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The production of PhDs in the United States and Canada

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The Production of PhDs in the United States and Canada

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December 2010

Forschungsinstitut
zur Zukunft der Arbeit
Institute for the Study
of Labor

The Production of PhDs in the United States and Canada

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ABSTRACT

The Production of PhDs in the United States and Canada

This paper is concerned with the production of PhDs in the United States and Canada in the post-WW II period, overall and by gender and major discipline. The effects of the explanatory variables lagged six years are consistent with the model. Military conscription with educational exemptions and the Vietnam War increased male PhD production in the U.S., but have no effect for U.S. females or in Canada. Government expenditures on research and development enhanced PhD production, especially for males and in the physical sciences in the U.S. A higher rate of growth of non-farm productivity encouraged PhD production in the U.S., but not in Canada. The cyclical indicator, the adult male unemployment rate, has a weak positive effect for males in both the U.S. and Canada, suggesting that the negative effect of the opportunity cost of time was stronger than the positive wealth effect. Other variables the same, there has been an increase over time in PhD production for females, but there is no such trend for males. The result has been an increase over time in PhD production for both males and females, but the faster increase for females has narrowed the gender gap.

JEL Classification: I21, J24

Keywords: PhD, educational attainment, conscription, Korean War, Vietnam War, research funding

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I. Introduction

From Colonial times to the present, it has been recognized that high-skilled workers are essential inputs in the economic growth of this country. The definition of high-skilled has changed over time from the skilled artisans of the colonial period to the highly-educated STEM (science, technology, engineering and mathematics) workers of today. The most highly skilled of these workers typically complete their formal schooling with a PhD degree. Yet, there has been remarkably little research on the determinants of the production of PhDs in the United States in the post-World War II period.

There has been a substantial growth in the number of PhDs awarded in the US over the past century, particularly after WWII, as shown in Table 1.

Table 1:

Average Number of PhDs Awarded Annually in the United States, by Decade, 1910-1919 to the present

Decade	PhDs	Decade	PhDs
1910-1919	546	1960-1969	16,284
1920-1929	1,081	1970-1979	32,094
1930-1939	2,697	1980-1989	31,948
1940-1949	3,349	1990-1999	40,377
1950-1959	8,376	2000-2006	41,998

Sources:

- U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970 House document-93rd Congress, 1st session; no 93-78. Bureau of the Census Series H 751-765 Institutions of Higher Education-Degrees Conferred, by Sex: 1870 to 1970 for the years 1950-1966
- NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/).

This paper is one of the first systematic analyses of the changes over time in the post-war period in the number of PhDs awarded annually in the United States and Canada. The analyses are performed separately by country, overall and separately by gender and major academic discipline (Physical or Natural Sciences, Social Sciences, Humanities, and Education).[1]

Section II is a review of the literature on the awarding of PhD degrees. The model is developed in Section III. The sources of the data for the US and Canada (PhDs awarded and the explanatory variables) are reported in Section IV. The empirical analyses, first for the US and then for Canada, are reported in Section V. While the Summary and Conclusions are presented in Section VI.

II. Literature Review

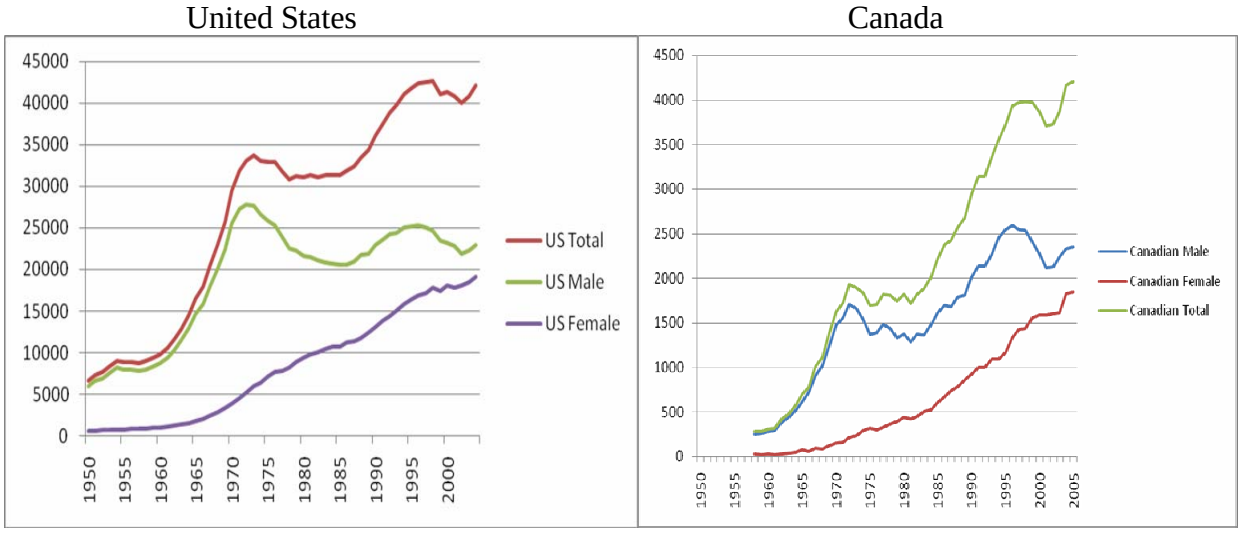
The annual numbers of PhD recipients in the United States increased at a rapid rate from 1950 to 1966 with a downswing during the 1970s, followed by a gradual increase from 1980 to 2005 (Figure 1). Since the 1980s around 50 percent of the growth of PhD production in the United States is attributed to temporary residents (foreign students) earning PhDs, primarily in the fields of mathematics, science, and engineering (Stephan, Black, Adams & Levin 2002). Similar trends are seen for PhD recipients in Canada (Figure 1). The data also show that initially most PhDs awarded in the United States were earned by men born in the United States, but over time this changed as the percentage of both the foreign born and women PhD recipients rose. The literature that looks at the trends in PhD production in the United States generally focuses only on changes to one of the following factors: change in attrition rates and time-to-degree by gender and field of study, rising NSF funding, draft avoidance, the GI Bills for veterans, or

[1] For the purpose of this project Mathematics is included in the Physical Sciences and Psychology is included in the Social Sciences.

changes to the PhD labor market. The literature that examines the interaction of several or all these factors is primarily Bowen and Rudenstine (1992), which looks at PhD production from 1954 to 1988, and Chiswick (2008), which explains PhD production among Jews compared to others from 1950 to 2004.

Figure 1:

PhD Production in the United States and Canada, Overall and by Gender, 1950-2006.



Sources:

1. Total number of Ph.D.s awarded in the U.S (by gender, by discipline, by ethnicity and in total)
   - U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970 House document-93rd Congress, 1st session; no 93-78. Bureau of the Census Series H 751-765 Institutions of Higher Education-Degrees Conferred, by Sex: 1870 to 1970 for the years 1950-1966
   - NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/).
2. Total number of Ph.D.s awarded in Canada (by gender and in total)
   - Table W504-512 (Website address: http://www.statcan.gc.ca/pub/ 11-516-x/sectionw/4147445-eng. htm) for years 1955-1973.
   - Table 477-0014 available through CANSIM (Website address: http://cansim2. statcan.gc.ca/ cgi-win/CNSMCGI.EXE?LANG=Eng& Dir-Rep=CII/&CNSM-Fi=CII/CII_1-eng.htm) for years 1970-1997.
   - CANSIM (Website address: http://library.queensu.ca/webdoc/ssdc/ xcleduc99.htm#top) for years 1992-2005.

Estimates of rates of attrition among PhD students, measured as the percent of students who do not graduate or continue studying from one year to the next, range from 40 to 50 percent, which is far greater than the 10 to 20 percent attrition found at the most selective of undergraduate programs (Berelson 1960; Bowen & Rudenstine 1992; Lovitts 2001). The literature notes a difference between males and females in both time-to-degree and attrition rates. Women have a longer time to degree completion than men leading to a higher attrition rate, but these gaps have diminished over time within all degrees (Bowen & Rudenstine 1992). The trend over time has been an increase in the total number of PhDs awarded annually, with a lower level but faster growth rate for women narrowing the PhD gender gap, especially in the social sciences.

The difference in the trends of men and women, along with differences in the fields of study, provide support for disaggregation of PhDs by gender and field. The aggregate downturn of PhD recipients in the 1970s is driven primarily by the decrease among native-born males. Bowen and Rudenstine (1992), for example, note that while the severe depression of academic jobs in the 1970s reversed the previous upward trend of PhDs; the number of PhDs earned in the U.S. by native born women and foreign born men and women continued to rise.

Furthermore, Bowen and Rudenstine observe systematic differences in the fields of study. For example, the completion rates, the percentage of an entering cohort that earn a PhD degree, of males in the sciences (65.3%) is high compared to both the social sciences (55.7%) and the humanities (51.8%). Among women completion rates for a PhD in the sciences (58.8%) is also high compared to both the social sciences (50.8%) and the humanities (44.8%). They also find that time to degree for humanities and social sciences degrees averages 8 years, while among the sciences it averages only 6.1 years (Bowen and Rudenstine 1992).

The literature on the differences for why males and females entered PhD programs has focused primarily on two determinants, the increase in National Science Foundation (NSF) and other Federal funding after the launching of Sputnik in 1957 and the reaction of college age males seeking education deferments as the probability of conscription, and the probability of adverse consequences, increased during war time periods, especially the Vietnam War. The initial rise in doctoral degrees from 1954 to 1962 is attributed to two primary causes. Bowen and Rudenstine (1992), using data from the National Research Council, point to the launch of Sputnik in 1957 generating an increased public support for mathematics and sciences education in the United States. Increased support lead to more undergraduates entering these fields, with many continuing into graduate school. In a similar study on PhD production, focusing on American Jews, Chiswick (2008) observes that males appear to be more responsive to an increase in NSF funding than and females.

There is a relation between draft deferments and PhD program enrollment and completion. Initially explanations focused on the change in education draft deferments following the Selective Services Act of 1967. The Selective Services Act of 1967 reduced the number of deferments available to graduate students stating "... at the close of the 1967-1968 academic year, no more 2-S deferments would be granted to graduate students except those specifically written into law." Marmion (1968) showed that draft deferments, even if limited to undergraduates, would lead to an increase in the number of male students going to college for a BA, and given that a BA is a requirement for entering a PhD program, the increase would have a secondary effect of increasing the pool of students eligible for graduate (PhD) study.

Draft avoidance leading to an increase in college enrollment has been analyzed in a number of studies. Chiswick (2008) notes that a factor that is important in the decision of young

males continuing onto graduate school is the likelihood of their being conscripted into the military. Chiswick's results for men are further supported by the non-responsiveness of women in his analysis to a conscription variable, because women are exempt from a draft. Davis and Dolbeare (1968) found that males took advantage of education draft deferments by increasing their undergraduate enrollment. Baskir and Strauss (1978) estimate the increase in undergraduate enrollment due to the draft was between 6 and 7 percent. This is supported by Bound and Turner (1999), using Census data, and Card and Lemieux (2001), using data from the 1973 Occupational Change in a Generation, where a small portion of the increase could be from GI Bill benefits, but most of the increase is attributed to draft avoidance. Card and Lemieux also noted that total college entry rates for young males rose from 54 percent in 1963 to 62 percent in 1968. But, they also observed that while draft avoidance lead to about an 8 percentage points increase in the proportion of males who entered college, the number of males who actually attained a BA degree only increased by 2 percentage points during this time. They concluded that draft avoidance explains only a part of the 1970s story and attention needs to be paid to the economic return to education which fell during this time.

Using a cob-web supply and demand labor market model, Freeman (1971) found that positive demand shocks in the labor market lead to increases in earnings for someone with a PhD. This increased earnings enticed more people to enter graduate programs eventually decreasing their relative wages. A similar cob-web approach to the over and under supply of PhDs in the labor market has been used to explain trends in PhD production by Cartter (1965), Freeman and Breneman (1974), and W. Lee Hansen, et al. (1980).

Freeman (1975a and 1975b), and later by Bowen and Sosa (1989), attributes the rise in undergraduates continuing into graduate school to the increased returns to PhD education in the

labor market. Yet, Bowen and Rudenstine (1992) suggest that the favorable academic labor market is secondary to the increasing pool of undergraduates. Their observation is that as the number of undergraduates increased, many universities started to rely more heavily on graduate teaching assistants. Because of this, universities started to provide more funding to graduate students and increased the number and size of existing PhD programs. Cartter (1965) looked at the importance of the size of the cohort of university age students for predicting the demand for teachers by universities, as a PhD is now generally a requirement to teach in a college or university. Cartter found that as the "baby boomers" started to enroll in colleges the demand for PhD graduates by universities grew faster than the supply. This resulted in favorable labor market conditions for PhDs and more students went onto graduate school, eventually leading to an apparent "over-supply" of PhDs by 1969.

For physics PhDs, Freeman and Breneman (1974) observed a reversal in the labor market from 1964 to 1973. They observed that from 1964 to 1969 the real annual salaries for physics PhDs increased by 11.7 percent, but from 1969 to 1973 real annual salaries for physics PhDs fell by 23.1percent. Similarly, W. Lee Hansen, et al. (1980) forecasted that relative academic salaries would have to fall in the 1980s to account for an over-supply of PhDs. This is supported by Youn (2005) who finds that the launch of Sputnik in 1957 lead to a 9 percent annual increase in enrollment and a 10 percent increase in funding annually for higher education from 1957 to 1967. This rapid increase, Youn notes, leads to an oversupply of PhDs by the late 1970s, reducing PhD enrollment numbers. In later work, Cartter (1966, 1971, 1972, 1974, and 1976), and later supported by Bowen and Sosa (1989), predicted that the oversupply of PhDs by the end of the 1970s would weaken the job market for PhDs throughout the 1980s.

III. The Model

The time series analysis of the PhD output of American and Canadian universities can conceptually be put in the context of a supply and demand framework.

An important factor is the alternative use of time. During the post-WWII period from 1948 to 1973, there was military conscription for young males (age 18 to 26). For most of this period draft deferments were available for full-time male students in accredited academic programs. A student who could secure annual deferments up to age 26 would be exempt from conscription. Among those who viewed compulsory military service as a cost, there would be gains to continuing their academic studies up to at least age 26, that is, to continue beyond the undergraduate degree for a master's or PhD. Once successfully enrolled in a PhD program, there would be an incentive to remain until the degree is completed, even if this extends beyond age 26.

The cost of compulsory military service would be greater the greater the unpleasantness of this service or the higher the probability of injury or death. Hence, the incentive to avoid conscription would be greater during wartime. Thus, variables for military conscription and for the Korean and Vietnam Wars would enter the demand by young males for a PhD, and hence PhD production or completion several years later. It is not likely that the Korean War, which started unexpectedly in June 1950 and ended in June 1953, would have much of an impact given its short duration and limited number of troops. The Vietnam War, on the other hand, involved a gradual build up of U.S. forces, involved a much greater number of US troops annually, and lasted far longer, although conscription ended in 1973 before the end of the war in 1975.

Note, however, that these draft and wartime variables would be expected to effect the demand decisions for males but not for females who were not subject to the draft. Note also that

while these variables would influence the demand for a PhD among American men, these same variables for the US should not be relevant for an analysis of PhD production in Canada which did not have military conscription in the period under study.

When civilian labor market conditions are poor, recent labor market entrants, including new college graduates, experience a disproportionate burden of high unemployment and poor wage offers. This lowers the opportunity cost of continuing one's studies, and hence a higher unemployment rate would increase the demand for enrolling in a PhD program. The male unemployment rate can be used as a proxy measure of the state of the economy – higher unemployment rates would encourage enrollment in PhD programs, and hence the production of PhDs several years later when the recession is likely to be over. This effect might be tempered by the wealth effect of a recession—declining incomes increasing the difficulty of self financing the cost of graduate education.

The male unemployment rate reflects cyclical conditions, but secular trends also matter. In a dynamic economy in which productivity is rising rapidly, and is expected to continue to do so, those with greater schooling tend to earn more relative to those with lesser schooling. This may be due to their having higher levels of decision making or allocative skills (Schultz 1975). Alternatively, it may be that in the post-WWII period technological change has been skill biased, that is, it raises the productivity of high-skilled workers more than lower-skilled workers. If this were the case for the PhD relative to those with, say, merely a bachelor's degree, higher rates of productivity growth would increase the relative demand for the PhD. Again, productivity growth would be a predictor of PhD graduates several years later.

The demand for the PhD by individuals would be expected to be related to the economic attractiveness of obtaining a PhD, that is, the earnings of PhD recipients relative to those without

this degree, say, with only a bachelor's degree. Unfortunately, we have not located appropriate data for the entire sixty years of our study to include this variable in the empirical analysis. However the relative earnings of PhD recipients will be captured at least in part by our productivity variable.

The supply side of slots in universities for accepting PhD students is also relevant. In many fields PhD slots are made available by universities through externally funded Federal research grants. The grants may provide the funding for the research projects, centers or institutes that then create positions for PhD students, or the grants may provide direct support for the PhD students. One can view the external research resources as reducing the opportunity cost of being in a PhD program (demand side) and as expanding the number (supply side) of spaces that universities make available to PhD students.

A higher rate of growth of technology, that is, long term economic growth, may also provide public and private PhD granting institutions greater resources through government funding and philanthropic contributions. This greater funding may translate into expanding university educational programs, including PhD programs. The rate of growth of productivity in the economy can therefore be included in the equation for the supply of spaces for students in PhD programs.

Thus, using a simple supply and demand framework for a time series study, it is possible to identify variables that would be expected to shift one or the other equation for an analysis of the production of PhDs. It is not possible, however, to develop shift variables to identify statistically either the supply or demand equation. What can be estimated, however, is a time series reduced form equation based on the variables discussed in this section.

IV. Empirical Analysis

The econometric methods used to estimate the time series model are ordinary least squares (OLS) and the Cochrane-Orcutt (1949) method to adjust the ordinary least squares model for possible serial correlation in the error term. The dependent and explanatory variables are defined in greater detail and their sources are indicated in Appendix A[2]. The dependent variable in the estimating equations use the number of PhDs awarded annually overall and by gender and broad field of study for the US and overall for Canada. The explanatory variables used to estimate the time series model of PhD production in the post-war period in the US are: government research and development expenditure, conscription variable (annual conscription in the US), the Korean and Vietnam Wars, adult male unemployment rate, nonfarm productivity growth, and a time trend and its square. The explanatory variables are lagged six years. The median registered completion time for the doctorate degree in the U.S. averaged approximately six years in the post-war period.

(A) United States

The ordinary least squares estimation for the total production of PhDs in the United States can be found in Table 2. Research and development expenditures are positive and statistically significant in all cases, except where it is negative for women and not statistically significant for the field of education, which receives little government research and development funding. This is consistent with the hypothesis that following the Soviet Union's launch of Sputnik in 1957 the large increase in Federal government funding, especially in the sciences, enhanced PhD production.

[2] In Appendix A the variables used in the empirical analysis are defined, their sources are reported and their descriptive statistics are presented. The actual data used in the analyses are presented in Appendix B.

The coefficient for the total PhDs in a year means that a one standard deviation increase in research and development expenditure increases the number of PhDs by 5,955. The largest partial effect by fields of study is in the physical sciences. A one standard deviation increase six years previously in research and development expenditures would result in a 4,431 increase in PhDs for physical sciences, approximately four times larger than in the humanities (a 1,053 increase in PhDs), approximately fifteen times larger than social sciences (a 283 increase in PhDs), and approximately twenty times larger than in education (a 217 increase in PhDs). Research and development expenditures also have a stronger effect on males than females, in large part because males are more likely to be in the physical science programs. For males a one standard deviation increase in research and development expenditures results in a 6,315 increase in PhDs, while a one standard deviation increase for women reduces PhDs by a statistically insignificant 426.

The military variables are dichotomous variables for both the Korean War and Vietnam War and a continuous variable for the number of males conscripted into the military. The hypothesis is that the wartime variables should have a positive coefficient for males who are using graduate school to avoid the war and a zero (statistically insignificant) coefficient for females who do not need the education deferment.

The Korean War was unanticipated and relatively short. The Korean War coefficients are statistically significant and negative for both males and in the humanities, statistically significant and positive for women, and not statistically significant for any of the other dependent variables (Table 2). The coefficients show that the Korean War contributed to a 2,692 decrease in the number of PhDs for males and a 1,363 increase in female PhDs.

The results for the Vietnam War and military conscription appear to tell a different story.

The Vietnam War coefficients and the conscription coefficients are positive and statistically significant in all cases, except for females and the physical sciences. In addition to its effect through conscription, the Vietnam War variable itself explains a 1,987 increase in total PhDs, which is primarily the result of an increase in male PhDs by 1,742. For military conscription, a one standard deviation increase would result in a 1,554 increase in total PhDs, which is also primarily the result of an increase in male PhDs by 1,976. This is consistent with the hypothesis that males will take advantage of education deferments to avoid the military, and women do not need to do this as they are not subjected to the military draft. Conscription reached its peak during the Vietnam War in 1966. Combined with the Vietnam War dichotomous variable, this increased the total number of PhDs by 4,049 in 1972, or more than 12 percent of the total for that year. The inconsistencies between the Korean War results, on one hand, and the Vietnam War and conscription variables, on the other, may be explained by the short duration of the Korean War, three years, compared to the Vietnam War and conscription, twelve years and thirty years respectively. The Korean War also involved far fewer military personnel than the Vietnam War.

The adult male unemployment rate is a proxy for the state of the economy. The male unemployment rate is only statistically significant in explaining the production of PhDs for the physical sciences and education. A one standard deviation increase in the male unemployment rate is associated with a 400 increase in physical sciences PhDs and a 118 decrease in education PhDs. A recession has two effects on PhD production. First, a decrease in the opportunity cost of time that would have upward pressure on the demand for a PhD. And second, the family income effect or wealth effect, as the decreased means of financing the investment in a PhD will have downward pressure on PhD production. The income effect is muted in a recession for the sciences and the opportunity cost is reduced because most science PhD candidates are receiving

financial support. Thus, a recession appears to increase science PhDs. A smaller proportion receives financial support in education, increasing the importance of the negative income effect which appears to dominate the decreased opportunity cost of time.

The growth of nonfarm productivity is positive and statistically significant for the total PhDs, males, social sciences, and education and not statistically significant for the other dependent variables for the US. A one standard deviation increase in nonfarm productivity growth will result in a 4,487 increase in total PhDs, a 3,924 increase in male PhDs, a 1,513 increase in social sciences PhDs, and a 2,698 increase in education PhDs. These results are consistent with the hypothesis that productivity increases in the United States tend to increase the rate of return from education, including PhD education.

The time trend variables indicate that the total production of PhDs is increasing at a decreasing rate for unmeasured reasons. The increase in total PhDs is attributed primarily to the significance of the time trend for females. Figure 1, for the United States, shows a steady increase in PhDs for women from 1950 to 2006, with little evidence of a slowdown, which is consistent with the observation that more women are entering high-skilled labor market positions. By field of study, the time trend variables show that both the Humanities and Social Science have been increasing at a decreasing rate, while both Physical Sciences and Education have negative time trends, though the decline is not statistically significant.

Table 2: Ordinary Least Squares: Analysis of PhD Production by Gender and Discipline, United States, 1950-2006

Independent Variables	Dependent Variables: Total	Gender: Male	Gender: Female	Field of Study: Physical Science	Field of Study: Social Science	Field of Study: Education	Field of Study: Humanities
Research and Development (trillions $)	256 (13.91)	272 (18.56)	-18.4 (-1.66)	191 (10.75)	12.2 (2.47)	9.39 (1.84)	45.4 (7.91)
Vietnam	1987.074 (4.01)	1742.479 (4.43)	269.035 (0.9)	-514.524 (-1.08)	695.934 (5.27)	1080.904 (7.89)	750.449 (4.88)
Korea	-1248.677 (-1.32)	-2691.932 (-3.57)	1363.487 (2.39)	-542.751 (-0.59)	-63.3821 (-0.25)	-118.472 (-0.45)	-988.341 (-3.36)
Conscription (millions)	7500 (3.1)	5900 (3.07)	1650 (1.14)	-73.1 (-0.03)	2610 (4.05)	1800 (2.69)	1940 (2.59)
Year	360.200 (2.18)	-117.446 (-0.9)	471.453 (4.75)	-191.838 (-1.21)	300.250 (6.83)	282.366 (6.19)	-6.273 (-0.12)
$Year^2$	-4.0151 (-3.43)	-3.382 (-3.63)	-0.740 (-1.05)	5.328 (4.72)	-4.0867 (-13.09)	-6.091 (-18.80)	0.795 (2.18)
Male Unemployment Rate	209.828 (1.46)	186.743 (1.64)	14.660 (0.17)	292.0368 (2.11)	-5.2048 (-0.14)	-86.367 (-2.17)	-34.581 (-0.78)
Non Farm Productivity Hours	202.368 (2.06)	176.963 (2.27)	34.558 (0.59)	-6.499 (-0.07)	68.251 (2.61)	121.684 (4.49)	-0.327 (-0.01)
Constant	-7014.100 (-1.78)	-2369.907 (-0.76)	-4908.529 (-2.07)	2983.036 (0.79)	-3990.947 (-3.80)	-5955.154 (-5.47)	858.257 (0.7)
Obs.	50	50	50	50	50	50	50
Adj. R sq.	0.994	0.986	0.994	0.978	0.991	0.987	0.967
DW-Stat	1.061	1.429	0.484	0.699	1.154	1.431	0.925

Notes: T-statistics are found in parentheses
For a sample of size 50 and 8 explanatory variables, the critical values for the Durbin-Watson Statistic are: dl=1.2 and du=1.93 at the 5% level (Savin and White 1977).
Source: see Appendix A.

In the OLS regression in Table 2 the Durbin-Watson statistic suggests autocorrelation of the residuals in many of the equations. The Cochrane-Orcutt method is used to correct for possible serial correlation, as shown in Table 3. For most cases, except for physical sciences, the Cochrane-Orcutt method shows considerable improvement in the Durbin-Watson statistic. For the total number of PhDs the only important change between the two methods is that in the Cochrane-Orcutt method the nonfarm productivity variable is no longer statistically significant, although it does retain approximately the same magnitude. The difference between ordinary least squares and the Cochrane-Orcutt Method for total female PhDs is that the Korean War variable is no longer positively statistically significant, but nonfarm productivity is now statistically significant[3]. In the humanities totals, the variables for the Vietnam War, Korean War, induction, and year squared went from being statistically significant to being insignificant. For the education PhDs induction, the male unemployment rate, and nonfarm productivity went from being statistically significant to being insignificant. For physical sciences the only change is that the male unemployment rate is now not statistically significant.

In separate regressions not shown in this paper, we also estimated OLS regressions using an ARIMA model with a six-period lag error structure. We obtained substantially the same results for all variables, indicating the robustness of our results to alternative estimation techniques.

[3] The serial correlation of the error terms is much higher in the female regressions than in the male regression. This suggests that there is a high level of persistence in female PhD production in response to changes in the explanatory variables, although we do not have a good economic reason for why this should be the case.

Table 3: Cochrane-Orcutt Method: Analysis of PhD Production by Gender and Discipline, United States, 1950-2006

	Dependent Variables						
		Gender		Field of Study			
Independent Variables	Total	Male	Female	Physical Science Total	Social Science Total	Education Total	Humanities Total
Research and Development (trillions $)	232 (8.00)	263.4 (13.79)	1.3 (.11)	113 (4.18)	18.6 (2.09)	13.8 (1.31)	30.7 (3.36)
Vietnam	1814.675 (3.29)	1666.346 (3.72)	246.623 (1.36)	140.940 (0.34)	471.282 (3.21)	661.397 (4.11)	235.202 (1.71)
Korea	-1334.864 (-1.26)	-2204.413 (-2.52)	-0.558 (-0.00)	149.958 (0.20)	37.646 (0.14)	53.920 (0.19)	-237.113 (-0.97)
Conscription (millions)	5850 (2.32)	5810 (2.71)	-1.01 (-0.00)	564 (0.33)	1180 (1.86)	911 (1.35)	832 (1.45)
Year	401.943 (2.02)	-91.808 (-.60)	568.582 (4.81)	-541.457 (-1.79)	278.0524 (4.39)	345.522 (2.86)	-94.549 (-0.75)
$Year^2$	-4.215 (-2.17)	-3.563 (-2.97)	-2.798 (-1.80)	9.623 (2.44)	-3.653 (-4.77)	-5.190 (-3.30)	1.442 (0.90)
Male Unemployment Rate	97.145 (.69)	133.555 (1.08)	-4.4019 (-.10)	113.701 (1.16)	26.00223 (0.73)	-45.084 (-1.19)	-19.377 (-0.60)
Non Farm Productivity Hours	201.347 (1.91)	175.882 (2.02)	68.182 (1.99)	70.0496 (0.90)	52.720 (1.90)	25.734 (0.85)	10.529 (0.40)
Constant	-5860.314 (-1.38)	-2120.428 (-.61)	-9725.22 (-4.30)	8996.791 (1.53)	-2918.688 (-2.35)	-1512.357 (-0.64)	3448.643 (1.34)
Obs.	49	49	49	49	49	49	49
Adj. R sq.	.965	.964	.932	.589	.858	.448	.310
DW-Stat	1.690	1.718	1.903	1.0490	1.965	1.765	1.658
Rho	.608	.333	.868	.882	.771	.885	.904

Notes: T-statistics are found in parentheses.
For a sample of size 50 and 8 explanatory variables, the critical values for the Durbin-Watson Statistic are: dl=1.2 and du=1.93 at the 5% level (Savin and White 1977).
Source: See Appendix A.

Next an analysis of the fields of study broken down by gender is conducted. Due to data availability, Tables 4 and 5, for males and females respectively, only show the number of PhDs in each field of study from 1964-2006 (41 observations). Research and development expenditures in the analysis for males is positive and statistically significant for all of the fields of study, while for women research and development expenditure are positive and significant for physical sciences and negatively statistically significant for education. A one standard deviation increase in the level of research and development expenditures results in a 4,348 increase in physical science PhDs for males and a 659 decrease in PhDs for females, while the same increase in research and development expenditures would result in a 399 increase in social science PhDs for males, a 292 increase in education PhDs for males and a 311 decrease for females, and a 652 increase in humanities PhDs for males. Again the coefficient on research and development expenditures is consistent with the hypothesis that following Sputnik a larger proportion of the Federal research and development expenditure funding went for the physical sciences and increased PhD production in this area. The negative effect for females may be due to their being crowded out by males entering the sciences.

During this time period, the military variables are a dichotomous variable for the Vietnam War and the level of military conscription. For men, the military variables are positive and statistically significant for all non-physical sciences fields, and are not statistically significant for the physical sciences. For women, the wartime variables are only positive and significant for the Vietnam War for both education and humanities PhDs. The Vietnam War effect resulted in a per year increase in social sciences PhDs for males by 679, an increase in education PhDs by 884 for males and 176 for females, and an increase in humanities PhDs for males by 458 and 273 for females. A one standard deviation increase in the conscription levels six years previously results

in an increase in social science PhDs for males by 674, an increase in education PhDs for males by 798, and an increase in humanities PhDs for males by 582. Overall, we still see that the wartime variables have a larger effect for males.

The adult male unemployment rate is only statistically significant, and positive, for males in physical sciences, where a one standard deviation increase in the male unemployment rate results in a 393 increase in PhDs. During a recession the decrease in the opportunity cost of time apparently dominates the wealth effect for males in the physical sciences. For social sciences, education, and humanities the non-significant coefficient implies that there is no cyclical effect on the number of people getting these PhDs. This is consistent with the hypothesis that a smaller proportion of students in these fields will receive financial support, increasing the importance of negative income effect compared to the effect of the opportunity cost of time.

The nonfarm productivity variable is significantly positive in the social sciences and education for males and not statistically significant for females. A one standard deviation increase in the nonfarm productivity will increase social science PhDs for males by 1,476 and an increase in education PhDs for males by 1,960. These results suggest that for males an increase in productivity in the economy increases the value of getting a PhD in both social sciences and education, but not for males in the fields of physical sciences or humanities and not for females in any of the fields of study.

The time trends imply that other measured variables the same there is an increase in social science PhDs for men, but a decrease in the humanities. This may be the result of changing expectations of labor market outcomes in these fields. For both the physical sciences and education the time component is not significant suggesting that for these fields' changes in PhD production over time are fully explained by changes in the other explanatory variables.

Using the Cochrane-Orcutt method, for men there is no time trend for PhD production in the physical sciences and a decline for education.

For women in the humanities, the social sciences, and education the significant positive time trends suggest that the production of PhDs has been increasing over time for unmeasured reasons. This could be due to market factors encouraging women into what used to be male dominated occupations requiring a degree in the physical sciences. On the other had, in the physical sciences, the non-significant time coefficient suggests that other variables are explaining in full the changes over time in PhD production.

Table 4: Analysis of PhD Production for Males,
by Statistical Method, United States, 1966-2006

	OLS				Cochrane-Orcutt			
Independent Variables	Physical Science Total	Social Science Total	Education Total	Humanities Total	Physical Science Total	Social Science Total	Education Total	Humanities Total
Research and Development (trillions $)	187 (8.97)	17 (3.35)	13 (1.97)	28 (5.75)	98 (3.66)	13 (1.79)	15 (1.86)	20 (2.67)
Vietnam	-350.079 (-0.91)	679.347 (7.18)	884.365 (7.46)	457.700 (5.07)	145.519 (0.39)	257.623 (2.45)	377.178 (3.28)	141.831 (1.33)
Conscription (millions)	-80 (-0.04)	2560 (4.84)	3030 (4.56)	2210 (4.38)	1050 (0.62)	1050 (2.19)	790 (1.52)	680 (1.39)
Year	-178.198 (-1.35)	126.857 (3.91)	-6.202 (-0.15)	-66.368 (-2.14)	-520.533 (-1.09)	-193.563 (-1.88)	-464.364 (-3.68)	-215.092 (-2.90)
$Year^2$	1.859 (1.89)	-3.252 (-13.48)	-2.396 (-7.92)	0.847 (3.68)	7.248 (1.18)	1.596 (1.15)	4.703 (2.82)	2.848 (2.72)
Male Unemployment Rate	287.407 (2.36)	-26.943 (-0.90)	-53.767 (-1.43)	-0.004 (-0.00)	83.888 (0.87)	11.435 (0.42)	-25.616 (-0.87)	-9.158 (-0.33)
Non Farm Productivity Hours	19.179 (0.24)	66.572 (3.36)	88.384 (3.56)	2.923 (0.15)	22.275 (0.30)	6.966 (0.33)	-12.865 (-0.57)	-10.647 (-0.50)
Constant	1287.085 (0.36)	-2361.829 (-2.73)	-1784.864 (-1.64)	1660.359 (2.01)	12881.660 (1.09)	8108.776 (3.15)	14017.740 (4.48)	6154.433 (3.12)
Obs.	41	41	41	41	40	40	40	40
Adj. R sq.	.886	.941	.966	.905	.307	.572	.747	.457
DW-Stat	0.861	1.638	1.569	1.485	1.122	2.159	2.0689	1.979
Rho					.878	.849	.863	.795

Notes: T-statistics found in parentheses.
For a sample of size 40 and 8 explanatory variables, the critical values for the Durbin-Watson Statistic are: dl=1.064 and du=1.997at the 5% level (Savin and White 1977).
Source: See Appendix A.

Table 5: Analysis of PhD Production for Females,
by Statistical Method, United States, 1966-2006

	OLS				Cochrane-Orcutt			
Independent Variables	Physical Science Total	Social Science Total	Education Total	Humanities Total	Physical Science Total	Social Science Total	Education Total	Humanities Total
Research and Development (trillions $)	28 (3.97)	7 (1.69)	-13 (-3.31)	8 (1.68)	11 1.18	7 1.51	-12 -2.14	6 1.25
Vietnam	-150.124 (-1.14)	12.989 (0.17)	175.969 (2.35)	272.708 (3.27)	-21.754 (-0.16)	39.991 (0.56)	160.149 (1.98)	59.312 (0.88)
Conscription (millions)	-500 (-0.68)	-520 (-1.23)	-750 (-1.79)	450 (0.96)	-60 (-0.09)	-110 (-0.32)	-120 (-0.32)	160 (0.51)
Year	-68.376 (-1.51)	168.042 (6.49)	297.815 (11.61)	60.769 (2.12)	-73.019 (-0.82)	196.320 (7.07)	342.802 (9.03)	31.430 (0.36)
$Year^2$	2.826 (8.39)	-1.120 (-5.82)	-3.490 (-18.30)	0.107 (0.50)	2.948 (2.33)	-1.604 (-4.48)	-3.916 (-7.35)	0.094 (0.08)
Male Unemployment Rate	64.368 (1.54)	22.692 (0.95)	-43.688 (-1.85)	-31.809 (-1.21)	33.474 (0.95)	21.570 (1.07)	-26.602 (-1.22)	-22.824 (-1.32)
Non Farm Productivity Hours	29.345 (1.06)	11.419 (0.72)	22.251 (1.42)	-5.369 (-0.31)	45.022 (1.67)	18.656 (1.28)	12.439 (0.76)	6.162 (0.46)
Constant	-2097.786 (-1.74)	-2651.215 (-3.84)	-3144.230 (-4.60)	-274.263 (-0.36)	-2252.140 (-0.94)	-3670.312 (-4.23)	-3502.017 (-3.10)	-31.589 (-0.01)
Obs.	41	41	41	41	40	40	40	40
Adj. R sq.	0.990	0.992	0.988	0.960	0.914	0.973	0.891	0.362
DW-Stat	0.780	0.781	0.925	0.560	1.476	2.253	1.649	1.717
Rho					0.784	0.577	0.690	0.880

Notes: T-statistics found in parentheses.
For a sample of size 40 and 8 explanatory variables, the critical values for the Durbin-Watson Statistic are: dl=1.064 and du=1.997at the 5% level (Savin and White 1977).
Source: See Appendix A.

(B) Canada

Table 6 presents the ordinary least squares regressions for the production of PhDs in Canada. Due to data limitations there are only 37 observations for Canada from 1968 to 2005. The Canadian results are consistent with the patterns for the U.S.

Similar to the United States results, Canadian research and development expenditures is statistically significant and positive for the total, male, and female PhDs. This result is consistent with the hypothesis that increases in research and development expenditure will increase the available funding for people earning their PhDs. One difference between the US and Canada is that the coefficient for females is statistically significant in Canada.

US military related variables are entered into the Canadian equation. The Vietnam War variable is statistically significant and negative for the total PhDs, but not significant for either males or females separately. The United States military conscription variable is not significant for any of the Canadian results. This is consistent with the hypothesis that since there was no military conscription during this time in Canada, the US values should have no effect on Canadian PhD production. This supports the hypothesis that these variables for the US are measuring the military effect and are not proxies for unmeasured variables that might have similar effects in the US and Canada.

The Canadian male unemployment rate is statistically positive for both males and females. The positive coefficient suggests that a decrease in the opportunity cost of time has a larger impact than the negative income effect. This may arise from a muted income effect since most students receiving a Canadian PhD do not pay tuition or fees.

The Canadian productivity variable is statistically significant and negative for both the total and for females, while being statistically insignificant for males. This is different than the

positive results for the United States. For females in Canada the increase in productivity will lead to a decrease in PhD production. The result could suggest that for females when there is an increase in productivity, suggesting a growth in the economy, they will enter into occupations that do not need a PhD. This is not the case for males in Canada; the insignificance of the productivity variable suggests that changes in productivity will have no effect on PhD production for males.

For Canadian PhDs, the time variables show that, other variables being the same, total PhD production in Canada is increasing, but at a decreasing rate. Analyzing the genders separately shows that neither the time trend nor its square is statistically significant for males. This suggests that the changes in the number of males getting a PhD each year are due to the other explanatory variables. While for females the time trend is statistically significant and positive and the time trend square is not statistically different from zero. This implies that females PhD production, ceteris paribus, in this period was increasing at a constant rate of about 30 PhDs a year.

Table 6: Ordinary Least Squares:
Analysis of PhD Production, Canada, 1968-2005

Independent Variables	Dependent Variables: Total	Gender: Male	Gender: Female
Research and Development (trillions $)	278 (3.63)	324 (2.54)	46 (2.5)
Vietnam	-186.808 (-1.93)	-186.148 (-1.46)	1.464 (.06)
Induction (millions)	-130 (-.24)	-130 (1.26)	0 (.02)
Year	302.332 (5.92)	332.521 (.72)	30.555 (2.5)
$Year^2$	-3.903 (-5.26)	-3.704 (-1.08)	0.201 (1.14)
Male Unemployment Rate	13.283 (.68)	29.390 (2.04)	16.314 (3.50)
Non Farm Productivity Hours	-310.758 (-5.12)	-348.580 (-1.63)	-38.512 (-2.66)
Constant	1607.908 (2.83)	1585.824 -0.18	-16.467 (-.12)
Obs.	37	37	37
Adj. R sq.	0.885	0.972	0.996
DW-Stat	1.082	1.195	1.994

Notes: T-statistics found in parentheses.
For a sample of size 37 and 8 explanatory variables, the critical values for the Durbin-Watson Statistic are: dl=1.011 and du=2.029 the 5% level (Savin and White 1977).
Source: See Appendix A.

V. Summary and Conclusion

This paper has analyzed the determinants of the production of PhDs in the United States and Canada in the post-World War II period. The empirical analysis for the US (1950-2006) overall, by gender, and by major discipline, and for Canada (1968-2005) overall and by gender are generally consistent with the hypothesis derived from the model.

The production of male PhDs in the U.S. was substantially increased by U.S. military conscription with educational exemptions, and the Vietnam War. As expected, there was apparently no separate effect of the brief Korean War, on female PhD production, or on PhD output in Canada. In both the U.S. and Canada government expenditures on research and development increased overall and male PhD production (and in Canada female PhDs as well). The effect is strongest in the Physical Sciences and weakest in Education reflecting where the funds were spent. The rate of growth of non-farm productivity generally has had a positive effect encouraging PhD productivity overall and for males in the U.S., perhaps suggesting it raises the economic returns to receiving a PhD, but has no effect for females. In Canada, on the other hand, the growth rate of productivity has a negative effect on PhD output. The cyclical indicator, the adult male unemployment rate, has a weak positive effect for males in the U.S. and Canada, suggesting that the positive effect of the reduced opportunity cost of time outweighs the negative wealth or income effect of a recession. Among women, however, the unemployment rate has no effect in the U.S., but a strong positive effect in Canada.

There has been an increase over time in both countries in the female receipt of the PhD over and above the effect of the other variables in the analysis. There has been no such increase for males. As a result, there has been a narrowing in the PhD gender gap. This may reflect the effects of the increased female attachment to the labor market, increasing the attractiveness for

women of the large investment in the PhD, and perhaps decreased discrimination against women PhD candidates in higher education and PhD holders in the labor market and the marriage market.

The analysis has implications for increasing PhD production in the U.S. and Canada. Clearly one would not advocate war or the reinstatement of military conscription to accomplish this objective. Nor would one advocate a higher unemployment rate (a recession) to encourage PhD enrollment. Higher rates of productivity growth in the economy are desirable, but have a mixed picture in terms of PhD production. Higher rates of government expenditure on research and development have the effect of increasing PhD production in the U.S. and Canada. In the U.S. the effect has been greatest among men and in the physical sciences, but this may because the funds have been largely targeted to the physical sciences, which is the most male intensive of the four major disciplines in the data.

Finally, continued increases in female labor force participation through increased attachment among those participating in the labor force and continued reductions in discrimination in higher education, in the labor market and in the marriage market against women who obtain a PhD would increase their numbers and reduce the PhD gender gap.

"The Production of PhDs in the United States and Canada"
Statistical Appendix:

Appendix A:

This appendix contains data on the awarding of PhDs by Universities in the United States (1950-2006) and Canada (1968-2005). The data are from the NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/) and from U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970 House document-93rd Congress, 1st session; no 93-78. Bureau of the Census Series H 751-765 Institutions of Higher Education-Degrees Conferred, by Sex: 1870 to 1970 for the years 1950-1966.

The data are reported separately by the four major subject divisions (Physical Science, Social Science, Humanities, and Education) and in total. Within each of these subject divisions the data are further separated by gender, minority group status, and citizenship.

The four major subject divisions are:

Physical Science: Engineering, Physical Science, Geosciences, Math and Computer Science, Life Sciences, and Architecture and Environmental Design.

Humanities: Humanities, Religion and Theology, Arts and Music, Communication and Librarianship, and Law.

Social Science: Social Science, Business and Management, Social Service Professions, Psychology.

Education: Education, Vocational Studies and Home Economics.

Data on PhDs awarded by Canadian Universities are taken from Table W504-512 (Website address: http://www.statcan.gc.ca/pub/ 11-516-x/sectionw/4147445-eng. htm) for years

1955-1973, from table 477-0014 available through CANSIM (Website address: http://cansim2.statcan.gc.ca/ cgi-win/CNSMCGI.EXE?LANG=Eng& Dir-Rep=CII/&CNSM-Fi=CII/CII_ 1-eng.htm) for years 1970-1997, and from CANSIM (Website address: http://library.queensu.ca/webdoc/ssdc/xcleduc99.htm#top) for years 1992-2005. Canadian PhDs are reported by gender and total.

Appendix Table A contains the definition of the variables, data sources, and the descriptive statistics of variables. Appendix B contains the number of PhDs awarded by year for the U.S. overall, by gender, and by major discipline and for Canada overall and by gender. Appendix B is available upon request.

Table A:

Definition of Variables, Data Sources,

and Descriptive Statistics of Variables

Dependent Variables:

1. Total number of Ph.D.s awarded in the U.S (by gender, by discipline, by minority status and in total)

    - U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970 House document-93rd Congress, 1st session; no 93-78. Bureau of the Census Series H 751-765 Institutions of Higher Education-Degrees Conferred, by Sex: 1870 to 1970 for the years 1950-1966.

    - NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/).

2. Total number of Ph.D.s awarded in Canada (by gender and in total)

    a. Table W504-512 (Website address: http://www.statcan.gc.ca/pub/ 11-516-x/sectionw/4147445-eng. htm) for years 1955-1973.

    b. Table 477-0014 available through CANSIM (Website address: http://cansim2. statcan.gc.ca/ cgi-win/CNSMCGI.EXE?LANG=Eng& Dir-Rep=CII/&CNSM-Fi=CII/CII_ 1-eng.htm) for years 1970-1997.

    c. CANSIM (Website address: http://library.queensu.ca/webdoc/ssdc/ xcleduc99.htm#top) for years 1992-2005.

Explanatory Variables:

United States:

1. Time trend (1954-2006, 1-53) and square of time trend

2. Unemployment rate (UR_{t-6})
    - Adult (over 25) male annual unemployment rate.
    - Statistics are from the Bureau of Labor Statistics (Website address: http://data.bls.gov).

3. Total Federal Government R&D spending (RnD_{t-6})

- NSF Survey of Federal Funds for Research and Development 1951-2006.

4. Indicator of Korea War and Vietnam War
    - Korean War = 1 from 1950-1953; 0 otherwise.
    - Vietnam War = 1 from 1964-1975; 0 otherwise.
    - Statistics are from Selective Services System (Website address: http://www.sss.gov/induct.htm).

5. Number of military induction
    - Number of men conscripted annually.
    - Statistics are from Selective Services System (Website address: http://www.sss.gov/induct.htm).

6. Productivity and productivity growth
    - Productivity measured as output/worker.
    - Productivity growth is percent change in productivity.
    - Statistics are from the Bureau of Labor Statistics (Website address: http://data.bls.gov).

Canada:

1. Time trend (1969-2006, 1-37) and square of time trend

2. Unemployment rate (UR_{t-6})
    - Adult (over 25) male annual unemployment rate.
    - Statistics are from StatCan: Table 282-0002 (Website address: *www.statcan.gc.ca*).

3. Total Federal Government R&D spending (RnD_{t-6})
    - Gross domestic expenditures, research/development all sectors 1997 dollars.
    - Statistics are from StatCan: Table 358-0001 (Website address: *www.statcan.gc.ca*).

4. Indicator of Vietnam War
    - Vietnam War = 1 from 1964-1975; 0 otherwise.
    - Statistics are from Selective Services System (Website address: http://www.sss.gov/induct.htm).

5. Number of military induction for US.
    - Number of men conscripted annually.

- Statistics are from Selective Services System (Website address: http://www.sss.gov/induct.htm).

6. Productivity and productivity growth
    a. Productivity measured as output/worker.
    b. Statistics are from the StatCan: Table 383-0003 (Website address: *www.statcan.gc.ca*).

Table A-1:
Summary Statistics of Dependent and Explanatory Variables, United States & Canada

Dependent Variable	Obs	Mean	Std. Dev.	Min	Max
U.S.					
Total	57	27802.86	12546.5	6633	45596
Gender					
Male	57	19128.19	6860.608	5990	27754
Female	57	8635.281	6640.122	643	20539
Field					
Physical Science	57	12726.3	6137.691	3122	24314
Social Science	57	6014.93	2858.339	1250	9160
Humanities	57	3747.263	1692.341	879	5859
Education	57	5159.702	2407.358	834	7793
Field and Gender					
Physical Science					
Male	41	12285.32	1931.995	8488	15763
Female	41	3537.415	2284.184	531	8508
Social Science					
Male	41	4619.854	661.2412	2708	5785
Female	41	2965.073	1429.902	452	5016
Humanities					
Male	41	2797.146	495.5761	2150	4080
Female	41	1875.439	703.6389	483	2946
Education					
Male	41	3338.293	1082.995	2075	5461
Female	41	3199.268	1168.084	620	4407
Canada					
Total	48	1552.292	699.5792	254	2595
Male	48	2210.208	1237.401	281	4200
Female	48	657.9167	580.1963	22	1848
Explanatory Variable Lagged Six Years					
U.S.					
Research and Development	57	5.94E+07	2.32E+07	8835813	9.88E+07
Vietnam War	57	0.210526	0.411306	0	1
Korean War	60	499.65	303.7646	0	1
Conscription	57	133354.1	263386.2	0	1591942
Year	53	27	15.44345	1	53
Year Squared	53	963	860.2706	1	2809
Male Unemployment Rate	53	4.016509	1.367848	1.675	7.725
Non-Farm Productivity Hours	53	2.196226	1.56069	-1.5	6.7
Canada					
Research and Development	44	9801.841	5916.655	2636	21661
Male Unemployment Rate	46	6.223913	1.958478	2.9	10.4
Non-Farm Productivity Hours	37	1.686887	1.749221	-1.53846	5.780347

Appendix B:

Number of PhDs Awarded by Year

Table B-1:

PhDs Awarded by U.S. Universities in Total and by Gender, Discipline, and Year, 1950 to 2006

Year	Total	Male	Female	Physical Science	Social Science	Humanities	Education
1950	6633	5990	643	3358	1250	879	1032
1951	7337	6663	674	3678	1536	1004	1113
1952	7683	6969	714	3862	1564	976	1314
1953	8307	7515	792	3185	1752	1114	1425
1954	8996	8181	815	4165	1865	1167	1509
1955	8840	8014	826	4242	1938	1152	1572
1956	8903	8018	885	3946	1765	1153	1636
1957	8756	7817	939	3122	1299	929	834
1958	8942	7978	964	4141	1885	1255	1491
1959	9360	8371	989	4370	1974	1314	1553
1960	9829	8801	1028	4673	2032	1472	1549
1961	10575	9463	1112	5048	2153	1528	1679
1962	11622	10377	1245	5676	2256	1668	1899
1963	12822	11448	1374	6349	2417	1814	2132
1964	14490	12955	1535	7141	2786	2027	2351
1965	16467	14692	1775	8377	2934	2357	2736
1966	17949	15863	2086	9019	3160	2665	3082
1967	20403	17961	2442	10084	3698	3075	3521
1968	22937	20005	2932	11219	4138	3459	4082
1969	25743	22355	3388	12382	4805	3743	4708
1970	29498	25527	3971	13641	5498	4249	5907
1971	31867	27271	4596	14335	6382	4537	6479
1972	33041	27754	5287	13962	6725	5113	7118
1973	33755	27670	6085	13664	7094	5622	7287
1974	33047	26594	6453	12903	7196	5517	7284
1975	32952	25751	7201	12723	7459	5260	7402
1976	32946	25262	7684	12207	7663	5148	7793

1977	31716	23858	7858	11799	7558	4784	7531
1978	30875	22553	8322	11497	7554	4515	7275
1979	31238	22301	8937	11858	7451	4406	7472
1980	31019	21612	9407	11891	7289	4113	7676
1981	31355	21463	9892	12140	7611	3965	7582
1982	31108	21015	10093	12467	7395	3839	7349
1983	31280	20748	10532	12635	7612	3741	7253
1984	31334	20636	10698	12988	7604	3804	6915
1985	31295	20552	10743	13365	7343	3721	6823
1986	31897	20592	11305	13781	7586	3737	6737
1987	32365	20934	11431	14389	7531	3808	6520
1988	33497	21677	11819	15533	7584	3862	6419
1989	34325	21812	12513	16217	7806	3866	6335
1990	36065	22960	13104	17252	7896	4205	6584
1991	37530	23521	13873	18322	8209	4400	6484
1992	38886	24232	14435	18973	8368	4727	6735
1993	39800	24384	15121	19505	8708	4754	6749
1994	41033	25057	15822	20285	8836	5080	6743
1995	41747	25160	16416	20612	8943	5430	6681
1996	42437	25285	16955	21128	9034	5386	6814
1997	42539	24939	17243	21049	9160	5613	6621
1998	42637	24628	17848	21096	9140	5713	6588
1999	41097	23436	17484	19672	9066	5652	6575
2000	41365	23163	18129	19847	9098	5859	6461
2001	40737	22775	17885	19654	8807	5816	6371
2002	40025	21805	18135	19108	8573	5703	6527
2003	40757	22257	18500	19568	8725	5703	6664
2004	42123	22963	19158	20596	9023	5692	6679
2005	43385	23738	19579	22386	8959	5655	6277
2006	45596	24986	20539	24314	9158	5848	6175

Sources:

(a) NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/)

(b) U.S. Department of Commerce, Historical Statistics of the United States, Colonial Times to 1970 House document-93rd Congress, 1st session; no 93-78. Bureau of the Census Series H 751-765 Institutions of Higher Education-Degrees Conferred, by Sex: 1870 to 1970 for the years 1950-1966

Table B-2:

PhDs Awarded by U.S. Universities by Discipline, Gender and Year, 1966 to 2006

	Physical Science		Social Science		Humanities		Education	
Year	Male	Female	Male	Female	Male	Female	Male	Female
1966	8488	531	2708	452	2182	483	2462	620
1967	9448	636	3185	513	2516	559	2793	728
1968	10464	755	3519	619	2750	709	3234	848
1969	11528	854	4063	742	2914	829	3755	953
1970	12697	944	4683	815	3284	965	4675	1232
1971	13216	1119	5347	1035	3496	1041	5094	1385
1972	12803	1159	5581	1144	3816	1297	5442	1676
1973	12320	1344	5734	1360	4080	1542	5461	1826
1974	11585	1318	5651	1545	3926	1591	5309	1975
1975	11276	1447	5766	1693	3559	1701	5072	2330
1976	10724	1483	5785	1878	3461	1687	5193	2600
1977	10273	1526	5559	1999	3113	1671	4883	2648
1978	9851	1646	5413	2141	2918	1597	4348	2927
1979	10040	1818	5135	2316	2801	1605	4289	3183
1980	9897	1994	4896	2393	2564	1549	4216	3460
1981	10016	2124	5030	2581	2399	1566	3972	3610
1982	10151	2316	4803	2592	2291	1548	3726	3623
1983	10186	2449	4769	2843	2204	1537	3565	3688
1984	10413	2575	4659	2945	2194	1610	3358	3557
1985	10592	2773	4490	2853	2190	1531	3255	3568
1986	10847	2934	4510	3076	2150	1587	3051	3686
1987	11305	3084	4474	3057	2187	1621	2903	3617
1988	12122	3411	4387	3196	2255	1607	2856	3563
1989	12402	3815	4462	3344	2209	1657	2677	3658
1990	13300	3952	4449	3447	2377	1828	2770	3813
1991	13920	4310	4414	3770	2433	1959	2698	3775
1992	14242	4584	4641	3684	2609	2102	2697	4025
1993	14379	4932	4634	4022	2563	2165	2755	3971
1994	14949	5237	4703	4100	2739	2329	2614	4119
1995	14998	5501	4676	4231	2892	2528	2550	4119

1996	15269	5733	4650	4352	2741	2626	2581	4213
1997	14952	5936	4578	4494	2952	2621	2399	4154
1998	14771	6232	4424	4676	2948	2755	2426	4144
1999	13719	5856	4377	4654	2931	2693	2343	4215
2000	13511	6288	4364	4718	2969	2886	2256	4200
2001	13316	6294	4226	4566	2940	2866	2249	4114
2002	12673	6400	4041	4509	2835	2854	2198	4316
2003	13010	6558	4098	4627	2843	2860	2257	4407
2004	13603	6992	4274	4749	2746	2946	2272	4406
2005	14679	7666	4129	4821	2801	2847	2075	4192
2006	15763	8508	4127	5016	2905	2938	2141	4026

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Sources:

NSF Survey of Earned Doctorates/Doctorate Records File for years 1966-2006 (Web address: http://webcaspar.nsf.gov/)

Table B-3:

PhDs Awarded by Canadian Universities in
Total, by Gender and Year, 1958 to 2005

	Canada		
Year	Total	Male	Female
1958	254	284	30
1959	259	281	22
1960	279	306	27
1961	295	321	26
1962	387	421	34
1963	443	481	38
1964	512	566	54
1965	619	696	77
1966	716	779	63
1967	908	1006	98
1968	1021	1108	87
1969	1247	1375	128
1970	1474	1625	151
1971	1564	1724	160
1972	1712	1929	217
1973	1662	1896	234
1974	1544	1840	296
1975	1375	1693	318
1976	1396	1702	306
1977	1488	1819	331
1978	1434	1803	369
1979	1339	1738	399
1980	1377	1816	439
1981	1290	1715	425
1982	1370	1821	451
1983	1368	1878	510
1984	1476	2004	528
1985	1612	2220	608
1986	1698	2375	677
1987	1680	2418	738

1988	1791	2573	782
1989	1815	2673	858
1990	2017	2947	930
1991	2136	3136	1000
1992	2136	3135	999
1993	2265	3357	1089
1994	2454	3552	1098
1995	2550	3717	1164
1996	2595	3927	1335
1997	2544	3966	1425
1998	2541	3978	1437
1999	2409	3966	1557
2000	2277	3861	1584
2001	2124	3708	1584
2002	2127	3729	1605
2003	2244	3861	1617
2004	2334	4164	1827
2005	2352	4200	1848

Sources:

(a) Table W504-512 (Website address: http://www.statcan.gc.ca/pub/ 11-516-x/sectionw/4147445-eng. htm) for years 1955-1973.
(b) Table 477-0014 available through CANSIM (Website address: http://cansim2.statcan.gc.ca/ cgi-win/CNSMCGI.EXE?LANG=Eng& Dir-Rep=CII/&CNSM-Fi=CII/CII_ 1-eng.htm) for years 1970-1997.
(c) CANSIM (Website address: http://library.queensu.ca/webdoc/ssdc/ xcleduc99.htm#top) for years 1992-2005.

Table B-4:

Explanatory Variables Lagged 6 Years in Used in the Regressions, United States

Year	Conscription	Vietnam War Dummy	Korean War Dummy	Research and Development	Unemployment Rate	Productivity	Productivity Growth
1944	1591942	0	0				
1945	945862	0	0				
1946	183383	0	0				
1947	0	0	0			42.565	
1948	20348	0	0		2.75	43.505	2.2
1949	9781	0	0		4.925	44.494	2.3
1950	219771	0	1		4.1	47.817	7.5
1951	551806	0	1	8835813	2.35	49.203	2.9
1952	438479	0	1	10662563	2.25	50.014	1.6
1953	471806	0	1	10523810	2.275	50.923	1.8
1954	253230	0	0	9549268	4.475	51.505	1.1
1955	152777	0	0	10986529	3.375	54.168	5.2
1956	137940	0	0	15645042	3.05	53.549	-1.1
1957	138504	0	0	19838552	3.25	54.298	1.4
1958	142246	0	0	22378658	5.675	55.096	1.5
1959	96153	0	0	32273433	4.25	57.74	4.8
1960	86602	0	0	35977828	4.3	58.129	0.7
1961	118586	0	0	42548722	5.2	59.743	2.8
1962	82060	0	0	47793530	4.125	62.652	4.9
1963	119265	0	0	57314729	3.925	64.846	3.5
1964	112386	1	0	64484832	3.325	67.566	4.2
1965	230991	1	0	65125887	2.8	69.884	3.4
1966	382010	1	0	66842644	2.25	72.044	3.1
1967	228263	1	0	69860943	2.025	72.072	0
1968	296406	1	0	64984522	1.8	74.104	2.8
1969	283586	1	0	61049524	1.675	73.696	-0.6
1970	162746	1	0	56768827	2.85	73.565	-0.2
1971	94092	1	0	54785026	3.475	76.131	3.5
1972	49514	1	0	55523039	3.1	78.817	3.5
1973	646	1	0	54159101	2.575	80.983	2.7
1974	0	1	0	52345544	3.05	78.6	-2.9

1975	0	1	0	51848633	5.475	79.599	1.3
1976	0	0	0	52780437	4.825	82.314	3.4
1977	0	0	0	55412044	4.225	83.144	1
1978	0	0	0	57217483	3.375	83.945	1
1979	0	0	0	57674471	3.325	83.104	-1
1980	0	0	0	56199005	4.8	82.009	-1.3
1981	0	0	0	56801517	5.1	82.817	1
1982	0	0	0	58507450	7.5	81.455	-1.6
1983	0	0	0	59537891	7.725	85.903	5.5
1984	0	0	0	62629583	5.675	88.195	2.7
1985	0	0	0	69472152	5.35	89.367	1.3
1986	0	0	0	72177964	5.375	91.225	2.1
1987	0	0	0	75596789	4.75	91.9	0.7
1988	0	0	0	75301001	4.2	93.133	1.3
1989	0	0	0	78414614	3.925	94.274	1.2
1990	0	0	0	78255936	4.45	94.953	0.7
1991	0	0	0	72736623	5.7	95.758	0.8
1992	0	0	0	75926137	6.45	100	4.4
1993	0	0	0	76216061	5.8	100.972	1
1994	0	0	0	74515560	4.775	102.459	1.5
1995	0	0	0	73979384	4.275	102.849	0.4
1996	0	0	0	72055647	4.025	104.974	2.1
1997	0	0	0	73086434	3.625	107.416	2.3
1998	0	0	0	74530416	3.175	110.278	2.7
1999	0	0	0	76870342	2.95	113.899	3.3
2000	0	0	0	72863318	2.825	116.221	2

Sources:

(a) Induction statistics are from the selective services (Website address: http://www.sss.gov/induct.htm).

(b) Research and Development statistics are from NSF Survey of Federal Funds for Research and Development 1951-2006 and adjusted to 2000 dollars and in thousands.

(c) Unemployment rate is annual rate for males over the age of 25 and the statistics are from the Bureau of Labor Statistics (Website address: http://data.bls.gov).

(d) Productivity is measured as output per worker (base year 1992). Productivity growth is the annual percentage change in productivity. The statistics are from the Bureau of Labor Statistics (Website address: http://data.bls.gov).

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