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Graduate Studies:

Harvard University, 2011 to present
Ph.D. Candidate in Political Economy and Government
Thesis Title: "*Essays on Innovation and Growth*"
Expected Completion Date: June 2017

Massachusetts Institute of Technology, 2011
PhD in Electrical Engineering and Computer Science

References:

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Professor Marc Melitz
Harvard University
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Teaching and Research Fields:

Primary fields: Economic Growth; International Trade
Secondary fields: Entrepreneurship and Innovation; Machine Learning; Behavioral Economics

Teaching Experience:

Fall, 2014	*Judgment & Decision Making*, Harvard Kennedy School, TF for Prof. J. Lerner
Spring, 2014	*Psychology in the Economic Wild*, instructor for sophomore tutorial
Fall, 2013	*Graduate Political Economics*, TF for Prof. A. Alesina
Spring, 2009	*Inference and Information (Grad)*, MIT, TF for Profs. P. Golland and G. Wornell

Research Experience and Other Employment:

2013-present	Harvard Institute for Quantitative Social Science (IQSS), Research Affiliate
2006-2011	MIT Computer Science and Artificial Intelligence Lab, Graduate and Postdoctoral Researcher
2005-2006	MIT Research Laboratory of Electronics, Research Affiliate

Honors, Scholarships, and Fellowships:

2015-2016	Bradley Fellowship
2011	Hewlett Packard Fellowship
2009	Honorable mention (runner-up), Francois Erbsmann Award in Medical Imaging
2006	MIT Graduate Alumni Fellowship

Research Papers:

"Innovation, Knowledge Diffusion, and Selection," (Job Market Paper)

Abstract: This paper constructs a theory of industry growth to study the implications of knowledge diffusion and selection for innovation policy. Firms' ideas determine their productivity and stochastically evolve over time. Firms innovate to improve their ideas and endogenously exit if unsuccessful. Entrants adopt the ideas of incumbents. In this model, creative destruction works through selection: when better ideas are innovated or adopted, they selectively replace worse ideas. Innovation externalities vary based on firm productivity: ideas generated by more productive firms create 1) longer-lasting positive knowledge spillovers and 2) stronger negative competition effects. Therefore, the net external effect of innovation is heterogeneous across firms. Quantitatively, this heterogeneity is large and matters for innovation policy when the model is calibrated to US data on manufacturing and retail trade.

"Structural Change with Long-run Income and Price Effects," with Diego Comin and Martí Mestieri, (Revise and Resubmit, *Econometrica*)

Abstract: We present a new multi-sector growth model that accommodates long-run demand and supply drivers of structural change. The model generates nonhomothetic Engel curves at all levels of development and is consistent with the decline in agriculture, the hump-shaped evolution of manufacturing and the rise of services over time. The economy converges to a constant aggregate growth rate that depends on sectoral income elasticities, capital intensities and rates of technological progress. We estimate the demand system derived from the model using historical data on sectoral employment shares from twenty-five countries and household survey data from the US. Our estimated model parsimoniously accounts for the broad patterns of sectoral reallocation observed among rich, miracle and developing economies in the post-war period. We find that income effects play a major role in generating structural change.

Research Papers in Progress:

"Optimal Incentives for Firm Growth: An Application to the Design of Fiscal R&D Subsidies"

Abstract: The effectiveness of ex ante (push) incentives or ex post (pull) incentives in spurring innovation has been a long-standing subject of debate. In this paper, I study government untargeted fiscal R&D incentives. I show that if firms are heterogeneous in their capacity for innovation but the social planner can only observe their success or failure ex post, the optimal mechanism involves combining both ex ante and ex post incentives. More specifically, I find that under certain conditions optimal ex ante and ex post subsidies have the same size but are in reverse directions. The government should optimally tax (or subsidize) R&D investment and simultaneously subsidize (or tax) profits reaped from successful innovation. My theory includes two sources of private information, first regarding the entrepreneurs' capacity for innovation and second, hidden choice of innovative efforts. I fully characterize the optimal policies in terms of parameters that may be empirically estimated from the data and can be applied in the design of R&D tax credits.

"Demand-Pull, Technology-Push, and the Sectoral Direction of Innovation," with Diego Comin and Martí Mestieri

Abstract: This paper studies the demand-side forces that determine the direction of firms' research and development investments. We develop a multi-sectoral endogenous growth model in which the direction of innovation across sectors is endogenous. The model provides a thoery for studying the

classical demand-pull versus technology-push drivers of innovation in a general equilibrium setting. A robust prediction is that innovation growth should be higher in more income- elastic sectors. We test this prediction using the universe of U.S. patents and firm R&D investments for the period 1976-2007. The analysis lends empirical support for the main predictions of the model.

"Heterogeneous Income and Price Elasticities in General Equilibrium," with Martí Mestieri
Abstract: Micro-level studies robustly document heterogeneity in price and income elasticity of goods produced by different industries or firms. However, this heterogeneity is absent from most theories of aggregate and macro-level phenomena. In this paper, we provide a flexible yet tractable general-equilibrium framework for the study of heterogeneity in price and income elasticity across goods. We first show that a broad class of demand systems that either focus on price or income elasticity heterogeneity implicitly impose strong restrictions on the correlation between income and price elasticities across goods. We show that data on trade flows does not support such correlations for import demand. We provide a generalization of the standard CES preferences that flexibly allows for general patterns of correlations between income and price elasticity. As an application of our demand system, we embed it in a Ricardian model of international trade and show it implies intuitive corrections to the standard results for the welfare gains from trade. These corrections stem from the fact that the gains from access to new varieties strongly hinge on the price and income elasticity composition of the traded goods. Empirically, we show that these compositional effects result in substantially higher welfare gains from trade in rich relative to poor countries.

Selected Publications in Machine Learning and Neuroscience:

E. Vul, **D. Lashkari**, P.-J. Hsieh, P. Golland, and N.G. Kanwisher, "Data-driven functional clustering reveals dominance of face, place, and body selectivity in the ventral visual pathway," *Journal of Neurophysiology*, 108(8): 2306-2322, 2012.

D. Lashkari, R. Sridharan, E. Vul, P.-J. Hsieh, N.G. Kanwisher, and P. Golland, "Search for patterns of functional specificity in the brain: a nonparametric hierarchical Bayesian model for group fMRI data," *NeuroImage*, 59(2):1348-1368, 2012.

B.T.T. Yeo, F. Krienen, J. Sepulcre, M. Sabuncu, **D. Lashkari**, M. Hollinshead, J. Roffman, J. Smoller, L. Zollei, J. Polimeni, B. Fischl, H. Liu, and R. Buckner, "The organization of the human cortex revealed by intrinsic functional connectivity," *Journal of Neurophysiology*, 106(3):1125-1165, 2011.

G. Langs, B. Menze, **D. Lashkari**, and P. Golland, "Detecting stable distributed patterns of brain activation using Gini contrast," *NeuroImage*, 56(2):497-507, 2011.

D. Lashkari, R. Sridharan, P. Golland, "Categories and functional units: an infinite hierarchical model for brain activations," *NIPS: Advances in Neural Information Processing Systems*, 23:1252-1260, 2010.

D. Lashkari, E. Vul, N.G. Kanwisher, and P. Golland, "Discovering structure in the space of fMRI selectivity profiles," *NeuroImage*, 3(15):1085-1098 2010.

D. Lashkari and P. Golland, "Convex clustering with exemplar-based models," *NIPS: Advances in Neural Information Processing Systems*, 20:825–832, 2008.

Innovation, Knowledge Diffusion, and Selection

Danial Lashkari*

Firm innovation is widely believed to be the main engine of productivity growth. Governments employ a variety of different policies such as R&D tax incentives and research grants to promote and support innovation among private businesses.[1] These programs, in part, aim to internalize the externalities that our canonical theories of growth attribute to the process of innovation. When each firm innovates, it creates positive *knowledge spillovers* and negative *competition effects* (business stealing) on other firms. My current research aims to understand the size of these firm-level externalities, their precise role in driving aggregate productivity growth, and their potential variations across industries in order to enable effective design of innovation policy.

Theoretical Framework One key step for understanding the link between firm-level innovation and aggregate productivity growth is to account for firm heterogeneity (Syverson, 2011). When firms vary in productivity, the reallocation of market shares from less to more productive firms may also contribute to aggregate productivity growth. Studies have found that, among these reallocations, the margin of firm entry and exit constitutes a particularly large component of productivity growth across different industries (e.g., Foster et al., 2001, 2006; Bartelsman and Haltiwanger, 2009). Inspired by these findings, several authors have recently begun to revisit the design of innovation policy in the presence of such reallocations (Acemoglu et al., 2013; Lentz and Mortensen, 2014; Atkeson and Burstein, 2015). Following the workhorse model of innovation proposed by Klette and Kortum (2004), they typically formalize these reallocations through the process of creative destruction: entrants build on the knowledge of an incumbent, steal its business, and push it out of the industry. However, this framework intrinsically ties together the two margins of innovation externalities, knowledge spillovers and competition; stealing one's idea means stealing one's business.

In my job market paper,[2] I contruct a theory of firm innovation and heterogeneity that disentangles the two externalities of knowledge spillovers and competition. Here, entrants can imitate the ideas of productive firms to steal business from unproductive ones. In other words, knowledge spillovers stem from the *diffusion* of productive ideas to new entrants, and competition results in the *selection* of unproductive ideas out of the industry. I show that this simple modification unleashes a host of novel, economically meaningful, and sizable externalities that matter for the design of innovation policy. I use the model to derive policies that internalize these innovation externalities, qualitatively and quantitatively examine their properties, and compare them across two broad sectors of the US economy, manufacturing and retail trade.

The structure of the model builds on the recent theories of knowledge diffusion and selection (Luttmer, 2007, 2012; Sampson, 2016) and extends them to include firm innovation (Ericson and Pakes, 1995; Atkeson and Burstein, 2010). Entrants receive knowledge spillovers from incumbent firms. Heterogeneous incumbents invest in innovation to raise their productivity and may endogenously exit due to fixed costs. Entry, exit,

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[1] For broad examples of these programs across developed and developing countries, see OECD (2012) and World Bank (2010). For more information on the design and scope of R&D tax incentives, see OECD (2010) and OECD (2011).

[2] My job market paper is available online here: http://scholar.harvard.edu/files/daniallashkari/files/danial_lashkari_jmp.pdf.

innovation, and the distribution of productivity in the industry are all endogenous. Three sets of structural features characterize these endogenous outcomes: costs of entry and innovation, volatility of firm productivity, and the strength of knowledge spillovers. I specify the strength of knowledge spillovers through two different characteristics of the process of entry and adoption: first, the imperfection of adoption, in the form of decreasing returns to adopting high productivity ideas, and second, directedness of adoption, in the sense of the probability of adopting the frontier idea in the industry.

The novel externalities arise from the interplay between diffusion and selection. Selection implies that the ideas of firms gradually become obsolete as better ideas emerge elsewhere in the industry. Of course, more productive ideas take longer before becoming obsolete. They therefore generate greater knowledge spillovers as, over the course of their longer lifetimes, more entrants have the opportunity to adopt them. Therefore, knowledge spillovers vary with the productivity of the ideas of firms. The dependence of knowledge spillovers on productivity constitutes the primary source of heterogeneity in externalities. In addition, when a firm innovates, the competition effect reduces the expected lifetimes of other firms and adversely affects their incentives for innovation. With each investment, a firm then reallocates innovation investments across other firms and toward itself. Since the spillover externalities are heterogeneous, this reallocation produces another external effect on aggregate growth.

Since externalities are heterogeneous under the market equilibrium, some firms overinvest and some underinvest in innovation. The social planner should therefore reallocate innovation investments across firms. I characterize the socially optimal allocation of innovation and production, and provide a method to compute it. Moreover, I derive the policy that implements this optimal allocation using taxes and subsidies to production and innovation. Under the assumption that we can observe the productivity ranking of firms, the derived policy uses a combination of a subsidy to startup costs for entrants, a lump-sum tax on the operation of firms, and a nonlinear subsidy to innovation investments that depends on the ranking of their productivity in the industry. The nonlinear innovation subsidy is the main instrument for the reallocation of innovation investments.

Early Empirical Results In my job market paper, I further try to examine the quantitative importance of these new forces by calibrating the model based on data from two broad sectors of the US economy, manufacturing and retail trade. In comparing retail and manufacturing, I have been inspired by the salient differences in the patterns of productivity growth that prior work has documented between the two sectors. For instance, case studies in the US retail sector often attribute the transformative innovations that have fueled the fast growth of productivity in this sector to mature and productive incumbents, particularly big-box stores such as Wal-Mart and Target (e.g., Foster et al., 2016; Basker, 2016). In this sector, firm productivity is highly correlated with measures of innovation such as IT investments (Doms et al., 2004). This pattern stands in contrast to manufacturing, where we typically associate transformative innovations with newcomers.[3] In addition, firm productivity is highly correlated with measures of innovation such as IT intensity in retail, and reallocations play a relatively larger contribution to aggregate productivity growth in retail compared to manufacturing (Doms et al., 2004; Foster et al., 2006). In the model, retail's distinctive growth experience is compatible with an environment that features high innovation costs, high business volatility, and weak knowledge spillovers. These structural differences in turn reflect in the design of innovation policy, as we saw above.

[3]Following Schumpeter's view of creative destruction, in our theories young firms have a comparative advantage for generating transformative innovations. New firms face larger incentives for innovation since they get to steal business from incumbents, whose incentives are partly curbed due to Arrow's replacement effect. New firms also face lower costs for performing disruptive innovation simply because they are more flexible and open to change (Acemoglu et al., 2014). In contrast, in the current model productive firms have an advantage for process innovation because of their longer expected lifetime.

I rely on the Business Dynamics Statistics (BDS) data that tabulates moments of the life cycle dynamics of firm employment for each sector. I calibrate a total of 6 parameters, two of which are directly calibrated to the rates of productivity and employment growth in the sector. For the remaining four parameters, I use a simulated moment matching strategy. The identification of costs of innovation and volatility comes from the rates of employment growth and reallocation among mature firms. To identify the two parameters of the process of entry, i.e., the imperfection and the directedness of adoption, I rely on the core logic of the model linking the quality of firm ideas to their expected lifetimes in the industry. According to this logic, any distribution on the initial productivity of a cohort of entrants translates into a distribution on the timing of their exit from the industry, conditional on the other model parameters. Therefore, I can use the empirically observed relationship between firm age and the hazard of exit to calibrate the parameters of the process of adoption. The results suggest that, despite its parsimony, the model provides a reasonable fit for the key moments in the data.

I investigate the productivity schedule of innovation subsidies that implement the optimal allocations. I find that for all but the very top firms we can approximate the policy by a subsidy rate that is an affine function of the productivity ranking of the firm. Incumbent firms receive a fixed subsidy rate for their innovation investments and a varying subsidy rate that is linear in their position relative to other firms in the distribution of productivity (with the rank normalized to be between 0 and 1). The dependence of the subsidy on the productivity ranking is weaker in retail compared to manufacturing (the approximate slope is about twice as large in manufacturing). Moreover, as productivity rises the pattern eventually reverses and the subsidy rate decreases among the most productive firms. But this pattern is more pronounced in retail trade, where the subsidy rate begins to fall among the top 5 percent of firms. This is a consequence of the stronger decreasing returns to adoption, which is implied by the calibrated parameters in this sector. For large firms in retail, their negative competition effect grows faster than their positive knowledge spillovers.

Plan for Future Work I intend to further expand on the framework of my job market paper by examining the sources of inter-industry variations discussed above using micro-level data on more disaggregated industries. Currently, I have access to comprehensive firm-level datasets that cover the entry and exit of firms (in France, Portugal, and Brazil) and, crucially, also include data on the identities of the entrepreneurs and their past work experiences. I plan to leverage this data to study the mechanisms highlighted in my theory, as well as a variety of other forces, in shaping the life-cycle dynamics of new firms across different industries.

First, I will explore the role of uncertainty in firm outcomes in delivering inter-industry variations in the life-cycle patterns of firm innovation and dynamics. Even though uncertainty has always been a cornerstone of our thinking about entrepreneurship, it plays a surprisingly muted role in most theories that link firm innovation to industry growth. By incorporating firm-level volatility, my model allows me to investigate the relation between life-cycle volatility and innovation behavior. Second, I plan to empirically investigate the incumbent-to-entrants spillovers that are at the heart of my theory, using the matched employer-employee data in France. In particular, I am currently investigating potential spillovers that work through the exposure of entrepreneurs to better business practices in their past work experiences. Third, I am working on an empirical extension of my work the allows structural estimation based on more detailed data on firm dynamics. The goal is to leverage my model for understanding potential inter-industry variations in the response of productivity growth to different economic policies. In the latter project, I am collaborating with researchers at INSEE (the National Institute of Statistics and Economic Studies of France) and the OECD.

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November 21, 2016

Dear Recruiting Committee Member:

I am writing to enthusiastically recommend Danial Lashkari to your department. Danial's research focuses on growth and innovation, but he is also working on applications to international trade.

His background is a bit unusual, as he came to Harvard after completing a Ph.D. in electrical engineering/computer science at MIT. In my experience with candidates with advanced degrees in technical fields, the transition to thinking as an economist (in terms of research design and approach) can be slow and arduous. There is often a tendency to gravitate toward problems that are more technical but not necessarily more interesting from an economic perspective. I have not witnessed any of these tendencies with Danial. He has great instinct for identifying important economic research topics and revealing the economic insights learned from addressing those topics. Naturally, his superior technical skills come in very handy in this process — but always as a tool and not as a means in itself. I should also note that his switch to the field of economics was purely motivated by his change in interests and not in the slightest related to any performance issues in his previous field. He was extraordinarily productive during his time at MIT. His seven publications in machine learning and neuroscience have already amassed over 1,700 Google citations.

Danial's job market paper represents a key breakthrough in the literature on growth and innovation. To my knowledge, he is the first to build a model of firm innovation and growth that incorporates firm productivity dynamics. Let me explain. There is a very important and active recent literature building/analyzing models of heterogeneous firm growth and innovation — exhibiting different growth and innovation patterns across firms. However, (to my knowledge), these differences are not related to differences in firm performance (productivity in a reduced form; i.e. how a firm contributes to real output per unit of inputs employed). Danial's model is the first to incorporate how a firm's productivity influences its incentives to innovate and the resulting growth rate. In parallel, there is another active recent literature analyzing how endogenous firm innovation effort varies with firm productivity/performance — but without growth. This literature emphasizes the critical nature of the feedback loops between firm productivity and innovation effort. Danial's model incorporates this critical feedback loop in a growth model with knowledge spillovers. In so doing, Danial's model is able to rationalize the most salient empirical moments regarding firm productivity dynamics (relating firm productivity to other firm-level observables such as size, exit probability, growth rate, and innovation) — while also generating predictions for long-run growth. Most importantly, his model generates some novel normative insights regarding the design of innovation policy by capturing differences in the social and private returns to innovation across firms with different productivity levels (once the feedback loop between productivity and innovation is operative).

There is a reason why such a model has not been developed/analyzed before: combining firm productivity dynamics (and endogenous entry/exit) and growth/knowledge spillovers presents some large technical hurdles. Danial has found a way to break those down and derive some key analytical predictions and decompositions regarding optimal innovation policy. Danial also develops some new tools for the quantitative analysis of his model. He shows how these can be used to calibrate the model to empirical moments for firm productivity dynamics. He applies this technique to the moments for the U.S. manufacturing and retail sectors. His parsimonious model is able to capture key differences between those two sectors. And they imply very different schedules for innovation policy across firms (both within and across sectors). In follow-up work, Danial is working on several extensions of his model that are fitted to much more detailed micro-level data on firm dynamics. In particular, he is investigating the use of cross-country data collected by the European Central Bank and the OECD. This analysis has also led Danial to develop some new empirical methods tailored to his model.

Danial only recently started working on his jobmarket paper (over the past year). Prior to that, Danial was mostly engaged with his multi-year collaboration project with Marti Mestieri (at Northwestern U.) and Diego Comin (at Dartmouth U.) on empirical growth dynamics (at the sector level). Their first paper is a strong "revise and resubmit" at *Econometrica*, (there were no dissenting referees; and the requested changes are straightforward). They are now working on a follow-up paper incorporating endogenous sectoral-level innovation dynamics. Danial also has a very exciting ongoing project with Marti where he extends the non-homothetic demand system developed in their work with Diego to an open economy setting. They show that this extension much more accurately captures the observed variation in price and income elasticities across goods – and that these variations critically affect the evaluation of the gains from trade across rich and poor countries. This work is very promising and on a trajectory that will hopefully generate another general interest publication. Diego and Marti both think extremely highly of Danial; he has been an integral part of their research team from the onset (Danial started the project as a full co-author). I have talked to Diego and he would be happy to serve as a reference for Danial.

Danial has already developed a remarkable maturity level as a researcher: he has very good instincts in identifying interesting research questions; he technical skills are outstanding; but has a good feel regarding the appropriate tradeoffs between simplicity and complexity; he is an independent and clear thinker. I think that all these qualities stand out in his job market paper, as well as his joint work with Diego Comin and Marti Mestieri. Danial is a very clear presenter, and I am confident that he will be an excellent and dedicated teacher. He could cover a wide range of courses in macroeconomics and international trade (including parts of the 1st year or field Ph.D. sequences in macroeconomics and the Ph.D. field sequence in trade). I enthusiastically recommend him to your department without any reservations. Please do not hesitate to contact me if you would like to discuss his application in any further detail.

Sincerely,



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ELHANAN HELPMAN
GALEN L. STONE PROFESSOR OF INTERNATIONAL TRADE

November 29, 2016

Dear Sir/Madam:

I am writing this letter on behalf of Mr. Danial Lashkari, a graduate student in our department, who is on the job market this year. Danial has a somewhat unusual background: he has a Ph.D. degree in computer science from MIT and he has published papers on machine learning and neuroscience. Unlike some students we have had with a Ph.D. degree in another discipline, Danial made a smooth transition to economics. That is, he thinks about significant economic problems and approaches them in ways that are familiar to economists rather than treating them as technical exercises. Not surprisingly, his technical skills are excellent and he takes advantage of them in his work. Yet none of his papers use technical analysis for its own sake.

Danial has a number of papers that focus on long-run growth, two of which are in very good shape, while the others have not yet been completed. A number of these papers are joint with Martí Mestieri, who was a graduate student at MIT and who now teaches at Northwestern University.

One of the completed papers is with Martí and Diego Comin, a professor at Dartmouth College, who was at the Harvard Business School when Danial and Martí started to work with him. This paper, entitled "Structural Change with Long-run Income and Price Effects," was submitted to *Econometrica*, and the journal requested a revision. In this paper Danial uses a nonhomothetic demand structure and explores the extent to which this nonhomotheticity in conjunction with sectoral capital intensities and sectoral rates of technological change shape structural transformation and long-run growth. The variation across sectors in income elasticities of demand plays a key role in this analysis, because as income per capita rises demand shifts towards sectors with high income elasticities and away from sectors with low income elasticities. This feature helps explain patterns in the historical data that they have assembled for rich countries, poor countries, and the fast-growing countries in the postwar period. A nice feature of the model is that not only does it account for the decline of agriculture and the rise of services, but it also accounts for the initial rise and subsequent decline of manufactures. This is an excellent paper on an important subject that is well executed, and will most likely receive substantial attention from scholars of economic growth and macroeconomists more generally.

In his job-market paper Danial develops a theory of long-run growth that explicitly incorporates a theory of firm dynamics. His firms invest in order to enter an industry and their investment yields a productivity level that depends on the productivity distribution of the incumbents. After entry, firms innovate in order to improve their performance and the incentives differ across firms with different productivity levels. Low-productivity firms exit the industry. At each point in time heterogeneous firms populate the industry, and they compete monopolistically in product markets, and invest in technology in order to enhance their competitive position.

Long-run growth of income per capita results from entry, exit, and innovation, affected by externalities from exiters and incumbents. An important modelling innovation in this work is the inclusion of firm selection and market-share reallocations that lead to long-run growth. Due to the externalities, there is room for

policies that raise welfare. Daniel shows that the optimal policies are intricate, and that contrary to conventional wisdom these policies favor large, productive firms, rather than small-business firms.

Danial plans to do extensive empirical work. In the meantime, in the job market paper, he shows that his model has interesting implications for different types of sectors. Moreover, his model replicates a variety of moments in U.S. data concerning firm dynamics and growth. Despite the complexity of the interactions, he nicely calibrates the model and uses powerful algorithms (that he developed) for quantitative analysis.

I believe that Daniel is a first-rate economist who will make important contributions to the economics of innovation and economic growth. He plans to incorporate international trade into his theory, to do more empirical work, and to further study structural transformation. His research program will keep him busy for several years.

Danial has excellent skills, he thinks about important economic problems, he is hard working, he is very intelligent, and he has great intellectual capacity. I strongly recommend him for a position in your school.

With my best regards,



Elhanan Helpman

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November 22, 2016

Dear Recruitment Committee:

I am writing this letter to support **Danial Lashkari's** application for a position at your institution.

Danial is a Ph.D. Candidate in the Political Economy and Government program at Harvard University. His research interests are in the areas of Economic Growth, Innovation and International Trade. I got to know Danial fairly late in his Ph.D. studies, but I have had several interactions with him in the last couple of years, so I feel I can give you an informed opinion about his current research and, more broadly, about his potential.

Danial is one of the most unique students I have advised at Harvard since I joined the department in 2003. Danial entered our program after having completed a Ph.D. in Computer Science at MIT in 2011. Despite being an accomplished computer scientist, Danial discovered Economics and decided to pursue his new passion at Harvard. Five and a half years later, Danial seems to have successfully completed his transition from being a computer scientist to being an economist, as is exemplified by the high quality of his research papers. I would advise all departments, including the very top ones, to take a close look at his application. He will likely not come across as being the most polished economist in his cohort at Harvard, but he may well be among the two or three in that cohort that are most likely to make big contributions to Economics.

Danial has been very productive during his years at Harvard, with his work focusing mainly in two areas: embedding non-homothetic preferences in general equilibrium models of growth and trade, and studying innovation in models with firm-level heterogeneity. The first research agenda was carried out in joint work with Diego Comín at Dartmouth and Martí Mestieri at Northwestern. It should be emphasized that Danial was never a research assistant for the project. Their collaboration emanated spontaneously from a few conversations they had a couple of years ago, and thus Danial should be considered a full co-author on those papers. I know both Diego and Martí very well, and they both offer the highest praise for Danial (I am sure they would both be happy to sing their praises to you if you contacted them). The second research agenda on innovation was carried out by Danial on his own, with the supervision of Philippe Aghion (until Philippe left for France), Elhanan Helpman, Marc Melitz and myself. Danial's job-market paper, which I will quickly overview below, is the main fruit of that research effort.

Let me begin by describing the papers on non-homothetic preferences that Danial has written with Diego Comín and Martí Mestieri. The unifying theme of these three papers is the exploration of the implications of a particular type of demand system (the *nonhomothetic Constant Elasticity of Substitution* demand system), for the workings of general-equilibrium growth and trade models. These preferences had been studied by Gorman (1965), Hanoch (1975), Sato (1975), and Blackorby and Russell (1981) but they had been pretty much forgotten ever since. They are particularly useful to work with because, even though

they allow for deviations from homotheticity, they still produce log-linear Engel curves, which are both empirically plausible, but also convenient to work with. Relative to standard CES preferences, the preferences Danial and coauthors work with allow for non-unitary income elasticities that are governed by parameters that can easily be made heterogeneous across sectors. Relative to other recent approaches to non-homothetic preferences, a key advantage of the non-homothetic CES demand system is that it allows for a complete decoupling of the income elasticity and the price elasticity in a given sector. In that respect, and as Danial and Martí discuss in their paper "Heterogeneous Income and Price Elasticities in General Equilibrium," most non-homothetic preferences that have been used in recent times impose a positive relationship between income and price elasticities of goods that appears to be at odds with empirical evidence. More specifically, relative to poor households, rich households appear to spend a higher share of their income on relatively differentiated goods, rather than on relatively homogeneous ones, and this is inconsistent with *any* additive demand system, a class to which most non-homothetic demand systems used to date belong to.

The three papers that Danial has written (or is working on) in this research agenda explore various implications of the non-homothetic CES demand system. The first paper, "Structural Change with Long-run Income and Price Effects," is focused on understanding the process of structural transformation that economies experience as they grow. Many growth theories emphasize the role of supply factors (e.g., technological change or variation in capital intensity) in shaping the transition from agriculture to manufacturing and from manufacturing to services. Danial and co-authors instead emphasize the role of demand factors which they tie to variation across sectors in the income elasticity of demand. Given the flexibility of the non-homothetic CES demand system, they are able to interpret the empirical evidence through the lens of a multi-sector growth theory that features log-linear Engel curves at all levels of income. The key finding of their paper is that, quantitatively, non-homotheticities appear to be a key determinant of the observed reallocations of employment across agriculture, manufacturing and services throughout the 20th century. The paper is a truly impressive piece, so it was no surprise to learn that it received an R&R at *Econometrica*. The revision will take some work, but the referees were unanimously favorable, so I am confident that the paper will end up being published in that journal.

The second paper in this research agenda introduces endogenous innovation to the multi-sector model developed in their previous paper. The main goal of the paper is to explore the role of heterogeneity in income elasticities across sectors in shaping the incentives of firms to innovate in different sectors. Their model formalizes the intuitive notion that innovation should be higher in more income-elastic sectors, because these sectors tend to feature larger market sizes in the long-run. The paper also includes an interesting empirical section which explores the validity of the model's predictions using data on U.S. patents and firm R&D investments.

The third and final paper in this research agenda is a bit more preliminary but I think it is quite promising (in fact, a year and a half ago, Danial considered the possibility of focusing more of his efforts on this paper to turn it into his job-market paper). The paper again explores some consequences of the non-homothetic CES demand system for the workings of a modern Ricardian model of international trade. A first contribution of the paper is to show – in line with what I described above – (i) that the non-homothetic CES demand system can accommodate variation in both income elasticities *and* price elasticities of demand, and (ii) that previously used non-homothetic preferences are inconsistent with the correlation between these elasticities observed in the data. Danial and Martí (Diego was benched for this particular project) then go on to show that accounting for the observed correlation between these elasticities leads to non-trivial corrections to standard measures of the welfare gains from trade, with richer countries appearing to gain more from trade (and poor countries less) than in standard models.

Overall, these three papers are likely to land in very good journals and I believe they will prove to be quite influential. As a signal to this, one of the most accomplished economists to have explored the role of

non-homothetic preferences in recent years (Kiminori Matsuyama) quickly recognized the importance of these papers and has adopted their demand system in his recent work. I am confident that others will follow suit in coming years.

Allow me to now turn to Danial's second broad research agenda on innovation and firm-dynamics, which is best exemplified by his job-market paper ("Innovation, Knowledge Diffusion, and Selection"). The paper connects and combines two recent research agendas. The first one, developed mostly by trade economists, has studied models of firm heterogeneity that emphasize selection effects that typically follow trade liberalization episodes. In a nutshell, trade liberalization brings about competition effects that weed out a set of unproductive firms in an industry (cf., Melitz, 2003). Recent contributions to that literature (e.g., Sampson, 2016) have also explored the implications of these selection effects for long-run growth, in a setting in which entrants draw their productivity from the productivity distribution of incumbent firms; by inducing the exit of the worst performing firms, trade implies that entrants are on average more productive, which leads to even more selection, and faster economic growth. A key limitation of these trade approaches to selection is that, though concerned with technological diffusion, they typically do not explicit model innovation efforts. The second branch of the literature that Danial builds on has been concerned with developing firm-level models of innovation with the aim to study the microeconomic underpinnings of endogenous growth theory. Much of that literature emanated from the seminal paper by Klette and Kortum (2004). However, most frameworks in that literature do not model industry dynamics (entry, exit and technological diffusion) in a fully satisfactory model.

Danial's job-market paper attempts to bridge these two literatures by developing a framework that simultaneously endogenizes entry, exit, and the innovation of firms. The structure of the model is as follows; in a given industry, heterogeneous incumbents invest in innovation to raise their productivity and may endogenously exit due to fixed costs if their productivity level falls below a given threshold (which is a function of the productivity of all active firms in the industry). At the same time, new firms may decide to enter the industry, in which case they are assigned a productivity level that is a flexible function of the distribution of productivity of incumbent firms. Whether the knowledge spillovers received by entrants are disproportionately tied to high versus low productive incumbents (what Danial calls the directedness of technology adoption) is governed by a parameter of the model. The model also features decreasing returns to adoption, which capture imperfect technology adoption.

In the model, the rate of productivity growth is shaped by the innovation efforts of incumbent firms, as well as by the process of selection. Importantly, these two forces interact with each other. On the one hand, when incumbents innovate, they also directly take into account selection forces because these shape their expected average life, and thus the extent to which they will be able to benefit from the fruits of their investments. On the other hand, entry and exit are affected by the incumbent's innovation efforts because of standard competition effects but also because depending on the directedness of the entrants' technology adoption, the productivity improvements of large versus small firms might play a particularly important role in an industry.

The equilibrium amount of innovation in the model is generically inefficient and Danial develops tools to characterize the optimal innovation policy depending on the parameters specific to an industry. A key consideration for the optimal taxes and subsidies to innovation is the extent to which, in a given industry, knowledge spillovers stem from relatively large (and productive) firms or from relatively unproductive ones. In practice, it is impossible to directly observe this in the data, but Danial shows that the dependence of the rate of exit on firm age is informative on the nature of these spillovers.

Danial then develops a quantitative analysis of the model that illustrates how optimal innovation policy can differ significantly across sectors depending on sectoral characteristics. Most notably, he draws a distinction between retail trade and manufacturing. This empirical part of the paper is a bit more tentative

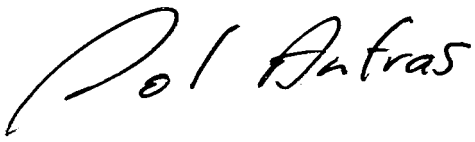
than the rest of the paper, in part because the nature of the data he uses somewhat limits the scope of what he can do with it. Nevertheless, Danial has given much thought to how to bring structural techniques from the Industrial Organization field to the question under study. In one instance, this led my colleague Ariel Pakes to praise Danial's knowledge of IO tools, something we not often hear from Ariel when it comes to students in fields other than IO.

In sum, Danial has the potential to become a leading researcher in Economic Growth and International Economics and all departments should consider him very seriously. He is technically superb and gets "stuff" done at a faster pace than I have witnessed with the vast majority of my past students, while doing so with great care and precision. For this reason, and beyond the high quality of his solo work, he is likely to have a very good career in academia (as his co-authored work with Comín and Mestieri exemplifies). His special background makes it somewhat hard for me to rank him relative to previous students of mine, but I can confidently say that he has as much potential as some of my best students in recent years. In many ways, he reminds me of Michal Fabinger, who was a star String Theorist turned Economist, and who was placed at Penn State in 2012 and subsequently moved to the University of Tokyo. Nevertheless, I think that Danial has made a more successful transition into Economics than Michal had done when going on the market.

In normal circumstances, I would anticipate that Danial would have a shot at landing a "top-ten" or even a "top-five" job, but I would advise lower-ranked schools to keep an eye on him, just in case top schools are particularly constrained this year.

Please feel free to contact me by phone or email if you have any questions.

Sincerely,



Pol Antràs

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December 2, 2016

Dear Recruiting Committee:

Danial Lashkari is an outstanding job-market candidate, and I would recommend him to the best economics departments and business schools. His research is on economic growth with connections to industrial organization and international trade. A key feature is the analysis of sectoral composition in a framework that allows for demand effects (Engel curves with differing slopes) and supply effects (differential firm productivity in a context of R&D choice and entry/exit decisions).

His basic research framework derives from the paper "Structural Change with Long-run Income and Price Effects," pending at *Econometrica*, and jointly written by Danial in conjunction with Diego Comin and Marti Mestieri. The underlying setting (non-homothetic, CES demand system) allows for Engel curves with different, constant income elasticities across sectors (such as manufacturing, services, and agriculture). Unlike Stone-Geary preferences, the differential income effects do not vanish asymptotically, thereby according better with empirical patterns. Moreover, unlike some other settings, the framework does not restrict the differing income elasticities to have a particular relationship with relative-price elasticities. The authors use this framework to analyze how changes in sectoral composition during the course of economic development relate to demand forces (the differing Engel curves) and supply forces (differences across sectors concerning technical change and capital intensity). I think this is a brilliant, home-run paper, which I would have been happy to publish in the *QJE*. I think the framework will be used by many researchers for studying economic growth and sectoral composition. Moreover, my understanding is that Danial is at least an equal partner in this research.

Danial's job-market paper, "Innovation, Knowledge Diffusion, and Selection," uses the basic framework to study innovative activity and productivity across sectors. Key forces involve exit of low-productivity firms, entry decisions by newcomers in the context of incomplete and uncertain spillovers of knowledge from incumbent firms, and choices of R&D investment by these incumbents. Important findings involve the relation of productivity to firm size and levels of R&D spending. The theoretical framework is related to disaggregated data for U.S. manufacturing and retail trade. One notable finding is that volatility and imperfect adoption are stronger forces in retail than in manufacturing. Moreover, in the retail sector, most transformative innovations come from established national chains rather than newcomers. Danial uses his results to evaluate alternative government policies, such as R&D tax credits and the relation of these credits to firm size and productivity. I think that this paper will ultimately land in a leading economics journal.

Danial and Marti Mestieri also have a promising preliminary project in which they apply their framework to international trade. An important finding is that previous preference structures implied counter-factual correlations between income and relative-price elasticities as observed in country panels. Their correction for this problem generates new results on the welfare gains from trade.

Danial has strong technical skills and is particularly knowledgeable in economic growth, industrial organization, and international economics. In terms of teaching, Danial would do well in macroeconomics, particularly with a stress on economic growth, and also in courses in industrial organization and international trade.

I strongly recommend him to the best economics departments and business schools.

Sincerely



Robert J. Barro