Dispensing Education: PharmD and Supply Side Responses in Higher Education

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Abstract

In 2000, the entry-level degree to become a pharmacist increased from an undergraduate degree to a graduate degree, raising the cost of entry into the profession. Despite higher costs, the number of new pharmacists nearly doubled over the following 15 years. This enrollment expansion is consistent with the underexplored quantity predictions of the Bennett hypothesis: the degree change increased students' borrowing capacity and relaxed borrowing constraints. We show that universities responded to this demand shock by opening new pharmacy schools and directing the new revenue toward investments in "quality," with no evidence of increasing undergraduate enrollment. These spending patterns are consistent with universities behaving as firms that adjust output and input quality in response to revenue opportunities created by expanded access to student loans. Finally, we document that the resulting growth in pharmacy education depressed pharmacist wages and, by some measures, reduced the quality of pharmacy graduates. This stands in stark contrast to the typical effects of increasing licensing costs.

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1 Introduction

In 2000, the entry-level degree requirement to become a pharmacist shifted from a five-year undergraduate Bachelor of Science in Pharmacy (BSPharm) to a six-year graduate degree, the Doctor of Pharmacy (PharmD), effectively raising the costs to become a pharmacist. Licensing requirements have long been seen as a barrier to entry that restricts supply and keeps wages high (Friedman and Kuznets, 1945). However, in this case, the number of new pharmacy school graduates not only did not shrink–it almost doubled between 2000 and 2015.[1]

In this paper, we analyze the consequences of the transition to the PharmD degree. We argue that pharmacy programs exploded in popularity shortly after expanding training requirements because the switch to the PharmD degree increased access to student loans and this in turn increased demand for pharmacy education. The high profit margins of these programs induced institutions of higher education to increase pharmacy education on the extensive and intensive margins. When schools opened new programs, they made additional investments in university quality rather than increasing undergraduate enrollment or reducing the price undergraduates paid. Eventually, growth in the supply of pharmacists affected the labor market, reducing wages and, by some measures, graduate quality.

Studying pharmacy education has intrinsic value as healthcare jobs have become the largest industry by employment (Gottlieb et al., 2025), but in addition, the episode we analyze also sheds light on several open questions in the economics of education. First, it contributes to the literature on how educational institutions respond to financial aid. Existing work has largely focused on the Bennett Hypothesis—that institutions raise prices in response to student aid (Singell Jr and Stone, 2007; Cellini and Goldin, 2014; Lucca et al., 2019; Baird et al., 2022; Black et al., 2023b). More generally, models of subsidy incidence predict adjustments along both price and quantity margins, yet empirical work has paid relatively little attention to quantity responses. Our setting shows that enrollment expansions can be substantial and that ignoring this margin can lead to misleading welfare conclusions.[2] Second, this episode provides a unique window into university objectives and operations. The introduction of PharmD programs generated large increases in revenue and profits, allowing us to study how institutions allocate resources. We ask whether universities expand enrollment, reduce undergraduate prices, or invest in quality through increased research activity or smaller class sizes. We find that profits are primarily reinvested in quality, consistent with predictions from the education economics literature (Bowen, 1980; Ehrenberg, 2000).[3] Finally, we contribute to the literature on how policy changes can lead to unintended consequences (e.g. Jacob and Levitt, 2003; Cellini and Goldin, 2014; Busso et al., 2024; Figlio and Ozek, 2024). Typically, raising licensing requirements restricts supply, increases wages, and ensures a minimum quality level (Acevado et al., 2024; Kleiner and Xu, 2025). In our setting, raising licensing requirements

[1] Authors' calculation based on data from the American Association of Colleges of Pharmacy.

[2] Related work has examined non-financial demand shocks, typically driven by labor market conditions (Gilpin et al., 2015; Conzelmann et al., 2023; Light, 2024), and finds universities to be relatively elastic along this margin.

[3] Related work has tried to understand university costs and response to student demand Jacob et al. (2018); Hemelt et al. (2021)

interacted with existing policies that provide much larger loans for graduate programs. This ultimately led to an expansion of supply, lower wages, and by some measures, worse graduate quality.

We start with facts about the growth in pharmacy education. The number of students pursuing a pharmacy degree increased sharply starting in the early 2000s. At the same time, the number of schools offering pharmacy programs grew substantially. Both existing and new schools contributed to increasing enrollment, but new schools represented the bulk of the increased enrollment. The newly opened schools were typically small, private, and non-profit.

We argue that student loan availability was a key driver of this expansion. In the final decade that both the BSPharm and PharmD degrees were offered, the rules for student loans allowed PharmD (graduate) students to borrow at least three times the amount that BSPharm (undergraduate) students could borrow. This was true overall and on a per-year basis, and has continued to be the case into the present. Mechanically then, the transition to the PharmD increased the amount that pharmacy students could potentially borrow and prior work has shown that increased borrowing limits increase actual borrowing (Denning, 2019; Denning and Jones, 2021; Black et al., 2023a; Black & al., 2023b). Using data from the National Pharmacist Workforce Study (NPWS), we document that among pharmacy students graduating in the years leading up to the PharmD transition, PharmD students had more student loan debt than BSPharm students. While student debt for both types of degrees was rising in that time period, debt for BSPharm students leveled off in the early 2000s (as the final BSPharm cohorts graduated) while PharmD borrowing continued to increase. Recent cohorts of pharmacy school graduates average $141,078 in federal debt, well beyond the federal undergraduate lifetime limit of $31,000.

We also present evidence that other factors were not driving the majority of the increase in demand for pharmacy education. Pharmacist jobs could have been increasing in attractiveness at the same time as the transition to PharmD. To test this we ask whether improvements in pharmacists' earnings and non-earnings amenities could explain the increasing demand for PharmD degrees. For non-earnings amenities, we use a question from the 2000 and 2014 NPWS that asks pharmacists if they would prefer to change careers if the other career provided the same income. In 2014, pharmacists were no less likely to answer that they would change careers than they were in 2000. This suggests that non-earnings amenities were not very different between 2000 and 2014 and so were unlikely to be driving growth in the demand for pharmacy. We use a simple model to show that changes in earnings are not likely to be the primary explanation. Our best estimate is that changes in pharmacists' labor market earnings can account for only one-fifth of the increased demand for pharmacy education.

An increase in demand does not guarantee an increase in available spots at pharmacy schools. We document that PharmD programs were very valuable with high profit margins. Fifty-seven percent of private schools state that they are unambiguously profitable and return profits to the broader university. The schools that opened programs in the wake of the change tended to be smaller, non-profit institutions. For non-profit schools, the sector overall had revenues 172 percent as large as expenditures–an impressive profit margin. So, as students experienced a shock to how

much they could borrow, universities responded by opening lucrative programs.

This expansion represents a unique opportunity to test ideas about how universities operate. Universities can be thought of as complex firms, with many inputs and outputs. For example, a "profit" in one area of a university may lead to spending or investment in a different part of the university. In an influential book, Howard Bowen set out a "revenue theory of cost" or "Bowen's law" (Bowen, 1980). In this framework, a university's dominant goals are excellence and prestige and there are many things that universities could spend money on to further educational goals. Universities raise as much money as possible and spend all of their money. Bowen proposed this framework to explain why the price of education kept climbing, but it yields testable predictions for how universities respond to opportunities for additional revenue.[4] This is hardly the only characterization of universities' objective function, but we argue that our results are consistent with this model of university functioning.

We use data from universities to document how university finances changed after opening profitable PharmD programs. We use a difference-in-differences set up where we compare universities that started new PharmD programs to similar universities that did not open a PharmD program, over time. We find that while graduate enrollment increased, we do not find meaningful effects on undergraduate enrollment or tuition.

Our estimates indicate that schools' total revenues increased by 12 percent. These additional revenues appear to have been spent across several categories including the number of faculty, faculty salaries, benefits, research, and institutional support. We see little evidence of changes in academic support or student services. In short, we find that schools that opened these PharmD programs used it to invest in "quality" rather than expanding enrollment.

These findings could be consistent with the mechanical effects of an institution opening a new school. To provide evidence on whether these increases reflect changes only in the pharmacy school or for the institution more broadly, we gather data on the number of faculty at new pharmacy schools from shortly after they opened. We show that our estimated increase in the number of faculty at the institution is considerably larger than the number of faculty employed by the pharmacy school, indicating that universities used money from the PharmD programs to hire faculty outside of the pharmacy school.

Given the expansion of pharmacy programs and students graduating with pharmacy degrees, the increase in demand for pharmacy education due to greater financial aid likely affected not only higher education, but also the downstream market for pharmacists. Aggregate data show that real earnings for pharmacists had been rising since at least the 1970s and continued to do so through the 2000s. However, in 2010, pharmacists' real earnings stagnated and began to decline. This reversal was largely driven by falling real wages rather than reductions in hours worked. Using data from the Census and the American Community Survey (ACS) in a differences-in-differences framework, we explore how the opening of a new PharmD program affects hourly wages and hours worked.

[4]Other economists propose similar models of university functioning (Ehrenberg, 2000). Namely, they pursue those opportunities and spend the money on additional quality.

We find that in the ten years after a PharmD program opens, median hourly wages decreased by 5 percent. We do not find similar changes for non-pharmacists with at least a BA degree, suggesting that our results are not being driven by an underlying reduction in demand for skilled labor. For pharmacists, we do not find strong evidence that a new pharmacy program changes either the average number of hours worked per week or the fraction who are working full time.

While increasing licensing requirements is typically thought to increase the quality of services provided by licensed individuals (Friedman and Kuznets, 1945; Kleiner and Xu, 2025), it is less clear that this will be true in our setting. The typical argument is that licensing eliminates the left tail of the quality distribution. However, because we see an increase in the number of pharmacists, the marginal pharmacist might be of lower quality or less well trained. On the other hand, the influx of new pharmacists could increase service quality by increasing available time per task for the pharmacist. We provide suggestive evidence on how quality changes in response to the switch to the PharmD degree. We show that admission rates to pharmacy school are much higher now than they were prior to the switch to PharmD and that pass rates on the licensing examination have fallen. For cohorts accepted into PharmD programs between 2004 and 2015, acceptance rates rose by 150 percent, but pass rates on the licensing exam fell and tended to be lower at the new PharmD programs. Despite the increase in the number of new pharmacists, data from the NPWS indicate that, if anything, pharmacists' workloads have increased between 2004 and 2014. Overall, we do not find evidence that quality of pharmacy services rose. If anything, there is suggestive evidence that pharmacy graduates' quality has fallen.

Other work in economics has used the pharmacy profession to shed light on broader labor market trends. In particular, Goldin and Katz (2016) highlight features of the occupation—most notably its standardized hours and limited returns to long workweeks—that help explain its unusually small gender pay gap. This insight has been highly influential in shaping subsequent work on gender differences in earnings and the organization of work (Goldin, 2014, 2024). While the hours structure of pharmacy is not central to our analysis, we examine wage effects separately by gender and do not find substantial differential impacts along this margin. More broadly, this literature demonstrates that pharmacy is a valuable laboratory for studying questions of general economic interest.

The rest of the paper proceeds as follows. In section 2 we describe some facts about the transition to PharmD and the growth in Pharmacy education. In section 3 we discuss the reasons for this growth. Section 4 focuses on the effects of the growth on universities. Section 5 discusses the effects on wages. Section 6 concludes

2 Background and Facts

Transition to PharmD

Our summary of the history of pharmacists' education and practice relies heavily on Urick and Meggs (2019). Prior to 2000, students could become practicing pharmacists either by having a

PharmD or a BSPharm. A BSPharm was typically a 5-year program with two years of science education and three years of pharmacy-focused coursework. At the same time, some schools offered a PharmD, which typically took 6 years.[5] The additional year of training focused on patient care and clinical skills (Kreling et al., 2010).

In 1946, the Pharmaceutical Survey was commissioned by the American Council on Education and recommended that six years of instruction be required for pharmacists. This was debated frequently after that point. In 1984, the American Pharmaceutical Association advocated for the PharmD to be the standard degree for pharmacists. Making a PharmD the standard degree was voted on by American Association of College of Pharmacy House of Delegates in 1985 where it was defeated in a close vote. In 1989, the Accreditation Council for Pharmaceutical Education declared their intent for the PharmD to be the standard degree by 2000. In 1997, the American Council for Pharmacy Education adopted a new standard requiring a PharmD by 2000 and by 2005, BSPharms were phased out (Urick and Meggs, 2019; Kreling et al., 2010)

The decision was controversial with people weighing in on both sides. McLeod (1992) lists the author's view of the costs and benefits of such a move. Proponents emphasized that five years of training was not sufficient to train students with all the necessary skills, and that the additional year would allow pharmacists to develop clinical and therapeutic skills. There was also a desire to raise the status of the profession and to more closely align with physician's training. Those opposed were worried about additional costs to students or that the skills were not necessary in many roles that pharmacists took in the labor market.

Interestingly, the CEO of the National Association of Chain Drug Stores argued against the transition claiming that the marketplace was working and that eliminating the BSPharm would potentially raise health care costs. He also suggested the transition was anti-competitive because it removed an option (BSPharm) that was producing many prepared graduates (National Association of Chain Drug Stores, 1998). We searched the quarterly earnings calls for CVS, Walgreens, and Rite Aid for mentions of the transition from BSPharm, but did not find any mentions. However we only have access to earnings calls from 2006 and later, after the transition had happened.[6]

Growth in Pharmacy Schools

We document several facts about the growth in pharmacy education over time. First, the number of pharmacy degrees conferred increased markedly beginning around 2000. Second, this was driven primarily by the opening of PharmD programs at schools where there previously was not a BSPharm program. Last, the new pharmacy schools were disproportionately opened in private, non-profit universities.

Using accreditation data we collected from the Accreditation Council for Pharmacy Educa-

[5] A BSPharm typically had two years of prerequisites with 3 years of pharmacy instruction. A six year program typically consists of 4 years of pharmacy instruction with two years of prerequisites in sciences. The two year prerequisites are often done as part of a bachelor's degree.

[6] Specifically we used a keyword search for "PharmD", "BSPharm", "education", "pharmacists", "shortage", and "staff."

tion (ACPE), Figure 1a shows the total number of pharmacy schools (with either a BSPharm or PharmD) available over time.[7] The number of schools grew between the 1940s and 1960s before plateauing for roughly 30 years. However, after a slight bump up in the early 1990s, the number of pharmacy schools grew rapidly from the 2000s to the present. In 1999, there were 75 accredited pharmacy programs in the United States. By 2023, the number had nearly doubled to 145.

Because pharmacy schools could only enroll PharmD students after 2000, the huge growth in pharmacy schools in the 2000s must be due to the growth in PharmD rather than BSPharm programs. To see this directly, Figure 1b shows the cumulative number of new PharmD programs. We only display PharmD programs that were not at schools that previously had a BSPharm program to focus on the expansion of pharmacy programs rather than the conversions of existing BSPharm programs to PharmD. As seen in the figure, there were very few PharmD programs at schools that had not had a BSPharm until the year 2000. By 2023, 71 new PharmD programs had opened.

The near doubling of PharmD programs represents a large change to the pharmacy education market and so begs the question of how social welfare in this market has been affected. We explore this question in Appendix B and briefly summarize our conclusions here. We assume that schools choose to create a new PharmD program if it will not lose money in the long-run, that PharmD programs have pricing power, and that there are no barriers to entry aside from a potentially large fixed cost. Then, using data we discuss later in this paper, we estimate that a PharmD program with the average profits and the average price (tuition+fees) and enrollments of programs that entered in 2000 or later generates approximately $7.6 million of social welfare per year despite higher prices and debt for students.

Of course, the simple approach we take in the appendix is somewhat limited. If we were to adopt additional structure, there are a number of interesting questions that could be addressed. However, that is beyond the scope of the current paper.

Growth in Pharmacy Enrollments

Growth in the number of schools does not automatically imply that the number of PharmD students rose because the new schools could simply have taken students away from the existing programs. However, as seen in the blue line in Figure A4, this was not the case.[8] The number of students enrolled in either a BSPharm or a PharmD grew from approximately 34,000 in the year 2000 to more than 57,000 by 2020.

This expansion reflects two areas of growth: 1) students enrolling in new schools that had not

[7] New Pharmacy programs are accredited by the ACPE. The ACPE lays out the process for a new PharmD program in detail on its website. Applicants must have legal authority to grant PhDs, propose curriculum, have a financial plan, etc. The ACPE then grants a school precandidate status which progresses to candidate status if certain milestones are met. Importantly, the ACPE focuses on ensuring quality of instruction rather than restricting the number of pharmacists in the market. See Appendix C for more detail on the stance of the accrediting body on expansion. Table A4 provides a full list of all the schools that opened.

[8] Authors' calculation using data from the American Association of Colleges of Pharmacy's (AACP) and the ACPE's websites. The data are available from the year 1990 forward. See
https://public.tableau.com/app/profile/aacpdata/viz/FirstProfessionalPharm˙D˙andGraduateEnrollmentTrends/Final

previously offered a BSPharm degree and 2) the expansion of schools that had previously offered a BSPharm degree. The red line in Figure A4 shows that in new schools (those that had not offered a BSPharm degree), the number of students enrolled grew to more than 20,000 in the late 2010s before shrinking somewhat after that. The increases in new schools accounts for 73 percent of the overall enrollment growth. The remainder is, by construction, due to schools that previously had offered a BSPharm degree. Those schools expanded enrollment by roughly 6,200 students over this time period.

Figure 2 digs deeper into the enrollment growth, splitting the trends by not only whether the school was new, but also by the type of school: Public, Private Non-Profit, or Private For-Profit. The figure on the left plots total enrollments while the figure on the right plots enrollments per school. As seen in Figure 2a, among existing schools, both public and private schools expanded their enrollment between 2000 and the early 2010s, but then enrollments began to drop off for the existing private non-profit schools. Among the new schools, private non-profits account for the majority of the growth. In Figure 2b, we can see that for the new public and for-profit schools, there was some growth from 2000 to 2015, but not nearly so much as occurred in existing public and non-profit schools. This means that the overall growth in enrollment in the new non-profit and public schools was primarily due to the increase in the number of schools rather than an increase in the size of schools after they were created.

3 Why Did the number of Pharmacists Grow?

Why did this large growth in pharmacy education happen? We discuss several potential explanations including excess demand for seats in pharmacy schools, an accreditation environment that did not restrict expansion, and high profit margins for pharmacy programs. Labor market conditions for pharmacists may also have contributed, although calibrations of a simple model suggest that rising pharmacist wages explain less than one-third of the rapid growth.

Until recently, there was a considerable amount of excess demand for pharmacy education. For example, for the 2003-2004 cohort, approximately 34 percent of applicants were admitted to a pharmacy school (American Association of Colleges of Pharmacy, 2024). This estimate comes from the Pharmacy College Application Service (PharmCAS), a centralized service for Pharmacy school admissions. PharmCAS began in 2003-2004 with 43 of the existing 89 pharmacy schools participating.[9] This suggests that there was sufficient demand for schools to expand the sizes of their incoming classes or new schools could have opened had they wanted to do so. Recent work (Blair and Smetters, 2021) suggests that selective schools face a tradeoff from expanding: although they gain larger revenues, they lose prestige and their costs rise. Intuitively, for a school to expand or to be created, the amount of revenue gained has to be large enough to justify the increased costs and also the cost to prestige. Models of this type would predict that non-elite colleges would

[9]Unfortunately, we have not found data on the fraction of applicants admitted to schools that do not use the PharmCAS. However, we can create a rough upper bound by assuming that all of those schools admitted one hundred percent of applicants. In that case, the acceptance rate would be no more than 68 percent.

expand enrollment the most in response to excess demand.

3.1 Accreditation Environment

The accreditation environment that schools operate in is crucially important for understanding how firms (universities) respond. In short, over this time period the attitude of the accrediting body in Pharmacy was not to restrict supply by limiting the creation of new programs. Instead, they were interested in maintaining standards of instructional quality. We discuss this environment in more detail in Appendix C

3.2 PharmD Program Profitability

We argue that pharmacy programs were likely to open over this time period because they were very "profitable." We use a survey from the American Association of Colleges of Pharmacy (AACP)'s office of Institutional Research and Effectiveness. The AACP conducts a yearly survey of Pharmacy schools finances, starting in 2011-12, and publishes aggregate information about revenue, costs, and answers to some survey questions.

One question from this survey indicates that the pharmacy school is "profitable", that is, that the program returns money to the university. If pharmacy school chooses the answer, "Totally self-reliant on funds I generate but a portion of which are returned/given back to (or taxed by) the campus/university", we classify the pharmacy program as being being profitable. The answers to this question are reported separately by private and public schools and so we discuss these separately.

In 2011-12, 50% of the 30 private schools that participated in the survey stated that they were profitable while only 3.3% indicated that they received a subsidy from the University, specifically answering "Reliant on funds I generate combined with a state (or private university) supplemental allocation all of which I keep." The other possible responses do not allow us to differentiate between programs that are profitable versus those that are subsidized, for example by answering that they both receive money from the campus but that they also return funds.[10] By 2021 there are 64 private schools responding to this survey and 57% say they are profitable. Over that time period there were 34 more schools that reported, and the increase in the number of profitable schools was 22.

We conclude that most private pharmacy schools are unambiguously "profitable." The survey further reports the total income and revenues as well as expenditures across the sector. In 2012-13, private institutions' income and revenues are 72 percent higher than expenditures. At the school level, the median income and revenues less expenses was $4.7 million. In short, private pharmacy programs are quite profitable. The single biggest source of revenue is college tuition and fees which in aggregate was 67 percent of income and revenue.

[10]The other options are "Totally self-reliant on the funds which I am able to generate and all of which I keep", "Reliant on funds I generate combined with a state (or private university) supplemental allocation some of which is returned/given to (or taxed by) the campus/university", or "Other".

In contrast, public universities are less likely to answer that they are unambiguously profit centers, with only 11.3 percent saying so in 2021. The most common answer is ambiguous, "Reliant on funds I generate combined with a state (or private university) supplemental allocation some of which is returned/given to (or taxed by) the campus/university" and is relatively stable over time. There is an increase in the number of schools reporting that they are "Totally self-reliant on the funds which I am able to generate and all of which I keep" from 0 to 3 over this time period. However, in aggregate public schools have income and revenues that is 34 percent higher than expenditures and at the school level, median revenue less expenses was $4.7 million.

It appears that public and private non-profit pharmacy schools have very different financial models. Public pharmacy schools tend to be subsidized by the university or state and rely on research to fund their school.[11] Private pharmacy programs rely much more heavily on tuition. Hence, if the growth in pharmacy schools after the move to PharmD is driven by an increased ability to generate revenue from tuition, we would expect most of the entrants to be private schools.

3.3 PharmD or a Reaction to the Labor Market?

Prior to the expansion of pharmacy schools and enrollments, pharmacists had projected that there would be labor shortages in the 1990s and 2000s due to an aging population and increased prescription use (Vlasses, 2019). Given the profitability of many pharmacy schools, there is a clear incentive for educational institutions to consider opening a new school. On the other side of the market, in addition to the factors just discussed, there could have been increasing demand for pharmacy education because of what was happening in the labor market for pharmacists. Figure 3 shows data on the number of full-time pharmacists and their median hourly wage (in year 2020 dollars) from 1980 through 2019.[12] Real, median hourly wages were rising steadily from 1980 through 2000 at the same time that the number of pharmacists was growing. This suggests that demand for pharmacists was rising during this time period by enough to offset the increased supply. Since human capital investments are in part determined by people's expectations about the current and future returns on those investments (Becker, 1964; Zafar, 2011; Arcidiacono et al., 2012), rising pharmacist wages in the 1980s, 1990s, and 2000s could have contributed to an increase in demand for pharmacy education and could have played some role in the expansion of pharmacy education.

In conjunction with data on the number of enrollees in and tuition for pharmacy school, we use a simple model to provide some insight into the importance of rising demand for pharmacy education even in the absence of the switch to PharmD. The idea of the model can be seen in Figure

[11] The primary sources of revenue for public pharmacy programs are research revenue (23.6 percent of total revenue) and state or campus allocations (22.4 percent). Tuition only represents 14 percent of total revenue.

[12] We follow Goldin and Katz (2016) and consider a pharmacist to be full time if they usually worked at least 30 hours per week. We use data from three sources, the decennial censuses (1980, 1990, and 2000), the Annual Social and Economic Supplement (ASEC) from the Current Population Survey (1981-1989 and 1991-1999), and the American Community Survey (ACS) (2001-2019). The estimates from the ASEC are much noisier because the sample sizes are only 15 percent of the sample sizes from the ACS. The small sample sizes in the ASEC do not allow us to make reliable estimates of the number of pharmacists in the US. We focus on the median rather than the mean to minimize well-known issues related to the topcoding of income in these data sources.

4 which shows the market for pharmacy enrollments. For the year 2000, we can observe tuition and fees (the price of pharmacy school) and the number of students enrolled (the quantity); this equilibrium is point A, at the intersection of the year 2000 supply and demand curves, $S_{'00}$ and $D_{'00}$ respectively. Similarly, we have an analogous point, C, for the year 2010. C incorporates the impacts of both: 1) the switch to PharmD and 2) any increases in demand for pharmacy education for other reasons, including rising wages of pharmacists.

In the ideal world, we would observe $\tilde{D}_{'10}$, the hypothetical demand curve that does not incorporate the impacts of the switch to PharmD, and as a consequence, point B, the resulting equilibrium between $\tilde{D}_{'10}$ and the supply curve for 2010. Although we can not observe $\tilde{D}_{'10}$, we can estimate it. To do so, we use the idea that in the past, wage growth for pharmacists impacted demand for pharmacy education. Of course, many things aside from wage growth affect demand for human capital. Our approach will capture the impacts of anything that is correlated with wage growth, not just wage growth itself. To ease exposition, we will simply refer to this bundle of factors as wage growth, but we acknowledge that it will capture a number of important contributors to demand for pharmacy education. If the relationship between pharmacists' wage growth and demand for pharmacy education is stable over time, then we can use that to construct $\tilde{D}_{'10}$. This is consistent with work that suggests the monetary returns to education are a contributor to demand for education, but that students do not have full information about the current and future earnings from educational investments in general. We assume that pharmacists' wage growth in one decade affects the demand for pharmacy education in the following decade and that the relationship between past wage growth and current education demand is stable over time. In our model, this means that the impacts of wage growth between 1980 and 1990 on growth in demand for pharmacy education between 1990 and 2000 is the same basic relationship that exists for the impacts of pharmacists' wage growth between 1990 and 2000 on demand for pharmacy education between 2000 and 2010. With that, we calculate point B and from there, the fraction of the observed change from 2000 to 2010 that can be accounted for by rising pharmacists' wages: $(enrollees_B - enrollees_A)/(enrollees_C - enrollees_A)$.

The final assumptions needed to estimate the model are 1) a functional form for the supply and demand curves and 2) an elasticity of demand for pharmacy education. We could assume an elasticity of supply, but instead we will leverage the fact that the supply of pharmacy schools was approximately constant between 1990 and 1995.[13] This allows us to treat the differences in the 1990 and 1995 equilibria as movements along a supply curve, pinning down the elasticity of supply. Regarding functional form, we let the supply and demand curves for pharmacy school enrollments both have a constant elasticity. We are not aware of an estimate of the elasticity of demand for pharmacy school. Instead, our baseline elasticity of demand comes from Denning (2017) which estimates the elasticity for community college, though we test the sensitivity of our results to the particular elasticity chosen.

[13] While there were a few schools that opened up during this time period, they would not have graduated cohorts until the late 1990s.

With this setup, we estimate that rising pharmacist wages, and all factors associated with those increased wages, can account for approximately 21 percent of the observed increase in enrollments between 2000 and 2010. In Appendix D, we provide additional details of this exercise and assess the sensitivity of our results to our assumptions by changing the functional form of our demand and supply functions, varying the price elasticity of enrollment, and indexing wage growth over time in alternative ways. Our results are fairly robust to the range of assumptions we explore, and they suggest that rising pharmacist wages are unlikely to be driving the majority of the increase in demand after 2000: There is a lot of room for the transition to PharmD to have played a key role in rising demand for pharmacy education.

In addition to changes in demand due to rising pharmacist wages, it may be that that the non-monetary returns to becoming a pharmacist have been increasing with the transition to PharmD. Non-wage considerations have been highlighted as an important feature of the pharmacy occupation in Goldin and Katz (2016). To the extent that non-monetary returns are correlated with pharmacists' wage growth, our previous analysis would have picked it up. However, we can directly gauge whether this channel is playing a large role in the market for pharmacy school enrollments. We take advantage of a question posed in the National Pharmacist Workforce Study surveys. This is a series of surveys commissioned by several pharmacist associations to better understand the labor market for pharmacists.[14] The survey is designed to measure the pharmacist workforce in the United States and is nationally representative. Respondents are asked many questions about their experience in school and the labor market. The particular question of use here is "Please use the scale below to report your thoughts about pharmacy as a profession. ...If I could go into a different profession other than pharmacy which paid the same, I would probably do so" (Midwest Pharmacy Workforce Research Consortium, 2000; Gaither et al., 2014). Respondents choose a value from one through five where 1 = strongly disagree and 5 = strongly agree. We have data on this question in both 2000 and 2014. We run simple regressions of the form

$$y_{it} = \beta_0 + \beta_1(Year_t = 2014) + X_{it}\Gamma + \varepsilon_{it}$$

where y_{it} is the response to the question, $Year_t = 1$ is an indicator for whether the observation is from the 2014 survey year, X_{it} contains linear and quadratic controls for the pharmacist's age, an indicator for gender, and a set of dummy variables for the year the pharmacist was first licensed. We estimate the equation using the full five-point scale as the dependent variable as well as a binary indicator for whether the respondent agreed at all with the statement (i.e. the respondent chose either four or five).

Table 1 reports the regression results. The point estimate in the first column indicates that relative to 2000, in 2014, pharmacists agreed slightly more that they would choose to work in a different profession if it offered equal pay. The second column uses the binary version of the dependent variable and again suggests that if anything, pharmacists were more likely to want to

[14]There are several waves of the survey, 2004, 2009, 2014, and 2019, though many of the survey's questions changed over time or were only available in a few years. Notably, this data was used in Goldin and Katz (2016)

switch away to another profession. While the point estimates in the first two columns are positive, they are not statistically distinguishable from zero.

In columns (3) and (4), we repeat the regressions presented in columns (1) and (2) but we include a control for whether the respondent has a PharmD degree. It is not obvious whether this should be included as a control variable. Prior to the mandatory switch to the PharmD, students chose whether to receive a BSPharm or a PharmD. That selection almost certainly changed over time as the PharmD became mandatory. Because of that, comparing people within the PharmD category is potentially problematic. However, as seen in columns (3) and (4), including a control for the respondent's pharmacy degree has little material impact on the estimated coefficients. This again suggests that the non-monetary benefits of a pharmacist job are not increasing substantially between 2000 and 2014.

3.4 Did transition to PharmD increase Student Loans?

We argue that the transition to PharmD increased the use of student loans for pharmacy school. We make this argument from several angles. First, and most importantly, federal student loan rules meant that the transition dramatically increased maximum borrowing limits. After the transition, borrowers could borrow more in a single year of PharmD education than they could over the lifetime of a BSPharm education. Second, we confirm empirically that 1) students pursuing a PharmD borrowed more for school when both options were available and 2) that after the transition to PharmD, borrowing markedly increased.

Federal Student Loan Policy for Pharmacists

We will focus on federal student loan policy because non-federal borrowing comprises a minority of total borrowing (about 20 percent of total borrowing in 2004-05) (Ma et al., 2025) and typically offered worse terms (Consumer Financial Protection Bureau, 2012). In order to access federal loans from the U.S. Department of Education, a student must file the Free Application for Federal Student Aid (FAFSA).[15] We provide a succinct discussion of relevant federal student loan policy drawing on (Hegji, 2021; U.S. Department of Education, 2025) as references. We will focus on the Stafford Loan program, administered by the department of education, which is the majority of federal borrowing, but there are other programs with lower borrowing volumes, some of which are discussed in subsequent footnotes. For Stafford loans, financial need does not affect the maximum borrowing amounts annually or cumulatively and so we will focus primarily on two policy parameters, federal annual borrowing limits and lifetime borrowing limits.[16]

From 1994 to 1998, PharmD students could borrow Stafford loans of at least $31,000 annually. A

[15] Because federal student loans generally offer better terms, students wishing to borrow above federal maxima typically would file a FAFSA due to the generally better terms than private student loans and then would have to seek out via another source private student loans.

[16] Financial need can affect the terms of the loans in some cases. These two parameters, most succinctly capture the differences in available credit but other features also differ; for example the amount that can be borrowed in a particular year (say the second year of enrollment), interest rates, etc.

dependent (traditional) BSPharm student could borrow a maximum of $5,500 in their third or later year using the Stafford loan program.[17] PharmD students could borrow Stafford loans from the Department of Education up to a lifetime maximum of $189,125. Dependent BSPharm students could borrow up to a Stafford lifetime maximum of $23,000. In summary, for dependent students, annual borrowing maximums increased from $5,500 to $31,000 annually and from $23,000 to $189,125 over a lifetime when pharmacy students transitioned from the undergraduate BSPharm to the graduate PharmD degree. The details are different for needy and independent (nontraditional) students, but in all cases the transition to a PharmD dramatically increased both annual and lifetime federal borrowing limits.

From 1998 to 2005, the policy of much much higher borrowing limits for PharmD students was largely unchanged as schools began transitioning to PharmDs. In 2006, the Grad PLUS program was created which essentially uncapped borrowing for graduate programs.[18] This allowed pharmacy students to borrow even more–up to the Cost of Attendance (roughly tuition and fees plus living expenses) with no lifetime cap. So the gap between borrowing limits for PharmDs and (at this point hypothetical) BSPharms opened even wider.

Students not only were eligible for more loans in a PharmD program, they actually borrowed more. The median debt for graduates of pharmacy programs included in the College Scorecard is $141,078. The lifetime maximum for independent undergraduates in 2024 was $57,500 and 93 percent of pharmacy programs have graduates with median debt larger than this amount (Hegji, 2021).[19] In fact, in 2016, the median annual federal borrowing among federal borrowers for a professional pharmacy degree was $35,777–greater than the lifetime maximum for dependent undergraduate students at the same time Libassi et al. (2025).

We provide additional evidence that the transition to PharmD increased borrowing from the NPWS. The NPWS surveys allow us to see how closely related highest degree and debt are within a year. Figure 5 shows that average debt for PharmDs is higher than BSPharms when they are licensed in the same year. Average debt is increasing from 1991 to 1999 for BSPharm recipients, but the increase in debt for PharmDs is increasing by approximately the same amount. From 1999 to 2005 the debt for BSPharm is decreasing slightly or flat. This is notable for a few reasons. First, this is around the federal maximum a student could borrow for a BSPharm. Notably, the average debt is below the maximum allowable for dependent undergraduate borrowers in this time period, while PharmDs are borrowing more than dependent undergraduates could borrow. We also plot

[17] Needy students could also borrow using the Health Education Assistance Loan (HEAL) program which was administered by the Department of Health and Human Services rather than the Department of Education. HEAL loans were for students that met need-based requirements (U.S. Department of Education, 2025). In general, the increase in borrowing capacity form the HEAL program applied to both PharmD and BSPharm students and so we do not focus on it in the discussion. The maximum they could borrow in HEAL Loans is $12,500 annually in the years after the students' third year. In 1998, the HEAL program was phased out and so BSPharm students could borrow the HEAL amounts as part of the Stafford program, increasing loan limits for Stafford students. At this point, many programs were transitioning to the PharmD and all programs transitioned by 2001.

[18] See Black ⊕ al. (2023b) for a discussion.

[19] Authors calculations from the Oct 10, 2024 College Scorecard data. This covers the 2018-19 and 2019-2020 cohorts. This debt is only reported for graduates and only includes debt accumulated at the Pharmacy program.

data from the Baccalaureate and Beyond surveys from the National Center for Education Statistics. These surveys ask recent graduates several questions and importantly for our purposes, they ask about debt for undergraduate degrees. Debt for undergraduate degrees is increasing over this time frame, but at a pace far below that experienced by PharmD graduates. This suggests that absent a change to PharmD, student debt would not have seen such dramatic growth.

We show that as PharmDs became more prevalent, student debt increased substantially. Using the surveys from the NPWS, Figure 6 shows that the average debt and fraction of PharmDs (relative to BSPharms) are highly correlated. By 2001, the average debt for newly licensed pharmacists had increased to $47,469–above the maximum that a dependent undergraduate student can borrow.

In sum, we provide policy evidence that the amount of debt that students take out today to pursue a PharmD would not have been possible had the program not shifted from a BSPharm to PharmD. Bolstering this interpretation is the divergence of debt between PharmDs and undergraduate students as well as the tight time series correlation between student debt and the fraction of pharmacists licensed in a given year that are PharmDs.

So far we have discussed federal borrowing policy reasons that the transition to PharmD increased borrowing. However, there are other reasons that this may have occurred. The transition to requiring a PharmD did not only increase access to higher student loan limits, it also eliminated a cheaper pathway to becoming a pharmacist. PharmD programs no longer had to compete with cheaper, BSPharms which likely contributed to increasing debt after the elimination of BSPharm.

4 Effects on Institutions

We turn our attention to what universities did with the additional "profit" that they earned from pharmacy programs asking, "How does the marginal dollar of funding change universities' behavior?" This gives insight into what a university's objective function is. It also yields some insight into a policy relevant parameter, if universities are able to raise revenue–how will they spend it? Further, it's related to work on the Bennett Hypothesis which states that universities raise tuition in response to additional financial aid. However, that literature has typically not focused on how universities use the money they raise

To date, in higher education, we know very little about the supply side responses to new resources due to a lack of natural experiments. There are numerous ways institutions could use the increased funds. A few examples include cross-subsidizing undergraduates by increasing undergraduate enrollment, reducing tuition/increasing institutional aid, investing in measures of "quality" such as research or additional faculty, paying down debt, investing in infrastructure, and so on.

We provide evidence on these possibilities using a differences-in-differences approach. We use data from the Integrated Postsecondary Education Data System (IPEDS) which is a set of surveys that all colleges and universities that received federal financial aid are required to complete. IPEDS includes information on enrollment, financial aid disbursed, staffing, and spending in broad

categories.[20]

To fix ideas, consider the following two-way fixed effects specification

$$Y_{jt} = \beta_0 + \beta_1 PharmDOpen_{jt} + \gamma_j + \alpha_t + \varepsilon_{jt} \quad (1)$$

where $PharmDOpen_{jt}$ is an indicator for whether school j had opened a new PharmD program by year t, γ_j are university fixed effects, and α_t are cohort fixed effects. To avoid confusing a new PharmD program with a BSPharm converting to a PharmD program, we set $PharmDOpen_{jt} = 0$ for schools that had a BSPharm program prior to the switch to PharmD. We also require that new schools have IPEDS data for two years prior to opening their program. This results in 45 PharmD programs that we use for identifying variation.

Given the issues inherent in staggered timing differences-in-differences, we use the approach in Callaway and Sant'Anna (2021) to estimate the average treatment on the treated for these schools. In our preferred specification we use logged outcomes and weight the regressions by the size of total full-time enrollment in 1997, the year prior to when we define new PharmD program openings. We report the difference-in-differences coefficient based on the data from seven years before and after a PharmD program opens. Note that when we discuss our results, we will apply the standard transformation to the estimated coefficients to convert them to percent changes, $(e^{\hat{\beta}} - 1) * 100$. Additionally, we restrict the "control" schools to be those most similar to schools that opened PharmD programs during this period. We do this by restricting the sample to schools with graduate programs, we remove institutions that are primarily theological schools, and we require that institutions have an average of 500 students.[21] With the remaining schools, we use data from 1997 to predict whether a school opened a PharmD program using a logistic regression and institutional characteristics.[22] Last, we choose control schools as those that are in the 75th percentile or higher of predicted probability of opening a pharmacy school.

We first check to see how universities' overall financial situation changed. As seen in Table 2, we find that total revenue increased for these schools by a statistically significant 12 percent and assets increased by 7 percent ($p<.1$). We do not find statistically significant changes in liabilities. This can be thought of as a check on our earlier discussion about profitability. It appears that revenue increased as a result of starting a new PharmD program.

We next check whether there is evidence of a cross subsidy to undergraduates by considering enrollment and the price that undergraduates pay. These results are presented in Table 3 and corresponding event study plots appear in Figure A5. We estimate that the number of students enrolled

[20] There are several issues with the IPEDS data. We provide related details in Appendix E.

[21] We identify schools as primarily theological if any of the words theology, seminary, biblical, rabbinical, theological, ministry, talmudical, Buddhist, divinity, rabbi, yeshiva, bible, or Torah are in their title.

[22] Our predictors include indicators institutional affiliation, revenues, total expenditures, hospital expenditures, salary expenditures, benefit expenditures, academic support expenditures, student services expenditures, research expenditures, instruction expenditures, institutional grant expenditures, pell grant expenditures, state grant expenditures, full-time undergraduate enrollment, full-time graduate enrollment, full-time female enrollment, full-time non-white enrollment, average undergraduate and graduate tuition, and all indicators for missing variable imputation. The regressions are weighted by total full-time enrollment

increased by a statistically significant 19 percent. This was driven by graduate enrollment which grew by approximately 109 percent. We do not see large changes in undergraduate enrollment; our point estimate suggests a small, 2 percent, increase, though, we note that our standard errors are somewhat large.

Undergraduates might be cross-subsidized with lower prices. There are multiple ways to achieve this goal including lowering tuition and fees or increasing institutional grants. As seen in Table 3, we do not find strong evidence of either of these possibilities.[23] If anything, institutional grants appear to have fallen, though our standard errors are large enough that we can not rule out very large increases or decreases. The point estimates are not always precise, but they paint a consistent picture in which the increased revenue did not clearly lead to reductions in the price undergraduates paid for college.[24]

Having concluded that the additional revenue was likely not spent increasing undergraduate enrollment or reducing tuition, we next turn our attention to investments in "quality." This is what Bowen (1980), would predict revenues would be spent on. In Table 4, we see that total expenditures went up by 12 percent. Salaries and benefits went up by approximately 10 percent. Research salary increased markedly by almost 90 percent and institutional support spending increased by 20 percent.

We are also able to measure salaries in different categories (benefits, instruction, research, academic support, student services, and institutional support) and present the results in Table 5. Expenditures on instruction salaries grew by 9 percent and research salaries by 73 percent. Event study figures for these outcomes appear in Figure A6. These additional expenditures could be increases that are only accommodating the growth in pharmacy education and so we next turn to see if there was more faculty hiring than would be expected for a pharmacy program.

We present results for the number and rank of faculty in Table 6. We estimate that faculty increased by 21 percent which implies an increase of 99 faculty. Lecturers increase by a statistically significant 36 percent and Assistant Professors increase by 26 percent. Our estimates for Associate and Full Professors are smaller and not statistically significant. While we cannot measure which department hired these faculty, we know that the increase in faculty is estimated to be 99. We collected data from historical websites of all of the pharmacy schools that opened and the average number of faculty was 30.1.[25] Using the lower bound on the 95-percent confidence interval implied by our estimate, we can reject that total faculty grew by less than 62. Given that and the average number of faculty at the new PharmD programs, we can rule out that the increase in faculty was driven solely by Pharmacy faculty hiring. Rather, it appears that the additional revenue was used to hire non-Pharmacy faculty.

[23] Institutional grants are measured for first-time full-time undergraduate students. The grants were originally reported in IPEDS only for those who received them. We have scaled the estimates to be per first-time full-time undergraduate student.

[24] We also have measures of total grants, federal grants, state grants, and loans. As with institutional grants, our standard errors are very large. As a result, unfortunately, we are not able to learn much from those outcomes.

[25] We used the wayback machine to view new PharmD programs' webpages five years after they opened. We chose five years after opening because that gives new programs time to stabilize.

In summary, we see that revenue and expenditures increased. We do not see evidence of the new graduate program cross-subsidizing the number of undergraduates or the tuition they pay. However, we find increases in research and the number and salaries for faculty; broadly, these look like investments in school "quality." Interestingly, the increase in faculty went beyond those working directly in Pharmacy suggesting that the new PharmD programs cross-subsidized other parts of the universities.

5 Labor Market Impacts

The increase in new pharmacists, seen in Figure A4, is large enough that there could be impacts on market outcomes for new and existing pharmacists. In this section, we will explore how labor market outcomes have changed as a result of the influx of graduating pharmacists and provide suggestive evidence on whether quality fell as quantity increased.

How Have Wages and Hours Responded?

Figure 7 shows the simple time series of median earnings per hour, median wages per hour, and the number of new pharmacy school graduates by year since 2000. All dollar amounts have been converted to real 2020 dollars. We can see that through the 2000s, both earnings and the flow of new pharmacists were increasing steadily. However, starting around 2010, hourly earnings and hourly wages stopped rising and remained stagnant, or even declined, over the next ten years. It took another seven to eight years for the number of new pharmacy graduates to peak.

The coincident rise of hourly earnings and graduates suggests that demand for pharmacists' services was rising over this time period and, as a consequence, a simple regression of prices on quantities will suffer from the classical simultaneity issue. To reduce concerns about this and other omitted variables bias issues, we run a difference-in-differences analysis where the treatment is the opening of new pharmacy schools in a state. While progress, this approach is not perfect. Pharmacy schools could be opening in response to the increased demand for schools by students who can now borrow, but they could also be opening in part in response to the rising demand for pharmacists. However, to the degree this simultaneity issue still exists, it will bias our estimates up and make it less likely that we find any significant reductions in wages due to the larger supply of pharmacists.

We use data from the American Community Survey from 2001 through 2022 in conjunction with the 5 percent sample of the 2000 census.[26] We limit the sample to individuals who mark their occupation as pharmacist and use the accreditation data discussed in Section 2 to determine the first year that a new pharmacy program began graduating students in a given state during our sample time period. The timing of treatment is based on the program's first graduating cohort

[26] We use the IPUMS processing of these data.

rather than the year it opened because we are concerned with the flow of pharmacists into the market rather than the existence of the school itself.

Again, to fix ideas, consider the following two-way fixed effects model

$$y_{st} = \beta_0 + \sum_{i \neq -1} \theta_i T_s \, \mathbf{1}\left[openyear_t = t - i\right] + \beta_1 age_{st} + \beta_2 age_{st}^2 + \beta_3 female_{st} + \varepsilon_{st} \tag{2}$$

where y_{st} is the outcome for state s in year t, T_s is an indicator for whether the state will have a new PharmD program open up during the sample period, $\mathbf{1}\left[gradyear_t = t - i\right]$ is an indicator for whether the year the program will first graduate students is i periods from the observation's current year, age_{st} is the average age in the state and year, age_{st}^2 is the square of age in the state and year, $female_{st}$ is the fraction of the pharmacist population that is female, and ε_{st} is a residual term. In practice, we estimate the difference-in-differences coefficient using the Callaway and Sant'Anna estimator (Callaway and Sant'Anna, 2021) and then we summarize the results with the difference of the pre- and post-periods using ten years on either side of the first program opening in the state. Unlike our previous analyses that analyzed seven years on each side of the opening of a new PharmD program, we use a longer time period in these analyses to increase power because we have fewer treated units (states instead of individual PharmD programs). The regressions are weighted by population and the standard errors are cluster-bootstrapped at the state level.

First, Figure 8 presents event-study results to confirm that there is an increase in the number of pharmacists in the state after a new PharmD program begins graduating students. Because total pharmacists is a slow moving stock and we are trying to confirm a flow into the market, we focus on the number of pharmacists who are 35 years old or younger.[27] While this is closer to what we would ideally measure, it comes with the tradeoff of greater sampling variation since the ACS is a small sample of the entire population. While the estimates are understandably noisy, there is an apparent increase in the number of pharmacists younger than 35 in the years following the first graduating cohort from a new PharmD program in the state. The corresponding difference-in-differences estimate, found in the first column of Table 7, suggests that there were an average of approximately 288 additional young pharmacists per year after the treatment occurred. This is a 19 percent increase.[28]

Figure 9 presents the event-study estimates for median wages and salary per hour. The point estimates suggest that shortly after the first cohort of students graduates from the new PharmD program, hourly wages and salary fall and remain depressed for the next ten years. We observe a similar pattern for median income per hour as well (Figure A1).[29] The corresponding difference-

[27] We also exclude the controls for age and gender in this one regression.

[28] As an alternative way to gauge the magnitude, we can estimate the number of students who would have graduated from the newly opened schools in the ten years after the first school opens. We estimate that in the ten years following the first cohort from a new program, there is an average of 1.59 additional pharmacy programs (including the first new program) and that the average graduating class is 60 students. Over a ten year period, this would imply an additional 954 PharmD graduates.

[29] The Census and ACS contain two variables about income that we use. The first asks for all wage and salary income that the person has; the second asks for income from all sources.

in-differences results for the ten periods on each side of the event are presented in Table 7. The estimated reduction in median hourly wages and salary is $2.73. Relative to the average of the median hourly wage and salary for the treated group prior to treatment, $57.20, this is a little less than a five percent reduction. Our estimates for median hourly income again provide a very similar figure.

As a check on these results, we re-estimate our model where the dependent variable is the median hourly wages for non-pharmacists with at least a BA degree. If our previous results were capturing broader, negative changes in the skilled labor market that coincided with the opening of a new pharmacy program, then we would expect to find results similar to those we presented for pharmacists. Appendix Table A1 presents these results. The first two columns provide our original estimates for pharmacists for comparison. Columns (3) and (4) show that the association between the opening of a new pharmacy program and wages or income for non-pharmacists with at least a BA degree is an order of magnitude smaller than our estimates for pharmacists and is not statistically distinguishable from zero. This suggests that there were not broader changes in the labor markets where pharmacy programs opened that are driving our results. The final two columns present results where the dependent variable is the difference between the outcome variable for pharmacists and non-pharmacists with at least a BA. Again, we see that pharmacists' wages and income appear to have fallen when a new pharmacy program opened.

Another dimension along which labor markets could react to the influx of new pharmacists is hours worked. We estimate whether the number of hours worked by pharmacists changes and whether the fraction of pharmacists working full time changes.[30] Figure A2 plots the event-study results for the average number of hours worked per week by pharmacists and Figure A3 plots the event-study results for the fraction of pharmacists who are working full time. In each case, there is no obvious, discernible change. The corresponding difference-in-differences estimates shown in columns (4) and (5) of Table 7 confirm this general takeaway. The lack of strong effects is consistent with the literature on physicians' labor supply (Nicholson and Propper, 2011).

Unlike many professions, the gender earnings gap in pharmacy is quite small after accounting for differences in hours of work (Goldin and Katz, 2016). We conduct the same analyses reported in Table 7 separately for male and for female pharmacists. Broadly speaking, the reductions in median hourly wages and income appear to affect female physicians more than male physicians, though we lack the statistical power needed to reject the null that the effects are the same. The results can be seen in Appendix Table A2.

We might be concerned that the labor market outcomes we observe are being driven by changes in the retail pharmacy market. Since the start of the 1980s, the retail pharmacy market has shifted toward large chain pharmacies (e.g. CVS), mass merchandisers (e.g. Wal-Mart), and Supermarkets (e.g. Kroger), and away from small chain and independent pharmacies. For ease of exposition, we will refer to large chain pharmacies, but will include mass merchandise and supermarket phar-

[30] Following Goldin and Katz (2016), we record a pharmacist as full time if they are working at least 30 hours in a usual week.

macies in that group. Large chain pharmacies were roughly forty percent of all pharmacies during the 2000s and 2010s (Qato et al., 2017). If wages at large chains are lower, then our results could simply reflect a change in the type of employment that pharmacists receive. Using the 2000, 2004, and 2009 NPWS, we test whether pharmacists working at large chains earn a different amount than pharmacists working at other retail outlets.[31] Column (1) of Appendix Table A5 shows that on average, staff pharmacists at large chain pharmacies had hourly wages approximately 13 percent higher than staff pharmacists at small chain and independent pharmacies. Including year fixed effects, year of licensure fixed effects, state fixed effects, and an indicator for gender does not materially affect this average difference in wages (see column (2)). Columns (3) and (4) show that the same qualitative finding holds for pharmacists who are managers and owners. Taken together, if anything, shifting the pharmacist workforce towards large chains would have mechanically increased wages rather than decreased them.[32]

The results on pharmacist quantity and wages have similarities to cobweb models or hog cycles (Ezekiel, 1928; Kaldor, 1934; Rosen et al., 1994). If that is the correct model here, wages may eventually rise and the cycle may repeat.

How Has Quality Responded?

Historically, an argument in favor of licensing was that the requirements to obtain the license guaranteed a higher quality of service than might have occurred in the marketplace in the absence of licensing requirements (Friedman and Kuznets, 1945). In our setting, the switch from a BSPharm to a PharmD is an increase in the requirements needed to obtain the license, not a change from no license to requiring a license. Holding all else equal, the extra year of training required for the PharmD could increase the quality of services provided by pharmacists. In addition, the large expansion in the number of pharmacists might actually mean fewer tasks for each individual, and as a result, higher quality output. However, that expansion in pharmacy programs and students might mean that the marginal student, and later pharmacist, is now of lower quality. Given these opposing forces, it is not clear what the net effect of the switch to PharmD will be on the quality of pharmacy services.

We provide evidence on quality in three different ways. First, we explore how acceptance rates at pharmacy programs have evolved over time. Second, we show data on the rates at which pharmacy students pass the licensing exam over time. Third, we use data from the NPWS to examine whether practicing pharmacists' workloads have changed over time.

Figure 10 plots acceptance rate data from pharmacy programs from 2003 through 2022.[33] The

[31] Starting with the 2014 NPWS, the survey began asking about changes in earnings from the previous year rather than earnings. Because of that change, we are not able to use the later data for this analysis.

[32] We have not found state by year counts of the number of pharmacies, by type of pharmacy, that we could include as a control in our analysis presented in Table 7. We have two noisy measures of the number of pharmacies in each state and year, one from the Bureau of Labor Statistics and one from the County Business Patterns data. Neither series matches totals from industry groups over the entire time frame of our sample (Qato et al., 2017). Our findings are qualitatively similar, though somewhat attenuated, when these controls are included. See Appendix Table A6.

[33] These data are collected by the American Association of Colleges of Pharmacy.

blue line is the number of unique individuals who were accepted into a pharmacy program divided by the number of unique individuals who applied to pharmacy programs. Because the data are derived from an application portal that was being rolled out to pharmacy schools, the PharmCAS, not all schools are represented in every year. Between the 2003-2004 and the 2011-2012 application cycles, the fraction of pharmacy programs represented in the data grew from 48 percent to 94 percent. By the 2017-2018 cycle the data cover at least 90 percent of pharmacy programs. Because the composition of schools included in the data is changing so much over time, it is not clear whether the large upward trend in the blue line is a true representation of changes in acceptance rates or simply changes in the set of schools reporting. To speak to this issue, we also plot two gray lines which bound the true acceptance rates. The upper bound is constructed by assuming every school that does not use the PharmCAS has a 100 percent acceptance rate while the lower bound is constructed by assuming that every non-PharmCAS school has a zero percent acceptance rate.

It appears as though acceptance rates are likely rising throughout this time period. Among schools using PharmCAS, the acceptance rate increased from approximately 34 percent in the 2003-2004 cycle (2004 on the figure) to 87 percent in the 2019-2020 cycle. Although we do not know whether the schools that adopted PharmCAS early are representative of the entire population of pharmacy schools, by 2015, the lower bound of the estimates exceeds the upper bound of our estimates for 2004.[34] So even a very conservative interpretation of this figure would indicate that acceptance rates have risen from 68 percent in the 2003-2004 application cycle to at least 81 percent in the 2019-2020 cycle.

We now turn to exploring pass rates for the North American Pharmacist Licensure Examination (NAPLEX). The National Association of Boards of Pharmacy publishes first-time pass rates for each pharmacy program in recent years. Because there were major changes to the content and length of the exam in 2015 and 2016, it is not clear how to interpret the time-series variation in pass rates.[35] With this caveat in mind, Ried et al. (2023) report that the NAPLEX pass rate fell from 97 percent in 2008, the earliest year that data are available, to 93 percent in 2015, and then to 88 percent in 2019. While some portion of the overall decline in pass rates between 2008 and 2019 could be due to changes in the NAPLEX exam, the pass rate was declining before those changes occurred.

Because the majority of the expansion in pharmacy program enrollment was due to the entry of new schools, another way to gauge the change in quality is to compare the distributions of first-time pass rates for pharmacy programs that graduated students prior to 2000 ("Existing") and those that began graduating students in 2000 or later ("New"). We have school level pass rates between the years 2019 and 2024. Figure 11a shows the distributions for the New (blue line) and

[34] We have collected data on which pharmacy schools used the PharmCAS in the 2003-2004 and 2018-2019 application cycles. We would have preferred the 2019-2020 cycle, but the data were not available for that year. If we create bounds based on enrollment weights, rather than by the fraction of schools as in the text, we get an upper bound of 69.8 percent in 2003-2004 and a lower bound of 71.7 percent in 2018-2019. The analogous numbers for the method used in Figure 10 are quite similar at 68.2 percent and 75.6 percent.

[35] Changes to the NAPLEX included a longer test time, a 35 percent increase in the number of questions asked, more focus on clinical assessment questions, a switch from a computerized adapative test to a computerized linear test, and others.

Existing (red line) groups for 2019. While not every existing school has a higher pass rate than every new school, the pass rates for new schools are lower on average, have a lower median pass rate (85 percent vs 92 percent), and some of the new schools have pass rates as low as 51 percent. This general relationship holds true in later years as well. Figure 11b plots the distributions of scores for New and Existing schools in 2024. Again, the New schools tend to have much lower pass rates.

It is possible that growth in the number of pharmacists led to lighter workloads and thereby, potentially, higher quality. The 2004 NPWS and the 2014 NPWS both contain the following question: "How would you rate your workload in your workplace?" The five possible answers are excessively low, low, about right, high, and excessively high. Among pharmacists working in a licensed pharmacy in 2004, 43 percent rated their workload as high and another 10 percent rated is as excessively high. By 2014, despite the influx of pharmacists, the percentages rose to 48 percent and 15 percent, respectively. The fraction of pharmacists who responded in each of the other categories fell between 2004 and 2014. We formalize this comparison in a regression analysis of pharmacists' responses to the question on an indicator for it being the 2014 survey and demographic controls. The results are presented in Appendix Table A3 and are consistent with the simple comparisons: pharmacists report higher workloads over time. This is again consistent with a narrative that the quality of pharmacists' output is not rising over time. Taken together, the results presented in this section indicate that the quality of pharmacy graduates seems to have fallen. It is less clear how the quality of practicing pharmacists has been affected, though it does not appear to be the case that quality would have increased solely because of additional time available to complete tasks.[36]

6 Conclusion

The transition to PharmD had many consequences for universities and pharmacists. In this paper we argue that the transition increased the amount students could borrow and removed the cheaper, BSPharm. As a result, universities could charge more and engaged in an unprecedented growth in pharmacy education. These were profitable programs which yields insight into what universities do with additional profit. Rather than cross subsidize undergraduates, universities invested in quality by hiring faculty not directly involved in the Pharmacy program.

Our results highlight an underappreciated feature of the Bennett Hypothesis, quantity adjustments. The original quote by William Bennett makes it clear that his view was that the potential increase in tuition as a result of financial aid was bad. However, quantity adjustments can alter the calculation of welfare. In this case, we argue that additional financial aid for pharmacy education

[36]We have explored two other potential measures of pharmacist quality, malpractice rates and adverse actions against pharmacists. The former is extremely rare while the latter is only loosely tied to the actual services that pharmacists provide. We estimated difference-in-differences models at the state-year level exploiting the opening of a new PharmD program as in our analysis of pharmacist labor markets. Unfortunately, we lacked the statistical power to learn much from these analyses: The standard errors were sufficiently large that we could not rule out very large positive or negative effects.

substantially increased consumer and total welfare by expanding enrollment. The increase in financial aid allowed universities to overcome substantial fixed costs and open up programs that students valued. This insight opens up new avenues for policy. For example, providing additional financial aid for specific programs may lead to increased quantity. This may be a useful policy tool for increasing certain majors or graduate programs. Indeed, recent action by the U.S. Department of Education in choosing which graduate programs are "professional degrees" could affect the quantity of those degrees produced.

Universities are very complex organizations with many competing objectives and constituencies. They also play a large role in their local economy and in state budgets. Despite this, evidence on their objective function is scant. Our results, demonstrate that they respond to opportunities to increase revenue and use the proceeds to invest in "quality" rather than in quantity. Ideally, this would be the start of additional research on "universities as firms." For example: How do universities use additional funding? What do they do to seek additional sources of revenue? etc.

Last, this work highlights the need to consider the equilibrium effects of policy. Where increases in licensing requirements typically lead to reductions in practitioners and higher wages, in our case, the interaction with loan policies actually led to the opposite.

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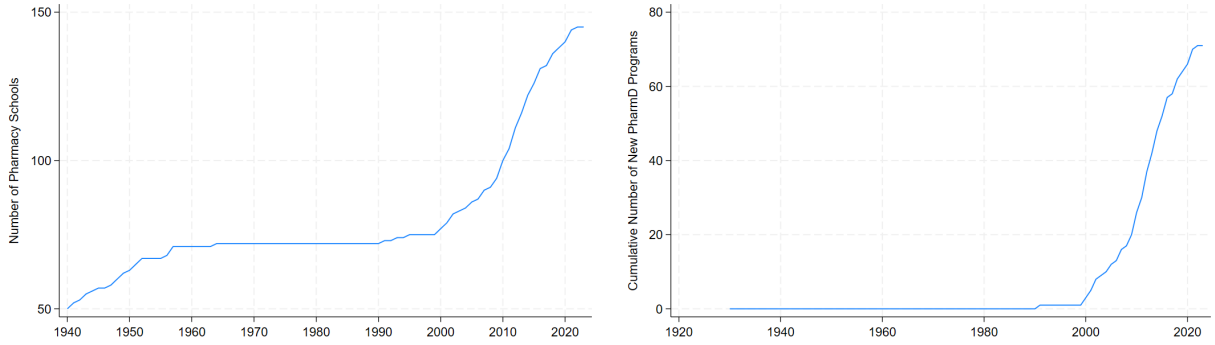
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7 Tables and Figures

Figure 1: Number of Pharmacy Programs Over Time

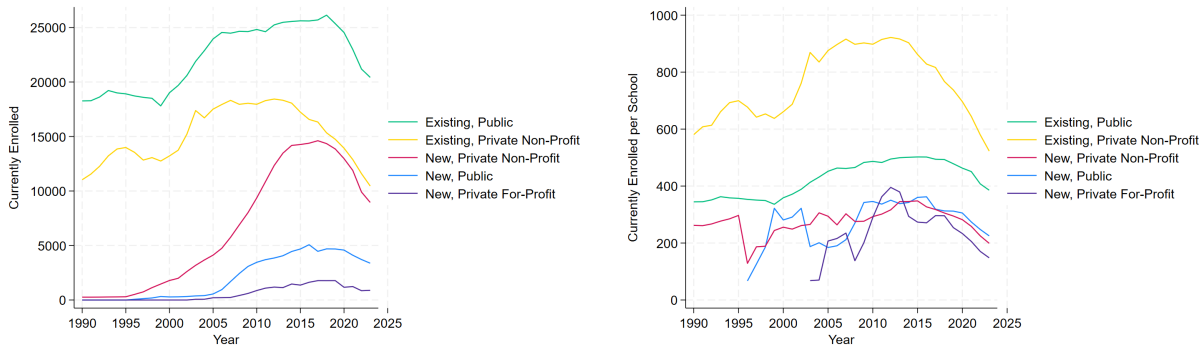


(a) Number of Pharmacy Schools

(b) Cumulative Number of New PharmD Programs that did not Offer BSPharm Previously

Figures based on data authors collected from the Accreditation Council for Pharmacy Education. Figure 1a presents the number of pharmacy programs that graduated students in each year (BSPharm or PharmD). Figure 1b shows the number of schools that graduated PharmD students and had not previously graduated BSPharm students.

Figure 2: Enrollment by School Type

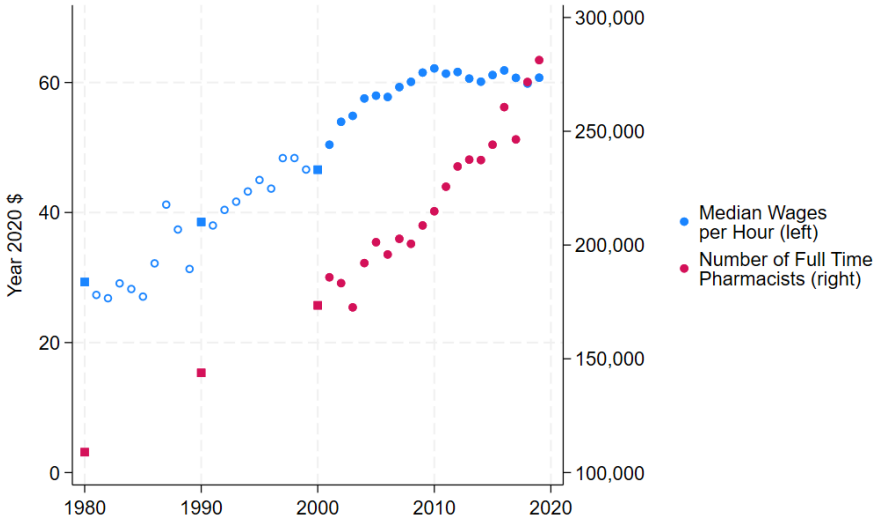


(a) Total Enrollment

(b) Enrollment per School

Data collected from American Association of Colleges of Pharmacy and the Accreditation Council for Pharmacy Education. New schools are those that created a PharmD program and did not previously have a BSPharm program. Existing schools are those that did previously have a BSPharm program. School type, e.g. public, private non-profit, comes from the National Center for Education Statistics (via IPEDS).

Figure 3: Real Hourly Wages and the Number of Pharmacists Over Time



The blue symbols are estimates of full-time pharmacists' median hourly wages. Hollow blue circles use data from the Annual Social and Economic Supplement; solid blue circles use data from the American Community Survey; solid blue squares use data from the decennial censuses. Red symbols are estimates of the number of full-time pharmacists. The solid red squares use data from the decennial censuses; the solid red circles use data from the American Community Survey. The Annual Social and Economic Supplement data are not large enough to create reliable estimates of the number of pharmacists between 1980 and 1999.

Figure 4: Market for Pharmacy School Enrollments

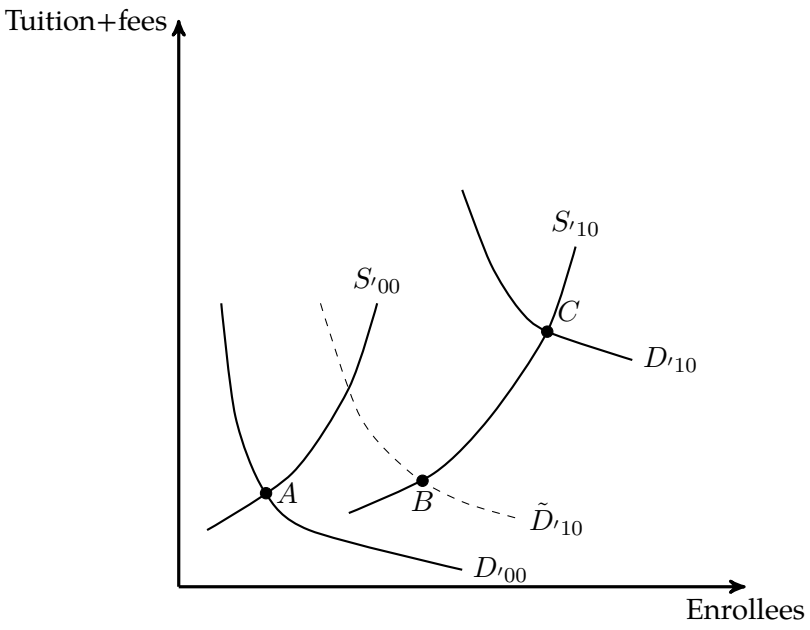
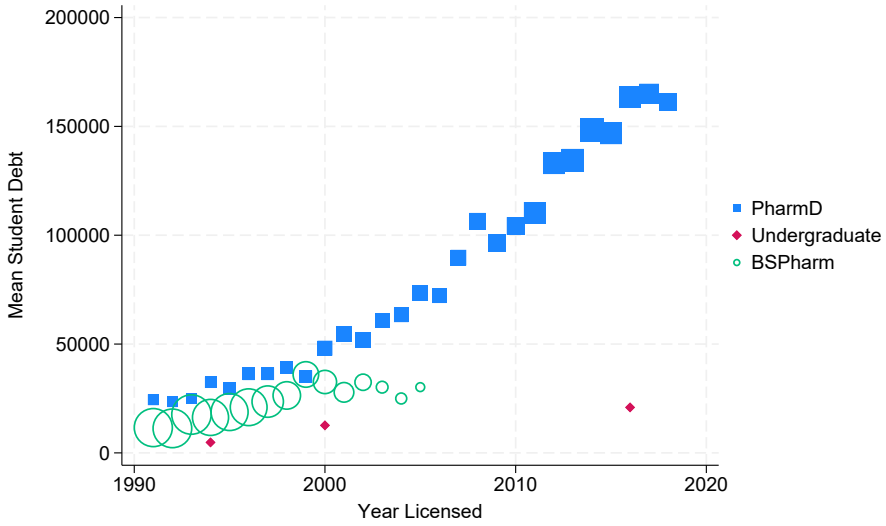
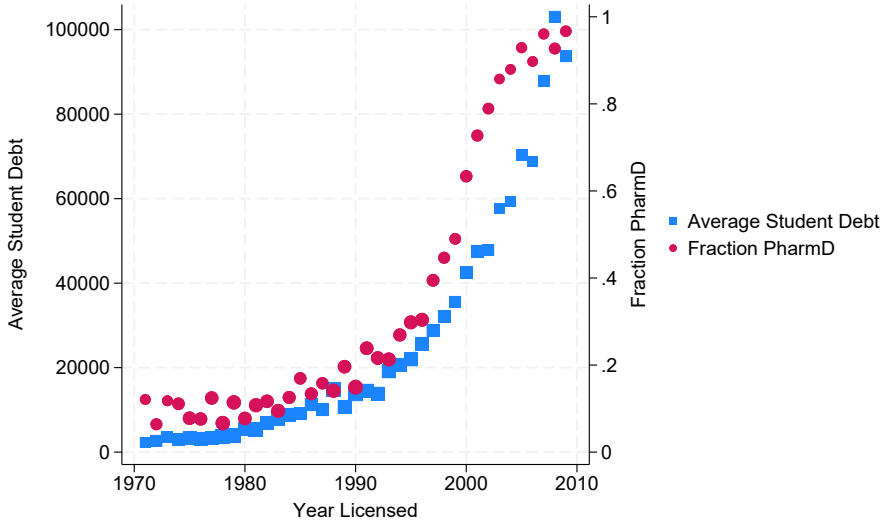


Figure 5: Debt by Education



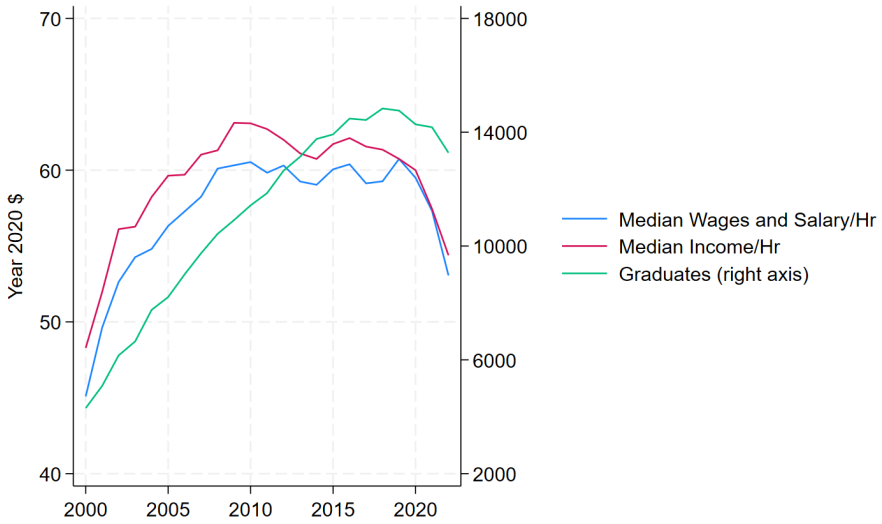
Data for PharmD and BSPharm comes from the 2004, 2009, 2014, 2019 National Pharmacy Workforce Study surveys. The dots are proportional to the number of observations in each year licensed. The data for the undergraduates comes from the U.S. Department of Education, National Center for Education Statistics Baccalaureate and Beyond surveys 1994, 2008, 2016. Codes to retrieve results: vgzbgx, kcfbfi, myqmwb.

Figure 6: Fraction PharmD and Debt Over Time



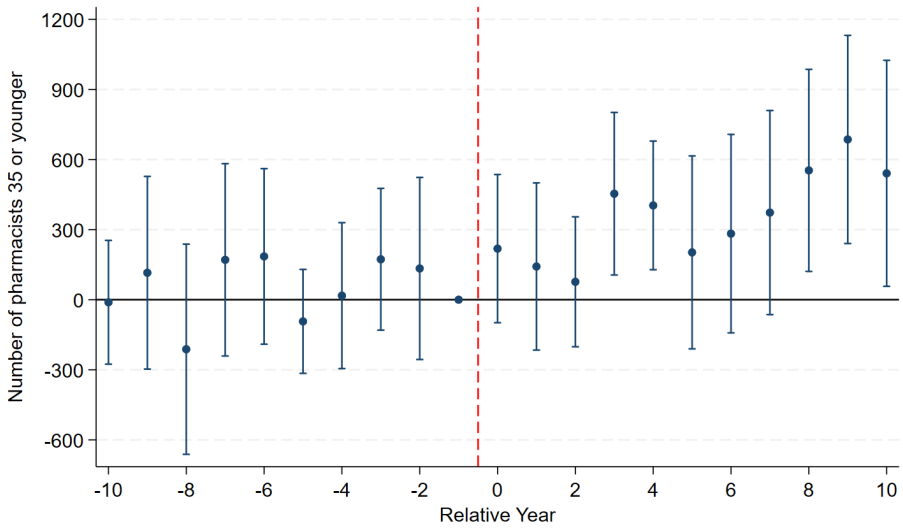
Data comes from the 2004, 2009, 2014, 2019 National Pharmacy Workforce Study surveys. The dots are proportional to the number of observations in each year licensed. The outcome is the amount of student debt at the time of graduation from pharmacy school and the fraction of respondents who had a PharmD as their highest degree.

Figure 7: Pharmacist Income and New Graduates Over Time



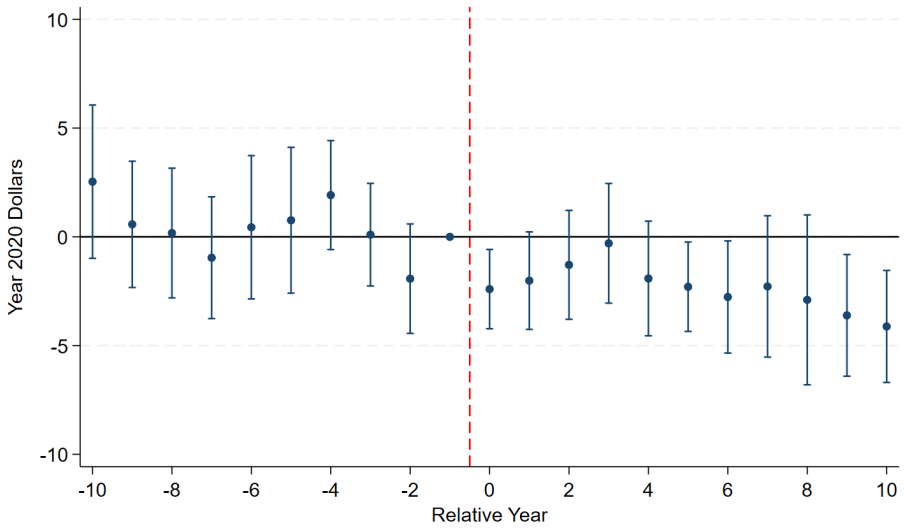
Data are from the 2000 census, the 2001-2022 American Community Survey, and the American Association of Colleges of Pharmacy.

Figure 8: Pharmacists $\leq$ 35 Years Old



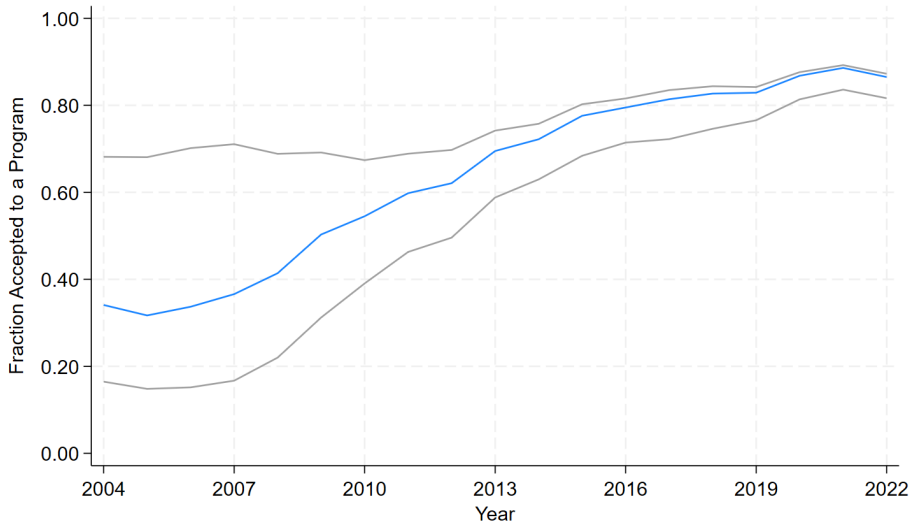
Data are from the 2000 census and the 2001-2022 American Community Survey. Point estimates and 95 percent confidence intervals are reported.

Figure 9: Median Wage and Salary per Hour



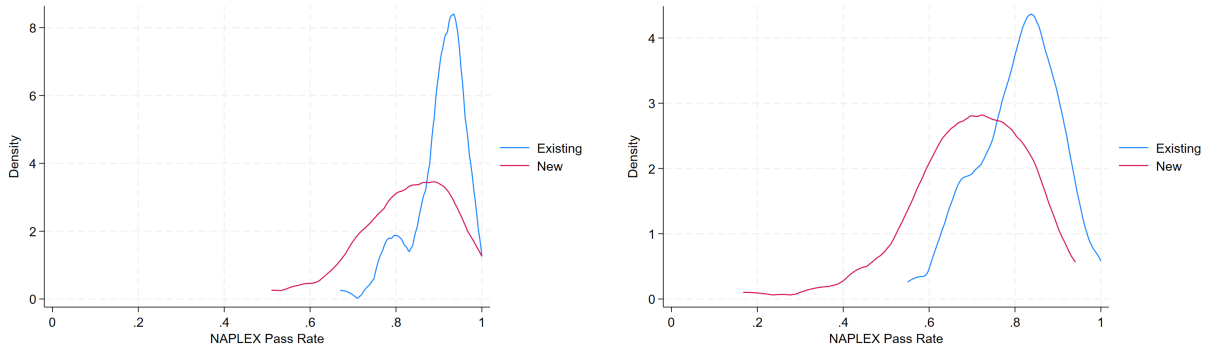
Data are from the 2000 census and the 2001-2022 American Community Survey. Point estimates and 95 percent confidence intervals are reported.

Figure 10: Fraction of Applicants Accepted to Pharmacy School



Data are from the Association of American Colleges of Pharmacy. The blue line represents the reported fraction of applicants accepted. The gray lines provide bounds on the fraction accepted that account for the increase in the fraction of pharmacy programs that are included in the data over time.

Figure 11: NAPLEX Pass Rates



(a) 2019 Scores by Program Type

(b) 2024 Scores by Program Type

Data are first-time pass rates on the North American Pharmacist Licensure Examination (NAPLEX) which is overseen by the National Association of Boards of Pharmacy. "New" denotes pass rates for students who attended PharmD programs that did not have a BSPharm program. "Existing" denotes students from other programs.

Table 1: Pharmacists' Preferences for Switching Professions

	(1) Full scale, values 1-5	(2) Binary	(3) Full scale, values 1-5	(4) Binary
Year=2014	0.021	0.020	0.034	0.026
	(0.104)	(0.038)	(0.105)	(0.038)
PharmD control			x	x
Mean	3.184	0.417	3.184	0.417
Observations	3,008	3,008	3,008	3,008

Data are from the 2000 and 2014 NPWS. The dependent variable is whether the pharmacist would go into a different profession that paid the same if that were an option. The second two columns include an indicator for whether the individual has a PharmD. * p<0.10, ** p<0.05, *** p<0.01

Table 2: Balance Sheet Items

	(1) Revenues	(2) Assets	(3) Liabilities
DiD	0.114***	0.071*	-0.051
	(0.032)	(0.036)	(0.099)
Mean (millions)	415.0	735.0	356.5
Observations	4,998	4,998	4,998

Dependent variables are logged. The sample period spans the 2001 AY to the 2017 AY. The regressions are weighted by full-time enrollment in 1997. Mean reports the unlogged pre-treatment averages for PharmD institutions in millions of dollars. Standard errors clustered by institution are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 3: Enrollment Characteristics and Undergraduate Pricing

	(1)	(2)	(3)	(4)	(5)	(6)
	Enrollment					
	Total	Undergrad	Graduate	Minority	Tuition	Institutional Grants
DiD	0.170***	0.024	0.737***	0.204***	-0.019	-0.129
	(0.039)	(0.057)	(0.208)	(0.069)	(0.044)	(0.128)
Mean	4,100	3,259	841	1,332	14564	4,401
Observations	5,066	5,066	5,066	5,066	4,692	4,131

Dependent variables are logged. The sample period spans the 2001 AY to the 2017 AY. The regressions are weighted by full-time enrollment in 1997. Mean reports the unlogged pre-treatment averages for PharmD institutions. Standard errors clustered by institution are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 4: Aggregated Expenditures by Category

	(1) Total	(2) Salaries	(3) Benefits	(4) Instruction	(5) Research	(6) Acad. Supp	(7) Student Serv.	(8) Inst. Supp.
DiD	0.117***	0.097***	0.101**	0.089	0.641**	0.021	-0.459	0.186**
	(0.026)	(0.031)	(0.041)	(0.069)	(0.298)	(0.077)	(0.494)	(0.076)
Mean (millions)	389.1	170.6	122.3	39.5	69.4	35.6	18.7	33.3
Observations	4,998	4,998	4,998	4,998	4,998	4,998	4,998	4,998

Dependent variables are logged. The sample period spans the 2001 AY to the 2017 AY. The regressions are weighted by full-time enrollment in 1997. Mean reports the unlogged pre-treatment averages for PharmD institutions. Standard errors clustered by institution are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 5: Salary Expenditures by Category

	(1) Instruction	(2) Research	(3) Acad. Supp	(4) Student Serv.	(5) Inst. Supp.
DiD	0.085**	0.547*	-0.013	-0.449	0.035
	(0.043)	(0.301)	(0.078)	(0.472)	(0.045)
Mean (millions)	77.3	32.5	18.1	8.8	15.2
Observations	4,998	4,998	4,998	4,998	4,998

Dependent variables are logged. The sample period spans the 2001 AY to the 2017 AY. The regressions are weighted by full-time enrollment in 1997. Mean reports the unlogged pre-treatment averages for PharmD institutions. Standard errors clustered by institution are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 6: Instructional Faculty Counts

	(1) Total Faculty	(2) Professors	(3) Associate Professors	(4) Assistant Professors	(5) Lecturers
DiD	0.191***	0.046	0.108	0.230**	0.309***
	(0.033)	(0.045)	(0.074)	(0.096)	(0.090)
Mean	471	142	121	134	73
Observations	4,496	4,496	4,496	4,496	4,496

Dependent variables are logged. The sample period spans the 2001 AY to the 2017 AY. The regressions are weighted by full-time enrollment in 1997. Mean reports the unlogged pre-treatment averages for PharmD institutions. Standard errors clustered by institution are in parentheses. * p<0.10, ** p<0.05, *** p<0.01.

Table 7: New PharmD Programs and Pharmacists' Labor Market Outcomes

	(1) Number Pharmacists, Age≤35	(2) Median Wage and Salary/hr	(3) Median Income/hr	(4) Average Hours	(5) Fraction Fulltime
DiD	287.875**	-2.725**	-2.936**	0.093	-0.013
	(120.291)	(1.121)	(0.992)	(0.610)	(0.020)
Mean	1,510.944	57.200	59.373	38.344	0.725

Wage and salary and income data are from the five percent microdata sample of the 2000 census and the 2001-2022 American Community Surveys. Data are at the state-year unit of observation. Standard errors are cluster bootstrapped with clusters at the state level. The mean of the dependent variable is the average of the outcome variable for the treated states in the years prior to being treated. Wages include wage and salary income; earnings include all income. * p<0.10, ** p<0.05, *** p<0.01

A Additional Tables and Figures

Table A1: New PharmD Programs and Labor Market Outcomes

	(1) Median Wage and Salary/hr, Pharmacists	(2) Median Income/hr, Pharmacists	(3) Median Wage and Salary/hr, Non-Pharmacist BAs	(4) Median Income/hr, Non-Pharmacist BAs	(5) Difference in Median Wage and Salary/hr	(6) Difference in Median Income/hr
DiD	-2.725**	-2.936**	-0.380	-0.679	-2.330**	-2.072*
	(1.121)	(0.992)	(0.522)	(0.535)	(1.087)	(1.064)
Mean	57.200	59.373	28.742	32.879		

Each column is a separate regression. The first two columns repeat results for pharmacists provided in Table 7. Columns (3) and (4) present results from the same regressions run in columns (1) and (2), but now the dependent variable is only for non-pharmacists with at least a BA degree. In columns (5) and (6), the dependent variable is the difference between pharmacists and non-pharmacists with at least a BA for the specified wage or income variable. Standard errors are clustered at the state level. * p<0.10, ** p<0.05, *** p<0.01

Table A2: New PharmD Programs and Pharmacists' Labor Market Outcomes, by Gender

	(1) Number Pharmacists, Age≤35	(2) Median Wage and Salary/hr	(3) Median Income/hr	(4) Average Hours	(5) Fraction Fulltime
Male					
DiD	188.948**	-1.984	-0.763	-0.064	-0.006
	(68.014)	(1.231)	(1.078)	(0.649)	(0.021)
Female					
DiD	85.784	-3.112*	-2.899*	-0.598	-0.020
	(77.667)	(1.329)	(1.290)	(0.768)	(0.027)

The top panel presents estimates for men, the bottom panel for women. Wage and salary and income data are from the five percent microdata sample of the 2000 census and the 2001-2022 American Community Surveys. Data are at the state-year unit of observation. Standard errors are cluster bootstrapped with clusters at the state level. The mean of the dependent variable is the average of the outcome variable for the treated states in the years prior to being treated. * p<0.10, ** p<0.05, *** p<0.01

Table A3: Changing Workloads for Pharmacists Over Time

	(1) Workload, 1-5 scale	(2) Workload, 1-5 scale	(3) If high or excessively high	(4) If high or excessively high
Year=2014	0.019***	0.016**	0.010***	0.008**
	(0.003)	(0.006)	(0.002)	(0.004)
Age		0.003		0.001
		(0.004)		(0.003)
Year licensed		0.003		0.002
		(0.004)		(0.003)
Male		0.010		-0.004
		(0.037)		(0.023)
BSPharm degree		-0.015		0.003
		(0.047)		(0.029)
Mean	3.636	3.636	0.574	0.574
Observations	2,116	2,116	2,116	2,116

Data are from the 2004 and 2014 National Pharmacist Workforce Study surveys. The sample is restricted to pharmacists working in licensed pharmacies. The workload variable takes on five distinct values with lower values indicating a lighter workload. The dependent variable in columns (3) and (4) indicates that the respondent chose "high" or "excessively high" as their response. Heteroskedasticity-robust standard errors are shown. * p<0.10, ** p<0.05, *** p<0.01

Table A4: Pharmacy Schools by Rank, Sector, and Year of PharmD Start

Rank	School Name	Sector	Start of PharmD	Treated in School Regressions
12	University of California, San Diego Skaggs School of Pharmacy & Pharmaceutical Sciences	Public	2002	X
44	Thomas Jefferson University Jefferson College of Pharmacy	Private Non-Profit	2008	X
44	Texas Tech University Health Sciences Center Jerry H. Hodge School of Pharmacy	Public	1996	
49	Texas A & M University Health Science Center Irma Lerma Rangel School of Pharmacy	Public	2006	X
60	University of California, Irvine School of Pharmacy & Pharmaceutical Sciences	Public	2021	
60	University of South Florida Health Taneja College of Pharmacy	Public	2011	X
60	Southern Illinois University Edwardsville School of Pharmacy	Public	2005	X
69	East Tennessee State University Bill Gatton College of Pharmacy	Public	2007	X
73	Medical College of Wisconsin School of Pharmacy	Private Non-Profit	2018	
73	Loma Linda University School of Pharmacy	Private Non-Profit	2002	X
73	Northeast Ohio Medical University College of Pharmacy	Public	2007	X
73	Western University of Health Sciences College of Pharmacy	Private Non-Profit	1996	
80	University of North Texas Health Science Center UNT System College of Pharmacy	Public	2013	X
80	St. John Fisher University Wegmans School of Pharmacy	Private Non-Profit	2006	X
80	Chapman University School of Pharmacy	Private Non-Profit	2015	X
80	Wilkes University Nesbitt School of Pharmacy	Private Non-Profit	1996	
86	Shenandoah University Bernard J. Dunn School of Pharmacy	Private Non-Profit	1996	
86	University of the Incarnate Word Feik School of Pharmacy	Private Non-Profit	2006	X
86	University of Findlay College of Pharmacy	Private Non-Profit	2006	X

Rank	School Name	Sector	Start of PharmD	Treated in School Regressions
86	Regis University Rueckert-Hartman College for Health Professions School of Pharmacy	Private Non-Profit	2009	X
86	Western New England University College of Pharmacy and Health Sciences	Private Non-Profit	2011	X
86	Belmont University College of Pharmacy and Health Sciences	Private Non-Profit	2008	X
95	Lipscomb University Health Sciences Center College of Pharmacy	Private Non-Profit	2008	X
95	Manchester University College of Pharmacy, Natural and Health Sciences	Private Non-Profit	2012	X
95	Binghamton University State University of New York School of Pharmacy and Pharmaceutical Sciences	Public	2017	
95	Pacific University School of Pharmacy	Private Non-Profit	2006	X
99	MCPHS University School of Pharmacy - Worcester	Private Non-Profit	2001	
99	Touro University - California College of Pharmacy	Private Non-Profit	2005	
99	University of Maryland Eastern Shore School of Pharmacy and Health Professions	Public	2010	X
99	University of Texas at El Paso School of Pharmacy	Public	2017	
99	Palm Beach Atlantic University Lloyd L. Gregory School of Pharmacy	Private Non-Profit	2001	X
99	University of Hawaii at Hilo Daniel K. Inouye College of Pharmacy	Public	2007	X
99	Roseman University of Health Sciences College of Pharmacy	Private Non-Profit	2001	
99	Concordia University Wisconsin School of Pharmacy	Private Non-Profit	2010	X
99	Wingate University School of Pharmacy	Private Non-Profit	2003	X
99	Union University College of Pharmacy	Private Non-Profit	2008	X
111	Notre Dame of Maryland University School of Pharmacy	Private Non-Profit	2009	X
111	Marshall University School of Pharmacy	Public	2012	X
111	High Point University Fred Wilson School of Pharmacy	Private Non-Profit	2016	X
111	Touro University Touro College of Pharmacy	Private Non-Profit	2008	X

Rank	School Name	Sector	Start of PharmD	Treated in School Regressions
111	University of New England Westbrook College of Health Professions School of Pharmacy	Private Non-Profit	2009	X
111	Harding University College of Pharmacy	Private Non-Profit	2008	X
111	Rosalind Franklin University of Medicine and Science College of Pharmacy	Private Non-Profit	2011	X
111	Cedarville University School of Pharmacy	Private Non-Profit	2012	X
111	University of Texas at Tyler Ben and Maytee Fisch College of Pharmacy	Public	2015	X
111	University of Saint Joseph School of Pharmacy and Physician Assistant Studies	Private Non-Profit	2011	X
122	Keck Graduate Institute (KGI) School of Pharmacy and Health Sciences	Private Non-Profit	2014	
122	Fairleigh Dickinson University School of Pharmacy & Health Sciences	Private Non-Profit	2012	X
122	Sullivan University College of Pharmacy and Health Sciences	Private For-Profit	2008	
122	Presbyterian College School of Pharmacy	Private Non-Profit	2010	X
122	Philadelphia College of Osteopathic Medicine - Georgia School of Pharmacy	Private Non-Profit	2010	X
127	Lake Erie College of Osteopathic Medicine School of Pharmacy	Private Non-Profit	2003	X
127	Roosevelt University College of Science, Health and Pharmacy	Private Non-Profit	2011	X
127	University of Charleston School of Pharmacy	Private Non-Profit	2006	X
130	Appalachian College of Pharmacy	Private Non-Profit	2006	
130	D'Youville University School of Pharmacy	Private Non-Profit	2010	X
132	West Coast University School of Pharmacy	Private For-Profit	2014	
132	Marshall B. Ketchum University College of Pharmacy	Private Non-Profit	2017	
132	South University School of Pharmacy	Private For-Profit	2003	
132	Husson University College of Health and Pharmacy School of Pharmacy	Private Non-Profit	2009	X
136	Chicago State University College of Health Sciences and Pharmacy	Public	2008	X
136	South College School of Pharmacy	Private For-Profit	2012	
136	California Northstate University College of Pharmacy	Private For-Profit	2009	

Rank	School Name	Sector	Start of PharmD	Treated in School Regressions
136	William Carey University School of Pharmacy	Private Non-Profit	2018	
140	Larkin University College of Pharmacy	Private Non-Profit	2016	
141	American University of Health Sciences School of Pharmacy	Private For-Profit	2020	
	Hampton University School of Pharmacy	Private Non-Profit	1998	X

These data on the dates of opening come from the Accreditation Council for Pharmacy Education (ACPE). The rank data come from the 2024 US News Best Pharmacy School rankings. Sector comes from IPEDS. Included as Treated in School Regressions indicates which openings are included in the regressions of school level outcomes.

Table A5: Hourly Earnings at Independent and Chain Pharmacies

	Staff pharmacist		Manager/Owner	
	(1)	(2)	(3)	(4)
Large chain pharmacy	0.129***	0.112***	0.084**	0.086**
	(0.037)	(0.031)	(0.041)	(0.038)
Controls		X		X
Observations	1,107	1,082	861	831

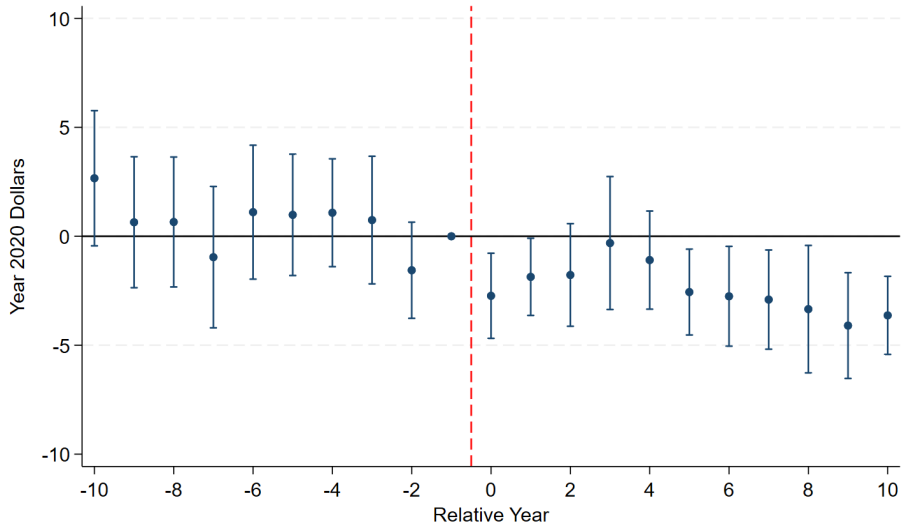
The dependent variable is the natural log of hourly earnings (inclusive of all earning from working at the pharmacy such as wages, bonuses, earnings from ownership, etc.). Data are from the 2000, 2004, and 2009 NPWS. The sample is restricted to practicing pharmacists who work at either a large chain pharmacy, a small chain pharmacy, or an independent pharmacy. The omitted group is those working at either a small chain or an independent pharmacy. Columns (1) and (2) restrict to staff pharmacists; columns (3) and (4) restrict to owners or managers at a pharmacy. Controls include year fixed effects, year of licensure fixed effects, state fixed effects, and an indicator for male. * p<0.10, ** p<0.05, *** p<0.01

Table A6: New PharmD Programs and Pharmacists' Labor Market Outcomes

	(1) Median Wage and Salary/hr	(2) Median Income/hr	(3) Average Hours	(4) Fraction Fulltime
DiD, baseline	-2.725**	-2.936**	0.093	-0.013
	(1.121)	(0.992)	(0.610)	(0.020)
DiD, CBP	-1.777	-1.681	0.601	-0.009
	(1.977)	(1.831)	(0.924)	(0.030)
DiD, BLS	-1.598	-1.766	0.554	-0.008
	(1.831)	(1.590)	(0.824)	(0.029)
Mean	57.200	59.373	38.344	0.725

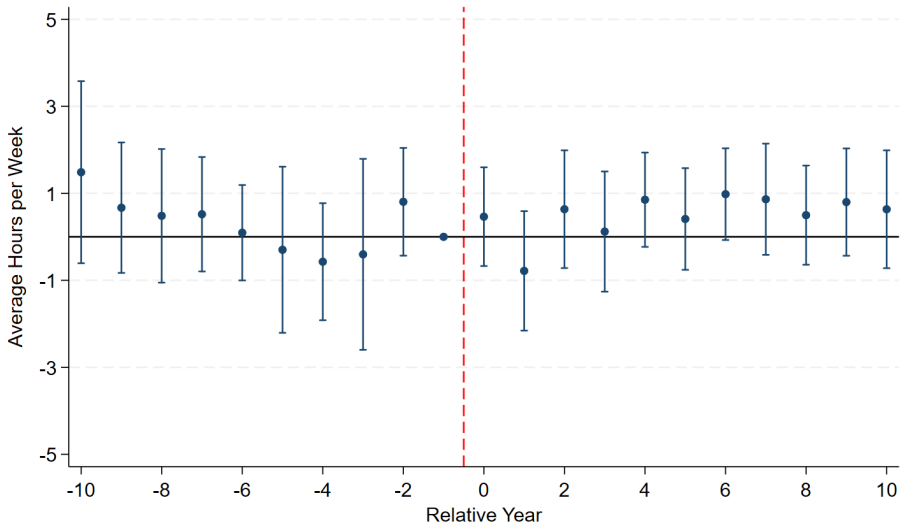
The top row reports our baseline results. The second row includes a control for the number of pharmacies in the state based on County Business Patterns data. The third row includes an analogous control based on Bureau of Labor Statistics data. Wage and salary and income data are from the five percent microdata sample of the 2000 census and the 2001-2022 American Community Surveys. Data are at the state-year unit of observation. Standard errors are cluster bootstrapped with clusters at the state level. The mean of the dependent variable is the average of the outcome variable for the treated states in the years prior to being treated. Wages include wage and salary income; earnings include all income. * p<0.10, ** p<0.05, *** p<0.01

Figure A1: Median Income per Hour



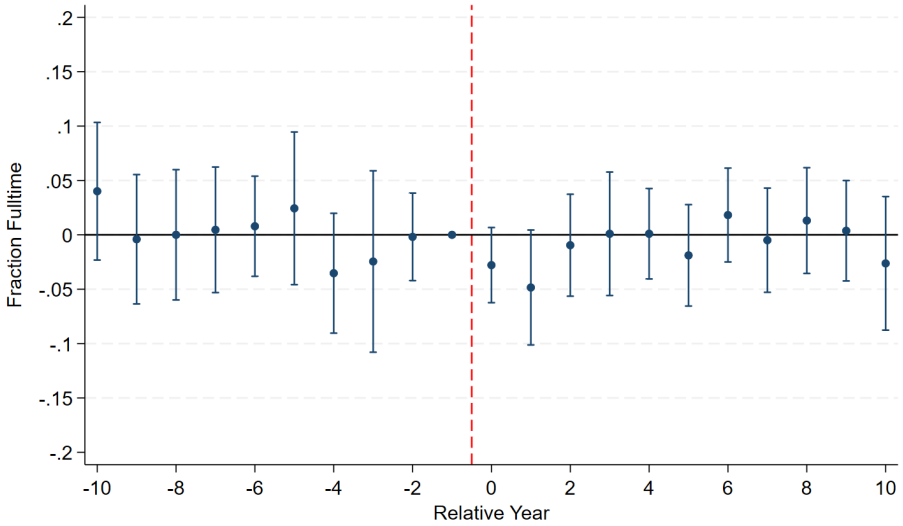
Data are from the 2000 census and the 2001-2022 American Community Survey. Point estimates and 95 percent confidence intervals are reported.

Figure A2: Average Hours Worked per Week



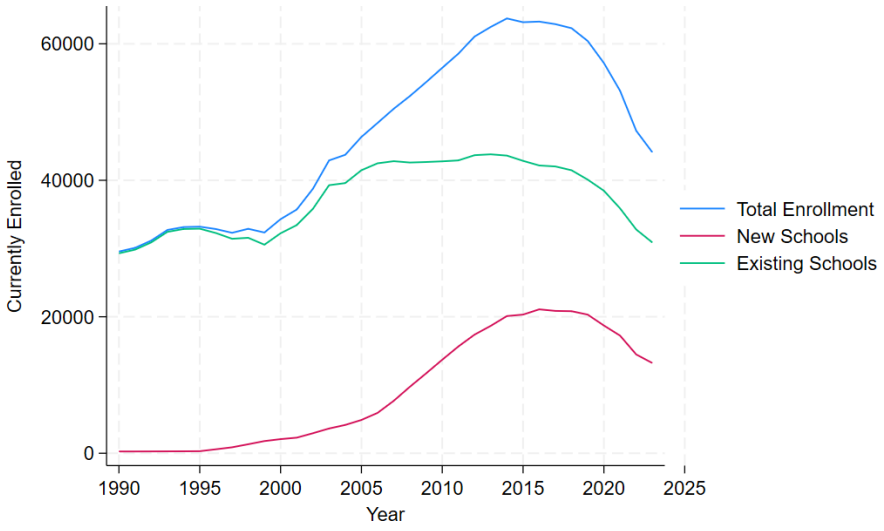
Data are from the 2000 census and the 2001-2022 American Community Survey. Point estimates and 95 percent confidence intervals are reported.

Figure A3: Fraction of Pharmacists Working Full Time



Data are from the 2000 census and the 2001-2022 American Community Survey. Point estimates and 95 percent confidence intervals are reported.

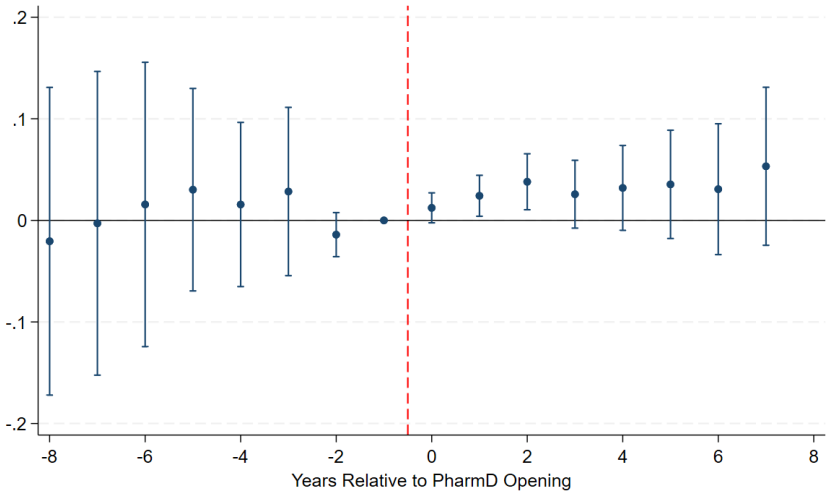
Figure A4: Pharmacy School Enrollment Over Time



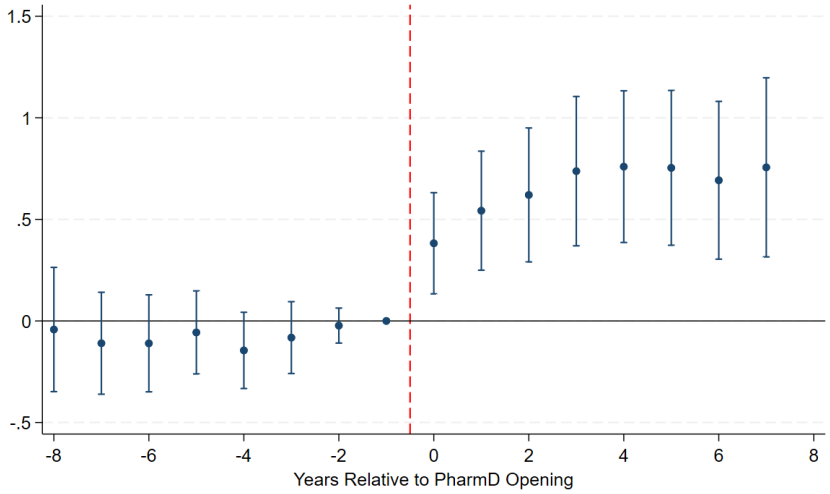
Data collected from American Association of Colleges of Pharmacy and the Accreditation Council for Pharmacy Education. New schools are those that created a PharmD program and did not previously have a BSPharm program. Existing schools are those that did previously have a BSPharm program.

Figure A5: Effects of Opening a PharmD program on Enrollment

(a) Changes in Undergrad Enrollment

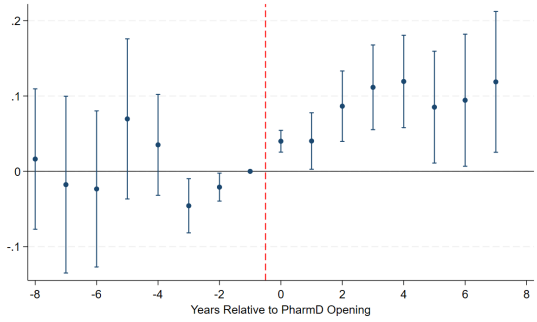


(b) Changes in Grad Enrollment

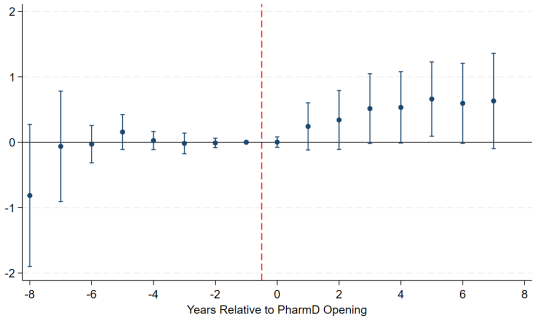


These plot event study coefficients from estimation of discussed in Section 4. The data come from the National Center for Educational Statistics Integrated Postsecondary Education Data System.

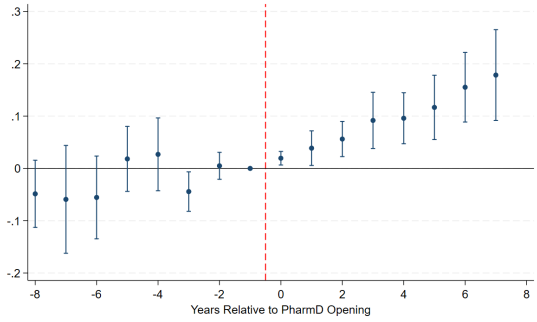
Figure A6: Effects of Opening a PharmD program on Institutional Behavior



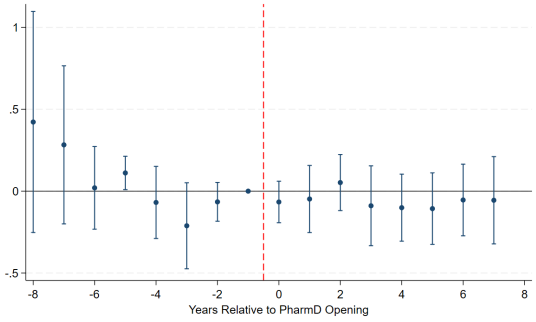
(a) Instructional Salary



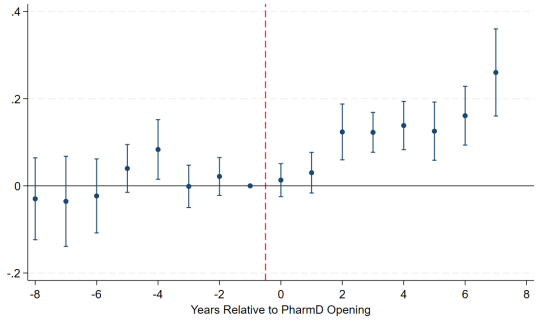
(b) Research Salary



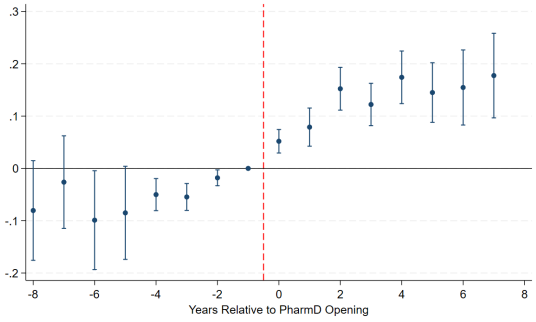
(c) Expenditures



(d) Institutional Grants



(e) Total Revenue



(f) Total Employment

These plot event study coefficients from estimation of discussed in Section 4. The data come from the National Center for Educational Statistics Integrated Postsecondary Education Data System.

B Entry and Welfare

Market Structure

Each pharmacy program is a differentiated product because of branding, geographic isolation, and other factors. This implies that each school will have some pricing power. Each program also faces competition from other programs, but also from other majors or careers that students consider. This suggests that each program is not operating as a monopolist. In addition, as discussed in Section 3.1, there appears to be very little in the way of barriers to entry in the pharmacy school market.

With those observations in hand, assume we have schools that are choosing whether or not to open up a pharmacy program. While the university might care about its overall reputation for quality, we will treat the professional pharmacy program as a profit center. In that case, all that matters is whether the pharmacy school will make profits or not, given the actions of other programs. Suppressing the prices of other programs to simplify notation, the present long-run profits for a potential pharmacy school are:

$$\max_{q_t} \sum_{t=0}^{\infty} \beta^t \left[p(q_t) q_t - VC(q_t) \right] - F \tag{3}$$

where t indexes time, β^t is the discount rate, $p(q_t)$ is the inverse demand curve/price (tuition+fees), q_t is the number of students enrolled, $VC(q_t)$ are the variable costs of production, and F are the fixed costs of production.

Because there is nothing inherently dynamic about the profit maximization problem, conditional on being in the market, we get the usual Lerner Rule relating the markup and price to the elasticity of demand. If we let ε be the price elasticity of demand for enrollment in the pharmacy school and $MC(q_t)$ be the marginal cost,

$$\frac{p(q_t) - MC(q_t)}{p(q_t)} = -\frac{1}{\varepsilon} \tag{4}$$

Because there are no barriers to entry, schools will enter the market up to the point where long-run profits are equal to zero. This standard zero-profit condition implies

$$\sum_{t=0}^{\infty} \beta^t \left[p(q_t^*) q_t^* - VC(q_t^*) \right] = F \tag{5}$$

where F is the fixed cost of entry. Then with the simplifying assumption that per-period profits are constant, the zero-profit condition implies that for the marginal entrant, $F = profits_t/(1-\beta)$.

Estimating Welfare

Ideally, for each pharmacy program, we would have the following data: per-period profits, the number of enrolled students, and the price (tuition+fees). With that data, we could estimate each program's elasticity of demand and put an upper bound on its fixed costs. Unfortunately, we do not have program-level data on profits. However, as discussed in Section 3.2, we do have some information on average and median profits for a number of pharmacy schools. Using that information in conjunction with equilibrium price and enrollments, denoted p^* and q^* respectively, and an assumption on the functional form for demand, we can recover the ingredients

needed to estimate the social welfare impacts of a representative pharmacy school.

First, for a specified value of profits and an observed p^*, we can use the Lerner Rule to back out the elasticity of demand. We assume that the demand curve has a constant elasticity: $q_t = ap_t^{\varepsilon}$. With equilibrium values for q^*, p^* and an estimate demand elasticity from the Lerner Rule, we can pin down $\tilde{a} \equiv q_t^*/p_t^{*\varepsilon}$ to have the entire demand curve. In that case, suppressing time subscripts, we can calculate per-period consumer surplus as

$$CS \equiv \int_0^{q^*} \left[\left(\frac{q}{\tilde{a}} \right)^{1/\varepsilon} - p^* \right] \mathrm{d}q = \left(\frac{1}{a} \right)^{1/\varepsilon} \frac{\varepsilon}{\varepsilon + 1} q^{* \frac{\varepsilon+1}{\varepsilon}} - p^* q^*. \tag{6}$$

The welfare impact of an entrant can then be calculated as

$$\Delta Welfare = \frac{CS}{1-\beta} + \frac{Profits}{1-\beta} - F$$

where both the consumer surplus and profits are per-period values.

In our data, the median pharmacy program earns approximately \$4.7 million in profits per year. In our price and enrollment data, among the pharmacy programs that were created after 2000, the average tuition and enrollment in 2019 is \$43,435 and 285, respectively.[37] If the marginal pharmacy program had these attributes, then we would estimate that it had fixed costs of roughly \$157 million and that it generates approximately \$7.6 million of welfare benefits per year.

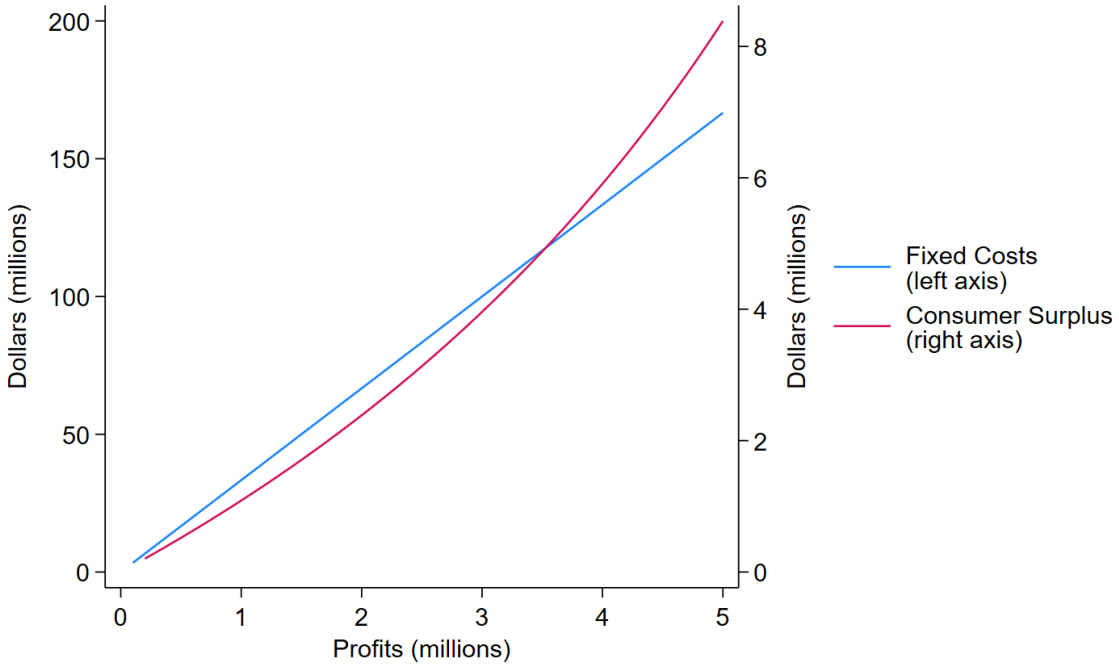
To see how these values change with the marginal entrant's profits, Appendix Figure B7, plots the fixed costs and per-year welfare benefits of entrants for various values of assumed profits.

The figure shows that as profits rise, the marginal entrant's fixed costs must also rise. This is a natural consequence of the zero-profit condition. The figure also shows that as per-period profits for the pharmacy program rise, per-period consumer surplus also rises for the marginal entrant. If the program is making \$1 million in profits, consumer surplus is \$1.09 million. If the program makes \$2 million, consumer surplus is \$2.39 million. By the time the program earns \$5 million, consumer surplus becomes \$8.39 million. If the market is in a long-run equilibrium, then the marginal firm's per-period profits are exactly offset by the fixed cost of entry leaving consumer surplus as the overall impact on social welfare in the market for pharmacy education.

Of course, this back-of-the-envelope approach is somewhat limited in what it can address and it relies on a number of additional assumptions that might not be true (e.g. no income effects on enrollment demand, that potential enrollees have good information on all of the factors relevant to going to pharmacy school so that their revealed choices are informative about welfare, etc.). If we were to adopt additional structure, there are a number of interesting counterfactuals that could be addressed. However, that is beyond the scope of the current paper.

[37] We assume that the discount rate, β, is 0.97.

Figure B7: Fixed Costs and Consumer Surplus as a Function of Profits



Notes

C Accreditation

In 2019, the executive director of ACPE (who has held that role for 20 years) wrote an opinion piece explaining why the ACPE continues to approve new pharmacy school openings despite calls to act as a gatekeeper to restrict new programs to keep salaries high. Part of this quoted below.

> We live in a free market society. When I started in my position, pharmacy had 78 accredited schools, and we were graduating approximately 7,000 students a year. Because projections were made of an upcoming pharmacist shortage due to an aging population with increasing medication needs, existing colleges and schools of pharmacy expanded their class sizes and/or opened branch campuses. Many new schools began to apply for accreditation.
>
> Now we have 143 accredited schools and are graduating approximately 14,500 students per year. Until recently, this dramatic increase in graduates has been accommodated by the job market, with almost all students having employment options, although lately, not always in their preferred geographic area.
>
> This is the type of market response I learned about years ago in economics. Had ACPE acted to limit the growth of existing programs or new ones, many of the new graduates would have been robbed of the opportunity to practice pharmacy.
>
> Educational program accreditors do not exist to control the employment markets of their associated professions. ACPE's standards are based on quality, not quantity. Our focus is making sure students have the best information to make career and program decisions at the time of application. Source: Vlasses (2019)

This view is not universally held. A change.org petition starting in 2019 has nearly 25,000 signatures and calls for a pause to all new accreditation (until 2030) among other restrictions.[38]

[38] https://www.change.org/p/protect-the-profession-we-honor-and-cherish-for-the-coming-decade-and-beyond?recruiter=935439682

D Estimating the Fraction of Growth in Pharmacy Enrollments that is Correlated with Pharmacists' Wage Growth

In this appendix section, we explore the sensitivity of our estimate of the fraction of growth in pharmacy enrollments that is due to pharmacists' wage growth (and anything correlated with observed wage growth) along four dimensions. The first is the elasticity of demand for enrollment in pharmacy schools. The second is the functional form of the supply and demand curves in the market for pharmacy education. The third is the degree to which potential pharmacy students are able to forecast wage growth in the market for pharmacists. The fourth is how to scale the relationship between pharmacists' wage growth and demand for pharmacy enrollments over time. Note that all wages were converted to real 2010 dollars for this exercise.

As stated in the text, we have not found any estimates of the elasticity of demand for a spot in a pharmacy school. In our main model specification, we assume that the elasticity of demand is -0.29 based on Denning (2017). However, it seems likely that this might overstate the elasticity of demand since it comes from the context of community colleges. Students at community colleges are more likely to be on the margin of schooling or not than high-achieving students enrolling in advanced degree programs. Because of that, we re-estimate our model under the assumption that demand is completely inelastic and under the assumption that the elasticity is -0.10.

In our primary specification, we assumed that the supply and demand curves both had a constant elasticity. In many cases, a natural alternative would be to assume that the demand curves are linear; when changes in the market equilibrium are relatively small, linearity is a reasonable approximation. We did not default to linearity in our case because enrollments grew so much over time. However, in this appendix, we will present results under the assumption that both the supply and demand curves are linear.

The third dimension we will allow to vary in this appendix is the information that the potential pharmacy student uses to forecast wage growth in the pharmacy market. Past research suggests that medical students form wage expectations that are not simply today's wages nor are they able to perfectly predict what their wages will be in the future (i.e. not an extreme form of rational expectations) (Nicholson and Souleles, 2001). We test out a number of different alternatives: 1) wage growth from the previous ten years, 2) wage growth from the present to the next ten years (comparable to the rational expectations approach), 3) the same as 1), but using wage growth relative to wage growth for those with a BA, 4) the same as 2), but using wage growth relative to wage growth for those with a BA.

The final piece of the model that we vary is how the relationship between pharmacists' wage growth and pharmacy school enrollments is scaled over time. In our preferred setup, we estimate the growth in pharmacy school enrollments between 1990 and 2000 and compare that the growth in pharmacists' wages from 1980 to 1990. Once we have that number, we have to decide how to apply that the present time. We do this in two ways. Our baseline method is to scale the growth in enrollments by each dollar of growth in pharmacists' wages. Our second method is to scale enrollment growth by a percentage point increase in pharmacists' wage growth.

The results are presented below in Appendix Table D7. The top panel in the table corresponds to supply and demand curves that each have their own constant elasticity; the bottom panel assumes the supply and demand curves are linear. Within each panel, the row corresponds to the elasticity of demand specified in the first column. Subsequent columns describe the way that pharmacists' wages affect pharmacy school enrollments as well as how these changes are scaled to the 2000 to 2010 time period. Each entry in the table is the fraction of the observed in-

crease from 2000 to 2010 in pharmacy enrollments that could be attributed to the growth in pharmacists' wages (and correlates of wages).

Table D7: Fraction of Observed Demand Related to Pharmacist Wages (and Correlates), 2000 - 2010

	Lagged wage growth, per dollar of growth	Lagged wage growth, per percentage point	Current wage growth, per percentage point	Lagged relative wage growth, per unit of relative wages	Lagged relative wage growth, per percentage point
Constant elasticity supply and demand					
$\varepsilon = -0.29$	0.21	0.12	0.13	0.25	0.22
$\varepsilon = -0.10$	0.23	0.16	0.17	0.27	0.24
$\varepsilon = 0$	0.24	0.18	0.19	0.27	0.25
Linear supply and demand					
$\varepsilon = -0.29$	0.44	0.36	0.37	0.47	0.44
$\varepsilon = -0.10$	0.33	0.27	0.28	0.37	0.34
$\varepsilon = -1^{-10}$	0.24	0.18	0.19	0.27	0.25

The elasticity of demand is given by the specified value of ε. The elasticity of supply is estimated from 1990 and 1995 data.

For specifications with constant elasticity supply and demand curves, reducing the elasticity of demand tends to increase the fraction of enrollment growth that can be attributed to pharmacist wage growth and its correlates; for linear supply and demand, the opposite is true. Moving from a scaling factor that is per dollar of growth to a scaling factor that is per percentage point tends to reduce the fraction that can be explained by pharmacists' wages. Using relative wages rather than the levels of wages produces results quite similar to our baseline specification.

While there is some variation in the fraction that can be explained by wages, there is always a substantial fraction left over not explained by wages.

E Details of the IPEDS data

There are two main issues that must be addressed when using IPEDS data. First, IPEDS surveys have changed over time. This requires researchers to aggregate variables to be consistent over time or to harmonize the variables in some other manner. Second, is how multi-campus institutions report their data. In some cases, the data is aggregated up to the entire system while in others, it is reported at a more granular level. Below, we provide information on how we address each of these issues.

E.1 Creating consistent measures

We use data from the Institutional Characteristics, Fall Enrollment, Human Resources, and Student Financial Aid surveys to build a panel spanning the 1992-1993 and 2017-2018 academic years in addition to the Urban Institute's harmonization of the Finance survey data. We harmonize/aggregate variables from these surveys as follows:

- Post-baccalaureate enrollment contains two categories of students, graduate and first-professional, that are reported together in some years and separately in others. We combine the groups in the years where necessary and refer to these students as "graduate" students.
- The variables in the Finance surveys vary by year and type of school, e.g. public/private, non-profit/for-profit. We use the Urban Institute's harmonization of these surveys (which in turn built upon the work of the Delta Cost Project). Details on the Urban Institute's process and data can be found in (Blom et al., 2020)

E.2 Multi-campus Institution Reporting

In IPEDS, multi-campus institutions, e.g. the University of California system or the University of Wisconsin system, report some variables together for all campuses and other variables individually, and that reporting changes over time. To address this issue, we aggregate campuses within the institution. The details of this aggregation follow.

First, we implement a set of sample restrictions to help identify the flagship school in each system. We 1) require that schools with new pharmacy programs have IPEDS data for two years prior to opening their pharmacy program, 2) restrict control schools to have graduate programs for more than 85 percent of the sample years, 3) remove theological schools, 4) require that institutions have at least 500 students, 5) remove for-profit institutions, 6) remove institutions that change their identifier (OPEID, discussed shortly), and 7) remove institutions located outside of the United States. From there, we use each campus's identifier, the OPEID, which is an eight digit code assigned to campuses by the U.S. Department of Education's Office of Postsecondary Education. For the vast majority of institutions, each campus within the institution is assigned the same OPEID. Thus, with the set of flagship institutions and their OPEIDs, we go back to the whole sample and aggregate all of the campuses into the flagship campus's observation if they share the same OPEID.[39]

Once the variables have been aggregated to the OPEID level, we take data from the 1997-1998 academic year and see how many different campuses fed into the variables for each OPEID. Then by OPEID, we divide each variable in each year by the relevant number of campuses. By doing so, the flagship campus becomes a representative for the entire system. On average, approximately ten percent of the observations in our sample represent multi-campus institutions

[39] The exception is when an OPEID contains a campus that is for-profit. If that is the case, then we exclude all campuses with that OPEID.

and, conditional on being multi-campus, there are 2.7 campuses per institution.