MIT Economics

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DOCTORAL STUDIES	Massachusetts Institute of Technology (MIT) **PhD** in **Economics** (Sep. 2015 -- June 2021) DISSERTATION: "Essays in Financial Economics" DISSERTATION COMMITTEE AND REFERENCES

Professor Daron Acemoglu
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PRIOR EDUCATION	University of Michigan	
	PhD in **EECS** (stochastic control)	2013
	MS in **Mathematics** (stochastic and optimization)	2012
	MS in **OR** (EE-systems)	2011

CITIZENSHIP	USA	**GENDER:**	Male

FIELDS	Primary Fields: Finance Secondary Fields: Macroeconomics, Theory, Applied microeconomics

TEACHING EXPERIENCE	Asset Pricing (graduate, MIT Sloan course 15.456) TA to Professor Leonid Kogan	2020
	Strategy and Information (undergrad., MIT Econ course 14.16) TA to Professor Muhamet Yildiz	2020
	Game Theory (undergrad., MIT ECON course 14.12) TA to Professor Muhamet Yildiz	2018
	Microeconomics (undergrad., MIT ECON course 14.01) TA to Professor Jon Gruber	2018,19
	Contract Theory (graduate, MIT ECON course 14.281) TA to Professor Daniel Garrett	2018
	Mathematics for Financial Engineering (quantitative methods in finance) (graduate, MIT Sloan course 15.455) TA to Professor Paul Mende	2018, 19, 20
	Stochastic process (graduate, UMich EECS course 501) TA to Professor Demos Teneketzis	2012, 13
	Stochastic Control (graduate, UMich EECS course 558) TA to Professor Demos Teneketzis	2012

RELEVANT POSITIONS	Research Assistant to Prof. Daron Acemoglu	2015-18
	Res. Assistant to Prof. Ali Jadbabaie and Prof. Asu Ozdaglar	2013-15

PROFESSIONAL ACTIVITIES	Referee for: Journal of Political Economy, RFS, Management Science, Journal of Economic Theory, AEJ: Micro, Operations Research

FELLOWSHIPS, HONORS, AND AWARDS	Neekeyfar Fund Award, for Graduate Education MIT	2018
	HAND foundation MIT Doctoral Fellowship	2015
	Richard and Eleanor Towner Prize for Distinguished Academic Achievement (Univ. of Michigan)	2013
	Outstanding PhD Thesis Award, Springer Outstanding PhD Thesis award (Univ. of Michigan)	2013
	University of Michigan Doctoral Fellowship	2008
	Ranked second (university level) in National math Olympiad	2006
	Silver medal (high school level) in National math Olympiad	2003

Papers under Revision	**Advising the Management** (with U. Loginova, A. Malenko, N. Malenko) *Review of Financial Studies (RFS), (Revise and Resubmit)*
PUBLICATIONS	**Information Choice and Amplification of Financial Crises** (with T. Ahnert), *Review of Financial Studies (RFS), vol 30, no 6, 2018.* **Optimal Contracting in Networks** (with A. Jadbabaie), *Journal of Economic Theory (JET), vol 183, no 9, 2019.* **Dynamic Pricing in Social Networks: The Word of Mouth Effect** (with A. Ajorlou and A. Jadbabaie), *Management Science (MS), vol 64, no 2, 2018.* **Dynamic Price Discovery: Transparency vs. Information Design** (with F. Song), *Games and Economic Behavior (GEB), vol 122, no 9, 2020.* **Competition in Electricity Markets with Renewable Energy Sources** (with Daron Acemoglu and Asu Ozdaglar), *The Energy Journal (EJ) (invited), vol 38, no SI1, 2018.*
BOOK	**Resource Allocation in Decentralized Systems with Strategic Agents: An Implementation Theory Approach**, 2014 - *Springer Outstanding PhD Thesis Series* - *Richard and Eleanor Towner Prize for Distinguished Academic Achievement*
BOOK CH.	**Power Allocation, Spectrum Sharing and Revenue Maximization in Networks: An Implementation Theory Approach**, *Ch. 5 in Mechanisms and games for dynamic allocation.* (with A. Nayyar, S. Sharma, D. Teneketzis) Cambridge University Press.
RESEARCH PAPERS	**Liquidity, Welfare and Transparency in Dynamic OTC markets** (Job Market Paper) (with F. Song) (Topic) Microstructure of asset markets A common concern about over-the-counter (OTC) markets is their opaqueness. After the 2008 financial crisis, OTC markets have become subject to new regulations requiring mandatory transparency (through TRACE). This paper

studies how transparency (information disclosure), along with long term incentive of informed dealers, affects price informativeness (efficiency), market liquidity and welfare in dynamic OTC markets. We show more transparency, via the public disclosure of additional information about past trades, paradoxically, makes the markets more opaque, by reducing market price informativeness. However, this market opacity creates liquidity and improves welfare. Our policy implications are threefold: (i) forward-looking incentive of informed dealers reduces price efficiency but improves liquidity; (ii) the post-trade public disclosure of prices may have no impact on price efficiency and liquidity; (iii) however, public disclosure of past transaction orders or volumes reduces price efficiency but improves liquidity. We also derive several testable implications about price efficiency and market liquidity and demonstrate the robustness of our findings in face of a general class of payoff functions, stochastic trading positions, divisible and indivisible orders, finite and infinite trading calendars, and fixed or time-varying fundamentals.

Information Choice and Amplifications of Financial Crisis (with T. Ahnert)
Review of Financial Studies (RFS), vol 30, no 6.
(Topic) Banking and financial crisis

We propose an amplification mechanism of financial crises based on the information choice of investors. Information acquisition always makes investors more likely to act against what is suggested by the prior. Deteriorating public news under an initially strong (weak) prior increases (reduces) the value of private information and induces more (less) information acquisition. Deteriorating public news always increases the probability of a crisis, since the initially strong (weak) prior suggests do-not-attack (attack). This effect is amplified when information choices are endogenous. To enhance financial stability, a policymaker can use taxes and subsidies to affect information acquisition. We also derive testable implications for the magnitude of amplification.

Liquidity Regulation, Bank Complexity and Policy: GFC vs COVID-19 Crisis, (with J. Bosshardt). (Topic) Banking and financial crisis

We introduce a general equilibrium model to analyze the interactions between liquidity regulations and banks' investment in complex assets. Complexity improves bank liquidity in good times but heightens vulnerability to runs during crises. Banks underinvest in complex assets when liquidity regulations are loose and overinvest when liquidity regulations are tight. Liquidity regulations qualitatively affect the structure of complementary ex-ante policies, such as asset-specific taxes, but they can also undermine the benefit of ex-post interventions that support interbank loan prices, such as quantitative easing. The

implications of the model are examined empirically in the context of the Liquidity Coverage Ratio.

Advising the Management, (with U. Loginova, A. Malenko, N. Malenko)
R&R in the Review of Financial Studies (RFS). (Topic) Corporate governance

We study the optimal size and composition of an advisory committee when shareholders differ in preferences and beliefs and strategically acquire and communicate information. If shareholders and management have similar objectives but disagree due to different beliefs, and information is cheap, the optimal advisory body includes all shareholders. Conversely, if agents have conflicting preferences or information is sufficiently costly, the optimal advisory body is a strict subset of shareholders. Thus, advisory voting (board) is optimal in the former (latter) case. Similar implications hold if the committee also has authority, but unlike purely advisory committees, committees with authority are more diverse.

Optimal Contracting in Networks, (with A. Jadbabaie)
Journal of Economic Theory (JET), vol 183, no 9.
(Topic) Principal-agent problems, contracting

We study the optimal size and composition of an advisory committee when shareholders differ in preferences and beliefs and strategically acquire and communicate information. If shareholders and management have similar objectives but disagree due to different beliefs, and information is cheap, the optimal advisory body includes all shareholders. Conversely, if agents have conflicting preferences or information is sufficiently costly, the optimal advisory body is a strict subset of shareholders. Thus, advisory voting (board) is optimal in the former (latter) case. Similar implications hold if the committee also has authority, but unlike purely advisory committees, committees with authority are more diverse.

Dynamic R&D Contracting, (with K. Li).
(Topic) Principal-agent problems, dynamic compensation

We study a contracting problem in continuous-time where the principal hires an agent to conduct an R&D project for which progress towards success is binary. Under general concave payoffs, we explicitly derive the optimal dynamic incentive contract. In the first best scenario where incentives between the agent and principal are aligned, the optimal contract is constant. In contrast, when incentive compatability is a binding constraint, the optimal contract is explicitly characterized by the unique solution of an ordinary differential equation. The duration of employment is also uniquely specified by an endogenous threshold. The principal is patient near that threshold and his continuation value may in

fact be negative in a neighborhood of the threshold. Importantly, due to the lumpy nature of the project completion, the optimal incentive-pay is two-dimensional: a flow payments during the R&D phase, and a lump-sum reward upon successful completion of the project. Finally, in numerical simulations, we find that the optimal contract features a miniscule level of flow payments, where most of the agent's benefit come from the lump-sum reward when the project is successful. This theoretical feature of our model agrees with empirical evidence that CEO compensation is tied to the success of research agendas taking place over a long time horizon.

Dynamic Pricing in Social Networks: The Word of Mouth Effect,
 (with A. Ajorlo and A. Jadbabaie) *Management Science, vol 64, no 2.*
(Topic) Dynamic pricing, information diffusion

We study the problem of optimal dynamic pricing for a monopolist selling a product to consumers in a social network. In the proposed model, the only means of spread of information about the product is via Word of Mouth communication; consumers' knowledge of the product is only through friends who already know about the product's existence. Both buyers and non-buyers contribute to information diffusion while buyers are more likely to get engaged. By analyzing the structure of the underlying endogenous process, we show that the optimal dynamic pricing policy for durable products with zero or negligible marginal cost, drops the price to zero infinitely often. By attracting low-valuation agents with free-offers and getting them more engaged in the spread, the firm can reach out to potential high-valuation consumers in parts of the network that would otherwise remain untouched without the price drops. We provide evidence for this behavior from smartphone app market, where price histories indicate frequent free-offerings. Moreover, we show that despite infinitely often drops of the price to zero, the optimal price trajectory does not get trapped near zero. We demonstrate the validity of our results in face of strategic forward-looking agents, homophily-based engagement in word of mouth, network externalities, and consumer inattention to price changes. We further unravel the key role of the product type in the drops by showing that the price fluctuations disappear after a finite time for a nondurable product.

Managerial Protections, Capital Requirements, and Bank Lending
(with J. Bosshardt). (Topic) Banking, Capital structure

We introduce a model to illustrate how the effect of capital requirements on bank lending can qualitatively depend on the extent of managerial protections against shareholder actions. Protections encourage managers to pursue unprofitable projects. Protected managers can still be disciplined by debt. If debt is constrained by capital requirements, then a higher level of investment can serve as a partial substitute. Capital requirements can therefore spur increased investment for firms with managerial protections. Empirically, bank stress-

testing after the 2008 financial crisis led to an increase in lending for banks with strong protections compared to banks with weak protections.

Market Power and Asymmetric Learning in Product Markets,
(with G. Lanzani). (Topic) Dynamic trading, learning, liquidity

We study how market power, along with asymmetries in learning technologies, affect trading in a product market. In this market, a new product of unknown quality is introduced to challenge a pre-existing product of known quality. We show that market efficiency (the first-best) is achieved independent of how large or small the market power is if buyers are symmetric in their learning technologies. However, if buyers are asymmetric, only a monopolistic market in which the seller of the old product also markets the new one is efficient. We identify inefficiency as a learning externality that consumptions of the unknown quality product by one buyer generates to the other buyers. The equilibrium inefficiency has two important features: (i) Efficiency at the top: the threshold for starting to serve the best learners (i.e., to enter into a Beta phase) remains the optimal one; (ii) Non-monotonicity: distortions are not monotone in the extent of the asymmetry. Importantly, if sellers can offer take-it-or-leave-it multilateral contracts, the distortion disappears. Finally, we explore the robustness of our results under different assumptions about the ability to price discriminate and other market structures.

The Effect of Liquidity Regulation on U.S. Bank Risk-Taking: Evidence from Non-Performing Loans and CDS Spreads, (with J. Bosshardt)
(Topic) Banking, Risk taking, Liquidity regulation

This paper illustrates channels by which regulations that require banks to hold liquid assets can either increase or decrease a bank's incentive to take risk with its remaining ineligible assets. A greater capacity to respond to liquidity stress increases the potential profits a bank would put at stake by making risky investments, but it also mitigates the illiquidity disadvantages of holding risky assets. We then empirically estimate the effect of two liquidity regulations on bank risk-taking as measured by the ratio of non-performing loans to total loans and credit default swap (CDS) spreads. Using a regression discontinuity design, we do not find evidence that reserve requirements significantly affected non-performing loans ratios. Using a differencein-differences specification, we also do not find evidence that the liquidity coverage ratio significantly affected non-performing loans ratios or CDS spreads.

Dynamic Price Discovery: Transparency vs. Information design,
(with F. Song) *Games and Economic Behavior, vol 122, no 7.*
(Topic) Price discovery, learning, dynamic trading

This paper studies how information design, via public disclosure of past trade details, affects price discovery in a dynamic market. We model that an informed forward-looking buyer sequentially trades with a series of uninformed sellers (hedgers) with heterogenous hedging motives. We discover that sellers' price discovery over the underlying hidden fundamentals is crucially affected by what they can observe about past trade details. Specifically, Post-trade price transparency *delays* price discovery, but once it happens, it is always perfect. In contrast, when only past order information is available, *price discovery can never be perfect, and can even be in the wrong direction.* Finally, we show that our findings are robust for diminishing bargaining power, non-zero outside options, and different trading positions.

Speed Competition and Segmentation in Illiquid Markets
(with O. Celebi and K. Li). (Topic) Microstructure of asset markets

In this paper we present a model in general equilibrium to analyze competition between multiple venues (dealers), endogenous market segmentation, transaction speeds and fees, trading volume, optimal regulator's choice for taxing traders, and welfare in illiquid asset markets. Offering heterogenous trading speeds leads to endogenous market segmentation, increasing overall liquidity via higher trading volume in asset markets. While this liquidity decreases with higher regulatory taxes, it increases with higher speed in the slower venue and lower transaction fees. With com- petition, optimal choice of transaction fees are increasing (decreasing) in the trading speed of the faster (slower) venue. When venues entries is sequential, the new entrant's optimal choice of trading speed increases with lower entry costs and trading taxes. We further consider different notions of welfare: surplus from trade, trading volume, and trading revenue. In each of these cases, we consider the optimal regulator's choice for taxing traders, and the resulting optimal choice of speed for a new entrant. Depending on the regulator's objective, the optimal trading tax choice can be zero or strictly positive. Finally, we investigate welfare loss due to competition and the speed choice of a new entrant.

Two dimensional communication technologies in social networks: Welfare Analysis (with U. Loginova). (Topic) Corporate governance, communication

This paper studies when introducing verifiable communication choices between agents (players) in a cheap-talk benchmark setting, with social tie, is beneficial to welfare. In our model agents have two ways to communicate their private information: either through a costly verifiable information (hard) link or through a low-cost cheap talk (soft) link. We identify that the appearance of hard links in the pure cheap talk setting has two opposing effects on welfare: (i) a positive effect stems from the information improvement and (ii) a negative effect arises from crowding out soft communication with costly verifiable communication. Surprisingly, the final welfare outcome of the two opposing forces depends on the cost structure. If only one party bears the cost of a hard link, then the positive

(informational) effect always dominates the negative (crowding out) effect, and thus introducing hard links is beneficial to welfare. In contrast, if the cost of a hard link is shared by both parties, then allowing for verifiable communication can be detrimental to welfare. We also derive several testable implications about introducing hard links in corporate governance, and demonstrate the robustness of our findings in face of heterogenous costs, as well as the case where cost is endogenizied via negotiation about how to split the costs.

Why did Firms Draw Down their Credit Lines during the COVID-19 Shutdown? (with J. Bosshardt). (Topic) Banking, COVID-19, credit lines

The economic shutdown associated with the COVID-19 pandemic witnessed a dramatic surge in drawdowns on pre-existing credit lines. This paper examines how this liquidity was used by firms. Drawdowns were associated with the accumulation of liquid assets, suggesting a precautionary motive to mitigate future liquidity risk. We do not find strong evidence that drawdowns were generally associated with greater levels of investment. However, we find evidence that firms in industries that were less affected by the shutdown, such as professional services that can be per- formed remotely, were more likely to use drawdowns to maintain investment. On the intensive margin, this is especially true for firms in such industries that drew a relatively small amount of funds.

Competition in Electricity Markets with Renewable Energy Sources, (with D. Acemoglu and A. Ozdaglar), *The Energy Journal, vol 38, no SI1*. (Topic) Energy finance, renewable energy, policy

We offer a parsimonious model to investigate how strategic wind producers sell energy under stochastic production constraints, where the extent of heterogeneity of wind energy availability varies according to wind farm locations. The main insight of our analysis is that increasing heterogeneity in resource availability improves social welfare, as a function of its effects both on improving diversification and on reducing withholding by firms. We show that this insight is quite robust for any concave and downward-sloping inverse demand function. The model is also used to analyze the effect of heterogeneity on firm profits and opportunities for collusion. Finally, we analyze the impacts of improving public information and weather forecasting; enhanced public forecasting increases welfare, but it is not always in the best interests of strategic producers.

Selling Wind (with A. Ozdaglar and I. Schneider), *The Energy Journal, vol 40, no 30.* (Topic) Energy finance, renewable energy, policy

We offer a parsimonious model to investigate how strategic wind producers sell energy under stochastic production constraints, where the extent of heterogeneity of wind energy availability varies according to wind farm

locations. The main insight of our analysis is that increasing heterogeneity in resource availability improves social welfare, as a function of its effects both on improving diversification and on reducing withholding by firms. We show that this insight is quite robust for any concave and downward-sloping inverse demand function. The model is also used to analyze the effect of heterogeneity on firm profits and opportunities for collusion. Finally, we analyze the impacts of improving public information and weather forecasting; enhanced public forecasting increases welfare, but it is not always in the best interests of strategic producers.

Publications in
Operations research and Control:

Tight Bounds On the Redundancy of Huffman codes, (with S. Mohajer and P. Pakzad) *IEEE Transactions on Information Theory (IT), vol. 58, no. 11, 2012.* (Topic) Information theory, Bayesian inference

An Efficient Game Form for Unicast Service Provisioning, (with D. Teneketzis) *IEEE Transactions on Automatic Control (TAC), vol. 57, no. 7, 2012.* (Topic) Market-Mechanism design, Networks

Power Allocation and Spectrum Sharing in with Strategic Users, (with D. Teneketzis) *IEEE Transactions on Automatic Control (TAC), vol. 57, no. 9, 2012.* (Topic) Market-Mechanism design, Networks

On Describing the Routing Capacity Regions of Networks, (with S. M. S. Yazdi) *Mathematical Methods of Operations Research (MMOR), vol. 72, no 9, 2012.* (Topic) Discrete optimization

Pay To Bid Auctions: To bid or not to bid, *Operations Research Letters (ORL), vol 41, no. 5, 2014.* (Topic) Dynamic auction, trading

An Efficient Game Form for Multirate Multicast Service Provisioning, (with D. Teneketzis) *IEEE Journal on Selected Areas in Communications (JSAC), Lead article in the Special issue on "Network Economics" vol. 30, no. 9, 2012.* (Topic) Market-Mechanism design, Networks