CPB Netherlands Bureau for Economic Policy Analysis

CPB Discussion Paper | 276

Individual Returns to a PhD Education in the Netherlands

Income Differences between Masters and PhDs

Marc van der Steeg
Karen van der Wiel
Bram Wouterse

Individual Returns to a PhD Education in the Netherlands: Income Differences between Masters and PhDs.[1]

Marc van der Steeg[1] **Karen van der Wiel**[2] **Bram Wouterse**[3]

May 2014

Abstract

In this paper we investigate the individual returns to a doctorate education in the Netherlands over the first twenty years of a career. We compare monthly incomes of PhDs to that of Master graduates with the same years of experience, gender and field of study and who took the same time to obtain a Master degree. The latter covariate can be seen as a measure of ability.

It turns out that over the first twenty years of experience, the average annual return (AAR) to a PhD education is not significantly different from zero. During the PhD track and the first years after PhD graduation PhDs earn less than Masters, but this initial investment is compensated by higher earnings in later years. Extrapolation of the return suggests an average annual return to a PhD education over the entire career of six percent. Similarly, the internal rate of return (IRR) – an alternative measure that takes both the timing and level of income differences into account - would equal nine percent over the entire career.

Returns to a PhD education differ strongly by sex. Female PhDs experience a positive annual return of ten percent over the first twenty years after graduation, whereas male PhDs experience a negative return of seven percent. Positive returns for women are largely driven by the fact that they tend to work more hours than female Master graduates.

[1] Part of this research is funded by the Dutch Ministry of Education, Culture and Science. We would like to acknowledge Statistics Netherlands for use of the PhD survey data 'Careers of Doctorate Holders'. We would furthermore like to thank Jos de Jonge, Roel van Elk, Bas ter Weel, Daniel van Vuuren and Dinand Webbink for comments on an earlier draft of this paper. The data that the authors use for the analysis in this paper is highly confidential but available under certain conditions from Statistics Netherlands, 'Centrum voor Beleidsstatistiek'. The programs that the authors use are available upon request at B.Wouterse@cpb.nl.

[1] CPB Netherlands Bureau for Economic Policy Analysis and Erasmus University Rotterdam. Contact: M.W.van.der.Steeg@cpb.nl.

[2] CPB Netherlands Bureau for Economic Policy Analysis and IZA. Contact: K.M.van.der.Wiel@cpb.nl.

[3] CPB Netherlands Bureau for Economic Policy Analysis. Corresponding author. Contact: B.Wouterse@cpb.nl.

1. Introduction

The number of PhD defenses in the Netherlands has risen sharply over the last decades - by more than seventy percent since 2000. This development is similar to that in many other countries (Nature, 2011). It is also common ground that a large share of doctorate holders leaves academia to work in the public and private sector (OECD, 2013). Both stylized facts trigger a debate about the value of obtaining a PhD to the individual. To defend a PhD thesis successfully is a great achievement. But to what extent will a doctor benefit later on in terms of income and employment possibilities? In this paper we contribute to this debate by estimating the individual returns to a PhD education in the Netherlands over the first twenty years of their career. We allow for dynamics in the returns to a PhD over experience, and investigate underlying mechanisms in employment, sector of work, and hours worked.

It is not clear a priori whether a higher income for PhDs compared to Masters can be expected. On the one hand, the attractiveness of highly educated individuals might increase by obtaining a PhD as this will improve their knowledge and skills. On the other hand, research is a particular trade. The highly specialized knowledge and skills obtained as a PhD student could be irrelevant to other employers.

Whether the returns to a PhD education are positive or negative is thus an empirical matter. Compared to the extensive research on the returns to other types of education, there are surprisingly few studies on the returns to a PhD. The studies that do exist yield mixed findings. Studies for the UK suggest a very small but positive return to a PhD education (e.g. Dolton and Makepeace, 1990 and O'Leary and Sloane, 2005). For Germany and Switzerland a considerable return is found (e.g. Engelage and Hadjar, 2008 and Mertens and Röbken, 2012). For the Netherlands no recent study into the returns to a PhD education exists. Although empirical studies differ substantially in terms of data sources and included covariates, they generally have two things in common. First, they assume constant annual returns to a PhD education. Second, they do not address self-selection issues. In this paper, we add to the empirical literature by addressing the first issue. We do so by estimating returns in two-year experience classes. We also address the second issue by controlling for a measure of ability. However, additional selection effects cannot be ruled out in our estimates.

First, we have used a unique dataset that follows the monthly income of a sample of PhD and Master graduates in the years 1999 to 2010. This group contains individuals that have obtained a Master degree after 1987, as we are able to identify all diplomas in higher education from this period onwards. The literature on PhD income typically follows the standard Mincer methodology (Mincer, 1974) and models the difference with Master graduates as a constant percentage of Master income. We argue that such an approach typically ignores the opportunity costs during the PhD track. Furthermore, after obtaining a PhD, the returns might increase or decrease over experience. Young PhDs straight from academia might need some time to adjust to the labor market, before they can reap the benefits of their additional skills. Our paper's contribution is to empirically investigate the career development of PhDs inside and outside of science.

We try to explain differences in income further by looking at employment, selection into different sectors of work, and differences in hours worked. Although a number of studies exists that investigate employment of PhDs, or the distribution of PhDs over sectors of work (for example Auriol et al., 2007, 2010), there are few studies that use a reference group. Studies that look at longitudinal dynamics in PhD careers are especially scarce. A first reason why career

dynamics are of importance is that it is likely that the distribution of PhDs over sectors differs from that of Master graduates. This can either be the case because of different preferences for different types of jobs, or because skills obtained as a PhD are more applicable, or profitable, in specific sectors. A second reason is that PhDs might have different career preferences. For women for instance, working a substantial number of hours seems more important for those who have obtained a PhD.

These points relate to the second issue that is generally not addressed in the literature: selection. People with certain, unobserved characteristics (e.g. independent minds, strong cognitive abilities) are more likely to pursue a PhD degree, and those characteristics might be related to wages and employment possibilities. This could lead to an under- or overestimation of the return to a PhD education. On the one hand, academically talented students are more likely to obtain a PhD degree. When such talent is also positively correlated with income, this leads to an overestimation of the return. On the other hand, students who have a preference for high wages over free research time are less likely to obtain a PhD diploma. Then, the return to a PhD education might partially reflect a preference for non-monetary compensation, and will be an underestimation. In this paper, we are able to partly correct for the selection issues introduced by unobserved heterogeneity in ability or talent. By controlling for the time students take to a Masters degree we correct for some of the talent differences between PhD and Master graduates.

The average annual return (AAR) is presented here as the main outcome variable, which is equivalent to the constant return to a PhD education generally used in the literature. As an alternative measure we use the internal rate of return (IRR), which takes differences in the size of returns over experience into account. We find that over the first twenty years after their Master graduation, the AAR is not significantly different from zero. PhDs incomes tend to be lower than that of Masters during the first 12 years of experience and higher over the remainder of the first twenty years. Thus, the returns to a PhD are not constant over experience. The individual returns strongly differ by sex, field of study and type of PhD student. Female PhDs actually earn more than Master graduates in the first twenty years after graduation, on average ten percent more, whereas male PhDs earn on average seven percent less than their counterparts. The positive returns to a PhD education for women are partly driven by the fact that female PhDs work more hours than Master graduates. An interesting result is that external PhD graduates - those who were employed elsewhere during their graduate years - continue to do much better in terms of income then regular PhD students. The IRR generally has the same sign as the AAR. Our main results therefore seem robust to the way in which the returns are measured. The IRR does tend to lead to stronger differences between Masters and PhD, both for negative and positive returns.

What seems important in explaining income differences is the degree to which Masters and PhDs are employed in different sectors. PhDs are much less likely to be employed in the better paying private sector. Within the private sector annual returns to a PhD education remain negative over a relatively long time after graduation. PhDs graduates work in other sectors more often: in science, the public sector or the subsidized sector. While wages are generally lower in these sectors, PhDs do on average have a higher income than their master counterparts employed in the same sector.

This paper proceeds as follows. Section 2 describes the institutional setting of PhD programs in the Netherlands and the relevant academic literature. Section 3 describes the data. In section 4 we present the empirical strategy. Section 5 provides the main estimation results and Section 6 presents a discussion of these results.

2 Institutional setting and literature

Before we present our analysis about the returns to a PhD education in the Netherlands, this section first deals with the specifics of the Dutch doctorate education system. It also discusses the international literature on income differences between Master graduates and PhDs and relates this to our analysis.

2.1 PhDs in the Dutch context

We first discuss the time trend in the number of PhD graduations in the Netherlands. Then we turn to the specifically Dutch treatment of PhD candidates, who are mostly university employees rather than students. Finally, we discuss earlier findings on the labor market position of Dutch PhDs.

First, the number of PhD graduations in the Netherlands has been increasing gradually over the years, and the percentage of women among the graduates has also risen. In 1990, about 1,900 new PhDs graduated, of which 18 % were women. In 2012, this was about 4,000, with 45 % women. Figure A.1 displays the increase in PhD graduations since 1991 compared to the increase in Master graduations. The latter equals the sum of those that obtained a *Doctoraal* degree and those that obtained a Master degree in the new, post Bologna, system. Both graduation rates seem to follow a similar, upward, trend.

At 1.8 percent PhD graduates in the relevant age category, the Dutch PhD graduation rate it is slightly above the OECD average (OECD, 2011). Many PhD graduates at Dutch universities are foreigners. The difference between the PhD graduation rate with or without foreigners is 0.6 percentage points which is twice the average difference in the OECD. The internationalization of graduate programs is a trend, unlikely to stop in the near future. In 2011, more than 40% of PhD students employed by universities were non-Dutch nationals. Although this phenomenon seems important, we lack sufficient data to investigate this group. It is important to stress that this paper focuses on *Dutch* PhDs and their income and careers in the *Dutch* labor market.

Second, a relevant characteristic of the Dutch system is that most PhD students are employees. In most countries, some PhD students are real students who pay tuition fees. Instead, Dutch "regular" PhD students are official university employees with the pertaining benefits such as wages and social security options. [2] The typical employment conditions for PhD students are bargained for through collective wage bargaining between the Association of Universities (VSNU) and the labor unions. Within Europe, only in Denmark and Bosnia-Herzegovina PhD students have a similar employee status (EUA, 2007). Although exact figures are unknown, in 2011 about fifty percent of PhD graduates was employed at a university (VSNU, 2008). Most other PhD graduates are in fact external candidates who are employed elsewhere (business, government, hospitals, research institutes, retirement). The fact that Dutch PhD students earn an income throughout their PhD track has consequences for our analysis. It is

[2] The Netherlands is now slowly moving in the direction of a more mixed system - mixed in terms of employees and students. In 2008 half a percent of PhD students were no longer employees but students with a scholarship (VSNU, 2008). Since then regulations have changed so that it is now easier to recruit this type of PhD students.

important to include this income in the estimation of income differences between PhDs and Masters. In our analysis we also highlight differences between regular PhDs and external candidates, since they may have very different career perspectives.

Third, earlier studies have also investigated the employment status of (recent) PhD graduates in the Netherlands. It seems that PhD graduates have good employment prospects (CBS, 2011): they are slightly more likely to be employed and they are more likely to work full-time. In terms of sectors of employment PhDs differ from Master graduates more substantially. Doctorate holders work more often in non-commercial services such as government, health care or higher education. Of recent PhD graduates one third stays in the higher education sector, one quarter moves to the private sector, one fifth goes to public research institutes and university medical centers and the remainder moves abroad (Van der Schoot et al, 2012; De Goede et al., 2013). On income or wage a lot less is known. We are not aware of recent studies that analyze differences in incomes or wages between PhDs and Masters in the Netherlands. To our knowledge, this study is the first on PhD incomes in the Netherlands within twenty years (Van der Neut and De Jonge, 1993). Moreover, we are not aware of studies that consider the dynamic aspect of income, i.e. that follow Dutch PhD recipients over their career.

2.2 International literature

Human capital theory sees the set of marketable skills of workers as a form of capital in which workers can invest, for instance through education. As higher human capital leads to a higher productivity, workers with more human capital can earn higher wages. Individuals thus have to determine the optimal mix between working and spending time on human capital investment. Economic theory generally suggests that the highest investment in human capital takes place at the beginning of life (first in fulltime schooling and later in on-the-job investment) (Ben-Porath, 1967). This would lead to an earnings profile that increases with experience.

The decision to obtain a PhD can be seen in this light using the literature on the returns to schooling initiated by Mincer (1974). Individuals are willing to follow an additional year of schooling when their opportunity costs, in terms of income they would have earned if they had started working right away, are compensated by higher earnings later in life. In most countries, the PhD track can be seen as additional schooling. In countries like the Netherlands, PhDs are employees, but a large amount of their time is spend "training on-the-job". Thus human capital theory would suggest that their earnings are lower than that of Masters who do not pursue a PhD education at the beginning of their career, but will be higher later on.

However, there are a number of reasons why PhD incomes might not only reflect the additional skills attained during PhD education. First, there might be compensating differentials: PhDs might receive part of their compensation through better working conditions instead of in terms of higher wages. For instance, there is some empirical evidence that researchers are willing to trade higher income for more freedom in how to spend their research time (Roach & Sauermann, 2010). Second, there can be unobserved heterogeneity in skills and preferences between workers. Individual characteristics can both be related to the choice of doing a PhD and to their general earnings capacity. As we have already mentioned, it is not clear a priori whether this selection leads to higher or lower incomes of PhDs. Third, labor market imperfections could result in wages that do not fully reflect worker's productivity.

Whether the returns to a PhD education are positive or negative is thus an empirical matter. Fortunately, there are some studies for other countries that deal with returns to a PhD education. However, the number of studies that use a control group and systematically correct for characteristics such as age, experience and field of study is rather limited. A general issue with most other studies is that they do not take income during the PhD track into account. This means that relevant opportunity costs, in terms of relatively low income during the PhD track, are neglected.

Institutional settings and macro-economic circumstances may influence the returns to a PhD education. One would expect differences between countries when for example the relative compensations in the academic, public and private sector differ or when government subsidies induce different amounts of PhD graduates. Also, the demand for research skills will probably be higher in countries with a relatively large R&D sector, which may have an impact on the returns to a PhD as well. It is however not necessarily the case that the return is higher in such a country. This is because higher demand can bring about a higher supply of PhDs. Therefore, it is not surprising that a very mixed picture emerges from this literature - from non-existing wage returns in the UK to considerable returns in Germany and Switzerland.

For the U.S., we have only seen studies (e.g. Siegfried and Stock, 1999; Nature, 2011) that do not identify a relevant control group or focus on one field of study instead of on the entire population of PhD's (Siegfried and Stock, 1999). For the UK, Germany and Switzerland econometrically solid comparisons between Master graduate and PhD graduate wages are available. For the UK O'Leary and Sloane (2005) use cross-section data from the Labor Force Survey to estimate educational premiums for different education levels. Relative to obtaining an academic Master, male PhDs earn a two percent higher hourly wage and female PhDs a three percent higher hourly wage. Casey (2009) does highlight that these findings differ substantially by field of study. The dynamic aspect of the return - does it go up or down over experience? - is not addressed. Dolton and Makepeace (1990) compare wages of Master graduates to those of PhD graduates in the UK six years after both received a Masters diploma. No wage differences could be identified within this short timespan.

The German experience for PhD graduates is very different. There seems to be a high return to PhD education in Germany (Mertens and Röbken, 2013). The authors study the German micro-census of 2006 and focus on full-time workers. After having controlled for a whole range of background characteristics (e.g. sex, age, marital status, field of study) and job characteristics (e.g. company size, working in leading position, federal area), they still find significant positive income differences in all fields of study. Particularly in the fields of economics and law the benefits are high for doctorate holders (29 percent higher income compared to Masters). In the field of education the return is lowest (11 percent). Expressed relative to the average number of years spent on a PhD education, the corresponding rates of return are 14 and 3 percent, respectively. Mertens and Röbken (2013) refrain from pinning down the returns over different age or experience classes.

For Switzerland, Engelage and Hadjar (2008) found positive returns across all fields of study two years after graduation. They use survey data of Master graduates and PhD graduates between 1983 and 2001. In their wage regressions, the authors control for period effects, sex, interaction terms between sex and PhD graduation, and age. This positive return ranges from 11 percent in the humanities and social sciences to 35 percent for engineering. The authors found that there was a particularly high wage return for men.

3. Data

We first discuss the construction of our dataset from several data sources. Then, we describe the characteristics of the sample, and compare these to the population of PhDs and Masters in the Netherlands. Finally, we show descriptive data on the outcome variables.

3.1 Data sources

The aim of the analysis is to compare income profiles between Master graduates who obtain a PhD to those who do not. We combine several datasets to obtain all the relevant information. These datasets can be merged on an individual level using the (recoded) personal identification key which is available in all micro datasets of Statistics Netherlands. The construction of the dataset is undertaken in three steps. First, we identify a group of PhDs and a group of Master graduates. To identify PhDs, we use a survey of Statistics Netherlands (CBS) among PhD graduates. The control group of Master graduates is obtained from the Dutch Labor Force Survey (LFS). Second, we link respondents from both surveys to the Dutch nationwide higher education register to obtain the exact date of Master graduation. Finally, income records from the Dutch tax services are used for those Masters and PhDs whose data of Master graduation was identified.

3.1.1 PhD Survey

To identify PhD graduates we use a survey among PhDs conducted by Statistics Netherlands in 2010 (CBS, Careers of Doctorate Holders (CDH) 2009, 2011). In the Netherlands, there is no national registration system of PhD diplomas. Instead, Statistics Netherlands manually collected information on PhD graduates between 1990 and 2008 from almost all Dutch universities. Only one university (Tilburg University) was unable to participate. Due to data matching problems respondents from the University of Amsterdam were also not included. In total, 49,689 names of PhD graduates were received from Dutch universities. For 21,315 of those names, a current address could be found and they were invited to take part in the survey. Of those invited, 10,326 individuals took part in the survey. This is about 20% of the total number of PhDs graduating between 1990 and 2008[3]. Survey questions include date of graduation, field of study, source of finance during PhD education, and a number of background characteristics.

3.1.2 Control group: Master graduates without a PhD

To obtain a control group of Master graduates without a PhD, we use the Labor Force Survey (LFS). The LFS is a labor market survey for the Dutch population. The survey collects data on some 120,000 respondents each year. We use the survey years 2008 to 2011. The survey contains self-reported information on highest obtained level of education (ISCED levels).We use this information to identify respondents with a Master or PhD. Identification of PhDs using self-reported information from the LFS is known to be imperfect, because it is not always clear to respondents how to report a PhD in the survey. Therefore, we apply a number of decision rules

[3] Data reported in this section on total number of PhD and Master graduates by sex and field of study are obtained through statline.cbs.nl. Although there is no national database of PhD diplomas, universities do report aggregated data each year to Statistics Netherlands.

used in an earlier study by Statistics Netherlands to identify Master graduates (CBS 2007; 2009). We also apply a number of additional rules[4]. The effect on contamination of the control group with PhDs is small[5]. We identify 21,000 respondents as having a Master diploma but not a PhD.

3.1.3 Obtaining date of Master graduation

We link both the PhD survey respondents and the Master graduates from the LFS to the higher education registry. This allows us to obtain administrative information on date of graduation and field of study. The higher education registry contains information on all diplomas obtained at Dutch institutes of higher education in the Netherlands between 1987 and 2007. We use the first obtained Master degree from a Dutch university as the reference point. This means that respondents who obtained their Master degree in another country, or before 1987, are excluded from the sample. Furthermore, we limit the sample to individuals aging 25 to 50. This leaves 5,835 PhDs and 6,636 Master graduates.

3.1.4 Income data

Income data is obtained from the Dutch tax services. The reason to use income instead of hourly wages is that we can also include individuals with others sources of income, such as the self-employed. Also, the available administrative data on hourly wages proved to be too unreliable for the purpose of this research. Monthly data on source and amount of the main source of income for the years 1999 to 2010 are available. To clear the sample from seasonal variation in income (for instance due to end of year bonuses), only monthly income in January of each year is used. There are four sources of income: self-employed, employed, social benefits, and other. Monthly income from the main source of income is our main outcome variable. Incomes for each year have been adjusted to 2010 prices by using consumer price index data.

Depending on the year of Master graduation, income profiles are observed over a 12 year period during the first 23 years after Master graduation. For example, for someone who obtains his Master degree in 1987, the income profile between 12 and 23 years of experience is available. For someone who obtained his degree in 1998, the first 12 years of experience are

[4] There are a number of reasons why PhDs do not always report having done a PhD in the LFS. For some studies, such as computer science, the questionnaire does not provide PhD as a standard answer category. Also, for some PhDs, especially in medical sciences, the Master and PhD track are perceived as being part of one integral education track. Furthermore, some respondents seem to be confused between the Dutch word for a Master degree "doctoraal" and the word for a PhD "doctoraat". The decision rules to correct for not reporting a PhD are: exclusion of individuals who report having done the same Master track twice in two consecutive periods, who report an education longer than four years after their Master graduation, or who report having done a post doctoral education or "unknown" form of education after their Master. We also exclude engineers (who have a different title from Masters, namely Ir.) who report having done a Master after their graduation. Note that these rules are likely to exclude a relatively large number of non-PhDs from the control sample. However, given the relatively large amount of available Master graduates this is not a problem. There seems to be little reason to think that the exclusion rules lead to bias in our results.

[5] Using the overlap between the PhD survey and the LFS, we are able to test the identification of PhDs in the LFS. There are about 300 PhDs in our sample who participated in the PhD survey as well as in the LFS. Of those 300, 25% are not identified as PhD based on the LFS survey. Given that around 6% of the Master graduates has a PhD (according to figures of Statistics Netherlands), and that the PhD survey contains 20% of all PhD graduates between 1990 and 2008, this means that our control group contains approximately 1 percent (=0.25*0.06*0.8) of not-identified PhDs.

observed. For individuals graduated after 1998 fewer number of years are available. Due to small sample sizes at the higher experience years, only observations pertaining to the first twenty years of experience are used.

The data contains the main source of income, allowing for additional analysis on the employment status of PhDs. For the employed, the data also contains additional information on sector of work. Thus differences in sector of work between PhDs and Master graduates can be compared. We differentiate between the private sector, subsidized sector, public sector (except science), and science. Science if defined as universities plus research institutes, such as academic hospitals. The subsidized sector consists of private institutions or companies that are not part of the government but are funded by the government by law. This includes most parts of the health care sector.

3.2 Sample characteristics

Tables 1, 2, and 3 describe the sample characteristics. We first discuss the differences in our sample between PhDs and the control group of Master graduates. Moreover, we report whether these differences correspond to differences between the populations. Then, we describe how representative our sample of PhDs is in terms of distribution of type of PhDs and share of foreigners.

3.2.1 Differences between Masters and PhDs

Table 1 presents the main descriptive statistics for the estimation sample. Table 2 provides some insight in possible period and cohort effects, by dividing the sample into individuals who obtained their Master degree between 1987 and 1995, and individuals who graduated after 1995. Three main differences between Masters and PhD graduates can be observed. First, the share of women is 15 percentage points lower for PhDs than for Masters, for which men and women are equally distributed. The under representation of women is in accordance with the share of female PhD graduates from Dutch universities between 1990 and 2008, which is 31 %. Women are catching up however, which can also be seen by comparing the first cohort to the second in Table 2.

A second difference is that Masters on average spend a year longer studying for their Master degree than PhD graduates. This corresponds with the lower age at Master graduation forPhDs. If a shorter duration of Master education is as an indication of (academic) ability, the shorter time to Master degree by PhDs suggests a selection issue: the more able individuals are (self)-selected into a PhD track.

The third noticeable difference is a different distribution by field of Master study. Compared to Masters, PhDs are overrepresented in the fields of Agriculture, Nature, Physics, and Health, while they are underrepresented in the fields of Economics, Law, Behavior & Society, and Language & Culture. The distribution of Master graduates over fields is largely in line with that of the total number of Master graduates between 1990 and 2008. Comparison to national data shows that Agriculture, Nature, and Physics are indeed the fields with a relatively large number of PhDs (compared to Master graduates)[6].

In all three cases, the sample differences seem to correspond to differences between the actual populations of PhDs and Master graduates in the Netherlands. The three aspects are

[6] National data for Masters and PhDs can be found on statline.cbs.nl. See footnote [1].

likely to be related to differences in income. Therefore, to make a fair comparison between PhDs and Master, we include sex, duration of Master education, and field of study as controls in our main analysis. We also perform separate analyses by sex and field of study.

Table 1 Descriptive statistics of estimation sample, total sample and by sex

	Total sample		Males		Females	
	Master	PhD	Master	PhD	Master	PhD
Share of females	49%	34%	-	-	-	-
Share born in the Netherlands	93%	95%	93%	96%	93%	94%
Age at Master graduation	25.2	23.9	25.5	24.0	24.8	23.7
Time to Master degree (years)	5.9	4.9	6.1	4.9	5.7	4.7
Field of study of Master (shares)						
- Agriculture	3%	9%	4%	9%	3%	10%
- Nature	7%	27%	10%	29%	5%	22%
- Physics	15%	21%	25%	28%	5%	22%
- Health	9%	20%	6%	15%	12%	30%
- Economics	16%	4%	6%	15%	12%	1%
- Law	12%	2%	10%	2%	15%	3%
- Behavior & Society	23%	11%	15%	7%	32%	19%
- Language & Culture	13%	6%	8%	5%	18%	7%
Number of (unique) observations	6,636	5,853	3,395	3,836	3,241	2,017

Table 2 Descriptive statistics by period of Master graduation

	Total sample		Master graduation between 1983-1995		Master graduation between 1996-2007	
	Master	PhD	Master	PhD	Master	PhD
Share of females	49%	34%	44%	25%	52%	42%
Share born in the Netherlands	93%	95%	95%	96%	93%	95%
Age at Master graduation	25.2	23.9	25.0	24.0	25.1	23.7
Time to Master degree (years)	5.9	4.9	5.5	4.8	6.1	4.9
Field of study of Master (shares)						
- Agriculture	3%	9%	4%	10%	3%	8%
- Nature	7%	27%	8%	27%	7%	26%
- Physics	15%	21%	16%	21%	15%	21%
- Health	9%	20%	6%	19%	10%	21%
- Economics	16%	4%	15%	4%	17%	4%
- Law	12%	2%	14%	2%	12%	2%
- Behavior and society	23%	11%	21%	9%	25%	13%
- Language and culture	13%	6%	16%	8%	12%	5%
Number of (unique) observations	6,636	5,853	2,267	2,529	4,369	3,324

3.2.2 Characteristics of PhD respondents

We first discuss the share of foreign PhDs in our sample, and then turn to the different types of PhDs. Table 1 shows that almost all the PhDs in our sample are Dutch natives. This percentage of graduates born in the Netherlands does not correspond to the percentage within the current population of PhD graduates. There has been a sharp increase in the number of foreign PhD students in the Netherlands (Nuffic, 2012; De Goede et al., 2013). The share of foreign PhD students employed by universities has risen from 36 to 43 percent between 2003 and 2011, and

their numbers have increased by 65 percent.[7] The under representation of foreign PhDs in the sample is due to the sample design: we select PhDs who obtained a Master degree in the Netherlands and who were living in the Netherlands during the period in which the PhD survey was conducted. Thus, an important limitation of the study is that it considers careers of *Dutch* PhDs in the *Dutch* labor market. In our opinion, this selective group does remain a relevant group to investigate.

As discussed in Section 2, Dutch PhDs are mostly employees. They can be divided into regular PhDs, who are employed by universities, and non-regular PhDs. The PhD survey divides the second group into two categories. The first group consists of the external PhDs or *buitenpromovendi* as they are called in Dutch. They have no position at or contract with a university. Often their only official link with a university is their supervisor. The other group consists of PhDs who are not employed by a university, but who have a more frequent and institutionalized relationship with a university. This, for instance, includes PhDs funded through a scholarship. Table 3 provides an overview of the share of each type of PhD in our sample. The share of regular PhDs is 73 percent. Although the exact share of non-regular PhDs is unknown, VSNU (2008) estimates their share at around fifty percent. This implies that non-regular PhDs are likely to be underrepresented in our sample. In terms of time to Master degree, or even time to a PhD degree, non-regular PhDs differ only slightly from regular PhDs. It is likely that external PhDs, who already work outside of academia during their PhD track, might experience different dynamics in income and careers than regular PhDs. Therefore, we also present estimation results by type of PhD.

3.2.3 Descriptive statistics on the outcome variables

Figures 1 to 4 show descriptive statistics of our main outcome variables: income, employment, and sector of work. Figure 1 depicts the sample means of monthly income for Master and PhD graduates by experience and sex. Experience is measured as years since *Master* graduation. Generally, women have a lower average monthly income than men. Male PhDs with up to sixteen to seventeen years of experience have a lower monthly income than Masters with the same amount of experience. Male PhDs with more experience tend to have a higher income than comparable Masters. For women, PhDs earn more after 9 to 10 years of experience.

Table 3 Descriptive statistics by type of PhD

	Regular PhD	External PhD	Other PhD
Share	73%	6%	20%
Time to Master degree (years)	4.9	4.8	4.9
Time to PhD degree (years)	5.2	5.6	5.3

[7] Although we are not aware of any figures on foreign non-university employed PhD students, is it very likely that the share of foreigners in this category is lower.

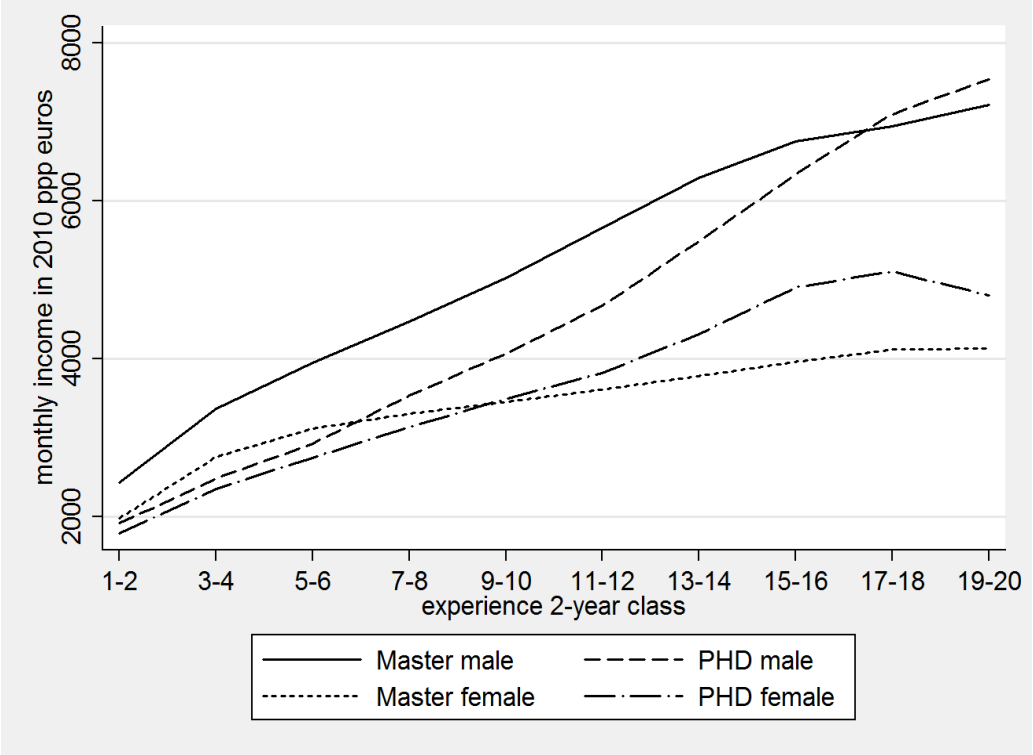

Figure 1 Monthly income for Master graduates and PhDs. Sample averages, by sex and experience.

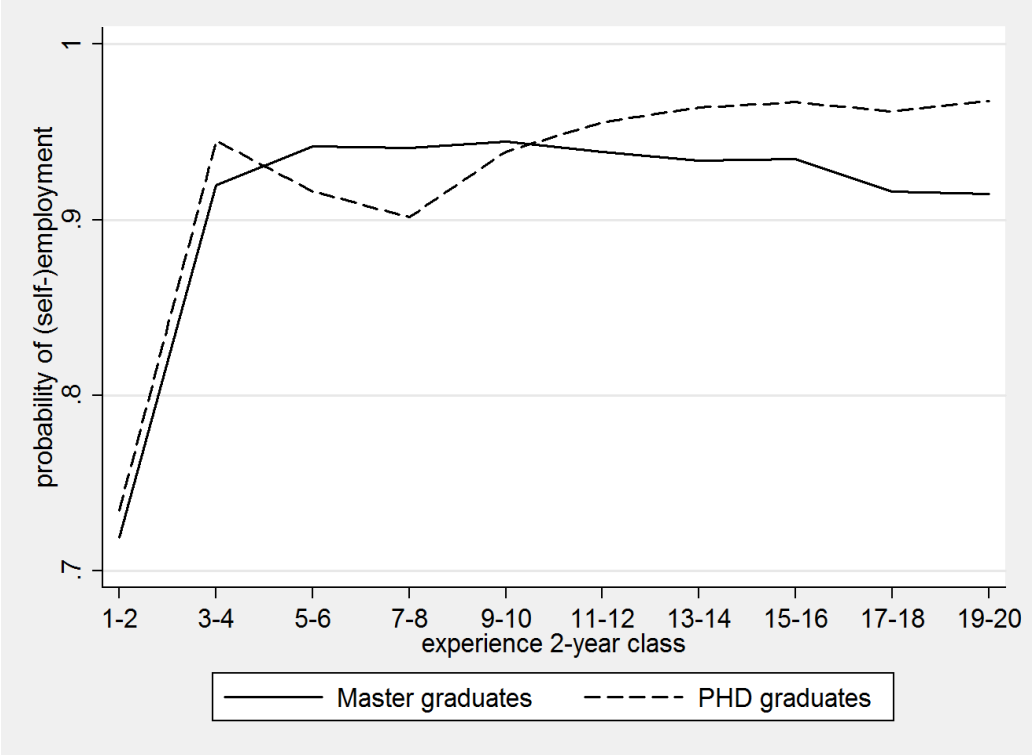

Figure 2 Share of (self-)employment: PhDs and Master graduates, sample averages by experience class.

On average, Figure 2 shows a slightly higher probability of employment of PhDs compared to Masters. This picture is different 4 to 11 years after Master graduation, in which PhDs are less likely to be employed. This period also includes the PhD graduation date for most PhDs in our sample. For the majority of regular PhD students this PhD graduation implies the end of a labor contract with the university and hence a reasonable probability of temporary unemployment.

Figure 3 show that PhDs tend to work less often in the private sector, especially in the beginning of their career. The distribution of PhDs over sectors of employment differs considerably over experience. The share of PhDs working in the private sector for PhDs with little experience is about 10 percent, while for PhDs with more than 10 years of experience this is around 40 percent. This is still substantially lower than the private sector shares of at least sixty percent for Master graduates for all levels of experience. For lower levels of experience, almost 60 percent of PhDs works in science. For higher experience levels, this is only twenty percent. This indicates that most PhDs eventually do not continue their career in science.

The average incomes of Masters and PhDs per sector are depicted in Figure 4. The figure shows the income of PhDs after obtaining their PhD degree. On average, incomes for both Masters and PhDs are highest in the private sector. It turns out that, with the exception of the private sector up to 15 years of experience , average income is equal or higher for PhDs compared to Master graduates employed within the same sector.

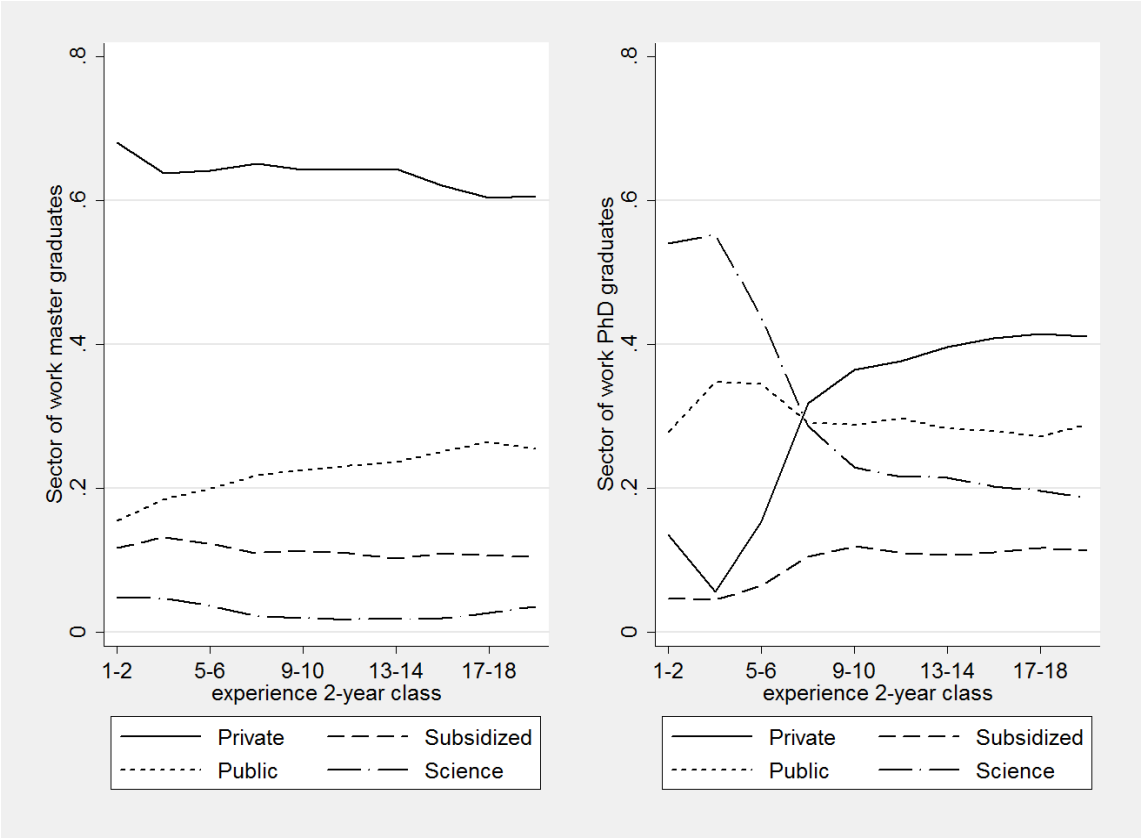

Figure 3 Sector of work: Proportion of individuals working in a particular sector, PhDs compared to Master graduates, sample averages by experience.

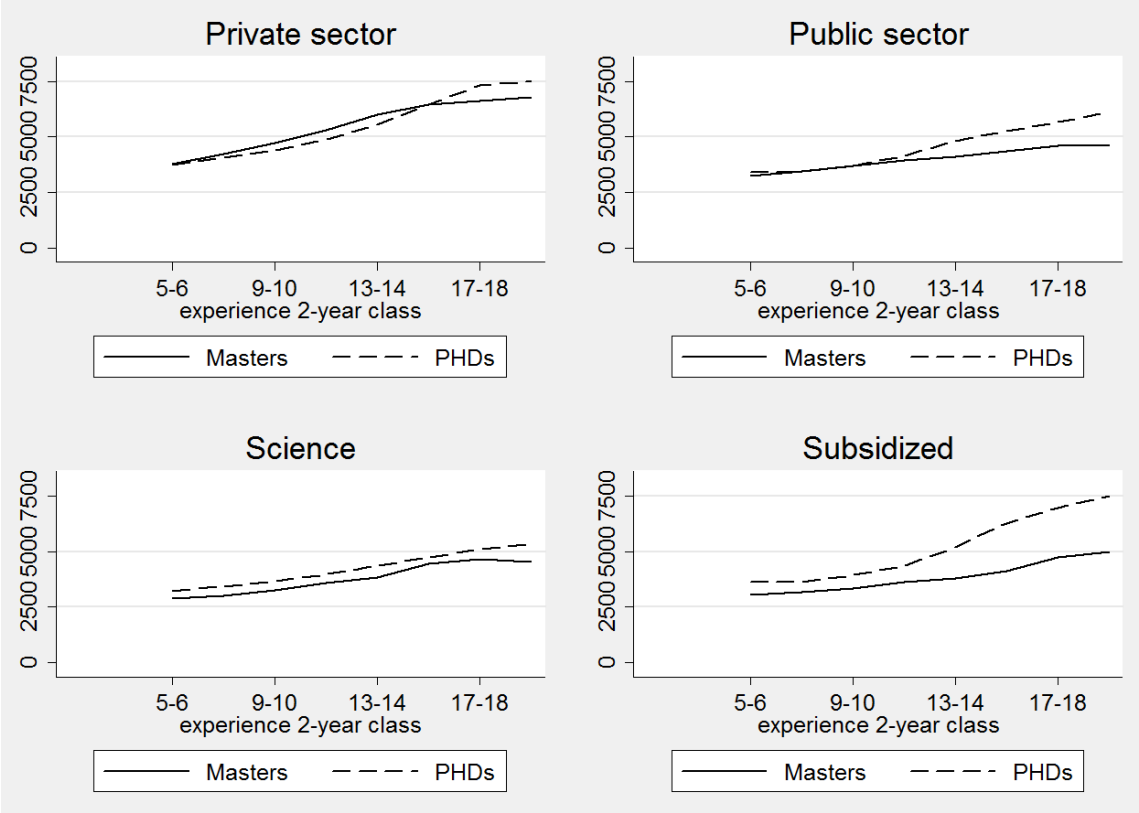

Figure 4 Income by sector. Sample averages of monthly income for Master graduates and PhDs, by sector and experience.

4. Empirical framework

4.1 Return to a PhD education

4.1.1. Modeling differences in income between Masters and PhDs over experience

The aim of the analysis is to estimate income differences over experience between PhDs and Masters. The most commonly used method to estimate lifetime returns to education is to estimate a Mincer equation (Mincer, 1974). To clarify our estimation strategy and to relate it to the Mincer approach, Figure 5 shows a hypothetical example of the income profile for Masters and PhDs. Panel A shows income-experience profiles, with experience measured as time since Master graduation. Panel B shows the same profiles, but as a function of experience measured as time since *highest* education. The dashed lines represent constant returns to a PhD education over experience (measured as time since Master graduation), and the dotted lines represent rising returns to a PhD. The example reflects the Dutch case, where a PhD is an employee and receives an income.

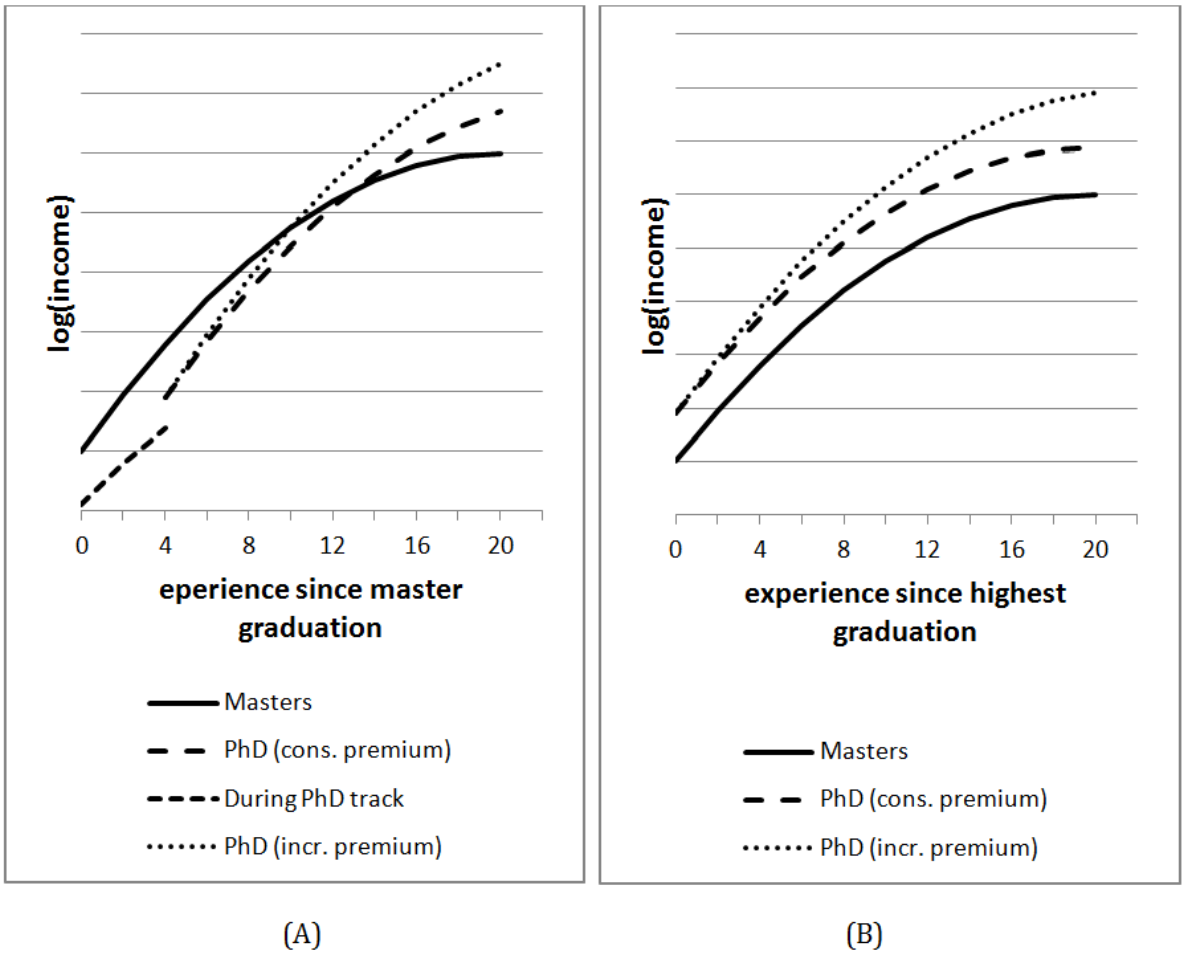

Figure 5 Income differences between Masters and PhDs. Hypothetical example.

In a Mincer equation, experience is measured as years since obtaining the highest education level. Furthermore, the relationship between experience and income is approximated by a second order polynomial. The return to an additional year of education is assumed to be a constant premium on log-income. When this assumption is met we have the situation illustrated by constant returns to a PhD in Figure 5[8]. The difference in log income between PhDs and Masters is increasing in experience as measured by time since *Master* degree (Panel A), but constant over experience when measured as time since *highest* degree (Panel B). When experience is measured as in (B), lifetime returns to a PhD can be estimated by using the following regression:

$$\log(inc_{i,t}) = \beta_1 + \beta_2 PhD_i + \beta_3 experience_{i,t} + \beta_4 experience_{i,t}^2 + \varepsilon_{i,t}. \qquad (1)$$

In order to interpret β_2 as the lifetime return to a PhD we have to assume that there are no private tuition costs, that earnings during the PhD track are zero, and that doing a PhD track has

[8] The standard Mincer equation estimates the return to years of education for the general population. Instead, studies focusing on the difference between Masters and PhDs generally use a dummy for PhD instead of years of education as independent variable.

no effect on total number of working years (see Heckman et al., 2003, for an extensive discussion of the assumption behind the Mincer equation).

We use a similar framework as above, but we make two important modifications. The first is that we include income during the PhD track. As we have discussed, Dutch PhDs are mostly employees. Thus we cannot assume that they have no income. Therefore, we define experience as years since obtaining a Master degree for both Master graduates as well as PhDs. This means that we can estimate the situation as illustrated by Panel A. It is an advantage of the longitudinal dataset, compared to cross-section data, that exact dates of Master as well as PhD graduation are observed. Moreover, the data also includes income of PhDs before they obtain their PhD. This allows the incorporation of the opportunity costs associated with a (possibly) lower income during the PhD track in the estimate of the PhD returns.

The second modification is that we do not model the returns to a PhD as a constant (in log-levels). The right panel of Figure 5 shows why. To accommodate inclusion of income during the PhD track, and measuring experience as time since *Master* graduation, a constant return is not sufficient. This is the case even if the return to a PhD education is constant in experience after highest graduation. Moreover, it is not a priori clear that the return to a PhD education should be constant after obtaining a doctorate diploma. Instead, the return could be increasing in experience (as illustrated by the dotted line). For instance, suppose there is a positive return in the private sector. PhDs coming from academia will very likely have to adjust to their new surroundings, and the value of a PhD only materializes after considerable time. Also, investment in human capital during their working life might differ between Masters and PhDs. The assumption of constant returns to education does not always hold in the empirical returns to education literature either (Heckman et al., 2003). Instead of assuming constant returns, we include an interaction effect between being a PhD and experience. For even more flexibility, we use two-year experience classes instead of a quadratic polynomial.

Controlling for sex and other covariates, we estimate the following equation:

$$\log(inc_{i,t}) = \beta_1 + \beta_2 PhD_i + \beta_{3,c} EXP^c_{i,t} + \beta_{4,c} PhD_i \times EXP^c_{i,t} + \beta_5 Fem_i + \beta_{6,c} Fem_i \times EXP^c_{i,t} + X'_{i,t}\gamma_{i,t} + \varepsilon_{i,t}, \quad (2)$$

where the subscript *c* denotes experience-class. In contrast to most studies estimating the returns to a PhD, our sample also includes observations of PhD graduates before they had obtained their PhD degree. In those cases the PhD dummy is also one. Experience is constructed as a 2-year class of years since obtaining a Master degree. Sex is interacted with experience. *X* is a vector of individual covariates consisting of calendar year, field of study and time to Master degree. Time to Master degree is defined as time between the first day at university and the day when the individual received his or her Master degree. We use this variable to control for possible differences in ability between non-PhDs and PhDs. Income is inflated to 2010 levels using the consumer price index. We estimate the equation with OLS using clustered standard errors, correcting for repeated observations per individual.

In addition to the model in Equation (2), we estimate the returns to a PhD for two types of subgroups. First, we estimate the return to a PhD by type of PhD (regular, external, and other) by including interaction effects between type of PhD and experience class in Equation (2). Second, we estimate the returns for eight different fields of study. We do this by separately estimating Equation (2) for each subsample of Masters and PhDs with the same field of study. In these regressions, field of study is obviously excluded as a covariate. The total set of ten models

(one overall, one by type of PhD, eight for each field of study) is estimated for men and women jointly and separately, resulting in a total of thirty models. This way, differences in returns by sex can be identified over the whole range of experience classes.

4.1.2. Outcomes

When income differences between PhDs and Masters are not constant over experience, β_2 in Equation (1) is no longer equal to the rate of return to a PhD. Instead, it equals the average *annual* returns (AAR) in earnings. To make our results comparable to earlier studies, we use the regression outcomes to produce similar estimates of the average annual returns. We do this by averaging over the experience class specific coefficients from Equation (2) in the following way:

$$AAR = \frac{1}{10}(e^{\beta_2} - 1) + \frac{1}{10}\sum_{c=2}^{10}(e^{\beta_2 + \beta_{4,c}} - 1). \qquad (3)$$

Standard errors of this measure are calculated using the delta method. We prefer this way of calculating the average return to estimating it using the PhD dummy from Equation (1) because Equation (3) is insensitive to whether the sample is unbalanced in experience.

The return to a PhD in Equation (3) tells something about average differences in *annual* earnings. The estimate does not take the time pattern of returns into account, nor does it account for differences in the level of income over time. For instance, an estimate of returns to a PhD of 10 % means that the annual income of a PhD is on average 10 % higher than that of a Master graduate. This does not necessarily imply that total earnings over the first twenty years are 10 % higher.

As an alternative outcome this paper presents a measure of returns that does take timing and differences in the level of income into account: the internal rate of return (IRR). The IRR is the discount rate at which a recently graduated Master would be indifferent between directly going to work or doing a PhD. Or formally, the IRR is equal to the discount rate *r* such that

$$\sum_{t=0}^{N} D_t(1+r)^{-t} = 0, \qquad (4)$$

where $D_t = inc_t^{PhD} - inc_t^{MSc}$.

For applications of the IRR to estimations of the returns to education see Hanoch (1967) and Heckman et al. (2003). We expect PhD incomes to be lower than Master incomes during the first years of experience and higher during later years. In that case, the foregone earnings in the beginning can be interpreted as an investment, and the higher earnings later on as the return to that investment. Then, the IRR can for instance be compared to the interest rate to see whether doing a PhD is a sound investment (Heckman et al., 2003; Hirschleifer, 1970). When PhD incomes are lower (or higher) than Master incomes over the whole experience range, the IRR is not defined. When the levels of PhD and Master incomes cross more than once, the IRR does not necessarily have a unique solution. In those cases, we do not report an IRR. For additional insight in the dynamics of the returns to a PhD education over experience, the next section also includes plots of the income difference between Masters and PhDs over experience.

Although income data are only available for the first twenty years of experience, we also want to provide some insight into the effect of a PhD over the entire career. We do this by

extrapolating the returns over the rest of the working life. We assume that the returns remain constant after twenty years of experience.

4.2 Additional analysis: employment, sector of work, and hours worked

We analyze three underlying mechanisms for the observed differences in the income profile between PhDs and non-PhDs: differences in employment, in sector of work, and in hours worked per week.

4.2.1 Employment

The employment variable is based on the main source of income as registered in the wage data. Employment is defined as either being employed or being self-employed. We run logit regressions using the same covariates as in Equation (2) to estimate the odds ratio of employment for PhDs compared to Masters. The odds ratio is defined as

$$\frac{P(work \mid PhD) / (1 - P(work \mid PhD))}{P(work \mid Master) / (1 - P(work \mid Master))}.$$

The odds ratio shows the relative difference in the odds of employment between PhDs and Masters. An odds ratio higher than one indicates that PhDs are more likely to be employed than Masters. We plot the odds ratio over experience.

4.2.2 Sector of work

Differences in income profiles might be the result of differences in the sector in which Masters and PhDs typically work. These differences can arise because of the PhD training. For instance, PhDs might acquire particular skills that are more valuable in the public sector than in the private sector. These differences can also arise because of other preferences. For instance, individuals who choose to do a PhD also have a (a priori) stronger preference to work in the public sector than individuals who do not.

For respondents who are employees, we have additional information on type of job, including sector. We define four sectors: private sector, subsidized, government, and science. Differences in sector of work are estimated between PhDs and non-PhDs over experience, using a multinomial logit model. We include the same covariates as in Equation (2). The relative risk ratios are plotted against experience. These are

$$\frac{P(sector_i \mid PhD) / P(sector_1 \mid PhD))}{P(sector_i \mid Master) / P(sector_1 \mid Master)},$$

where the reference sector, $sector_1$, is the private sector. Furthermore, we look at differences in incomes between PhDs and Master graduates, conditional on sector of work. This gives an idea of the return to a PhD education within different sectors.

4.2.3 Hours worked

Differences in hours worked per week can also partially explain variation in income. Both the PhD survey and the Labor Force Survey (LFS) contain information on self-reported hours worked.[9] For each respondent, we therefore have one observation on hours worked. This is for the year 2009. We run an OLS regression on hours worked per week on this cross-section sample to obtain estimates of the difference in hours worked between PhDs and non-PhDs, for men and women separately. Since the reported hours worked in the PhD survey, by design, only pertain to PhDs who already have their PhD degree, we exclude the first experience-class in this analysis.

5. Results

5.1 Income differences between Masters and PhDs

5.1.1 Returns during the first 20 years of experience

Table 4 shows the main estimation results with respect to monthly income. The table reports both the AAR over the first twenty years of experience, as in Equation (3) and the IRR, as in Equation (4). Results are shown for the total population and by different subgroups (by sex, by type of PhD, and by field of study). Estimates that significantly differ from zero at a 5 percent significance level are highlighted in bold. We first discuss the average annual returns in this section, and then turn to an appraisal of the IRRs.

For men and women together, we find a small, insignificant, negative AAR of 1.2 percent per year over the first twenty years after Master graduation. However, this estimate masks important differences by sex, PhD status and field of study. Regarding differences by *sex*, male PhDs experience an average *negative* income difference of 6.8 percent over the first twenty years after Master graduation, whereas women experience an average *positive* return of 10.4 percent over the same period.

Regarding differences by *PhD status*, we find that regular PhDs experience a negative AAR of 4 percent. This contrasts with external PhDs, who experience a positive return of on average 16 percent. The return for the category of "Other PhDs" is slightly positive. We find the same pattern within each PhD status category of (substantially) more positive PhD returns for women than for men. The AAR ranges from -9 percent for male regular PhDs to +26 percent for female external PhDs.

The bottom part of Table 4 shows marked differences in returns to a PhD education by *field of study* as well. For men and women together, we find significant negative AARs for the fields of Nature, Physics and Economics. Apart from these fields of studies, AARs for men are significantly negative as well for graduates in the field of Law, and Behavior & Society. This yields five out of eight fields where AARs are significantly negative, ranging from minus 8.1 (Nature) to minus 14.1 percent (Law). For the other fields of study, point estimates are negative as well, but not significantly different from zero. For women, estimated AARs are significantly

[9] Although the information we use is from two different sources, we think this is not problematic. We have a small sample of individuals for which information from both sources is available. Differences in reported hours worked between the two sources are small and not statistically significant.

positive for graduates in the field of Law, Behavior & Society, and Language & Culture. Point estimates for the other fields of studies are positive, but not significantly different from zero.

Table 4 Estimated return to a PhD education compared to a Master: average annual return and internal rate of return over the first twenty years of experience. In percentages.

	Total		Men		Women	
	AAR	IRR	AAR	IRR	AAR	IRR
All PhDs	-1.2	1.7	**-6.8***	-9.0	**10.4***	19.9
	(1.0)		(1.1)		(2.1)	
By PhD status						
- Regular PhD	**-4.0***	-5.5	**-9.3***	-20.7	**7.9***	14.9
	(1.0)		(1.1)		(2.2)	
- External PhD	**15.8***	#	**10.3***	53.5	**25.5***	#
	(2.9)		(3.4)		(5.5)	
- Other PhDs	1.5	6.7	**-4.4***	-3.7	**12.9***	29.5
	(1.5)		(1.5)		(3.6)	
By field of study						
- Agriculture	-3.4	#	-5.8	#	0.7	-33.9
	(4.0)		(3.9)		(5.9)	
- Nature	**-5.2***	-15.3	**-8.1***	-17.1	3.1	32.9
	(2.2)		(2.5)		(4.5)	
- Physics	**-9.1***	-26.0	**-8.7***	#	3.3	4.6
	(1.5)		(1.5)		(7.2)	
- Health	-2.3	10.0	-5.4	-3.5	7.9	21.2
	(2.7)		(4.0)		(4.6)	
- Economics	**-8.7***	-19.3	**-11.8***	-26.7	9.1	9.5
	(2.9)		(3.3)		(7.0)	
- Law	-6.0	#	**-14.1***	#	**13.9**	14.8
	(4.8)		(6.4)		(6.3)	
- Behavior & Society	-1.0	9.4	**-8.2***	-16.3	**9.7***	37.1
	(2.2)		(2.6)		(4.0)	
- Language & Culture	-2.8	9.8	-4.0	#	**13.7***	21.8
	(3.3)		(4.6)		(4.9)	

Estimates in column 1 are based on OLS regressions controlling for sex, experience in two-year classes, interaction terms between sex and experience class, year in which income was measured, and time to Master degree. Estimates in columns 2 and 3 are based on regressions that control for the same covariates as in column 1, except sex, estimated for men and women separately.
Robust standard errors are presented in parentheses.
* Significantly different from 0 at a five percent significance level.
# IRR is not defined because PhD returns are always lower (or in case of external PhDs, higher) than Masters'.

As an estimate of the return to a PhD education, the AAR ignores two important issues. The first is the difference in income level over experience. Given that income tends to increase with experience, this means that a ten percent average annual returns for PhDs compared to Masters is a smaller amount (in euros) during the beginning of the career than in later years. Ignoring this increase results in an underestimation of the return to a PhD based on average returns. The second is the timing of income differences between Masters and PhDs. Due to discounting, an income difference later in the career is less valuable to a young individual than the same difference early in the career. Given that we expect PhD premiums to increase with experience, ignoring the timing of income differences will result in an overestimation of the return to a PhD. The IRR does take both issues into account. The differences between the AAR and the IRR will depend on the relative sizes of the two opposing effects.

For the total sample, the IRR is slightly positive (1.7%). For men and women separately the IRR shows the same sign as the average estimate, but the results are stronger in size (more negative for men, and more positive for women). The same pattern of stronger IRR with the same sign as the average estimate can be seen for all significant average estimates. This suggests that for the negative returns, the timing is more important, while for positive returns the higher income *levels* during later years are more important. For insignificant results the IRRs sometimes have a reversed sign compared to the annual average. For instance, the fields of study Behavior & Society and Language & Culture have slightly negative average annual estimates (-1.0, -2.8), while the IRR is positive (9.4, 9.8).

For a further insight in dynamics Figures 6 and 7 show the income differences over experience underlying the results in Table 4. In Figure 6, the return to a PhD education is plotted over experience, for the total sample, as well as for men and women separately. Experience is grouped by (ten) two-year experience classes, starting from 1-2 to 19-20 years of experience, as measured since year of Master graduation. The figure shows a negative income difference over the first 11 to 12 years after Master graduation, and a positive difference thereafter. The difference ranges from -13 %, after 5 to 6 years of experience, to + 13 % at 20 years of experience.

The picture is markedly different for women than for men. Male PhDs experience negative income differences (compared to men with only a Master degree) that are larger and continue much longer than those experienced by female PhDs. Whereas male PhDs start to witness positive income differences only after 15 years of experience, women start to witness positive income differences about 8 years earlier. Men start with a negative income difference of -11 percent, turning even more negative to -20 percent 5-6 years after Master graduation. Female PhDs start with a lower income difference of -6 percent, topping at -8 percent 3-4 years after Master graduation, and reaching around 30 percent at the highest experience classes.

Judging from the descriptive picture in Figure 1, the relatively high return to a PhD education for women (compared to women with a Master degree) is mostly the result of relatively lower wages of female Masters (compared to male Masters). In fact, the income profile of male PhDs (in levels) is steeper than for female PhDs. However, female Masters start with a higher negative difference (compared to male Masters).

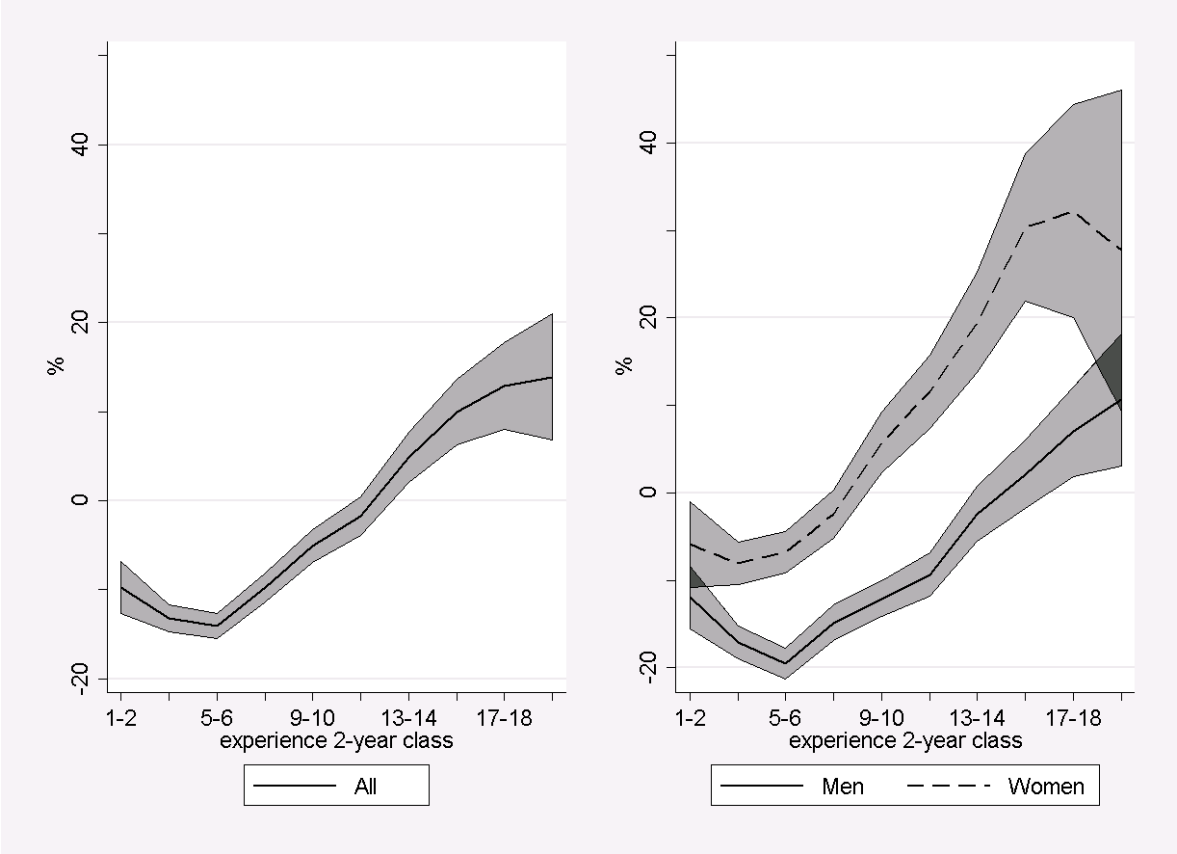

Figure 6 Predicted income difference between PhDs and Masters as a percentage of income of Master graduates with the same level of experience, by sex and experience class. 95% confidence intervals.

Figure 7 compares the returns between regular and external PhDs. The pattern for regular PhDs is similar to that in Figure 6. The experience pattern of external PhDs is almost parallel to that of regular PhDs. However, they start with a positive difference of about 10 %. This difference declines to zero 3 to 4 years after Master graduation and starts to rise to almost 35% at 20 years of experience. The higher returns for external PhDs compared to regular PhDs seem to be related to the fact that, due to their employment outside of science, they are able to keep up with the career path of other Masters during their PhD track. The initial positive income difference seems to suggest a selection effect: employees with a high ability could be more likely to pursue a PhD in combination with their career outside of science.

5.1.2. Lifetime income differences

The findings presented in the previous subsection pertain to income differences between Masters and PhDs over the first twenty years of experience. To enable a more direct comparison to estimates of *lifetime* differences in income, we extrapolate our findings over the remaining working life. First, the lifetime AAR is calculated. Second, the discounted lifetime income difference between PhDs and Masters is determined. For this, step, the distribution over fields of study, and the duration of the Master degree are set at the average PhD sample levels. The calendar-year effect is set at baseline level. Third, the lifetime IRR is calculated. In all cases, the main estimation results are used, for men and women jointly and separately.

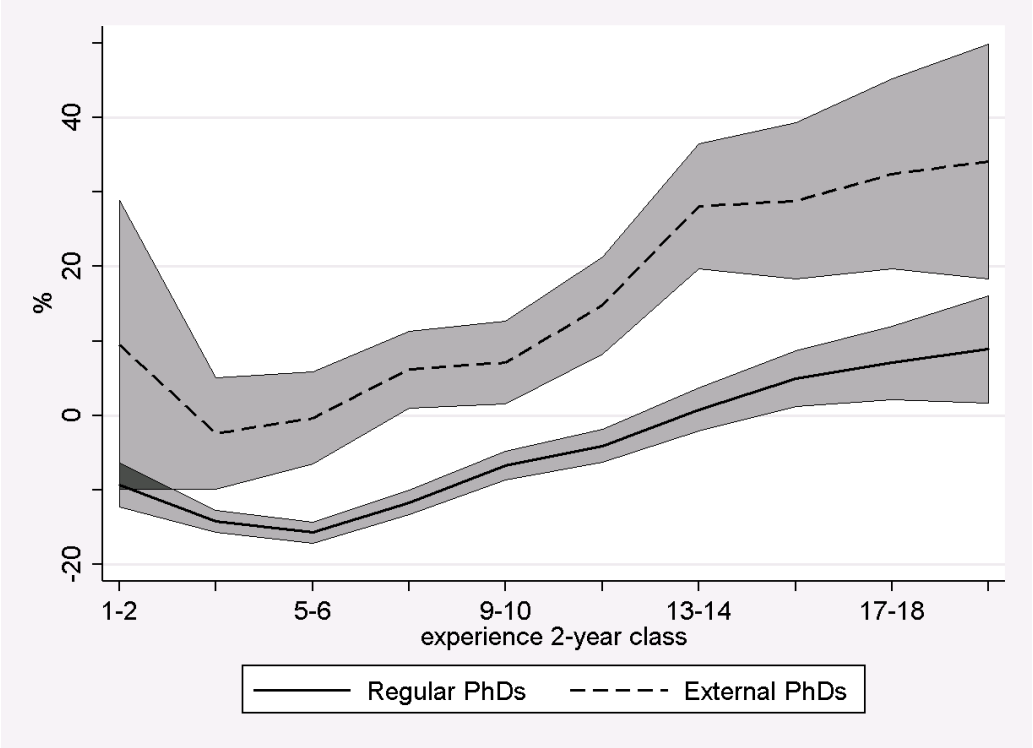

Figure 7 Predicted differences between PhD and Master income as a percentage of income of Master graduates with the same level of experience, by type of PhD track and experience class. 95% confidence intervals.

For the first approach (AAR), we assume that total working life will equal 40 years. Furthermore we assume that the return is constant after twenty years of experience. That is, from experience years 20 to 40 the return is equal to 13 %. In that case, the average annual AAR is 6.3 % (1.9 % for men, 19 % for women). For further comparison to other studies, if we also ignore the opportunity costs during the PhD track (as is done in most studies), and only include the return from 6 years of experience onwards, we arrive at a return of 9.6 % (5.1 % for men, 23.6 % for women).

For the second approach (IRR), we first calculate the income difference between PhDs and Masters in euros. Using an annual discount rate of 3 %, the discounted income difference between PhDs and Masters over the first twenty years is -3,000 euros (-42,000 euros for men, +63,000 euros for women). We extrapolate the income differences by assuming that the returns remains constant after twenty years. That is, we set the annual income difference at 8,240 euros (6,700 for men, 14,000 for women).[10] The result is a discounted lifetime income difference of 65,000 euros (13,000 euros for men, 178,000 euros for women). To calculate the return to a PhD, we calculate the IRR over the entire career. The IRR is then equal to 9.3 % (4.1 % for men, 20.9 % for women).

[10] Assuming a constant PhD premium in levels, instead of a constant relative premium to Master income, allows us to ignore the experience profile for Masters over the rest of working life. Note that when Master income is stable after the first twenty years of experience, the assumption of a constant level difference in incomes is equivalent to the assumption of a constant relative PhD premium.

5.2 Additional results: employment, sector of work, and hours worked

So far we have presented differences in the returns to a PhD education by experience, field of study, sex and PhD status. In this section we explore some of the underlying mechanisms that can explain some of these differences.

5.2.1 Employment

Figure 8 shows the odds ratios of employment over experience classes. Results are reported for men and women together, as well as separately (where we compare the odds with Masters of the same sex). PhDs are more likely to be employed than Masters during the first 5 to 6 years of their career. This is not surprising, given the fact that individuals with a PhD are likely to have been employed as a PhD student at a university during the first part of their career. From 6 to 10 years of experience, we can see that PhDs are actually less often employed than Masters. This finding is very likely related to PhDs who have to search for a new job after PhD graduation. Over the last 10 years of the range of observed experience classes, PhDs are again more likely to be employed than non PhDs. For female PhDs the positive employment effects are generally larger than for men (compared to Masters with the same sex). To get an idea of the effect of differences in employment between PhDs and Masters on the return for women, we can estimate the return for workers only. That is , we can compare the average income of employed women with a PhDs to that of employed Masters. The AAR for employed female PhDs compared to employed female Masters is 8.4 percent over the first twenty years of the career. This is two percentage points lower than the AAR calculated on the whole sample.

5.2.2 Sector of work

The distribution over sectors of employment differs rather substantially between PhDs and Master graduates. This could already be seen from the descriptive statistics in Figure 3. Figure 9 shows the results of a multinomial regression on sector of work for those individuals who are employees. For the sake of visibility, the relative risk ratio for science is excluded. For the same reason, the 95 % confidence bounds are not shown. All three relative odds ratios are significantly different from one at a 5 % significance level over all experience classes. As can be expected, PhDs are much more likely to be working in science than Masters. However, the likelihood of working in science for PhDs declines with experience. PhDs are also more likely to work in the subsidized and government sector. The relative risk ratio of working in government shows a peak at 3 to 4 years of experience, but PhDs are more likely to work in government or the subsidized sector than in the private sector over the entire time period.

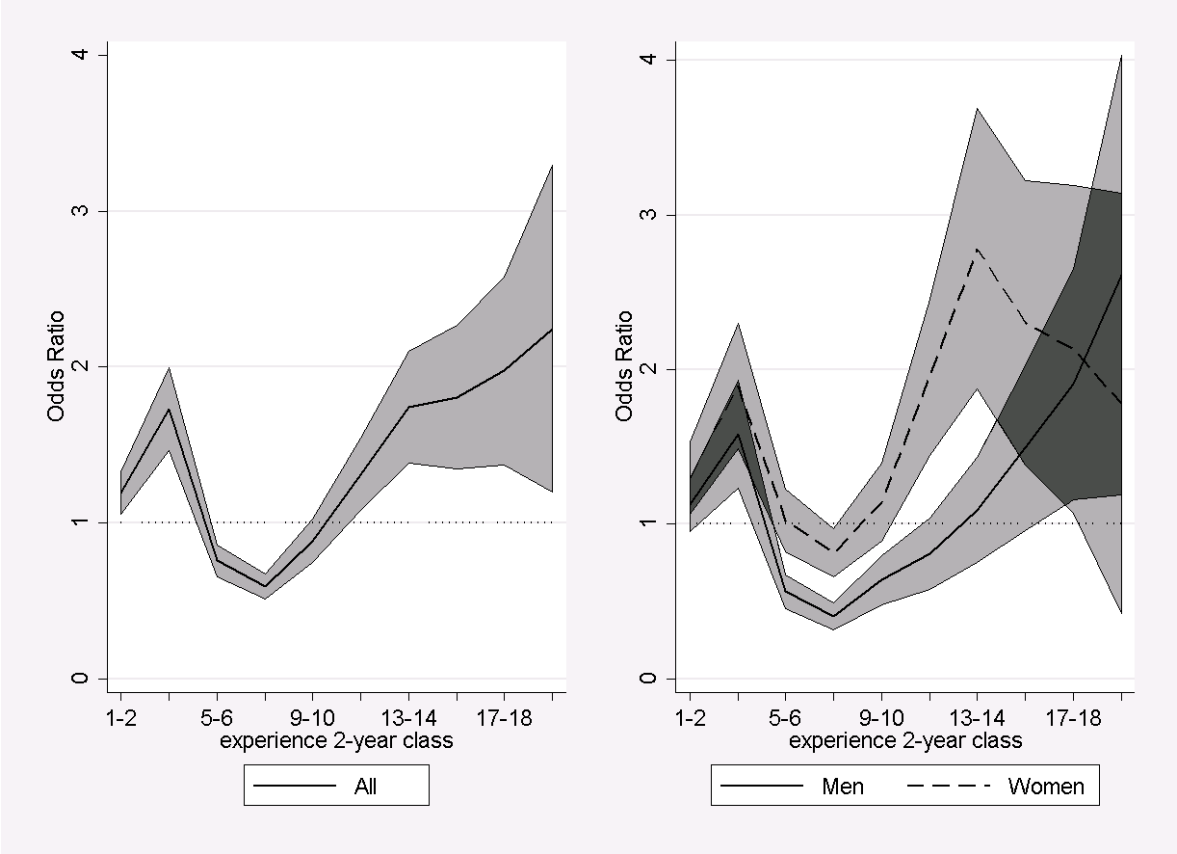

Figure 8 Predicted probability of (self-)employment: Odd Ratios of probability of employment (versus non-employment) for PhDs compared to Master graduates with the same experience and sex, by sex and experience class. 95% confidence intervals.

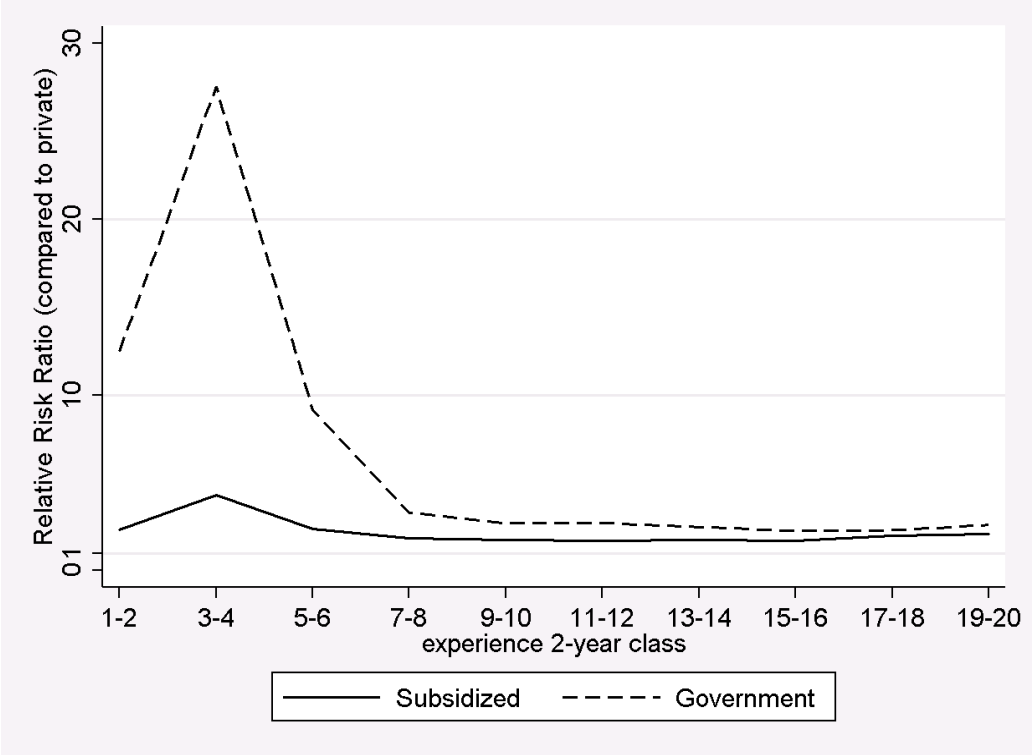

Figure 9 Predicted probabilities of sector of work: relative risk ratio of the probability of working in the subsidized or government sector versus working in the private sector for PhDs compared to Master graduates with the same

This difference in private sector shares contributes negatively to the returns to a PhD education. This is because incomes in the private sector are on average higher than those in other sectors, particularly as one grows in experience (see Figure 4). Figure 10 provides insight in the relative income position of PhDs compared to Master graduates working in the same sector. The figure is based on similar regressions as in Equation (2), ran separately for each sector for all employees in the sample. To make a fair comparison, we only include observation for PhDs after PhD graduation. Returns are positive for all included experience classes in science and the subsidized sector. The relatively high return in the subsidized sector is likely to be explained by the medical sector. In the medical sector in the Netherlands a PhD is often an (unofficial) requirement for becoming a medical specialist. In the public sector, PhDs are confronted with a small negative income difference during 5 to 10 years of experience, but after that PhDs have a considerably positive return. In the private sector, income differences with Masters are slightly negative up to 14 years of experience. After that, the returns to a PhD are positive but still lower than in the public sector. The effect of the difference in sector of work between Masters and PhDs can be assessed by recalculating the returns under the assumption that PhDs have the same sector distribution as Masters. The AAR (for comparison only after PhD graduation) is 2.8 percent. Whit equal sector distribution for Masters and PhDs, the AAR is 6.7 percent.

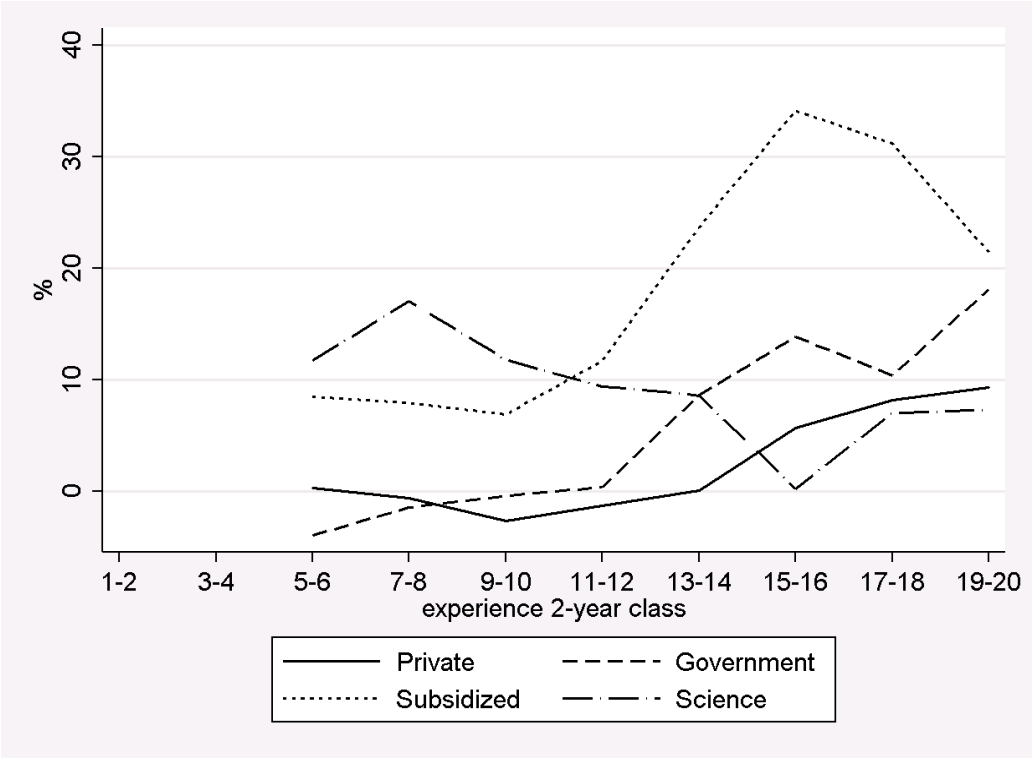

Figure 10 Predicted returns to a PhD education by sector of work: return as a percentage of income of Master graduates with the same level of experience, by experience class. Observations for PhDs are only included after obtaining of PhD degree.

5.2.3 Hours worked

Figure 11 shows the difference of hours worked for PhDs compared to Masters with the same sex and experience. As explained in Section 4.2.3 these estimates are self-reported, and based on cross section survey data. It turns out that part of the positive female PhD return is driven by female PhDs working more hours per week than female Master graduates. They do so over the whole experience spectrum. The estimated difference is on average 3.8 hours per week (statistically significant at a 5-percent significance level). This corresponds to a more than 10 percent difference as female Master graduates work on average 32.5 hours per week. For men there is a small, but non-significant, negative association between being a doctorate holder and hours worked. To get an idea of the influence of differences in employment on the return for female PhDs, we rescale monthly incomes of PhDs by the differences in hours worked and recalculate the AAR for women. We do this only for female workers. After rescaling by differences in hours worked, the AAR for women is -2.3 percent over the first twenty years of experience. This is considerably lower that the AAR of 8.4 percent for employed female PhDs reported in Section 5.2.1.

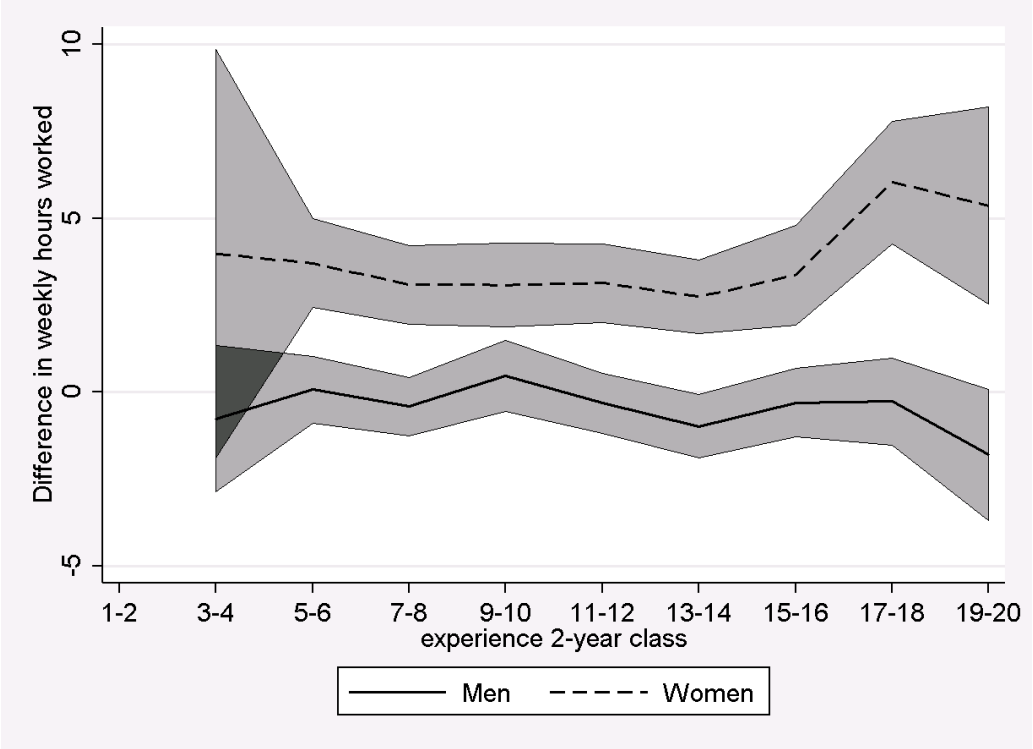

Figure 11 Predicted differences in hours worked. Differences in weekly hours work of PhDs compared to Master graduates with the same experience, by experience class and sex. Based on cross-section of 2009 survey data. 95% confidence intervals.

6. Conclusion and discussion

In this paper, we have compared monthly incomes of Dutch Masters and PhDs over the first twenty years of experience. PhD students earn a lower income than other Masters during the process of writing a PhD thesis and during the first years after PhD graduation. The annual returns to a PhD education show an increasing pattern and are positive from twelve years of experience onwards. These higher returns compensate the initial opportunity costs, resulting in an annual average return (AAR) to a PhD education that is not significantly different from zero over the first twenty years of experience. Estimates of the internal rate of return (IRR), an alternative measure that takes timing of income differences into account, indicate that our main results are robust to the way in which returns are measured. Our findings show that an approach that ignores the opportunity costs during a PhD education overestimates the return to a PhD. Similarly, an approach using a constant return to a PhD education ignores the way this return varies over experience.

Interpretation of the overall estimate has to be done with some caution, as the results differ strongly by sex. Women experience a much more positive return to a PhD education than men. This difference seems to be driven mainly by differences in hours worked: female PhDs work on average four hours more each week than female Masters. Another relevant result is that PhDs tend to work less in the private sector, where income levels are highest. The differences in distribution over sectors of work between PhDs and Masters could be related to the particular skills attained during the PhD track, but could also be a result of unobserved differences in job preferences.

Our extrapolations, under the assumptions of constant returns after twenty years of experience, result in an AAR of six percent over the entire working life. This adds up to ten percent when income during the PhD track is ignored. Our estimate of the IRR to a PhD over total working life is nine percent. Given that most other studies only estimate a constant return over experience, it is difficult to compare our results to other studies. The extrapolated lifetime returns seem relatively low compared to the findings for Germany and Switzerland (especially for men), that report returns between ten to thirty five percent (Engelage & Hadjar, 2008; Mertens & Röbken, 2013). Our findings are similar or higher than what is reported for the UK (O'Leary & Sloane, 2005). However, we find increasing returns over the first twenty years of experience. This pattern suggest that our assumption of constant returns after twenty years might be on the conservative side.

The most important limitation of our study is that we are not able to fully control for self-selection into a PhD track. It is likely that Master graduates who choose to enter a PhD track have different unobserved characteristics from graduates who do not. An important unobserved characteristic is academic ability, but others include self-discipline, creativity and a lack of commercial skills. We have attempted to control for academic ability by including duration of the Master study (time to Master graduation). PhD graduates on average take one year less to obtain their Master degree. The effect of study duration on income was negative, but very small and not significant in any of the model specifications. However, study duration is at best a proxy for academic ability, while the other confounding factors are not controlled for. Besides differences in capabilities the labor market preferences of those people that decide to write a PhD thesis will also be different. Some studies suggest that scientists are willing to earn less in return for more research freedom (Roach and Sauermann, 2010). The relatively small proportion of PhDs working in the private sector might partially be explained by such preferences.

The results in this paper do not provide clear cut policy suggestions. However, it is of interest to note that only twenty percent of Dutch PhDs work in science at eight to ten years of experience. This means that the adaptation of PhDs to the rest of the labor market is an important issue. The higher individual returns to a PhD education for external students in the first years after PhD graduation might offer an indication that external experience can improve the labor market position of PhDs. These skills could for example be obtained through a more active participation in the world outside of academia during the PhD track.

Bibliography

Auriol, L. (2007). *Labor market characteristics and international mobility of doctorate holders: results for seven countries*, 2007/2, OECD Publishing.

Auriol, L. (2010). *Careers of doctorate holders: employment and mobility patterns*, 2010/4, OECD Publishing.

Auriol, L., Misu, M., & Freeman, R.A. (2013). Careers of doctorate holders: Analysis of labor market and mobility indicators. *OECD Science, technology and industry working papers*, 2013/04, OECD Publishing.

Ben-Porath, Y. (1967). The production of human capital and the life cycle of earnings. *The Journal of Political Economy*, 352-365.

Casey, B. H. (2009). The economic contribution of PhDs. *Journal of Higher Education Policy and Management*, *31*(3): 219-227.

CBS (2009). Careers of doctorate holders (CDH) 2007, Satistics Netherlands, The Hague/Heerlen.

CBS (2011). Careers of doctorate holders (CDH) 2009, Satistics Netherlands, The Hague/Heerlen.

De Goede, M., Belder, R., & De Jonge, J. (2013). Academische carrières en loopbaanbeleid. *Feiten en cijfers*, Rathenau Instituut, The Hague.

Dolton, P. J., & Makepeace, G.H. The Earnings of Economics Graduates. *The Economic Journal*, 100(399): 237-250.

Engelage, S., & Hadjar, A. (2008). Promotion und Karriere: Lohnt es sich zu promovieren? Eine Analyse der Schweizerischen Absolventenstudie. *Schweizerische Zeitschrift für Soziologie*, *34*(1): 71-93.

EUA (2007). Doctoral Programmes in Europe's Universities: Achievements and Challenges. *Report prepared for European universitiesand ministers of higher education*. European University Association, Brussels.

Heckman, J. J., Lochner, L. J., & Todd, P. E. (2003). *Fifty years of Mincer earnings regressions* (No. w9732). National Bureau of Economic Research.

Hanoch, G. (1967): An Economic Analysis of Earnings and Schooling. *The Journal of Human Resources*, 2(3): 310-329.

Janson, K., Schomburg, H., & Teichler, U. (2006). Wissenschaftliche Wege zur Professur oder ins Abseits? Kassel: Incher.

Hirshleifer, J. (1970). Investment, Interest, and Capital, Englewood Cliffs: Prentice-Hall, Inc.

Mertens, A., & Röbken, H. (2013). Does a doctoral degree pay off? An empirical analysis of rates of return of German doctorate holders. *Higher Education*, 66:217-231.

Mincer, J. A. (1974). Schooling and earnings. In *Schooling, experience, and earnings* (pp. 41-63). Columbia University Press.

Nature (2011). The PhD factory. The world is producing more PhDs than ever before. Is it time to stop? *Nature*, 472: 276-279.

Nuffic (2012). Mobiliteit in beeld. Internationale mobiliteit in het Nederlands hoger onderwijs. Netherlands organisation for international cooperation in higher education (Nuffic), The Hague.

OECD (2011). Education at a glance 2011. OECD, Paris.

O'Leary, N. C., & Sloane, P. J. (2005). The return to a university education in Great Britain. *National Institute Economic Review*, *193*(1): 75-89.

Recotillet, I. (2007). PhD Graduates with Post-doctoral Qualification in the Private Sector: Does It Pay Off? *Labour*, *21*(3): 473-502.

Roach, M., & Sauermann, H. (2010). A taste for science? PhD scientists' academic orientation and self-selection into research careers in industry. *Research Policy*, *39*(3): 422-434.

Siegfried, J. J., & Stock, W. A. (1999). The labor market for new Ph. D. economists. *The journal of economic perspectives*, *13*(3): 115-134.

Van der Schoot, R., Yerkes, M., & Sonneveld, H. (2012). The Employment Status of Doctoral Recipients: An Exploratory Study in the Netherlands. *International Journal of Doctoral Studies*, *7*: 331-348.

Van der Neut, A.C., & De Jonge, J.F.M. (1993). *De meerwaarde van een promotie; een vergelijkende studie van de loopbanen van gepromoveerde en niet-gepromoveerde academici*, *Achtergrondstudies Hoger onderwijs en Wetenschappelijk onderzoek*, Ministerie van Onderwijs en Wetenschappen, The Hague.

VSNU (2008). Passend promoveren. *VSNU-notitie*, VSNU, The Hague.

Appendix A: Master and PhD graduation rates

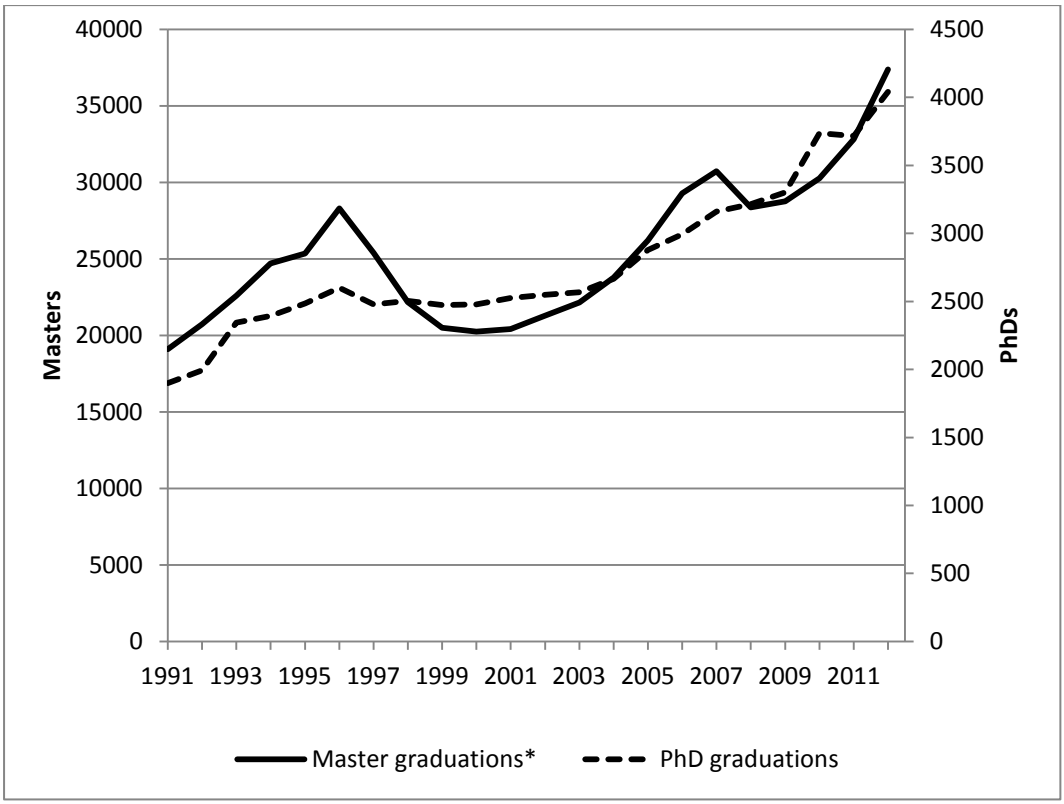

Figure A 1 Master and PhD graduations in the Netherlands (source: Statistics Netherlands)

Publisher:

CPB Netherlands Bureau for Economic Policy Analysis
P.O. Box 80510 | 2508 GM The Hague
T (070) 3383 380

May 2014 | ISBN 978-90-5833-642-2