Are all High-Skilled Cohorts Created Equal? Unemployment, Gender, and Research Productivity[1]

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Using life cycle publication data of 9,368 economics PhD graduates from 127 U.S. institutions, we investigate how unemployment in the U.S. economy prior to starting graduate studies and at the time of entry into the academic job market affect economics PhD graduates' research productivity. We analyze the period between 1987 and 1996 and find that favorable conditions at the time of academic job search have a positive effect on research productivity (measured in numbers of publications) for both male and female graduates. On the other hand, unfavorable employment conditions at the time of entry into graduate school affects female research productivity negatively, but male productivity positively. These findings are consistent with the notion that men and women differ in their perception of risk in high skill occupations. In the specific context of research-active occupations that require high skill and costly investment in human capital, an ex post poor return on undergraduate educational investment may cause women to opt for less risky and secure occupations while men seem more likely to "double down" on their investment in human capital. Further investigation, however, shows that additional factors may also be at work.

Keywords: Research Productivity, Human Capital, Graduate Education, Gender Differences

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1. Introduction

A significant literature has recently been developed on how risk perceptions and risk aversion differ between women and men. In general women appear to be more risk averse than men.[2] Experimental work by Gneezy et al (2003) shows that women are less effective than men in competitive environments, although no significant gender differences are observed in non-competitive environments. These experimental findings are perfectly in line with survey results obtained by Ülkü-Steiner et al (2000) on 341 doctoral students that "women in male-dominated programs expressed lower academic self-concept, (…) and lower career commitment compared with all other students" (p.296).

When discussing potential reasons for gender differences Hartog et al. (2002) point out: "At a deeper level, there may be biological reasons, with women's position in procreation relative to men's requiring them to be more risk averse" (p. 18). In support of this argument, Sapienza et al. (2009) find positive correlation between salivary testosterone and the choice of a risky career (finance sector in the context of their experiment), and note that "this correlation becomes insignificant after the analysis was controlled for gender". (p.15270). On the other hand, Booth and Nolen (2012) conduct an experiment in a setting where they can control for social environment. They conclude that "observed gender differences in behavior under uncertainty found in previous studies might reflect social learning rather than inherent gender traits" (p. 56). Investigating performance of male and female runners, Frick (2011) finds that the gender performance gap is closing due and attributes this to increasing returns to success.

Attending graduate school and choosing a research-active career afterwards are voluntary actions, and individuals self-select themselves into these paths. The decision to do so is affected both by opportunity cost and the perception of future reward. There exists an extensive literature[3] investigating the differences between male and female graduates in the academic profession, what determines male and female productivity, and whether female graduates face discrimination. Our study is more narrowly focused. We ask how research productivity of male and female economics PhDs is affected by prevailing economic, specifically, employment conditions as they both enter and exit graduate school.

The opportunity cost of human capital investment and how this is affected by business cycle conditions is discussed by Dellas and Sakellaris (2003), Dellas and Koubi (2003), and Kahn

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[2] See, e.g., Gustafson (1998), Agnew et al. (2008), Eckel and Grossman (2008), Borghans et al. (2009).

[3] See, e.g., Broder (1993), Kahn (1995), Ginther and Kahn (2004), Barbezat (2006), Hilmer and Hilmer (2007). Our study is more narrowly focused.

(2010). Individuals substitute away from work and into schooling in order to accumulate more human capital and at the same time postpone their job search. Bedard and Herman (2008) investigate cyclical patterns of advanced degree enrollment across genders. They document that "male PhD enrollment is counter-cyclical, (…) and female enrollment is generally acyclical across all advanced degree types" (p. 198).

Decisions regarding human capital investment that are motivated by business cycle conditions may affect productivity of cohorts in high skill occupations. Boehm and Watzinger (2012) find that the business cycle at the time of PhD application affects publication productivity of graduates positively, implying that talent is positively selected into cohorts that are made during times when talented individuals face less outside options.

Using a unique dataset on a specific subset of highly skilled labor we investigate if and how research productivity of male and female economics PhD graduates[4] is affected by prevailing economic, specifically, employment conditions as they both enter and exit graduate school. We focus on graduates of economics PhD programs in the U.S. from 1987 to 1996. This is a particularly interesting class of highly skilled labor, because research productivity of these individuals is almost perfectly measurable (at least retrospectively in the long run) as it reveals itself in the number and quality of publications.

We investigate how unemployment rates prevailing in the economy prior to start and at the end of graduate education affect research productivities of male and female economics PhD graduates. Availability of academic job openings at the end of PhD has a positive effect on research productivity (measured in number of publications) of both male and female graduates. This finding is in line with earlier literature suggesting that a first job where research skills can be built further has positive effect on research output of graduates (Oyer, 2006). Such a favorable first job may also help fresh graduates to learn about the precise degree of their talent and credibly signal it to future potential employers.[5] Oyer (2007) claims that being on the inside track for tenure is among the several benefits of a good first job.

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[4] PhD holders from U.S. institutions that obtained their undergraduate degree outside the U.S. make about 40% to 50% of graduates as documented by Oyer (2006) and Grove and Wu (2007). PhD applicants from abroad are affected by unemployment rates prior to PhD in similar ways as native applicants. They have to compete for the limited incoming class seats and assistantships. Assuming that quality of foreign applicant pool remains constant a significant increase in quality of native applicant pool will affect quality composition of the incoming class. Moreover, availability of assistantships and scholarships are mostly procyclical which makes the competition even fiercer during times of unfavorable economic conditions.

[5] See Terviö (2009) and Oyer (2008) for a formal discussion.

We find, however, that unemployment rates prior to starting graduate school have opposite effects on female and male graduates' research productivity. This effect is negative and significant for female graduates. Although the opportunity cost of attending graduate school is lower, the fact that many of their peers are having a hard time finding employment may suggest to women that the payoff to education is not as high as might have been hoped. Higher quality women who are able to find jobs may be more inclined to take them than to risk making additional investments in education.

To the extent that higher female risk aversion yields these effects, the female applicant pool for economics graduate programs might be weaker and thus, we should expect to see lower research productivity after graduation. Equivalently, highly talented female PhD graduates, who start graduate school during times of high unemployment, might be avoiding a risky research-active career upon graduation. Men, on the other hand, seem to pay more attention to the opportunity costs. Rather than being discouraged by the poor current return to human capital, men seem more likely to "double down" and go for even more education. Thus, the male applicant pool may go up in quality in bad economic times and higher research productivity is the result. Moreover, proportionally more male PhD graduates choose to stay in a risky research-active career.

Our results contribute to the current literature by documenting differences in research productivity between female and male PhD graduates and showing that a low opportunity cost of human capital investment in times of high unemployment can be outweighed by increased risk and uncertainty concerning availability of future high skill occupations. Men and women seem to differ in how they weigh these two costs.

2. Data and Methods

We obtain complete publication records of economics PhD holders by merging the list of economics PhD holders from U.S. institutions between 1987 and 1996[6] and list of publications provided by the EconLit from 1986 to 2005. That way, we are able to create a complete list of publications for each graduate from one year before graduation up to nine years after graduation.

Table 1 documents the number of economics PhD holders graduating from U.S. institutions between 1987 and 1996. Of 9,368 graduates from that period, 7,339 are male, and 2,029 are female. We restrict our attention only to those graduates who publish at least once within six

[6] These data are provided by the American Economic Association.

years after graduation (we refer to this group as "publishing graduates" throughout this paper), and hence we are left with 4,611 individuals in our analysis.

About half of all male graduates in our sample published at least once within six years after graduation. This ratio varies little across cohorts of male graduates from 1987 to 1996, fluctuating between 46.6% and 51.8%. Publishing female graduates make up about 46% of all female graduates in our sample. Interestingly, this ratio has a higher variation across cohorts compared to that for male graduates, fluctuating between 38.7% and 52.6%.

Table 1. Number of Economics PhD Holders Graduating from U.S. Institutions

	All Graduates	*Male*	*Female*	*Percentage of Females in all Graduates*	*Publishing Male*	*Publishing Female*	*Percentage of Publishing Male in all Male Graduates*	*Percentage of Publishing Female in all Female Graduates*
1987	684	547	137	20.0	265	55	48.4	40.1
1988	840	670	170	20.2	312	72	46.6	42.4
1989	984	794	190	19.3	382	100	48.1	52.6
1990	943	759	184	19.5	377	82	49.7	44.6
1991	918	729	189	20.6	375	85	51.4	45.0
1992	928	722	206	22.2	357	106	49.4	51.5
1993	1067	814	253	23.7	413	124	50.7	49.0
1994	1032	783	249	24.1	405	120	51.7	48.2
1995	1025	782	243	23.7	404	94	51.7	38.7
1996	947	739	208	22.0	383	100	51.8	48.1
Total	9368	7339	2029	21.7	3673	938	50.0	46.2

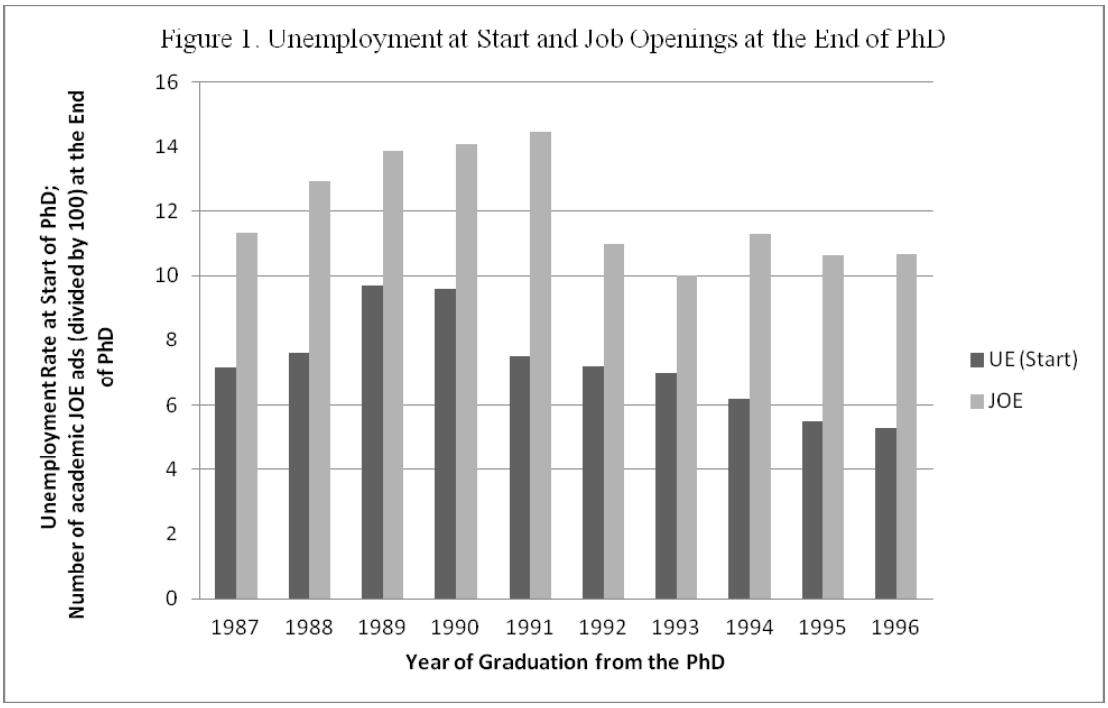
We have 4,611 publishing PhDs in our sample that have accumulated a total of 27,694 articles in 831 different journals cited in the EconLit. We measure research productivity by total count of publications (raw counts of publications) as well as by quality adjusted number of publications at the end of six and nine years after graduation. In order to account for publication quality we weigh each publication by the quality index provided by Kalaitzidakis et al. (2003), where the American Economic Review (AER) is assigned the highest quality. We use their journal quality indexes as an exchange rate between the AER and other journals[7]; measuring the quality of an individual article in a given journal by expressing it as a fraction of an AER article. We refer to

[7] All journals below top 65 are assigned a constant quality index of 0.0012. See Conley et al. (2012) for more details about this procedure.

this quality measure as “number of AER equivalent publications”. We discount for coauthorship in a publication by dividing its quality index by the number of its authors and assigning each author an equal share.

Description of dependent and independent variables used in the subsequent analysis are shown in table 2.

Unemployment rates during the application period to graduate school and number of academic job openings (JOE) at the end of PhD correspond to seven years and one year before the graduation year[8], respectively. Thus our sample covers those who applied to graduate education between 1980 and 1989, and those who faced academic job openings advertised between 1986 and 1995. These periods are especially interesting, because they cover times of unusually high unemployment rates and recovery thereafter. Figure 1 shows trends in unemployment rates prior to start and number of academic job openings at the end of graduate studies faced by each cohort.



[8] According to Stock et al. (2009), it takes five to six years to graduate from an economics PhD program, on average. Since most graduate programs have application deadlines in January for admission in the next fall term, and applicants should have their standardized test scores ready by then, it is safe to assume that a potential graduate student should decide whether to apply for graduate school about a year before starting PhD. A regular academic job market takes place during the first half of spring semester, and academic jobs are advertised in the “Job Openings for Economists” (JOE) listings during the fall semester before that. Assuming that one graduates after the job search process is concluded, most relevant data on JOE originate from the year before finishing PhD.

Table 2. Descriptive Statistics

A. Independent Variables

	Mean	Std. Dev.	Min.	Max.
Unemployment prior to PhD	*(unemployment rate in the US economy seven years prior to graduation year)*			
	7.24	1.45	5.26	9.71
JOE	*(number of academic job openings (rescaled dividing by 100) published in "JOE" the year before graduation year)*			
	11.99	1.59	10.02	14.47
Change in Unemployment (prior to PhD)	-0.115	1.09	-2.09	2.09
Change in JOE	-0.112	1.369	-3.49	1.6
Top 30	*(equals one, if graduated from a top 30 institution)**			
	0.622	0.48	0	1
Female	*(equals one, if female)*			
	0.203	0.403	0	1

*) Top 30 economics departments in the U.S. are based on rankings presented in Coupe (2003).

B. Dependent Variables

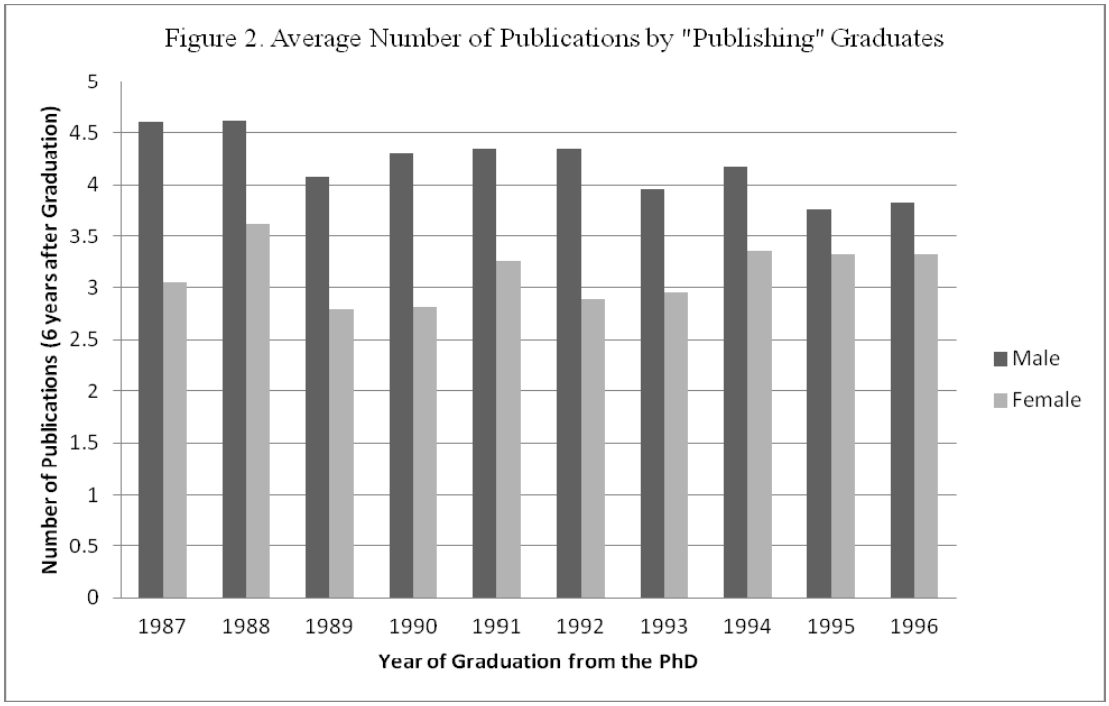
	6 years after PhD				*9 years after PhD*			
	Mean	*Std. Dev.*	*Min.*	*Max.*	*Mean*	*Std. Dev.*	*Min.*	*Max.*
Total Number of Publications	*(total number of publications, including no control for quality, not discounting for coauthorship)*							
for all graduates	3.96	3.7	1	32	5.88	5.66	1	56
for male graduates	4.18	3.93	1	32	6.23	6	1	56
for female graduates	3.13	2.46	1	16	4.5	3.79	1	26
Total Number of AER Eq. Publications	*(AER-equivalent number of publications accumulated, discounting for coauthorship)***							
for all graduates	0.32	0.63	0.004	8.85	0.45	0.89	0.004	10.26
for male graduates	0.34	0.67	0.004	8.85	0.48	0.94	0.004	10.26
for female graduates	0.24	0.46	0.004	3.73	0.33	0.63	0.004	5.21
At least 1 Publication in 6 years after PhD	*(equals one, if published at least once within 6 years after graduation)*							
for all graduates	0.49	0.5	0	1				
for male graduates	0.5	0.5	0	1				
for female graduates	0.46	0.5	0	1				
At least 1 Publication in a Top 20 Journal	*(equals one, if published at least once in a top 20 journal within 6 years or 9 years after graduation)****							
for male graduates	0.35	0.48	0	1	0.39	0.49	0	1
for female graduates	0.3	0.46	0	1	0.34	0.47	0	1

**) See text for details on how to calculate AER-equivalence of a publication.

***) Top 20 economics journals are based on rankings presented in Kalaitzidakis et al (2003).

Data in figure 1 read as follows: Graduates who obtained their PhD degree in 1987 faced an unemployment rate of 7.18 at time of application for graduate education. When this cohort was participating in the academic job market, number of academic job ads in the JOE was 1134[9].

Figure 2 shows the average number of total publications (not adjusted for quality and coauthorship) achieved by male and female graduates in respective graduate cohorts by the end of six years after obtaining PhD degree.



Research productivity of publishing graduates has an extremely skewed distribution, as documented in detail for a larger sample of graduates by Conley et al. (2012). Therefore publication data have more than one single dimension to consider, and these figures should be seen as merely descriptive statistics. We employ appropriate regression analyses to unveil various patterns in the next section.

[9] Since JOE variables are scaled by 100, we obtain 11.34x100=1134.

3. Results and Discussion

Marginal effects from the negative binomial regression of total number of publications accumulated within six and nine years after graduation on unemployment rates and other characteristics are shown in table 3 panels A and B, respectively.

Based on the total number of publications accumulated by the end of six years after graduation, graduates of top thirty institutions perform significantly better than graduates of non-top 30, and female graduates perform significantly worse than male graduates in every specification presented in panel A.

Neither unemployment at the start nor academic job openings at the end of the PhD turn out to be significant for the pooled sample. The number of academic job openings is significant in one specification, but it becomes insignificant when we control for annual changes in the number of academic job openings or for unemployment prior to starting PhD. Joint significance of unemployment prior to start and job openings at the end is rejected at 10% significance level in column 5.

When we investigate male and female graduates separately, however, it becomes obvious that results obtained in the pooled estimation are driven by male graduates. An interesting finding about male graduates is that unemployment prior to start and job openings at the end are jointly significant, although both coefficients are individually insignificant[10].

The number of academic job openings is positively correlated with research productivity for male and female graduates (columns 7, 9, 10, 15 in panel A, table 3). Availability of academic positions during the year of academic job search has a positive effect on research productivity of both male and female graduates. This finding is in line with Oyer (2006, 2008). Oyer (2006) established a causal relationship between first job placement and research productivity, suggesting that a first job that allows fresh graduates to further develop their research skills increases research productivity. Such research positions are abundant in supply during years that offer a good academic job market, and hence the probability of finding such a “skill-improving” first job is positively correlated to the volume of academic job advertisement.

[10] Since unemployment rate prior to PhD and number of job openings at the end of PhD may be expected to be correlated across time (due to fluctuations of the business cycle), this can lead to inflated standard errors which yield individual insignificance where it should not be. The variance inflation factor for both variables is about 2.4, indicating non-orthogonality, but comfortingly low. Randomly dropping a year from our analysis creates no change in sign and no dramatic change in magnitude of regression coefficients.

Table 3. Unemployment and Research Productivity (Total Number of Publications)

A. 6 Years After Obtaining PhD

	All					*Male*					*Female*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
UE (Start)	0.047		0.056		-0.018	0.093**		0.101**		0.041	-0.110**		-0.098		-0.211**
	[0.035]		*[0.040]*		*[0.055]*	*[0.043]*		*[0.048]*		*[0.067]*	*[0.056]*		*[0.063]*		*[0.084]*
JOE		0.065**		0.059	0.077		0.090**		0.099**	0.062		-0.022		-0.072	0.122*
		[0.032]		*[0.037]*	*[0.050]*		*[0.039]*		*[0.045]*	*[0.062]*		[0.049]		[0.056]	[0.074]
Δ in UE (Start)			-0.024					-0.021					-0.032		
			[0.055]					*[0.066]*					*[0.082]*		
Δ in JOE				0.014					-0.022					0.122*	
				[0.045]					*[0.055]*					*[0.067]*	
Top 30	0.821***	0.823***	0.820***	0.823***	0.822***	0.870***	0.873***	0.869***	0.872***	0.873***	0.644***	0.654***	0.644***	0.654***	0.639***
	[0.108]	*[0.108]*	*[0.108]*	*[0.108]*	*[0.108]*	*[0.132]*	*[0.132]*	*[0.132]*	*[0.132]*	*[0.132]*	*[0.158]*	*[0.158]*	*[0.158]*	*[0.158]*	*[0.158]*
Female	-1.025***	-1.021***	-1.025***	-1.021***	-1.021***										
	[0.102]	*[0.102]*	*[0.102]*	*[0.102]*	*[0.102]*										
Observ.	*4611*	*4611*	*4611*	*4611*	*4611*	*3673*	*3673*	*3673*	*3673*	*3673*	*938*	*938*	*938*	*938*	*938*
Wald Stat.	*155.7*	*159*	*155.8*	*159.5*	*159.7*	*44.11*	*45.89*	*44.18*	*45.86*	*45.98*	*20.84*	*16.44*	*20.79*	*22.15*	*24.82*
Log Likelihood	*-11012*	*-11011*	*-11012*	*-11011*	*-11011*	*-9005*	*-9005*	*-9005*	*-9005*	*-9004*	*-1980*	*-1982*	*-1980*	*-1980*	*-1979*

*Standard errors are reported in parantheses. ***p<0.1 **p<0.05 *p<0.1*

B. 9 Years After Obtaining PhD

	All					*Male*					*Female*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
UE (Start)	0.072		0.067		-0.009	0.143**		0.136*		0.074	-0.152*		-0.154		-0.264**
	[0.055]		*[0.062]*		*[0.084]*	*[0.066]*		*[0.074]*		*[0.103]*	*[0.087]*		*[0.098]*		*[0.130]*
JOE		0.091*		0.087	0.097		0.133**		0.150**	0.082		-0.046		-0.108	0.135
		[0.049]		*[0.057]*	*[0.077]*		*[0.060]*		*[0.070]*	*[0.094]*		[0.077]		[0.086]	[0.116]
Δ in UE (Start)			0.014					0.02					0.005		
			[0.082]					*[0.099]*					*[0.125]*		
Δ in JOE				0.008					-0.041					0.147	
				[0.069]					*[0.085]*					*[0.099]*	
Top 30	1.592***	1.594***	1.593***	1.595***	1.594***	1.715***	1.717***	1.716***	1.715***	1.717***	1.178***	1.191***	1.178***	1.193***	1.175***
	[0.162]	*[0.162]*	*[0.162]*	*[0.162]*	*[0.162]*	*[0.199]*	*[0.199]*	*[0.199]*	*[0.199]*	*[0.199]*	*[0.241]*	*[0.241]*	*[0.241]*	*[0.240]*	*[0.241]*
Female	-1.697***	-1.692***	-1.697***	-1.692***	-1.692***										
	[0.157]	*[0.157]*	*[0.157]*	*[0.157]*	*[0.157]*										
Observ.	*4611*	*4611*	*4611*	*4611*	*4611*	*3673*	*3673*	*3673*	*3673*	*3673*	*938*	*938*	*938*	*938*	*938*
Wald Stat.	*207.7*	*210*	*208*	*210.1*	*210.1*	*70.89*	*71.53*	*71.11*	*71.5*	*71.83*	*25.62*	*23.04*	*25.63*	*26.27*	*28.36*
Log Likelihood	*-12809*	*-12808*	*-12809*	*-12808*	*-12808*	*-10457*	*-10456*	*-10456*	*-10456*	*-10456*	*-2335*	*-2336*	*-2335*	*-2335*	*-2334*

*Standard errors are reported in parantheses. ***p<0.1 **p<0.05 *p<0.1*

Unemployment rates prior to starting the PhD are positively correlated with male graduates' research productivity within six as well as nine years after graduation. These findings can be explained along the lines of simple human capital models centered on opportunity cost of human capital investment and self-selection of talent, which is in line with findings presented in Boehm and Watzinger (2012).

During times of high unemployment, it is hard to find appealing and lucrative outside options, thus the opportunity cost of undertaking graduate studies decreases at such times. Economics graduate students are usually selected from a pool of highly qualified applicants in terms of their academic background (Grove and Wu, 2007). Given this background, it is presumed that these people face very high opportunity costs if they choose graduate school over work, as they forgo placement in well paying jobs with high skill requirements. In times of high unemployment, good jobs might disappear, thereby reducing the opportunity cost of joining a graduate program so that a greater number of individuals might be tempted to invest in human capital.

Following Roy's (Roy, 1951, Heckman and Honore, 1990) argument for self-selection of talent into sectors where comparative advantage pays off most, it is straightforward to argue that it is very likely that incoming classes of PhD are comprised of more able students during years of high unemployment. We do not observe applications for graduate education in our data, but since cohort sizes of economics PhD holders are similar, it is fair to assume that incoming class sizes must also be similar[11]. With a broader applicant pool and fairly stable class sizes, it is more likely that economics PhD cohorts in such years are composed of more talented students.

Our results for female graduates, however, tell a different story. Unemployment prior to starting PhD has a negative and significant effect on research output of female graduates accumulated at six years after graduation. Female graduates in our sample accumulate 3.1 publications within six years after PhD, on average. Coefficients in column 15 can be interpreted as follows: one percentage point increase in pre-PhD unemployment rate decreases an average female graduate's research productivity by 0.21 publications. If the number of academic jobs advertised in JOE increase by 100, this increases an average female graduate's research productivity by 0.12 publications. Although the effect of academic job openings is quantitatively small, it is statistically significant at the 10% level.

This implies that the simple theory outlined for male graduates above does not apply to female graduates. As discussed in the introduction, one important factor underlying this finding might be

[11] PhD education is mostly financed by departments by distributing assistantships, and these are limited in supply no matter how big and talented the applicant pool may be.

the fact that men and women react differently in risky situations. This could mean that rather more talented female candidates choose not to apply for graduate education during times of high unemployment, or alternatively more talented female graduates do not choose a research-active career after graduation and opt for more secure (and yet very well paying) jobs outside academia. A research-active career is a risky path, because promotion strictly depends on publication productivity which yields volatile outcomes.

Panel B in Table 3 show how our results are affected when we take a larger time span to measure research productivity, namely nine years after PhD. Most of the qualitative results discussed above for the first six years after graduation still hold when the time span is extended to nine years. An average female graduate reaches 4.5 publications at nine years after PhD, and the unemployment rate prior to starting PhD still has a negative and significant effect on the stock of publications accumulated until nine years after PhD by female graduates. A three percentage point increase in pre-PhD unemployment rate costs an average female graduate about one publication. The number of academic job openings does not manifest itself as a statistically significant factor on size of publication stock at nine years after graduation.

Unemployment prior to starting on a PhD and number of academic job openings are positively and significantly correlated with male graduates' research productivity at nine years after receiving a PhD. Although both of these coefficients are individually insignificant in specification in column 10 on panel B, they are jointly significant. An average male graduate achieves about 6.2 publications at nine years after graduation. Comparing this average to the level of estimated coefficients, one must acknowledge that statistical significance once again does not necessarily carry over to economic significance in the case of male graduates.

The question remains whether the results continue to hold when research productivity is adjusted for quality of the outlet and for number of coauthors. Table 4 shows coefficients from OLS estimates using (as the dependent variable) the coauthor-discounted AER-equivalent number of publications achieved by the end of six and nine years in panels A and B, respectively.

Controlling for quality of research output, we still obtain qualitatively very similar results in Table 4 to those presented in Table 3 (no control on publication quality). Thus our finding of negative selection of female students into graduate studies during high unemployment years has statistical as well as economic significance even after adjusting research productivity for coauthorship and publication quality.

Regression results for coauthor and quality-adjusted number of publications achieved nine years after graduation in panel B do not reveal a very different story from the one we have seen at six years after graduation in panel A. Academic job availability has positive and negative point

Table 4. Unemployment and Research Productivity (Total Number of AER Equivalent Publications)

A. 6 Years After Obtaining PhD

	Male					*Female*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
UE (Start)	0.0164**	0.0123			0.0135	-0.0139*	-0.0162*			-0.0253**
	[0.007]	*[0.010]*			*[0.012]*	*[0.007]*	[0.009]			*[0.009]*
JOE			0.0129*	0.0153*	0.0035			-0.0037	-0.0106	0.0136*
			[0.007]	*[0.008]*	*[0.012]*			[0.008]	[0.008]	*[0.007]*
Δ in UE (Start)		0.0117					0.006			
		[0.020]					*[0.011]*			
Δ in JOE				-0.006					0.0164**	
				[0.008]					*[0.007]*	
Top 30	0.3112***	0.3116***	0.3113***	0.3111***	0.3113***	0.1587***	0.1586***	0.1600***	0.1594***	0.1581***
	[0.025]	*[0.026]*	*[0.025]*	*[0.025]*	*[0.025]*	*[0.021]*	*[0.021]*	*[0.023]*	*[0.021]*	*[0.020]*
Constant	0.0229	0.0539	-0.0133	-0.0426	0.0021	0.2450***	0.2622***	0.1884**	0.2735***	0.1652**
	[0.045]	*[0.068]*	*[0.082]*	*[0.090]*	*[0.084]*	*[0.055]*	*[0.070]*	*[0.090]*	*[0.091]*	*[0.070]*
Observ.	*3673*	*3673*	*3673*	*3673*	*3673*	*938*	*938*	*938*	*938*	*938*
Adj. R-squared	*0.052*	*0.052*	*0.052*	*0.051*	*0.052*	*0.028*	*0.027*	*0.026*	*0.027*	*0.028*
F Stat.	*95.96*	*148*	*108.5*	*73.7*	*83.54*	*32.83*	*25.61*	*27.8*	*20.46*	*24.16*

*Standard errors are reported in parantheses. ***p<0.1 **p<0.05 *p<0.1*

B. 9 Years After Obtaining PhD

	Male					*Female*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
UE (Start)	0.0183**	0.0118			0.0159	-0.0259**	-0.0314**			-0.0307*
	[0.009]	*[0.013]*			*[0.017]*	*[0.012]*	[0.014]			*[0.015]*
JOE			0.014	0.0185*	0.0029			-0.0153	-0.0248**	0.0058
			[0.010]	*[0.011]*	*[0.019]*			[0.011]	[0.011]	*[0.011]*
Δ in UE (Start)		0.0183					0.0145			
		[0.026]					*[0.011]*			
Δ in JOE				-0.0113					0.0226**	
				[0.013]					*[0.010]*	
Top 30	0.4596***	0.4602***	0.4597***	0.4593***	0.4597***	0.2409***	0.2407***	0.2430***	0.2422***	0.2406***
	[0.036]	*[0.037]*	*[0.036]*	*[0.035]*	*[0.035]*	*[0.029]*	*[0.028]*	*[0.031]*	*[0.029]*	*[0.028]*
Constant	0.0581	0.1066	0.0227	-0.0327	0.0408	0.3686***	0.4102***	0.3630**	0.4805***	0.3349***
	[0.059]	*[0.087]*	*[0.119]*	*[0.128]*	*[0.127]*	*[0.088]*	*[0.105]*	*[0.128]*	*[0.136]*	*[0.111]*
Observ.	*3673*	*3673*	*3673*	*3673*	*3673*	*938*	*938*	*938*	*938*	*938*
Adj. R-squared	*0.057*	*0.057*	*0.056*	*0.056*	*0.056*	*0.036*	*0.036*	*0.034*	*0.035*	*0.035*
F Stat.	*92.59*	*114.3*	*99.7*	*71.67*	*74.25*	*36.37*	*24.4*	*32.61*	*24.07*	*24.8*

*Standard errors are reported in parantheses. ***p<0.1 **p<0.05 *p<0.1*

estimates for female graduates depending on specification, and it becomes insignificant when used with unemployment prior to PhD in the same specification. One should note that pre-PhD unemployment rates consistently have negative and significant point estimates in all specifications for female graduates.

3.1. Selection

So far we have focused on publishing graduates only, and have shown that unemployment prior to the start of PhD and availability of academic jobs at the time of job market have different effects on research productivities of male and female graduates. The next question is whether these patterns are preserved when we investigate how pre-PhD unemployment and academic job availability affect graduates' probability of becoming a "publishing" graduate, that is, publishing at least once? We create a probit model with a binary dependent variable and the same independent variables as in tables 3 or 4. The dependent variable is one, if a graduate published at least once[12] within six years after graduation, and zero otherwise.

Unemployment prior to starting PhD has a negative and statistically significant effect on the probability of publishing at least once for male graduates: an increase of one percentage point in unemployment is associated with one percentage point decrease in the probability of publishing. For female graduates, it works in the opposite way: one percentage point increase in unemployment is associated with 2.2 percentage point increase in probability of publishing. Furthermore, for female graduates, an increase of 100 academic openings is associated with 1.5 percentage point increase in the probability of publishing. Although statistically significant, one should note that, given variations in unemployment rates and academic job advertisements, these probabilities are hardly economically significant. Especially in the case of male graduates, no economic significance can be claimed, which is supported by the low variation in percentage of publishing male graduates across cohorts as documented in table 2.

There are two interesting findings one can draw from the probit results in table 5: first, statistically significant coefficient estimates for unemployment prior to PhD and academic job openings in columns 10 and 15 have exactly opposite signs as their counterparts in tables 3 and 4. With these findings at hand, we cannot reject the following alternative line of thinking: talented female students enter graduate education during times of high unemployment, and they are motivated students, probably publishing some of their dissertation chapters, so that they appear as

[12] Our findings in this section are robust to defining "publishing" graduate as those who publish at least twice or three times within six years after graduation.

Table 5. Probability of Publishing after PhD

(Dependent variable: "publish=1" if at least 1 pulished article within 6 years after graduation)

	All					*Male*					*Female*				
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*
UE (Start)	-0.003	-0.002			-0.003	-0.007**	-0.004			-0.010**	0.01	0.008			0.022**
	[0.004]	*[0.004]*			*[0.005]*	*[0.003]*	*[0.003]*			*[0.005]*	*[0.008]*	*[0.008]*			*[0.011]*
JOE			-0.002	-0.002	-0.001			-0.003	-0.004	0.003			0.001	0.003	-0.015*
			[0.003]	*[0.003]*	*[0.004]*			*[0.003]*	*[0.004]*	*[0.003]*			[0.007]	[0.008]	[0.009]
Δ in UE (Start)		-0.004					-0.007					0.005			
		[0.005]					*[0.004]*					*[0.012]*			
Δ in JOE				-0.0002					0.001					-0.006	
				[0.004]					*[0.004]*					*[0.009]*	
Top 30	0.205***	0.205***	0.205***	0.205***	0.205***	0.209***	0.209***	0.209***	0.209***	0.209***	0.192***	0.192***	0.191***	0.191***	0.192***
	[0.011]	*[0.010]*	*[0.011]*	*[0.011]*	*[0.011]*	*[0.009]*	*[0.009]*	*[0.010]*	*[0.010]*	*[0.009]*	*[0.025]*	*[0.024]*	*[0.026]*	*[0.026]*	*[0.024]*
Female	-0.038***	-0.038***	-0.038***	-0.038***	-0.038***										
	[0.013]	*[0.013]*	*[0.013]*	*[0.013]*	*[0.013]*										
Observ.	*9368*	*9368*	*9368*	*9368*	*9368*	*7339*	*7339*	*7339*	*7339*	*7339*	*2029*	*2029*	*2029*	*2029*	*2029*
Wald Stat.	*384.1*	*461.7*	*371.1*	*371.3*	*384.2*	*481.4*	*545.8*	*463.8*	*470.2*	*507.9*	*56.94*	*90.34*	*55.64*	*60.65*	*71.61*
Log Likelihood	*-6289*	*-6288*	*-6289*	*-6289*	*-6289*	*-4925*	*-4924*	*-4926*	*-4925*	*-4924*	*-1362*	*-1362*	*-1363*	*-1363*	*-1361*

*Standard errors are reported in parantheses. ***p<0.1 **p<0.05 *p<0.1*

“publishing” graduates in our data. However they either do not take a research-active career upon graduation or they switch in a few years. This would explain the observed increased likelihood of publishing at least once, because these female student cohorts are talented and motivated (overall, a good student). Upon graduation or shortly thereafter, they switch to occupations where they are not required to publish research, so that our results about female PhDs’ research productivity presented in tables 3 and 4 are driven by talented female graduates who published some articles early in their life cycle and then withdrew from research intensive occupations. This creates high volatility in the total number of female graduates’ publications across cohorts, which is documented by the high variation in ratio of publishing female graduates in table 2. Moreover this explains why the sign for the unemployment rate prior to starting PhD education switches from negative in tables 3 and 4 to positive in table 5.

This line of thinking supports the view that with respect to women, there is not necessarily a negative selection of talent when opportunity cost of human capital investment decreases. That is, talented women do not shy away from undergoing extra years of graduate education. However, upon graduation they opt for a less risky occupation than a research-active career. Thus, risk-aversion may be the key element in allocation of female talent across high skill occupations. This can be a potential explanation for observed differences in gender unemployment rates across different occupation categories that were documented by Rives and Sosin (2002).

From the viewpoint of economic significance, one can argue that the unemployment rate prior to start of PhD education and the number of academic jobs at the end of PhD education have an impact on the intensive margin but not on extensive margin of research publishing among graduates. Extensive margin in this context is the decision about becoming a “publishing graduate” or not. Intensive margin, on the other hand, is quantity and quality of research output.

4. Conclusion

Using a unique dataset on graduates of economics PhD programs in the U.S. from 1987 to 1996 we investigate research productivity differences between and within genders over the business cycle. We find that graduates of top thirty institutions perform significantly better than graduates of non-top 30, and female graduates perform significantly worse than male graduates.

We control for the economic environment prior to start of PhD and at the end of PhD, and we find that availability of academic job positions has a positive effect on research productivity of male and female graduates. This supports earlier findings in the literature.

Unemployment prior to starting PhD has a negative and significant effect on research output of female graduates whereas this affect is positive but (in most specifications) insignificant for male graduates. This is an interesting result, because it points to an important difference between men and women in self-selection of talent into occupations: there exists gender difference in perception of risk in occupations with high skill requirements. This result is in line with previous findings of the literature on competitiveness and risk-aversion of women.

This paper contributes to the current literature by bridging the literature on selection of talent into occupations and the literature on competitiveness and risk-aversion of women. A research-active career in economics necessitates graduate education that takes a long time. It would be interesting to see how robust these findings are to the duration of human capital investment for the high skill occupation under question. We leave this for further research.

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