How Responsive is Higher Education?
The Linkages between Higher Education and the Labor Market

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Working Paper: March 2011

Abstract:

Higher education is considered vital for developing a productive and dynamic labor force to meet the demands of the global economy. How effectively does the US higher education sector respond to labor market signals? We match US post-secondary degree completions from 1984 to 2008 with occupational employment statistics and employ an instrumental variables strategy to examine the supply response to changes in occupation specific demand. The supply of educated workers appears weakly responsive to short-term wage signals and moderately responsive to longer-term employment conditions. Analysis reveals a sizeable degree of heterogeneity and lag in the responsiveness across specific occupation-degree pairings. Failure to respond rapidly to changes in labor demand may be one factor driving inequality in wages across occupations and in the aggregate economy. We suggest some simple policy measures to help increase the responsiveness of the higher education sector, both in terms of the output of specific degree programs and the overall mix and composition of graduate completions.

Acknowledgments: We are especially grateful to David Autor, Joan Hamory, Barry Hirsch, Cynthia Kroll, David Levine, Richard Lyons, and Edward Miguel for their encouragement and suggestions. We would also like to thank seminar participants at the Sloan Industry Studies Conference 2009, the 2009 AEA meetings, and the Center for Studies in Higher Education for helpful comments and discussions.

I: Introduction and Motivation

The last decade has witnessed the rapid growth of a globally integrated labor market. Competitive pressures are increasingly felt not just across countries, but at the level of occupations and individual workers. Significant attention has therefore been directed towards education reform in an effort to prepare a skilled and dynamic work force capable of coping with these challenges. This paper focuses on allocative efficiency: examining the post-secondary education sector's responsiveness to signals from the labor market. In particular, how effectively does the *quantity and composition of post-secondary degree completions* respond and adjust to labor market signals? What are the implications for policy?

Our analysis suggests that the overall system of higher education in the United States is moderately responsive to labor market signals. Previous growth in demand, including both increased employment opportunities and rising wages for specific occupations is associated with higher levels of current completions. This association is strongest around lags of four to seven years, consistent with the time to degree at a four-year institution or the time to degree required in specialty programs. Furthermore, we find that there is a great deal of heterogeneity in responsiveness across degree programs and their corresponding occupations. Degree completions provide a measure of both individual and institutional responsiveness because student interest has to be coupled with increased enrollments made available by schools. Some programs appear highly responsive to labor market outcomes, whereas others such as doctors of medicine and medical dentistry appear largely unresponsive, consistent with anecdotal evidence that institutional barriers restrict the flexibility of higher education in the US.

This paper makes several important contributions. First, we create a new dataset by combining information on post-secondary degree completions from the Integrated Postsecondary Education Data System (IPEDS) of the National Center for Educational Statistics (NCES) with occupational employment data from the Current Population Surveys (CPS). This entails matching individual degree programs from the former with the detailed occupations in the latter. Second, our analysis focuses on the responsiveness of numbers graduated across these pairings to demand side signals from the labor market at the level of the individual occupation. This methodology enables us to examine changes over time within specific pairs of degrees and occupations. Third, by employing a subset of time-consistent occupations from the CPS, we are able examine long lags and to employ an instrumental variables approach to circumvent common problems such as simultaneity when estimating the effect of occupation specific demand growth on educational output. Our analysis involves instrumenting for occupational demand using occupation specific retirements (which we in turn estimate from occupational age structure). Finally, we discuss potential informational and institutional reforms to make the "supply-side" of higher education more elastic.

Our paper is structured as follows. Section II provides background on related literature. Section III describes the data sources employed and the methodology used in matching consistent specific occupations and degree programs. Section IV provides summary statistics and discusses selected individual occupation-degree pairs. Section V presents empirical analysis. Section VI concludes.

II: Related Literature

The relationship between higher education and the labor market has been studied extensively by economists. A number of papers have analyzed incentives to invest in human capital, returns to education, and individual response models (Card, 2001; Leslie and Brinkman, 1987; Psacharopoulos and Patrinos, 2004). At the national level, the evidence generally suggests that schooling choices are responsive to changes in the rate of return to education. Several authors have document enrollments increases when the return to education rises (Mattila, 1982; Walters, 1986; Mincer, 1994). Others have examined aggregate changes in demand and supply. For instance, Bound and Turner (2007) examine college enrollment on the supply side exploiting the pressure placed on government provision of higher education using variations in demographic cohort size across generations. They find large effects with increased cohort size decreasing college completion rates. They also show that the responsiveness of colleges to cohort size differs dramatically by type of institution with community and public institutions being much more responsive than private liberal arts institutions.

There is also abundant micro-level research. Freeman (1986) surveys the literature providing labor supply elasticities for individual occupations and notes that "U.S. survey evidence provides additional support for the notion that students are highly responsive to economic rewards in decisions to enroll in college." He argues that in general, these elasticities are large, and when combined with evidence on wage growth, are sufficient to explain a sizeable share of student enrollment and degree completions. Other studies have focused on individual programs such as Hansen (1999) which examines the market for economics PhDs and Ryoo and Rosen (2004) which finds a strong connection between observed labor market variables, such as wages and demand shifters like R&D spending, and engineering student enrollment decisions. Psacharopoulos (1986) provides an evaluation of efforts around the world to integrate higher education more closely with the labor market. He argues that individuals may in fact be better at making this link than institutions.

The closest exercise to our own is that of Freeman and Hirsch (2007). The authors link US degrees with the "knowledge content" of occupations listed in the O*NET occupational coding scheme. This pairing scheme covers 27 specific areas of knowledge. College major choices are found to be responsive to changes in the knowledge content of occupations and, to a less robust extent, to wage differentials. A relative strength of their work is that by focusing on knowledge categories, they effectively limit concerns over occupational switching – as they build pairings off of broader skill sets.

Our work is similar in spirit, but focuses on a more disaggregated matching scheme, pairing individual or small sets of degrees directly with an occupation or cluster of related occupations, rather than pairing across broader knowledge categories. This allows us to examine individual markets, control for a range of individual characteristics within specific occupations, and to employ an instrumental variable approach. Freeman and Hirsch focus specifically on bachelor's degrees, which drives their empirical approach of fixing a 4 year lag for the analysis. This paper, in contrast, deals the quantitative responsiveness of the educational sector to labor market demand across a spectrum of occupations and fields at multiple degree levels. As such we take a less parameterized approach, exploring responsiveness across multiple lags.

Similar research has been done outside the US. For instance, Boudarbat (2008) examines the Canadian National Graduate Survey and focuses on students' choices concerning field of study. Utilizing a repeated cross section of community college students who graduated from 1990 to 1995, he finds that individuals are heavily influenced by their anticipated earnings in a given field relative to those in other fields. In related work, Boudarbat and Montmarquette (2007) find that Canadian students are influenced by the expected lifetime earnings from a particular field of study, conditional on their parents having less than a college education.

Dougherty and Psacharapoulous (1977) analyze the costs associated with the misallocation of educational resources across countries. While their analysis is focused on the entire educational sector, the authors estimate that in some cases, costs are as large as the entire educational budget itself. The potential benefits of a more responsive educational sector include more flexible labor markets, lower frictional unemployment (search costs), and potentially reduced aggregate inequality if demand is rapidly increasing for skilled or well paid occupations. In the case of a specific occupation, a more elastic supply would suggest that for a given increase in demand, more of the adjustment would occur in employment than in wages, implying a beneficial terms of trade effects for those purchasing the services of a specific occupational group. An analogous argument has been made before, both in trade theory and in debates on skilled immigration in response to occupational cartels (Baker, 2008).

Policy discussion surrounding the future direction of the US higher education system is often broadly focused. Blinder (2008) makes the case that in order to remain competitive the education sector should focus on training individuals to provide personal or face to face services, because these skill sets will remain valued as the world transitions to freer trade in impersonal and tradable services. Our analysis abstracts from this issue from a policy perspective and attempts to shed light on the flexibility of higher education in the US by examining responsiveness over time within individual markets.

III: Data Description

We utilize data from several sources in our analysis.[1] Data on educational degree completions and enrollments is available in the Integrated Postsecondary Education Data System (IPEDS), compiled by the National Center for Educational Statistics (NCES). Our focus is on completions, not enrollments, because completions data span a broad range of majors and are affected by student decision making within an institution. The IPEDS covers all degree completions in programs designed for US students beyond the high school level and cover the period 1984-2008, although in some cases degree coding has been fine-tuned and over the years new degree programs have been added.[2] Degree programs are classified according to the Classification of Instructional Programs (CIP) codes created and maintained by NCES. Beginning in 1980, NCES has since updated the CIP coding system in 1985, 1990, and 2000. In order to create a longer time series for some of the analysis provided in the next two sections, we

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[1] A complete discussion of the data can be found in the appendix.
[2] The IPEDS database is described and accessible from https://surveys.nces.ed.gov/ipeds/

have employed the official CIP crosswalks provided by NCES, which reconcile changes to the coding system over time, to maintain as much comparability as possible for many of the major instructional programs.[3]

Data on occupational characteristics, wages, and employment for the period 1984-2008 are taken from the Center for Economic Policy Research (CEPR) Uniform Extracts of the Current Population Survey (CPS) Outgoing Rotation Groups. The CPS Outgoing Rotation Groups (ORG) comprise a subsample of the 60,000 individuals interviewed yearly for the CPS, for whom information on usual working hours and hourly earnings are obtained. In a given month includes labor market outcomes and on background characteristics for approximately 30,000 individuals.[4] Because individuals in the CPS are resurveyed and thus can appear in two years of the sample, we have adjusted our analysis for Huber-White standard errors as suggested in Feenberg and Roth (2007). In order to obtain a set of occupations which are consistent in definition and coverage for the period 1984-2008 we employ the Meyer and Osborne (2005) classification scheme for matching across the 1980, 1990, and 2000 census occupational coding schemes.[5]

The NCES provides a formal crosswalk between CIP educational program codes and the Census 2000 occupation codes used in the CPS. Some occupations and degrees are clearly better matched than others such as for degrees which have less mobility across different occupations. For example, an individual earning a degree as a licensed vocational nurse is highly likely to seek employment as a nurse. We have narrowed the NCES crosswalk to a selection of 79 matches for which there is a clear correspondence between educational degree program and occupational code over our entire sample period using systematic rules and common sense. For instance, we require pairs to have completions and employment data for all paired years, occupational employment and completions to exceed 5000 and 1000 respectively in all paired years, employment to exceed completions for all paired years, and drop pairs with annual changes in completions exceeding 250% for any year.[6]

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[3] Full documentation and CIP crosswalks can be accessed from http://nces.ed.gov/pubs2002/cip2000/

[4] The CEPR Uniform Extracts have been manipulated in order to obtain a robust hourly wage series. Adjustments to the CPS data include a log-normal imputation and adjustment for top-coding, exclusion of outliers, and an estimation of usual hours among some survey respondents. This treatment is described in detail in Schmitt (2003).

[5] No completions data was released by the NCES for the year 1999, leaving us with 24 years of data.

[6] This excludes a number of degree programs which undergo CIP changes and relabeling which would otherwise yield unreasonable jumps in completions.

An effort was made to exclude links for which individuals earning a degree could pursue a very wide range of occupations, including those which are beyond the crosswalk. For instance, CIP code 260401 for students earning degrees in Cellular Biology and Histology are linked by the NCES to Natural Sciences Managers, Biological Scientists, Medical Scientists, and Postsecondary Teachers. The reason for excluding these matches is twofold – in part because the degree was linked to multiple Census 2000 occupations, and in part because these four occupations would still likely not catch the majority of graduates with this degree.

Furthermore, in a small number of cases, individuals earning a particular degree would work likely pursue work in one of a small number of occupations and would be expected to be motivated by the wages and employment prospects of this small number of occupations. For example, individuals earning a degree in funeral service or mortuary science are likely seeking employment in a specific occupation. Table 1 provides an example of a one to one match, a one to many match, and a many to many match.[7] Where there were multiple matches on the education side, we linked degree and occupation by summing completions across the corresponding unique degree programs. When there were multiple occupation matches on the employment side, we summed employment across occupations and calculated a weighted average of the wages among the linked occupations, where the weights were the employment share of that occupation as a fraction of all linked occupations in that grouping. In this way we were able to preserve the total wage bill of the occupations in the pairing and provide a proxy of the expected wage one might expect from work in one of many similar occupations.

It should be noted that our system of education-occupation pairs adds an additional level of precision to the crosswalk provided by the NCES. In addition to linking degrees to occupations we also take into account the level of the degree program completed. For instance, only individuals receiving a Ph.D in a designated number of CIP fields are linked to post-secondary professors. In this case, limiting to Ph.D completions gives us a more accurate link between degree and occupation. Grouping similar occupations and limiting our analysis to specific occupations within the Meyer and Osborne (2005) set of consistent occupations, we are able to match 79 occupations and degree pairs for the entire 1984-2008 period.

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[7] The appendix and an online data manual provide a complete description of the matching exercise, lists of included and excluded occupation-degree pairings (by reason for exclusion), and discuss alternative pairings schemes.

Table 2 explores the degree to which our sample is representative of the US higher education system as a whole. Because many pairs contain multiple CIP codes and because the sample is comprised predominantly of larger degree programs, the linking covers roughly half of the degree programs and 75 to 80% of total degrees awarded in the US over the sample period. Total completions awarded have more than doubled from around 2 million a year in 1984 to 4 million a year today. Given both additions and reduction to program classifications, the total number of CIP degree programs has fluctuated and only grown modestly. Taken together, these facts imply increasing numbers of degrees awarded per degree program. Aggregate Completions estimates are consistent with a growing and increasingly educated workforce but also mask growth heterogeneity across degree programs which we explore in greater detail in Section IV.

The representative nature of our sample and of our linking exercise in terms of wage and employment is examined in detail in Table 3. Our sample is heavily skewed towards larger and higher paying occupations. While our sample covers roughly one fourth of all occupations, these comprise three-fourths of the total working population. Consistent with most of these occupations requiring a post-secondary education, the mean wage in these occupations is about 135% of the US average. The sample is also a revealing source for macroeconomic patterns over the past 22 years. Total employment has increased from 105 million in 1984 to 145 million in 2008, expanding at a much slower rate than the rate of completions growth. Real wages calculated using the CEPR's preferred methodology have expanded from about $34,000 in 1984 to around $42,000 today.

Table 4 compares occupation level characteristics from the paired sample to the full US CPS sample, pooling over all 24 years of data. Workers in our sample are similar to the total US workforce in many respects. Specifically, workers in paired degrees are more likely to be married (60% vs. 65%) or work for the government (15% vs. 21%). At the same time, fewer individuals in our sample are paid by the hour (60% vs. 38%) or unionized (15% vs. 12%). A significantly larger share of our sample has a degree above a high school diploma - 84% have greater than a high school diploma in comparison to 55% for the US as a whole over the same period. This suggests that our paired occupations are appropriate in the sense that they predominantly employ individuals who have completed a post-secondary education.

Ideally, we would have liked a higher share of total occupations and degrees paired and we recognize the limitations of our matching exercise. Nonetheless, we do not believe that selection and construction are likely to introduce systematic bias as our occupation and degree completion pairings constitute a sizeable and representative share of both the US higher education system, as well as of relevant portions of the labor market. Even if our sample is heavily comprised of jobs which clearly demand a high degree of specialization, because of their inelastic nature, this should also be the segment of higher education where one should care about the responsiveness of individual degrees as opposed to focusing on the aggregate supply of college graduates which instead should be relevant for highly substitutable occupations.[8]

Section IV: Total Educational Output and Individual Case Studies

Figure 1 tracks yearly absorptions (net changes in employment), wages and degree completions at the aggregate level. Mean wages and employment in the US have increased over the period, stagnating only briefly during the early 1990s recession and again from 2002-2004. The high level of degrees earned relative to absorptions by the labor market reflects both the retirement of skilled workers and an overall increase in the skill level of the labor force as the occupational structure of the economy has evolved.

The correlation of degree completions and lagged employment growth across a range of lagged values for absorptions are plotted in Figure 2. The correlation rises from roughly .15 the previous year to .3 in years 4 through 7 and then subsequently falls. While these are not particularly large correlations, they are consistently positive and informative about the time lag in responsiveness of the higher education sector. Specifically, this suggests that the largest impact of the labor market on schooling outcomes operates with a rather sizeable delay.

Rapid growth in completions discussion in the previous section masks a great deal of heterogeneity in several ways. First, the number of graduates has been increasing most rapidly among post-secondary degrees of two years or less. At the same time, growth of degree completions at the Masters and Ph.D levels have outpaced those of Bachelors suggesting that a greater fraction of those who complete college are continuing on further with their education. Second, these values disguise a great deal of across occupation heterogeneity.

Just how responsive are individual degree programs? One concern is that US level data may appear unresponsive only as a result of aggregation across occupations. Some occupations

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[8] Very broad and general degrees likely fill a need for flexibility in the labor market and should be extremely relevant among occupations with a good degree of on the job training. We should also be concerned about "aggregate" responsiveness in and of its own right.

are highly responsive, albeit with a lag. Perhaps the clearest case of this is for computer scientists. Figure 3 documents a rather steady rise in absorption and wages for computer scientists in the mid-to-late 1990s. The response of the higher education sector is rather dramatic, with completions nearly doubling from 1998 to 2002. Degree completions are clearly indicative of a lag in responsiveness of roughly 4 years, with employment growth peaking in 2000 and completions peaking around 2003. Accounting for the lag, completions appear to track outcomes in the labor market (as during the technology boom of the 1990s). One potential explanation for the rapid responsiveness among computer science is a lack of strong barriers to the creation of new IT programs and schools, particularly those with associate and professional degrees, as well as the low cost of marginal enrolments.

Among some occupations, it is unclear that completions are responsive to even long-term secular growth trends in total population, employment and wages. Figure 4 suggests that in spite of rather large volatility in terms of both job creation and real wages, the number of architectural degree completions has remained relatively flat for the past two decades. Figure 5 illustrates this case for physicians as well, but it is typical of other professional occupations such as dentistry. Annual completions of MDs have remained largely unchanged in the US over the past two decades, in spite of rather sizeable growth in real wages, employment and an ageing population. This implies that employment growth of doctors in the US has in part been met with imported labor through programs such as H1B visa programs. The expansion of these programs and a more responsive labor supply in general for doctors is considered a critical concern in the current debate surrounding health care reform (Bhagwati and Madan, 2008).

In addition to technological progress and changes in consumer, other degrees are impacted by demographic factors. Figure 6 profiles licensed practical and licensed vocational nurses. Employment levels declined during the 1990s and concerns over a growing shortage of nurses led to successful lobbying for special immigration status for nurse practitioners under H1C visas beginning in the late 1990s. The large negative absorption for this occupation, even given immigration, is likely attributable to attrition. Nursing is classified by the BLS as an aging occupation, with the average age of licensed practical nurses above the norm for US occupations and the consequent surge in retirements driving the need for replacements.[9]

Why are some degree programs like computer science so responsive and others like MDs rather unresponsive? There are a number of possibilities. The first is that specialist occupations such as doctors, dentists, and lawyers operate under a high degree of regulation and oversight. Regulation may come from institutions such as the American Medical Association (AMA), the American Dental Association (ADA), and the American and State Bar Associations, or it may come from governmental agencies and legislation. In many cases, individuals in these fields must pass qualifying examinations or obtain certifications before beginning employment even after earning their educational degree, which can take additional months or years of study and may entirely exclude some individuals from entering that particular market. This is the conclusion of Kleiner and Kudrie (1992), who study licensing restrictions for dentists and of Tenerelli (2006) who examines entry constraints in the market for physicians.[10] Another possibility is that if these occupations require learning by doing or on the job training, the total time required to enter the market may be greater than the actual time to degree completion which would drive a wedge between labor market signals and degree completions.

V: Empirical Results and Analysis

In this section we examine the strength of the relationship between post-secondary degree completions and labor market signals such as wage and employment growth. How reactive is the US supply of higher education to the demands of the labor market? If the educational sector is responsive, which signals does it use? In theory, a number of factors come into play in determining both labor supply and labor demand for educated workers. From an accounting standpoint, we consider changes in employment, recognizing growth from factors such as new entrants such as new degree completions, reentrants of former workers, immigration (for instance through H1B visas), and reductions from retirements and firings. Conceptually, we would expect absorption to be related to completions in the following manner:

$$(1) employment_t - employment_{t-1} = completions_t + reentrants_t + immigration_t - retirements_t$$

[9] This is true for a number of other occupations such as dentistry. For example, the median age of US employees in 1998 was 39 and the percent employed aged 45 and over was 33.7%. Among dentists the comparable figures are 45 years and 51.3%. For a complete list of occupations, visit: http://www.bls.gov/opub/mlr/2000/07/art2full.pdf.

[10] This may manifest in a high cost of increasing supply, particularly barriers to entry. For example, it is often mentioned that costs associated with the creation of new schools of medicine is prohibitively high.

Given the complexity of the education-labor market relationship in equation (1) as well as the nature of the data we employ in our analysis, there are a number of limitations to our empirical approach. This section attempts to address them ab initio. A primary concern in our analysis is the issue of sample selection. The education-occupation pairs included in our sample are predominantly composed of occupations which require a high degree of specialized training. In part this is tautological because pairs are only defined where tertiary completions data exists. But, it also results from the fact that matches are much cleaner for occupations requiring a specific skill set for which there is a particular type of training. Focusing on the most robust matches gives us a more accurate picture of the linkages, but limits the degree to which one can generalize our results. A good example would be college professors, where in most cases a Ph.D is required, or lawyers where in many cases a J.D. is necessary.

Furthermore, for education-occupation pairs in which tertiary education is not required, the post-secondary degree linked to these pairs may only be relevant for a small subset of new hires. For instance, students may obtain specialized degrees as a musician or composer, but clearly not all individuals working as musicians or composers have these degrees. While we might still expect these degree programs to respond to economic incentives, because of the greater disconnect we might expect to see a greater degree of noise in the relationship. This form of sample selection suggests that our findings are more clearly interpreted in relation to specialized degrees and occupations.

Another key concern is the existence of occupational switching. When demand for a specific occupation rises rapidly, if the higher education sector does not respond promptly, some of that demand may be met by individuals switching from other related occupations. Because our focus is predominantly on occupations requiring a higher education degree, this switching is likely limited to individuals in related fields, and the degree of occupational mobility is likely to vary across groups of occupations and degrees. Given this variation, one concern is that the size of the error induced by this effect will vary across pairs and bias the errors in our regressions. In order to account for this, we have created broad industry categories on which we cluster our standard errors.[11]

[11] We have run the analysis with and without clustered standard errors and the primary results are not dramatically affected.

Another first order concern is that causality runs in both directions. While labor market variables likely influence decisions regarding schooling, the supply of post-secondary educated workers is also likely to impact wages and employment outcomes. We first employ lagged values for our labor market variables of interest. Contemporaneous completions should not affect previous years' employment or wage growth – although they may still be related to previous year's completions and those completions may be related to labor market variables in the past. While this may not totally alleviate the problem of simultaneity, the lag structure itself may be of descriptive interest.

In order to address the problem directly, we employ an instrumental variable - the age structure within an industry. Retirements create job vacancies and are largely a function of employment prospects in the distant past as well as demographic trends. They are likely to be related to growth in employment opportunities, but otherwise unrelated to the number of individuals earning a degree directly. While we cannot observe retirements directly, we can proxy for them using the age structure of the occupation, with aging occupations likely to have higher rates of retirement. This analysis is described further in section V.I.

Omitted variable bias is another possible issue, as the decision making involved in an individual's educational choices and firm hiring decisions are complex phenomenon. As a first pass, we include reasonable controls from the CPS for individual occupations such as degree of unionization. Further, in a number of specifications, we include degree-occupation pair fixed effects. Doing so limits our identification to within pair variation over time, and thus helps isolate the effect of labor market signals on completions changes from any factors which may be specific to particular pairings.

Since we look at completions rather than enrollments, another concern is that our results are tempered by drop-outs. If the dropout rate for an occupation is systematically positively correlated with labor market signals, i.e. increasing wages lead to increasing drop-outs then it is possible. However, it is more likely that the opposite is true. Graduates opting for another degree immediately after graduation can also generate noise in the data, but it is difficult to envision a systematic bias that would be large enough to materially affect our results.

Finally, given the idiosyncrasies from year to year among occupation and degree coding schemes there are occasionally discrete changes in definition and coverage. Furthermore because both completions and the labor market are heavily influenced by the state of the overall macroeconomy and demographic profile of the US they are likely to both be trending up or down over time. To help address both of these issues, we include year fixed effects.

To determine the responsiveness of post-secondary degree completions to labor market signals, we then run a number of OLS regressions of the following form:

$$(2)\quad \ln(completions_{it}) = \alpha + \beta_{\tau}\ln(X_{i,t-\tau}) + \delta_1(Z_{it}) + \Omega_i + \Phi_t + \varepsilon_{it}$$

where subscript i indexes a given occupation-degree pair and t indexes time. τ represents the lags on our X variables and varies from 1 to 10 years depending on the specification.[12] X are measures of labor market demand at the occupation level such as occupation-specific absorption. Z is a vector of controls derived from the CPS data at the occupation level. This includes the share of individuals in a given occupation who are female, married, unionized, self-employed, or employed by the government, as well as their average age and average weekly hours. Ω_i represents individual degree-occupation pair fixed effects and Φ_t captures time fixed effects. Pair fixed effects absorb any information specific to individual sets of paired and occupational degrees, so that identification comes from changes in degree completions and absorptions over time within individual sets of matched degrees and occupations. If there is any concern that factors specific to individual occupation-degree pairs may drive the results, the inclusion of pair fixed effects should soak up this idiosyncratic variation.

The results from running regression equation (2) for the full 1984-2008 period are presented in Table 5. In an effort to be parsimonious, we begin the analysis by including lags of up to 10 years, which is possible because of the long time series. Several things stand out. First, historical growth in employment is associated with increases in completions. For instance, from column (1) we observe that an increase in absorptions of 10%, 4 years in the past, is associated with a 1.6% increase in completions today. This effect seems to level off for employment growth about 7 years prior. It is not especially surprising that absorptions are significant from one to seven lags given that the time to degree varies across degree programs. Nevertheless, these results suggest a sizeable lag in the full response of the educational sector to growth in labor market opportunities. Standard errors rise once we cluster on industry type in column 2, and in some cases lagged absorption becomes insignificant. Nevertheless, in almost all cases the coefficients are still positive and we still observe increasing magnitude through seven lags.

[12] In some specifications we vary the number of lags. This is often because additional lags were uninteresting, as the association between labor market signals and completions appears to taper out at varying lags for different variables.

Some occupation-degree pairs comprise a larger share of total employment than others. While pair fixed effects and the use of logs should largely address concern, we additionally to use weighted least squares (WLS) to account directly for variation in the relative size or share of each linked degree and occupation grouping. A simple way to do this is to utilize the total employment of the paired occupations as weights. This weights each pair by its relative share of total employment in the sample.[13] WLS results are presented in columns (3) and (4) of Table 5. The use of WLS attenuates the results and estimated coefficients on log absorptions are slightly smaller in magnitude than the OLS results. Furthermore, the inclusion of clustered standard errors in WLS specifications completely removes significance, although again, the magnitude and sign of the coefficients remain similar and the WLS results largely echo those of OLS.

Table 6 examines the relationship between completions and a proxy of employment demand. Specifically, we create an occupational payroll share measure which captures changes in an individual occupation's share of the total US wage bill; the justification being that changes in an occupation's share of the total US wage bill simultaneously reflects both a quantity (change in numbers employed) and a price (change in wages) signal. Specifically, ΔShareOcc = $(Emp_{i,t}*Wage_{i,t})/(Emp_{US,t}*Wage_{US,t}) - (Emp_{i,t-1}*Wage_{i,t-1})/(Emp_{US,t-1}*Wage_{US,t-1})$ would represent changes in a specific occupation (or set of occupations) share of US demand. The coefficients on ShareOcc presented are positive and significant. These results can be interpreted as with Table 5, a 10% increase in our Shareocc measure is associated with a 1.91% increase in completions 4 years later. Completions appear rather responsive to changes in the ShareOcc measure up through 8 lags. The positive coefficients are consistent with the previous findings on absorption and together are suggestive of a somewhat responsive but also lagged response of the higher education sector to the needs of the labor market. As with absorptions, longer lags appear to be more strongly related to completions growth than more recent lags.

V.I: Instrumental Variables

A major concern is that lagging our labor market indicators is not sufficient to address causal concerns. Because there is a good deal of autocorrelation in both degree completions and in employment and wages, we have to be concerned about reverse causality. Consider a regression of degree completions this year on a four-year lag of employment growth. If degree

[13] Results are largely unaffected by the decision to use a constant weight or allow the weight to vary across years.

completions today are a function of degree completions in previous years, and employment is affected by labor supply, then a four- or five-year lag of degree completions will affect both completions today and employment four years prior. One way to circumvent this problem is through the use of an instrumental variable, correlated with our labor market indicators but unrelated to degree completions.

One possible instrumental variable is the level of retirements. Retirements create job vacancies and are largely a function of employment prospects in the distant past as well as demographic trends. They are likely to be related to growth in employment opportunities, but otherwise unrelated to the number of individuals earning a degree directly. The evidence presented in our case studies and in Dohm (2000) suggests that there is a good deal of variation in the rate of retirements across occupations. For instance the average age of nurse practitioners and dentists is higher than that for the workforce as a whole, and these two occupations are experiencing higher-than-average numbers of retirements as the baby-boomers leave the workforce.

While retirements are not directly observable in our data, we do have a range of demographic information for each occupation because our occupational data are constructed from the CPS micro-data. From this information, we can construct the share of individuals in an occupation who are close to retirement age, i.e. above age 60.[14] As long as retirement age does not vary significantly across occupations than this should provide a proxy for overall retirements in a specific occupation in a given year. This is plausible given that we are already limited to a subsample of white collar occupations requiring post-secondary degrees. Occupations with a large existing stock of workers of retirement age in a given year are more likely to see increased retirements that year and thus have additional job openings and higher market demand.

Second stage results from running this IV strategy are presented in Table 8. Because of the large number of first stage regressions, we do not reproduce these results. In all specifications some lagged instruments are individually significant. Column 1 reproduces our preferred OLS specification. As an instrument for labor market absorption, therefore, we employ two separate strategies. Column 2 presents results from instrumenting using the share of workers of retirement age and the average age in the occupation. Column 3 presents results using as an

[14] We ran regressions using several variations: Share 55+, Share 60+, and Share 65+. Results were not dramatically altered. In practice using 60 and above yielded the most promising instrument as share 65+ lacked significant variation across occupations and share 55+ made less theoretical sense than looking at those closer to retirement.

instrument the log of total employment interacted with the share of workers of retirement age and interacted with average age. Ideally, higher numbers of individuals of or close to retirement age should influence occupational demand by creating more job openings, without influencing completions other than through these new absorptions.

The magnitude of the coefficients on absorption is significantly larger when estimated using our first IV in column 2. At the same time, this IV strategy reduces precision as seen in the larger standard errors. One concern is that the simply using the share of the occupation near retirement and the average age may leave the analysis facing a weak instrument problem.[15] This does not appear to be an issue for our second IV strategy. Here, we get results that are slightly smaller than the OLS results in magnitude and significant only from 3 to 6 lags. For example, a 10% increase in absorptions 4 years in the past is associated with a 1% higher amount of degree completions today. In theory, these IV estimates are preferable to both the WLS and the OLS outcomes because they circumvent concerns over omitted variables and address the problem of simultaneity mentioned above. The IV results, particularly from column 3 confirm our finding that completions are reasonably responsive to labor market signals at a duration that is consistent with time to degree in university.

V.II: Price and Demand Signals

A student's information on differences in work force prospects across occupations may be more heavily influenced by wages than employment opportunities, since market wages are frequently reported and often cited by collegiate programs themselves. In order to investigate the relationship between wage growth and completions, we estimate the following logarithmic regression:

$$(3)\ \ln(completions_{it}) = \alpha + \beta_1(\ln(wage_{i,t-\tau})) + \delta_1(Z_{it}) + \Omega_i + \Phi_t + \varepsilon_{it}$$

With the exception of the logarithmic transformation of completions and wages, this is the same regression specification as (1). τ represents lags. Z is our vector of labor market controls from the occupation-level CPS data. As before, Ω_i represents degree-occupation pair fixed effects and Φ_t time fixed effects.

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[15] Although the Anderson-Rubin test statistic indicated that the instruments are jointly significant, given the low value for the Kleibergen-Paap Wald F-Stat, one possible concern here is that the our instrument is weak, potentially pushing up our coefficients and standard errors in Column 2.

Results from regression equation (3) are presented in Table 8. It is perhaps less clear that long lags of wage growth should affect current completions and in all specifications we ran, only short lags were ever significant.[16] We observe a strong positive association between real wages and completions for short time lags. A coefficient of 0.213 in column 1, suggests that when wages rise by 10%, the associated level of completions in the following year is 2.13% higher on average. Several differences from the absorption results are worth mentioning. First, the relationship between wage growth and completions appears strongest for shorter lags instead of the significant longer lags of the previous analysis which implies that students may view wages as a more proximate signal than vacancies. Column 2 replicates the results using WLS, with employment for each occupational pair as weights. The results are remarkably similar to the OLS specifications and suggest that our results are not being driven by the finite degree of pairings we have chosen.

VI: Conclusion

This paper addresses the question of how quickly and effectively the supply of college educated workers responds to signals from the labor market. Several conclusions can be drawn from the analysis. First, at the aggregate level, growth in employment opportunities and in demand for specific occupations appears to drive increased completions. This relationship operates with a lag, with the strongest association for lags of 3 to 7 years – consistent with time required to obtain many post-secondary degrees or change degree major within a university. This relationship proved robust to the use of WLS and 2SLS IV estimators. Using a proxy for occupation specific demand combining both price and wage signals, we found that occupations with growing shares of the US wage bill were likely to see increased completions. This effect was robust across several specifications and stronger for lags for 3 to 7 years as with absorptions. Interestingly, the evidence on wage growth, a pure price signal, told a slightly different story. Within paired occupations over time, our results suggested that individual were somewhat responsive to price signals, but that the response of degree completions to a wage signal may be more proximate than to changes in employment opportunities.

[16] As such here we report results which include only 5 lags, as the benefits from shortening the lag structure - increased sample size and precision - seemed to outweigh the addition of uninteresting lags.

A case by case investigation suggested that there is a great deal of heterogeneity in the responsiveness of higher educational degree programs to corresponding occupations. While several degree programs such as computer science and information technology are highly responsive to labor market outcomes (albeit with a short lag), other degrees such as for medical doctors or doctors of medical dentistry appear largely unresponsive, even in the face of longer term trends.

Our sample constituted a sizeable share of both the US higher education system and the portion of labor market employing college educated workers. Nonetheless, a remaining concern is that our occupation and degree completion pairings may overweight narrower specializations by the very nature of our matching exercise. To the extent that narrower specializations might be more inelastic in their response to labor market needs, because of institutional, financial and personnel related constraints our results might not generalize beyond such occupations and doing so may imply estimates biased both in terms of magnitudes and lag structure. Similarly, without further disaggregation, our results may not capture underlying differences in responsiveness across institutions, for example between public and private universities.

Economic theory suggests that flexibility and responsiveness within a particular market can yield societal welfare gains. Given the intricacies of higher education, what implications can be drawn for policy? One implication is that there is a need for further research identifying specific barriers within the higher education sector restricting the supply-side response. Welfare gains from a program on skilled immigration such as H1B are potentially greater in markets where the domestic supply is restricted, provided these programs can correctly identified.

Policies and programs which improve the information flow between the labor market and the institutional supply-side would also likely lead to welfare gains. For example, this could include efforts to lower barriers to the creation of new specialty schools, subsidies for more responsive institutions, or the creation of additional incentives for existing institutions to cope with variable or growing enrollment. In many cases the benefits of such efforts should be weighed against associated costs such as negative externalities from increased class sizes. Finally, it is clear from this analysis that future research is still needed. Additional studies should focus on solving the empirical challenges in estimating the causal relationship between the supply side of higher education in the US at the level of the individual occupation. Higher education in the US faces both an efficient flexible market system for the generation of information and a responsive but complex institutional establishment governing output. Our analysis brings them together.

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Table 1: Sample Pairings

Example 1: Licensed Practical Nurses

Census 2k Code	Census 2K Title	Level	CIP CODE	CIP Title
350	Licensed Practical & Licensed Vocational Nurses	Specialty	511613	Licensed Practical Nurse Training (LPN, Cert, Dipl, AAS)

Example 2: Chemists

Census 2k Code	Census 2K Title	Level	CIP CODE	CIP Title
172	Chemists & Materials Scientists	BA	400501	Materials Science
172	Chemists & Materials Scientists	BA	400502	Chemistry, General
172	Chemists & Materials Scientists	BA	400503	Analytical Chemistry
172	Chemists & Materials Scientists	BA	400504	Inorganic Chemistry
172	Chemists & Materials Scientists	BA	400506	Physical & Theoretical Chemistry
172	Chemists & Materials Scientists	BA	400507	Polymer Chemistry
172	Chemists & Materials Scientists	BA	400508	Chemical Physics (New)
172	Chemists & Materials Scientists	BA	400599	Chemistry, Other

Example 3: Speech Therapists

Census 2k Code	Census 2K Title	Level	CIP CODE	CIP Title
314	Audiologists	BA	51.0201	Communication Disorders, General
314	Audiologists	BA	51.0202	Audiology/Audiologist & Hearing Sciences
314	Audiologists	BA	51.0204	Audiology/Audiologist & Speech-Language Pathology/Pathologist
314	Audiologists	BA	51.0299	Communication Disorders Sciences & Services, Other
323	Speech-Language Pathologists	BA	51.0201	Communication Disorders, General
323	Speech-Language Pathologists	BA	51.0203	Speech-Language Pathology/Pathologist
323	Speech-Language Pathologists	BA	51.0204	Audiology/Audiologist & Speech-Language Pathology/Pathologist
323	Speech-Language Pathologists	BA	51.0299	Communication Disorders Sciences & Services, Other

Note: These pairings are a subset of the NCES Occupational Code Crosswalk for CIP 2000. Broad or general Census 2k and CIP codes have been excluded and we have limited matches to specific degree levels.

Table 2: Educational Degree Completions Characteristics

	Full US Sample			*Paired Sample*			*Relative Coverage*		
Year	Total Degree Programs	Total Degree Completions	Completions Per Program	Paired Degree Programs	Total Paired Degree Completions	Completions Per Paired Program	Share of Degree Programs	Share of Total Degrees	Completions Per Degree Program
1984	1009	1991889	1974	389	1604458	4125	38.60%	80.50%	209%
1990	951	2230371	2345	392	1739609	4438	41.20%	78.00%	189%
1995	898	3038517	3384	508	2248731	4427	56.60%	74.00%	131%
2000	890	3059682	3438	501	2370016	4731	56.30%	77.50%	138%
2005	1184	3763953	3179	815	3142914	3856	68.80%	83.50%	121%
2008	1185	4055000	3422	817	3369209	4124	68.90%	83.10%	121%

Source: IPEDS 1984-1998; 2000-2008

Table 3: Employment and Earnings Characteristics

	Full US Sample				Paired Sample				Relative Coverage		
Year	# of Occupations	Employment* Total	Mean Employment* Per Occ.	Mean Real Wage	# of Paired Occupations	Employment* Total	Mean Employment* Per Occ.	Mean Real Wage	Share of Total Occupations	Share of Total Employment	Relative Wage
1984	363	105041	289	$34,513	79	72700	920	$45,874	22%	69%	133%
1990	363	117914	325	$35,973	79	84500	1070	$49,292	22%	72%	137%
1995	362	124900	345	$37,584	79	89900	1138	$51,401	22%	72%	137%
2000	358	135208	378	$40,883	79	103000	1304	$55,655	22%	76%	136%
2005	321	141730	442	$42,075	79	119000	1506	$55,980	25%	84%	133%
2008	321	145362	453	$42,606	79	126000	1595	$56,961	25%	87%	134%

* Figures are in Thousands of Workers
Source: CEPR CPS 1984-2008

Table 4: Occupation Level Sample Characteristics

CPS-IPEDS Sample

Demographics	*Full US CPS Sample*	*Our Paired Sample*
Average Age	39.08	40.40
Share Female	0.46	0.46
Share Married	0.60	0.65
Employment		
Usual Weekly Hours	37.78	38.74
Share Unionized	0.15	0.12
Share Self Employed	0.11	0.12
Share Public Sector	0.15	0.21
Share Paid By Hour	0.60	0.38
Educational Characteristics		
Share < HS Education	0.12	0.03
Share HS Education	0.33	0.13
Share Some College	0.28	0.23
Share BA Grad	0.18	0.34
Share Graduate Degree	0.09	0.27

Source: CPS MORG 1984-2008

Table 5: Estimates of the Relationship Between Log Absorptions and Log Post-Secondary Degree Completions

	OLS	OLS	WLS	WLS
	Dependent Variable: Log(Completions)			
	(1)	(2)	(3)	(4)
Log(Absorptions)				
1 Lag	0.076**	0.076	0.052	0.052
	(0.035)	(0.052)	(0.057)	(0.052)
2 Lags	0.138***	0.138*	0.090**	0.090
	(0.042)	(0.063)	(0.042)	(0.066)
3 Lags	0.161***	0.161*	0.104**	0.104
	(0.041)	(0.077)	(0.043)	(0.087)
4 Lags	0.160***	0.160*	0.096**	0.096
	(0.043)	(0.075)	(0.048)	(0.077)
5 Lags	0.153***	0.153*	0.093*	0.093
	(0.049)	(0.067)	(0.051)	(0.073)
6 Lags	0.200***	0.200**	0.165**	0.165
	(0.056)	(0.061)	(0.077)	(0.131)
7 Lags	0.151***	0.151*	0.089	0.089
	(0.057)	(0.080)	(0.073)	(0.101)
8 Lags	0.061	0.061	-0.014	-0.014
	(0.054)	(0.053)	(0.073)	(0.065)
9 Lags	-0.003	-0.003	-0.053	-0.053
	(0.050)	(0.044)	(0.073)	(0.066)
10 Lags	-0.006	-0.006	-0.076	-0.076
	(0.051)	(0.049)	(0.066)	(0.062)
Clustered S.E.		X		X
CPS Controls	X	X	X	X
Year Fixed Effects	X	X	X	X
Pair Fixed Effects	X	X	X	X
Observations	1078	1078	1078	1078
R-squared	0.98	0.98	0.99	0.99

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. CPS Controls: Occupational Share (Female, Married, Self Empl., Public Employees, Paid by the Hour, Union Members). Standard errors are clustered at the industry group level (Financial, Science, Engineering, Healthcare, Computer Related and Other).

Table 6: OLS Estimates of the Relationship Between Log ∆ShareOcc and Log Post-Secondary Degree Completions

	Dependent Variable: Log(Completions)	
	(1)	(2)
Log(ΔShareOcc)		
1 Lag	0.083**	0.083
	(0.034)	(0.051)
2 Lags	0.154***	0.154**
	(0.038)	(0.062)
3 Lags	0.193***	0.193**
	(0.038)	(0.080)
4 Lags	0.191***	0.191**
	(0.040)	(0.082)
5 Lags	0.205***	0.205**
	(0.043)	(0.070)
6 Lags	0.237***	0.237**
	(0.046)	(0.075)
7 Lags	0.214***	0.214*
	(0.047)	(0.097)
8 Lags	0.120***	0.120*
	(0.045)	(0.061)
9 Lags	0.035	0.035
	(0.044)	(0.041)
10 Lags	0.032	0.032
	(0.041)	(0.037)
Clustered S.E.		X
CPS Controls	X	X
Year Fixed Effects	X	X
Pair Fixed Effects	X	X
Observations	1078	1078
R-squared	0.98	0.98

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. CPS Controls: Occupational Share (Female, Married, Self Empl., Public Employees, Paid by the Hour, Union Members). Standard errors are clustered at the industry group level (Financial, Science, Engineering, Healthcare, Computer Related and Other).

Table 7: IV Estimates of the Relationship Between Log Absorptions and Log Post-Secondary Degree Completions

	OLS	IV	IV
	Dependent Variable: Log(Completions)		
	(1)	(2)	(3)
Log(Absorptions)			
1 Lag	0.076	0.100	0.057
	(0.052)	(0.151)	(0.044)
2 Lags	0.138*	0.477	0.076
	(0.063)	(0.361)	(0.046)
3 Lags	0.161*	0.500	0.087**
	(0.077)	(0.432)	(0.044)
4 Lags	0.160*	0.364**	0.103**
	(0.075)	(0.150)	(0.046)
5 Lags	0.153*	0.117	0.086*
	(0.067)	(0.309)	(0.048)
6 Lags	0.200**	0.321	0.038
	(0.061)	(0.323)	(0.068)
7 Lags	0.151*	0.391	-0.039
	(0.080)	(0.315)	(0.089)
8 Lags	0.061	0.435	-0.143
	(0.053)	(0.385)	(0.110)
9 Lags	-0.003	0.102	-0.223
	(0.044)	(0.352)	(0.140)
10 Lags	-0.006	-0.001	-0.432
	(0.049)	(0.177)	(0.290)
Clustered S.E.	X	X	X
CPS Controls	X	X	X
Year Fixed Effects	X	X	X
Pair Fixed Effects	X	X	X
Observations	1078	1002	1002
R-squared	0.98	0.98	0.98
Anderson-Rubin Wald F-Stat		79.64	169.20
Kleibergen-Paap Wald F-Stat		2.30	9.54

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. CPS Controls: Occupational Share (Female, Married, Self Empl., Public Employees, Paid by the Hour, Union Members). Standard errors are clustered at the industry group level.

Table 8: Estimates of the Relationship Between Log Wages and Log Degree Completions

	OLS	WLS
	(1)	(2)
Ln(Real Wage) 1 Lag	0.213***	0.222***
	-0.082	-0.082
Ln(Real Wage) 2 Lags	0.160**	0.164**
	-0.076	-0.076
Ln(Real Wage) 3 Lags	0.116	0.118
	-0.081	-0.081
Ln(Real Wage) 4 Lags	0.072	0.072
	-0.083	-0.082
Ln(Real Wage) 5 Lags	-0.034	-0.038
	-0.078	-0.078
Clustered S.E.	X	x
CPS Controls	X	X
Year Fixed Effects	X	X
Pair Fixed Effects	X	X
Observations	1557	1557
R-squared	0.97	0.97

Notes:

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

CPS Controls: Occupational Share (Female, Married, Self Empl., Public Employees, Paid by the Hour, Union Members) as well as average age and a year trend.

Figure 1: Annual Output of Post-Secondary Degrees, Net Change in Employment and Wages, 1984-2008

Source: Completions from IPEDS, 1999 linearly interpolated. Real wage and absorption data from CEPR CPS ORG extracts. Absorptions are not smoothed.

Figure 2: Correlation of Degree Completions with Labor Market Absorption Including Lags across all Paired Occupations

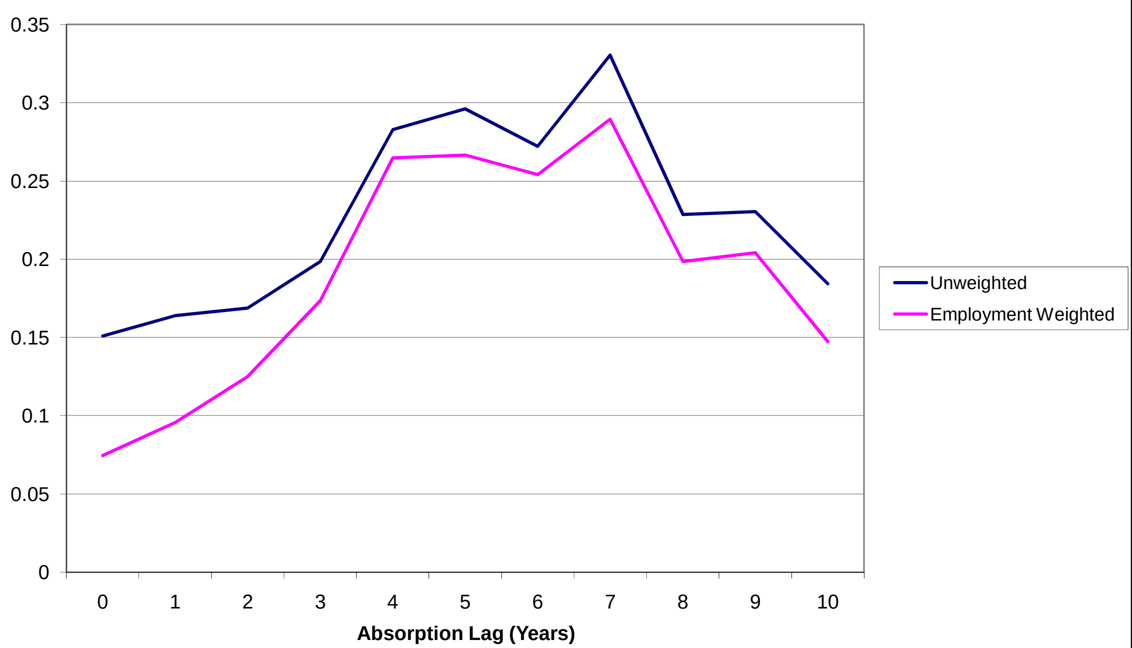
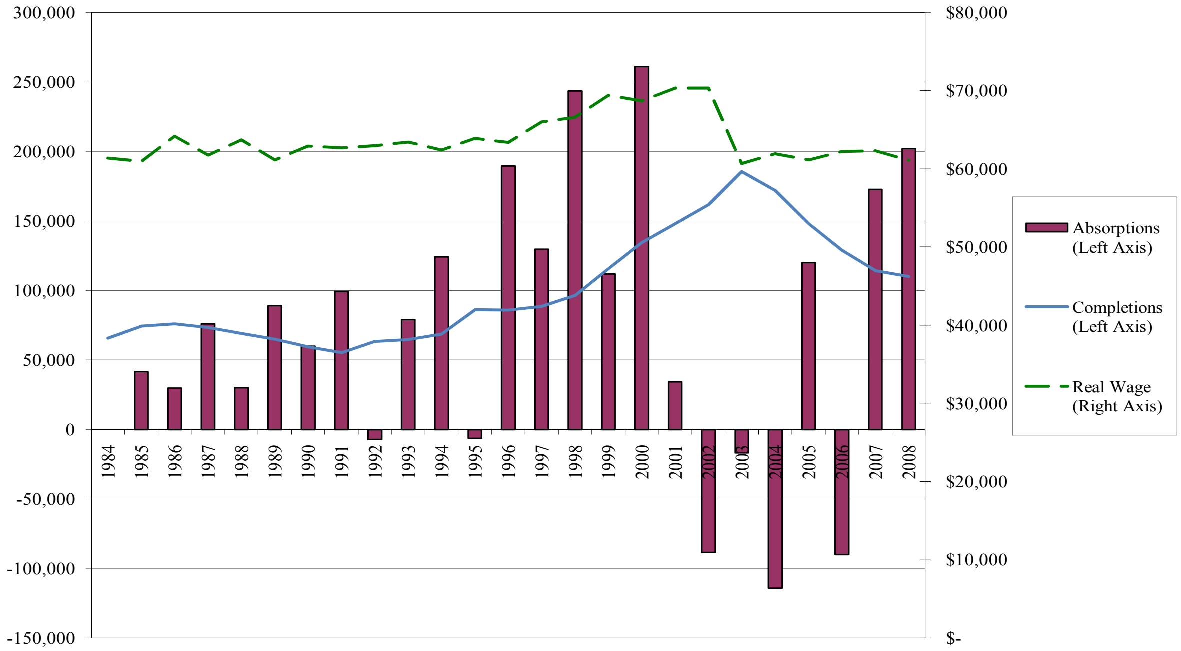


Figure 3: Computer Scientists

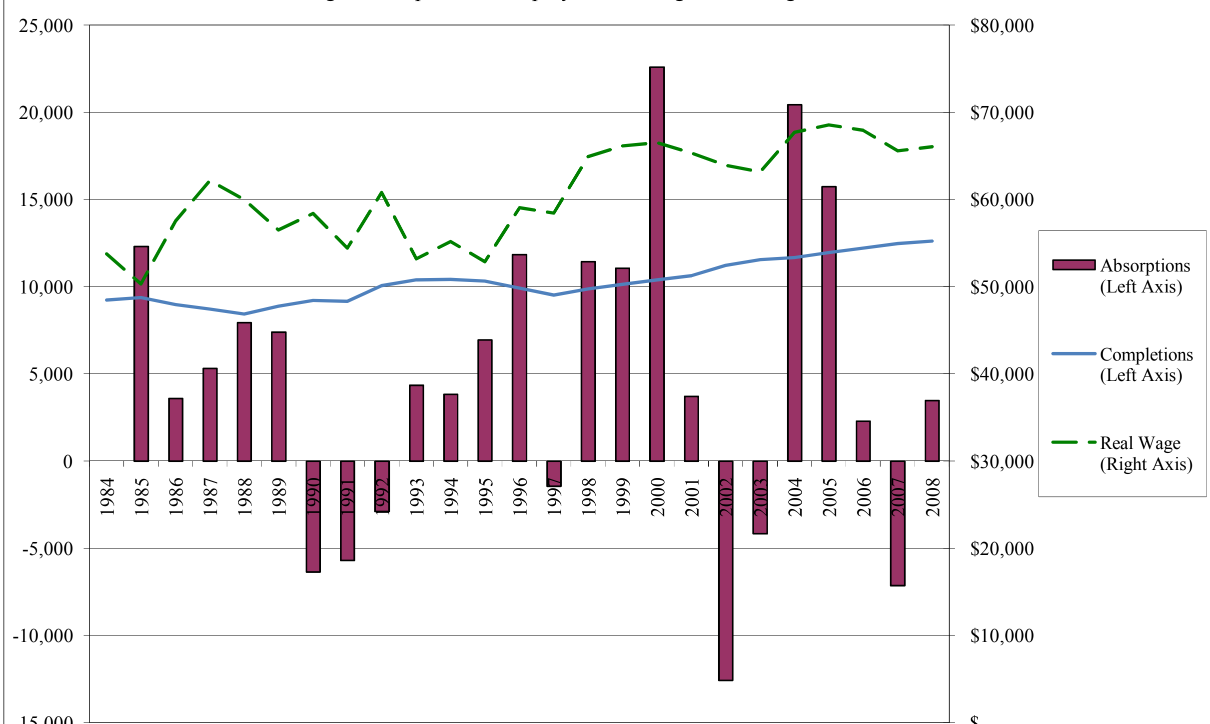
Degree Completions, Employment Changes, and Wages, 1984-2006



Source: Completions from IPEDS, 1999 linearly interpolated. Real wage and absorption data from CEPR CPS ORG extracts. Absorptions are a smoothed using a 3 year moving average.

Figure 4: Architects

Degree Completions, Employment Changes, and Wages, 1984-2006



Source: Completions from IPEDS, 1999 linearly interpolated. Real wage and absorption data from CEPR CPS ORG extracts. Absorptions are a smoothed using a 3 year moving average.

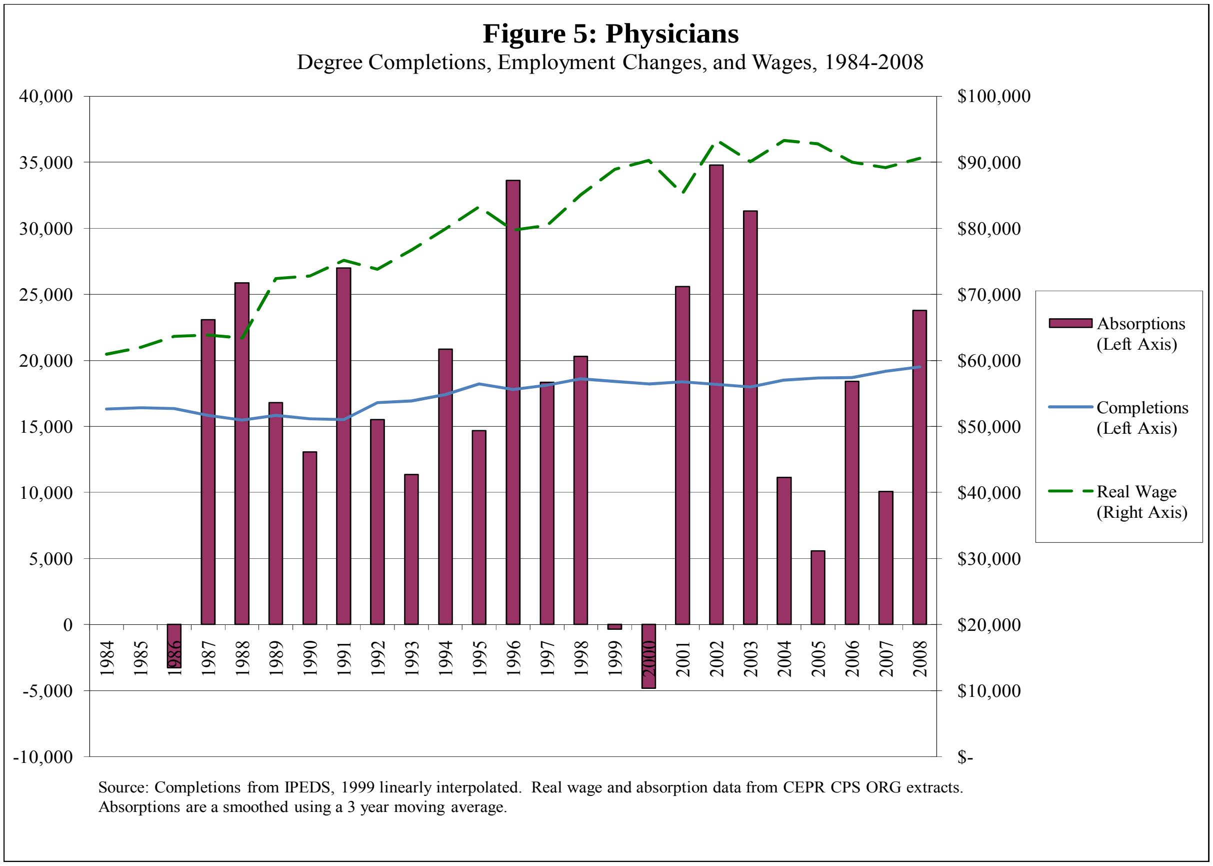


Figure 5: Physicians
Degree Completions, Employment Changes, and Wages, 1984-2008
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
$100,000
$90,000
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$-
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Absorptions (Left Axis)
Completions (Left Axis)
Real Wage (Right Axis)
Source: Completions from IPEDS, 1999 linearly interpolated. Real wage and absorption data from CEPR CPS ORG extracts.
Absorptions are a smoothed using a 3 year moving average.

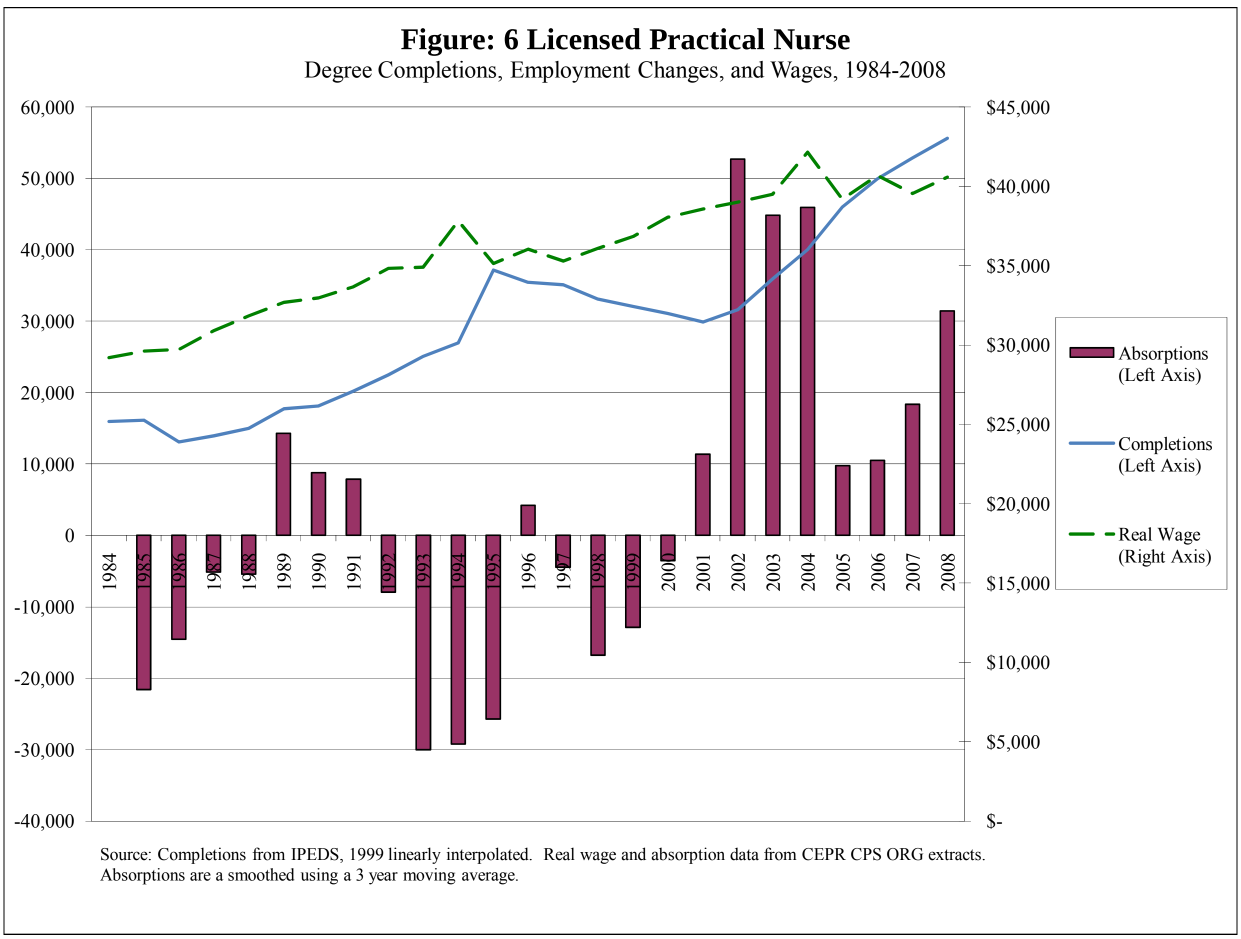


Figure: 6 Licensed Practical Nurse
Degree Completions, Employment Changes, and Wages, 1984-2008
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
$45,000
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$-
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
Absorptions (Left Axis)
Completions (Left Axis)
Real Wage (Right Axis)
Source: Completions from IPEDS, 1999 linearly interpolated. Real wage and absorption data from CEPR CPS ORG extracts.
Absorptions are a smoothed using a 3 year moving average.