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DESIRED RESEARCH AND TEACHING FIELDS:

PRIMARY	SECONDARY
Industrial Organization, Public Finance	Household Finance

FIELDS OF CONCENTRATION:
Industrial Organization, Public Finance

DISSERTATION TITLE: "Pricing, Selection, and Welfare in the Student Loan Market: Evidence from Borrower Repayment Decisions"

Expected Date of Completion:	May 2017
Principal Advisors:	Professors Ben Handel & David Sraer
Other References:	Professors Emmanuel Saez & Ulrike Malmendier

PRE-DOCTORAL STUDIES:	DEGREE	DATE	FIELD
Stanford University	BA, w/ Honors	2012	Economics (minor Mathematics)

PAPERS:
"Pricing, Selection, and Welfare in the Student Loan Market: Evidence from Borrower Repayment Decisions" (**Job Market Paper**)
"Messaging and the Mandate: The Impact of Consumer Experience on Health Insurance Enrollment Through Exchanges" joint with Ben Handel, Jonathan T. Kolstad and Neale Mahoney, *Papers & Proceedings, American Economic Review 2015*

RESEARCH:
Research Assistant to Prof. Ben Handel, Department of Economics UC Berkeley, Summer 2013
- Examined the impact of insurance "Pay-for-Quality" incentives and information technology on chronic illness and preventative care outcomes using data from Hawaiian primary care physicians.

Research Assistant to Prof. Stefano DellaVigna, Department of Economics UC Berkeley, Summer 2012 & Summer 2013
- Assisted on project looking at potential bias in movie reviews associated with media conglomeration. Helped develop several algorithms employing individual-level data to suggest similar films based on users' past movie rentals and ratings.

Research Assistant to Prof. Caroline Hoxby, Department of Economics Stanford, 2008-2011
- Compiled data for analyses of educational outcomes of charter school education as part of the *New York Charter School Evaluation*

TEACHING:
Teaching Assistant, Department of Economics, UC Berkeley (Fall 2014 – Spring 2015). Taught "Introduction to Economics".
Teaching Assistant, Department of Economics, UC Berkeley (Fall 2016). Taught "Pedagogy Workshop".

FELLOWSHIPS AND AWARDS:
2014 George Break Prize in Public Finance – Outstanding performance in the Public Finance field courses at UC Berkeley.
2013 INET Prize for Best Economic History Paper- Recognized for first-year Economic History paper at UC Berkeley.
2012 National Science Foundation Graduate Research Fellowship – Recipient.
2012 Anna Laura Myers Prize for an Outstanding Thesis – Recognized for senior honors thesis in Economics at Stanford.
2012 Deans' Award for Academic Accomplishment Stanford - One of 7 Stanford undergraduates honored for exceptional academic endeavors in independent research and superior performance in the creative arts.
2012 J.E. Wallace Sterling Award for Scholastic Achievement – Recognized for overall academic performance at Stanford University with award presented to the top students of each year's graduating senior class.
2009 President's Award for Academic Excellence- Distinguished academic record during freshman year at Stanford.

OTHER INFORMATION:
Citizenship: United States

Research Statement: Innovations in Fin-Tech, Borrower Welfare, and Market Structure

Natalie Cox

November 17, 2016

The financial technology, or "fin-tech", industry is characterized by a growing number of online lenders who use data on educational, employment, and financial outcomes to quickly assess the risk of prospective borrowers and offer more individualized loan terms. In many ways, their financial "innovations" can be thought of as movements towards more personalized, accessible products: interest rates that better reflect individuals' risk, payment plans that are tailored to individuals' monthly income and expenditures, and user-friendly interfaces that make financial decisions more intuitive and uncomplicated. On an individual level, as firms expand and customize product offerings, there is the potential for large efficiency gains. These innovations could also have wider implications for market structure; for example, if more accurate risk-based pricing creates clear winners and losers, it will change the government's role in ensuring equity and redistribution of surplus.

My research agenda seeks to understand, through the use of micro-data and structural econometric methods, how technological advances in the consumer finance industry will impact borrower decisions and welfare. My research is specifically focused on the student loan market, which has now become the second largest sector of household debt. Student borrowers, who tend to be young, have underdeveloped credit histories, and high debt-to-income ratios, could benefit substantially from more customized financial products. However, my findings speak more generally to the many consumer credit and insurance markets where risk-based pricing algorithms have become widely used and more fine-grained. Below I provide a description of data sources and work in progress, grouped by topical issue.

Data: I use a combination of both proprietary and public datasets to study student borrowing decisions and the impact of financial innovations. I currently have access to a proprietary dataset from a student loan refinancing firm that exemplifies several features of the fin-tech movement, such as an online interface, data-driven underwriting, and flexible loan terms. The dataset contains observations for both borrowers who fully refinance their loans (N=12,000), as well as a larger, more representative sample of applicants who are shown an interest rate quote and may or may not fully refinance (N = 200,000). The dataset allows me to link individuals' refinancing decisions to a wide set of variables used by the firm to underwrite the borrower, including their income, degree type, occupation, employment history, location, age, credit score and report, assets, liabilities, and savings behavior. It also contains supply-side information on risk scores and prices, as well as interest rate variation stemming from firm experimentation and A/B testing. These features highlight the opportunities and benefits of partnering with a private firm to access rich financial data.

In several projects I also use the National Postsecondary Student Aid Survey for Graduate Students from 2008 and 2012, a nationally representative survey that contains individual-level data on financial aid, demographics, earnings, and educational outcomes. The survey allows the researcher to observe administrative, loan level data that lists the interest rate, loan amount, and creditor for each loan in a borrowers' portfolio. It is fruitful to use this survey in conjunction with the proprietary dataset: it provides a less selected sample of the national student borrower population, while the private dataset contains more compelling interest rate variation and comprehensive, detailed micro-data.

Beyond FICO: Measuring the Impact of Data-driven Underwriting Online lenders have the ability to collect and analyze a larger amount of data when underwriting potential borrowers. These "data-driven" pricing algorithms use many variables in addition to FICO score to predict borrower risk, from income to spending behavior. By incorporating more information and making interest rates more accurate, these algorithms could reduce credit constraints for individuals with under-developed FICO scores (for example student borrowers). I use data on risk score inputs, interest rates, and repayment outcomes to identify what portion of the population benefits from comprehensive risk based pricing – Panel (a) of Figure 1 compares the distribution of interest rates that my firm would offer if it was only able to price on FICO score, to the distribution of interest rates they currently offer using comprehensive risk based pricing. The use of additional variables allows the firm to extend lower interest rates to a significant portion of the applicant pool. There is suggestive evidence that these lower interest rates could benefit consumers' financial health – Panel (b) of Figure 1 plots the average FICO score of individuals 20 months after refinancing their student loans. Individuals who began in the lowest FICO-score quartile experience the strongest upward movement in FICO score. In the future I plan to use discrete cutoffs in the risk-scoring formula to identify what portion of this improvement is due to the availability of non-traditional pricing.

Pricing, Selection, and Welfare in the Student Loan Market *(Job Market Paper)* I am also interested in understanding how fin-tech innovations will transform the traditional lending landscape, particularly with respect to how private and public sources of credit coexist. As data-driven lending technologies advance in the private sector, they could change the role of, and population serviced by, government-sponsored sources of credit. In my job market paper, I specifically study the student loan market, which has long been dominated by a Federal lending program that sets a uniform interest rate on student loans regardless of borrowers' default risks. This contrasts with the growing number of private online refinancing firms, who have begun using financial technology to offer risk-based interest rates. The "break-even" nature of the existing government-run student loan program's uniform interest rate produces a potential tension between emerging private-sector developments in risk-based pricing and the the federal program's equity goals: as low risk types refinance into the private sector, the average risk, and break-even interest rate, of the remaining federal borrowers will rise. My findings highlight how developments in the private sector's ability to price borrower risk will simultaneously i) improve welfare for low risk borrowers by over $2,300 on average and ii) potentially increase sorting of low risk borrowers out the public repayment pool, which under the Direct Loan program's current break-even pricing rule would generate welfare loss for high risk types of $2,100 on average.

Do Interest Rates Influence Student Borrowing Decisions? Evidence from Bunching at Loan Limits My job market analysis focuses on how interest rates impact repayment decisions, but student borrowers could also respond to interest rate levels at earlier steps in the borrowing process when taking out debt.[1] In a separate paper, I ask whether the availability of risk-based interest rates will change these decisions as well. I measure the sensitivity of loan *principal* decisions with respect to interest rates, and combine this with proprietary data on the distribution of lending costs to provide an estimate of how borrowing decisions would change.

To provide an elasticity of loan principal decisions to interest rates, I use discrete changes in the marginal interest rate for the Federal Direct Student Loan program at specific loan amounts. For example, graduate students are currently able to borrow up to $20,500 at an interest rate of 5.31%, and then can borrow additional funds up to the cost of attendance at an interest rate of 6.31% (plus a 4.3% fee). If there is distinct "bunching" of students at this cutoff, the size of this excess mass can be used to derive an elasticity of borrowing with respect to interest rates following methodology from

[1] In my job market paper I measure borrower sensitivity with respect repayment decisions (maturity choice and refinancing), which is the relevant maturity once loan principal is fixed and provides a lower bound on any distortions caused by uniform pricing.

the bunching literature.[2] To measure this elasticity, I use the National Postsecondary Student Aid Survey for Graduate Students from 2012, which allows me to plot the distribution of loan amounts. A preliminary graph is shown in figure 3 – it shows distinct bunching in the distribution of borrowing at the kink in the interest rate schedule.[3] I next plan to combine this elasticity with proprietary, private sector data on risk-based interest rates. Combined with the empirical elasticity, I can then calculate how much more or less student debt each borrower would take out under a uniform pricing scheme vs. a risk-based pricing scheme.

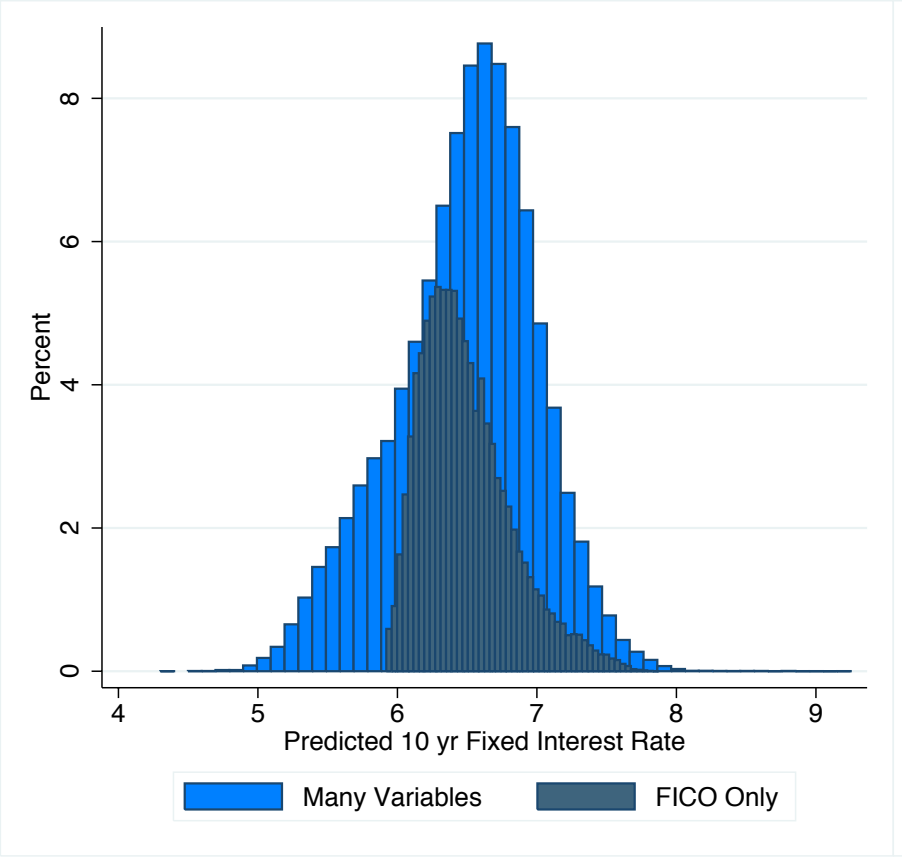
How Does Refinancing Student Debt Impact Borrowers' Financial Health? When refinancing student debt, borrowers are able to obtain lower interest rates and/or adjust their loan maturities. This leaves some borrowers with substantially higher or lower monthly payments after they refinance their loans, and could impact households' financial health and financial decisions on other margins. I plan to investigate how student borrowers' consumption, borrowing, and saving decisions are affected by anticipated changes in monthly interest payments brought about by refinancing their federal loans in the private sector. I have access to panel data on borrowers' credit reports and financial account balances, where I observe transaction level data for borrowers' credit card, banking, loan, and investment accounts for an average of 6 months before and after refinancing. A raw time series shows that borrowers use monthly payment savings to pay down other types of debt more quickly and increase investment contributions – however, this analysis pools together the causal impact of accessing lower interest rates with the selection effect of certain types of borrowers refinancing their loans at a particular time. I therefore plan to use experimental variation in the refinanced interest rates offered to different cohorts of borrowers, as well as distinct cutoffs in minimum and maximum loan maturities, to generate differential exposure to refinancing "benefits" across otherwise comparable borrowers.

Maturity Matters: The Value and Impact of Flexible Loan Terms Another fin-tech innovation that I study is the ability of borrowers to "customize" their monthly payments by choosing from a wide array of loan maturities. Student borrowers have the potential to gain substantially from this flexibility – currently under the Federal Direct Loan program they are defaulted into a standard 10 year fixed installment plan when they enter repayment, which automatically determines their monthly payment level.[4] The ability to lower monthly payments by extending the loan maturity could allow borrowers to both smooth consumption and potentially decrease default rates. Borrowers in my dataset are able to choose from a continuum of loan maturities from 5 to 20 years – figure 2 shows that borrowers with lower monthly cash flow are much more likely to choose a longer maturity, thereby lowering their monthly payment. My current analysis of borrowers' loan maturity decisions in an online lending context shows that moving away from "one-size-fits-all" lending contracts would increase consumer surplus, in particular for liquidity-constrained individuals. In future research I plan to look at how flexible maturity impacts other repayment and financial outcomes, like delinquency rates, credit scores, and home ownership.

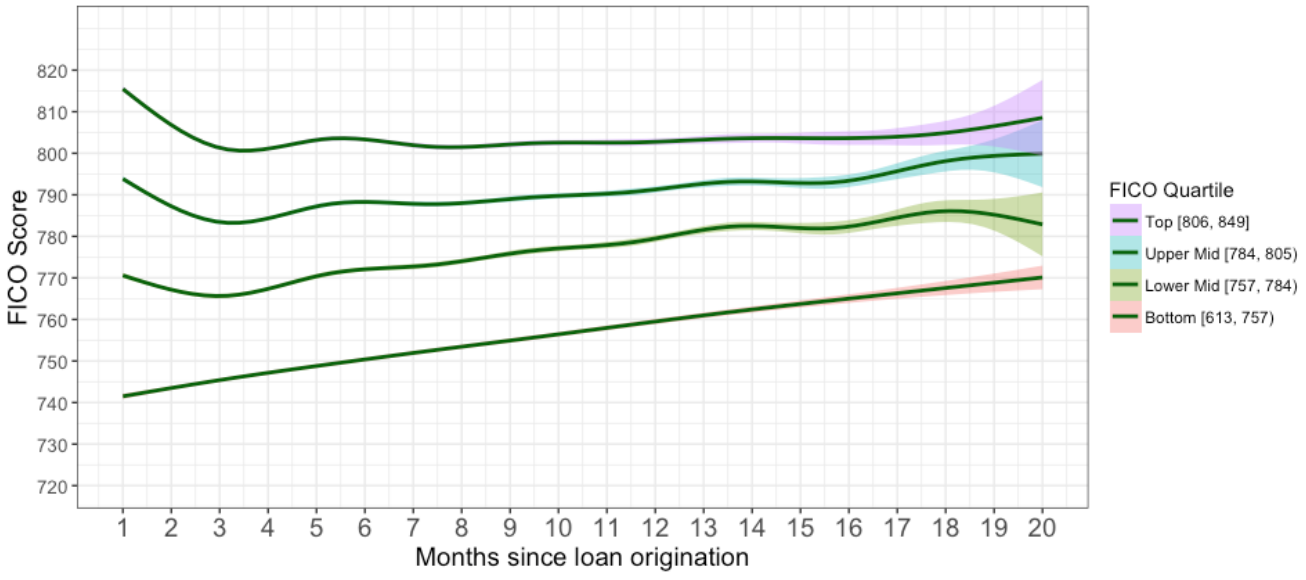
[2]Both loan limits, and the corresponding marginal interest rates, have changed over the years, which allows for additional robustness checks.

[3]The detail of the data also allows me to distinguish between loans that were originated by the federal government and by private lenders, and therefore control for the fact that some borrowers might substitute on the extensive margin with cheaper private sources of credit when they face higher costs of borrowing.

[4]The option to extend repayment for up to 20-25 years under an income based plan was introduced only recently by the Direct Loan program. The true extent of this flexibility requires awareness and diligence on the borrower's part: to pay a loan off faster, borrowers must actively increase their monthly payment each month above that which they are billed, and to increase term they must enroll in an extended maturity plan. This means that the majority of borrowers remain in 10 year fixed payment plans. The latest aggregate figures from the Direct Loan Portfolio show that 51% of borrowers remain in 10 year fixed plans.



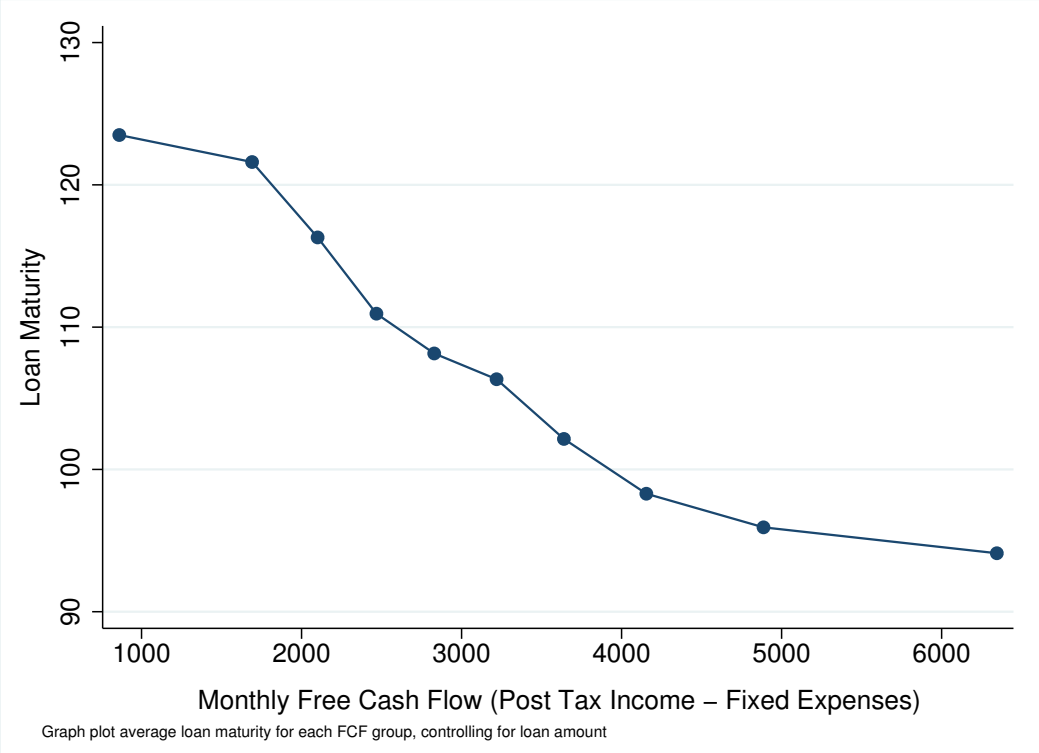
(a) Distribution of Interest Rates when Pricing on FICO vs. Comprehensive Set of Observables



(b) Changes in FICO Score After Refinancing

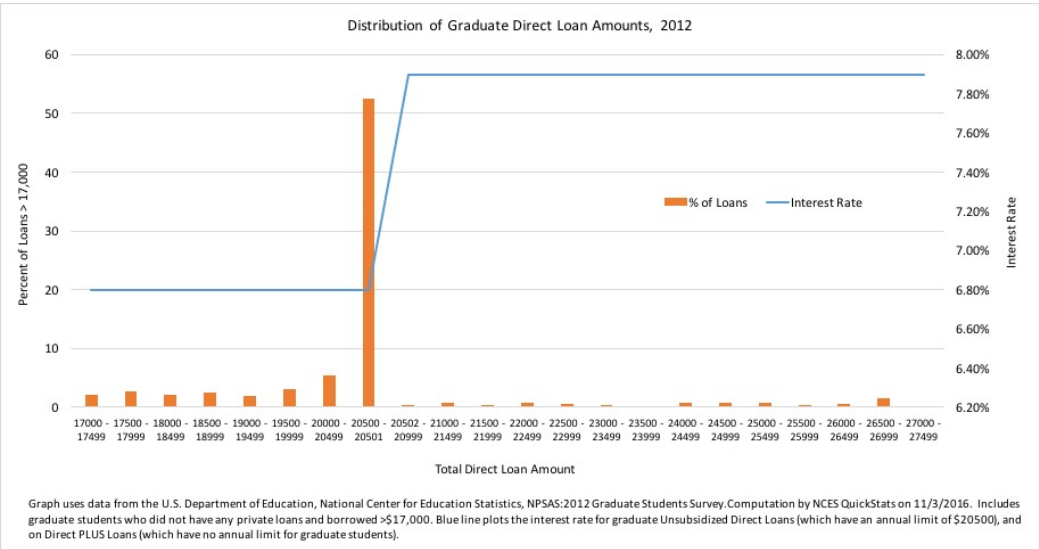
Panel (a) compares the distribution of interest rates that my firm would offer if it was only able to price on FICO score, to the distribution of interest rates they currently offer using comprehensive risk based pricing. The use of additional variables allows the firm to extend lower interest rates to a significant portion of the applicant pool. Panel (b) plots the average FICO score of individuals 20 months after refinancing their student loans. Individuals who began in the lowest credit-score quartile experience the strongest upward movement in FICO score.

Figure 1: Interest Rates Offered under FICO-based vs. Comprehensive Modes of Underwriting



Borrowers in my dataset are able to choose from a continuum of loan maturities from 5 to 20 years – this figure shows that borrowers with lower monthly cash flow are much more likely to choose a longer maturity, thereby lowering their monthly payment.

Figure 2: Loan Maturity Choices, by Free Cash Flow Quantile



This figure shows excess mass in the distribution of graduate borrowers that occurs at the specific loan amount where there is a discrete change in the marginal interest rate for the Direct Student Loan program. The sample of graduate students in this plot were able to borrow up to $20,500 at an interest rate of 5.31%, and could then borrow additional funds up to the cost of attendance at an interest rate of 6.31% (plus a 4.3% fee). There is distinct bunching at the $20,500 loan mark.

Figure 3: Evidence of Bunching in Graduate Student Loan Amounts at Kink in Marginal Interest Rate

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November 1, 2016

Dear Colleague:

It is my pleasure to recommend **Natalie Cox** for an assistant professor position at your institution. Natalie is a graduate student in the department of Economics at the University of California at Berkeley who will be completing her doctoral dissertation this year. Her primary fields are industrial organization and public finance, and her current research uses techniques and questions from these fields to study applications in household finance. Natalie is also well versed in the literature on insurance markets, which cross-cuts these traditional disciplines.

I am Natalie's primary advisor, and have known her since she arrived at Berkeley a little over four years ago. Natalie worked for me as a research assistant during her first year at Berkeley, on a health care project, and took my graduate IO class during her second year, where she stood out as an impressive student. During her third year, Natalie worked on a project with Jon Kolstad, Neale Mahoney and I that ended up in a short co-authored paper. I have served as Natalie's primary advisor since that point. She is an extremely talented economist and is the complete package in the sense that she excels on all of the dimensions that generate successful research. This is borne out in her job market paper, which (i) is on a set of very interesting questions (ii) includes impressive data collection (iii) shows strong applied micro sense (iv) shows strong modeling and estimation skills.

I recommend Natalie enthusiastically and with no reservations. She is in the top group of students coming out of Berkeley this year and should be among the best applied microeconomists on the job market. She should get strong consideration from any economics department or business school, including the very best. Her research interests spanning IO / public / household finance remind me of, e.g., Neale Mahoney, and, if she is able to deliver on her current promise, I think she has the potential to be that kind of elite researcher.

Natalie's job market paper studies regulation of the student loan sector, with a focus on the interplay between public and private sector loan provision. Student loans are a market that is vital for promoting post high school education, and has several unusual features due to the fact that most consumers in this market are typically young consumers with no job and limited collateral. First, via the Federal Direct Loan program, the government is responsible for over 90% of loans in the market, effectively serving as a backstop lender to ensure access to credit. Second, the Direct Loan program pools all consumers into one "break-even" interest rate (approximately 7% right now) to ensure equitable loan terms. Third, student debt, whether through the Direct Loan program or a private firm, is non-dischargeable, i.e. consumers cannot default from these loans, even in the event of bankruptcy. Lenders, including the federal government, can garnish wages and property in order to achieve payment, and typically 80% of loans that go into delinquency are paid back.

Over the past half-decade a private refinancing sector has developed alongside the Direct Loan program. Firms in this sector, over time, have used increasing amounts of information about consumers to price delinquency risk via differential interest rates. Information used to price risk in the current market includes, e.g., income, degree type, occupation, employment history, location, FICO score, assets, liabilities, saving behavior, and more. It is clear from the descriptive facts in Natalie's paper that this sector is effectively "cream skimming" the lowest risk consumers from the Direct Loan program, and refinancing them at rates lower than the Direct Loan 7% rate, sometimes all the way down to 3%.

Within this context, Natalie has acquired a novel dataset from one larger private refinancer, with a substantial amount of detail on both refinancers and potential refinancers. Natalie acquired these data entirely on her own, and the data have a number of key advantages. First, during the several years of data she observes, the firm experimented internally with a range of different interest rate / maturity offer combinations for consumers *conditional on an internal risk score*. As a result, conditional on observables, Natalie observes pseudo-random variation in pricing / product offerings, which allows her to precisely understand and estimate consumer demand for both interest rate and maturity when refinancing. Second, the data contain all of the granular data that the companies observes from refinancers (and potential refinancers) including credit history details, FICO score, income, profession, savings, and a range of other important characteristics. This allows Natalie to understand the precise links between such characteristics and product / price offers, as the firm innovates in those over time.

With these data in hand, Natalie's paper asks a number of important questions related to the operation and regulation of this market. Let me first describe her questions and main results, then provide some details on the methods used to arrive at these results.

First, she asks what the welfare impact of the development of the private refinancing sector is, assuming that the Federal Direct Loan program interest rate remains unchanged. In this context, she finds that the private sector increases welfare by approximately $480 per borrower on average. A key related sub-question is studying the increased ability of the private refinancing sector to price risk over time, as they gain access to increasingly granular consumer information. For example, Natalie investigates the welfare impact of the private sector when they are (i) pricing risk based on FICO score only vs. (ii) a whole slate of additional characteristics observed in the current market. Natalie finds the private sector innovation in the ability to price risk can be a crucial ingredient to driving increased consumer welfare: when the private sector uses only FICO score to price risk only about $80 of surplus per borrower is achieved, compared to $480 when all information is used.

Next, Natalie asks what would happen if the Direct Loan program maintained its goal of "breaking even" with its uniform interest rate, as the private market evolves. This is a classic case of adverse selection: as the private sector cream skims the lowest delinquency / risk borrowers, the risk of those in the Direct Loan program increases and the break-even interest rate goes up along with that risk. If the government sticks to this rule, it is possible that over time the Direct Loan program could unravel, leaving a private sector that prices risk perfectly and does not fulfill the Direct Loan program goals of providing equitable access to loans at a reasonably low rate.

Natalie shows how much the Direct Loan program interest rate would increase, for different pricing information regimes in the private sector, and what the implications for consumer welfare are. Specifically, she finds that, when the private sector is using its current information set in pricing, when the government maintains its break-even rule, lower-risk consumers have a $2,300 per borrower increase in surplus and higher-risk consumers have a $2,100 decrease in surplus. This spread increases as the private sector uses more information in pricing / product offerings over time. It is important to note that, in the context of these results, Natalie also considers the role that refinancing choice frictions play in facilitating this advantageous selection into the private sector.

She finishes with the complementary question of how much of a subsidy the government would have to offer in order to maintain a 7% interest rate in the Direct Loan program, to achieve its equity goals when coexisting with the private sector. The subsidy per consumer remaining in the Direct Loan program is quite large at just over $2,000 per borrower. Taken together this shows the tension that exists between allowing a private sector that increases welfare for some consumers (sometimes facilitating better product matches), achieving equity goals in promoting education, and ensuring that government are not incurring huge losses by only enrolling and subsidizing the highest risk consumers.

These are impressive results on important topics. How does Natalie leverage her data and empirical environment to arrive at them? Her approach presents a very nice combination of reduced form evidence, to clearly show the key economic patterns in the data, and structural modeling to estimate the key economic primitives necessary to conduct the counterfactuals / welfare analysis just described. The level of detail that goes into both of these sections is comprehensive. For the reduced firm analysis, Natalie leverages the experiments on interest rate terms and loan maturity to clearly show how different types of consumers are offered different loans and, conditional on what they are offered, how they substitute between interest rate and loan maturity. Though I am not an expert on this literature, my understanding is that modeling choice and substitution along both of these dimensions is novel. She shows pricing and demand results that leverage the firm experiments, along with those that use the entire sample of borrowers and potential borrowers.

Her structural model of consumer demand for different loan terms is very crisp and tightly linked to theory. She sets up a life-cycle model where consumers choose an interest rate X maturity pair from a menu offered to them. Natalie derives first-order conditions from the model and uses the choices that consumers make to estimate key choice parameters. The intertemporal elasticity of substitution (IES) parameter she estimates is the key parameter for investigating how consumes trade-off marginal income over the life-cycle, i.e. whether they choose a shorter loan with lower total interest but higher monthly payments, as opposed to a longer loan with higher total interest but lower monthly payments. In her primary approach in the current draft, she estimates a constant IES parameter across all consumers, but allows for heterogeneity on a number of other key dimensions. Most crucially, she estimates heterogeneous income growth paths, which are crucial to understanding loan choices in the context of a given IES parameter. These estimated income growth paths looks quite similar to those in the broader student loan population, which is reassuring and also motivates a second approach Natalie is working on where she (i) calibrates heterogeneous income paths as a function of consumer demographics and (ii) estimates heterogeneity in the IES parameter. I expect she will have results from this approach well in advance of the market. She has a number of other robustness exercises that explore key alternative approaches, all showing the general robustness of her primary approach.

This is an elegant and sophisticated model, and Natalie describes the identification of the key parameters very well, following the reduced form evidence and variation in the data presented (most notably the experimental variation in menus offered to different cross sections over time by the firm). A real strength of Natalie's paper is the way she carefully describes identification of the model and links it to evidence in the data. This is a fantastic trait for a young up and coming researcher to possess and the clarity of exposition throughout the paper is fantastic.

Natalie uses the results of the model to study the policy counterfactuals (with corresponding welfare impacts) described earlier in this letter. To do this, she makes a number of assumptions, very clearly stated, about (i) how she maps her data on borrowers and potential borrowers to simulate the private / public markets under different policies and (ii) how the behavior she observes at her firm maps to modeling the private refinancing sector more broadly.

Overall, I really like this paper and think it is very likely to land in a top five journal. Natalie is very impressive in both her ability to work independently and her ability to incorporate comments. As she has

worked on the project over the past several years, myself and her other advisers have been very impressed by her ability to integrate comments we make during short meetings into entire new sections / results in the paper (with many follow up insights generated on her own). She naturally is very precise and thorough, and great at explaining what she is doing. So, not only do I like this paper, but the way she has made progress on it bodes very well for her ability to complete a long string of similarly successful projects during her research career.

In terms of other projects, I expect Natalie to work on a series of follow up projects in the student loan sector, and also work on other industries related to household finance, such as credit cards and/or insurance markets. For example, in the student loan sector I know she is working on a related project about what would happen in the student loan market if the government allowed consumers to default on loans only when they are privately refinanced, but not when in the public Direct Loan program. It is important to mention that Natalie is in her fifth year as a PhD student now, which is becoming increasingly rare for students on the job market doing structural empirical papers like this one.

Natalie, myself, Jon Kolstad, and Neale Mahoney published a short paper in *AER P & P* on the impacts of insurance-mandate related advertising on insurance purchasing in the Affordable Care Act. This paper was part of a project the four of us started with a large insurance broker that did not go further than this short paper because of some internal issues at the broker. Nevertheless, working on this short paper with Natalie was a pleasure for all of us and showed us her command of key topics in the health insurance space.

I have not supervised Natalie as a teaching assistant, but I have seen her speak on many occasions. She is an excellent public speaker already and always has command of the material that she is presenting. I have no doubt that she will be an excellent teacher immediately. In a graduate economics program, she could easily teach public finance and industrial organization. I think she would be absolutely fantastic teaching MBAs or other professional level students, much more so than the typical top research candidates on the job market.

It is important to mention that I also believe Natalie would excel as a researcher / colleague / teacher in finance departments looking for someone with crossover skills between economics and finance. Natalie is well versed in asset pricing and corporate finance, and could easily be a productive member of a top finance group looking for someone with her profile.

Finally, while I'm sure this is already clear from my letter, I should mention explicitly that Natalie is an absolute pleasure to be around and a true team player. She has exactly the kind of personality and research ability that we look for when hiring assistant professors at Berkeley.

I give Natalie my highest recommendation; please do not hesitate to contact me for any further information, I would be happy to discuss her candidacy or her profile further at any point.

Best regards,

Benjamin Handel
Associate Professor of Economics
University of California at Berkeley



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November 21, 2016

Dear colleague,

It is a pleasure to provide this letter of reference for Natalie Cox. Natalie works in the areas of Industrial Organization and Finance, with much of her research being focused on household finance topics, specifically student loans. I have been working with her since she started her graduate program; she was a super-star RA on a behavioral economics project that required structural modeling skills, she is now a very engaged and thoughtful participant in the "finance lunches" I organize, and she has been wonderful to advise on her own research. She is the top student from the Economics Department this year, and she has also thoroughly impressed my colleagues at the Haas Finance group where she has presented her work. I would encourage any economics department and business school (both economics and finance groups), including the very top ones, to look at her file.

Natalie's Job Market paper, "Pricing, Selection, and Welfare in the Student Loan Market: Evidence from Borrower Repayment Decisions," investigates the welfare implications of the introduction of more comprehensive risk-based pricing into the student loan market. The set-up is familiar from the large literature on mortgage pricing: consumers (students) are facing a publicly subsidized financing option and a private financing options, and only the latter employs full risk-based pricing, while the former one is subject to some uniform pricing constraints. The difference is pricing options is particularly relevant after students have finished their studies, when their major and post-graduation job offers allow the private lender to update and drastically reduce noise in the assessment of future ability to repay.

What are the effects of the coexistence of these two markets, for pricing, selection, profitability of the lender and ultimately welfare of the borrower? For example, similarly to the mortgage, health insurance and other insurance markets, the public lender is confronted with severe adverse selection, with the best prospects switching to the private option.

Differently from much of the mortgage (or other finance) literature studying this question, Natalie got access to truly experimental data: A private (fintech) lender shared the data on a series of interest rate experiments, allowing her to study how exogenous variation in the private-public differential alters

borrower choices. Even better, she was able to negotiate not only for students who ultimately receive refinancing but data of all applicants (who were faced with the different experimental treatments).

The experiment consists of 10 variations in the interest offered, and doing so within 7 risk classes of borrowers that the private lender generated from internal information about borrowers. In terms of outcome variable, Natalie focuses on their repayment choices (i.e., choices of maturity), controlling for the vast array of observable characteristics provided by the firm as well as time- and geography-specific effects. The focus on maturity is both a "convenience" outcome (–there is no choice of loan size, nor of different interest rate options for different conditions in the data–) and a very plausible focus of borrowers' attention when picking a financing choice: The design of the website of the private lender allows interested borrowers to pick a maturity and immediately see what the implications are in terms of monthly payment, total interest payments, and annualized interest rate.

Her main result is that students who decide to refinance their student loan respond to increases in interest rate by significantly increasing the chosen maturity. Interestingly, the result is particularly large for low-risk borrowers, who can afford higher payments.

Building on this reduced-form evidence, Natalie the constructs a structural model to assess the welfare implications of borrowers' choices. Her model allows for life-cycle components, where the stochastic income path of borrowers is affected by their risk type. The borrower chooses the optimal maturity by trading off the increased NPV of the loan repayment (when increasing maturity) with the benefits of reduced monthly payments (in order to smooth consumption). When she assumes that the public-financing option remains unchanged (same interest rate), she estimates a welfare increase of more than 50% on average for her sample arising from refinancing. She also illustrates that this average increase is strongly driven by the fintech firm's ability to fully risk-adjust: If the private lender where restricted to using only the FICO score, most of the welfare gain ($384 out of $450) vanishes. Her model also illustrates that the result reflects "cherry picking" among private lenders – low risk borrowers will gain most and are most likely to switch.

Natalie also explores the interaction of the private/public competition with various levels of (additional) public funding. As will be obvious from the above, the prevalence of "good types" refinancing their loan privately, implies that the public lender is left with more "bad types." Hence, if we impose that the lender has to break even, the bad types suffer reduction in welfare relative to a world without private lenders.

Natalie is also very clear on the limitations of a rational refinancing model. In fact, in a robustness check, she indirectly captures borrowers' reluctance to refinance by simply imposing empirical financing elasticities, and illustrating that it reduces the average welfare gain from refinancing. In future work, it would be great to model the underlying behavioral biases (limited attention, status quo bias) directly, account for their interaction with risk types and model it directly.

One of the reasons why I like the paper a lot is that it brings IO approaches and techniques to data and questions from neighboring fields, mostly finance, but also public economics (inequality) and labor

(education). In the vast household finance literature, including the literature specifically on student loans, we aim to address the welfare implications of different institutions and lending markets; but we tend to stop short of fully modelling them out. Natalie does so, and provides us with a blueprint for future analyses. At the same time, she does not fall prey to living within her structural modelling assumptions but builds her analysis on strong and cleanly identified reduced-form evidence. She is also careful to model out heterogeneity and the variation in welfare implications for different groups.

Natalie is also working on several follow-up projects using the same dataset. In the project we have discussed most, she zooms into the choice between fixed-rate and variable-rate financing – again a question very familiar from the mortgage literature. And again, she is able to utilize a much better source of variation for identification purposes: The experiments conducted by her data provider also implied experimental variation in the spread between fixed and variable rates, allowing her to credibly estimate consumer elasticities to variations in these spreads. By introducing this choice of safe versus uncertain future rates into her model, she is adding interest rate risk as a determinant and can start estimating a coefficient of relative risk aversion for her borrowers. (Her CRRA estimates are around 1.) This paper has the potential to be an important contribution to the insurance literature, featuring a less explored empirical setting combined with clean sources of variation.

Natalie also has joint work with Ben Handel, and we are discussing a more behavioral paper exploiting her data to identify heterogeneity in biases. I have no doubt that she will produce a string of first-rate papers. As of now, her CV is not as full as that of some the other very top candidates across universities; however, she is one of our few candidates already going on the market in her fifth year, and it is also not atypical for structural work to be more time-consuming initially. In light of her pipeline and work attitude, as well as the importance of her of research (student loans), both within the academia and among policy makers, I would predict her publication prospects for the coming years to be outstanding.

Natalie is an excellent presenter. I really admire her clear, firm, and at the same time very friendly style. She will be great in the class-room and as a presenter in conferences. On a personal note, it is wonderful to work with her. She is extremely sharp in grasping the implications of questions or suggestions I make, and never fails to amaze me in how well she understands and immediately implements them. When we discuss ideas, she is a new partner

I very much hope that you will be able to consider her file and to interview her at the ASSA in Chicago.

Best,



Ulrike Malmendier

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November 3, 2016

Letter of Recommendation for **Natalie Cox** from Emmanuel Saez (UC Berkeley)

This letter is to recommend Natalie Cox for a position in your department. Natalie Cox is an outstanding applied-micro researcher working at the intersection of industrial organization and public economics, with a strong focus on household finance. Natalie's main advisor is Ben Handel. Natalie has produced an outstanding job market paper on the student loan market and is considered to be at the top of our best students group on the job market from UC Berkeley this year. Therefore, she should be considered by any top department, top business school, or top public policy school.

Natalie's job market analyzes the student loan market. Student loans have become a large component of household debt. The government, through the Direct Loan program, is responsible for over 90% of loans in the market to ensure access to credit. The Direct Loan program offers a uniform "break-even" interest rate (about 7%) to all borrowers (a lower subsidized interest rate is offered up to small cap for undergraduate students). Student debt is non-dischargeable even in the event of bankruptcy (about 80% of loans that go into delinquency are paid back). In recent years, a private refinancing sector has developed alongside the Direct Loan program. Private firms can use increasing amounts of information about borrowers to price delinquency risk. Firms use FICO scores but also information on assets, liabilities, education degree completion, employment, etc. Firms can then offer more advantageous interest rates or different maturities to borrowers to "cream skim" lowest risk borrowers from the Direct Loan program.

For her analysis, Natalie has obtained proprietary data from a large provider of student loan refinancing. The data contain detailed borrower and applicant-level data on both the demand and supply of student loans. The data provide precise, borrower-level data on risk-score inputs and formulas, interest rates, repayment decisions, and balance sheets. It contains both borrowers who fully refinance their loans, as well as a larger, more representative sample of borrowers who are shown an interest rate quote and may or may not fully refinance.

The company adopted a series of pricing experiments regimes overtime (to assess how elastic demand was and set their pricing optimally). Natalie exploits these pricing experiments to study borrowers' refinancing decisions. In particular, she finds very compelling evidence than an exogenous increase in the offered interest rate reduces the

maturity of loans chosen by borrowers who want to refinance. To put it simply, with a higher interest rate, borrowers want to repay faster, i.e., shift consumption into the future, as predicted by the conventional Euler equation of individual inter-temporal maximization. Natalie then builds a structural model of individual consumption and refinancing decisions. She finds that her reduced form responses are consistent with an inter-temporal elasticity of substitution around 0.8.

Next, Natalie estimates the welfare impact of the private refinancing sector, assuming that the Federal Direct Loan program interest rate remains unchanged. She estimates that the private sector increases welfare by approximately $500 per borrower on average. Interestingly, when the private sector uses only FICO score to price risk, the surplus is only $100 per borrower. Hence, most of value comes from the ability of the private sector to use a much broader set of information to provide customized pricing.

Next, Natalie considers the situation where the government adjusts the uniform interest rate to keep breaking even as the private market comes in. This situation generates adverse selection as the private sector takes away the lowest risk borrowers so that the break-even interest rate of the government increases. In this scenario, Natalie finds that lower-risk consumers have a $2,300 per borrower increase in surplus while higher-risk consumers have a $2,100 decrease in surplus. This shows that, on top of creating efficiency gains, the private market creates significant distributional effects (by undoing the implicit subsidy to high risk borrowers that exists in the uniform price government Direct Loan program).

Finally, Natalie shows that the government would have to offer a sizeable subsidy to maintain a 7% interest rate in the Direct Loan program in the presence of the private sector. Hence, there is a trade-off between allowing a private sector that can increase the welfare for some consumers by offering better product matches and equity goals in offering loans to all students at a uniform price.

I was impressed by Natalie's broad set of skills to carry out the research: (1) ability to find an topical and important but largely understudied question, (2) ability to obtain proprietary data for research from a large player in this market, (3) knack to find and exploit exogenous variation to identify compellingly behavioral responses, (4) ability to set up and estimate a more structural yet still parsimonious model, (5) thinking through the industrial organization and welfare implications of private firms in this market. This demonstrates that Natalie has all the skills needed to succeed in producing research at the highest level. I am highly confident that this paper will end up published in a top journal and become a reference for future studies in this large and socially important but yet still vastly understudied market.

There are several future avenues of research on the student loan market that Natalie has started exploring. In particular, in her second paper "The Impact of Interest Rates and Liquidity Constraints on Fixed-Variable Rate Decisions", she studies how student borrowers choose between fixed and variable rate loan contracts and how these choices are influenced by liquidity constraints. Fixed and variable rate contracts are used in several consumer lending markets. Therefore, an understanding of how borrowers navigate this decision is of broad importance and applicability. She uses small quasi-experimental changes in the fixed-variable spread offered to borrowers over time to measure how the proportion of borrowers choosing a fixed rate loan responds to the size

of the fixed rate premium. Her reduced form evidence shows that borrowers are price sensitive and fast to switch between fixed and variable rate loans as the premium changes. Natalie then writes down and estimates a structural choice model that maps the fixed variable choice to the coefficient of relative risk aversion. A more risk averse individual is willing to pay a higher fixed rate premium to insure against interest rate uncertainty – therefore the fixed-variable choice provides a revelation of borrowers' risk preferences. She then estimates the CRRA as both a constant parameter and a function of observables using maximum likelihood estimation, finding a value around one. She also analyzes how the fixed-variable choice interacts with borrower liquidity levels: liquidity constrained individuals may choose a variable rate contract to reduce their monthly payments, even if they are sufficiently risk-averse to choose a fixed contract in a non-constrained setting. She shows that borrowers who are not liquidity constrained have higher estimated risk aversion. This is also a very good paper that shows that Natalie will be able to produce a series of valuable papers using the great data she obtained.

Natalie has also published with Ben Handel, Jon Kolstad, and Neale Mahoney a short AER P&P paper studying the impacts of insurance-mandate related advertising on insurance purchasing in the Affordable Care Act.

Natalie is going to complete her PhD in only 5 years, which is a fast pace relative to the current norm. Natalie is an excellent presenter and has an engaging personality. Therefore, I have no doubt that she will be an excellent teacher as well. She would excel at teaching economic students but I am also confident that she would have the qualities needed to teach successfully MBAs or other professional level students, much more so than the typical top research candidates on the job market.

Overall, I am enthusiastic about Natalie's research projects, which are very likely to turn into important contributions. Natalie has incredible work ethics, outstanding ability for finding interesting issues to study, great technical skills, and excellent presentational skills. Natalie is our best student from Berkeley on the market this year (across all fields). In sum, Natalie is an outstanding candidate for positions in all top economic departments, business schools, and public policy schools. I recommend her in the strongest possible terms.

Sincerely,

Emmanuel Saez



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Berkeley, November 19, 2016.

Letter of Recommendation for **Natalie Cox**

I am writing to recommend Natalie Cox, currently a 5th year Ph.D. student in economics at UC Berkeley, for a position as an assistant professor in your school or institution. I know Natalie very well: we have been discussing weekly her progress on her job market paper since about a year and a half; she attends regularly the finance student lunch that Ulrike Malmendier and myself organize. I believe that I am in a very good position to judge Natalie and her work. In a nutshell, I think that Natalie is a star and I *urge* all economics departments *and* business schools, including and especially the top 5 ones, to interview her in Chicago.

Natalie's work is broadly at the intersection of Industrial Organization, Public Finance and Household Finance. She has an impressive combination of skills that I believe will make her one of the leader in applied micro: Natalie works on important and policy-relevant topics; she has a knack for original data collection; she builds her structural work around well-identified reduced form evidence – Natalie thinks very clearly about issues related to identification; she is a very elegant modeler; she is passionate about her work.

Natalie's job market paper deals with the interplay between public and private loan supply in the student loan market. The student loan market has become the second largest credit market in the US. It plays a crucial role in fostering access to higher education for millions of students every year. However, students are risky borrowers, with uncertain future income stream and very little collateral. As a result, the US government currently acts as the main originator of student loans, through the Federal Direct Loan program, which covers about 90% of origination in the market. One defining feature of the government loan program is that it pools all borrowers into a single, uniform rate, which hovers around 7%.

A recent trend in the student loan space is the rise in refinancing of student debt through private lenders, which constitute now an important fraction of the "fintech" industry. Refinancing can take place at any point over the course of a loan – immediately when a borrower begins repayment to the Federal government, or in the midst of a repayment schedule. But even when the refinancing occurs right after graduation, these private lenders are in a position to offer more competitive loan terms relative to the original loans issued by the government, as they can precisely assess the risk of borrowers using a myriad of data (type of degree, income in post-graduation job, credit history throughout college, location, etc.). This interaction between private firms using sophisticated risk-based pricing and a public option with a uniform rate create a "cream-skimming" situation, in which the best borrowers exit the public program and obtain much lower rates at private lenders. Natalie's job market paper offers a precise quantification of the implications of the rise in private lenders in the student loan market.

Let me first summarize what Natalie does in the paper, so you can easily grasp the breadth of her study: (1) she collects unique, proprietary data from one of these large private lenders with extensive information on all borrowers applying to refinance their student loan (2) she exploits a series of experiments run by the firm to obtain

random variations in interest rates offered to applicants, conditional on their observable risk score; she uses these experiments to document how loan maturity choices are affected by interest rates (since the size of the loan is fixed, conditional on an interest rate, the main variable of adjustment for borrowers is the length of repayment they select) (3) she uses these reduced form evidence to motivate a structural model of borrowers repayment decisions, which she she then estimates (4) she conducts a series of important counterfactual addressing the following questions: (i) what are the welfare gains from offering a private refinancing options in the student loan market? (ii) given the potential cream-skimming situation created by private lenders, how much would the interest rates on the Direct Loan program have to go up for the program to still break even? (iii) alternatively, what is the implicit subsidy the government would have to provide to leave the interest rate on the Direct Loan program unchanged despite the adverse selection of borrowers into the program?

These counterfactuals address crucial questions for a market that is of a vital importance for the US economy. Natalie uses the perfect methodology to provide a credible answer to these questions: a unique dataset; a clean identification strategy; and a rigorous structural modeling approach. I have no doubt her paper will have a significant influence .

Let me now provide more details on what Natalie exactly does in her paper.

The dataset comes from one of the largest private lenders in the market, a San-Francisco based company, which operate mostly online. It consists of repeated cross-sections of all new borrowers refinancing with the firm over the period of a year; it contains information on debt amount, income, assets, credit score, as well as a variety of socio-demographic characteristics (age, education, type of degree, homeownership, etc.). The data also proves the menu of interest rates that are offered to borrowers and the ultimate term choices they made when refinancing with the firm. I want to emphasize that this is a large dataset: it consists of 12,000 borrowers who fully refinance their loans and 200,000 borrowers who submit a "quick" application. This is the perfect dataset to study the questions at the heart of Natalie's paper.

The key feature of the data is that it contains 10 interest rate changes within risk-types (the firm produces an internal credit score based on borrowers' information, which is used to construct 7 risk-types) that were conducted at a firm-wide level to gather experimental evidence on maturity and application elasticities. By comparing the repayment choices of observably similar borrowers (matched on characteristics like debt, income, risk, and age) under different price regimes within risk type, Natalie is able to measure how borrowers who decide to refinance respond to these changes in interest rates by adjusting their loan maturity (since loan size is fixed, this is the main decision for borrowers). The data reveals that there is a significant response of term choices to interest rates: faced with an increase in interest rates, borrowers increase the maturity of their loan. This elasticity is larger for low-risk borrowers, suggesting that (1) low-risk borrowers try to minimize interest payment (2) high-risk borrowers try to minimize monthly payment. Of course, this elasticity is crucial for understanding demand in this market: for a given future income process and a given interest rate, a more impatient borrower will defer payment for a longer time period and select a longer maturity loan. In other words, this elasticity reveals borrowers' Intertemporal Elasticity of Substitution, or IES.

Natalie uses these reduced-form evidence to estimate a structural model of borrowers' demand. She builds a life-cycle model where CRRA borrowers choose an interest rate and a maturity from a menu and face stochastic heterogeneous income path, whose volatility depend on the observable borrower's risk-type. There is no default risk in the model – student loans are also not dischargeable in bankruptcy, even when refinanced privately (in an extension, Natalie allows borrowers to delay ex post the repayment of the loan in exchange for a penalty and shows conditions under which this option does not affect borrowers optimal decision ex ante). At the optimum, borrowers are trying to balance the benefit from reduced monthly payments against the cost of more interest rate payments. Combining borrowers' Euler equation with the actual choices they make, Natalie is able to recover the key parameters governing the income process, as well as the average IES, through a simple non-linear least square. This structural approach is very transparent, well adapted to the question at hand, and the estimation method is straightforward. As an out-of-sample test, Natalie checks that the estimated income paths are in fact similar to

those in the broader student loan population. In an extension of her approach, Natalie allows for heterogeneity in the IES by calibrating these heterogeneous income paths as a function of consumer demographics.

One important thing to note is also that in Natalie's setting, it is *very plausible* that borrowers do behave like the agents in the model, in the sense that they are making a very conscious choice when deciding on maturity. The reason is that when borrowers compare between terms, the website calculates and displays the monthly payment, total interest paid, and APR associated with each maturity so that the trade-off central to the model is in fact extremely salient to the borrower.

Equipped with the estimated model, Natalie goes on to analyze several counterfactuals.

First, Natalie simply computes the average welfare gains for borrowers who refinance out of the public program into a private option that does comprehensive risk-based pricing. This first exercise is done assuming the interest rate charged in the government program remains unchanged. In this case, she finds an increase in average borrower welfare by $480, more than 50% of the average monthly payment in the sample. In contrast, if private lenders are restricted to price only based on FICO score for instance, welfare improves only by $64. These average welfare gains conceal a good deal of heterogeneity, as low risk borrowers obviously benefit more from the private option while high risk borrowers would be worse off by refinancing with the private lenders, .

Second, Natalie considers the distributional consequences of opening the market to the private option in terms of advantageous selection. As discussed above, the cream-skimming induced by the private refinancing option creates a budget constraint on the government program. Natalie shows that if the government continues to set a breakeven, uniform rate, low risk borrowers gains about $2,300 in surplus, while high risk borrowers suffer an average welfare loss of $2,100.

Natalie then analyzes the reverse question, i.e. how much of a net interest rate subsidy by the government would be required to maintain the current uniform rate in the public sector and allow low risk types to benefit from risk-based pricing. Her model suggests that a subsidy of $2,090 on average per borrower. Importantly, this estimate accounts for both endogenous selection and maturity responses.

Finally, Natalie introduces refinancing frictions into her welfare computation. It is well known in the household finance literature that borrowers do not refinance as often as they should. To deal with this issue, Natalie simply uses empirical refinancing elasticities to interest rate variations. These refinancing frictions naturally imply that there is less self-selection of low-risk types into the private sector. As a result, in equilibrium, the average consumer surplus only increases by $208 per borrower.

Overall, I am really a fan of the paper. The combination of unique data, experimental variations in prices, structural modeling allows to get a complete and meaningful answer to the question central to the paper. Natalie is currently working on additional extensions, such as allowing for heterogeneous IES as I mentioned above. In the end, I have no doubt the paper will constitute an important contribution to the literature on consumer credit, household finance and public finance.

Natalie also has another work-in-progress using the same dataset. While Natalie's JMP is fundamentally about time-preference, this other project is more about risk-preference. More precisely, she analyzes the choice of borrowers between fixed and variable rate contracts. She again uses experimental variations in the fixed-variable spread offered to borrowers to measure how the proportion of borrowers choosing a fixed rate loan responds to the size of the fixed rate premium. She then use this elasticities to estimate a model of borrowers' repayment decision, similar to the one she has in her job market paper, but where interest rate risk now plays a role. The key parameter is now the relative risk aversion coefficient, as the choice of variable vs. fixed rate is essentially a choice of insurance against fluctuations in future interest rate movement. The early estimation of the model suggests a coefficient of relative risk aversion of between .8 and 1.2, in line with other experimental studies using for instance insurance choice data.

This additional project represents a very natural extension of Natalie's work. I believe it could even be combined with the job market paper to provide a full estimation of a model of borrower demand where borrower would have Epstein-Zin utility, allowing for a separate identification of the IES and the risk-aversion in a unified empirical setting. Natalie is already working on such a broader framework and I believe this could provide very interesting results.

Natalie's portfolio also contains a paper joint with Ben Handel, Jon Kolstad, and Neale Mahoney and which was published as a short paper in AER P&P. I will let Ben discuss this paper, but my discussion with Ben and Jon have convinced me that Natalie was an efficient and productive co-author and that she displayed a strong command of topics related to health insurance markets.

Let me finish this letter by saying a few more words about Natalie herself. First, I want to emphasize that she has amazing presentation skills: she is very eloquent, very precise, straight to the point, handles questions in seminar very well and can think about difficult issues on the spot; in a seminar, she always asks deep and relevant questions, Natalie will be a star in the classroom. Natalie is also a very broad economist – she has an impressive knowledge of the IO literature, the public finance literature and the household finance literature. She is also very engaged in research – you can ask her opinion on any of your work – even if unrelated to her own research area – and she will make insightful and useful comments. She is eager to engage in discussion about research and will be a terrific asset for your department. In other words, you will be very lucky to have her as a colleague!

Let me reiterate that I think *all* schools should be interviewing Natalie at the meetings. Don't hesitate to contact me (sraer@berkeley.edu or 510-642-8363) if you need more information about Natalie or her work.

Best Regards,

