Preliminary
Comments welcome

Trade in University Training: Cross-State Variation in the Production and Use of College-Educated Labor

John Bound
University of Michigan and NBER

Jeffrey Groen
University of Michigan

Gábor Kézdi
University of Michigan

Sarah Turner
University of Virginia

May 9, 2001

Trade in University Training:
Cross-State Variation in the Production and Use of College Educated Labor

ABSTRACT

The main question addressed in this analysis is how the production of undergraduate and graduate education at the state level affects the local stock of university-educated workers. The potential mobility of highly-skilled workers implies that the number of college students graduating in an area need not affect the number of college graduates living in the area. However, if the production of relatively large numbers of university graduates by colleges and universities also affects the industrial composition in an area, then there may be an association between the production and use of university-trained manpower. The size of the association between the flow of educational production and the stock of skilled workers provides one indicator of the magnitude of the externalities provided by the higher education industry. We find that the strength of the link between individual location choice and the state of degree receipt varies with field of study and the level of degree. Overall, there is a moderate link between the production and use of BA degree recipients; states awarding relatively large numbers of BA degrees in each cohort also have higher concentrations of college-educated workers. For medical doctors, the long-term link between production and stock is much weaker. Explanations for variations in the relationship by field and degree level reflect differences in the nature of demand in the labor market and production technologies in the education market.

In the United States, college education draws heavily on the resources of state and local governments through direct subsidies and indirect subsidies in the form of exemption from taxation. A rationale often given for why states invest in the education of their residents is that states enjoy some of the returns from such investments – the more highly educated a workforce, the more productive it is. What is more, highly educated workforces may contribute to regional economic growth by attracting new business. In fact, there is increasing evidence that the overall skill level of an area's workforce has fundamental effects on the local economy. Cities with well-educated workforces tend to grow faster than do cities with less well-educated workforces, with such differences persisting over time (Glaeser, Scheinkman, and Shleifer, 1995; Glendon, 1998). Moreover, wages of both well- and less-well-educated workers tend to be positively associated with the educational attainment of a city's workforce (Rauch, 1993; Moretti, 1999).[1]

However, given the mobility of the labor force in general (Long, 1988; Bartik, 1991; Blanchard and Katz, 1992) and college-educated labor in particular (Long, 1988; Bound and Holzer, 2000), there may be little link between the number of college students graduating in a state and the number of college graduates living in the area. In fact, it seems unlikely that the production of large numbers of college graduates will have any significant impact on the fraction of a state's workforce that is college educated, unless the presence of a relatively large number of colleges and universities in an area significantly affects the industrial composition in an area and the associated demand for college-educated workers. The question addressed in this

[1] These wage differences presumably reflect productivity differences, but do not necessarily reflect differences in earnings adjusted for differences in the cost of living. Indeed, in theoretical models it is the presence of congestion costs that serves to maintain equilibrium in the labor markets (Roback, 1982).

analysis is whether the production of higher education in a state affects the local stock of human capital in a state.

Understanding the factors contributing to differences in the level of collegiate attainment across states remains key to assessing the return to state subsidies for higher education. At issue is how policies affecting the "supply side" or the production of college-educated workers compare to other incentives affecting the location choice of college-educated workers. Framing this analysis at the state level reflects the observation that it is state policymakers who determine the level of institutional subsidy for higher education and the associated tuition at public colleges and universities.

Our work is also relevant for understanding the nature of the adjustments that occur in local area economics in response to supply shifts. Labor economists have typically emphasized the importance of migration as the means by which local areas respond to supply shocks (Borjas, Freeman and Katz, 1997). However, more recently Hanson and Slaughter (1999) have emphasized the potential importance of changes in output mix. As far as we know, no one has tried to quantify the relative importance of these two factors.

A central finding of this paper is that the effects of degrees conferred (a flow) on the relative stock of university-educated workers is modest and, as such, states have only limited capacity to influence the human capital levels in their workforces by investing in higher education. The magnitude of this relationship does, nonetheless, vary by field of degree and sector of employment in the labor force, with skilled workers employed in sectors producing traded goods and services somewhat less geographically dispersed than those in the non-traded sectors. Beyond examining the aggregate category of BA degree recipients, we provide some more limited evidence on BA recipients in the fields of engineering and MDs as cases illustrating how differences in the nature of labor demand affect the long-term relationship between production and use of college-educated labor.

The first section of the paper presents a simple model that we use to help us interpret our estimates. In the second section, we describe our empirical strategy and discus the data we use. In the third section, we present descriptive statistics and, in the fourth section, we turn to the presentation of estimates of the relationship between flows and stock over the long run and in response to transitory shocks.

Section 1: Conceptual Framework.

We are interested in the effect that an exogenous change in the flow of college-educated labor (the number of people who graduate from college) will have on the stock of college-educated labor in an area. We start with the presumption that across states within the United States the market for labor, especially college-educated labor, is integrated and national. Over a reasonable span of time, migration flows equilibrate markets at the relevant margins. In this context, there may be little association between the rate of production of college graduates within a state (what we are calling the flow of college graduates) and the prevalence of college degrees in the state's workforce (what we are refer to this as the stock of college graduates). However, there may be such an association if large flows of college graduates tend to attract industries that tend to use college-educated labor. For the economy as a whole, and for traded goods in particular, it seems plausible that industries that employ large numbers of college graduates would tend to locate in regions that produce a large number of such individuals. At issue here is whether the effects are very large. On the other hand, for goods and services that are not traded across geographic areas (e.g., basic medical care, elementary and secondary education) it is hard to see, at least if state labor markets are integrated, how large flows of university-educated workers in these fields would translate into large stocks of such workers.

Figure 1 illustrates the market for college-educated labor within a state. The focus of the figure is on the labor market for the college educated and we assume that the labor force consists of two kinds of people, high school graduates and college graduates. We model changes within a state in a small open economy context: the wages outside the state are given and not affected by migration.[2] The horizontal axis represents the net supply of educated labor within the state, while the vertical axis represents wages for college-educated labor relative to high school educated labor within the state. The *F* curve represents the flow of college-educated labor to the state arising from those graduating from local colleges. Without post-college migration, this would be the supply of college-educated labor to the state. The *S* curve incorporates migration. In the absence of migration, the two curves coincide. Under infinitely elastic migration, *S* would be horizontal at the national wage ratio. The picture shows the case of imperfect but nonzero mobility, which gives a more elastic *S* curve than the *F* curve. The two curves cross at the wage level for which there is no net migration. For wages above this point there is net immigration of college educated labor and *S* lies to the right of *F*; for wages below this level there is net emigration of college educated labor and *S* lies to the left of *F*.

D represents the long run within state demand schedule for college-educated labor. Since many college-educated workers are employed in the traded goods sector of state economies, we expect *D* to be quite elastic. Supply shifts can be accommodated by

[2] We have confirmed the qualitative results from the above model using a simple parameterized

reallocation of production across sectors. The way we have drawn the demand curve, the initial equilibrium occurs at point A: the state is a net importer of college-educated labor. We are interested in the effect of an exogenous increase in the number of individuals graduating from college in the state. This supply shift is indicated in the figure as a shift from *F* to *F'*. The shift in *F* induces a shift in the net supply of college-educated labor in the state from *S* to *S'*, and the equilibrium shifts from point A to point B. The induced shift in *S* is likely to be somewhat smaller than the shift in *F* – at the given wage a fraction of those completing college in the state will leave it. At the same time, the way we have drawn the curves we are assuming that the shift in *F* (and *S*) does not induce a shift in *D* -- there are no direct effects of the increase in the flow of college graduates in the state the demand for college educated labor. Such direct external effects would reflect technological complementarity between the production and use of college-educated labor. With the shift in the schedule of college graduates from *F* to *F*' and the shift in the schedule of the supply of college-educated labor (the stock) from *S* to *S*', the magnitude of the shift in equilibrium wages (i.e. the shift from *w* to *w'*) and labor supplied (*A* to *B*) will depend positively on the elasticity of labor demand and negatively on the elasticity of labor supply.

Formulating this model algebraically, *F* represents the equation for the number of people graduating from college as a function of relative wages and exogenous factors, *S* represents the supply of college-educated labor, while *D* denotes demand for college-educated labor. This is a partial equilibrium model: we assume that outside wages are constant (in particular, migration does not affect them).

general equilibrium model of two equally large states. Results are available from the authors on request.

(*F*) $\dot{f} = \dot{x} + g\,\dot{w}$

(*S*) $\dot{s}^S = \dot{x}^S + g^S\,\dot{w}$

(*D*) $\dot{s}^D = \dot{z} - h\,\dot{w}$

? represents the supply shifter, ? the demand shifter and ?, ?^{S}, and ? represent supply and demand elasticities. A dot over a variable indicates a percent change in that quantity. Since *?*^{S} incorporates response in migration while *?* does not, it is natural to assume that *?*^{S} ≥ *?*. In the absence of mobility *?*^{S} = *?*, while under frictionless mobility *?*^{S}→∞.

In line with our assumption before, we will assume that a shift out in the *F* curve of $\dot{x}$ will induce a smaller shift in the *S* curve. In particular, let $\dot{x}^S = l\dot{x}$, $l \in [0,1]$. λ represents the fraction of the flow of college graduates that stay in state at the going wage. We also allow for supply shifts to have a direct effect on the demand for college educated labor. In particular, let *d* represent the proportional effect of supply on demand shifts: $\dot{z} = d\dot{x}^S = d\,l\dot{x}$, $d \geq 0$.[3] Under these assumptions, the effect of the shift in the flow of college graduates ($\dot{x}$) is:

(1) $$\dot{s} = \frac{h\,l + g^S\,l\,d}{h + g^S}\dot{x}$$

(2) $$\dot{f} = \frac{h + g^S - (1-d)g\,l}{h + g^S}\dot{x}$$

(3) $$\dot{w} = -\frac{(1-d)\,l}{h + g^S}\dot{x}$$

Positive shifts to flows decrease wages (as long as δ<1) and increase the flow and stock of college-educated labor. The size of the changes in flows and stocks depend on the magnitude

[3] Since college graduates are used as a input in the production of college graduates, we expect δ≥0. However, since only a small fraction (0.05) of college graduates are employed in the higher education sector, we expect that δ will be quite small.

of supply and demand elasticities.

We are interested in the effect of exogenous supply shifts ($\dot{x}$) on stocks, but we do not observe $\dot{x}$ directly. Rather we observe $\dot{s}$ and $\dot{f}$. Thus our goal is to estimate the effect of an exogenous shift in flows on stocks:

(4)
$$b \equiv \frac{\dot{s}/\dot{x}}{\dot{f}/\dot{x}} = \frac{l\,h + g^{S}\,l\,d}{h + g^{S} - (1-d)\,l\,g}$$

β represents the share of the increased flow of college graduates that remain in state.

Economic theory yields predictions about the sign and magnitude of b. As long as $?^S <$ ∞, β>0. Also, because $?^S \geq ?$ and $l \leq 1$, as long as δ≤1, we have $b \leq 1$. The effect of an exogenous change in flows on stocks is a function of the demand and supply elasticities, and the migration parameters. More mobility dampens the effect of flows on stocks through a larger $?^S$ and a potentially a smaller l. At one extreme, no mobility leads to a one-to-one mapping between changes in flows and changes in stocks ($b = 1$ if $?^S = ?$, $l = 1$). At the other extreme, frictionless mobility leads to a zero effect of flows on stocks ($?^S \rightarrow \infty$). In contrast, the larger the within state elasticity of demand, the larger will be the effect of changes in flows on stocks. At the extreme, if demand for college-educated labor is infinitely elastic, supply shifts will induce the stock of college-educated labor to rise by l.

So far we have focused on the within state market for college graduates, however a similar framework can be used to analyze the market for more specialized kinds of skilled labor. In this regard, the parameters of the model are likely to differ across labor markets for different types of skilled labor. Thus, for example, the elasticity of demand for types of skilled labor likely to be employed in the non-traded goods sector alone (e.g. Medical Doctors, Nurses, and teachers) is likely to be quite small. In such cases, we expect the effects of flows on stocks to be minimal. We have suggested that for BAs d, the proportional effect of shifts in the supply of college-educated labor on demand, is likely to be small. However it seems likely that in some cases (e.g. for Ph.Ds) d might be reasonably large, owing to potentially strong complementarities between doctorate training and R&D activities of firms. What is more, a large fraction of PhDs in the labor market are employed by universities and are used in the production of PhDs and other university-trained workers. Furthermore, in cases where the local supply elasticity (γ) is likely to be small (e.g. Medical Doctors), one might expect that employers and schools would work together to create institutions that would facilitate geographic mobility.

Section 2: Empirical Strategy and Data

Estimating Equations

In placing this model in an empirical context, we analyze the association between cumulative per capita flows of degrees awarded for birth cohort (g) in state (j) and the per capita stocks for the same cohort in the same state in some subsequent year (t) by estimating the following equation:

$$(5) \qquad \ln \frac{Stock_{jgt}}{Population_{jgt}} = a_{gt} + b \ln \frac{Flow_{jg}}{Population(r)_{jg}} + e_{jgt}$$

The independent variable is the total flow accruing to a cohort relative to the size of the cohort in the state around some modal year (r), where this year reflects the typical year of degree completion. The dependent variable is the stock of degree recipients measured years after degree conferral for each cohort relative to the population in the state. We present estimates for different degree types and age groups of observation. The parameter $\hat{b}$ estimated from running the cross-sectional equation in (5) corresponds to the theoretical specification outlined in (1)-(4).[4] In this specification, the (intended) identifying variation in the measure of flows reflects long-standing differences across states in the outputs of higher education institutions, represented by cross-state variation in x. These cross-sectional measures are intended to capture long-run equilibrium effects on the concentration of college-educated workers in a state attributable to differences in the outputs of higher education across states.

While we would like to be able to measure the effect of exogenous supply shifts (i.e. exogenous shifts in flows) on the utilization of college-educated labor within a state, what we are able to estimate is the cross sectional association between variation in stocks and flows. The relationship between the coefficient we estimate and the parameter we would like to estimate depends on what is driving the cross sectional variation in stocks and flows.

There is considerable variation across states both in terms of the production (flows) and the use (stocks) of college graduates. Some states have -- loosely speaking -- a comparative advantage in producing college-educated labor. This comparative advantage could come from such sources as historical forces affecting the location choice of colleges more than a century ago, proximity to population centers, or willingness of voters to support higher education. In the labor market, other states presumably have a comparative advantage in the production of goods and services that are intensive in college-educated labor. The nation's political and financial

[4] The unit of the static model (5) is the state-cohort cell. As discussed in more detail with the presentation of the empirical results, the inclusion of year effects means that variation across states is what

capitals (D.C. and N.Y.C.) might be examples of this kind of phenomena.

The variation across states in terms of stocks and flows depends on the combination of these two factors. If there were variation in states' comparative advantage for production but not the use of college-educated labor, we would expect to see that the states that produced the most educated labor would, uniformly, be the states that used the most educated labor. Market forces would tend to induce those trained in high production states to emigrate, but this phenomenon would not change rank orderings. In this case we would expect to find a negative association between both stocks and flows and relative wages. In contrast, if there were variation in states comparative advantage in the use, but not in the production of college educated labor we would still expect to see a very high rank order correlation between states the produced a lot and states that used a lot of college-educated labor. In this case, we would expect to find a positive correlation between both the production and the use of college-educated labor and the relative wages of this group; however, causation would run from the labor market to the education market.

In fact, what we observe is that some of the states with highly educated workforces also produce a disproportionate share of college graduates, while others import college graduates. Likewise, some of the states that produce a disproportionate share of college graduates also have a disproportionate share in their work forces, while others export college graduates. This is consistent with the notion that there is cross state variation in the comparative advantage in both the production and use of college graduates. The implication of these potential sources of variation across states for our estimates of $\hat{b}$ is that cross-state differences in demand for

identifies our estimates. Estimated standard errors allow for arbitrary clustering of residuals across states.

educated labor will tend to bias estimates of b upwards [Appendix A presents an algebraic derivation of this result]. The more exogenous variation across states in the demand for college educated labor there is, the greater will this bias be. On the other hand, the more exogenous variation across states in the supply of college educated labor, the less the bias will be.[5]

In addition to the cross-sectional analysis we investigate how changes in cohort specific flows translate to changes in cohort specific stocks. We look at changes between 1960 and 1970, 1970 and 1980, and 1980 and 1990. Here, the focus is on differences in the measures of flows and stocks over ten-year intervals defined for people of the same age referenced by birth cohort *g* and *g-10* in a state (*j*). Again, we present the relationship in an elasticity form:

$$(6) \qquad \Delta \ln \frac{Stock_{jgt}}{Population_{jgt}} = a_{gt} + b \Delta \ln \frac{Flow_{jgt}}{Population(r)_{jgt}} + e_{jgt},$$

where Δ means differences between 1970 and 1960, etc. More specifically, for a variable x_{jgt}, the ten-year difference Δx_{jgt} is defined as

$$\Delta x_{jgt} = x_{j,g,t} - x_{j,g-10,t-10} ,$$

where *g* identifies birth cohorts, measured as year of birth. In this part of the analysis, we focus solely on the BA measure.

This differenced specification has a somewhat different interpretation than does the cross-section specification, capturing medium-run dynamic effects rather than long-run differences. In terms of interpreting estimates as reflecting the causal effects of flows on stocks, these specifications have the advantage of eliminating state-specific fixed effects. Thus, the

[5] These propositions echo standard results on the bias obtained when one uses OLS to estimate demand of supply curves (Working, 1927).

variation that we hope to consider in identifying our parameters is the extent to which idiosyncratic changes in a state's degree output in higher education have sustained effects on the concentration of college-educated workers in the population. Still, one concern is that causality is running in the reverse direction with changes over time in the state-specific demand for college educated labor feeding back into changes in the fraction of the college-aged population receiving a degree.

At first blush, one might imagine that the medium run impact of any flow changes should be larger than the long run impact. After all, we expect the migration elasticity to be larger in the long as against the medium run. However, the demand elasticity will also be less elastic in the medium as against the long run, and it is the combination of these two parameters that determine the medium and long run equilibrium. More concretely, one might imagine that in the medium run, labor is more mobile than capital, while in the long run, the opposite might be true. In such a case, the medium run effect of flows on stocks might be smaller than the long run effects.

For both the cross-sectional and dynamic specifications, we present results and analyses at different degree levels (BA and MD). To the extent that there are well-defined links between particular fields of study and sectors of employment in the labor market (such as the case of engineering), we present these stock-flow analyses by field.

Data

The data used in this analysis are from the decennial Census surveys and annual institutional surveys of degrees awarded by colleges and universities conducted by the Department of Education (further details are available in the Data Appendix). For each degree type, we aggregate across institutions to obtain the number of degrees of each type awarded per year in each state. To obtain measures of per capita flows for each cohort, we distributed degrees awarded in each state and year across cohorts following the procedures detailed in the appendix and then divided these imputed cohort specific flows by an appropriate age-specific measure of population. For BA degree recipients, the population variable at age 22 is calculated from widely-available tabulations of the age distribution in a state, made available by the Census Bureau. This procedure undoubtedly introduces a certain amount of error in our flow measure. Since there is substantial stability in state-specific flows across time, these errors are unlikely to have any substantial effect on our cross-sectional estimates. We were worried, however, that they would have substantial effect on our dynamic estimates. To gauge the magnitude of this problem, we have done a number of simulations, which suggest that the magnitude of the bias introduced by the imputation error is relatively small – on the order of 10%.[6]

For MD data only, we are able to organize information by birth cohort so we are able to mitigate some of the measurement problems associated with the timing of degree receipt for this group. The data for MD degree recipients is from a database maintained by the AMA that records age and other demographic characteristics, institution of degree receipt, and professional employment location. We observe this universe in 1980 and 1991 and are therefore able to make overtime comparisons as well as cross-sectional comparisons.

To estimate the per capita stock of college graduates at the baccalaureate level in a state we use micro data from the decennial census for years 1960, 1970, 1980, and 1990. We

[6] Further discussion of these issues together with the results from the simulations are available upon request from the authors.

calculate the share of BA recipients in an age group relative to the population size as our age measure. The 1990 Census provides an advantage over previous decennial files for this analysis because degree levels are coded explicitly, rather than presenting years of completed education. For earlier census years (1960-1980), we make the standard assumption in equating college graduation with 16 years of completed education. The 1990 Census identifies both the state in which a person lives and, for those that work, the state in which they work.[7] Earlier Census enumerations either do not identify state of work, or do so for a subset of the sample. For consistency sake all results we report are based on state of residence. We did, however replicate our 1990 cross sectional results classifying individuals according to the state in which they work. Switching to state of work made virtually no difference to any of our results. Among MDs, we use data from the AMA database on degree receipt to measure the numerator and data from the Census to measure the denominator or cohort size.

In the cross-sectional analysis, we present data for a long range of age cohorts or degree receipt years, as well as several ten-year age groups to determine whether the stock flow relationship differs with age. For the dynamic analysis, we compare individuals of the same age at different points in time. Because our differences in stock observations are linked to the decennial census data, we use ten-year differences in age groups.

Section 3: Concentration of Flows and Stocks

[7] We limit the analysis to the 48 continental states as data for Alaska and Hawaii are often difficult to obtain in early years and the obvious differences in geographic integration may lead to somewhat different dynamics. In most cases, we present estimates without DC as the unusual political and industrial structure of this area often leaves this case an outlier.

The starting point for the empirical analysis is the consideration of the concentration of flows and stocks across states and the population. We begin with the consideration of those receiving degrees between 1966-1985; for BA degrees this reflects the 27-46 age group and for MDs the 32-51 age group (Table 1). The mean flow and stock measures, presented in the first column are indicative of degree receipt, with BA degree recipients nearly 75 times more prevalent than MDs. A focal measure of our analysis is the coefficient of variation, which captures the dispersion relative to the mean. A low coefficient of variation is indicative of relatively uniform degree production across states while a high coefficient of variation is indicative of large cross-state differences in degree production. Across degree types, the dispersion in flows of BA degrees is much less than for MDs.

This dispersion is evident geographically when maps of the flow level by states are considered in Figure 2. At the BA level, the plains states and northeast states are particularly strong producers in higher education. States like New Hampshire, Vermont, and Massachusetts in the East have nearly twice the per capita flow as states like Georgia, South Carolina and California at the BA level. Turning to the production of MD degrees, there is appreciably more variation across states in the production of degrees. At one extreme, states that are not densely populated such as Montana, Idaho, and Wyoming do not record any institutions awarding the MD. At the other, states such as New York, Illinois and Iowa report relatively high production of MD degrees. A second type of disaggregation is within field in the

BA degree category.[8] Engineering, and industry-specific fields within engineering, are more geographically concentrated than BA degrees more generally.

Table 1 also presents the analysis of variance for the stock and flow measures, considering variation over time, across states, and within states for BA degrees in aggregate, engineering BAs and the component fields, and medical degrees. Decomposing the observed variance for the two decades of state-level observations reveals that the bulk of the variation is consistently across states. For example, at the BA degree level, about 77 percent of the observed variation in flows is across states. Such persistence in the difference in the production of degrees awarded points to the presence of long-run differences across states in the production of degrees awarded. In fact, these cross state differences have been quite persistent over the entire 20th century. The map showing the dispersion of flows in 1929 (Figure 2, bottom left) is remarkably similar to the more recent distribution of flows in the top panel of Figure 2 and with the correlation between the two being 0.5.[9]

Explanations for these long-term differences across states include factors related to the historical evolution of higher education across the states, as well as differences across states in their comparative advantage in degree production. The strength of the eastern states in the production of BA degrees can be traced to the relatively intensive concentration of private colleges, many formed before the Civil War by denominational organizations, in this part of the country. The passage of the Land Grant College Act, commonly known as the first Morrill

[8] We do not produce a full stock-flow analysis in all of the fields, as we are only able to construct appropriate stock measures when field of study and occupation are closely coupled.

[9] The two maps suggest a certain amount of convergence between 1929 and the post World War II period. Indeed, the coefficient of variation across states drops by a factor of two between 1929 and the current period.

Act,[10] in 1862 provided the first large-scale federal support for public provision of higher education and placed colleges and universities in states that some might have regarded as too small to support a college of efficient size (Jencks and Reisman, 1968). Geographic specialization and complementarities with local industry provides another explanation for the dispersion of colleges and universities across states. For example, it is surely easier to provide instruction in geology or agriculture in areas that are non-urban, while other clinical fields like nursing or social work benefit from proximity to densely populated areas. Moreover, the composition and preferences of the population within a state during the early part of the century shaped the willingness of state governments to invest in the expansion of public higher education. Goldin and Katz (1999) suggest that the level of income in a state and the degree of homogeneity (in terms of religion, ethnicity and income) in the early 20th century were important indicators of state-supported expansion of colleges and universities. A key point to take from a brief discussion of the history of higher education is that the distribution and scale of colleges and universities across states reflects a range of factors including the founding of private colleges in the 18th and 19th centuries, the willingness of local populations to support public expenditures on higher education, the introduction of federal support through the land-grant colleges, and the industrial composition of a state. Some of these factors would seem largely exogenous to state labor markets, while others are clearly not. To the extent that the observed variation across states in the degree outputs of colleges and universities reflects historical factors independent of demand in local labor markets, cross-sectional ordinary least squares estimates can be

[10] This bill granted each state thirty thousand acres for each senator and representative in Congress and the proceeds from this land resource were to be used to fund at least one college.

interpreted as causal. However, if historical differences in demand for college-educated workers are substantially related to collegiate degree outputs, cross-sectional estimates will be upward biased.

Section 4: Stock-Flow Analysis

Cross-Sectional Analysis

While the concentration in the production of university-educated workers and the concentration in location are readily evident from measures of dispersion, the analytic question of interest is the impact of flows on stocks. Table 2 presents estimates in elasticity form of the cross-sectional link between flows and stocks, represented by equation (5). In the category of BA level flows and stocks, there is a modest association between flow and stock, with an elasticity of 0.32. Plainly, states with relatively high production of undergraduate students also have relatively high concentrations of the university-educated in their working age populations. Yet, this relationship is appreciably less than 1:1. At the other extreme, the cross-sectional relationship between the production of MD degrees and the representation of MDs in the population is remarkably weak, with an elasticity estimate very close to zero. The comparisons across degree types highlight the quite different labor market faced by university-educated labor with different levels of training. The weak link between flows and stocks in the MD field is surely indicative of the non-traded aspect of medical services and the associated inelastic demand within a geographic area. This is not to say, however, that the MDs are equally distributed across the country or within states. Rather, the link between stock and flow is much weaker than it is among other degree types.

Graphical presentation of flows and stocks helps to sharpen the understanding of these estimates. Each panel in Figure 3 represents the stock-flow relationship averaged over the 1966-85 degree cohorts, with the diagonal line distinguishing net importers (above) and net exporters (below). For the stock and flow of BA degrees, states such as California and Connecticut are BA importers while other states like Utah and Vermont consistently export baccalaureate-trained personnel.[11] The picture for MDs is striking in the lack of association between flows and stocks, as the line showing flows is essentially flat, with the pattern of stocks across states approaching a straight line at the level of abit more than 4 MDs per thousand.

Turning to the engineering fields at the BA degree level in the bottom panel of Table 2, the estimated elasticities are positive, with the magnitudes varying appreciably by subfield. As we will discuss more below, scatter plots reveal a number extreme outliers in the data. We present results with and without these outliers and the presentation of alternatives without the outliers is intended to simply show the impact of these cases.[12] In subdisciplines like aerospace and chemical that are likely to be closely linked to industry, the magnitudes of the stock-flow relationship are much higher than in fields like civil engineering, where demand is likely to widely dispersed geographically. What we see in the graphical presentation in Figure 4 is a relatively strong link between stock and flow in sub-fields like aerospace, chemical and mechanical where the geographic concentration of firms hiring a substantial fraction of these workers is likely to be sizable. For example, Washington state, Missouri and California dominate aerospace; Michigan

[11] Looking at this picture divided by cohort (not shown), demonstrates some consistency indicative of the measurement of long run equilibrium, as well as variation over time, with states like Washington shifting from a relative exporter of BA-level workers in the early decades of observation to a relative importer in the 1980s and the state of Arizona demonstrating the opposite shift from relative importer to exporter.

and the Great Lakes states dominate in automobile production; and the location of the DuPont company in Delaware is a magnet for chemical engineers. Civil engineers, often with specializations in transportation construction which might be thought of as widely-dispersed in demand, demonstrate little connection between stocks and flows. Caution against the overinterpretation of these cross-sectional measures is nonetheless in order as it may well be the case that universities develop applied engineering programs in response to local demand, rather than the supply of engineers affecting the location choice of firms.

The examination of outliers in the flow-stock relationship among engineers reveals considerable information about the geographic integration of the labor markets for specific skills. One notable class of outlier includes states like South Dakota, North Dakota, Wyoming and Montana which, on a per capita basis, are quite substantial producers of engineers. Yet, as shown in Figure 4, these states "export" a substantial share of their college graduates in these fields and, not surprisingly, dropping the outliers in production from the cross-sectional regressions serves to drive up the estimated effect of flows on stocks. A different type of outlier is represented by states with a dominant industry intensive in the employment of engineers, with examples including the employment of aerospace engineers in Washington state or chemical engineers in Delaware. In both cases, while these states produce a substantial number of engineers, they must also attract college-graduates with these skills from other states.

Calculating stock-flow relations for different age ranges and at different points in time for all BA degrees underscores the persistence of the basic result. Table 3 presents cross-sectional estimates with stocks observed in 1970, 1980, and 1990 as well as disaggregation of

[12] Outliers were identified visually from the scatter plots presented in Figure 4.

the stock variable into ten-year age groups. The point estimates of the stock-flow relationship are notably consistent, with only modest variation around the overall cross-sectional result of 0.32 presented in Table 2.

If states with industries that have historically hired a disproportionate share of college graduates are those that have invested in producing a supply to match the demand, the cross-sectional estimates will be biased upward. Instrumental variables estimation provides a strategy to isolate the causal effect of the production of college-educated workers on the long-term stock. At issue is the identification of factors that might exogenously affect the production of college-educated labor in a state but that can also be thought to be independent of labor market conditions. For our cross-sectional estimates, where we are considering relatively permanent differences across states, we use historical dimensions of the higher education industry and demographic differences across states to try to isolate factors that affect production today but that are exogenous to contemporary developments in the labor market. The first type of instrument is motivated by the observation that large cross-state differences in the degree outputs and mission of colleges and universities were set in place by state policies well before World War II. In this regard, we employ the per capita flow of BA degrees in 1929 as one cross-sectional instrument in this analysis. Presented in Figure 2 (bottom left), the historical pattern of variation is quite evident. As an alternative instrument we have used a version of the ethnic diversity measure used by Alesina, Baqir, and Easterly (1999) in their work on public expenditures (bottom right panel).[13] The notion here is that ethnic diversity lowers the

[13] The computation of this index is discussed in the data appendix.

willingness of voters in a state to support public expenditures. The simple correlation between the diversity index and the historical BA flow measure is -0.36.

Cross-sectional instrumental variables estimates are presented in Table 3, with appropriate comparisons to the OLS estimates. Column (2) and column (3) present estimates with the single instruments of BA production in 1929 and racial disparity in 1960. If anything the IV estimates tend to be somewhat larger than the corresponding OLS estimates, though the IV estimates tend to be somewhat imprecise and the differences between the OLS and IV estimates are not statistically significant. The IV estimates thus support the notion that there is a modest (causal) relationship between flow and stock. Nevertheless, we are cautious in our interpretation of these IV estimates. In the context of the 1929 BA flow variable, we are essentially using a long lag in the explanatory variable of BA flows as an instrument for flows observed for cohorts in our data. Plainly, the validity of this strategy relies on the assumption that there is no serial correlation in the outcome measure. If there is a substantial correlation between the industrial composition of a state in 1929 and 1990 that is driven by something other than the educational attainment of the population – as we would expect -- then the IV estimates will tend to overestimate the causal effect of flows on stocks just as the OLS estimates do.

At first blush the racial disparity index might seem more plausibly exogenous. Still an issue arises as to just how long the arm of history is. As can be seen quite clearly in the bottom panel of Figure 2, the states that rank highly on the disparity index are the states of the Confederacy. Thus, one interpretation of our results would point to the legacy of slavery, with racial divisions in the South affecting the willingness of populations in these states to invest in higher education. On this account, the division of the U.S. into slave and free states may have had very long run effects on the economies of the North and the South, but is exogenous to other factors currently influencing regional economies. However, one can tell a quite different story. Presumably, the reason that Northern states eliminated slavery early while the Southern States did not was not primarily because Northerners were morally superior to Southerners, but because the industrializing economy of the North did not lend itself to a slave based economy. Thus, on this account, the racial disparity index is correlated with long standing differences in industrial structure and, as such, cannot be thought of as entirely exogenous.

The overall conclusion that follows from the analysis of the relationship between stock and flow among BA recipients is that there is a persistent and significant link between BA degrees awarded and the representation of college-educated in the state. While it is plausible that part of this difference is indicative of other long-run differences in the structure of local economies, the persistence of these results do support the link between higher education and the labor market. Nevertheless, the magnitude of this link is appreciably less than one and theoretical information about the link between demand and supply would point to an upward bias in the estimated effects.

Variation in relative wages across states with the concentration of college-educated workers provides another indicator of the degree of mobility in the labor force and the direction of the causal relationship between flows and stocks. Table 4 presents estimates of the regression of relative wages for college graduates on the concentration of college graduates at the state level for different decennial points of observation. The first column uses the observed concentration of college graduates as the explanatory variable and column (2) uses the aggregate of flows (from 1950 to the indicated year) as an instrument for stock to capture variation attributable to differences in the flow from the higher education market. In the presence of an integrated labor market in which labor adjusted fully in location to changes in demand, these coefficients would be uniformly indistinguishable from zero. Yet, particularly in the instrumental variables estimates, these estimates are consistently negative, implying an inverse relationship between flows and relative wages.[14] This result is consistent with a situation in which some states have a comparative advantage in production in the higher education market, while others have a comparative advantage in the use of college-educated labor and labor is, even in the long run, *not* perfectly mobile across states.[15] College graduates residing in states that produce a relatively large number of college graduates per capita tend to earn relatively little, while college graduates in states that employ a large number of college graduates but do not produce a large number tend to receive something of a wage premium.

If the flows used as instruments in these specifications are exogenous, the coefficients reported in the 2nd column of table 4 can be interpreted as $-1/\eta$. If, however flows are endogenous, the reported coefficients will tend to underestimate the causal effect of relative supply on relative wages[16] and, as a result, will tend to overestimate η.

Taking the estimates in the second column of the table at fact value (i.e. interpreting them as

[14] Table 4 also presents estimates using the instruments of 1929 BA Flows and the racial diversity index discussed later in conjunction with Table 3. These results, presented in Column (3) and (4), are qualitatively similar to those presented in (2).

[15] If college graduates have a preference for living near other college graduates, then one might find the college wage premium to be low in states with a high concentration of college graduates. In this case, the high premium in states with relatively few college graduates would reflect a compensating differential for living in such areas. Such preferences could rationalize an association between the stock of college graduates and relative wages. This explanation does not, however, rationalize an association between the flow of college graduates and relative wages.

[16] If flows are endogenous, then the regression of stocks on flows will tend to over estimate the causal effect of flows on stocks. Similarly, in this case the regression of relative wages on flows will tend to underestimate the causal effect of flows. The IV estimates are the ratio of these two estimates, and therefore will tend to underestimate the causal effect of stocks on relative wages.

estimates of $-1/\eta$), suggests a within state relative demand elasticity in the neighborhood of 5. These estimates are all substantially larger than comparable estimates using U.S. times series data (Katz and Murphy, 1992), suggesting that there is considerable reallocation of production across states to take account of cross state differences in the relative supply of college graduates. However, it also seems clear that even in the long run, within state relative demand elasticities are well bellow infinity. Exogenous, cross state differences in the supply of college graduates are accommodated by the out migration of college graduates and the drop in their relative wages as well as by demand shifts. In fact, our estimates would seem to suggest that migration plays a larger role in accommodating supply shifts than do shifts in demand.

Dynamic Analysis

Beyond comparing flows and stocks in the cross-section, the consideration of the relationship between these measures overtime provides some leverage on the question of causation. Difference estimates plausibly eliminate fixed differences across states from affecting the estimates of flows on stocks. These difference estimates capture changes over a relatively short horizon and thus measure something conceptually different than our cross-section estimates, which reflect permanent cross-state differences in educational capacity. In this regard, we ask the question of what happens to the stock of college graduates in a state if the degree output of the state's higher education institutions changes at a rate different than the national norm for a short interval. The data support this interpretation, as there is not uniformity in the correlation of changes in flows.[17]

Table 5 presents the means of the decennial log differences in flows and stocks by age and period of observation. As is well-known, overall college going expanded dramatically into the early 1970s, accounting for the large and positive changes in flows for those in the 25 to 34 age range between 1960 and 1970 and between 1970 and 1980. Decreased returns to college education faced by cohorts making educational investments in the mid and late 1970s contributed to the decline in flows for the 25-34 age group over the interval from 1980 to 1990.

Turning back to the first table, the analysis of variance numbers give an indication that variation within states over time is an appreciably smaller share of the total variance than the cross-sectional differences. However, as Table 5 and Figure 5 indicate, there is still significant cross state variation in the change in the flows from one decade to the next. Thus, for example, while on average per-capita flows for 25-34 year olds increased by roughly 25% between 1970 and 1980, the growth ranged from close to 0% for states such as Oregon, Utah, Wyoming and Nebraska to close to 40% for Florida, Nevada, Alabama and Virginia, over 60% for New Mexico and over 80% for Delaware.

Since it is the per capita flow variable we use in our analysis, changes in this variable can reflect movements in either the numerator or the denominator. In fact, in our data there is a strong negative correlation between changes over time in the size of the 22 year old population and changes in per capita flows. Indeed, regressions of the change in per capita flows on the

---

[17] States that increased relative flows between 1960 and 1970 were not identical to those with relative increases between 1970 and 1980, though there is a positive relationship between the 1970 to 1980 change and the 1980 to 1990 change. Overall, none of these relationships among flows is very strong nor is

change in the size of the cohort suggest that a 10% increase in cohort size is associated with 7% decrease in per capita flows. Statistically, cohort size explains about 25% of the variation in the change over time in per-capita flows, with this phenomenon more important in some states than others.

While in our overtime analysis we eliminate permanent cross state differences, the change over time in per capita flows could still be endogenous to state specific changes in the demand for college educated labor. When thinking about how serious an issue this is, it is important to understand that the variation at issue represents differences across states in the growth of flows from one decade to the next. Since typically growth in one decade is not followed by growth in the next, it is appropriate to think about the cross state variation as reflecting variation in the timing of the growth in flows. All states experience a dramatic increase in the fraction of their college aged population attending and finishing college between 1950 and 1970, however, the timing of these increases varied across states. We suspect that the timing of these changes is largely exogenous to changes in the demand for college-educated labor. The actions of governors in the sphere of higher education are one such potentially exogenous force.

To give but one example, the expansion of higher education in New York state under the gubernatorial terms of Nelson Rockefeller represents a striking case in point. Few observers early in the Rockefeller administration would have predicted a six-fold increase in state funding for higher education in New York state in the decade between 1956 and 1966, with the increase in New York exceeding the changes in neighboring Connecticut and New Jersey by 60% and 45%, respectively. Yet, denied a national office with the nomination of

there evidence that they persist over time.

Nixon in 1960, Rockefeller threw his considerable personal energy and ambition into capital projects in the state including the transformation of the SUNY system from teachers colleges to a national-level university system.

While the New York case is a dramatic example of expansion led by the governor, other examples such as Michigan Governor Milliken's $50 million reduction in state support for higher education in 1983 point to public colleges and universities as an open and politically viable target for gubernatorial budget slashing when faced with revenue shortfalls (Gove, ECS, 1998). Another type of relative contraction in state level higher education is apparent in the tightly constrained growth of southern systems of higher education during the 1960s, as pressure to desegregate higher education may have also attenuated political support for colleges and universities.

While the state political process clearly plays a substantial role in the overtime variation in the outputs of higher education within a state, the strength of this effect varies appreciably across states with the composition of public and private institutions. In states such as California where public institutions constitute the majority provider of higher education, there are likely to be substantial accommodations to changes in population. Alternatively, in a state like Massachusetts where higher education has been provided largely by private institutions, accommodations in degree outputs to population growth or political pressure are likely to be more muted. To put this in perspective, 74 percent of BA degrees awarded in California in 1988 were awarded by public institutions compared to 32 percent in Massachusetts during this year. Not surprisingly, the examination of residuals in a regression predicting flows with state and year effects indicates that in Massachusetts periods of rapid population expansion were met with below average flows.

These kinds of considerations lead us to suspect that there is considerable exogenous variation in the state-specific changes over time in per capita flows. This, of course, does not mean that all of the variation is exogenous. Just as was true in the cross section, if part of the state-specific variation over time in flows represents a response to labor market conditions, then our ols estimates will tend to over-estimate the causal impact of flow changes on stock changes. Thus, our estimates represent upper bounds on the causal effect of flows on stocks.

Table 6 presents estimates with the decennial change in stock regressed on the decennial change in flow for different age cohorts. These dynamic estimates, reflecting the difference presentation from equation (6), use variations over time within states rather than fixed differences across states to identify the effect of flows on stocks. Estimates for relatively recent college graduates – those that are 25-34 years old as of the census years – are shown in the first column. For these cohorts, the difference estimates show significant effects of flow on stock in the range of 0.37 to 0.44 for the 1960-1970 and 1980-1990 intervals, while the estimate for 1970-80 is somewhat weaker. Inspection of scatter plots for the 1970-80 decade revealed two outlier states, Delaware and New Mexico [Figure 5]. Both of these states showed a dramatic growth in the number of individuals receiving a BA, during the 1960s, but no corresponding growth in the fraction of the population with a BA Removing these two states from our calculations (columns (4)-(6)) produces results for this cohort that are much more in line with results for other cohorts and that show statistically and quantitatively large associations between changes in flows and changes in stocks [0.31 (0.08)].[18] However, we want to emphasize here, as well as elsewhere, that we think outliers usually contain valuable information. Here the very fact that despite enormous increase in the number of individuals receiving BAs from New Mexico and Delaware, the increase in flows did not seem to translate into an increase in stocks some years down the line. Thus, these outliers would seem to confirm for us the sense we get from these tabulations that flows have a best a moderate effect stocks.[19]

Also in this table (columns 2, 3, 5, 6), we present results for older age groups that would typically have graduated from college more than 10 years prior to the year in which we observe them. These results would seem to indicate that the relationship between flows and stocks tends to diminish somewhat as cohorts age, with the elasticity declining to about 0.22(0.07) for the 35-44 age group and then falling further to .08(0.07) for those in the 45-52 age group. When thinking about this diaspora[20] of college graduates, it is important to bear in mind that, typically, the growth in flows in one decade is not 'ratified' by a growth in flows in following decades. Thus, the impact of a change in flows on stocks two to three decades later is conceptually distinct from the long run impact of a change in flows (i.e. the kind of quantity we were attempting to estimate using the cross state variation in flows).

[18] For those in the 25-34 age cohort, difference estimates for other cohorts include 0.32(0.10) for 1970-1960 and 0.41(0.06) for 1990-1980 for regressions limited to 46 states and excluding DC, Delaware and New Mexico.

[19] Here, and in other places, we see evidence that the impact of flows on stocks in states that are small either in terms of land area or population, tends to be particularly weak. We tried testing such hypotheses statistically by including interaction terms in our models. Generally speaking, the estimates on the interaction terms suggested that the smaller a state the weaker is the association between flows and stocks. However, the estimated interaction terms were generally not statistically significant. Given the sample size we are dealing with (effectively 48 observations), this was hardly surprising.

[20] Jim Hines coined this phrase.

Graphical presentations in Figure 5 illustrate the dynamics underlying the regression results. States above the 45 degree line are cases where the changes in the stock of college-educated workers exceed the change in flows and these states increased net imports of college graduates. In turn, states below the line shifted on balance to exporting college-educated workers. There is considerable variation over time in the patterns across states, and the shifts observed in the 1970-1960 are markedly larger than those observed for 1990-1980. In the early interval, notable outliers are the Dakotas, Nebraska and Wyoming. These states, which are not densely populated, struggled to maintain a well-educated population in the face of demonstrated "brain drain" to more urban areas. Yet, increases in the flow of college-graduates from these states appear to have little impact on the long-run concentration of college graduates.

Just as in the case of our cross sectional estimates, these first difference estimates do not necessarily reflect the causal effect of flow shifts. One potential problem is that demographic changes may affect not only the proportion of any cohort graduating from college but also the location decisions of these individuals. Because young and old college graduates are not perfect substitutes (Freeman 1979; Stapleton and Young, 1988), large cohorts of college-age youth will tend to drive down the rate of return to college in a state. Lower rates of return will work to discourage college enrollment, and will also tend to encourage college graduates to migrate out of state. To control for the direct effect of cohort size on the fraction in the state with a BA we include cohort size at the time of college graduation (the population aged 22, measured in logs) as an additional covariate. These results are shown in the bottom panel of Table 6 and, while the additional covariate places downward pressure on the coefficient, this effect is relatively small.

More directly, we are concerned that the estimated elasticity between flow and stock is capturing the effect of local demand shocks on flows rather than the effect of supply shocks in higher education on the concentration of college-educated in the potential labor force within a state. Including direct measures of demand captured by the employment level in the reduced form differenced regression (bottom right panel of Table 6) is one avenue to address this problem and, in this specification, point estimates change only slightly from the original specification.

The optimal fix would be the employment of exogenous factors that have changed over time as instruments for changes in flows in our difference specification. Tuition rates at state universities and colleges would seem an obvious alternative and there is ample evidence that tuition rates do, indeed, have strong effects on enrollment rates (see Kane, 1999, and the literature cited therein). However, tuition rates are, themselves, plausibly endogenous to local labor market developments. Indeed there is some evidence of a relationship between the strength of state economies and state-specific changes in tuition levels (Kane, 1999), with tuition levels at state institutions often moving upward in periods of economic contraction. Empirically, the relationship between tuition levels and cohort completion rates is relatively weak, proving insufficient to serve as a strong instrument.[21]

[21] Preliminary analysis of the pattern of completion rates indicates that increases in tuition have a modest and negative impact on completion rates while increases in the unemployment rate are positively associated with college completion in specifications that allow for state and year fixed effects. These estimates are consistent with the estimates reported in Kodrzycki (1999). We have also experimented with two other time series measures of state-level support for higher education as potential instruments: the level of state appropriations and the number of institutions of higher education in the state. Results based on these instruments were not more satisfactory that the estimates based on tuition.

Examination of the dynamic relationship for available cohorts in the engineering medical fields suggests a somewhat different story than is evident for BA degree recipients in general. What we find in the case of engineers as evidenced by the string of uniformly small and insignificant estimates in Table 7 is that changes in flows do not appear to affect changes in stocks (with the exception of the aerospace sub-field). These results are consistent with the notion that for engineering, at least in the medium run, within state demand curves are quite inelastic. One plausible explanation for this would that, in the medium run, the location of production for establishments employing engineers is geographically relatively immobile. This would be true if the industries in question showed increasing returns to scale and if their were also substantial geographic mobility costs for the industry (Krugman, 1991). At any rate, it appears that states with industries intensive in the employment of engineers will continue to draw these college-educated workers, regardless of the source of production. The state of Washington in aerospace engineering and the state of Delaware in chemical engineering are notable examples of this phenomenon, as both are plainly intensive in engineering and increase their stocks at a rate greater than their flows [see Figure 6]. One result, which carries over from the cross-sectional analysis, is the persistent out-migration of engineers trained in states like Montana and North Dakota. While these states experienced among the largest growth in the flow of engineers, the representation of workers with these skills in the changed very little over time.

For MDs, the evidence presented in Table 8 indicated that there is a positive and significant relationship between changes in flows and changes in stocks. Close inspection of the data reveals (see Figure 7) a clear and compelling story. States that had the largest changes in flows tended to be states like West Virginia and South Dakota that may have been underserved in medical care at the beginning of the interval. As such, adding a medical college in West Virginia is one policy remedy to increase the supply of doctors in the state. For example, the state of West Virginia has two universities recently established programs awarding medicaldegrees: the West Virginia University School of Medicine (part of the Robert C. Byrd Health Sciences Center) and the Joan C. Edwards School of Medicine at Marshall University.[22] Both institutions have mission statements that explicitly address the need to provide physicians and medical personnel for underserved areas and make explicit reference to recruiting students from rural West Virginia and placing graduates in clinical practices to improve health care in West Virginia. In the context of our model, it is likely that the medium term effects of changing the production of MDs within a state may be relatively large as the additional MDs producedin a state like West Virginia include many people who are from West Virginia and have a preference for remaining in the state. Still the absolute magnitudes of the coefficients are small (0.2) and indicate that for each ten additional physicians trained in the state, only about 2 will remain in the state's population for the long term.

Section 5: Conclusion

The empirical evidence in this analysis points to a modest relationship between degree production in the education market and the concentration of college educated workers in a state's population. For the general pool of BA degrees, we estimate the long-term elasticity

[22] West Virginia University awarded its first MD in 1962 and Marshall University established its medical school in 1977.

between stock and flow to be on the order of 0.3.[23] Taking BA degrees in engineering and MD degrees as special cases, our results point to the nature of demand in the labor market as a substantial determinant of the stock-flow relationship. For MD degrees, the relatively inelastic nature of demand within states in long-term equilibrium contributes to the wide dispersion across states and the relatively weak link between flows and stocks. For engineering fields, it is most difficult to infer causation from the sizable cross-sectional estimates, as it may well be that colleges and universities adjust their offers to meet the needs of local industry. The dynamic estimates, taking advantage of within state variation in output, point to a generally weak link between the output of such specialized labor and the change in the concentration of workers with these skills. It may be that, in the medium run at least, capital is less mobile than labor and the increase in specialized labor within a state is likely to be met be emigration to states with established industrial centers for the employment of specific skills.

In this regard, our estimates are also suggestive of how state economies adjust to supply shocks. The labor literature (e.g. Blanchard and Katz, 1992; Borjas, Katz and Freeman, 1997) have argued for the importance of migration as a means that states have of adjusting to macroeconomic shocks. Our results suggest that migration does work to mitigate the effects of shocks to the supply of labor – eliminating roughly more than half of the original impact – but clearly other adjustment processes are also at work. Workers surely face costs of moving from one state to another and, in a related point, many have preferences to live near family or friends from college.

---

[23] This estimate is likely to be an upper limit. It is likely that there is an association between states with a comparative advantage in the production of college-educated workers and those with a comparative advantage in employment. In this case, our estimates are likely to be biased in an upward direction.

Our results point to the finding that state policy makers have only a modest capacity to influence the human capital levels of their populations by investing in higher education. Within this relatively limited sphere of influence, the structure of specific labor markets – particularly the elasticity of demand for labor and the relative mobility of capital and labor – will substantially affect the expected link between degree production in the education market and the concentration of college-educated workers in the work force. What is far less clear from the analysis is how policy makers should evaluate the payoff to modest increments in the size of the population with BA degrees.[24] Even if there are no externalities in the form of wage spillovers, there may well be other types of externalities such as higher tax revenues, improved governance, or other amenities that make public subsidies in collegiate education a good investment.

[24] Efforts to trace out the effects of changes in the production of college-educated labor on state labor markets have not been terribly successful. The flow and especially the change in flow of college graduates in a state simply does not seem to have a large enough impact on the stock or changes in the stock of college educated workers in a state to allow for meaningful estimation of the effects of these changes on wages. At the heart of this problem is the fact that the workers in a state reflect cohorts of workers that entered the labor market over more than a half century of time. Presumably this is a problem not just for our attempts to estimate the effect of flow of college graduates on labor market outcomes, but also for others attempts to do so. The evidence concerning whether states with relatively high wages are those in which college-educated workers are used relatively intensively is inconclusive. Our capacity to identify such equilibrium agglomeration effects is confounded by the presence of demand shocks that do not appear to be fully dissipated in the labor market. As such, evidence that relies on cross-cohort differences is very sensitive to the choice of intervals of estimation. Moreover, variation in the flow of college graduates explains only a modest fraction of the overall variation in the stock of college graduates across states.

References

Alesina, Alberto; Reza Baqir and William Easterly. 1999. "Public Goods and Ethnic Divisions." *The Quarterly Journal of Economics*. Volume 114, No. 4.

Angrist, Joshua and Darren Acemoglu. 1999. "How Large are the Social Returns to Education? Evidence from Compulsory Schooling Laws," MIT mimeo.

Bartik, Timothy. 1991. *Who Benefits from State and Local Economic Development Policies?* W.E. UpJohn Institute, Kalamazoo, MI.

Beeson, Patricia and Edward Montgomery. 1993. "The Effects of Colleges and Universities on Local Labor Markets." *The Review of Economics and Statistics*. Volume 75, No, 4.

Blanchard, Olivier and Lawrence Katz. 1992. "Regional Evolutions." *Brookings Papers on Economic Activity,* No. 1, pp 1-61.

Borjas, George J.; Richard Freeman, and Lawrence Katz. 1997. "How Much Do Immigration and Trade Affect Labor Market Outcomes?" *Brookings Papers on Economic Activity* v0 n1 1-67.

Bound, John and Harry Holzer. 2000. "Demand Shifts, Population Adjustments, and Labor Market Outcomes during the 1980s." *Journal of Labor Economics*, 18:20-54.

Card, David and Thomas Lemieux. 2000. "Dropout and Enrollemnt Trends in the Post-War Period: What Went Wrong in the 1970s?" mimeo.

Card, David and Thomas Lemieux. 2000. "Can Falling Supply Explain the Rising Return to College for Younger Men?" mimeo.

Freeman, Richard. 1979. "The Effect of Demographic Factors on the Age-Earnings Profile in the U.S." *Journal of Human Resources* XIV:3.

Glaeser, Edward L., Joes A. Scheinkman, and Andrei Shleifer. 1995. "Economic Growth in a Cross Section of Cities," *Journal of Monetary Economics*, 36:117-143.

Glendon, Spencer, 1998. "Urban Life Cycles." Harvard University Mimeo.

Goldin, Claudia and Larry Katz. 1999. "The Shaping of Higher Education: The Formative Years in the United States, 1890 to 1940." *The Journal of Economic Perspectives*, Vol. 13, No. 1 (Winter).

Hanson, Gordon and Matthew Slaughter. 1999. “The Rybczynski Theorem, Factor Price Equalization, and Immigration: Evidence from the U.S. States” NBER Working Paper 7074.

Hanson, Gordon. 2000. “Firms, Workers and the Geographic Concentration of Economic Activity,” in *The Handbook of Economic Geography,* Oxford University Press.

Hanson, Gordon. 2000. “Scale Economies and the Geographic Concentration of Industry,” *Journal of Economic Geography* (forthcoming).

Jaffe, Adam. 1989. “Real Effects of Academic Research.” *American Economic Review* 79 (5) 957-970.

Katz, Lawrence and Kevin Murphy. 1992. “Changes in Relative Wages, 1963-1987: Supply and Demand Factors.” *Quarterly Journal of Economics*, Vol. 107, No. 1. (February), pp. 35-78.

Kodrzycki, Yolanda. 1999. “Geographic Shifts in Higher Education.” *New England Economic Review* (July/August).

Krugman, Paul. 1991. “History versus Expectations.” *Quarterly Journal of Economics*. Volume 106, No. 2.

Long, Larry E. 1988. *Migration and residential mobility in the United States*. New York: Russell Sage Foundation.

Moretti, Enrico. 1999. “Estimating the Social Return to Education: Evidence from Repeated Cross-sectional and Longitudinal Data.” Center for Labor Economics, Working Paper 21.

Rauch, James E. 1993. “Productivity Gains from Geographic Concentration of Human Capital: Evidence from the Cities.” *Journal of Urban Economics* v34 n3 380-400.

Rauch, James E. 1993. “Does History Matter Only When it Matters a Little? The Case of City-Industry Location.” *Quarterly Journal of Economics,* Volume 108, No. 3.

Roback, Jennifer. 1982. “Wages, Rents, and the Quality of Life.” *Journal of Political Economy*. 90:1257-78.

Stapleton, David C. and Douglas Young. 1988. “Educational Attainment and Cohort Size.” *Journal of Labor Economics* v6 n3 330-61.

Working, E.J. 1927. What Do Statistical "Demand Curves" Show? *Quarterly Journal of Economics*, Vol. 41, No. 2. pp. 212-235.

Theoretical Appendix

Recall that we are interested in the effect of exogenous shifts in the flow of college graduates in a state on the stock of college graduates in the state. However, what we observe is a cross-sectional relationship between stocks and flows. What is the relationship between the parameter we would like to estimate and the one we do? Intuitively, this will depend on the extent of exogenous variation across states in the production and use of college educated labor. A little algebra will serve to make this intuition somewhat more precise.

For each state, j, we have a supply curve of college graduates (F_j), a supply curve in the labor market (S_j) and one demand curve D_j.

(F_j) $$f_j = x_j + g\, w_j$$

(S_j) $$s_j^S = x_j^S + g^S w_j$$

(D_j) $$s_j^D = z_j - h\, w_j$$

As before, we assume that ?^{S} ≥ ? and define l such that $x^S = l\,x$ for each state. We assume that $l \leq 1$: this reflects the regression to the mean relationship between x_j and x_j^S. States with a comparative advantage in producing college-educated labor will have a larger x_j than those with a comparative disadvantage. The same is true for x_j^S but to a lesser extent: some college graduates move to the states with a disadvantage in producing them. Then, in equilibrium, we have that

(A.1) $$s_j = \frac{l h x_j + g^S V_j}{h + g^S}$$

(A.2) $$f_j = \frac{\left(h + g^S - l g\right) x_j + g V_j}{h + g^S}$$

(A.3) $$w_j = -\frac{l x_j - z_j}{h + g^S}$$

The parameter we are interested in estimating is $b \equiv \frac{\dot{s}/\dot{x}}{\dot{f}/\dot{x}} = \frac{l h}{h + g^S - l g}$ which corresponds to equation (4) in the text, with the simplifying assumption that the supply shock does not affect demand ($\dot{z} = 0$). A cross-sectional regression of stocks (s_j) on flows (f_j) estimates:

(A.4) $$\hat{b} = \frac{Cov\left(s_j, f_j\right)}{Var\left(f_j\right)} = \frac{\left(h + g^S - l g\right) l h s_x^2 + \left(g^S\right)^2 s_z^2 + \left[\left(h + g^S - l g\right) g^S + l h g\right] s_{xz}}{\left(h + g^S - l g\right)^2 s_x^2 + g^2 s_z^2 + 2\left(h + g^S - l g\right) g s_{xz}}$$

If the sole source of cross state variation arises from exogenous variation in flows (i.e. $s_z^2 = 0$), then $\hat{b} = b$. In contrast, if the sole source of variation across states arises because of exogenous variation demand (i.e. $s_x^2 = 0$) $\hat{b} = \left(g^S / g\right)^2 > 1 > b$ unless there is not mobility. In that case (?^{S}=?, l=1), $\hat{b} = 1 = b$. More generally, $\hat{b} > b$ as long as $s_x^2 > 0$, $s_{x,z} \geq 0$, and ?^{S}

≥ ?. Ceteris paribus, the magnitude of the bias $\hat{b} - b$ is negatively related to the exogenous variation in flows (s_x^2), and positively related to the exogenous variation in demand (s_z^2), and the covariance between the variation in demand and supply (s_{xz}).[25] Since we expect there to be some exogenous demand for college-educated labor we expect $s_x^2 > 0$. Since we also suspect there will be some degree of complementarity between the production and use of college educated labor, we also expect that $s_{xz} > 0$. Thus we expect that OLS estimates of β will be biased upwards. At the same time we know that β≥0. Moreover a negative association between (relative) wages (*w*) and flows (*f*), as is true in our data, implies that β>0. Thus, we have bounding result, $\hat{b} > b > 0$.[26]

A further elaboration of the model relaxes the assumption that $x^S = lx$. Presumably, however, there is variation across states in this relationship. Define k such that $x_j^S = lx_j + k_j$ for each state The additional variation in x_j^S may be a result of labor supply amenities that make new graduates prefer some states to others. In this more general case, we have that

(A.1') $$s_j = \frac{lhx_j + hk_j + g^S z_j}{h + g^S}$$

(A.2') $$f_j = \frac{(h + g^S - lg)x_j - gk_j + gz_j}{h + g^S}$$

(A.3') $$w_j = -\frac{lx_j + k_j - z_j}{h + g^s}$$

A regression of stocks (s_j) on flows (f_j) estimates:

(A.4')

$$\hat{b} = \frac{\text{cov}(s_j, f_j)}{\text{var}(f_j)} = \frac{Ahl s_x^2 + (g^S)^2 s_z^2 + (A - lg)hs_{xk} + (Ag^S + lhg)s_{xz} + (hg - g^S)s_{zk}}{A^2 s_x^2 + g^2 s_k^2 + g^2 s_z^2 - 2Ags_{kx} + 2Ags_{xz} - 2g^2 s_{zk}}$$

where $A \equiv h + g^s - lg \geq h$, with strict inequality if there is migration ($?^S > ?$). Note that in this

[25] These results echo classic results from in the economics literature on estimating supply and demand elasticities going back at least to the work of Working (1927).

[26] We have continued to assume that supply shifts have no direct effect on demand. In this context, positive covariance between ξ_j and ζ_j will work to exacerbate the upward bias on $\hat{b}$. If, however, there is a direct link between demand and supply (i.e. if $\frac{\partial z}{\partial x} > 0$), then part of the positive covariance between ξ_j and ζ_j represents the direct effect of supply on demand. In this case, $b > h(lh)/(h + g_S - lg)$, and the expressions we have derived will to some extent exaggerate the upward bias of the estimate of β.

case, s_k^2 mitigates the upward bias of $\hat{b}$. On the other hand, all of the qualitative results regarding (A.4) hold if the variation in d is relatively small, or the covariance supply and demand amenities (s_{kz}) and the covariance of supply amenities and advantage in higher education (s_{xk}) are positive.

Data Appendix

The primary sources of data for this analysis are: the decennial Census files, the decennial Census publications, population estimates by the Census Bureau, the October CPS files, institutional surveys of degrees awarded, the National Survey of College Graduates, and the AMA Physician Professional Data. Appendix Table 1 lists specific references.

In the paper, we analyze four types of degrees: BAs, Engineering BAs, and MDs. The first part of the appendix is organized by degree type. Steps that apply to all types are discussed with all BAs.

BA Degrees

Flows

We wish to compute the *per capita flow* of college graduates for each state and birth cohort, and the *per capita stock* of college graduates for each state and cohort for the census years 1960, 1970, 1980, and 1990.

A major measurement problem arises from the fact that, in our baseline data, the *stock* variable is defined for birth cohorts, while the *flow* refers to the year of graduation. Therefore, we had to estimate *flows* for birth cohorts from the degree-year data. We do not observe the flow of BA degrees awarded to members of birth cohorts directly, but only the sum of degrees awarded to cohorts of different ages. While age 22 is the modal age group for BA recipients, not all BA degree recipients are this age.

First, in each year, we estimated the number of college degrees conferred for different ages. Using micro data from the October Current Population Survey, we estimated the age distribution of college seniors and then estimated the number of college degrees conferred to individuals in each birth cohort each year. Micro data from the October CPS is available from 1969 to the present. For years prior to 1969 we assumed the age distribution of college seniors was similar to the age distribution in 1969. Since the age distribution corresponds to the age distribution in October, while most individuals receive their degrees in June, we estimated the spring age distribution by assuming that half of each cohort was a year younger at that time (basically assuming uniform distribution of month of birth).

To estimate the number of degrees conferred by cohort in each state, we multiplied the age distribution of the BA degrees conferred by the annual number of degrees awarded in each state as reported in institutional surveys of colleges and universities. We then assigned the different year-by-age numbers to the corresponding cohorts (defined by year of birth) in each state. Thus, for example, if we estimated that 40 percent of graduating seniors in 1980 were 22, we would assign 40 percent of the degrees conferred in each state in 1980 to that cohort.[27]

Third, we divided this absolute number by the size of the cohort in the state. Since the modal year of college completion is 22, we used estimates of the size of the cohort at age 22 for this purpose. The U.S. Census Bureau reports population estimates by state and single year of age 1970 and later. For the years prior to 1970, we estimated the share of 22 years old in the total population in a state by a weighted average of the corresponding birth cohorts from the two closest census figures, the weights being inversely proportional to the distance from the given census year.[28] We then used these estimated shares and the total population of the states in the corresponding years to estimate the number of 22 years old.

The per capita flow data is the ratio of these two estimates: the estimated number of degrees conferred for a given birth-cohort in a given year, divided by the size of that cohort in the state when they were 22 years old.

In the analysis, we use stock variables referring to different years: 1960, 1970, 1980, and 1990. When analyzing flows with these different stocks, one does not want to include in the flows those college graduates who received their degrees after the year of the stock. Therefore, were carried out the estimation of the flows four times, each corresponding to one stock variable.

Stocks

To estimate the per-capita stock of college graduates in a state we used micro data from the decennial census for the years 1960, 1970, 1980 and 1990. For 1960, the largest sample available represents a 1 percent random sample of the population. For 1970, the largest sample for which state of residence is available represents a 2 percent random sample of the population. For 1980 and 1990, the samples we used represent 5 percent of the population. In 1990, the census asked about the highest degree received by an individual. We assume that all those who identified themselves as having a Bachelors, Masters, Professional, or Doctorate degree were college graduates. For earlier years, the census asked how many years of college a person had completed. For these years, we assumed that anyone who completed 4 or more years of college was a college graduate.

---

[27] Since we did not have degrees conferred data for years prior to 1950, our per capita flow estimates are truncated for those cohorts that turned 22 in the early 1950s. The (extrapolated) age distribution of the graduates suggests that approximately 70 per cent of a cohort graduated at the age of 22 or before. This means that a 30 per cent of those who turned 22 in 1950 received their degree before 1950, for the time-period we have no data. For similar reason, we don't have degrees conferred data for 20 per cent of the cohort that turned 22 in 1951, and for 15 per cent of those that turned 22 in 1952, and so on.

[28] For example, the share of 22 years old in the population of a given state in 1963 was estimated by 0.3 times the share of the 29 years old in the 1970 census plus 0.7 times the share of the 19 years old in the 1960 census.

The 1980 and 1990 censuses allow one to identify state of work as well as state of residence. We did separate tabulations using data organized by state of residence, but found it made very little difference whether we identified individuals by their state of residence or their state of work.

Engineering BA Degrees

For the analysis that focuses on BA degrees in engineering, we use a similar strategy to assign degrees to birth cohorts. Instead of the October CPS, we used the 1993 National Survey of College Graduates (NSCG). The 1993 NSCG is a nationally representative sample of all college degree holders who were identified through the 1990 Census. While the survey includes people with a BA or higher in any field, we focus on those who earned a BA in engineering. The survey provides information on the each degree earned, including field and year. Together with the age in 1990 of each respondent, we used this information to estimate the distribution of age at degree for engineering BA degrees. We did this separately for each degree year. Since the distribution of age at degree does not vary substantially by field within engineering, these estimates do not distinguish between the different sub-fields of engineering.

We used the occupation data in the 1980 and 1990 Census to identify engineers, counting as engineers only those individuals that identified their occupation as engineer and who also are college graduates. Conceptually, we would have like to have been able to identify individuals who received an engineering BA, regardless of their occupation or employment status, but doing so is not possible using the Census data.[29] However, the tabulations we have done using the 1993 National Survey of College Graduates data show that most of those who received a degree in engineering work as engineers (66 percent), and that most of those who work as engineers received a BA in engineering (68 percent).

MD Degrees

For MD degree recipients, we constructed degree flows from the AMA Physician Professional Data. This is a comprehensive source of information on U.S. physicians, including both members and non-members of the AMA. The file includes information on date of birth and medical school for each physician. For physicians trained at U.S. medical schools, we used the year-end files for 1980 and 1991 to construct an estimate of degree flows by state and year of birth. We matched these degree flows – by State and year of birth – with population in the five-year age group 25-29. (About 80 percent of the physicians in the 1991 AMA file received their MD between the ages of 25 and 29.)

[29] As an alternative, we had hoped to use the National Survey of College Graduates, since it separately identifies degrees and occupation. However, the data do not contain the proper geographic identifiers.

We calculated the population age 25-29 in each state and year using Census Bureau data and a followed the imputation strategy discussed above under BA degrees in the years prior to 1970 when single year age tabulations were unavailable.

To estimate the per-capita stock of MD's in 1980 and 1991, we tabulated the number of physicians by State and year of birth. For our stock measure, we dropped those who are not actively practicing medicine and those in residencies. To put these stocks in per-capita terms, we divide them by the population in 1980 or 1991, by State and year of birth.

Other Variables

Birth Cohort Size: Data on the size of a birth cohort for each state from 1928 – 1970 (these are the cohorts that would have been 22 between 1950 and 1992) were entered from vital statistics data distributed by the National Center for Health Statistics. The original data came from birth registrations.

BAs in 1929: Counts are from Table 4a "Summary of degrees conferred in 1929-30" of the *Biennial Survey of Education*, 1928-1930.

Racial Disparity Index: Calculated to replicate the variable used by Alesina, Baqir, and Easterly (1999). In particular, we computed the index for a state as:

$$Q_{kt}=1-\Sigma_k \, s_{jkt}^2 \, ,$$

where s_{jkt} is the share of the jth racial group in the kth state in year t. Following Alesina, Baqir, and Easterly (1999), we categorized individuals as white, black, American Indian, Asian, or other.

Relative wages: The adjusted average relative wage measures are computed as the return to exactly a BA Degree (or 16 years of completed education) from state-specific hourly wage regressions with a full set of controls for demographic characteristics.

Data Appendix Table 1: Sources of data

Source	*Use*
Census of Population and Housing, United States Department of Commerce. Bureau of the Census. 1960 Public-Use Sample: 1 Percent Sample 1970 Public-Use Sample: 1 Percent Sample, 15 Percent State Questionnaire 1970 Public-Use Sample: 1 Percent Sample, 5 Percent State Questionnaire 1980 Public-Use Sample: 5 Percent Sample 1990 Public-Use Sample: 5 Percent Sample	Census data provide stock measures of educational attainment by state. Occupational codes such as teacher and physician permit the identification of skills beyond years of educational attainment.
U.S. Census Bureau 1950, 1960, and 1970 State Volumes	Population estimates by State and single year of age, in 1950, 1960, and 1970. Used for estimating cohort size per State at age 22 and age 25-29, for years 1950-1970.
U.S. Census Bureau Population Estimates (http://www.census.gov/population/www/estimates/st_stts.html)	Population estimates by State and year, 1950-1970.
U.S. Census Bureau Population Estimates (http://www.census.gov/population/www/estimates/popest.html)	Population estimates by State, age, and year from 1970.
Current Population Survey, October, 1969-1990. U.S. Census Bureau and Bureau of Labor Statistics	Used to estimate the age distribution of college seniors, 1969-1990.
Higher Education General Information Survey (HEGIS): Earned Degrees, 1967-1968 through 1985-1986. U.S. Department of Education, National Center for Education Statistics.	Data on degrees conferred at the levels of Associate, BA, and First Professional

	collected annually through institutional surveys conducted by the Department of Education. Data contain detailed information on field of study.
Integrated Postsecondary Education Data System (IPEDS): Earned Degrees, 1986-1987 to present. U.S. Department of Education, National Center for Education Statistics.	
"Earned Degrees Conferred," Department of Education annual, 1950-1966.	
National Survey of College Graduates, 1993, National Science Foundation.	For a nationally representative sample of college graduates in 1990, the survey contains data on age in 1990 and year of degrees earned. Used for estimating the distribution of age at degree for Engineering BA degrees.
Physician Professional Data, 1980 and 1991 year-end files, American Medical Association.	Data contain information on date of birth, medical school, and current state of residence for physicians practicing in the U.S. We use these data to construct stocks and flows by State and birth cohort.

Table 1: Stock and Flow Summary Statistics Cohorts Turning 22, 1966-1985

Panel A: Major Degree Types

		# per 1000	CV	Analysis of Variance State	Cohort	Within
BA	Flow	256.09	1.1	0.77	0.12	0.11
	Stock	243.29	0.8	0.69	0.21	0.10
MD	Flow	3.47	2.7	0.87	0.05	0.08
	Stock	4.33	0.8	0.53	0.26	0.21

Panel B: Stock and Flow Summary Statistics, By BA Field Cohorts Turning 22, 1966-1985

		# per 1000	CV	Analysis of Variance State	Cohort	Within
Engineering All						
	Flow	14.6	1.6	0.69	0.20	0.11
	Stock	10.0	1.7	0.54	0.08	0.39
Engineering subfields						
Aerospace	Flow	0.4	5.5	0.80	0.06	0.14
	Stock	0.6	6.4	0.64	0.03	0.33
Chemical	Flow	1.6	3.2	0.75	0.12	0.13
	Stock	0.5	6.3	0.53	0.02	0.46
Civil	Flow	2.8	2.2	0.80	0.05	0.15
	Stock	1.6	1.5	0.17	0.02	0.81
Mechanical	Flow	3.0	1.9	0.63	0.21	0.16
	Stock	1.0	2.8	0.26	0.02	0.72
Electrical	Flow	3.8	1.8	0.63	0.22	0.15
	Stock	2.7	2.5	0.48	0.06	0.46

Notes: "Flow" data represent the number of degree recipients from a state divided by the age-appropriate population. "Stock" data are the number of degree recipients in the state relative to the population base in the state. "Years" are defined as the year of degree receipt. The CV, or coefficient of variation, is the partial coefficient of variation reflecting between state variation.

Table 2: Cross-section stock-flow elasticities, 1966-85 Degree Cohorts

A. By type of degree

	Elasticity Ln-Ln (1)	Linear (2)	Elasticity from (2) (3)
BA	0.34	0.30	0.32
	(0.08)	(0.07)	(0.08)
MD		0.08	0.07
		(0.04)	(0.04)

B. By field of BA

	Elasticity Ln-Ln	Linear	Elasticity from (2)	Elasticity Estimate Outliers Deleted		Outliers	
				Flow	Fl & Stock	Flow	Stock
	(1)	(2)	(3)	(4)	(5)		
Engineers All	0.26	0.07	0.11	0.56		MT, WY	
	(0.20)	(0.12)	(0.18)	(0.11)		ND, SD	
Aerospace		0.46	0.31	0.27	0.18	CO	WA
		(0.14)	(0.09)	(0.16)	(0.13)		
Chemical		0.16	0.52	1.43	0.59	MT, WY	DE
		(0.16)	(0.50)	(0.70)	(0.21)		
Civil		0.06	0.10	0.34		MT, WY	
		(0.08)	(0.13)	(0.15)		ND, SD, VT	
Mechanical		0.16	0.48	0.59	0.28	SD	MI
		(0.10)	(0.29)	(0.33)	(0.14)		
Electrical		0.11	0.15	0.56	0.32	WY, SD	MA, UT
		(0.17)	(0.24)	(0.15)	(0.21)	ND	NM

Notes: The regressions include data for 48 continental states and exclude the District of Columbia. The stock and flow variables correspond to the degree type listed in the first column. The regressions include year-specific effects and correspond to the specification in equation (1) in the text. Standard errors are calculated using the method of Huber-White and allow for arbitrary clustering at the state level. Flow and stock variables are associated with the 1990 Census year.

Table 3: Cross-section estimated elasticities, BA Only, 48 States

Age Range	OLS (1)	Instrumental Variables: BA Flow 1929 (2)	Instrumental Variables: Racial Disp (3)
1990			
25-62	0.30	0.62	0.40
	(0.08)	(0.21)	(0.15)
25-34	0.40	0.61	0.32
	(0.09)	(0.24)	(0.17)
35-44	0.32	0.79	0.51
	(0.08)	(0.27)	(0.15)
45-54	0.20	0.63	0.42
	(0.09)	(0.24)	(0.14)
55-62	0.31	0.48	0.32
	(0.10)	(0.17)	(0.15)
1980			
25-34	0.31	0.74	0.52
	(0.07)	(0.24)	(0.13)
35-44	0.23	0.72	0.48
	(0.08)	(0.26)	(0.15)
45-52	0.27	0.47	0.31
	(0.11)	(0.19)	(0.15)
1970			
25-34	0.23	0.56	0.43
	(0.08)	(0.22)	(0.14)
35-42	0.30	0.45	0.39
	(0.10)	(0.20)	(0.16)

Notes: Standard errors are calculated using the method of Huber-White and allow for arbitrary clustering at the state level.

Table 4: Estimates of effect on relative wages of concentrations of college-educated labor

	OLS	Instrumental Variables		
		Aggregate Flow 1950-t	BA Flow 1929	Racial Disparity
	(1)	(2)	(3)	(4)
1960	-0.02	-0.38	-0.31	-0.50
	(0.06)	(0.31)	(0.23)	(0.22)
1970	-0.06	-0.28	-0.26	-0.23
	(0.03)	(0.15)	(0.11)	(0.10)
1980	-0.04	-0.16	-0.19	-0.26
	(0.02)	(0.08)	(0.06)	(0.07)
1990	-0.03	-0.19	-0.20	-0.28
	(0.02)	(0.09)	(0.07)	(0.11)

Notes: The dependent variable in the cross-section measure is the regression-adjusted state-specific measure of the relative difference in college high school wages (measured in logs). The independent variable is the log of the ratio of college degree recipients to those with a high school degree or less.

Table 5: Means of difference measures of flow and stock

Census Years	Age Range	Ln Difference of BA Flow		Ln Difference of BA Stock	
		Mean	Std Dev	Mean	Std Dev
1970-60	25-34	0.41	0.14	0.37	0.11
1980-70	25-34	0.23	0.11	0.45	0.09
1990-80	25-34	-0.10	0.10	-0.08	0.10
1980-70	35-44	0.42	0.13	0.41	0.09
1990-80	35-44	0.23	0.11	0.36	0.08
1990-80	45-52	0.42	0.13	0.36	0.08

Notes: Table entries reflect the log difference over the indicated decade of averages of flows and stocks for the indicated age ranges.

Table 6: Dynamic estimates of the effects of flows on stocks

	OLS, 48 States			OLS, 46 States		
	25-34	35-44	45-52	25-34	35-44	45-52
1960-70	0.37			0.32		
	(0.09)			(0.10)		
1970-80	0.15	0.22		0.31	0.20	
	(0.10)	(0.07)		(0.08)	(0.07)	
1980-90	0.44	0.22	0.08	0.41	0.31	0.10
	(0.06)	(0.07)	(0.07)	(0.06)	(0.07)	(0.08)

	48 States, Population			48 States, Population, Empl.		
	25-34	35-44	45-52	25-34	35-44	45-52
1960-70	0.34			0.40		
	(0.13)			(0.13)		
1970-80	0.08	0.16		0.07	0.14	
	(0.09)	(0.10)		(0.09)	(0.09)	
1980-90	0.40	0.10	-0.08	0.41	0.11	0.00
	(0.07)	(0.04)	(0.09)	(0.07)	(0.05)	(0.09)

Notes: The regressions include data from the 48 continental states. The regressions are specified with differenced observations for each year within the decennial interval with the inclusion of year fixed effects and correspond to the specification presented in equation (2). Standard errors are calculated using the method of Huber-White and allow for arbitrary clustering at the state level.

Table 7: Dynamic estimates for engineering and associated subfields, 1990-1980

	Elasticity Ln-Ln (1)	Linear (2)	Elasticity from (2) (3)	Elasticity Estimate Outliers Deleted Flow (4)	Elasticity Estimate Outliers Deleted Fl & Stock (5)	Outliers Flow	Outliers Stock
Engineers All	0.14	-0.05	-0.09	0.16	0.04	MT,ND	WY
	(0.29)	(0.09)	(0.15)	(0.16)	(0.19)		
Aerospace Engineers		0.21	0.17	0.27	0.27	MT,AL	WA
		(0.19)	(0.15)	(0.15)	(0.15)		
Chemical Engineers		-0.02	-0.06	0.10	0.14	MT,WY	DE
		(0.03)	(0.08)	(0.22)	(0.22)		
Civil Engineers		-0.14	-0.26	-0.23		MT,ND	
		(0.06)	(0.11)	(0.12)			
Mechanical Engineers		0.01	0.03	0.10	0.11	MT,WY	ID
		(0.04)	(0.12)	(0.18)	(0.18)		
Electrical Engineers		0.00	0.00	0.08		ND, NE, WY	
		(0.12)	(0.20)	(0.26)			

Notes: The regressions include data from the 48 continental states. The regressions are specified with differenced observations for each year within the decennial interval with the inclusion of year fixed effects and correspond to the specification presented in equation (2). Standard errors are calculated using the method of Huber-White and allow for arbitrary clustering at the state level.

Table 8: Dynamic estimates for MDs, 1990-1980

Field and Cohort	Linear	Elasticity from (1)
	(1)	(2)
Medical Doctors		
35-44	0.22	0.17
	(0.06)	(0.04)
45-44	0.25	0.16
	(0.07)	(0.05)

Notes: The regressions include data from the 48 continental states. The regressions are specified with differenced observations for each year within the decennial interval with the inclusion of year fixed effects and correspond to the specification presented in equation (2). Residents are not included in the tabulations.

Figure 1: State-level adjustments to changes in flows.

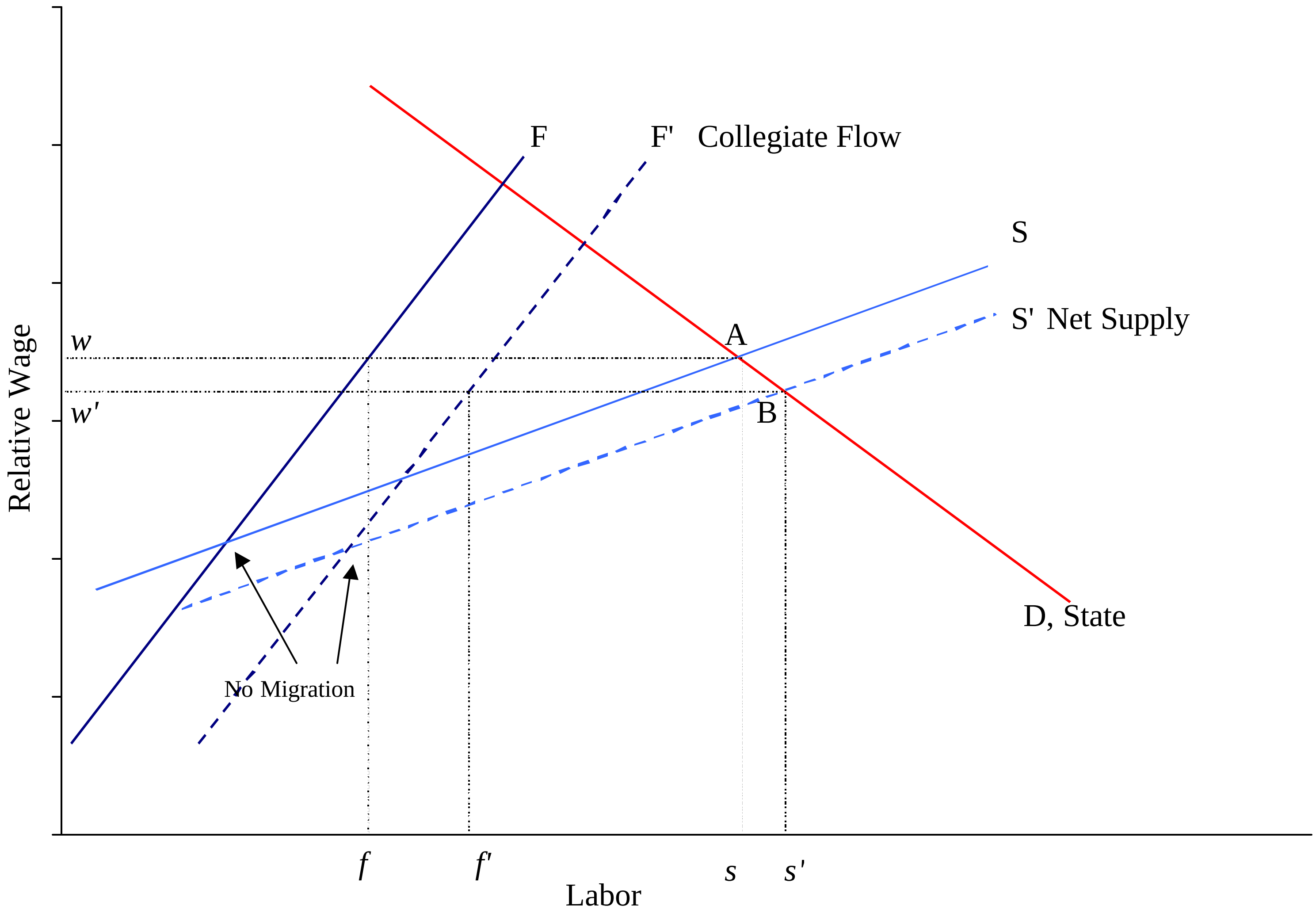


Figure 2: Flows of degrees awarded relative to cohort size by degree type, 1966-85 degree cohorts

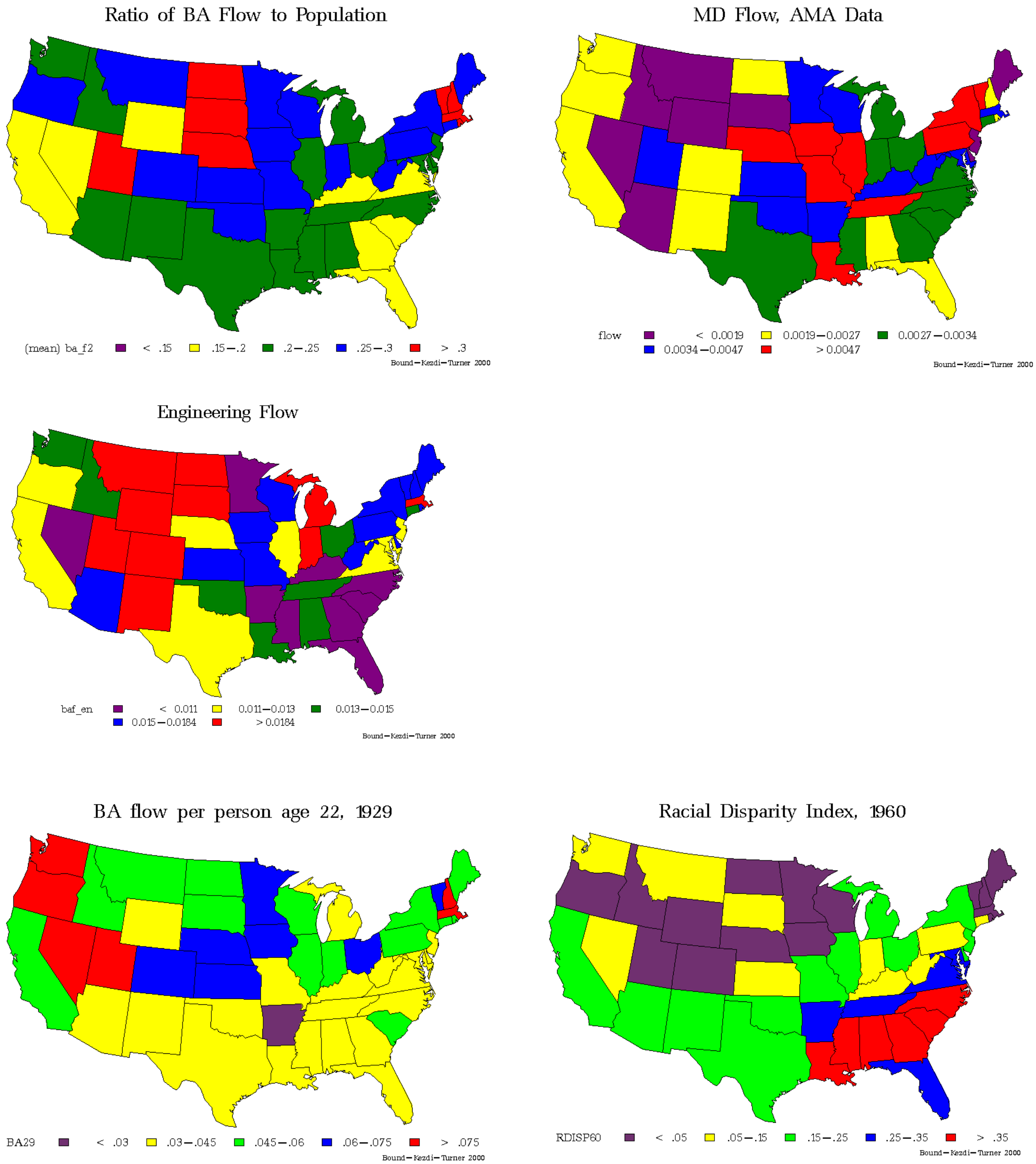
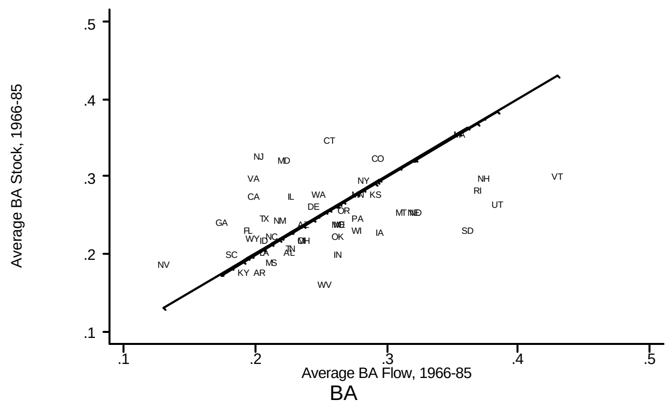


Figure 3: Stocks and flows of degrees awarded relative to cohort size, 1966-85 degree cohorts



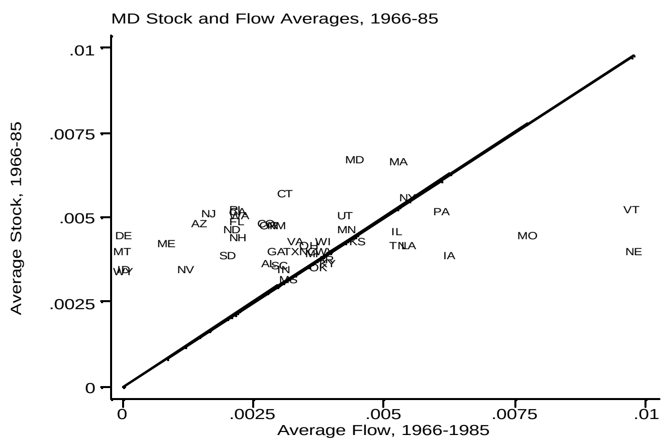


Figure 4: Stocks and flows of degrees awarded relative to cohort size, 1966-85 degree cohorts by field of BA

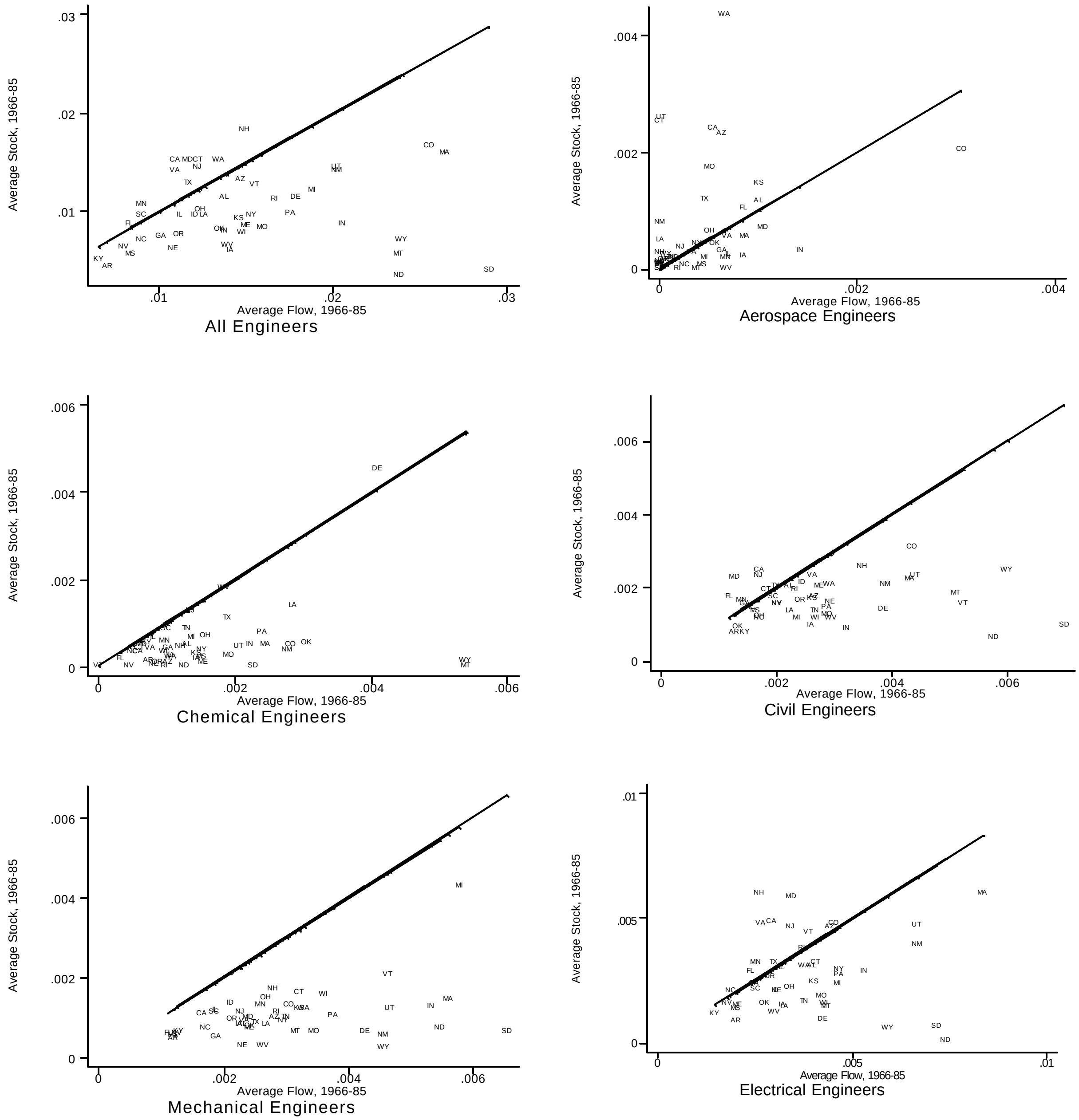


Figure 5: Changes in flows and stocks relative to cohort size, BA degrees by field

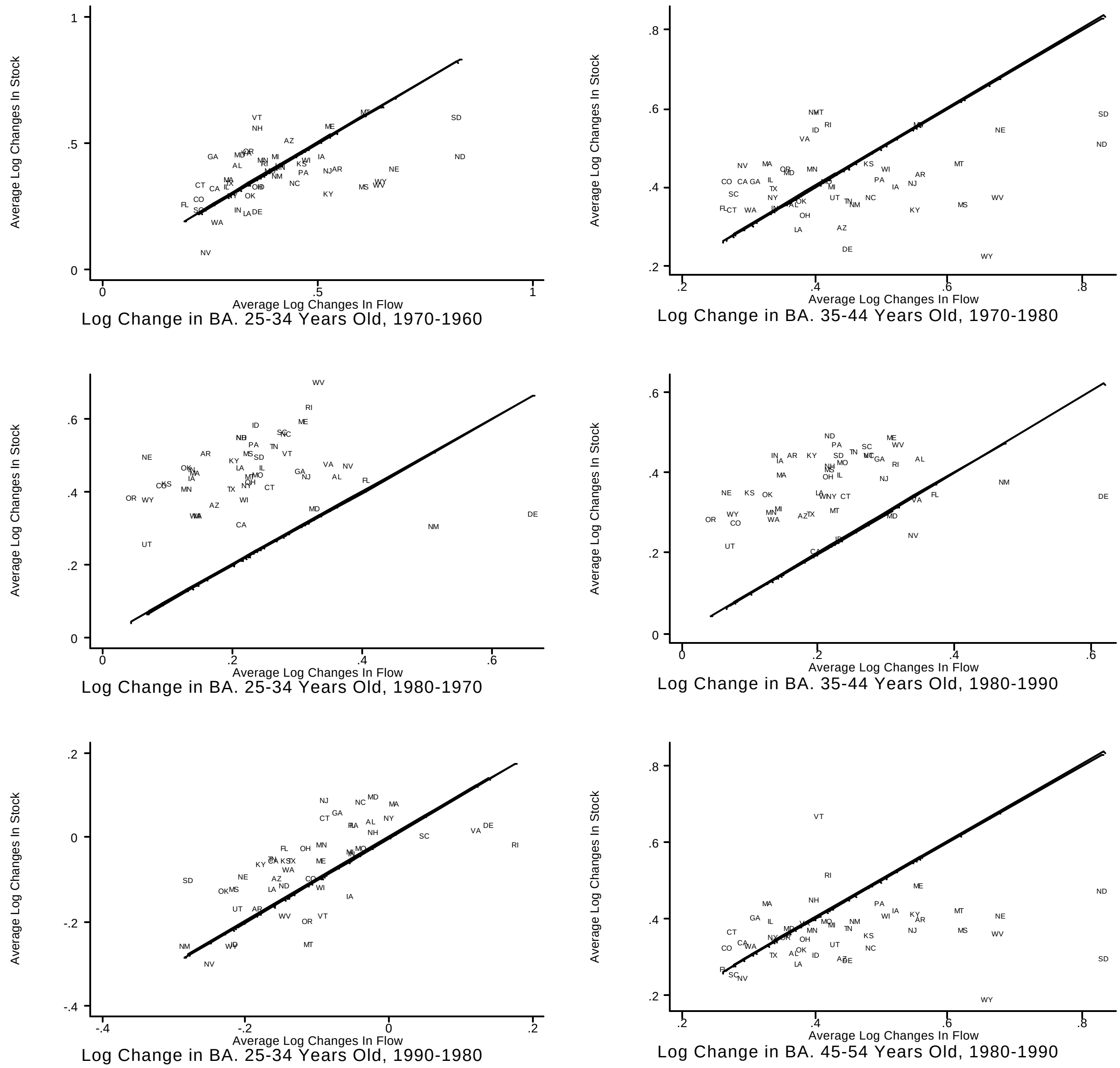


Figure 6: Changes in flows and stocks relative to cohort size, BA degrees by field

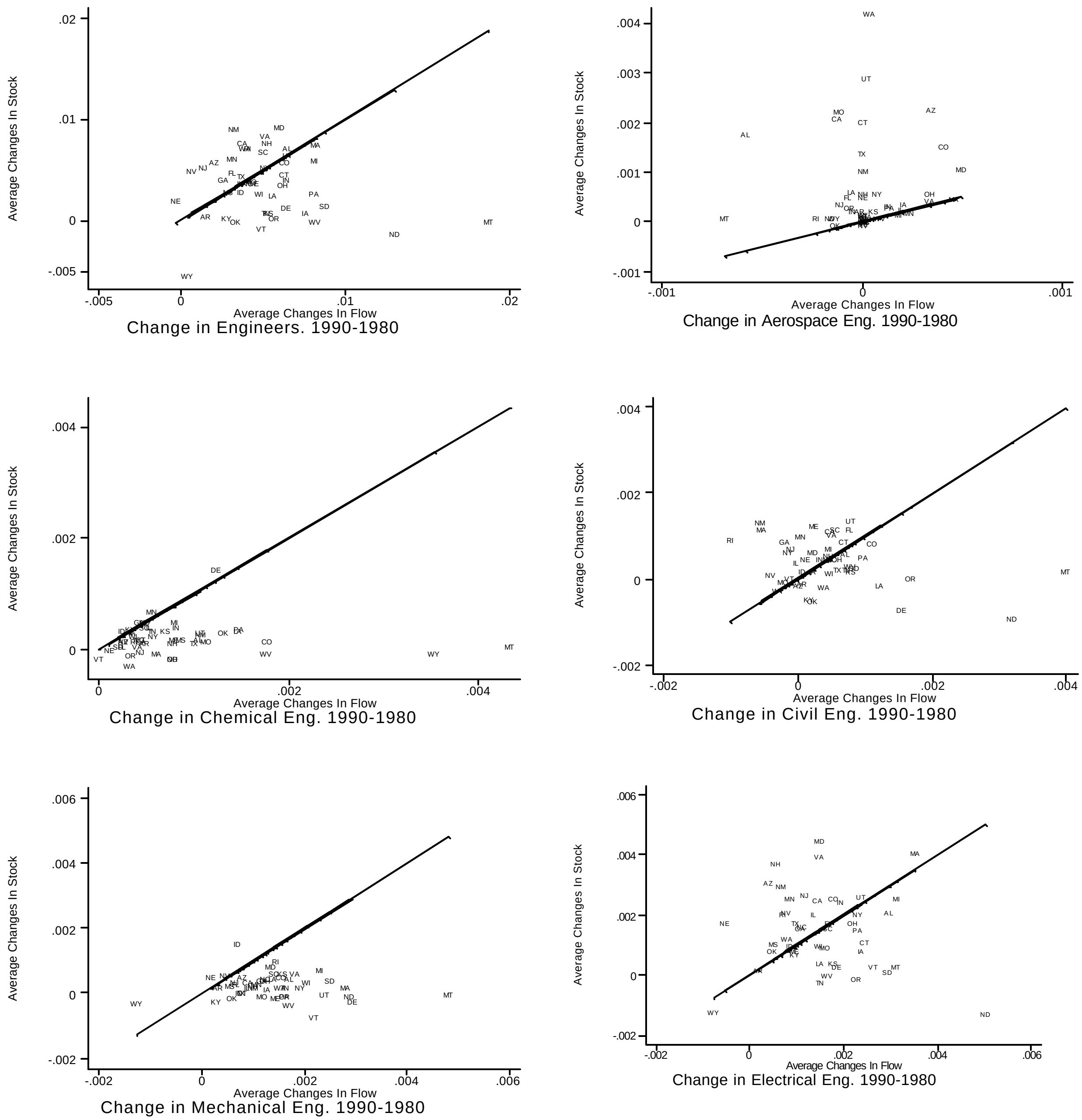
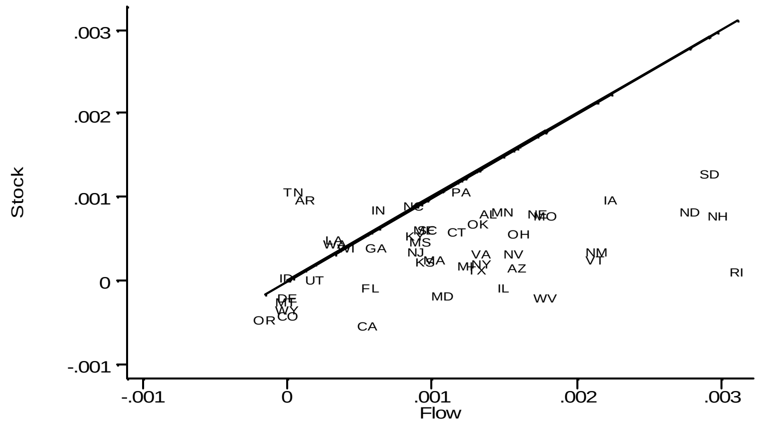
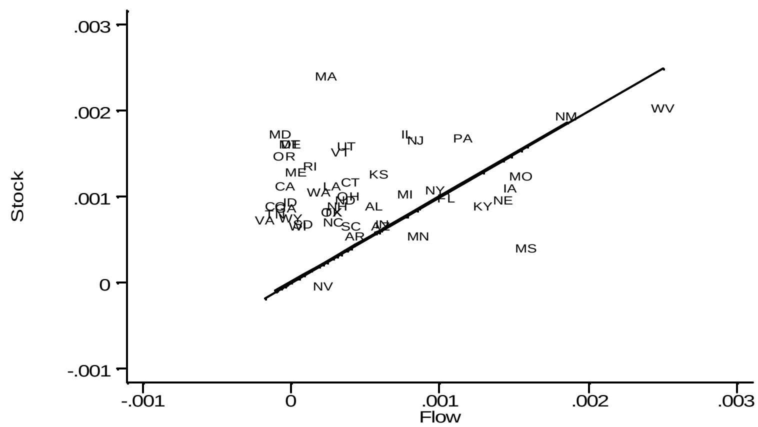


Figure 7: Changes in flows and stocks relative to cohort size, MD degrees



MD 1980-1991 Change, Ages 35-44



MD 1980-1991 Change, Ages 45-54