RESEARCH STATEMENT

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August 2024

I am a macroeconomist interested in production networks, aggregate fluctuations and the intersection of macroeconomics and labor economics. Below, I summarized my research in those areas.

Production networks

Firms in a modern economy are interconnected through complex supply chains, making them vulnerable to shocks that might disrupt their suppliers and customers. For example, if the plant of a tire manufacturer catches on fire, its rubber supplier might slow down operations due to weaker demand. Similarly, an automobile company relying on the tire producer may struggle to complete its trucks. The disruption could then cascade to a delivery company waiting for those trucks, and so on. Through this propagation process, a local shock can be amplified and have a larger impact on the aggregate economy than it would have otherwise. The nature and extent of this amplification depend, however, on the structure of the supply chain network. Identifying what factors shape this network is therefore crucial for understanding how microeconomic shocks lead to macroeconomic fluctuations.

In my paper with Alexandr Kopytov, Bineet Mishra and Kristoffer Nimark, **Endogenous Production Networks under Supply Chain Uncertainty** (forthcoming, *Econometrica*), we develop a macroeconomic model of endogenous network formation to explore how uncertainty influences the formation of supply chains and the broader economy. Our model features firms that produce differentiated goods, which can be used as intermediate inputs by other firms. Before production takes place, firms must decide on which suppliers to rely on, in the spirit of Oberfield (2018). Once these decisions are made, firm-level productivity shocks are realized, and transactions occur. Competitive forces ensure that firms with lower productivity charge higher prices, while more productive firms offer lower prices. Firms with more volatile productivity therefore have more volatile prices.

Markets are complete and so firms use the stochastic discount factor of the risk-averse household when making input-output decisions. As a result, firms avoid riskier suppliers, and those play a less important role in the production network. Specifically, we show that firms with productivity processes with lower mean or higher volatility have smaller Domar weights (sales share in GDP) in

equilibrium. We also characterize how uncertainty affects GDP through its impact on the production network. As uncertainty rises, firms gravitate toward more stable suppliers, even if those suppliers are less productive on average. This 'flight-to-safety' process reduces expected GDP but also lowers the variance of GDP, ultimately increasing welfare compared to a scenario in which supply chains remain fixed.

In my solo paper **Cascades and Fluctuations in an Economy with an Endogenous Production Network** (conditionally accepted, *Review of Economic Studies*), I study an environment in which firms are also interconnected through the exchange of intermediate inputs. Additionally, firms must pay a fixed cost to produce, so that some firms might remain idle depending on economic conditions. Cascades of firm shutdowns can arise in this environment. For example, if a firm experiences a negative productivity shock, it may choose not to incur the fixed cost, resulting in its shutdown. But then that firm's customers, having lost a valuable input, or its suppliers, facing reduced demand, are also at risk of shutting down. Since the same logic applies to the firm's second neighbors, and so on, this chain reaction can propagate through the production network, triggering widespread economic disruptions. Such cascades were a significant concern for policymakers during the Great Recession, and my model provides a framework to explore their origin and implications.

I study the problem of a social planner in this environment. The fixed costs introduce a discrete margin in the optimization problem that makes the planner's problem hard to solve using standard methods. I propose instead an algorithm that relaxes the discrete margin and reshapes the objective function of the planner. I derive conditions under which that approach is guaranteed to solve the planner's problem. Even when these conditions are not fully met, I show through numerical simulations that the algorithm closely approximates the true solution. With this method in hand, I calibrate the model to the U.S. economy and show that it successfully replicates key features of real-world data, including how cascades propagate and the correlation between the structure of the production network and business cycle fluctuations.

Business cycles

Understanding the origin of aggregate fluctuations and how they propagate is one of the main goals of macroeconomics. Traditional business cycle models generate limited propagation, with the economy quickly reverting to its unique steady state once a shock dissipates. In the aftermath of the 2007-2009 Great Recession, however, the U.S. economy appeared to settle on a lower growth trajectory, suggesting that temporary shocks might have long-lasting consequences. I have worked on models with multiple steady states and nonlinear dynamics to try to explain this type of behavior. I have also investigated what creates business cycles fluctuations in the first place. Below, I cover my work in these areas.

In a new working paper titled **The Origin of Risk** (working paper), co-authored with Alexandr Kopytov and Zebang Xu, we construct a model in which productivity risk, at the micro and the macro level, is endogenous. The paper is motivated by the fact that economic agents constantly

make decisions that affect how much and what type of risk they face. Firms, for instance, influence their risk profile by deciding which workers to hire, what projects to invest in, where to locate a factory, etc. Growing crops near the shore, for example, might ensure a steady supply of water but it also increases the risk of flooding. Growing inland instead reduces flood risk but might make the crops vulnerable to droughts. When aggregated, these individual risk-taking decisions shape the risk profile of the entire economy and can give rise to macroeconomic fluctuations.

Instead of modeling every single decision involving risk individually, we adopt a holistic approach and let the firms directly choose the mean and the variance of their productivity process, as well as how it correlates with that of other firms. To evaluate the impact of distortions on risk-taking decisions, we also assume that firms price their goods at a markup over marginal cost. We characterize the unique equilibrium in this environment and show that risk-taking decisions vary systematically with firm characteristics. Larger firms and those with smaller markups are, all else equal, less volatile and tend to commove less with the aggregate economy. We verify that these predictions are visible in the data. We also investigate the impact of the model's mechanisms for aggregate fluctuations. The presence of wedges, as it makes risk-taking decisions inefficient, can make GDP more volatile. In a calibrated version of our model, we find that this mechanism has a significant impact on the economy.

In **Herding Through Booms and Busts** (Journal of Economic Theory, 2023), co-authored with Edouard Schaal, we investigate whether herding behavior, in the spirit of Banerjee (1992) and Bikhchandani et al. (1992), can generate aggregate boom and bust cycles. To do so, we build a dynamic model in which rational investors have dispersed information about the quality of a new technology. Each period, these investors must decide whether to invest or not in that technology. They base that decision on their private information and the observed investment behavior of others. We show that boom-bust cycles can arise in this environment when the technology is unproductive, but initial investor information is optimistic. This initial optimism leads to high investment rates, which investors mistakenly attribute to the new technology being productive. As a result, they become even more optimistic, which leads to more investment, and so on. Information continues to accumulate, however, and investors eventually realize their mistake, leading to a rapid bust. We calibrate a quantitative version of this model to the U.S. economy and show that it can roughly explain episodes like the dot-com bubble of the late 1990s.

In **Uncertainty Traps** (Quarterly Journal of Economics, 2017), co-authored with Pablo Fajgelbaum and Edouard Schaal, we investigate how uncertainty can lead to prolonged periods of weak economic activity. To do so, we construct a dynamic model in which firms learn by observing the investment return of others. Each period, firms decide whether to undertake an irreversible investment project whose return depends on a common fundamental. When a firm invests, the (noisy) return on the project is publicly observable. As more firms invest, the collective beliefs about the fundamental become more precise, reducing uncertainty and encouraging further investment. We show that this feedback loop can lead to two distinct steady states: an "uncertainty trap" where high uncertainty and low investment reinforce each other, and a "good" steady state characterized

by low uncertainty and widespread investment.

We investigate the impact of shocks in this environment. Starting from the good steady state, small negative shocks cause brief recessions from which the economy recovers rapidly. Large (but temporary) shocks, in contrast, can trigger a transition to the uncertainty trap. In this case, only a large enough positive shock can bring the economy back to the good state. We embed this mechanism into a standard quantitative business cycle model and show that it can improve the model's ability to account for the slow recovery observed following the Great Recession. The paper also discusses how policy interventions can help the economy avoid uncertainty traps.

In **Coordinating Business Cycles** (working paper), co-authored with Edouard Schaal, we propose another mechanism to create long-lasting recessions out of temporary shocks. It relies on demand externalities and non-convexities in the production process. In the paper, we build a dynamic model in which firms sell differentiated goods to a household with CES preferences, giving rise to monopolistic competition and a demand externality. Firms have Cobb-Douglas production functions and can pay a fixed cost to increase their total factor productivity (TFP). That fixed cost is there to capture some form of non-convexity of the type that has been documented in the empirical literature (see, for instance, Bresnahan and Ramey, 1994). We show that, within a period, the interaction of the demand externality and the non-convexity can lead to multiple equilibria. In the "good" equilibrium, firms adopt the high TFP technology, leading to high household income, which boosts demand and justifies the high productivity. Conversely, in the "bad" equilibrium, low demand discourages firms from paying the fixed cost, leading to low productivity. We employ a global game framework to select an equilibrium when multiple outcomes are possible.

When this model is extended to include capital accumulation, some important dynamic mechanisms emerge. For instance, if firms coordinate on the bad technology today, the household becomes poorer, and it accumulates less capital. The limited amount of capital implies that the bad technology is more likely to be selected next period, which then perpetuates the depressed state. In this environment, small negative shocks lead to brief recessions, but large temporary shocks can push the economy to a bad steady state. Our calibration of the model to the U.S. economy replicates the shift to a lower growth trajectory following the Great Recession. In the model, fiscal policy can be a powerful tool to push the economy out of a recession.

In **Aggregate Demand and the Dynamics of Unemployment** (working paper) co-authored with Edouard Schaal, we embed a similar mechanism into a search and matching model of the labor market. In that model, firms usually pay a fixed cost to post a vacancy, and so we do not need to modify the environment to get non-convexities in production. We, however, endow households with CES preferences to generate monopolistic competition and an aggregate demand externality. In this setup, because firms care about the demand for their products, an increase in unemployment reduces the incentives to post vacancies which further increases unemployment. Multiple equilibria can arise, but we show that the multiplicity disappears when there is enough cross-firm heterogeneity. In this case, the unique equilibrium can exhibit multiple stationary points in the dynamics of unemployment. When calibrated to the U.S. economy the mechanism generates

additional volatility and persistence in labor market variables, in line with the data. Notably, the model is capable of producing deep, long-lasting unemployment crises, offering a potential explanation for such phenomena in real economies.

In **Short-Run Pain, Long-Run Gain? Recessions and Technological Transformation** (Journal of Monetary Economics, 2018), co-authored with Alexandr Kopytov and Nikolai Roussanov, we explore the interaction between recessions and technological transitions. Over the past few decades, rapid advances in information technology, electronics, and robotics have facilitated the automation of routine and repetitive tasks. As a result, employment in those jobs has declined, while employment in non-routine cognitive occupations (e.g., engineers and scientists) and non-routine manual jobs (e.g., low-skill services) has increased. Evidence by Jaimovich and Siu (2020) suggest that this polarization process accelerates during recessions.

We propose a model to explain this phenomenon. In the model, firms can produce using an "old" technology that relies more on low-skill manual labor or a "new" technology that depends more on high-skill cognitive labor. Over time, the productivity of the new technology increases, leading firms to gradually transition from the old to the new technology. However, adopting the new technology is costly, both in terms of the inputs required for the transition and the profits lost during reorganization. As a result, firms are more likely to switch to the new technology during downturns, when input costs are lower, and profits are already depressed. A calibrated version of the model can replicate the employment transition patterns observed in the data.

Macroeconomics and labor economics

I have also worked at the intersection of macroeconomics and labor economics. In my solo paper **The Union Threat** (Review of Economic Studies, 2020), I explore how the *possibility* of unionization might distort the behavior of non-union firms. In the model, workers and firms meet through a search process. Workers have heterogenous skills, and firms use workers with different skills to produce. The workers of a firm can form a union if most of them wishes so. As union wages are set though collective bargaining, unionization compresses wages and lowers profits. As a result, nonunion firms, to prevent their own unionization, over-hire high-skill workers (who are against unionization) and under-hire low-skill workers (who prefer unionization). As a result, the marginal product of high-skill workers declines and that of low skill workers increases. The possibility of unionization therefore leads to a decline in wage inequality in non-union firms. In a calibrated version of the model to the U.S. economy, the misallocation of workers from the union threat lowers aggregate output but also reduces wage inequality.

Hours worked have been fallen around the world over the last century. The standard explanation is that higher wages are responsible for this decline, as workers no longer have to work long hours to afford a high quality of life. In **Cheap Thrills: The Price of Leisure and the Global Decline in Work Hours** (Journal of Political Economy Macroeconomics, 2023), co-authored with Alexandr Kopytov and Nikolai Roussanov, we explore instead the idea that a large decline in recreation prices

played a role. Indeed, since 1900 the aggregate price index tracking U.S. recreation goods and services has fallen by more than a half in real terms. If households can allocate their time between work and recreation, it is natural to think that cheaper recreation would lead to a decline in work hours.

We investigate this idea in an augmented balanced-growth framework. We follow the approach of Boppart and Krusell (2020) and first characterize the general form that the household's utility function must take in this setup to be consistent with balanced growth. This general class of preferences imposes restrictions on the data that allow us to estimate key parameters that govern how much wages and recreation prices affect work hours using standard techniques. Using a cross-section of countries, we show that the recreation channel has been about a third as important as the wage channel in driving the decline in work hours.

Our framework also allows us to investigate puzzling trends in the cross-section of workers in the United States. Since 1985, groups that have experienced the slowest wage growth (e.g., low-skill workers) have seen their leisure time increase the most (Aguiar and Hurst, 2007). This pattern is hard to reconcile with the dominating income effect of wages needed to generate the observed long-term decline in aggregate work hours. Over the same period, however, the price of recreation items consumed by low-skill workers has declined significantly, providing an explanation for why they now work less. In contrast, more-educated households consume recreation items (mostly services) that have become more expensive. As a result, their leisure time has been roughly stable during the last decades. Through a series of exercises using our theoretical framework, we find that these heterogenous movements in leisure prices can roughly account for the overall increase in leisure time inequality.

In **The Future of Labor: Automation and the Labor Share in the Second Machine Age** (working paper), co-authored with Hong Cheng, Lukasz Drozd, Rahul Giri, and Junjie Xia, we examine the declining labor share of national income in the context of China's rapidly industrializing economy. While one common explanation attributes this decline to firms substituting capital for labor due to falling capital prices, this hypothesis relies on the elasticity of substitution between capital and labor being greater than 1. Our study focuses on the Chinese manufacturing sector, where we measure the elasticity between labor and automation capital, specifically. Using detailed survey data on firms' investments in various forms of capital, we construct an instrumental variable based on geographic and industry variation in automation subsidies provided under the "Made in China 2025" program. Estimating our structural model, we find the elasticity of substitution between labor and automation capital to be 3.8, significantly higher than 1. This result suggests that the declining prices of automation capital might have played a role in reducing the labor share in China's manufacturing sector.

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