Dear Members of the Selection Committee,

I am writing to express my interest in the Review of Economics and Statistics Fellowship for the NBER Summer Institute 2025. I earned my Ph.D. in Economics from Harvard University in May 2020, and I am currently an Assistant Professor in the Economics Department at Georgia State University's Andrew Young School of Policy Studies.

Current Research Activity:

My research focuses on the intersection of inequality and innovation. For example, my recent work examines the impact of higher education financing on innovation, focusing on how student loan policies shape the innovative potential of individuals from diverse socioeconomic backgrounds. This research contributes to the field by providing insights into how financial barriers affect the development and diffusion of innovation across different demographic groups.

Distinctive Perspective:

As a faculty member at Georgia State University, an institution that has been historically underrepresented at the NBER Summer Institute, I offer a unique perspective that can broaden the diversity of the conference. Additionally, my research on the socioeconomic determinants of innovation introduces innovative methodologies and viewpoints that are not widely represented in the current discourse.

Objectives for Attending:

Participating in the NBER Summer Institute will provide an invaluable opportunity to engage with leading scholars in applied microeconomics. I aim to gain insights into the latest research developments, receive constructive feedback on my work, and establish collaborative relationships that can enhance the quality and impact of my research.

Preferred Sessions:

I am particularly interested in attending the sessions on Labor Studies and/or Innovation, as they closely align with my research interests and will provide relevant insights for my ongoing projects.

Thank you for considering my application. I have attached my curriculum vitae and a recent research paper titled "Borrowing for Breakthroughs" for your review. I look forward to the possibility of contributing to and learning from the esteemed community at the NBER Summer Institute.

Sincerely,



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Education Background

Harvard University, PhD in Economics *May 2020*
Dissertation: "Essays on Income Inequality"
Committee: Nathaniel Hendren, Raj Chetty, Lawrence Katz, and Elie Tamer

Brown University, ScB in Computer Science and Economics *May 2013*

Employment History

GSU Dept. of Economics, Assistant Professor *2024-present*

California Policy Lab UCLA, Post-Doctoral Scholar *2020-2024*

UCLA California Center For Population Research, Affiliate *2021-2024*

Publications

"UI Benefit Generosity, Labor Supply, and Job Outcomes from 2002-2020: Evidence from California UI records" (with Geoff Schnorr, TJ Hedin, and Till von Wachter). *Journal of Labor Economics*, April 2024.

"Disparities in Access to Unemployment Insurance During the COVID-19 Pandemic: Lessons from U.S. and California Claims Data" (with TJ Hedin, Peter Mannino, Roozbeh Moghadam, Geoffrey Schnorr, and Till von Wachter), *RSF: The Russell Sage Foundation Journal of the Social Sciences.* May 2023, 9 (3) 78-109.

"Estimating the Cumulative Impact of the Pandemic on Workers Using Administrative Unemployment Insurance Data" (with TJ Hedin, Peter Mannino, Roozbeh Moghadam, Carl Romer, Geoffrey Schnorr, and Till von Wachter), *American Economic Association: Papers & Proceedings.* 112(May):2022.

"Do Tax Cuts Produce More Einsteins? The Impacts of Financial Incentives vs. Exposure to Innovation on the Supply of Inventors" (with Raj Chetty, Xavier Jaravel, Neviana Petkova, and John van Reenen), *Journal of the European Economic Association* Volume 17 (3): 65177, 2019.

"Who Becomes an Inventor in America? The Importance of Exposure to Innovation" (with Raj Chetty, Xavier Jaravel, Neviana Petkova, and John van Reenen). *Quarterly Journal of Economics*,

Volume 134, Issue 2, May 2019, Pages 647713.

"Team-Specific Capital and Innovation" (with Xavier Jaravel and Neviana Petkova). 2018. *American Economic Review*, 108(4-5):1034-73.

Working Papers

"The Long-Term Impacts of Mentors: Evidence from Experimental and Administrative Data" (with Neviana Petkova)

"Job Amenities and Earnings Inequality"

"Pricing Neighborhood Amenities: A Proxy Based Approach" (with Sophie Calder-Wang and Shusheng Zhong)

"An Anti-IV Approach for Pricing Residential Amenities: Applications to Flood Risk" (with Stephen Billings, Sophie Calder-Wang, and Shusheng Zhong)

"Borrowing for Breakthroughs: Student Loans and Innovation" (with Vikram Jambulapati)

"Paying for Prestige: Compensating Differentials in Faculty Job Choice" (with Todd R. Jones)

Selected Policy Writing

"Early evidence on federal government income supports for U.S. individuals, workers, and families during the COVID-19 pandemic." The Recovery Reports: Socioeconomic Impacts of COVID Relief. Washington Center for Equitable Growth, December 2022.

"Disparities in Access to Unemployment Insurance During the COVID-19 Pandemic: Lessons from U.S. and California Claims Data" (with Thomas J. Hedin, Roozbeh Moghadam, Geoffrey Schnorr, and Till von Wachter), report to the US Department of Labor issued February 2022.

"Analysis of Unemployment Insurance Claims in California During the COVID-19 Pandemic" (with Thomas J. Hedin, Roozbeh Moghadam, Geoffrey Schnorr, and Till von Wachter) *(Rapid-Response Series of Policy Briefs, 2020-2022)*

Selected Grants, Fellowships & Awards

NBER Fiscal and Economic Effects of Innovation and Productivity Policies Fellowship	*2025*
Laura & John Arnold Foundation	*2022*
Ewing Marion Kauffman Foundation (Co-PI)	*2022*
US Dept. of Labor Summer Data Equity Challenge	*2021*
Washington Center for Equitable Growth Doctoral Grant	*2018*
Ewing Marion Kauffman Foundation Knowledge Challenge	*2018*
Weatherhead Initiative on Gender Inequality Fellowship	*2017*
NBER Health & Aging Economics Fellow	*2016*

Inequality & Social Policy Fellow at Malcolm Weiner Center for Social Policy *2015*

Teaching Experience

PhD Labor Economics, GSU *Fall 2024*
- Instructor Preparedness: 5.0; Communication Effectiveness: 5.0; Learning Environment: 4.9

Volunteer high-school equivalency tutor, Massachusetts Correctional Inst. Framingham *2016-2018*

Senior Thesis Mentor, Harvard, Weatherhead Center for International Studies *Summer 2018*

PhD Labor Economics, Harvard, TF for Prof. Roland Fryer *Fall 2017*
- Certificate of Distinction in Teaching from Bok Center

Undergrad. Intro. Econometrics, Harvard, TF for Dr. Gregory Bruich *Spring 2017*
- Certificate of Distinction in Teaching from Bok Center

Development Economics, Brown, TA for Prof. Andrew Foster *Spring 2013*

Database Management Systems, Brown, TA for Prof. Stan Zdonik *Spring 2012*

Professional Activities

Referee: *AEJ: Applied, AEJ: Policy, AER: Insights, Applied Economics Letters, Econometrica, Economics of Transition, Journal of Human Resources, Journal of Labor Economics, Journal of Political Economy, Journal of the European Economic Association, Journal of Environmental Economics and Management, Management Science, Quarterly Journal of Economics, Review of Economic Studies, Review of Economics and Statistics*

Program Committee Service: Atlanta Conference on Science and Innovation Policy, Labor and Employment Relations Association (LERA), National Tax Association (NTA)

Undergraduate Program Committee at GSU *2024-present*

Member, CA Policy Lab Race Equity Working Group *2020-2024*

Volunteer Mentor, CA Policy Lab Undergraduate Sumer Institute *2020*

Organizer, Harvard Economics Peer Mentoring Program *2016-2018*

Chair, Diversity & Inclusion Committee, Harvard Graduate Economics Association *2019-2020*

Conferences, Seminars, and Presentations (including scheduled)

2025: Atlanta Conference on Science and Innovation Policy, Columbia Management, Analytics, and Data Conference, Georgia Institute of Technology (Economics), NBER Investments in Early Career Scientists Research Meeting, NYU Stern Summer Climate Finance Conference, Society of Labor Economists, University of Georgia (Agricultural & Applied Economics), Upjohn Institute, Wellesley College (Economics), Workshop on Economics of Education (Valle Nevado, Chile)

2024: AEA/ASSA Meeting (chair); APPAM (chair, moderator of cross-cutting roundtable); Cornerstone Research; Georgia State University Andrew Young School of Policy Studies (Economics); Keio University (Economics); Louisiana State University (Economics); NBER SI Real Estate;* NBER SI Science of Science Funding (discussant); Osaka University (ISER); Southern Economics Association; Stanford Hoover Institution Conference On Collaborative State & Local Policy Research;* University of Rochester (Economics/GIDS); US Census Bureau (virtual); World Congress for Social Economics at UMass Boston

2023: AEA/ASSA Meeting;* APPAM Meeting; Econometrics Society NASM; EEA/ESEM Congress; Southern Economic Association; UCLA Economics; UCLA California Center for Population Research; Urban Economics Association;* NBER Spring Childrens Meeting

2022: AEA/ASSA Meeting (virtual);* APPAM Meeting

2021: APPAM Meeting (virtual); National Academies of Sciences, Engineering, and Medicine Workshop on Women in Entrepreneurship (virtual); Equitable Growth: People and Research Advancing Economic Evidence in Washington, DC; Kauffman Foundation Entrepreneurship Issue Forum: The Great Resignation and Entrepreneurship (moderator); Russell Sage Foundation Conference on the Socioeconomic Impacts of Covid-19; US Department of Labor Conference on Equity and Underserved Communities (virtual)

2020: Equitable Growth: People and Research Advancing Economic Evidence (virtual); Kauffman Foundation Early Stage Research Showcase (virtual); UCLA California Policy Lab; University of Bath (Economics); University of Essex (Economics); University of Nottingham (Economics); University of South Alabama (Economics); VentureWell Webinar on Advancing Equity in Innovation

2019 (and earlier): AEA/ASSA Meetings in Philadelphia and San Francisco;* Big Brothers Big Sisters of Massachusetts Bay Board of Directors; Harvard University Econometrics Clinic; Harvard University Gender Inequality Workshop; Harvard University Labor/Public Workshop; Harvard University IO Workshop; Inventing America 2017 Conference; National Inventors Hall of Fame Induction Ceremony; National Inventors Hall of Fame Webinar: Supporting Next-Generation Inventors with STEM Learning; NBER SI Labor Studies;* NBER SI Innovation;* NBER SI Productivity, Development, and Entrepreneurship;* Society of Labor Economists Annual Meeting

* Indicates co-author presentation

Last Updated: April 2, 2025

Borrowing for Breakthroughs: Student Loans and Innovation*

Alex Bell† Vikram Jambulapati‡

January 10, 2025

Abstract

This preliminary conference paper investigates the impact of higher education financing on innovation, focusing on how student loan policies shape the innovative potential of individuals. Leveraging a novel dataset linking administrative patent records to consumer credit data, we first document a variety of stylized facts pertaining to household finance and innovation, including event studies of credit scores around the time of innovation and age-debt profiles of inventors in comparison to the general population. Then, we explore the causal relationship between access to student loans and the likelihood of subsequent patent filings. Our quasi-experimental design exploits changes in federal student loan limits to estimate causal effects, revealing that increased borrowing capacity causes higher rates of patenting among constrained borrowers. While preliminary, the findings suggest that alleviating credit constraints through student loan policy may generate significant social spillovers by enabling broader participation in innovation. This research contributes to understanding the role of education financing as a lever for sustaining economic growth and reducing innovation disparities across socioeconomic groups.

JEL: I22, G51, J24, H52, O31

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"When it comes to technological innovation, we are rowing with one hand tied behind our back."
—U.S. Under Secretary of Commerce for Intellectual Property Michelle K. Lee , 2019 Testimony to Congress

1 Introduction

Although economists have long viewed innovation as a key driver of economic growth, systemic barriers stifle the innovative potential of many talented Americans. The amount of innovation that leaks out of the pipeline is alarming: equalizing innovation rates across gender, race, and parent background could result in as much as four times as many inventors in the next generation (Bell et al., 2019b), which could in turn boost GDP between 0.6 and 4.4 percentage points (Cook and Yang, 2018). Yet research so far has failed to shine light on particular programs or policies that can remedy these innovation gaps.

This paper contributes the first empirical investigation into whether higher education financing can be an effective policy lever to bring talented students back into the innovative ecosystem. Specifically, we focus our analysis on the role of student loan policy in shaping the innovation of subsequent generations. Along the way, our unique linked dataset also allows us to document a number of novel and interesting stylized facts pertaining to the household finance side of innovation.

Existing evidence and economic theory offer ambiguous predictions about how the generosity of student loan policy shapes innovation. On the one hand, student loan availability can increase access to higher education and allow students to focus more on education instead of working while in school (Black et al., 2023; Card and Solis, 2022). The positive "human capital" effect of student loans may increase students' future innovation. On the other hand, because innovation is often viewed as a risky career with potential payoffs accruing later in life (Bell et al., 2019b; Akcigit et al., 2017), "debt overhang" may push students to pursue higher-paying and less risky careers (Field, 2009; Rothstein and Rouse, 2011; Krishnan and Wang, 2018).[1] This tendency of student loans to push students away from high-growth ca-

[1]Contrary to the findings of this paper, the findings of prior literature has emphasized the effects of debt overhang in pushing students away from careers with social spillovers. For instance, Rosenblatt and Andrilla (2005) find that medical students are less likely to enter into primary care (with high public demand but low

reers crops up in several other studies (Minicozzi, 2005; de Gayardon et al., 2018; Gervais and Ziebarth, 2019; Daniels Jr. and Smythe, 2019; Black et al., 2023; Sauers, 2023).

To produce novel empirical evidence pertaining to how student loan policies shape innovation, we undertake a large-scale record linkage effort. We link nation-wide individual-level data on inventors from administrative records of the US Patent Office to student loan data from credit bureau records. We view patents as a proxy for innovative activity. Our linked database allows us to view 20 years of complete credit histories for almost 250,000 US patent inventors that have ever lived in California, which constitutes about a third of all US inventors. While recent literature on higher-education financing has focused on various measures of students' own short- and long-run success, our work is the first that we know of to explore effects on innovation, which is particularly relevant to public policy due to its social spillovers.

Although little is known about direct impacts of student loans on innovation, the literature has established some evidence that student loans negatively impact entrepreneurship (Lammers, 2015; Checovich and Allison, 2017; Krishnan and Wang, 2018; Desai et al., 2020). While different from innovation, there is overlap in the skillsets and risk profiles, and starting a firm is often in practice a means of commercializing one's innovation. The entrepreneurship literature may lead one to expect a negative effect of student loan policy on innovation, although the outsized importance of access to higher education for innovation relative to for entrepreneurship may help to explain the apparently contradictory findings of this paper.

Understanding how education financing policies influence innovation is critical for shaping equitable and growth-oriented public policy. While innovation is widely recognized as a cornerstone of economic growth, disparities in access to higher education continue to limit the development of innovative talent. By examining the relationship between student loan availability and subsequent patenting activity, this research addresses a gap in the literature on the mechanisms that enable or hinder innovation. Preliminary findings suggest that poli-

wages) if they hold student loans than medical students without student loans, though the effects are modest when demographic characteristics are taken into account. This comports with the findings of Rothstein and Rouse (2011) relating to public-interest careers. Other studies have suggested that the psychology of debt matters a great deal in pushing students away from public interest careers: In an experiment at NYU's Law School studied by Field (2009), two career-contingent financial aid packages with equivalent monetary value were randomly assigned to students, and the negative psychological effects of student loans pervade into more than just initial job choice.

cies reducing credit constraints may have the potential to boost innovation rates, particularly among underrepresented groups. Even as these results remain subject to further validation, the questions explored here highlight the importance of rethinking higher education financing as a tool for fostering economic dynamism and inclusivity in the innovation economy. This study's novel linkage of patent and credit data provides an unprecedented opportunity to examine how education financing shapes pathways to innovation, offering insights for both policymakers and academic researchers.

2 Student Loans in the US

Over the last two decades, student loans have become an increasingly prominent form of debt for many individuals in the U.S. As shown in Figure A1, aggregate student loan debt balances in the U.S. rose from $240 billion in 2003 to $1.6 trillion in 2024 (nominal dollars). During this period, student loans became the third largest category of debt behind mortgages ($12.6 trillion) and auto loans ($1.6 trillion).[2] In terms of aid to access education, student loans are a significant form of aid to undergraduates. Almost 40% of full-time undergraduate students were awarded some form of federal student loan in 2020 (National Center for Education Statistics, 2023). The federal government primarily makes student loans available to borrowers.[3]

For decades, the bulk of federal student loan programs were provided under the Stafford Loan program. Stafford Loans are loans made available by the United States federal government to students attending accredited higher-education institutions. For undergraduates, borrowers may access loans up to a specific dollar amount based on their dependent status and their years of enrollment. Undergraduate students may be eligible for either subsidized or unsubsidized loans based on financial eligibility determined by the Free Application for Financial Student Aid (FAFSA). Subsidized loans do not accrue interest while students maintain an enrollment status of at least half-time. In addition, from 2008 to 2013, subsidized

[2]See Center for Microeconomic Data (2024) for additional details.

[3]Ma et al. (2024) estimates federal student loan lending comprises between 75% and 93% of all education borrowing each year with non-federal student loan amounts coming from states, post-secondary institutions and private markets.

loans had a slightly lower interest rate.

The Stafford Loans borrowing limit experienced two significant increases in the last two decades. The Higher Education Reconciliation Act of 2005 raised borrowing limits from $2,626 to $3,500 and $3,500 to $4,500 for first-year and second-year students, respectively. These new limits went into effect for the 2007-2008 academic year, which began on July 1, 2007. The Ensuring Continued Access to Student Loans Act of 2008 increased borrowing limits for the 2008-2009 academic year. First-year borrowing limits increased from $3,500 to $5,500, second-year limits increased from $4,500 to $7,500, and finally third-, fourth- and fifth-year students' limits increased from $5,500 to $7,500. Table 2 summarizes these changes for each academic cohort by enrollment year. The Stafford Loan program stopped offering loans for the 2010-11 academic year and was replaced by the Federal Direct Loan Program, which preserved the limits established by the Ensuring Continued Access to Student Loans Act of 2008.

3 Data

Our main source of data on student loans comes from the University of California Consumer Credit Panel (UC-CCP). The UC-CCP consists of quarterly loan-level credit records from an anonymized longitudinal panel of over 70 million individuals. As described in Section 2, borrowing limits vary by an individuals enrollment year and academic level. However, while the UC-CCP contains detailed information on individual loans, it does not contain education enrollment information of borrowers. In order to identify the first-year of enrollment of borrowers, we assume the first year of enrollment coincides with the first year of borrowing. More specifically, we define a borrower's academic year of enrollment if they first took out a loan during that academic year. For example, if a borrower's first education loan originated on September 24, 2004, then their enrollment year is defined as 2004-05 since that origination date falls within July 1st, 2004 and June 30th, 2005. One limitation of the UC-CCP is that the panel only begins in 2004. However, since the UC-CCP contains information on the origination date and the origination amount, this allows us to construct a panel of student loan borrowing that starts before 2003.

The credit dataset consists of loan-level credit records from a consumer credit bureau totaling 60 million individuals each quarter from 2004 to 2021. The data include a complete sample of every individual with a credit record in California and a 2 percent random sample of individuals with a credit record in the U.S. For a complete picture of household borrowing, the dataset also includes the credit records of all household members and associated borrowers (e.g., co-signers or joint-account holders) of each individual sampled. Even after an individual leaves California, the credit panel continues to observe the credit records of the individual along with their household members and associated borrowers. In other words, an inventor does not necessarily need to live in California at time of invention to be in the 100 percent California sample if the inventor lived or studied in California in an earlier year. For instance, a student who studied in California in 2004 but has lived in Texas since would remain in the UC-CCP for each year since moving out of CA. While our paper has a national scope, we see the 100 percent coverage of California as a strength on top of the 2 percent national sample. In particular, California is the most useful state to over-sample because although it only accounts for 12 percent of the U.S. population, we find that it accounts for nearly one quarter of all U.S. patents, which is far higher than any other state.

A patent is an exclusive right granted by the government to an inventor for a product or process. Most but not all patents are assigned to firms by their inventors, and the term of force is generally 17 years. The United States Patent and Trademark Office (USPTO) is the entity responsible for evaluating and approving patent applications in the U.S. In 2020, the USPTO received 646,244 applications and issued 388,900 patents.

An example of one such granted patent is shown in Figure A2, which helps convey the richness of the data available. Data on inventors and their patents are sourced directly from the USPTO. This dataset is built from administrative records first made public in response to the Obama administration's Open Government Initiative; we use the Patent Examination Research Dataset (PatEx) dataset produced by Graham et al. (2018), which contains two types of documents. First, it contains all patents granted since approximately 1980. Second, it contains most patent applications that were filed—regardless of whether they were granted—since the passage of the American Inventors Protection Act (AIPA) heavily incentivized application publication beginning in late 2000. We will define an individual as

an inventor if they are listed as an inventor on a patent grant or application during the timeframe for which we can observe individuals in the UC-CCP, which runs from 2004 to present. Following Bell et al. (2019b), we include all individuals listed as inventors, not just those assigned intellectual property rights. In particular, inventors employed by companies are listed as inventors, while their company is typically listed as the assignee.

Our main approach to measuring patent value is the number of citations a patent has received from future patents. Because more recent patents have mechanically had less time with which to accumulate citations, we define a citation-based ranking relative to other patents granted in the same year. Though still not a perfect measure of quality, Bell et al. (2019b) have established that inventors of higher-cited patents earn more than inventors of patents with fewer citations, suggesting that citations may be a reasonable proxy of quality. Griliches (1991) points out that there is good empirical support to view patents as a proxy for innovation because a very robust relationship exists across firms between expenditures on R&D and patent output. Still, many important innovations are not patented (or patentable), and many patents do not correspond to real innovation. Because not all patents are equally innovative, our future work will also examine robustness to several measures of patent quality. Prior work by Hall, Jaffe, and Trajtenberg (2000) to link patent records to the Compustat database has established that firms with more highly cited patents have higher stock market valuations. In addition, citation-weighting patents may down-weight so-called "defensive" patents that add less value to society.

For every student loan borrower in the credit data, we observe detailed information on each of their loans. Variables include the loan origination date, original loan amount, remaining balance, and scheduled payment amount for every quarter that the loan provider reported information to the credit bureau. In addition, even loans that have been closed will remain in the credit bureau data for up to seven years. We also have limited information on the characteristics of the borrowers. For each borrower, the dataset includes birth year and month, household composition, ZIP Code, and Census Block.

There are two key limitations to the credit panel data. First, the data do not contain high-quality self-reports of individuals' race and ethnicity. However, imputed demographic variables are available from the credit bureau. For this reason, as described in further

detail in the methods section, we will be limited to studying disparities according to the racial breakdown of individuals' ZIP Codes and Census Blocks, in addition to analysis with individual-level racial categories derived from patent records as described in the next section. Second, not all people have credit records: an analysis by Brevoort, Grimm, and Kambara (2016) suggests as many as 26 million adult Americans may be lacking credit reports, and this population of so-called "credit invisibles" is concentrated among the young or elderly, racial minorities, and low-income consumers. We expect the incidence of credit invisibles among both student loan holders and inventors to be low. Thus, the issue of absence of credit reports is unlikely to significantly impact our record linkage rate and analysis. Despite these caveats of the credit bureau data, we believe the lack of alternative data and importance of the research question justify its use and will continue to note how our methodologies are designed to mitigate impacts of these limitations on the research.

4 Descriptive Results

Given the novelty of our linked dataset, we highlight several stylized facts about credit histories and student loan usage among inventors.

Table 1 summarizes the data. Applying imputation methods for race and gender, we find that 88% of our linked inventor sample is White or Asian (relative to 60% of the general CA population) and 17.5% are women. These roughly align with already existing estimates of the demographic backgrounds of inventors (Bell et al., 2019b).

Figure 1 shows how the likelihood of filing a patent varies with credit scores at the start of the sample. We find that inventors' credit histories are quite good: People with credit scores in the top 10% of the distribution are ten times as likely to invent as those with below-median credit scores.

We do not find obvious evidence of large private returns to innovation for the average invention. Panel A of the event studies in Figure 2 shows that around the time of innovation credit scores are increasing, but if anything increase somewhat more slowly after the time of innovation. Panel B shows a similar analysis for credit card usage, which we view as a rough proxy for consumption. If anything, credit card usage also exhibits a decline relative to

trend following an innovation. These findings are consistent with other recent work that has sought to identify the private returns to innovation, which have suggested that the private rents accruing to individual inventors are likely on average small (Depalo and Di Addario, 2014; Bell et al., 2019a; Kline et al., 2019). Our complimentary contemporaneous work is exploring using an examiner-leniency instrument to more causally isolate the effects of patent allowance on household finances.

Figure 4 investigates how student loan amounts accrue to inventors over the lifecycle. During their early 20s, inventors accumulate substantially more student loan debt than most people, but also pay off the debt more quickly; by age 40, inventors are actually substantially less likely to hold any student loan debt than their peers.

5 Empirical Framework

Following Black et al. (2023), we identify the causal effect of student loan borrowing by comparing borrowers constrained versus not by the Stafford Loan limit before and after the expansion to borrowing limits.[4] This empirical strategy relies on the identifying assumption that the difference between constrained and unconstrained students would be similar across cohorts if limits did not expand. We use the following event-study specification to examine the similarity of cohorts before and after the policy change where we interpret the post-policy period as the causal effect of increasing student loan limits on borrowers.

$$y_{ic} = \beta_0 + \beta_1 Constrained_i + \sum_{j \neq 2005} \beta_c Constrained_i \times \mathbf{1}\{j = c\} + \delta_c + \varepsilon_{ic} \tag{1}$$

where y_{ic} refers to the dependent variable of interest for individual i in cohort c. Our sample consists of cohorts from academic year 2001-02 ($c = 2002$) through 2012-13 ($c = 2013$).

The coefficients of interest for the event graph specification in Equation 1 are on the interaction terms, $\beta_c Constrained_i \times \mathbf{1}\{j = c\}$. Finally, we include cohort fixed effects denoted δ_c.

Our main regression specification takes the following form:

[4]This design has subsequently been applied in other work, including by Sauers (2023).

$$y_{ic} = \alpha + \beta_1 Constrained_i + \beta_2 Constrained_i \times \mathbf{1}\{c > 2005\} + \delta_c + \varepsilon_{ic} \tag{2}$$

where δ_c corresponds to cohort fixed effects for $c \in [2001, 2013]$. For cohorts before 2006, borrowers are considered constrained if they borrowed exactly the Stafford borrowing limit. For cohorts 2006 and onward, they are considered constrained if they borrowed between the original Stafford loan limit and the Stafford borrowing limit for their relevant cohort.[5] See Table 2 for additional details on Stafford borrowing limits.

In order to make the magnitude of the causal effect of student loan debt comparable to existing studies, we follow the approach outlined in Black et al. (2023) where we instrument student loan borrowing with the interaction of being constrained and an indicator for affected cohorts. More specifically, we estimate the following system using two-stage least squares:

$$\begin{aligned} y_{ic} &= \beta_0 + \beta_1 Constrained_i + \beta_2 Loans_{ic} + \delta_c + \varepsilon_{ic} \\ Loans_{ic} &= \gamma_0 + \gamma_1 Constrained_i + \gamma_2 Constrained_i \times \mathbf{1}\{c > 2005\} + \delta_c + \eta_{ic} \end{aligned} \tag{3}$$

6 Causal Estimates

As described in Section 2, the statutory borrowing limit rose for students in the academic cohorts of 2007-08 (denoted as 2008). Figure 3 shows the distribution of loans for earlier cohorts versus the 2007-08 cohort. For both sets of cohorts, we observe bunching at the dependent individual Stafford loan limit, which we exploit for this paper. For the earlier cohorts, the bunching point occurred at \$2,625, whereas the mass shifted to \$3,500 after the loan limit was raised.

To provide graphical intuition of how innovation rates varied for these cohorts, Figure 5 plots innovation rates by student loan amounts, separately by cohort. As constraints became higher in subsequent cohorts, innovation rates among the constrained students increased. While this analysis abstracts from important confounders like overall cohort effects,

[5]The variable $Constrained_i$, is defined as an indicator variable that equals 1 for borrowers in cohorts before the academic year 2006-07 ($c \leq 2007$) who borrowed $\$2,625$, or for borrowers in the academic year 2007-08 cohort ($c = 2008$) who borrowed between $\$2,625$ and $\$3,500$, or for borrowers in cohorts in the academic year 2008-09 and onward ($c \geq 2009$) who borrowed between $\$2,625$ and $\$5,500$ and $Constrained_i$. See Table 1 for additional details on Stafford borrowing limits.

it provides visual intuition for how the lifting of the constraints can be used to identify the positive effects of access to higher education financing on future innovation.

Figure 6 shows how much constrained borrowers actually borrowed additionally relative to unconstrained borrowers in their respective cohorts. Prior to the policy change, the difference within cohorts in borrowing between constrained and unconstrained borrowers remained fairly similar to the academic cohorts of 2004-05 (denoted as 2005). There is no confidence interval for 2005 because that cohort is normalized as the base year. The estimated effect increases by roughly $680 for the 2007-08 cohort, who experienced an increase of $875 in their borrowing limit, and increases by more than $1,700 over the later cohorts, who experienced an increase of $2,500 in their borrow limit relative to the 2004-05 cohort. The increase in actual amounts borrowed is less than the increase in the limit because not all students borrow at the new limit.

Figure 7 shows a significant increase in patenting among constrained borrowers after the policy change, indicating a clear positive link between loan access and innovation. Constrained borrowers relative to unconstrained borrowers in their respective cohorts after the policy change were more likely to file patents. Prior to the policy change, the difference within cohorts in borrowing between constrained and unconstrained borrowers remained fairly similar to the academic cohorts of 2004-05 (denoted as 2005). The estimated effect increases by roughly 1 patent filer per 1,000 individuals in the 2007-08 cohort and onward.

Table 3 presents OLS and IV estimates that are helpful for interpreting magnitudes. Columns 1-3 present the näive OLS specifications, with a varying set of controls. In column 1, without any instrumental variation, we find no significant relationship between amount of loans and future patenting rates. While not significant, here student loan debt is associated with slightly lower future patent rates: $1000 of first-year borrowing is associated with .044 fewer inventors per thousand (6.7% of the mean innovation rate). Column 2 adds in a control for whether the student was constrained, and Column 3 also adds cohort fixed effects. While it is clear that innovation rates are lower among constrained students than unconstrained students, there remains no significant relationship between first-year borrowing and future innovation rates.

Our IV results are presented in Column 4 of Table 3. As in the prior columns, this

specification regresses innovation rates on first-year borrowing, but in this specification first-year borrowing is instrumented by time variation in student loan limits. The IV coefficient implies that $1,000 of student debt leads to .454 more inventors per 1,000 students (with a lower bound of .16). Given the base rate of innovation in the sample, the IV estimate suggests $1,000 more loans leads to approximately a 73% increase in innovation rates (lower bound of 25%). Though preliminary, these results suggest the social spillovers from lifting credit constraints at the margin may be quite large.

7 Conclusion

This paper documents preliminary findings stemming from a first-of-its-kind large scale linkage of administrative patent records with comprehensive credit records. The novel data linkage allows us to implement a quasi-experimental research design to measure the effects of access to higher education financing on students' future innovation.

A priori, theories were ambiguous as to the direction of the causal effect. While debt overhang presumably pushes some students away from innovative careers that may be seen as having risky payoffs that are not fully captured by the individual, our preliminary results actually suggest that the human capital channel may dominate. In practice, our results are more consistent with a story in which increased access to higher education financing enables doorways to further education for students, which have downstream benefits on innovation. While the results thus far should be regarded as preliminary, this line of research stands to inform our understanding of policies to sustain American innovation through education financing policies.

Much work remains to be done to understand the iceberg below the surface. We plan to carry out additional robustness checks, including placebo checks that would apply the research design to detect effects on pre-determined outcomes. We are also exploring heterogeneity of the result by race, gender, and geography. We will also bring in additional measures of patent quality such as citation metrics to better understand how education financing affects the quality of innovations produced, with an eye toward differentiating between the "lost Einsteins" of Bell et al. (2019b) versus the more marginal misallocations

modeled by Hsieh et al. (2019). In the longer run, we also look forward to leveraging the unique linked dataset for additional research questions at the intersection of household finance and innovation.

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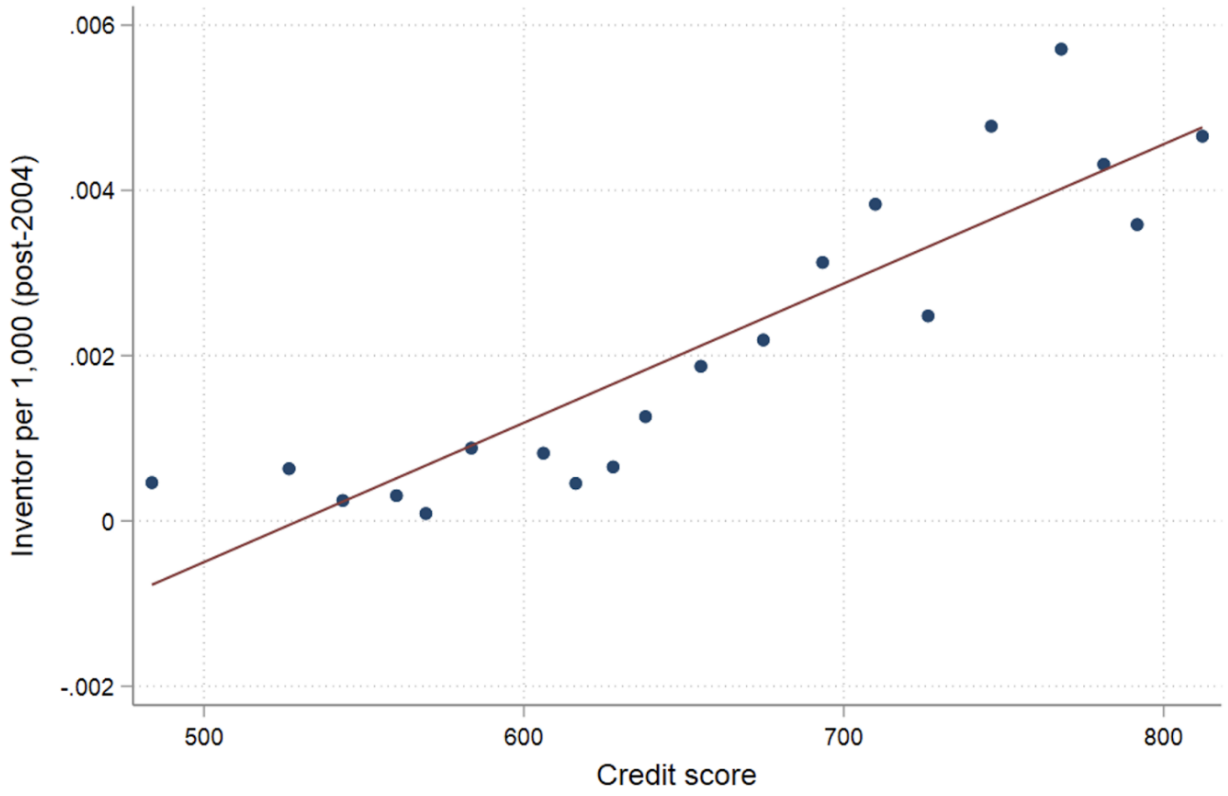
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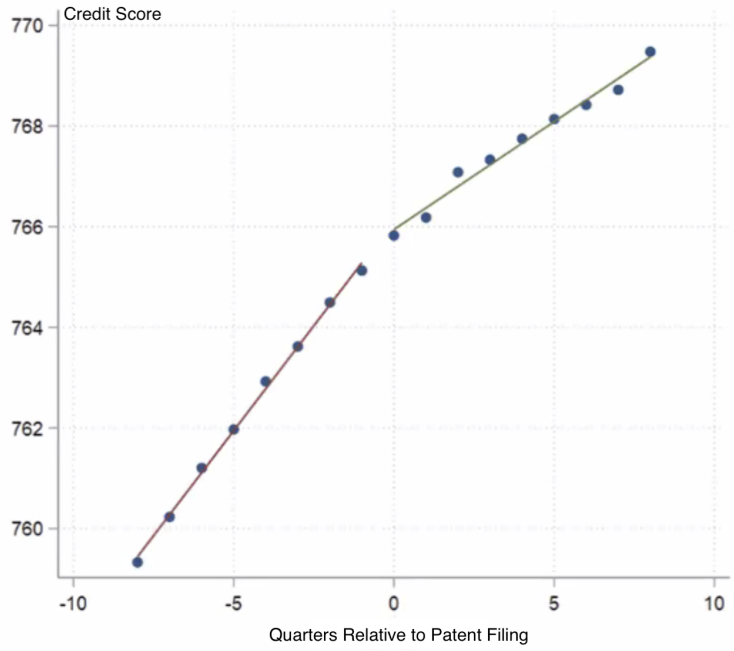
8 Figures

Figure 1: Innovation Rates by Credit Score

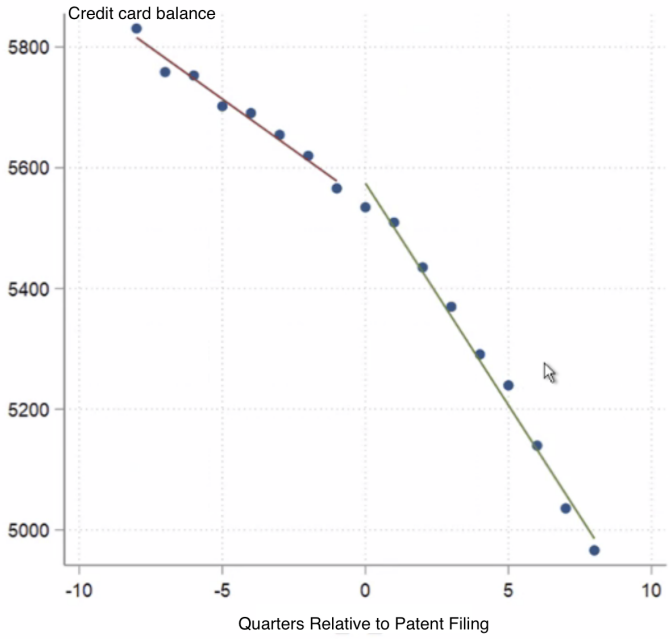


Notes: This figure plots innovation rates (per 1,000) by credit score in 2004.

Figure 2: Event Studies Around Patenting



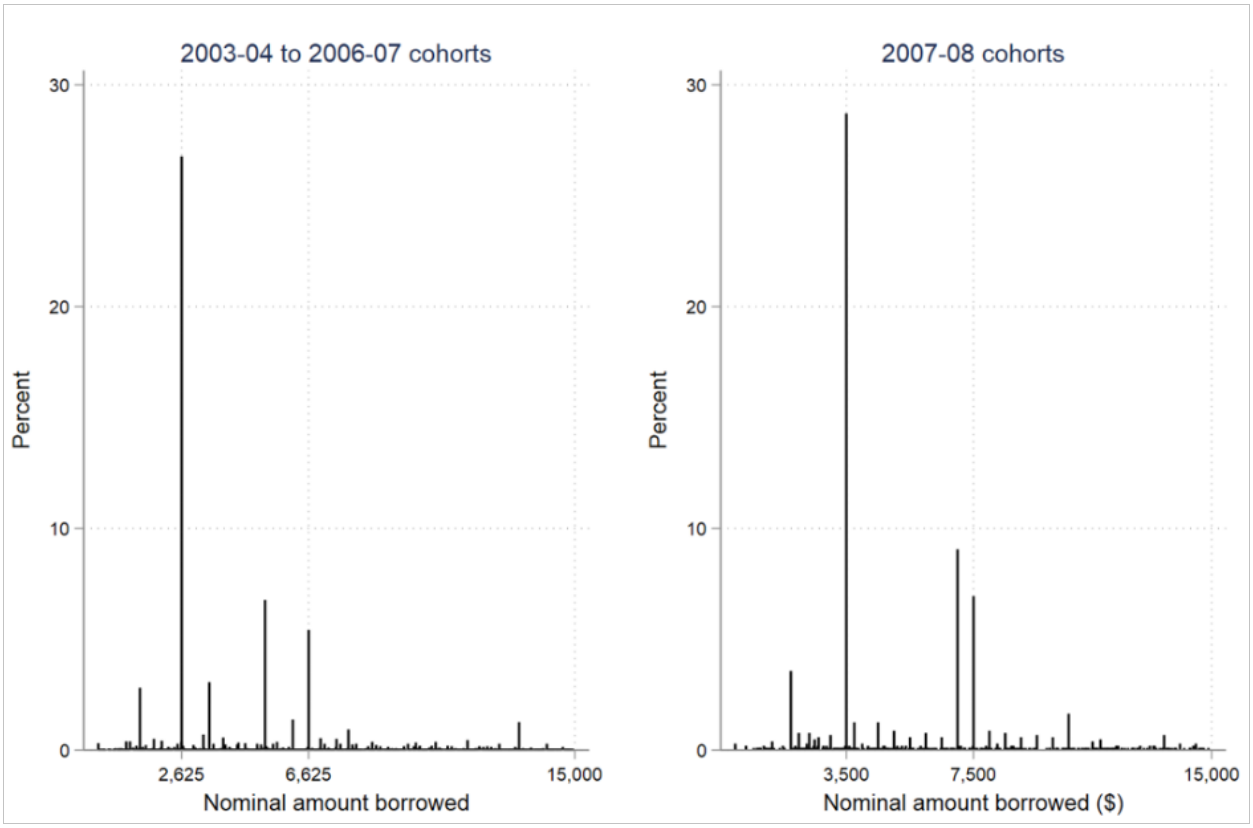
(a) Credit score



(b) Credit Card Balance Amount

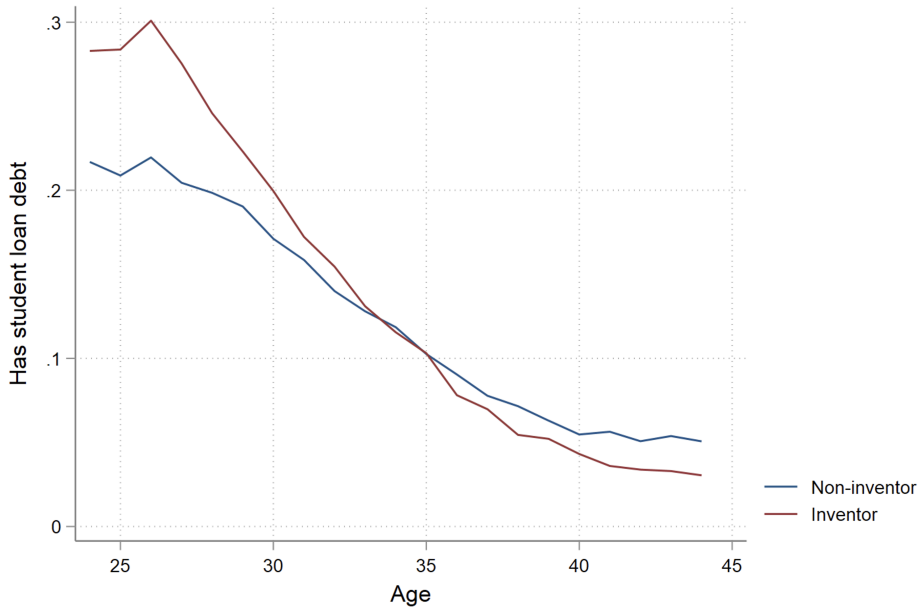
Notes: Panel (a) shows that credit scores around the time of innovation. Panel (b) shows a similar analysis for credit card usage. For individuals with more than one patent in the sample frame, we choose a random one as the event.

Figure 3: Bunching response to policy change

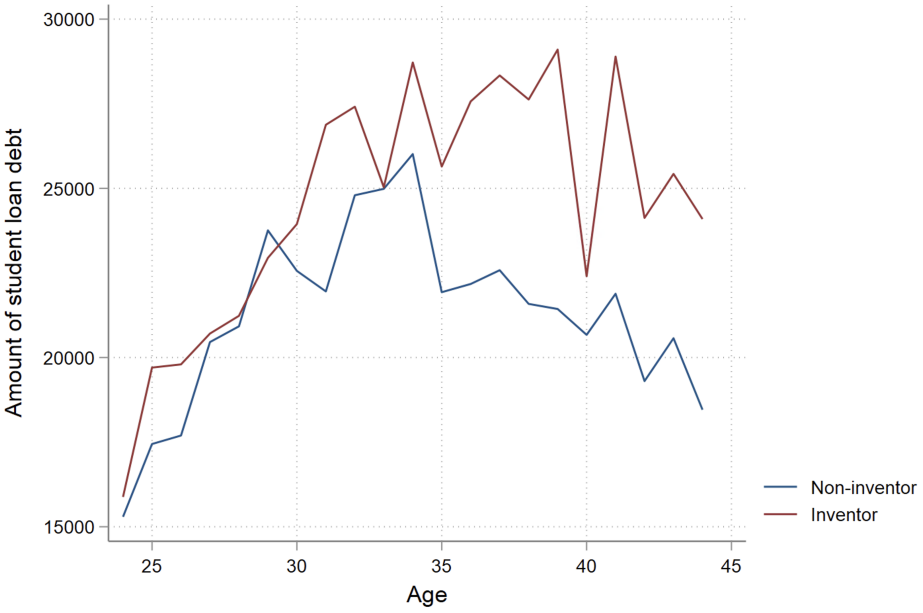


Notes: This figure shows student loan borrowing during first year of college (i.e., the year in which person is observed to have student loans). Source: Authors' calculations based on the UC-CCP. For the earlier cohorts, the individual dependent Stafford loan limit was $2,625 and the non-dependent limit was $6,625. For the 2007-08 cohort, the dependent limit was changed to $3,500 and the non-dependent limit was changed to $7,500.

Figure 4: Student Debt Over the Lifecycle



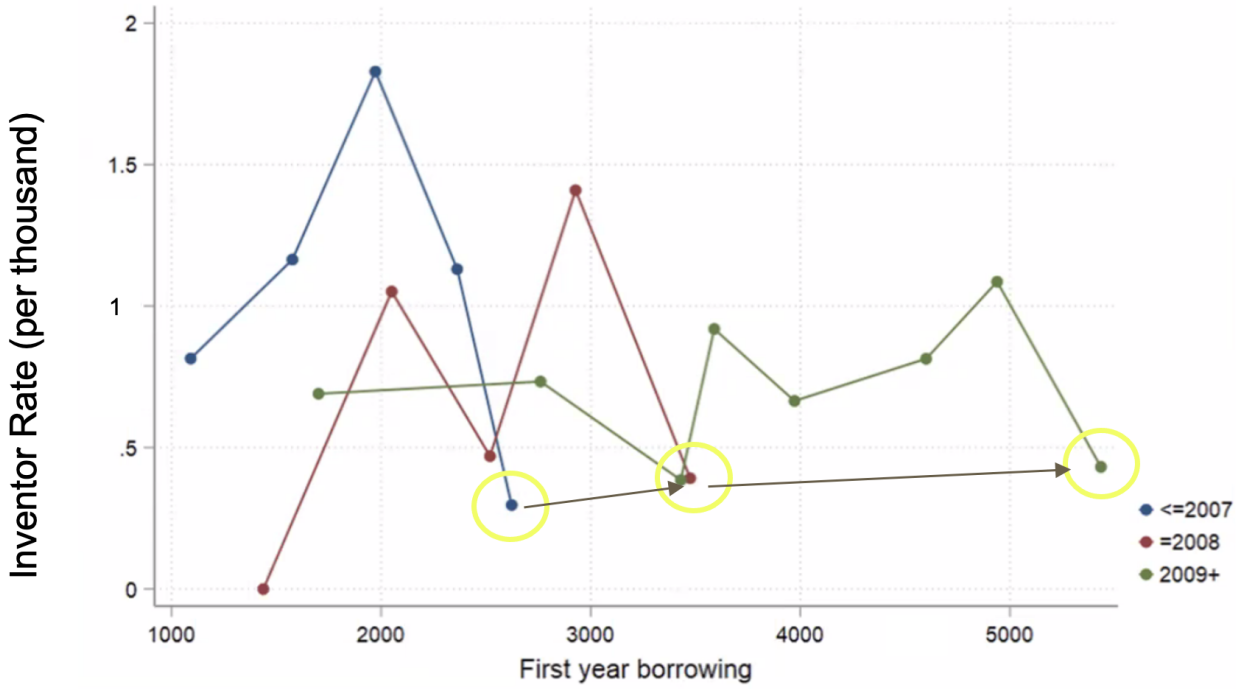
(a) Share of Observations with Any Student Loans



(b) Amount of Student Loan Debt

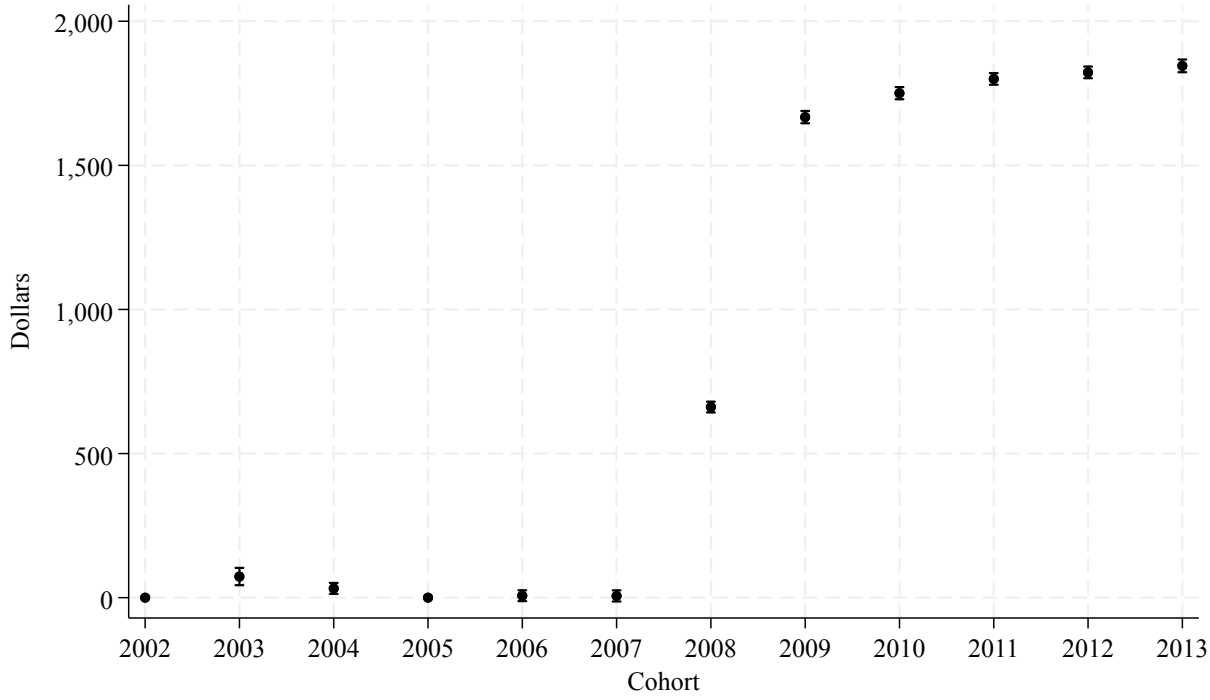
Notes: Panel (a) plots the share of individuals in the credit panel that have student loans and the amount of student loan by age, separately by whether the individual has filed a patent or not. Panel (b) plots the amount of loans, among those that have any loans. Age and student loans are both measured in 2004, and inventor status is aggregated over all years since 2004.

Figure 5: Innovation Rates by First Year Borrowing, by Policy Regime



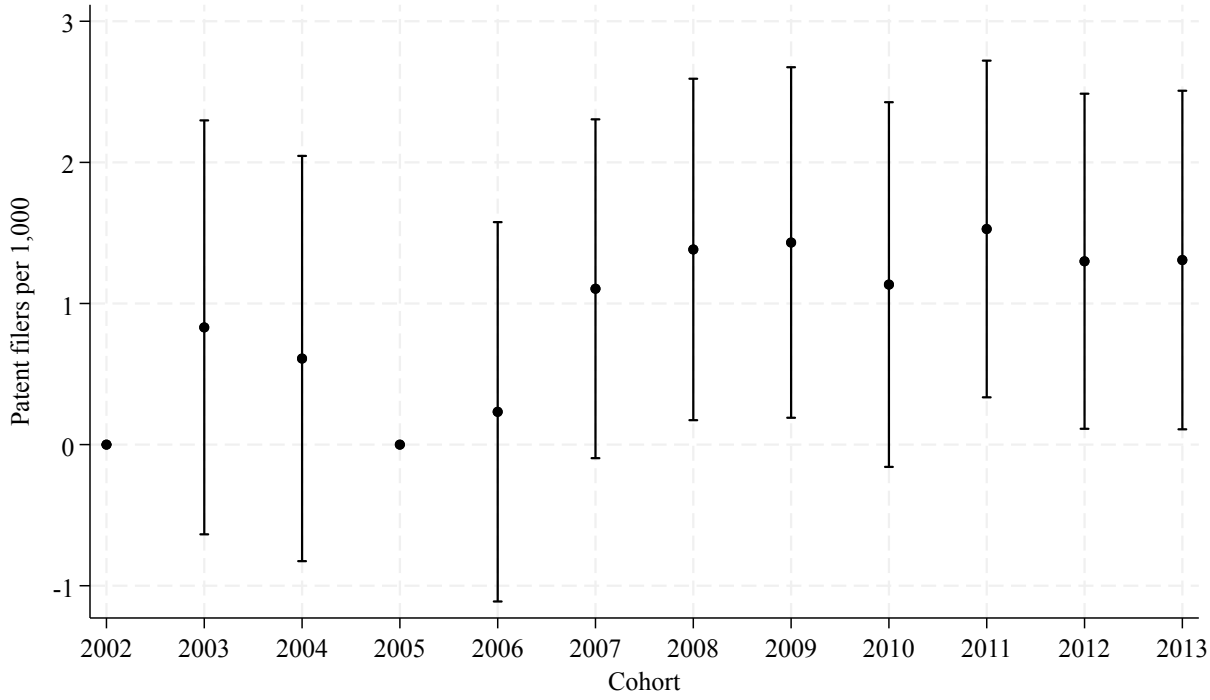
Notes: This figure shows innovation rates per thousand individuals based on the amount the individual borrowed in their first year of college. For cohorts prior to 2007, the borrowing limit was $2,625, which was raised for the 2008 cohort to $3,500 and for subsequent cohorts to $5,500.

Figure 6: First-Stage Effect of Loan Limits on Borrowing



Notes: Estimated coefficients from the event-study regression specification described in Equation 1 where the dependent variable is first-year borrowing.

Figure 7: Reduced-From Effect of Loan Limits on Innovation



Notes: Estimated coefficients from the event-study regression specification described in Equation 1 where the dependent variable is patent filers per 1,000 individuals.

9 Tables

Table 1: Descriptive Statistics

	Inventor	Non-inventor
BISG Race Probability		
White	0.611348	0.448608
Black	0.030516	0.069227
Latino	0.074786	0.320737
Asian Pacific Islander	0.257257	0.13684
Female	0.175	0.466
Credit score	761	677
Share with student loans	0.066	0.111
Amount of student loans ($)	2,544	3,707

Notes: Variables measured in most recent year available.

Table 2: Loan limits by entry cohort and academic level

	Academic level (year in school)					
Entry cohort	1st	2nd	3rd	4th/5th	Total	Relative
2004-05 and earlier	$2,625	$3,500	$5,500	$5,500	$17,125	-
2005-06	$2,625	$3,500	$5,500	$7,500	$19,125	$2,000
2006-07	$2,625	$4,500	$7,500	$7,500	$22,125	$5,000
2007-08	$3,500	$6,500	$7,500	$7,500	$25,000	$7,875
2008-09 and later	$5,500	$6,500	$7,500	$7,500	$27,000	$9,875

Notes: This table shows the Stafford Loan borrowing limits for dependent undergraduate student loan borrowers by entry cohort and academic level. Columns (6) shows the aggregate loan amount available to borrow for each entry cohort over the course of their four years of enrollment. Column (7) shows the amount cumulative amount in Column (6) relative to the 2004-05 entry cohort. The entry cohort, "2004-05 and earlier," applies to cohorts from 2001-02 to 2004-05. Stafford Loan limits were different for cohorts before the 1995-96 academic year, but our sample begins with cohorts in 2001-02. Source: Federal Student Aid (2006, 2007, 2008)

Table 3: Regression Specifications

Outcome: inventors per 1,000 Mean of outcome: 0.613				
	OLS (1)	OLS (2)	OLS (3)	IV (4)
First Year Borrowing ($1,000)	-0.0440 (0.0341)	0.0339 (0.0398)	0.0267 (0.0515)	0.454** (0.152)
Cohort Fixed effects	No	No	Yes	Yes

Notes: Regression specification from Equation 3. The outcome is patent filers per 1,000 individuals. Columns 2, 3, and 4 include controls for whether the student is constrained.
Standard errors in parentheses
* $p < 0.05$, ** p < 0.01, *** $p < 0.001$

10 Appendix

10.1 Supplementary Tables and Figures

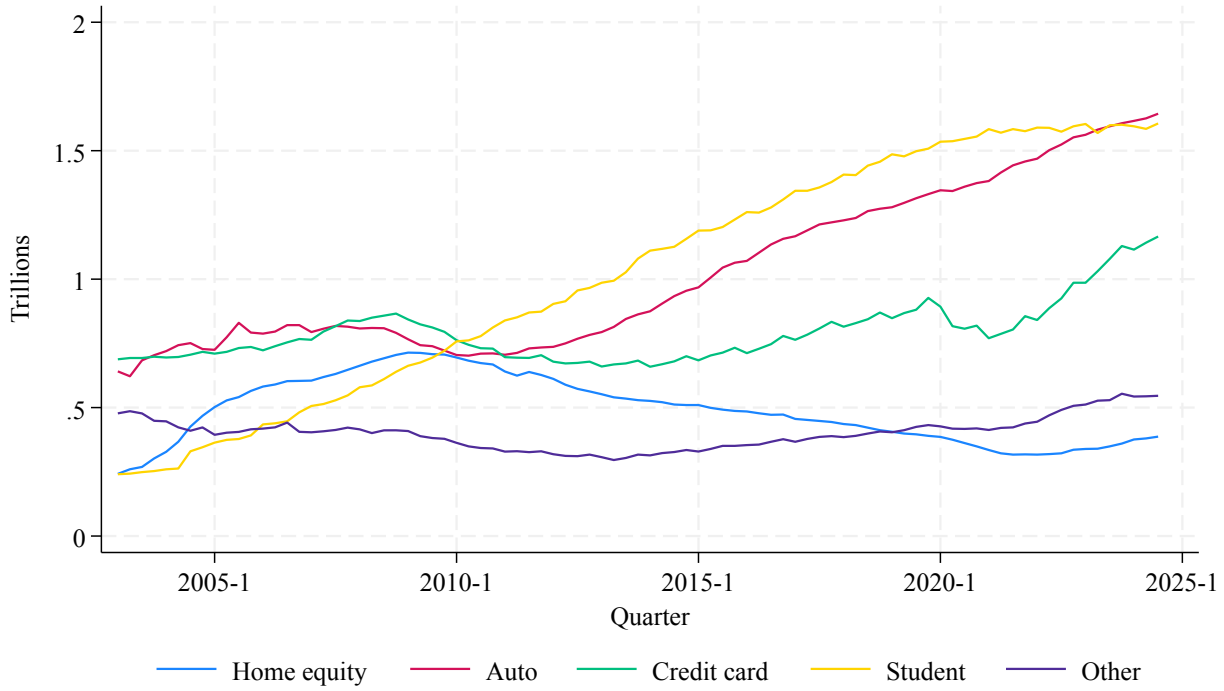


Figure A1: Top forms of debt by quarter (excluding mortgages)

Each line depicts the nominal dollar value of debt over time by each quarter for each major category of debt aside from mortgages from 2003, Quarter 1 to 2024, Quarter 3. Mortgage debt has been excluded. Source: Center for Microeconomic Data (2024)

United States Patent [19]

Johnson

[11] **Patent Number: 4,591,071**

[45] **Date of Patent: May 27, 1986**

[54] **SQUIRT GUN**

[76] Inventor: **Lonnie G. Johnson,** 1463 E. Barkley Dr., Mobile, Ala. 36606

[21] Appl. No.: **541,898**

[22] Filed: **Oct. 14, 1983**

[51] **Int. Cl.**[4] **B67D 5/32**

[52] **U.S. Cl.** ..... **222/39;** 222/79; 222/401; 340/384 E; 340/406; 116/137 R

[58] **Field of Search** ..... 340/384 E, 406; 116/137 R, 139; 222/39, 79, 323, 324, 401

[56] **References Cited**

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Primary Examiner—H. Grant Skaggs
Attorney, Agent, or Firm—John A. Beehner

[57] **ABSTRACT**

A toy squirt gun which shoots a continuous high velocity stream of water. The squirt gun is configured as a structure facilitating partial filling with water leaving a void for compressed air. The squirt gun includes a nozzle for ejecting water at high velocity, a pressurization pump for compressing air into the gun to pressurize water contained therein, and a trigger actuated flow control valve for shooting the gun by controlling flow of pressurized water through the nozzle. A battery-powered oscillator circuit and a water flow powered sound generator produce futuristic space ray gun sound effects when the gun is shooting.

9 Claims, 7 Drawing Figures

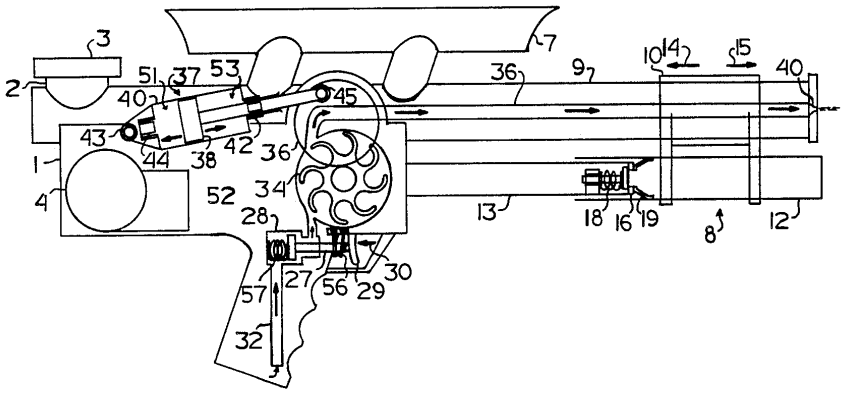


Figure A2: Example of a granted patent

10.2 Match Appendix

In order to match our patent data to the UC-CCP, we undergo an anonymized "hashed merge" process. The patent data were systematically linked to the CCP records by employing a standardized name-matching process similar to that of Bell et al. (2019b). Initially, all names were converted to lowercase and assigned a match priority of 1. Any subsequent modifications to a name resulted in the creation of a new observation, with the match priority incremented by one. Excessive spaces within names were identified and removed. Furthermore, all non-Latin alphabet characters and punctuation marks were eliminated. Extraneous information, such as "(Deceased)", "(Owner)", "(Esq)", "(Real Party in Interest)", "(patentee/owner)", and "(3rd Party Rq.)", was also removed. Honorifics were stripped from names, specifically if "PhD", "JD", "MBA", or "PE" appeared at the end of a name. In cases where nicknames were indicated by parentheses or "aka", the nickname was initially used to replace the given first name; subsequently, these nicknames were removed. Suffixes, which occasionally appeared at the end of first, middle, or last name fields, were extracted if they included "JR", "SR", "1st" through "5th", or numerals I-V, and were stored separately from the name. The sequence of these edits, while not necessarily aligned with the "match priority" variable if each round did not yield an edit, was as follows: names were converted to lowercase, spaces were removed, punctuation was eliminated, extraneous information was discarded, honorifics were stripped, nicknames were processed, and suffixes were extracted and stored separately. For city and state data, all entries were converted to lowercase. Additionally, it was ensured that the entries were within the United States or that the inventor region code corresponded to one of the 51 states plus the District of Columbia.