Massachusetts Institute of Technology
Sloan School of Management

Room E62-618
100 Main Street
Cambridge, MA 02142-1347

Telephone: (617) 253-0920
Facsimile: (781) 891-9783
E-Mail: alo@mit.edu
http://web.mit.edu/alo/www/

ANDREW W. LO
Charles E. and Susan T. Harris Professor
Director, MIT Laboratory for
Financial Engineering

March 30, 2015



Dear Sir or Madam,

I am delighted to write this letter of recommendation for Pablo Azar, a Ph.D student in the Economics department at MIT. I was first introduced to Pablo about four years ago by his primary thesis advisor, Silvio Micali, when he was a student in MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL) concentrating in theoretical computer science, because of our mutual interests at the intersection of economics and computer science. In addition to serving on his thesis committee, I have also worked with Pablo on joint research projects involving the application of natural language processing techniques to the recent Supreme Court healthcare decision, and an analysis of the entire U.S. legal code as a piece of software, so I have firsthand experience with Pablo as a co-author.

This letter of recommendation will be a very easy one to write. Pablo is an extraordinary candidate who comes along only once every few years. Given the opportunity to apply his experience to the areas of entrepreneurship and corporate finance, I am confident that Pablo will contribute fruitful research to the fields.

Pablo's research interests span several areas in computer science and economics, but the majority of his contributions to date fall in the area of mechanism design, the design of auctions and other market mechanisms for allocating scarce resources to parties in efficient ways. This a well-trodden field of economics that has become revitalized by computer scientists like Michael Kearns, Silvio Micali, and Michael Rabin, and Pablo has already made major contributions to this literature. In a series of papers ("Parametric Digital Auctions", "Optimal and Efficient Parametric Auctions", and "Crowdsourced Bayesian Auctions"), Pablo develops auction mechanisms that maximize revenues under various assumptions about the supply of the good, the amount of information available to participants and the autioneer, and the motivations. These contributions generalize several well-known results in the economics literature by Bulow, Klemperer, Maskin, and Myerson, often providing much more

general nonparametric versions of their more restriction economic counterparts. However, apart from the sheer technical prowess that these generalizations showcase, Pablo's work presents a fundamentally new way of looking at mechanism design, a more practical and robust perspective that yields fresh insights into the strengths and weaknesses of the extant literature on market mechanisms and their implementation.

However, Pablo's research does not just involve applying computer science to economics; he has also applied economics to computer science to great effect. In his paper titled "Rational Proofs," Pablo extends the vast literature in computer science on interactive proofs in one very important direction: the case in which provers are assumed to be rational in the economic sense of maximizing their expected utility at all times. This one new assumption yields surprisingly sharp results, especially in the case with only a finite number of rounds of interaction. These results give much greater practical relevance to interactive proofs than the classical theory in which provers can be malicious or benevolent because the truth is somewhere in between.

Perhaps because of his undergraduate training in economics, or perhaps because of his personal interests, Pablo brings a novel dimension to the computer science literature that makes this body of work much more relevant to economists and applied mathematicians. His technical skills in discrete mathematics are formidable, but he possesses an intuition about the theory that guides his research, which is far too rare a commodity among budding economic theorists and theoretical computer scientists.

On a personal level, Pablo is a wonderful colleague; pleasant, intellectually curious, and unfailingly polite but honest and direct with comments and criticism. In short, he is a first-rate scholar who will be a credit to your summer program.

In summary, I believe Pablo is on a very strong academic trajectory and is one of the rising young stars in theoretical computer science and economic theory. I recommend him without reservation and with the strongest level of enthusiasm. Please let me know if I can provide any further information.

Sincerely,



Andrew W. Lo

NBER Entrepreneurship Research Boot Camp Application

Pablo Daniel Azar

I am applying for the NBER Entrepreneurship Research Boot Camp. A research statement and CV are enclosed with this cover letter. Professor Andrew Lo (`alo@mit.edu`) will be sending a support letter.

Thank you,

Pablo Daniel Azar
MIT Economics Department
50 Ames Street, E19-750
Cambridge, MA, 02139
pazar@mit.edu
`http://people.csail.mit.edu/azar`

Research Statement

I am a Ph.D. student in the Economics department at MIT, and I am interested in attending the entrepreneurship boot camp at NBER because I want to learn more about entrepreneurship research and hope to write a dissertation topic related to the area. I am currently taking the finance graduate course sequence at MIT, and plan to take my general exams in finance. I have research experience in auction design and natural language processing, and I would be excited to apply some of the techniques in these fields to entrepreneurship and corporate finance.

My line of work on auction design focuses on how auctioneers can set prices for goods when they have very limited information on how much buyers are willing to pay. Traditional models assume that the buyers' willingness to pay is a random variable whose distribution is known to the seller. With several coauthors I have studied how goods can be priced when the seller does not know this distribution, and how simple rules can be very robust. For example, even when the seller only knows what the median buyer is willing to pay, he or she can still obtain half of the optimal revenue that a seller who has full knowledge of the distribution could achieve. This type of reasoning generalizes to pricing problems with multiple goods, where the optimal auction mechanism is unknown—but where we can still prove that simple auctions guarantee a significant fraction of the optimal revenue.

With new ventures, a similar problem arises where there is very little information about the distribution of firm returns. Thus, traditional principal-agent models of funding where we assume that investors fully know the distribution of outcomes produced by a good (or bad) manager may not be applicable in practice. I would be interested in exploring whether the techniques can help us make contracts between investors and entrepreneurs more robust, even in the presence of extremely limited information.

Another area that I am interested in is the use of non-traditional sources of data, such as text data. I have worked with Andrew Lo and an interdisciplinary team including other computer scientists and lawyers on several projects analyzing texts written by government entities, including the Supreme Court, Congress and the Federal Reserve. These new sources of data can help us analyze the authorship of anonymous (per curiam) Supreme Court opinions, measure the

complexity of new laws and regulations passed by Congress, and quantify the effect of Fed officials' speech on future interest rates.

There are many of these non-traditional data sources associated with new enterprises, such as financial disclosures, news reports and corporate documents. I would be excited to study whether the text in these documents can help us predict future success of new ventures.

As a first year economics Ph.D. student with an interest in corporate finance, and a background in auction design and computer science, I hope I can benefit from attending the entrepreneurship research boot camp.

Pablo Azar

Pablo Azar
MIT Economics
50 Ames Street, E19-750
Cambridge, MA 02139
http://people.csail.mit.edu/azar
pazar@mit.edu

Education

Ph.D. in Economics, Massachusetts Institute of Technology. September 2014-Present
Ph.D. in Computer Science, Massachusetts Institute of Technology. September 2014
S.M. in Computer Science, Harvard University, June 2009.
A.B. in Applied Mathematics - Economics, Harvard University, June 2009.
Honors Magna Cum Laude. Highest Honors in Applied Mathematics. Phi Beta Kappa.

Work in Progress

1. **Computational Contracts**
   P. Azar and S. Micali
   Revise and Resubmit, *Theoretical Economics*
2. **Decoding FedSpeak: Text and VAR Analysis of Fed Transcripts**
   P. Azar, W. Li and A.W. Lo
3. **Sentiment Analysis in Financial News**
   Pablo Azar
   In progress

Publications

4. **Law is Code: A Software Engineering Approach to Analyzing the United States Code**
   W. Li, P. Azar, D. Larochelle, P.Hill, J.C. Cox, R. Berwick and A.W. Lo
   Journal of Business & Technology Law
5. **The Query Complexity of Scoring Rules**
   P. Azar and S. Micali
   Transactions on Economics and Computation. Forthcoming.
6. **Prophet Inequalities with a Single Sample**
   P. Azar, R. Kleinberg and S. M. Weinberg
   Symposium on Discrete Algorithms (SODA 2014). Forthcoming.
7. **Quantifying U.S. Supreme Court Decisions Using Authorship Attribution Techniques**
   W. Li, P. Azar, D. Larochelle, P. Hill, J.C. Cox, R. Berwick and A.W. Lo
   Stanford Technology Law Review, Volume 6, Number 3, Page 503-534.
8. **Super-Efficient Rational Proofs** (One Page Abstract)
   P. Azar and S. Micali
   Electronic Commerce (EC 2013). Pages 29-30
9. **Parametric Digital Auctions** (One Page Abstract)
   P. Azar and S. Micali
   Innovations in Theoretical Computer Science (ITCS 2013). Pages 231-232
10. **Optimal and Efficient Parametric Auctions**

P. Azar, C. Daskalakis, S. Micali and S.M. Weinberg
Symposium on Discrete Algorithms (SODA 2013). Pages 596-604

11. Rational Proofs

P. Azar and S. Micali
Symposium on Theory of Computing (STOC 2012). Pages 1017-1028.

12. Crowdsourced Bayesian Auctions

P. Azar, J. Chen and S. Micali
Innovations in Theoretical Computer Science (ITCS 2012). Pages 236-248.

Lectures and Talks

Rational Proofs

1. China Theory Week, Aarhus University, Aarhus, August 2012.
2. Symposium on Theory of Computing (STOC), New York, May 2012.
3. Northwestern University Theory Seminar, Evanston, April 2012.
4. Institute for Advanced Study Computer Science/Discrete Math Seminar, Princeton,April 2012.
5. Columbia University Theory Seminar, New York, March 2012.
6. Cambridge Area Economics and Computation Day (CAEC), Cambridge, November 2011.

Optimal and Efficient Parametric Auctions

7. New York Computer Science and Economics Day (NYCE), New York, December 2012.
8. North American Winter Meeting of the Econometric Society. Philadelphia, January 2014.

Parametric Digital Auctions

9. Workshop on Risk Aversion in Mechanism Design, (EC Workshop), Valencia, June 2012.
10. 3rd Market Algorithms and Optimization Workshop at Google NYC, May 2012.

The Query Complexity of Scoring Rules

11. 4th World Congress of the Game Theory Society (GAMES 2012), Istanbul, August 2012.
12. University of Chicago Economic Theory Working Group, Chicago, April 2012.
13. MIT Economics Theory Lunch, Cambridge, March 2012.

Crowdsourced Bayesian Auctions

14. Innovations in Theoretical Computer Science (ITCS), Cambridge, January 2012.
15. MIT Economic Theory Lunch, Cambridge, November 2011.
16. Auctions, Markets, Mechanisms and Applications (AMMA), New York, 2011.
17. North American Summer Meeting of the Econometric Society, St. Louis, June 2011.
18. Workshop on Bayesian Mechanism Design (EC Workshop), San Jose, CA, June 2011.

Budget Balanced Maximization of Social Welfare Resilient to Unrestricted Privacy, Collusion and Beliefs

19. 2nd Brazilian Workshop of the Game Theory Society. Poster Session. Sao Paulo, Brazil, August 2010.

Teaching Experience

Co-Lecturer. Introduction to Algorithms (Feb 2013 – June 2013.)

Research Mentor. MIT Super-UROP program (September 2012 –May 2013.)

Responsibilities include mentoring MIT undergraduate Marco Antonio Lopes Pedroso on a project evaluating the empirical performance of approximately optimal auctions.

Teaching Assistant. Resilient Mechanism Design (September 2011 – December 2011.)

Teaching Assistant. Cryptography and Cryptanalysis (February 2011 – May 2011.)

Course Assistant. Efficient Algorithms (September 2008 – January 2009. Harvard University.)

Course Assistant. Intelligent Machines: Perception, Learning and Uncertainty (February 2008 – May 2008. Harvard University.)

Work Experience

Research Assistant. (February 2007 – May 2007, September 2007 – June 2008.)
Harvard Economics Department and Institute for Quantitative Social Sciences
Worked on projects concerning corporate valuation.Responsibilities included implementing a search engine for financial reports and performing sentiment analysis on news data.

Intern. (June 2007 – August 2007.)
Ellington Management Group
Developed and tested models for risk management in Collateralized Debt Obligations.

Refereeing

Program Committee Member for AMMA 2015
Referee for SIAM Journal on Discrete Mathematics.
Reviewer for FOCS 2013
Subreviewer for EC 2013, ASIACRYPT 2013 and STOC 2012