ patents as collateral on a smaller scale and with a lower intensity than US firms, and (3) Chinese firms also increase innovation after adopting patent collateral as US firms. We then construct a heterogeneous firm general equilibrium model featuring idiosyncratic productivity risk, innovation capital investment, and borrowing constrained by patent collateral. The model emphasizes two barriers that hinder the use of patent collateral: high inspection costs and low liquidation values of patent assets. We parameterize the model to firm-level panel data in the US and China and find that both barriers are significantly more severe in China than in the US. Finally, counterfactual analyses show that the gains in innovation, output, and welfare from reducing the inspection costs in China to the US level are substantial, moreso than enhancing the liquidation value of patent assets. The paper is undergoing a major revision due to the arrival of new data.

Moving forward, I am actively exploring micro-frictions in various financial and real constraints, as well as their implications for firm growth and the aggregate economy. I look forward to working on it much more and exploring other types of firm growth constraints.[2]

1.4. Pricing/Inventory/Labor I am also actively exploring other essential micro-frictions that have significant aggregate implications in macro-finance and monetary economics. Most recently, I am very excited about how new technology, such as AI, would change pricing frictions and the macroeconomy. However, I will leave such discussions to the last section. Here, I introduce two papers: one on inventory management frictions and monetary policy implications, and the other on innovation labor market frictions and asset pricing, respectively.

[2]For instance, in a preliminary project "Conglomerate Market Power" (Work In Progress) [12], joint with my former classmate Xiaomei Sui and their Ph.D. student Yulin Wang, both at Hong Kong University, I study how firms exert market power through their ownership network and the resulting macroeconomic implications due to entry frictions and financial frictions at the micro-level. We have produced preliminary empirical results and are at the stage of building the quantitative model. However, due to state regulations in Florida, the project is on pause.

In the first paper "The Inventory Decelerator for Monetary Policy" (Working Paper) [13], joint with Wentao Zhou, we argue that the interaction between liquidity constraints and firms' inventory management acts as a decelerator for monetary policy transmission. Empirically, we document that firms with higher operating leverage—indicative of tighter liquidity constraints—reduce their inventories significantly less in response to monetary tightening than their less constrained counterparts. Quantitatively, we develop a New Keynesian model in which firms face financial frictions while managing inventory to avoid stock-outs. Reducing stock-outs generates more internal funds for firms and thus lowers their risk of liquidity constraints. Such an incentive drives firms to reduce their reliance on on-shelf goods to preserve internal liquidity in response to a monetary tightening, especially for those with more liquidity constraints. Using a calibrated model, we demonstrate that the deceleration mechanism weakens the impact of monetary policy on aggregate production by more than 20%, and the dampening effects are even more potent in economies featuring severe financial distortions and higher production and demand uncertainty. The paper is undergoing a minor revision due to the arrival of new microdata.

In the second paper "Return Predictability of Inventors: A Global Study" (Work In Progress) [14], joint with Po-Hsuan Hsu, Yan Xu from Hong Kong University, and Yan's student Hanni Jie, we study how the innovation labor market frictions affect the asset prices of listed firms. More specifically, we show that both cross-country and within-country evidence that firms with high versus low inventor-to-employee ratios generate an inventor premium, which remains significant after controlling for risk factors including R&D expense intensity. We build an equilibrium model with a frictional inventor labor market and human capital restrictions to explain the cross-section of inventor portfolios' returns, both cross-country and within-country.

2 Spatial Economics

My second research topic is how various spatial frictions affect firm and household decisions and their implications for the macroeconomy. More specifically, I study the aggregate implications of such microeconomic frictions embedded in migration, housing, land policy, and family formation, mainly in the context of China. I also started to explore the spatial economics of local fiscal policy and migration in the context of the United States.

I began my exploration with my classmate, Zibin Huang, currently at Shanghai University of Finance and Economics, in the first paper "Migration, Housing Constraints, and Inequality: A Quantitative Analysis of China" (Labour Economics, 2022) [15], on the joint role of migration and housing frictions in determining income inequality within and across Chinese cities. By combining microdata with a spatial equilibrium model, we quantify the impact of the massive

spatial reallocation of workers and the rapid growth of housing costs on the national income distribution. We build a spatial equilibrium model featuring workers with heterogeneous skills, housing constraints, and heterogeneous returns from housing ownership to explain these facts. Our quantitative results indicate that the reductions in migration costs and the disproportionate growth in productivity across cities and skills resulted in the observed massive migration flows. Combined with tight land supply policies in big cities, the expansion of housing demand caused the rapid growth of housing costs and generated further inequality between local housing owners and migrants. The counterfactual analysis shows that if we redistribute the supply of new land proportionally to migrant flows/stocks, both within-city income inequality and national income inequality would fall. This additionally allows for more migration into cities with higher productivity, with corresponding positive consequences for national income.

With a better understanding of the quantitative spatial equilibrium model, I further dive into migration and housing frictions in a second paper "Place-based Land Policy and Spatial Misallocation: Theory and Evidence from China" (International Economic Review, 2nd Round Revise and Resubmit) [16] with Libin Han from Dongbei University of Finance and Economics, Zibin Huang, Ming Lu from Shanghai Jiaotong University, and Li Zhang from Sun Yat-Sen University, to understand how place-based policies may create spatial misallocation. We investigate a major inland-favoring land policy in China aimed at reducing regional development gaps by allocating more urban land quotas to underdeveloped inland regions. We show empirical evidence that this policy decreased productivity in more developed eastern areas relative to inland regions.[3] We also built a prefecture-level spatial equilibrium model with migration, land quota constraints, and agglomeration. The model reveals that this policy led to substantial output and productivity losses by distorting both labor and production across regions. Regional output gaps narrowed, but workers from the underdeveloped areas reduced their migration to developed regions and earned less. Counterfactuals suggest that national output would have been 1.8% higher in 2010 if the policy had not been implemented, and workers from underdeveloped areas would have earned 6.3% more income. Instead, regional monetary transfer policies could reduce regional inequality without significantly increasing spatial misallocation. Finally, we demonstrate that eliminating the place-based land quota system yields substantial benefits.

[3]In a related third paper, "Place-based Land Policy and Firm Productivity: Evidence from China's Eastern-Inland Regional Border" (Working Paper) [17], we study the same event use a research design that combines difference-in-differences and regression discontinuity at the policy border. We find that the inland-favoring land policy decreased the firm-level productivity gap between more developed eastern regions and underdeveloped inland regions. More specifically, the relative changes are mainly due to slower productivity growth in eastern firms rather than faster productivity growth in inland firms. We find that this policy increased land costs, decreased new firm entry, and consequently reduced agglomeration and knowledge spillovers in the east. In response, Eastern firms reduced their R&D expenditures, potentially harming their long-term efficiency.

I further explore migration and family formation frictions in a fourth paper "Sex and the City: Spatial Structural Changes and the Marriage Market" (International Economic Review, Special Issue Inclusion) [18] with Zibin Huang, Yu Yang and Yu's student Yushi Wang from Peking University, to understand how gender-specific spatial structural changes lead to marriage rate decline. Using data from China, we first present stylized facts on the joint patterns of dramatic gender- biased spatial structural changes, persistent marital social norms, and the diverging spatial distribution of singlehood characterized by a high singles rate for females (males) in more (less) developed cities. We then build a prefecture-level spatial equilibrium model with multi-sector and multi-skill production, migration, and local marriage markets. The model reveals that, without gender-specific spatial structural changes, the singles rate would be 30% lower for average women and over 50% lower for college-educated women. The key mechanism is that spatial structural changes cause more highly educated women to sort into the service sector in more developed cities than men do. However, social norms remain persistent, particularly the strong preference for hypergamy. This results in more failed marriage matches for females (males) in more (less) developed cities, thereby lowering the national marriage rate. Counterfactual analysis shows that subsidizing marriage is costly and relatively ineffective amid continuing gender-specific spatial structural changes.

With the experience of the above four papers, I have leveraged the knowledge and techniques to combine risk cross-sectional microdata with static quantitative spatial equilibrium models, incorporating various household and firm choices. Moving forward, I am extending the framework to the dynamic quantitative spatial equilibrium models to answer questions that cannot be answered in the static framework.

The first example is "Development Zones in Space: Theory and Evidence from China" (Work In Progress) [19] with Binkai Chen from Central University of Finance and Economics, Zibin Huang, Ming Lu, and Kuanhu Xiang from Shanghai University. In this project, we further explore the dynamic effects of place-based policy. Specifically, we use the mass closure of development zones in 2004 as a natural experiment to examine the causal impact of development zones on firm-level TFP in China. We found that market access and local within-industry spillover effects largely determine the gains or losses from development zone policies. We develop a spatial firm growth general equilibrium model that includes development zones, which generate both selection and agglomeration effects, along with intranational and international trade. The separate identification of both effects is possible using our quasi-natural event study. We are currently solving and estimating the model using both Chinese Census data and firm-level data.

The second example is "Public Finance In Space: Mobile Workers Under Immobile Deficits" (Work In Progress) [20] with Minjie Deng, Zibin Huang, and Chang Liu, now at Stony Brook

University. In this project, we further explore the dynamic effects of local fiscal policies on intranational migration in the context of the United States. Specifically, we show that states with worsening fiscal conditions lose tax residents to those with relatively stable budgetary conditions. We are currently working on building and solving a dynamic spatial general equilibrium model to endogenize the feedback loop of local fiscal conditions and intranational migration.

3 Economics of Technology

My last and latest research topic is how various innovations and technological processes affect firm decisions and their implications for the macroeconomy. More specifically, I study the aggregate impact of such technological processes, focusing mainly on AI and data, and their interaction with existing micro-frictions, such as pricing, labor, and inventory management.

I began my exploration with my former colleague, Jonathan Adams, currently at the Federal Reserve Bank of Kansas City, Zheng Liu at the Federal Reserve Bank of San Francisco, and Yajie Wang at the University of Missouri, in the first paper "The Rise of AI Pricing: Trends, Driving Forces, and Implications for Firm Performance" (Journal of Monetary Economics, Previously Accepted) [21], on the dramatic rise of AI pricing and study its implications for firm performance, both on average and in response to monetary policy shocks. We find that at the aggregate level, the share of AI pricing jobs in all pricing jobs has increased more than tenfold since 2010. The rise of AI pricing jobs has been broad-based, spreading across more industries than other types of AI jobs. At the firm level, larger and more productive firms are more likely to adopt AI pricing. Firms that adopted AI pricing experienced faster growth in sales, employment, assets, and markups. Additionally, their stock returns are more responsive to high-frequency monetary policy surprises than those of non-adopters. We show that these empirical observations can be rationalized by a simple model in which a monopolist firm, with incomplete information about its demand function, invests in AI pricing to acquire information.

Moving forward, I am actively exploring how new technology in AI and data-driven analysis can either overcome or intensify micro-frictions in various financial and real constraints, along with their implications for monetary policy, labor market, and corporate policies. I look forward to working on it much more in the near future.

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