The Allocation of Talent: Evidence from the Market of Economists

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Abstract Recent research in labor economics has highlighted the substantial and long-lasting adverse effect of recessions on employment prospects and earnings. In this paper, we study whether individuals react to these shocks by changing career paths and thereby affect the selection of talent into sectors. More concretely, we examine how the publication success and career choice of graduates from the leading US economics PhD programs varies with the state of the business cycle at application and at graduation. Our results strongly support the predictions of a Roy-style model of self-selection into sectors: We find that adverse macroeconomic conditions at application lead to a substantially more productive selection of individuals into academia and at graduation they lead to more PhDs deciding to stay in academia.

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1 Introduction

There has been a growing interest in labor economics about the effect of macroeconomic conditions on microeconomic outcomes. In particular, recent studies have found a substantial and persistent negative impact of recessions on individuals' employment and earnings.[1] Yet, to the best of our knowledge, there is no study which examines whether individuals react to these recession shocks in terms of occupational choice and the potential impact the reaction might have on the talent allocation and productivity across sectors. Our paper fills this gap in the literature by looking at a specific market where individual skills can readily be measured - academia.[2]

We study the impact of the business cycle at application and graduation on the skill allocation in the academic labor market. This is done by relating the research productivity and career choice of (potential) economists graduating from top 30 US universities to the change in the unemployment rate during the last 50 years. To guide our empirics, we develop a Roy-style model (1951) of the selection of talent into business and academia, where entering academia is competitive but attractive during recessions. The model predicts that, while less of the economists who faced a recession at application to the PhD stay in academia after graduation, those who do stay are a better selection of academic productivity. Moreover, if there is a recession at the time of graduation, more economists pursue academic employment, which leads to more publications per PhD graduate.

The results of the empirical analysis show that individuals do react to recession shocks and they strongly support the theoretical predictions. Economists applying or graduating during recessions publish significantly more than economists applying or graduating in a boom. A recession at entry leads to less PhD students staying in academia, a recession at graduation has the opposite effect. Moreover, the effects are of economically substantial magnitude. Taking our estimates literally, we expect

[1]See, for example, Oreopoulos, Wachter, and Heisz (2008), Sullivan and von Wachter (2009), Kahn (2010), Kondo (2008), Oyer (2006),Oyer (2008).

[2]We use the terms “talent” and “skill” interchangeably throughout this paper. It seems to us that a lot of people think of skill as something that is acquired while talent is naturally endowed. The results in our paper suggest that this difference may not be too great for (potential) PhD economists.

assistant professors from the cohort of graduate students who applied for the PhD during the recession of 2008 (3.5% increase in unemployment) to be around 24 percent more productive than assistant professors from a cohort applying in an average year (0% unemployment change). We also expect PhD graduates from 2008 to produce on average 20 percent more publication output than economists graduating in an average year.

Our results contribute to several discussions in the academic literature: First, they show that individuals strongly and persistently react to (temporary) shocks in terms of career choice, which leads to a change in the allocation of talent among sectors. This adds to the broader debate about the allocation of talent, especially in the financial sector and in teaching.[3] Second, by observing that individuals at the top of the skill distribution switch among sectors we infer that they possess general ex-ante skills and that even ex-post, after six years of specific PhD training, some individuals' skills are general enough to go back to the private sector. This relates to the born versus made debate in labor economics (e.g. Bertrand 2009, Oyer 2008). Third, our results imply that it is possible to lure talent to research by increasing their wages. Fourth, we note that the predictions of a Roy-style model are strongly supported by the data in our quasi-experimental empirical setting.

For our empirical analysis we construct a new dataset of economists' career choice and publication output from publicly available sources. The dataset consists of graduation years and the degree granting universities of 13624 PhDs since 1955 from the top 30 American institutions. We match each person with all their publications available on JStor and with an indicator for becoming a faculty member or a member of the American Economic Association (AEA) after the PhD. Thus, we can calculate the propensity to stay in academia and the publication output for each economist. Finally, we aggregate each cohort according to its university and graduation year, and match macroeconomic (labor market) conditions at application to and at graduation from the PhD. In the analysis we use standard OLS regressions to quantify the influ-

[3]See, for example, Philippon and Reshef (2009), Bolton, Santos, and Scheinkman (2010) and Nickell and Quintini (2002).

ence of labor market conditions at application and at graduation on both, economists' propensity to decide in favour of academic employment and on their productivity.[4]

Our paper is closely related to three distinct strands of literature. First, as mentioned above, we contribute to the recent literature that analyzes the effect of business cycle shocks on individuals' careers. Kahn (2010) finds large and persistent negative wage effects of graduating from college in a worse economy. Oreopoulos, Wachter, and Heisz (2008) show that university graduates who enter the labor market during a recession experience a substantial initial loss of earning which fades only after 8-10 years, but that more highly skilled graduates suffer less because they switch to better firms rapidly.[5] Our study is the first to look at highly skilled individuals' response to these recession shocks by changing careers and its effect on the skill composition in one of the affected sectors. The results are consistent with those of Oreopoulos, Wachter, and Heisz (2008), as we find that more highly skilled individuals (are able to) respond more strongly.

The second strand of literature we contribute to is concerned with sorting in the labor market. While the papers above generally find that vertical, non-voluntary sorting (i.e. worse job placements whose effects are long-lasting) is the source of the negative impact of recession shocks, we consider horizontal, voluntary sorting (i.e. the individual's decision to continue his career in a different sector). In two papers in 2006 and 2008, Paul Oyer estimates the effect of vertical sorting on long term earnings and productivity by instrumenting MBAs' and economists' first placements with the state of the economy at the time of graduation. Combining Oyer's and our paper on economics PhDs, it may well be that we underestimate the strength of our selection effect because of his placement effect and vice versa.[6]

There are plenty of well-known studies that are concerned with the sectoral se-

[4]We use the change in unemployment instead of recession indicators as our preferred explanatory variable throughout. We do this because it is continuous and thus carries more information and because it may quite accurately proxy the change in the relative attractiveness of private sector employment for our individuals.

[5]Other papers in this literature include Sullivan and von Wachter (2009),von Wachter, Song, and Manchester (2008), and Kondo (2008).

[6]For a more detailed explanation, see section 4.4.

lection of skills and the empirical content of the Roy model.[7] These papers employ "structural" econometric techniques while our quasi-experimental study doesn't need to rely on specific distributional assumptions about skills, for example. We nonetheless find strong empirical support for the predictions of the Roy model. Another influential recent study by Philippon and Reshef (2009) describes the relationship between relative wages and human capital in the financial sector in the United States over the last century, but it is unable to establish a causal effect of the former on the latter. In contrast, we are able to shed some light on the causal relationship between sectoral attractiveness and talent allocation.[8]

The third group of literature this paper deals with is concerned with the determinants of scientific productivity and their potential policy implications.[9] Our study is most closely related to the papers that examine the impact of science funding on research productivity. Funding increases, like recessions, raise the attractiveness of the academic sector compared to the private sector. Goolsbee (1998) shows that up to 50% of a government spending increase go into higher salaries for scientists and engineers. Suggesting that the supply of such knowledge workers is relatively inelastic, he argues that a large fraction of governmental research funding may in fact be ineffective and may only constitute a windfall gain for scientists. On the contrary, our results imply that, depending on the exact institutional realities,[10] the quantity and/or quality of researchers should strongly and persistently increase with more funding.[11]

The remainder of the paper proceeds as follows. We derive our theoretical predic-

[7] See, for example, Heckman and Honoré (1990) and, more recently, Keane and Wolpin (1997) and Lee and Wolpin (2006).

[8] One paper that uses quasi-experimental identification to study sectoral selection is Bedard and Herman (2008). However, they do not explicitly study its effect on sectoral talent allocation and they lack a theoretical framework to support and extrapolate their empirics.

[9] Some recent studies have exploited exogenous shocks to cooperations between scientists in order to better understand the importance of peer effects (e.g. Waldinger 2009, Azoulay, Zivin, and Wang 2008). Other studies suggest that new communication technologies have changed the production and the dissemination of research (e.g. Kim, Morse, and Zingales 2006, Ellison 2007).

[10] Depending on whether there is a fixed or a flexible number of spaces in the academic sector. This may differ between the short- and the long run with the number of spaces adjusting over time.

[11] Along these lines, Freeman and van Reenen (2009) assert that, at least in the long run, not only the number of scientists but also the selection of talent into science will increase due to higher salaries.

tions from a modified version of the Roy Model in the next section. Then we describe how we assembled our novel dataset of PhD economists' publication success. Section 4 presents and interprets the empirical results while section 5 concludes.

2 Theory

We are interested in how the selection of skills into academia and business varies with the state of the business cycle. This section modifies a standard Roy (1951) model for the problem at hand. The Roy model analyzes the self-selection of individuals with heterogeneous skills into sectors according to their highest expected earnings. In the following, we model two sectors - academia and business - into which individuals can self-select. Each individual has distinct skills (and therefore different wages) in each sector but can only choose one occupation. The main departure from the original Roy framework is that salaries in business vary with the business cycle and that the number of open positions in academia is assumed to be fixed.

2.1 Assumptions

Suppose that individuals are endowed with two skills, an academic skill α and a business skill β. There are two sectors, academia (A) and business (B), which produce output utilizing the respective skills. Individuals are maximizing their expected lifetime income by applying for jobs in academia or business.

The business sector is assumed to hire anyone with a wage w_t corresponding to their marginal product. The wage depends on the state of the business cycle y_t, i.e. a business employee's marginal product is higher in a boom (high y_t) and lower in a recession (low y_t):[12]

$$w^B(\beta) = \beta + y_t$$

On the contrary, salaries in the academic sector do not vary with the business cycle

[12] We might adopt the more general notion of y_{app} and y_{grad} as the effect of the business cycle on current wage, but also on career outcomes in the future. This interpretation is consistent with recent papers that find substantial effects of the current business cycle on long term career outcomes, e.g. Oyer (2008) or Oreopoulos, Wachter, and Heisz (2008).

and each worker is deterministically paid corresponding to his marginal productivity[13]

$$w^A(\alpha) = \alpha.$$

To become an academic, an individual must decide for academia twice: First by applying for a PhD program (at application $t = app$) and a second time in pursuing an assistant professorship after the PhD (at graduation $t = grad$). At application, we assume that PhD programs admit the best N applicants only and that there are always more applicants than available spaces. Thus, the entry into the doctoral program is competitive. This assumption seems reasonable as we consider the top 30 PhD programs in the US only. At graduation, we assume that the student can choose freely if he wants to stay in academia or enter the business sector, instead. This assumption is much more disputable: obtaining an assistant professorship at a (top)ranked institution is very competitive. However, conditioned on graduating from one of the top 30 US economics departments it seems unlikely that a student cannot secure an academic job in a lower ranked institution, a teaching college or a university outside the United States.

When taking his decision to apply for a PhD program, the applicant should also take account of the option value of having another choice about his career path after graduation. To simplify our problem, we assume that this option value is a constant, i.e. that it does not vary with the state of the macroeconomy at application.[14] Thus, we can include it in the individual's expected earnings as an academic α.

Given these assumptions, every individual compares the expected earnings from academia α and business $\beta + y_t$ at application and at graduation. He decides to apply

[13] We can interpret α more generally as a combination of an individual's marginal product in academia and his non-pecuniary payoff for working in such an environment.

[14] In effect, the assumption amounts to imposing that the business cycle at application has no predictive power for the business cycle at graduation. We think that this is defendable as it takes on average six years to complete a PhD and we show in appendix C that there is no correlation between the business cycle at application and graduation in our data. In general, we expect that our results should also hold in all of the cases where there is reversal in the business cycle over that time frame, i.e. $Pr(y_{grad}^{Boom}|y_{app}^{Rec}) > Pr(y_{grad}^{Boom}|y_{app}^{Boom})$ and $Pr(y_{grad}^{Rec}|y_{app}^{Boom}) > Pr(y_{grad}^{Rec}|y_{app}^{Rec})$, and in a lot of cases where there is sufficiently strong mean reversion.

for the academic sector (the PhD program or the assistant professorship) whenever

$$\alpha > \beta + y_t. \tag{1}$$

with $t \in \{app, grad\}$.[15]

2.2 Predictions

We are interested in how the selection of skills into academia and business varies with the state of the business cycle. To ease the exposition, we compare a generic boom versus a recession cohort, i.e. $y^{Boom} > y^{Rec}$. All the proofs are relegated to appendix A.

Proposition 2.1 *For PhD applicants, the joint distribution of academic- and business skills selected into the academic sector during recession first order stochastically dominates (FSD) the corresponding boom distribution.*[16]

Proof See appendix. ∎

Figure 1 illustrates proposition 2.1 when academic and business skills are distributed uniformly on the unit interval. Given our assumptions, individuals' career choice is governed by the "one-shot" decision with those individuals preferring academia for whom $\alpha > \beta + y_{app}$. During boom (a high y_{app}^{Boom}), less individuals apply for academia than during recession (a low y_{app}^{Rec}), which is depicted by a higher cutoff line for the former than for the latter. Academic employers always hire a fixed number of N graduates (PhDs+"only in boom" in boom, PhDs+"only in recession"

[15]We could have added to the model that a PhD constitutes an (uncertain) investment into academic (and business) skills. This is clearly an important feature of obtaining graduate education and we have done it in an earlier version of this section. However, as long as the skill update and the uncertainty about it can be assumed independent of the state of business cycle, it doesn't do anything to the predictions of the model other than adding noise.

[16]On the flipside, this implies that the joint distribution of skills selected into business in boom first order stochastically dominates its recession counterpart. Note that, in contrast to the well-known result of the general Roy model (e.g. see Heckman and Honoré 1990), we can make a definitive statement about the stochastic dominance for a general distribution of skills here. This is due to the assumption of quantity constraints and the resulting competitive admission into the academic sector.

in recessions) and therefore the distribution of skills for the recession cohort lies to the "North-East" of the corresponding distribution of the boom cohort.

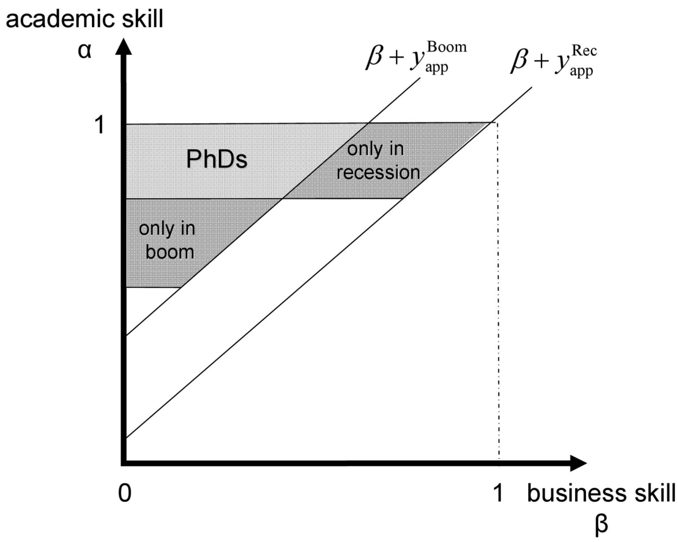


Figure 1: Selection with a U(0,1) distribution of both skills at application.

However, proposition 2.2 shows that fewer of the PhDs who applied in a recession will decide to stay in academia and become assistant professors after the PhD.

Proposition 2.2 *For every realization of the state of the economy at graduation y_{grad}, a (weakly) higher fraction of the members of a "recession at application" cohort will not decide to stay in academia after the PhD.*

Proof See appendix. ∎

The proposition implies that, "on average", cohorts of PhD graduates more often want to leave academia if they experienced a recession at the time of application. Figure 2 provides some intuition for the proposition. The academic skill cutoff above which individuals will prefer academic employment after the PhD, "on average" moves down to the dashed line in the figure for a boom cohort and up for a recession cohort. Thus, in the figure, some individuals of the recession cohort want to exit academia and enter business after the PhD when the economy is out of recession, while everyone of the boom cohort wants to stay in academia. The recession graduates who want to leave academia here are the marginal ones who applied for the PhD "because of" the recession in the first place.

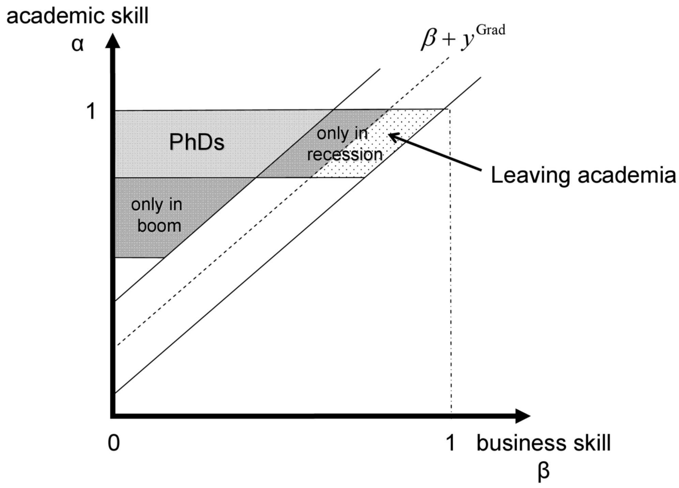


Figure 2: Selection with a U(0,1) distribution of both skills at graduation.

Proposition 2.3 *For any given realization of the business cycle at graduation y_{grad}, the (partial) distribution of academic skills of the members of a "recession at application" cohort who want to stay in academia after the PhD FSD the distribution of skills of the corresponding members of the "boom at application" cohort.*[17]

Proof See appendix. ∎

Proposition 2.3 implies that, no matter how many more recession than boom PhD students leave academia after the PhD, the recession individuals who want to stay in academia are still better in each quantile of their (academic) skill distribution. In our specific example in figure 2 we see that, although some mass of the recession cohort is cut off, the recession distribution of skills in academia still lies to the "North-East" of the boom distribution.

The effect of the business cycle at graduation is more straightforward. During a recession, more graduates decide to take up academic employment than during boom. For these graduates who enter academia "because of" the business cycle the following equation holds: $\beta + y_{grad}^{Rec} < \alpha \leq \beta + y_{grad}^{Boom}$.

Proposition 2.4 restates this observation and figure 3 provides a graphical representation in the special case of PhD graduates with academic and business skills

[17]However, the stochastic dominance of the joint distribution of business- and academic skills does not feed through in general. The proof in appendix A shows that one can come up with counterexamples.

distributed uniformly in the unit square.

Proposition 2.4 *A higher fraction of PhD economists decide to stay in the academic sector if they experience a recession at graduation.*

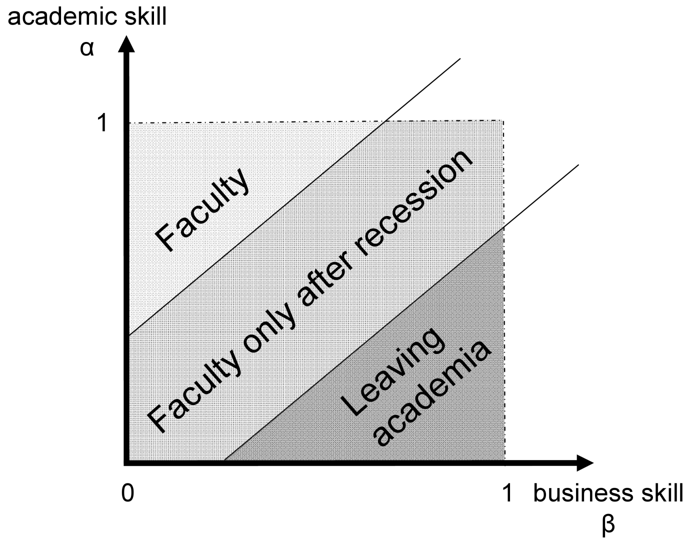


Figure 3: Selection at graduation.

Finally, we can reformulate the three propositions of the model into empirical predictions for our data:

1. Economists who experienced a recession at application for the PhD are less likely to stay in academia after graduation (from proposition 2.2).

2. However, if they stay, they are better researchers, both, on average and in each quantile of their publication distribution (from proposition 2.3).

3. Economists who experienced a recession at graduation from the PhD are more likely to stay in academia (from proposition 2.4),

4. and, therefore, recession PhD graduates are publishing more on average (also from proposition 2.4).

3 Data

We collect a new dataset of career choice and individual productivity for a large sample of economists in the United States from 1955 to 2004. We aggregate the individuals to university year cohorts and match these with the change in unemployment in the year of application and the year of graduation.[18]

3.1 Economist Sample Selection

The basis of our dataset are the names, graduation years and PhD granting institutions of 13624 economists who graduated from the top 30 US universities from 1955 to 1994. The data is obtained from the American Economic Association's (AEA) yearly "List of Doctoral Dissertations in Economics", which was published in the Papers and Proceedings issue of the "American Economic Review" until 1986 and in the "Journal of Economic Literature" thereafter. We supplement this information with the tier of the degree granting university according to the ranking of the National Research Council.[19]

3.2 Career Choice and Productivity Measures

We add an "academic" indicator which obtains a value of one if the respective economist was a faculty member in a US economics, business or finance department in 2001 or if he was listed as a member of the American Economic Association and a zero otherwise. The US faculty directories are compiled by James R. Hasselback and

[18]For the details of the data collection procedure please refer to appendix B.

[19]The National Research Council rankings of economics graduate programs divide programs into tiers. The top three tiers include:

- Tier 1 (ranked 1-6): Chicago, Harvard, MIT, Princeton, Stanford and Yale
- Tier 2 (ranked 7-15): Columbia, Michigan, Minnesota, Northwestern, Pennsylvania, Rochester, California-Berkeley, UCLA, and Wisconsin-Madison
- Tier 3 (ranked 16-30): Illinois-Urbana, Boston University, Brown, Cornell, Duke, Iowa, Maryland, Michigan State, New York University, North Carolina, Texas-Austin, Virginia, California-San Diego, University of Washington, and Washington University-St. Louis.

Source: `http://www.vanderbilt.edu/AEA/gradstudents/`

made available on his webpage.[20] AEA Membership data is obtained from the American Economic Association Directory of Members in 1970, 1974, 1981, 1985, 1989, 1993, 1997, 2003 or 2007. AEA membership somewhat serves as a proxy for faculty membership outside of the United States, because Hasselback's faculty directories strongly focus on US colleges and feature only very few foreign institutions.

In order to compare the oeuvres of different economists over time we calculate a consistent measure of publication productivity. For all economists in our sample, we collect the publication records in the first ten years after their graduation, multiply each publication of an author by its weight ("publication points") according to a dynamic journal ranking, and divide it by the number of coauthors of the paper. We then sum up all these contributions within the ten years after graduation to obtain a productivity measure for every individual in our sample.

More specifically, we match the PhD graduates with their publications (including journal title, number of pages and the number and identity of co-authors) in 74 journals listed in Jstor, a leading online archive of academic journals. We select all journals contained in Jstor for which a ranking was available. Thus we include all major publications in economics and finance except the journals published by Elsevier, most notably the "Journal of Monetary Economics" and the "Journal of Econometrics".[21] To ensure comparability among researchers, we restrict our attention to the first ten years of publication. Jstor currently only provides full publication data up to the year 2004. With the ten year requirement we can thus rightfully analyze the sample from 1955 to 1994 without placing younger researchers at a disadvantage.

Comparing the value of the collected publications records for different researchers over the decades is difficult because the relative impact of economics journals has changed substantially over time (Kim, Morse, and Zingales 2006). Therefore, we construct a dynamic journal ranking with decade specific publication points for each journal from 1950 onwards. For the 1960s to the 1980s, we use the ranking from Laband and Piette (1994), for the 1990s the equivalent ranking published in Kalaitzi-

[20] Source: http://www.facultydirectories.com/

[21] Because we do not believe that either recession or boom cohorts systematically prefer or dislike Elsevier journals, this should be of no issue.

dakis, Mamuneas, and Stengos (2003) and for the 2000s the recursive discounted ranking available on the "ideas" webpage, respectively.[22] For the 1950s we were not able to find a journal ranking and thus decided to extrapolate a ranking for articles published in the 1950s from our 1960s ranking. A complete list of these journals with their associated publication points can be found in table 6 of appendix B.4.

Reassuringly, we show in appendix E.3 that our results are extremely robust to using several other intuitive productivity measures: publication points assigned according to the now very popular h-index, raw counts of articles written, and, most notably, counts of articles in the five top economics journals (as in Oyer 2006) plus the Journal of Finance.

3.3 Macro Data and PhD Entry Date

The main aim of our study is to relate the publication success of economists to a proxy for the state of the macroeconomy at application to and graduation from their PhD program. As our data contains only person-specific graduation dates, we infer the application date by subtracting the median duration of a PhD of 6 years from the graduation date.[23] As proxy for the state of the business cycle, we use the change in the rate of unemployment from june of the precedent year to june of the considered year. Therefore, we measure the creation of new jobs right before the start of the PhD program (at application) and during the academic job market (at graduation).

Unlike other potential proxies for the business cycle, for example job openings for university graduates or financial services activity, unemployment data is available for the entire study period.[24] Unemployment change is also a continuous variable and, therefore, preserves more information than, for example, mere recession indicators. Finally, we believe that the change in unemployment is a good proxy for the change in university graduates' private sector employment opportunities, i.e. their outside

[22]Refer to `http://ideas.repec.org/top/top.journals.rdiscount.html`. Note, however, that the ranking on the website is updated continuously and thus is not exactly the same as we use in this study.

[23]The median duration of a PhD stayed almost constant with five to six years since the 1970s (see table 7).

[24]We are indebted to Paul Oyer for sharing his data on financial services activity.

option from academia. Please refer to robustness section in the appendix E for a sensitivity analysis with regard to the duration of the PhD and with GDP growth as an alternative proxy for the state of the business cycle.

3.4 Aggregation to University-Year Level

Eventually, we manipulate the data in one other aspect which is appealing from an econometric perspective. We group our graduates' publication performances and the indicator for being an academic or not into university-graduation year averages. Thus, we reduce the number of our observations from 13,624 individuals who graduated from tier one, two and three universities between 1955 to 1994 to 933 cohort means. Because we do not use any explanatory or control variables that vary below the university-year level, the grouping entails no loss of information and the calculation of standard errors becomes significantly easier.[25]

3.5 Descriptive Statistics

Table 1 provides summary statistics for the PhD cohorts' average productivity, the average probability to become an academic and the macroeconomic variation.

The average ten year productivity of a university-year cohort is about 31.49 publication points. In order to translate these publication points in terms of articles in a certain journal, one has to take into account that the importance of journals changes over time. For example, an article in the American Economic Review (AER) in the 1990s was worth 100 publication points while it was "only" worth 40.2 points in the 1980s.[26] Therefore, the average ten year productivity of a university-year cohort in the full sample is about the equivalent of a third of an AER article in the 1990s.

The average probability to become an academic is about 60% and is slightly falling over time as we can see in figure (4a). Conditioned on being an academic, the average

[25]Angrist and Pischke (2008, 312-315) argue that grouping has advantages from a statistical perspective because the cohort averages should be close to normally distributed even with modest group sizes and there is no need for clustering standard errors on the group level anymore.

[26]Please refer to appendix B.4 for a more detailed interpretation.

	mean	sd	min	max	p10	p90
Productivity	31.49	84.89	0.00	1738.10	0.00	93.80
Productivity Academic	48.14	103.84	0.00	1738.10	0.00	144.72
Academic	0.60	0.49	0.00	1.00	0.00	1.00
Unempl Change (Application)	-0.01	1.13	-2.10	2.90	-1.10	2.10
Unempl Change (Graduation)	0.02	1.03	-2.10	2.90	-0.90	1.50
Observations	13624					

Table 1: Summary Statistics

ten year cohort productivity totals 48.14 publication points. This is about 50% of an article in the AER in the 1990s.

Figure 4b depicts the average productivity of the PhD cohorts for every year in our analysis. More specifically, it distinguishes between the average productivity of all graduates and graduates that becoming an academic. As expected, we see that the performance measures move together to a substantial degree.

The change in the unemployment rate, our main independent variable, has a mean value of zero. The 10% quantile is -1.1% and the 90% quantile is 2.1% for the change in the rate of unemployment at application. At graduation, the 10% quantile is -0.9% and the 90% quantile 1.5%. Figure (4c) plots the change in the unemployment rate of each cohort at application and at graduation from 1955 to 1994. As expected the change in unemployment exhibits significant variation over the years.

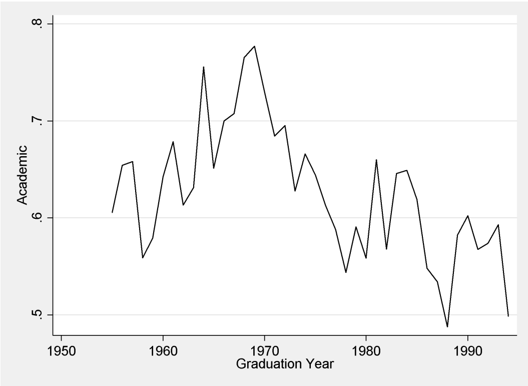
4 Results

In the following we examine the empirical predictions derived from the modified Roy model:

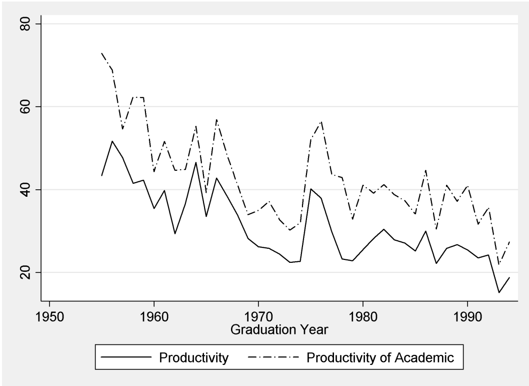
1. Economists who experienced a recession at application for the PhD are less likely to stay in academia after graduation (from proposition 2.2).

2. However, if they stay, they are better researchers, both, on average and in each quantile of their publication distribution (from proposition 2.3).

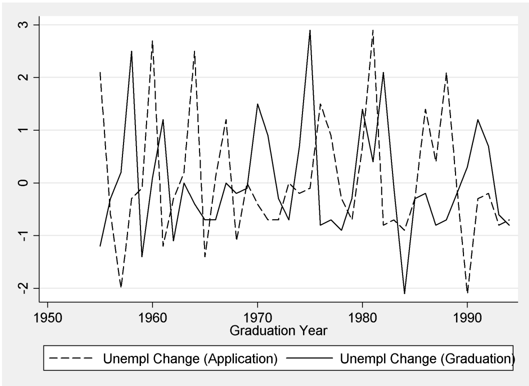
3. Economists who experienced a recession at graduation from the PhD are more



(a) Probability to become an academic



(b) Research productivity



(c) Unemployment Change

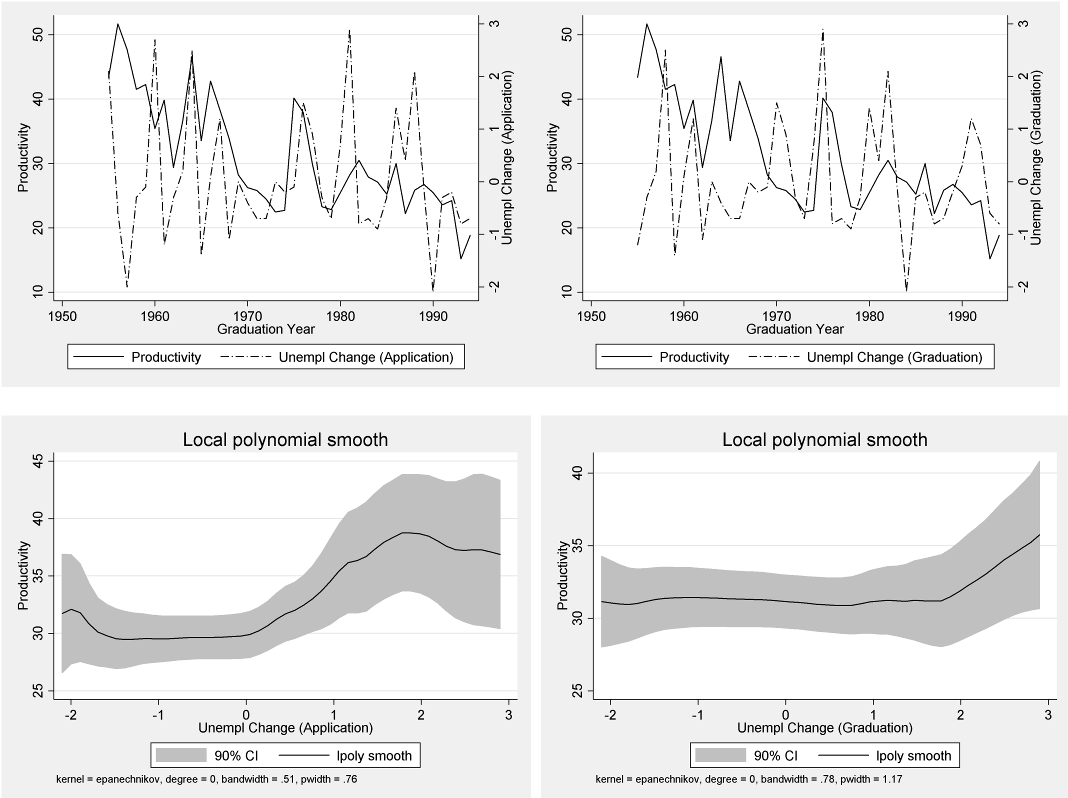
Figure 4: Dependent and independent variables over time

likely to stay in academia (from proposition 2.4),

4. and, therefore, recession PhD graduates are publishing more on average (also from proposition 2.4).

4.1 Graphical Relationship and Empirical Specification

To get an initial sense of the degree to which the unemployment change at application and at graduation are related to the career decisions and productivity of economists, the upper panel in figures 5 to 7 plots these variables over time. Moreover, the lower panel in each figure illustrates with a kernel-weighted local polynomial regression the degree of association of unemployment change and our outcome variables. The shaded areas indicate the 90% confidence interval.

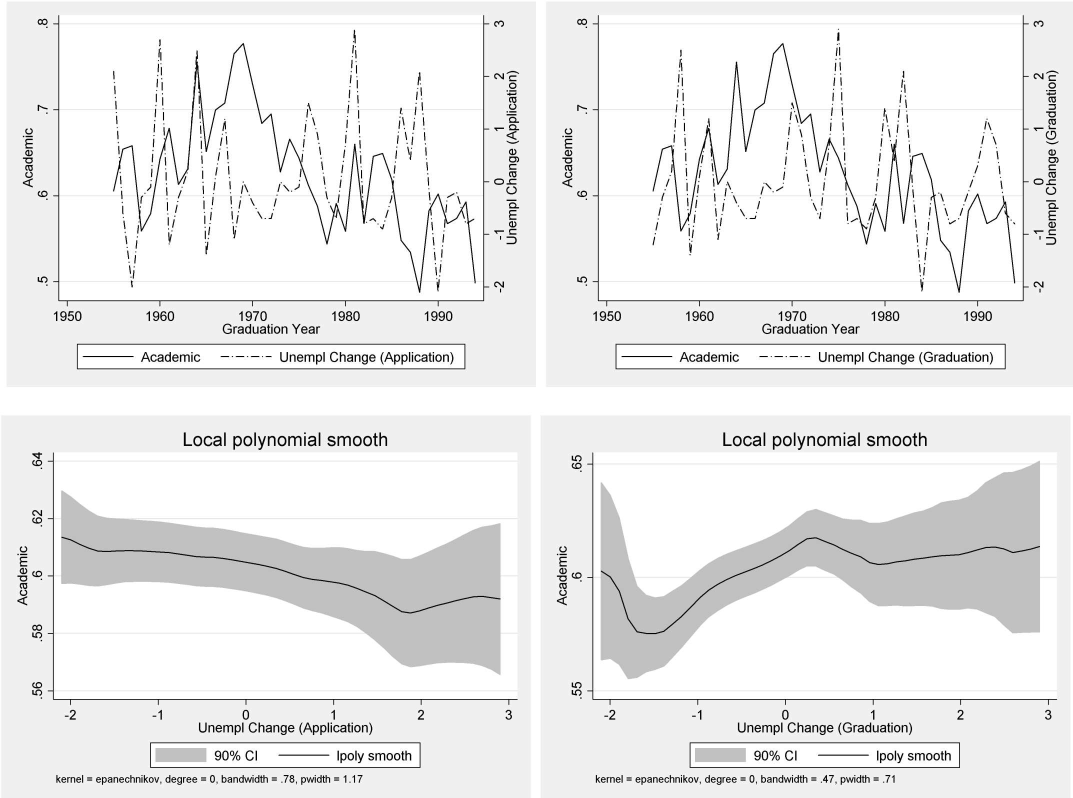


(a) at application (b) at graduation

Figure 5: Productivity and unemployment change

In accordance with our theoretical prediction 1, unemployment change at application seems to correlate slightly negatively with the propensity to become an academic (left panel of figure 6). The publication productivity of academics in the left panel of figure 7 correlates positively with unemployment change at application as in prediction 2. In accordance with predictions 3 and 4, a more positive change in unemployment at graduation seems to be associated with more PhDs staying in academia (right panel of figure 6) and a better publication record (right panel of figure 5), respectively. From the local polynomial smooths, we also infer that much of the effect stems from unemployment increases of 2% and above. This suggests that career decisions and talent selection are strongly affected during times of distress in the private sector.

In order to analyze more formally the relationships depicted in figures 5 to 7, we



(a) at application (b) at graduation

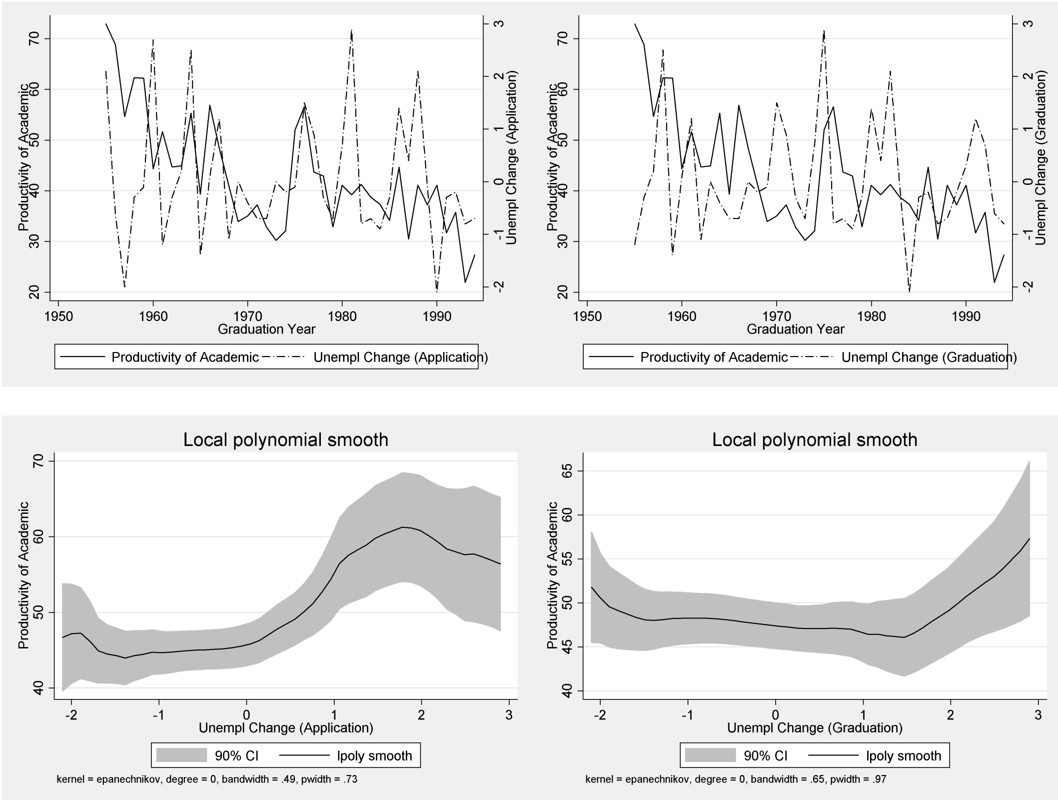
Figure 6: Fraction of academics and unemployment change

estimate the following model in three different specifications:

$$q_{i,t} = \beta \cdot y_{app,t} + \gamma \cdot y_{grad,t} + \delta \cdot \text{controls} + \epsilon_{i,t} \tag{2}$$

In the first specification, the outcome variable $q_{i,t}$ is the average publication output of a cohort of graduates from a university i in a year t. In the second specification, it is the average propensity to decide in favour of an academic career after the PhD, and in the third specification, $q_{i,t}$ is the average productivity of those who have decided to stay in academia after the PhD. The unit of observation in all three cases is the average of a given university in a given year, weighted by the amount of underlying individual observations in all three regressions.[27]

[27]In order to obtain correct standard errors, Angrist and Pischke (2008, 313-314) recommend averaging the individual outcome variables if there are no regressors or controls that vary below the group level and to weight these averages by the underlying individual observations. The standard



(a) at application

(b) at graduation

Figure 7: Productivity of academics and unemployment change

The regressors $y_{app,t}$ and $y_{grad,t}$ of interest are the unemployment changes at application and at graduation, respectively. As control variables, we include dummies for the full set of interactions of university and graduation decade. These dummies pick up the (changing) quality differences of PhD education among universities over time and they control for the higher standards of publication in recent decades (e.g. Ellison 2002a, Ellison 2002b).[28]

We estimate equation (2) using linear regressions. To identify the average treatment effect of the change in unemployment on the respective outcome variable, we

errors are then clustered on the graduation year level to allow for contemporaneous correlation between the outcome variables in the presence of regressors that do not vary within a given year (again see Angrist and Pischke (2008)).

[28]We have run regressions using GDP growth as a measure of the business cycle instead of unemployment change and we explored variants with linear and quadratic time trends. We also used different measures for research productivity. Our results are robust to these changes and reported in appendix E.

assume that the productivity and the career decisions of a cohort of (potential) PhD economists do not contemporaneously affect the business cycle in a given year. This assumption excludes potential reverse causality.[29] To be able to interpret β and γ exclusively as the causal parameters of the selection effect discussed in the theory section, we need an additional exclusion restriction to be satisfied: We assume that unemployment change affects a cohort's career decisions and publications only in terms of changing their choice of the sector to apply to (the selection effect). This assumption might not strictly be true in the light of the result of Oyer (2006) that the state of the business cycle affects an economist's first job placement and thus his productivity. We explain in section 4.4 that given Oyer's result we might actually underestimate the causal effect of selection in our regressions due to leaving out the quality of the first job.

Table 2 summarizes the main regression results of the three specifications, each in one column. The following subsections explain the columns in turn.

	Productivity	Academic	Productivity
Unempl Change (Application)	1.540**	-0.891	3.274***
	(0.661)	(0.576)	(0.945)
Unempl Change (Graduation)	2.312***	1.354**	2.738**
	(0.645)	(0.607)	(1.199)
Subsample	All	All	Academic
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2: The main regression results

4.2 Effect on the Publications of all PhDs

The first column of table 2 shows the effect of unemployment change on the publication output of an average PhD graduate in the sample. Unemployment change,

[29] Furthermore, no third factor is allowed to influence both directly - the business cycle and, the career decisions and productivity. This is the is the ubiquitous conditional independence assumption.

both at application and at graduation, has a significantly positive effect on research productivity on the 5% and 1% level, respectively. These two results are also economically substantial: a cohort on the 90% quantile of unemployment change at application is expected to achieve 4.9 publication points more than a cohort on the 10% quantile. This is approximately 12 % of the mean.

Similarly, if we do the same calculation for the graduation cohort, the difference is 5.5 points, which is 17.6 % of the mean.[30]

The effect of the unemployment change at graduation is in line with empirical prediction 4: PhDs who graduate during a recession are publishing more on average because more of them decide to stay in academia. Thus, the theoretical effect is at the "extensive margin" as opposed to an "intensive margin" effect in which those PhDs who would have stayed in academia anyway are publishing more if they graduate in recession than if they graduate in a boom.

The theory does not make a prediction which overall effect unemployment change at application should have on the publication output of an average PhD graduate. On the one hand, according to proposition 2.1 graduates who experienced a recession at application constitute a better selection of individuals. On the other hand, according to proposition 2.2 less of these individuals are expected to stay in academia and publish after the PhD. Empirically, it seems that the former effect dominates the latter, as a rise of unemployment at application is associated with a higher publication output of an average PhD.

4.3 Effect on the Career Decision

The second column of table 2 reports how the unemployment change is related to economists' career decisions after the PhD.

[30]Referring to table 1, the difference between the 10 and the 90 percent quantile of unemployment change at application is 3.2. Multiplying this by the parameter estimate of 1.540 gives a difference in average productivity between "boom" and "recession" cohorts of 4.92 publication points. Referring to table 6, this is about the number of publication points one gets assigned for an article in "Economica" during the 1990s. From table 1, we also find that the "average" PhD graduate achieves 31.49 publication points. Similarly at graduation the difference between the 90% and 10% quantile is 2.4. Multiplying this with the estimate of 2.312, yields 5.549 publication points, which is about 17.6% of the mean of 31.49.

PhD graduates are more likely to stay in academia when the economy is ailing, i.e. when there is a positive change in unemployment at graduation. The estimated coefficient is significant on the 5% level. This confirms empirical prediction 3 from the theory section and it is the source of the "extensive margin" effect on publication output per PhD student we mentioned above. Taking the estimates literally, a member of the cohort on the 90% quantile of unemployment change at graduation (+1.5%) has a 3.24 % higher probability to become an academic compared to a PhD student graduating on the 10% quantile (-0.9%). The average propensity to become an academic is 60%.

The theory also predicts that economists who experience a recession at entry to the PhD are less likely to stay in academia afterwards because some of them will enter only *because* of the recession (prediction 1).[31] The evidence in table 2 implies the existence of this effect, although the reported coefficient is not statistically significant.

More generally, we are not sure about the right empirical equivalent to the binary decision between academia and business regarding our theory. We think three different concepts of someone being an "academic" are conceivable. First, one could only consider faculty members of higher learning institutions as academics. This definition leaves out research staff at the IMF, the World Bank and at research institutes. Second, one could argue that the relevant distinguishing characteristic of an academic is producing novel and original research. And finally, one could more generally consider anyone an academic who works on research-related topics and upholds a relationship with the academic community.

The evidence reported in table 2 is based on the third notion of an academic by classifying anyone as such who is either a faculty member or a member of the American Economic Association (AEA) after the PhD. Table 3 additionally shows our measure of an academic according to the first two notions.

Column two in this table shows the propensity to become an academic measured by whether graduates end up as members of faculty of an economics, business or

[31] In a sense they hibernate in graduate school until the winter in the private sector is over and then they return there.

	Academic	Faculty	Publish	Academic
Unempl Change (Application)	-0.891	-0.427	-0.979**	-1.716***
	(0.576)	(0.475)	(0.457)	(0.579)
Unempl Change (Graduation)	1.354**	0.535	0.414	2.866***
	(0.607)	(0.409)	(0.397)	(0.938)
Subsample	All	All	All	Tier 1
Univ-Decade Dummies	Yes	Yes	Yes	Yes
Observations	1068	1068	1068	234

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Different measures for being classified as academic

finance department of a college or university in the United States according to the listings published by Hasselback (2001). We see that the direction of the effect is the same as in column one and in the main results table. However, the resulting coefficients are not statistically significant for either point in time. This might be the case because the employed faculty listings are not exhaustive. For example, faculty on leave are not included and we do not have faculty directories for other law and agriculture departments. Our faculty listings are also strongly focused on US institutions. Thus, they miss out many foreign graduates who become professors in their home countries and are members of the AEA.

Column three defines an academic as an individual who, according to our data, publishes at least one article in a ranked scientific journal after its PhD. The effect of the business cycle at application is strongly significant in the direction we expect from the theory while the effect at graduation is weak and not significant.[32]

Column 4 in Table 3 also shows regressions for the propensity to become an academic (according to our preferred academic measure) for a subsample of our graduates from the six top-ranked universities, i.e. the tier one schools. The effect here

[32]This seems to confirm the different reasons for becoming an academic in relation to the two points in time: on the one hand, those individuals who become an academic because the economy is bad at graduation are just added at the extensive margin and some of them might not be able to write a ranked article. On the other hand, those individuals who experienced a recession at application and decide against academia after the PhD are of high academic ability according to the theory. Thus, a larger share of them would have been able to write a ranked article had they stayed in academia.

is strongly significant in the predicted direction for both, unemployment change at graduation and at application. We interpret this as evidence that it is actually the individuals at the very top of the skill distribution which are most able to successfully switch back and forth between academia and business and who thus possess what one could call general skills. Overall, we conclude that the results at hand support the predictions made by our theory about the career decisions of PhD graduates.

4.4 Effect on the Publications of Academics

The last column of table 2 shows the results of regressing the publication output of individuals classified as academics on the change in the unemployment rate. The results here are largely robust to the sample selection according to any of the three definitions of an academic that were discussed above (see table 15 in appendix E.2).

The productivity of academics who experienced a recession at application is higher compared to academics who applied during a boom. This is in line with prediction 2 which states that the selection of PhD entrants is better during economically difficult times and that this better selection persists to the PhD graduates who stay in academia. The coefficient is significant on the 1% level and of economically relevant magnitude: Comparing the average member of the cohort on the 90% quantile of unemployment change at application to a cohort member on the 10% quantile, the former is on average 10.47 publication points better than the latter. This is about 20% of the mean.[33]

In fact, prediction 2 states that a generic recession cohort should first order stochastically dominate a generic boom cohort with respect to academic skill and that hence not only the mean but the whole distribution of academic skills should shift to the right if unemployment increases. Table 4 shows the effect of the unemployment change on the distribution of publication output within each cohort using quantile regressions. Hence, a unit of observation is now an individual academic's

[33]The 10% quantile of unemployment change at application is -1.1, the 90% quantile is 2.10 and the difference is therefrore 3.2%. Multiplying this difference with the mean estimate of 3.274 yields 10.4768. The mean productivity for an academic is 48.14 publication points.

publication output. Moreover, the measure of our variable of interest (academic skill) is left-censored as publication output cannot have values below zero. Following Angrist and Pischke (2008, 276-277), we limit the sample to individuals with a positive publication record.[34] We see that indeed - as predicted by the theory - all of the reported quantiles of the publication distribution are positively affected by an increase of unemployment at application.

	10%	25%	50%	75%	90%
Unempl Change (Application)	0.411**	1.102***	2.285***	7.636***	13.613***
	(0.194)	(0.382)	(0.873)	(2.068)	(5.053)
Unempl Change (Graduation)	0.560***	1.005**	1.459*	4.034*	3.038
	(0.199)	(0.395)	(0.878)	(2.073)	(5.126)
Subsample	Publish	Publish	Publish	Publish	Publish
Tier-Decade Dummies	Yes	Yes	Yes	Yes	Yes
Observations	4526	4526	4526	4526	4526

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Quantile regression for the academic subsamples

The second line in column three of the main results table 2 reports the effect of the unemployment change at graduation on the research productivity of academics. There are more PhDs deciding for an academic career if there is a recession at graduation. Without a specific assumption on the distribution of skills of PhD economists, our theory does not make a prediction whether the additional academics who enter at the "extensive margin" are of higher or lower academic skill than the average of those graduates who always decide to stay in academia after the PhD.

The empirical result in table 2 suggests that on average PhD students of higher quality decide to stay in academia if the economy is in a state of recession compared to a state of boom. This is in line with the result already noted in section (4.3) that

[34] An alternative would be to employ censored quantile regressions. We also only control for university tier - graduation decade fixed effects and their interactions because the quantile estimation becomes much less reliable with a large number of dummy controls. The standard errors are not clustered on the graduation year level as this is not feasible with quantile regressions. However, in unreported robustness checks we bootstrapped our estimators with and without clustering on the graduation year level and the significance of our results was largely unaffected.

it seems to be the individuals at the top of the skill distribution who (are able to successfully) move between the sectors. The estimated coefficient is significant on the 5% level. An academic graduating on the 90% quantile of unemployment change is on average 6.67 publication points better than an academic graduating on the 10% quantile. This is about 13% of the mean of 48.14.

At first glance, the result that academics who experience a recession at graduation are more successful at publishing than those who experience a boom, seems to contradict the findings by Paul Oyer (2006). He shows that PhDs who graduate during a favorable academic job market (which is correlated with economically good times in general) obtain better initial academic placements. He further shows that the first placement has a positive causal effect on an economist's research output by instrumenting the first placement with the state of the academic job market during the graduation year.

However, we think that Oyer's and our result may not contradict each other, but that they could actually reinforce each other: Suppose that both effects are relevant in reality - Oyer's placement effect and our selection effect. On the one hand, we would underestimate the effect of the business cycle at graduation on the skills selected into academia. This is because we would not take into account the worse placement a recession economist experiences on average, which would lower our measure of his skill, the publication output. Thus, the individuals selected into academia in recession would actually be better in terms of ex-ante skill than our estimate indicates. On the other hand, Oyer would underestimate the causal effect of the first placement on the research output of an economist. This is because he would not take into account the lower average ex-ante skill of a given economist during boom due to selection.

5 Conclusion

This paper investigates the effect of aggregate labor market conditions on the career choices and research productivity of economics PhDs in the United States. We document that individuals who applied for- and graduated from the PhD during a recession produce substantially more research. Moreover, our results on the economists' career decisions provide strong evidence that the productivity effects arise from a self-selection into sectors driven by the state of the labor market. Using a Roy-style model of self-selection into sectors, we provide consolidated findings for the larger debate about the allocation of talent. For example, we think that it is reasonable to believe that the same effects that we found for economists should (qualitatively) matter for the allocation of talent into the financial sector or the teaching profession, too.

Given the severity of last year's financial crisis and in response, the large extent to which people flooded graduate schools with applications, our findings suggest that an exceptionally able selection of students may graduate from these cohorts. Further, we provide a rationale for countercyclical governmental funding of graduate education that goes beyond mitigating the adverse impact of recessions on individuals. If it is the aim to attract more highly able individuals to science and academia, it may be efficient to specifically target recession cohorts with extra funding and additional spaces in graduate programs.

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Appendices

A Formal Results and Proofs

To simplify the notation in the proves, we denote the population distribution of the pre-selection skill $F(\alpha, \beta)$ with $\alpha, \beta > 0$ and the distribution of the post-selection skill as $G^s(\alpha, \beta)$ where s indicates the state of the business cycle at the time of selection. The associated density functions are denoted $f(\alpha, \beta)$ and $g^s(\alpha, \beta)$, respectively. To simplify the exposition, we compare a typical boom ($s = Boom$, high y) with a recession ($s = Rec$, low y) and assume that there is some strictly positive probability mass at every point of the pre-selection skill distribution, i.e. $f(\alpha, \beta) > 0$ for all α, β. At every selection point in time, only the N individuals with the highest α applying for academia are admitted. We denote by $\underline{\alpha}^s$ the individual with the lowest α that will still get into academia when the state of the business cycle is s. Further, we define $\beta(\alpha, s)$ to be the business skill β for which an individual of academic skill α is indifferent between the two sectors when the state of the business cycle is s, i.e. $\beta(\alpha, s)$ is such that $\alpha = \beta(\alpha, s) + y^s$.

In order to facilitate the proofs in the following, we do two more things. We first show (by contradiction) that the cut-off value $\underline{\alpha}^s$ is higher in recession than in boom. This means that the least able (in terms of academic skills) individual admitted into academia in a recession is academically more able than the least able individual admitted in a boom.

Lemma A.1 $\underline{\alpha}^{Boom} < \underline{\alpha}^{Rec}$.

Proof of lemma A.1: Suppose not. We know from the individual's optimal decision that for all α, the β at which they are indifferent between both sectors is higher for a recession individual, i.e. $\beta(\alpha, Rec) = \alpha - y^{Rec} > \beta(\alpha, Boom) = \alpha - y^{Boom}$. Filling all spaces in academia further requires that for all y and s

$$\int_{\underline{\alpha}}^{\infty} \int_{0}^{\beta(\alpha,s)} f(u_1, u_2) du_1 du_2 = N.$$

If $\underline{\alpha}^{Boom} \geq \underline{\alpha}^{Rec}$ and $\beta(\alpha, Rec) > \beta(\alpha, Boom)$, then this implies

$$\int_{\underline{\alpha}^{Boom}}^{\infty} \int_{0}^{\beta(\alpha,Boom)} f(u_1, u_2) du_1 du_2 < \int_{\underline{\alpha}^{Rec}}^{\infty} \int_{0}^{\beta(\alpha,Rec)} f(u_1, u_2) du_1 du_2.$$

Contradiction. ∎

Secondly, we define the following sets:

- $C = \{(\alpha, \beta) | \underline{\alpha}^{Rec} \leq \alpha, \alpha > \beta + y^{Boom}\}$ is the group of individuals who always enter the PhD. Within this group, $c(\tilde{\alpha}, \tilde{\beta})$ is the subset of individuals for whom also $\alpha < \tilde{\alpha}$ and $\beta < \tilde{\beta}$ while $C(y_{grad})$ is the subset of individuals for whom also $\alpha > \beta + y^{grad}$.

- $A = \{(\alpha, \beta) | \underline{\alpha}^{Boom} \leq \alpha < \underline{\alpha}^{Rec}, \alpha > \beta + y^{Boom}\}$ is the group of individuals who always want to enter the PhD but only get admitted in boom. Within this group, $a(\tilde{\alpha}, \tilde{\beta})$ is the subset of individuals for whom also $\alpha < \tilde{\alpha}$ and $\beta < \tilde{\beta}$ while $A(y_{grad})$ is the subset of individuals for whom also $\alpha > \beta + y^{grad}$.

- $B = \{(\alpha, \beta) | \underline{\alpha}^{Rec} \leq \alpha, \beta + y^{Rec} < \alpha \leq \beta + y^{Boom}\}$ is the group of individuals who only prefer to do a PhD during recession and in this case replace A. Within this group, $b(\tilde{\alpha}, \tilde{\beta})$ is the subset of individuals for whom also $\alpha < \tilde{\alpha}$ and $\beta < \tilde{\beta}$ while $B(y_{grad})$ is the subset of individuals for whom also $\alpha > \beta + y^{grad}$.

Looking at an example in figure **??** [INSERT FIGURE ABOUT HERE], we see that $C(y_{grad})$, $A(y_{grad})$ and $B(y_{grad})$ are the elements of C, A and B which lie to the left of the dashed y_{grad} line. Thus, in the case depicted, those are C and A as well as B_1. $c(\alpha, \beta(\alpha, y^{grad}))$, $a(\alpha, \beta(\alpha, y^{grad}))$ and $b(\alpha, \beta(\alpha, y^{grad}))$ are the elements of C, A and B which lie to the left of the dashed y_{grad} line **and** below the academic ability α. Hence, $c(\alpha, \beta(\alpha, y^{grad}))$, $a(\alpha, \beta(\alpha, y^{grad}))$ and $b(\alpha, \beta(\alpha, y^{grad}))$ are always (weakly) smaller than $C(y_{grad})$, $A(y_{grad})$ and $B(y_{grad})$, respectively. Finally, note that $|C| + |A| = |C| + |B| = N$.

Proposition 2.1 describes the effect of the selection into sectors under quantity constraints.

Proof of proposition 2.1: Formally, the proposition states that $G^{Rec}(\alpha, \beta) \leq G^{Boom}(\alpha, \beta)$ for all $(\alpha, \beta) \in \mathbb{R}$ and that there exists at least one $(\alpha, \beta) \in \mathbb{R}$ such that $G^{Rec}(\alpha, \beta) < G^{Boom}(\alpha, \beta)$. Distinguish two cases:

- Consider any (α, β) s.t. $\alpha < \underline{\alpha}^{Rec}$. In this case, $G^{Boom} > 0$ for $(\alpha, \beta) \epsilon A$ while $G^{Rec} = 0$ for all (α, β).
- Conversely, consider any (α, β) s.t. $\alpha \geq \underline{\alpha}^{Rec}$. We see that $G^{Boom}(\alpha, \beta) = \frac{|a(\alpha,\beta)|+|c(\alpha,\beta)|}{N}$ and that $G^{Rec}(\alpha, \beta) = \frac{|b(\alpha,\beta)|+|c(\alpha,\beta)|}{N}$. If $\beta \leq \beta(\alpha, y^{Boom})$ we have $b(\alpha, \beta) = 0$ and $a(\alpha, \beta) \geq 0$ and if $\beta > \beta(\alpha, y^{Boom})$ we have $a(\alpha, \beta) = |A| \geq b(\alpha, \beta)$. Thus, $G^{Rec} \leq G^{Boom}$ for all (α, β) where $\alpha \geq \underline{\alpha}^{Rec}$. ∎

Proof of proposition 2.2: We distinguish three cases in terms of the business cycle at graduation and we show that in every case weakly (and in one case strictly) more individuals of the "recession at graduation" cohort leave after the PhD.

1. Suppose that $y_{grad} \leq y^{Rec}$: everyone of the sets A, B and C will prefer to stay in academia in this case.
2. Suppose that $y_{Rec} < y_{grad} \leq y^{Boom}$: none of the members of the sets A and C will leave while some of the B will leave - namely those for whom $\beta + y_{Rec} < \alpha \leq \beta + y_{grad}$.

3. Suppose that $y_{grad} > y^{Boom}$: everyone from the set B will leave academia and a subset of A and C will leave, namely those for whom $\beta + y_{Boom} < \alpha \leq \beta + y_{grad}$. Weakly more of the recession cohort thus leave in this case as B is greater than a subset of A.

Therefore, members of a recession cohort are more likely to leave and, on expectation over all possible realizations of the business cycle at graduation, strictly more of members of a "recession at application" cohort will leave after the PhD. ∎

Proof of proposition 2.3: Define $H^s(\alpha, \beta)$ as the joint distribution of skills and $H_P^s(\alpha)$ as the partial distribution of skills after individuals left academia or stayed on after the PhD (the "post-graduation" joint- and partial distribution). Distinguish three cases again.

1. Suppose that $y_{grad} \leq y^{Rec}$: as nobody of either cohorts leaves, FSD of G^{Rec} over G^{Boom} carries over to H^{Rec} FSD H^{Boom}.

2. Suppose that $y_{Rec} < y_{grad} \leq y^{Boom}$ and consider two subcases:

   - if $\alpha < \underline{\alpha}^{Rec}$, $H^{Boom} > 0$ for $(\alpha, \beta) \epsilon A$ while $H^{Rec} = 0$ for all (α, β).
   - conversely, if $\alpha \geq \underline{\alpha}^{Rec}$ we see that $H^{Boom}(\alpha, \beta) = \frac{|a(\alpha,\beta)|+|c(\alpha,\beta)|}{|A|+|C|}$ and that $H^{Rec}(\alpha, \beta) = \frac{|b(\alpha, min\{\beta, \beta(\alpha, y_{grad})\})|+|c(\alpha,\beta)|}{|B(y_{grad})|+|C|}$. If $\beta \leq \beta(\alpha, y^{Boom})$ we have the counterexample why the joint distribution FSD doesn't feed through. $b(\alpha, min\{\beta, \beta(\alpha, y_{grad})\}) = 0$, but $|A| > |B(y_{grad})|$ and we can imagine skill distributions and points (α, β) where $|a(\alpha, \beta)|$ is very small (or converges to zero). Then $H^{Rec}(\alpha, \beta) > H^{Boom}(\alpha, \beta)$. However, the partial distribution for academic skills does work for all α: $H_P^{Boom}(\alpha) = \frac{|A|+|c(\alpha,\beta(\alpha,y^{Boom}))|}{|A|+|C|} > H_P^{Rec}(\alpha) = \frac{|b(\alpha,\beta(\alpha,y^{Rec}))|+|c(\alpha,\beta(\alpha,y^{Boom}))|}{|B(y_{grad})|+|C|}$ because $|b(\alpha, \beta(\alpha, y^{Rec}))| \leq |B(y_{grad})| < |A|$.

3. Suppose that $y_{grad} > y^{Boom}$. For the same reasons as in the previous case, the FSD result for the joint skill distribution doesn't hold here and thus we consider the partial distribution for academic skills right away. Distinguish two cases again:

- if $\alpha < \underline{\alpha}^{Rec}$, $H_P^{Boom} > 0$ for $\alpha \geq \underline{\alpha}^{Boom}$ while $H_P^{Rec} = 0$ always.
- conversely, if $\alpha \geq \underline{\alpha}^{Rec}$, we see that $H_P^{Boom} = \frac{|A(y_{grad})|+|c(\alpha,\beta(\alpha,y^{grad}))|}{|A(y_{grad})|+|C(y_{grad})|} \geq H_P^{Rec} = \frac{|c(\alpha,\beta(\alpha,y^{grad}))|}{|C(y_{grad})|}$.

We have shown that for every realization of the business cycle at graduation and the according types of PhDs who stay in academia and who leave, the partial distribution of academic skills of the "recession at application" cohort FSD its counterpart from the "boom at application" cohort. ∎

B Data Collection and Processing

This section explains in detail the data collection and processing procedure. Specifically, we discuss how the sample of economists and their background variables were acquired and how we computed a measure of publication success. An overview of the data sources is given in table 5.

All employed programs are available on request from the authors.

B.1 Database for Economics PhD Graduates

To construct our sample of economists, we downloaded the PDF version of all issues of the American Economics Associations (AEA) yearly "List of Doctoral Dissertations in Economics" from the JSTOR, an online journal repository from 1950 to 2006. The list was published in the Papers and Proceedings issue of the "American Economic Review" until 1986 and in the "Journal of Economic Literature" thereafter. The AEA "List of Doctoral Dissertations in Economics" specifies doctoral degrees conferred by U.S. and Canadian universities for every year since 1906. The name of the degree recipients and the year of graduation is provided to the American Economic Association by each degree granting university.

To convert the available PDF version of the AEA doctoral list into a text file, we used the optical character recognition (OCR) program included in the Adobe Acrobat 8 Professional Suite. The quality of the Adobe technology was best compared to

Variable	Description	Source
Personal information of graduates	Name, University and Graduation year	AEA "List of Doctoral Dissertations in Economics" of 1955 to 2004
Faculty membership	Faculty directory of (mainly American) Economics, Business and Finance departments by John R. Hasselback	`www.facultydirectories.com/`
Membership in the AEA	Membership data of the American Economic Association in 1970, 1974, 1981, 1985, 1989, 1993, 1997, 2003 and 2007	Supplement to the Papers and Proceedings Issue in the respective year digitalized by JSTOR
University ranking	Tier of a university according to the National Research Council	`www.vanderbilt.edu/AEA/gradstudents/`
Publication records	Publications in 74 journals listed in the JSTOR online repository, from 1955 to 2004	`dfr.jstor.org/`
Journal rankings	Citation ranking of journals in Economics, Business and Finance from 1950 to 2000	Laband and Piette (1994), Kalaitzidakis, Mamuneas, and Stengos (2003), Kim, Morse, and Zingales (2006) and `ideas.repec.org/`
Value of the outside option	seasonally adjusted change in unemployment or GDP growth from 1949 to 1994	Thomson Reuters Datastream
Duration of the PhD	Median years between registration and graduation from the PhD for 1977, 1986, 1996, 1997, 2001	National Science Foundation, Stock and Siegfried (2006), Hansen (1991)

Table 5: Data sources

other programs we have tried. This read-in procedure worked well in general and it accelerated the compilation of the dataset but, as every automated procedure, it also entailed several problems and imperfections. In some cases the original PDFs were scans of old printed versions and, therefore, due to the quality of the source files, the character recognition of some records was erroneous.

Particularly, there were problems with the letter “r”, which was mistaken as “n” or “i” from time to time. “O” was sometimes read as zero, “H” as “II”, and “M” as “IVI”. Also, dots sometimes were not readily recognized. We were able to correct faulty university names and graduation years because the set of those is finite. For example, we always replaced “IVIichigan” by “Michigan”. Due to limited resources, we were not able to correct all errors in the name spellings. We decided to drop observations with names that contain characters or sequences of characters that are highly unlikely to be correct and thus had no chance to return accurate results in a query for publications in JSTOR.

In a next step we used regular expressions, a way to assign database fields for some string combinations, to convert the text file into a database format. The data structure of the AEA doctoral list is quite regular so this procedure worked reasonably well. On some instances, the employed regular expression was not able to determine the end of a data entry due to missing dots. However, this did not happen systematically.

As mentioned above, the read-in procedure delivered some faulty results. We believe that all these errors are orthogonal to our effect of interest and that they thus just add noise to our data. Nevertheless we want to test how many read in names are faulty: To do this, we first correct some years (perfectly) by hand and compare the resulting “complete” graduation numbers to graduation numbers published by the National Science Foundation (NSF). We find that the “complete” graduation numbers from the AEA list are about 90% of the NSF graduation numbers. Then, for every year, we compare the fraction of the “not corrected” number in our database to the number in the NSF data. This fraction fluctuates from 0.6 to 0.9, which suggests that in the worst case we lose about 40% of graduates due to the imperfect automated read-in procedure.

In the next step we supplemented the information with the respective tier of the degree granting university according to the National Research Council. The National Research Council rankings of economics graduate programs divide programs into tiers.

We dropped all graduates from universities not represented in this NRC ranking because we are not sure if the application process and research environment in these institutions are comparable to the universities in the first three tiers. In order to ensure robustness we also considered the Top 30 US universities according to the EconPhD.net ranking (as in Oyer 2006), which yielded the same results. The EconPhd.net ranking is available online on `http://econphd.econwiki.com/rankings.htm`.

B.2 Indicator for Being an Academic

To complete the person-specific background variables, we add an indicator if a PhD graduate became an "academic" later on. We define "academics" according to the three concepts explained in section 4.3 - those who are faculty members, those who are faculty members or AEA members, and those who publish at least one ranked article. While the last concept derives from our publication measure explained in the next subsection, the data collection for the first two measures is described here.

Data about faculty membership in US economics, business or finance departments is acquired from the webpage of James R. Hasselback from the University of West Florida who regularly compiles U.S. faculty directories.[35] Unfortunately, there is no comprehensive database about faculty members of non-US universities, researchers in other US university departments, like law and agriculture, and academics in institutions other than universities, e.g. World Bank researchers. To construct a proxy for belonging to these groups, we analyze the membership records of American Economic Association. We think that the likelihood of being an AEA member is higher, if the graduate decided to become a member of the academic community.[36]

[35] http://www.facultydirectories.com/

[36] Specifically, we take the AEA directory of members in 1970, 1974, 1981, 1985, 1989, 1993, 1997,

The faculty listings and the AEA membership directories are only available as PDF. Therefore, we again use the Adobe OCR program and regular expressions to translate them into a database file. We use Apache Lucene, an information retrieval library, to match the data on graduates with the faculty listing and the AEA membership. This is necessary because some students drop their second name over the years or abbreviate it. As is common for search engines, Lucene employs a scoring algorithm based on the similarity of the name of the graduate and the name in the documents.[37] For the faculty directory (and a sample of the AEA members), we checked the matches found by hand to ensure accuracy.

B.3 Publications

After compiling the database of graduates, we used a program to match each entry with its publication record in JSTOR. To do this, we use the newly available XML application programming interface of JSTOR, called "Data for Research" (DfR).[38] Specifically, we entered the names and given names of all researchers contained in our database and extracted all recorded publications with journal title, number of pages and the number and identity of coauthors in the first 10 years after their graduation. To be as specific as possible, we restricted our search to articles classified as "research articles" published in English language in the fields of economics, business and finance.

The restriction to articles published ten years after graduation (as in Oyer 2006), has three reasons: First, it improves the specificity of the data processing, because economists with the same name who were born in different decades are not merged but kept as different persons. Second, the quality of an economist is arguably best revealed in the first decade after PhD graduation. Academic researchers are highly motivated (incentivized) in this period because their tenure decision depends on the publication record of these first years. Finally, graduates from more recent years

2003 and 2007.

[37]For a discussion of the algorithm `http://lucene.apache.org/java/2_4_0/api/org/apache/lucene/search/Similarity.html`.

[38]JSTOR (`http://www.jstor.org/`) is a leading repository for archiving academic journals which contains (in July 2010) around 3.1 Million research articles for all sciences with the first article published in 1545. The DfR interface is found under `http://dfr.jstor.org/`.

would be disadvantaged if we did not restrict the time frame. Currently JSTOR provides full publication data up to the year 2004, so the last individuals we can rightfully analyze following our ten year requirement are those who graduated in 1994.

B.4 Ranking Methods and Interpretation of the Productivity Measure

To measure the productivity of each individual on an ordinal scale, we have to value each publication in the record. This poses three challenges: First, the relative weight of an article in a certain journal compared to an article in another journal is a constant matter of discussion in the profession. Second, comparing the value of publications over the decades is difficult because the relative impact of economics journals has changed substantially over time (Kim, Morse, and Zingales 2006). Third, by summing up the contributions of different publications over ten years the resulting number becomes hard to interpret. We adress these challenges by showing the robustness of our result for several ranking methodologies with different strengths and weaknesses below.

Our preferred method is a citation ranking based on the methodology of Laband and Piette (1994). The authors of this study use the citations to articles in a particular journal (excluding self-citations) as a measure of its quality or impact. Their paper presents the journal impact factors from the 1960s to the 1980s, while Kalaitzidakis, Mamuneas, and Stengos (2003) use the same method for the 1990s and the recursive discounted ranking on the ideas.org ranking page delivers us the impact factors for the 2000s.[39] For the 1950s we were not able to find a journal ranking and thus decided to extrapolate our 1960s ranking back to articles published in the 1950s. In total, we collect impact factors of 74 ranked journals in economics, business and finance for five decades. Table 6 provides an overview of the dynamic ranking of the top forty

[39] `http://ideas.repec.org/top/top.journals.rdiscount.html`. Note, that this ranking is updated continuously and thus its online version at the time of reading is not exactly the same as the one we use.

journals used in this study.

The outcome measure in table 6 is denominated in publication points. The best journal in each decade receives 100 points and all others are scaled accordingly. For example, in the 1960s, a single-authored Econometrica article is worth 46.6 points while it is worth 96.8 points in the 1990s. The impact of the American Economic Review (AER) changed even more dramatically: It has been the leading journal in the 1960s and 1990s with 93.3 and 100 respectively. In contrast, in the 1970s, 1980s and 2000s it was "only" a top tier journal with 30-40 publication points. Consequently, when trying to interpret our results above in terms of actual papers, we need to mention the journal and the decade (e.g. "one third of an AER article in the 1990s").

Reassuringly, we show in section E.3 that our results are extremely robust to using several other intuitive productivity measures: publication points assigned according to the currently very popular h-index, raw counts of articles written, and, most notably, counts of articles in the five top economics journals (as in Oyer 2006) plus the Journal of Finance.

B.5 Imputing the PhD Entry Date

As mentioned in section 3.3, we have to impute the approximate application date to the PhD.

According to table 7, the median duration of a PhD stayed almost constant around five to six years since the 1970s. We therefore subtract six years from the graduation date and then use the change in unemployment during the preceding year as an indicator for the state of the macroeconomy at application.

For example, if a hypothetical graduate student obtained his doctorate in 2009, he is likely to have started the program either in August 2003 or August 2004 and must have applied either in the fall of 2002 or 2003. Consequently, we proxy the change in the outside option at application for a student who graduates in 2009 with the change in the unemployment rate from summer 2002 to summer 2003.[40]

[40] Of course, we cannot be sure that the median number of years is a good measure for the duration of the PhD for the considered graduate. There is micro data on the duration available with the

Rank	Journal (ordered by 2000 rank)	1960	1970	1980	1990	2000
1	The Quarterly Journal of Economics	65.6	16.2	41.6	58.1	100
2	Econometrica	46.6	31.6	78.4	96.8	68.7
3	Journal of Economic Literature	-	100	100	18.8	63.5
4	The Review of Economic Studies	100	30.7	40.7	45.2	54.3
5	Brookings Papers on Economic Activity	-	96.9	15.9	0.7	51.5
6	The Journal of Political Economy	63.5	59.1	63	65.2	49.8
7	Economic Policy	-	-	-	-	45.7
8	Journal of Labor Economics	-	-	15.4	12.8	45.5
9	The American Economic Review	93.3	34.5	40.2	100	39.9
10	The Journal of Economic Perspectives	-	-	23.3	34.3	39.8
11	The Review of Financial Studies	-	-	-	-	39.2
12	Journal of the European Economic Association	-	-	-	-	38.6
13	The RAND Journal of Economics (Bell Journal of Economics)	-	39.5	40.2	11.4	38.2
14	The Journal of Finance	37.8	14.6	34.1	34.1	31.1
15	The Review of Economics and Statistics	59.8	12.4	6.5	28	21.7
16	Journal of Business & Economic Statistics	-	-	7.9	38.4	20.8
17	The Economic Journal	47.5	28	23.9	20.7	20.5
18	Journal of Applied Econometrics	-	-	-	16.6	19.1
19	Journal of Money, Credit and Banking		18.5	22.1	18.6	18.6
20	The World Bank Economic Review	-	-	-	5.7	18.5
21	International Economic Review	35.1	19	12.3	23	18.4
22	IMF Staff Papers	-	-	-	5.1	18.3
23	Journal of Law, Economics, & Organization	-	-	-	4.1	16.1
24	Journal of Law and Economics	51.8	43.3	33.1	3.9	14.1
25	The Journal of Human Resources	-	13.6	4.6	21.3	13.4
26	Journal of Population Economics	-	-	-	2.41	10.6
27	The Scandinavian Journal of Economics	2.5	7.1	2.1	10.7	9.2
28	The Journal of Business		18.5	37.4	8.7	8.7
29	The Journal of Industrial Economics	14.9	16.4	16	3.85	8.7
30	The World Bank Research Observer	-	-	-	0.9	8.5
31	The Journal of Financial and Quant. Analysis	-	10.8	20	2.1	7.9
32	Oxford Economic Papers	35.2	16.8	25	3.7	7.9
33	Economica	20.7	36.2	4.1	4.5	7.2
34	Economic Theory	-	-	-	22.4	6.8
35	Industrial and Labor Relations Review	17	18.8	23.4	-	6.1
36	Econometric Theory	-	-	3.3	45.8	5.9
37	The Canadian Journal of Economics	-	11.8	10.2	5.09	5.6
38	The Journal of Legal Studies	-	-	51.6	5.4	5.4
39	Financial Management	-	-	-	-	5.1
40	Journal of Accounting Research	-	-	-	-	4.2

Note: These are the first 40 out of 74 journals. The rankings for the 1960s, 1970s and 1980s are taken from Laband and Piette (1994) and the ranking for the 1990s is from Kalaitzidakis, Mamuneas, and Stengos (2003). For the 2000s, we normalize the current discounted recursive impact factors ranking from the IDEAS RePEc website (`http://ideas.repec.org/top/top.journals.rdiscount.html`) to make it comparable to the other rankings.

Table 6: Ranking of journals in different decades.

Year	1977	1986	1996	1997	2001
	5.7	6.3	5.3	5.25	5.5
	Median years of registered time to PhD	Median years of registered time to PhD	Time to degree	median time-to-degree	Time to degree
Source	Hansen (1991)	Hansen (1991)	NSF*	Stock and Siegfried (2006)	NSF*

*NSF duration data includes masters degrees, therefore we subtract 1.5 years

Table 7: Duration of a PhD

C The Relationship Between (Potentially) Confounding Factors and the Business Cycle

This section addresses potential concerns about factors that might confound our results and analyzes possible impacts on our estimates. In the following we address concerns about the size of the entry and exit cohort, the attrition rate and the timing of graduation. Lastly, we adress a potential correlation of the business cycle at application and graduation.

In order to do this, we calculate the number of graduates from our dataset (in the following listed as "# of graduates (AEA)") and match it with the unemployment change at application and at graduation. Then, we supplement this data with data from the National Science Foundation's "Survey of Earned Doctorates".[41] From there we obtain the the number of PhD entrants and graduates for our top 30 universities since 1977. Using this data, we are able to estimate the attrition (dropout) rate of each cohort as the difference of the number of entrants minus graduates divided by the number of entrants. We aggregate the data to year levels to obtain the correct standard errors with regard to unemployment change in 8. We report the partial correlation coefficient of unemployment change at application and at graduation with application and graduation numbers in table 8. In order to obtain the correct standard errors we aggregate the data to yearly averages.

National Science Foundation Survey of earned doctorates but access is limited to on site use.

[41]This survey is publicly available through the WebCaspar Interface `https://webcaspar.nsf.gov/`

	Unem Ch Grad	Unem Ch App	# Graduates (AEA)	# Graduates (NSF)	# Entrants (NSF)	Attrition (NSF)
Unem Ch Grad	1.000					
Unem Ch App	-0.131	1.000				
	(0.419)					
# Graduates (AEA)	0.019	-0.168	1.000			
	(0.906)	(0.300)				
# Graduates (NSF)	0.149	-0.077	0.351*	1.000		
	(0.440)	(0.692)	(0.062)			
# Entrants (NSF)	-0.075	0.081	0.141	-0.018	1.000	
	(0.698)	(0.675)	(0.466)	(0.910)		
Attrition (NSF)	0.205	0.395	-0.395	-0.325	0.249	1.000
	(0.430)	(0.117)	(0.116)	(0.122)	(0.241)	
Observations	53					

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Correlation of unemployment change with attrition, the number of entrants and graduates (year level)

The first concern one might have is that the number of students admitted to the PhD systematically increases (decreases) in recessions. Within the framework of our model, this would weaken (strengthen) the selection effect at application. The estimated coefficient of unemployment change at application might then be underestimated (overestimated). According to table 8, we cannot reject that the relation of the number of entrants to the PhD and the change in unemployment differs from zero on conventional significance levels (p-value of 67.5%).

Second, one might be concerned that the attrition (or dropout) rate during the program may systematically differ between recession and boom cohorts. On the one hand, some business-inclined individuals who entered the PhD in order to bridge a recession might return to the private sector before they actually obtain the PhD. If this were the case, we would underestimate the effect of unemployment change at application on economists' career decision after the PhD (the "academic" variable). The reason is that many of those who would want to switch would have already done so before we consider them in our population of graduates. On the other hand, there might be a higher dropout rate for the boom cohort because its individuals are of lower academic quality. In this case, our parameters would underestimate the effect of unemployment change at application on the performance of graduates and academics. According to the correlation table 8, our estimate of the attrition rate is not significantly correlated with unemployment change at application or graduation.

Third, PhDs might time their graduation in order to circumvent entering the private or the academic job market during a time of recession.[42] The effect of such a graduation timing on our parameter estimates would depend on whether the high- or the low skilled bring their graduation date forward (or delay it). For example, if in a recession students with low academic talent delay their end of the PhD, we overestimate the effect on productivity at graduation, but underestimate the effect on becoming an academic. This would attenuate our effect of the business cycle on productivity at application. Table 8 reports the correlation of graduation numbers and unemployment change according to the NSF data and the AEA doctoral listings,

[42] Oyer (2006) documents that also academic job offers decline during recession.

respectively. Reassuringly, graduation numbers seem not to be at all related to the state of the business cycle.

Finally, a last concern might be that, contrary to our assumption in the model, the business cycle is systematically correlated with itself in the six years between a cohort's application and graduation. Table 9 reports this and the contemporaneous correlation between the unemployment change and GDP growth. Unsurprisingly both measures are strongly contemporaneously related. However, there is no significant correlation, neither of unemployment change nor GDP change, between the time of application and graduation. If at all, there may be a very slightly reversing relationship over the six years. This could imply that we potentially underestimate the effect of the business cycle on academic performance because a recession cohort at graduation is more likely a boom cohort at application (and thus is inherently not as able) and vice versa for a boom cohort at graduation. For the same reason we might in this case overestimate the effect of the business cycle on the career decision (i.e. the academic variable) at application and at graduation.

	Unem Ch App	Unem Ch Grad	GDP Ch App	GDP Change Grad
Unem Ch App	1.000			
Unem Ch Grad	-0.151	1.000		
	(0.271)			
GDP Ch App	-0.786***	0.158	1.000	
	(0.000)	(0.251)		
GDP Change Grad	0.130	-0.862***	-0.114	1.000
	(0.345)	(0.000)	(0.405)	
Observations	57			

p-values in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Correlation of unemployment change and GDP change at application and at graduation (university-year level)

D Supporting Evidence for the Selection Channel

In the theory section of the main text, we hypothesize that during downturns more individuals want to enter academia and, due to a fixed number of open spaces at entry to the PhD, only a favorable selection with superior ability is admitted. Unfortunately, however, we see ourselves unable to provide direct evidence for the selection mechanism at work. This is for the following reason:

In order to gather evidence, we were looking for data that provides observable ex ante characteristics of the students admitted to the PhD programs which we could then relate to the state of the business cycle. We obtained Graduate Record Examination (GRE) scores for a non-US PhD program that is comparable to a tier two school. The GRE consists of three sections: quantitative, verbal and analytical writing. In all universities, GRE scores are considered an obligatory part of the application documents and it is generally agreed that it is almost exclusively the quantitative section that matters for admission. For this reason, our GRE scores proved to be uninformative. We found that, independently of the state of the business cycle, virtually everyone accepted to the PhD as well as most applicants had the highest possible mark (800 points) in the quantitative section.

In general, we are very skeptical that easily observable ex ante characteristics, such as GRE data or undergraduate GPAs, of applicants or entrants would be informative about the selection into the programs because many successful and unsuccessful applicants do not differ in these dimensions. The truly informative quality differences of applicants and entrants are most likely to be more subtly hidden in "softer" information such as reference letters, research assistantships and types of courses taken during the undergraduate degree. This kind of information is very hard to obtain and to process in an objective way.

Although we are unable to present direct evidence for our hypothesized channel, Kelly Bedard and Douglas Herman published a study in the Economics of Education Review (2008) that documents supporting evidence for our main selection channel. They use data on recently graduated science and engineering Bachelor and Master students from 1990 to 2000 which is provided in the 1993 to 2001 National Survey of Recent College Graduates (NSRCG). Exploiting the variation in state-level unemployment rates, Bedard and Herman find that male PhD enrollment is counter-cyclical and the counter-cyclicality is driven by students with a high GPA in the hard sciences.[43] They state that the unemployment rate responses for this group are fairly precisely estimated and that their estimates imply a one-percentage point increase in the unemployment rate increases "high GPA" male Ph.D. enrollment by 0.356 percentage points.

In another paper, Fougere and Pouget (2003) find that the applications per spaces ratio in the French public sector rises strongly in economically hard times. Unfortunately they do not provide a quality measure of French public sector workers. c

E Robustness Checks

In this section we estimate different variants of our main empirical model in order to scrutinize the robustness of the results.

We restate our main findings in table 10: A recession at application leads to a more productive selection of academics (column 3). The propensity to become an academic is decreasing with unemployment change at application and increasing with unemployment change at graduation (column 2). Cohorts graduating in a recession are publishing more (column 1). In the following we consider GDP growth as an alternative measure for the business cycle, time trends as control variables instead of decade dummies, several measures for productivity and different assumed durations for the PhD. We also consider subsamples of our data by only looking at graduates from the elite tier one institutions and by removing "superstar" economists who are exceptionally prolific.

[43]They look at entry into all PhD programs in terms of quality and subject and not our only the top 30 economics programs. Therefore, quantity constraints in terms of entry should matter much less and it is not surprising that they not only find the expected quality differences in terms of entrants with respect to the business cycle, but also quantity differences. Moreover, it is also not surprising that GPAs matter (more strongly) for engineering and science majors and for a broader range of graduate schools than just the top 30 departments.

	Productivity	Academic	Productivity
Unempl Change (Application)	1.540**	-0.891	3.274***
	(0.661)	(0.576)	(0.945)
Unempl Change (Graduation)	2.312***	1.354**	2.738**
	(0.645)	(0.607)	(1.199)
Subsample	All	All	Academic
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 10: Main regression results

E.1 Alternative Measures for the Business Cycle and Controls for the Time Trend

	Productivity	Academic	Productivity
GDP Change (Application)	-0.658**	0.472*	-1.456***
	(0.286)	(0.245)	(0.421)
GDP Change (Graduation)	-0.705**	-0.407	-0.739
	(0.326)	(0.273)	(0.557)
Subsample	All	All	Academic
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11: Alternative business cycle measures: GDP change

	Academic	Faculty	Publish	Academic
GDP Change (Application)	0.472*	0.248	0.448**	0.750**
	(0.245)	(0.194)	(0.189)	(0.287)
GDP Change (Graduation)	-0.407	-0.047	0.051	-1.247***
	(0.273)	(0.193)	(0.229)	(0.361)
Subsample	All	All	All	Tier 1
Univ-Decade Dummies	Yes	Yes	Yes	Yes
Observations	1068	1068	1068	234

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12: Alternative business cycle measures: GDP change

We repeat our main specification with GDP growth as a measure for the business cycle in table 11.[44] Note that an increase in GDP indicates a boom and a decrease a recession. Therefore, the sign of the coefficients are reversed. The results on productivity hold up very well: the effect of unemployment change at application on the productivity of academics as well as the effect of unemployment change at graduation are not only significant but also in the direction that theory predicts. The direction of the coefficients is also correct in the regression on the propensity to become an academic. The effect is significant on the 10% level at application, but insignificant at graduation. In table 12, regressions on alternative interpretations of being an academic are reported and the picture stays the same.

	Productivity	Academic	Productivity
Unempl Change (Application)	1.873**	-0.942*	3.555***
	(0.723)	(0.534)	(1.013)
Unempl Change (Graduation)	1.551**	0.635	1.736
	(0.649)	(0.582)	(1.169)
Subsample	All	All	Academic
Time trend	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: Alternative controls: linear and quadratic time trend

	Academic	Faculty	Publish	Academic
Unempl Change (Application)	-0.942*	-0.083	-0.501	-1.214*
	(0.534)	(0.393)	(0.318)	(0.637)
Unempl Change (Graduation)	0.635	0.025	0.044	1.493
	(0.582)	(0.418)	(0.460)	(0.905)
Subsample	All	All	All	Tier 1
Time trend	Yes	Yes	Yes	Yes
Observations	1068	1068	1047	232

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Alternative controls: linear and quadratic time trend

[44]The growth of GDP might well proxy for a (potential) economist's earnings potential in outside employment with performance pay such as the financial sector.

Another concern might be that our graduation decade dummies inadequately control for the general trends in academia over time. In table 13 we therefore report the main regression with university dummies and a linear and quadratic time trend instead. The results of the main section on productivity are largely robust. Only the productivity of academics at graduation is not significant anymore, but theory made no prediction for the sign of this parameter in the first place. The results on the propensity to become an academic have the right sign and at application they are significant at the 10% level. The picture stays the same if we use different measures for being an academic in table 14.

E.2 Alternative Measures for Being an Academic

In the main text, we report three different measures which might indicate that an individual is an academic: Our standard "academic" measure equals one if he is a faculty member or a member of the American Economic Association after graduation from the PhD. The second measure is one if the PhD student becomes a faculty member at a US business, economics or finance department and the third one shows if the student is able to publish in one of our ranked journals after graduation. In the main text, due to conciseness, we left out the robustness of our productivity regressions of academics with regard to the last two measures. In table 15, we report this robustness check for completeness. All coefficients have the correct sign and all are significant at conventional levels (except the unemployment change at graduation for the faculty measure).

E.3 Alternative Measures for Productivity

One might be concerned that our dynamic productivity measure does not properly capture the actual achievements of an academic. We consider three alternative measures of academic productivity in tables 16 and 17: the number of top journal articles, the h-value and the raw number of articles. We classify articles in the "Econometrica", "The American Economic Review", "The Quarterly Journal of Economics",

	Productivity	Productivity	Productivity
Unempl Change (Application)	3.274***	6.837***	5.630***
	(0.945)	(2.471)	(1.291)
Unempl Change (Graduation)	2.738**	2.353	4.352***
	(1.199)	(1.868)	(1.094)
Subsample	Academic	Faculty	Publish
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1047	906	974

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 15: Alternative measure for being academic: Productivity

"The Review of Economic Studies", "The Journal of Political Economy" and "The Journal of Finance" as top journal articles. The h-index (Hirsch index or Hirsch number) is a currently very popular measure based on citations and number of articles. An economist has index h if h of his N papers have at least h citations each, and the other N - h papers have at most h citations each. The last measure is the raw number of articles written as recorded in JSTOR.

	Top Journals	h-index	# of Articles
Unempl Change (Application)	0.016	1.172	0.012
	(0.010)	(1.110)	(0.032)
Unempl Change (Graduation)	0.040***	3.980***	0.050**
	(0.009)	(0.869)	(0.022)
Subsample	All	All	All
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1068

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: Alternative productivity measures - Full sample

All results in tables 16 and 17 point in the same direction as the dynamic performance measure in the main text and as the selection theory predicts. Out of the effects predicted by the theory, only the effect of the unemployment change at application on the number of articles of academics is not significant. Thus, our results are extremely robust to the use of different productivity measures.

	Top Journals	h-index	# of Articles
Unempl Change (Application)	0.035**	3.161**	0.057
	(0.014)	(1.558)	(0.047)
Unempl Change (Graduation)	0.050***	4.838***	0.047
	(0.014)	(1.552)	(0.044)
Subsample	Academic	Academic	Academic
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1047	1047	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 17: Alternative productivity measures - Academics

E.4 Alternative Duration of the PhD

We explain in our data section that we impute the application date by subtracting six years from the graduation date. The rationale for the difference of 6 years is explained in section B.5 in the appendix. In tables 18 and 19, we change the duration of the PhD to 5 and 7 years, respectively, and report the results.

	Productivity	Academic	Productivity
Unempl Change (Application)	-0.648	-0.502	-0.609
	(0.659)	(0.584)	(1.035)
Unempl Change (Graduation)	2.220***	1.455**	2.502*
	(0.738)	(0.603)	(1.359)
Subsample	All	All	All
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 18: Alternative duration of PhD (5 Years)

The effect at graduation stays the same, of course, but the effect at application all but vanishes. We interpret this as a support for our argument of an estimated difference of 6 years between application and graduation.

	Productivity	Academic	Productivity
Unempl Change (Application)	-0.325	-0.853	-0.420
	(0.730)	(0.528)	(1.275)
Unempl Change (Graduation)	2.200***	1.467**	2.502*
	(0.661)	(0.599)	(1.287)
Subsample	All	All	Academic
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 19: Alternative duration of PhD (7 Years)

E.5 The Tier 1 Subsample

We also consider the subsample of economists who graduated from the elite tier 1 schools and repeat all our regressions for these highly skilled individuals. According to table 20, the magnitude of the effects appears to be larger in all considered dimensions. With regard to productivity, the estimates are significant on conventional levels. The only exception is the effect of unemployment change on productivity at graduation, which is insignificant but correctly directed. The effect at application and at graduation on the propensity to become an academic for our preferred measure is strong and highly significant. If we consider the two alternative measures of being an academic, the result is weaker, not significant, but correctly directed (see table 21).

	Productivity	Academic	Productivity
Unempl Change (Application)	5.394**	-1.716***	9.864***
	(2.123)	(0.579)	(2.935)
Unempl Change (Graduation)	4.347*	2.866***	3.969
	(2.385)	(0.938)	(3.449)
Subsample	Tier 1	Tier 1	Academic Tier 1
Univ-Decade Dummies	Yes	Yes	Yes
Observations	234	234	232

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 20: Main regression results (Tier 1)

	Academic	Faculty	Publish
Unempl Change (Application)	-1.716***	-0.080	-1.276
	(0.579)	(0.822)	(0.881)
Unempl Change (Graduation)	2.866***	0.719	0.532
	(0.938)	(0.474)	(0.786)
Subsample	Tier 1	Tier 1	Tier 1
Univ-Decade Dummies	Yes	Yes	Yes
Observations	234	234	234

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 21: Alternative measures for being academic (Tier 1)

E.6 Exclusion of Superstar-Economists

Finally, we want to make sure that our results are not driven by the exceptional performance of very few superstar-economists whose extraordinary talent would have made them academics independently of any state of the business cycle. First, consider

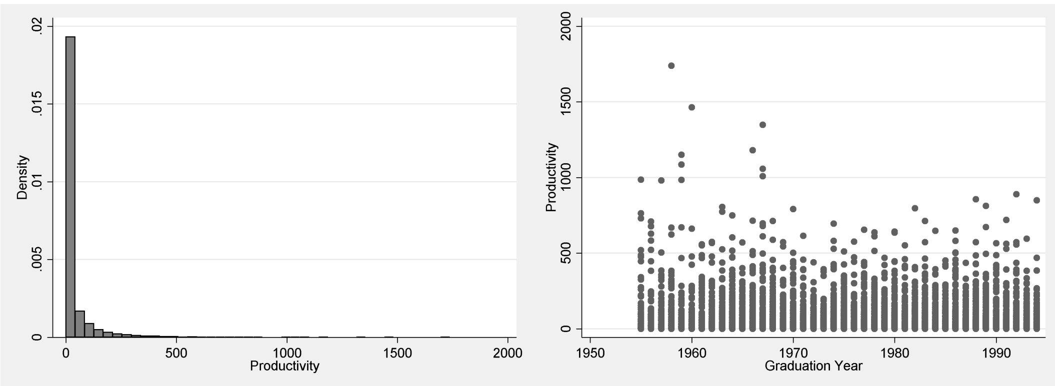

Figure 8: The publication distribution

in figure 8 the distribution of individuals' publication success as a histogram and over time. The modus and the median of the distribution of publications is zero while the mean is 31.49. Only 80 economists achieve more than 500 publication points with Nobel laureate Joseph Stiglitz scoring a stunning maximum of 1738 points. In table 22, we report the results of our main regressions 2 if we remove the 80 economists who publish more than 500 points. We see that our main results are not driven by these "outliers".

	Productivity	Academic	Productivity
Unempl Change (Application)	1.048	-0.008	2.358**
	(0.628)	(0.006)	(0.875)
Unempl Change (Graduation)	1.508**	0.010	1.835*
	(0.559)	(0.006)	(1.010)
Subsample	w/o Superstars	w/o Superstars	Academic w/o superstars
Univ-Decade Dummies	Yes	Yes	Yes
Observations	1068	1068	1047

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 22: Main regression results "ex superstars"