

RESEARCH ARTICLE

Over-Education Among Doctorate Holders in the Korean Labor Market

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Abstract: Most prior research addressing the topic of educational mismatch focuses on university graduates, while the analysis of microdata on doctorate holders has received relatively little attention in the literature. Using Korean survey of Careers and Mobility of Doctorate Holders (KCDH), this paper attempts to examine the incidence and wage effects of over-education among the most highly educated workers (i.e., doctorate holders) in the Korean labor market. Overall, the major findings of this study confirm the findings of existing studies. The analysis reveals a worrisome situation in which a non-negligible proportion of doctorate holders face over-education associated with a significant wage penalty. Approximately 44% of doctorate holders in our sample survey consider themselves as being over-educated. The significant wage penalty (approximately 6.5 percent) exists for over-educated workers compared with their adequately-matched counterparts. From theoretical perspectives on labor market mismatch, our results confirm the validity of the assignment theory, which asserts that the returns to additional investment in human capital appear to depend in part on the quality of the assignment of heterogeneous workers to heterogeneous jobs, and thus returns to investment in education are limited by how well jobs exploit workers' education.

Keywords: Over-education, doctorate holders, assignment theory, wages, Korea

South Korea's higher education graduation rate is relatively high among member states of the Organization for Economic Cooperation and Development (OECD), and over 69% of Koreans aged from 25 to 34 graduated from junior college, university, or graduate school, greatly exceeding the OECD average of 42%, according to the OECD's 2016

Education at a Glance report. Over the past several decades, the number of graduate school students has dramatically increased and, noticeably, the number of doctorate holders is rising at an even faster rate. In 2015, the number of enrolled graduate school students stood at 333,478, which is about 7.8 times greater than the 42,928 enrollees in 1981. The supply of new

doctoral graduates has also increased significantly by 19.6 times from 589 in 1981 to 11,525 in 2015. This increase happens to be higher than the one reported by other OECD countries.

The rapid increase in the number of doctorate holders has naturally led to the question of whether the Korean economy can successfully provide enough positions to accommodate the growing supply of persons with qualifications. The substantial improvement in educational attainment has generally given rise to concerns about the failure of the most highly educated individuals to obtain jobs commensurate with their qualifications, so-called education–job mismatch (hereafter denoted as educational mismatch), which is based on the concept of the discrepancy between the highest level of education held by a worker and the education level required by his or her job tasks. Indeed, workplaces that require the most highly educated workers are limited and the number of qualified candidates vastly exceeds the number of employment opportunities in the Korean labor market. As a consequence, those with doctoral degrees have no other choice but to lower their standards and get a “lesser” job. According to a recent report issued by Korea Research Institute for Vocational Education and Training (KRIVET), a total of 185,369 people with a Master’s degree or a Ph.D. were working at office jobs that did not require special skills, and 18,334 people were working as service industrial employees that had nothing to do with their specialty.

Since the seminal works by Richard Freeman in 1976 and Duncan and Hoffman in 1981, there also has been a growing economics literature investigating how individual private returns from education (i.e., higher wages for more educated workers) are affected by educational mismatch, and more specifically by over-education, which happens when the level of education required for a job are lower than the level of education workers have. This research trend is motivated by international trends in the ongoing worldwide expansion of higher education. The over-education literature tends to support the view that surplus education is a costly phenomenon, suggesting that over-education is a widespread, persistent problem and one that is likely to be associated with considerable

individual and societal costs. Indeed, over-education is typically found to be associated with a notable pay penalty relative to those adequately educated with the same level of education. This result is strikingly consistent over time and across countries. However, most previous studies in the literature have focused on the evidence from university graduates (e.g., Freeman, 1976; Duncan & Hoffman, 1981; Sicherman, 1991; Hartog, 2000; Mavromaras, McGuinness, & Fok, 2009; Mavromaras, McGuinness, O’Leary, Sloane, & Fok 2010; Mavromaras, McGuinness, O’Leary, Sloane, & Wei, 2013; Patrinos & Psacharopoulos, 2010; Cho & Lee, 2014), but the analysis of educational mismatch among doctorate holders has received relatively less attention. One possible reason is that doctorate holders generally have better economic condition in the labor market in terms of unemployment and wages.

The literature on the consequences of over-education among doctorate holders is limited and relevant papers have been published only rather recently. To the best of our knowledge, only a few papers have analyzed the impact of over-education on wages and suggest that an over-education wage penalty among Ph.D. holders actually exists. Bender and Heywood (2009) provided the first analysis of over-education among doctoral graduates. To analyze the career outcomes of Ph.D. holders who obtained their title in the United States, they used survey data from the 1997 and 1999 Survey of Doctorate Recipients (SDR). This article analyzed three indicators of labor market mismatch and found that they appear to be associated with substantially lower wages. In a later paper, Bender and Heywood (2011) also used the SDR data and presented panel data estimates of the wage penalty associated with a mismatch in different fields of study and at different career stages. They found worse effects for those with a degree in hard sciences and, to a lesser extent, social science, as well as for those at an advanced stage of their career. Focusing on a survey of doctorate holders from the Catalonia region of Spain, Di Paolo and Mañé (2016) found a wage penalty of 11% among those Ph.D. holders who are both over-educated and over-skilled. Finally, Gaeta, Lavadera, and Pastore (2017) used the cross-sectional survey of Italian doctorate holders and highlighted that the wage gap between over-educated and well-matched doctorate holders

ranges between -7% and -11% depending upon the specification considered.

The goal of this paper is to contribute to filling this important research gap by adding empirical evidence to the debate on the importance and consequences of over-education among doctorate holders. Being focused on Korean doctorate holders, this paper extends prior research that investigated the incidence and the wage effects of over-education among university graduates. The current analysis, in particular, is the first study to examine the issue of over-education among doctorate holders in the Korean labor market. The repercussion of over-education has been a concern not only for students but also for parents, educators, economists, and policymakers for many years. Furthermore, considering the importance of doctorate holders for the economy, the potential costs of over-education are much higher for doctorate holders than for other educational groups. Doctorate holders generally play an important role in innovation and creating technological progress in the economy. This group of workers represents a key element for the generation of the most up-to-date knowledge through their research, and on the other, they bring their capabilities to firms, where they help to transform inventions into new market products (Herrera, Munoz-Doyague, & Nieto, 2010). In recognition of the importance of ensuring an adequate supply of highly educated workers, many countries, including Korea, have expanded and reformed their doctoral programs (Park, 2007). Therefore, the quality of match between education acquired and the extent to which it is used in the workplace (i.e., educational mismatch) needs to be further investigated.

In this article, we use a unique dataset collected in 2013 by Korean Survey of Careers and Mobility of Doctorate Holders (hereafter denoted as KCDH) through a large cross-sectional survey of doctorate recipients in all fields of doctoral studies. This data provides the first nationally representative sample of doctorate holders in Korea. The homogeneity of this sample allows us to control for variables excluded from typical estimates when examining the consequences of over-education. Fortunately, the KCDH survey contains an appropriate educational mismatch question and provides sufficient data on doctorate holders' professional qualifications and employment, by

investigating school activity, socio-economic activities, and relevant personal information. Since this study only focuses on doctorate holders and this group has the highest level of education in general, under-education is not considered in the analysis.

Methods

This paper analyzes data from the KCDH survey. The KCDH is an official statistical survey which collects data on Korean doctorate holders and is coordinated by OECD. The OECD launched a Careers of Doctorate Holders (CDH) project with the UNESCO's Institute for Statistics (UIS), and the Statistics Office of the European Union (Eurostat) in 2004. The CDH project aims to address the evidence gaps about this population group and develop internationally comparable indicators on the careers and mobility of doctorate holders. The KCDH survey also provides a comprehensive assessment of personal and educational characteristics of domestic doctorate holders as well as their labor market status including career trajectories. As noted earlier, doctorate holders are both the most qualified in terms of educational attainment and those who have been trained to conduct research. Their contribution to the advancement of knowledge-based activities and innovation practices is also of particular importance in the labor market. Therefore, it is important to collect data on their characteristics and career path and mobility.

In this paper, we use the KCDH 2012 which was conducted by Science and Technology Policy Institute (STEPI), during the period June 2013 to August 2013. The target population of this survey was the doctorate holder residents in Korea as of December 1st 2012, aged over 15. The KCDH 2102 dataset is a representative sample of all Korean doctorate holders in academic disciplines or fields of study including the hard and social sciences. It is particularly suitable for the current analysis because it includes a wide range of information on Korean doctorate holders and their educational mismatch. Specifically, it contains questions relating to respondents' individual and employment characteristics, which include labor market achievements such as wages and job

satisfaction. The statistics are compiled with a view to measure the demographic, employment, international and intra-sectoral mobility, career, and earnings characteristics of Korean doctorate holders of advanced research qualifications at national and international level. This information deals with questions on how well the competencies of the highest educated are used by the society as well as with the attractiveness of different career paths for doctorate holders. Such questions are also of interest at the worldwide level.

The final sample used in this study consists of full-time salaried workers between the ages of 25 and 60 years holding a doctorate degree that have provided valid information for the variables of interest such as wages. Thus, self-employed and unpaid family-employed workers are excluded in this analysis. The selected sample contains 2,832 Korean workers with doctoral degrees. The definition and summary statistics of the full set of variables used in this empirical analysis are presented in Table 1 and Table 2, respectively.

With regards to Korean doctorate holders, some aspects of the data are worth noting at this point. In panel *C* of Table 2, the total respondents in the final sample, 2,463 are male and 369 are female, meaning that male respondents comprise 87% of the sample. About two-thirds of doctorate holders are men. It may indicate that a disproportionate number of female doctorate holders are engaged in economic activities as a full-time worker, suggesting that female doctorate holders' entry into the labor market is not as smooth as that of men in Korea. Indeed, Korean female doctorate holders are less likely to get a job, and even when they do, their jobs rarely meet their education level in the labor market. Regarding fields of graduate studies in panel *D*, the engineering and technology sciences are the most popular field for doctorate (approximately 38%), followed by the social science field (approximately 20%). Approximately 17% of doctorate holders got their degree in natural sciences such as physics, chemistry, or biology. In terms of employment status in panel *E*, not surprisingly, a large majority of doctorate holders (approximately 89%) hold a permanent employment contract, and most of them are employed in a medium-sized or large sized firm (approximately 70%).

Educational mismatch is usually measured as the difference between acquired and required education in the workplace. Individuals are defined as being over-educated if they claim that a lower level of education is most appropriate for the current job of a given individual. Conversely, individuals are deemed to be under-educated if the most appropriate level of education is higher than the level of education actually acquired by a given individual. As noted, since this paper focused on doctorate holders, under-education is generally not possible. Thus, the possible category of educational mismatch is limited to over-education in this empirical analysis. Although the KCDH 2012 survey does not provide direct information on educational requirements for jobs, it contains appropriate questions for measuring over-education and adequately-educated variables. Respondents are allocated different types of matches between education and job according to their responses to the following two questions:

1. *Did you hold a postdoc (temporary research) position?*
 - (1) *Yes, currently*
 - (2) *Yes, in the past*
 - (3) *No*

2. *What was the DESIRABLE education level required for the PRINCIPAL JOB you hold?*
 - (1) *Graduate (or lower) qualification*
 - (2) *Master's degree*
 - (3) *Doctoral degree*
 - (4) *Postdoc*
 - (5) *Other, specify ()*
 - (6) *Unknown*

The response to the first question provides us with information on his/her postdoctoral experience. Those who answer (1) or (2) can be defined as doctorate holders with postdoctoral experience. The second question is used to obtain the definition of educational mismatch (in terms of over-education and under-education). There is a six-point scale with respondents answering that the level of education needed to do the current job are (1) Graduate (or lower) qualification, (2) Master's degree, (3) Doctoral degree, (4) Postdoc,

Table 1
Definition of Variables

Variables	Definitions
<u>Panel A: Dependent Variable</u>	
<i>LNEARNINGS</i>	Log annual wages
<u>Panel B: Socio-Demographic Characteristics</u>	
<i>FEMALE</i>	Dummy variable: 1 if female, 0 if otherwise.
<i>AGE</i>	Workers age (years)
<i>AGESQ</i>	The square of <i>AGE</i> /100
<i>SINGLE</i>	Dummy variable: 1 if single (never married), 0 if otherwise. (Reference group)
<i>MARRIED1</i>	Dummy variable: 1 if married with a spouse, 0 if otherwise.
<i>MARRIED2</i>	Dummy variable: 1 if separated, divorced and/or widowed, 0 if otherwise.
<i>OVERSEAS</i>	Dummy variable: 1 if doctoral degrees overseas, 0 if otherwise.
<u>Panel C: Human Capital Endowments</u>	
<i>TENURE</i>	Workers job tenure in the current occupation (expressed in years)
<i>TENURESQ</i>	The square of <i>TENURE</i> /100
<i>SCI</i>	Dummy variable: 1 if majored in natural science, 0 if otherwise.
<i>ENGI</i>	Dummy variable: 1 if majored in engineering and technology, 0 if otherwise.
<i>SOCIAL</i>	Dummy variable: 1 if majored in social science, 0 if otherwise.
<i>HUMAN</i>	Dummy variable: 1 if majored in humanities, 0 if otherwise.
<i>AGRI</i>	Dummy variable: 1 if majored in agriculture, 0 if otherwise.
<i>MEDI</i>	Dummy variable: 1 if majored in medical and health sciences, 0 if otherwise. (Reference group)
<u>Panel D: Employment Characteristics</u>	
<i>PERT</i>	Dummy variable: 1 if permanent employment contract, 0 if otherwise.
<i>PRIVATE</i>	Dummy variable: 1 if employed in the private sector, 0 if otherwise. (Reference group)
<i>PUBLIC</i>	Dummy variable: 1 if employed in the public sector, 0 if otherwise.
<i>ACADEMIC</i>	Dummy variable: 1 if employed in academic institutes, 0 if otherwise.
<i>SMALL</i>	Dummy variable: 1 if a firm has less than 300 employees, 0 if otherwise. (Reference group)
<i>MEDIUM</i>	Dummy variable: 1 if a firm has 300 to 999 employees, 0 if otherwise.
<i>LARGE</i>	Dummy variable: 1 if a firm has more than 1,000 employees, 0 if otherwise.
<u>Panel E: Educational Mismatch</u>	
<i>OVER_EDU</i>	Dummy variable: 1 if the worker is over-educated, 0 if otherwise.
<i>WELL-MATCHED</i>	Dummy variable: 1 if the worker is well-matched in education, 0 if otherwise. (Reference group)

Table 2
Summary Statistics

Variables	Mean	Standard Error
Panel A: Dependent Variable		
<i>LNHRW</i> (The natural logarithm of hourly wages)	10.574	0.014
Panel B: Educational Mismatch		
<i>OVER_EDU</i> (Over-Education)	0.436	0.009
<i>MATCH_EDU</i> (Adequately educated)	0.564	0.009
Panel C: Socio-Demographic Characteristics		
<i>FEMALE</i> (Female Workers)	0.130	0.006
<i>AGE</i> (Workers Age; years)	50.458	0.150
<i>AGESQ</i> (The square of <i>AGE</i> /100)	26.093	0.147
<i>MARRIED1</i> (Married with a Spouse)	0.931	0.005
<i>MARRIED2</i> (Separated, Divorced, and/or Widowed)	0.012	0.002
<i>OVERSEAS</i> (Doctoral Degrees Overseas)	0.239	0.008
Panel D: Human Capital Endowments		
<i>TENURE</i> (Job Tenure; years)	14.375	0.185
<i>TENURESQ</i> (The square of <i>TENURE</i> /100)	3.036	0.061
<i>SCI</i> (Natural Science)	0.170	0.007
<i>ENGI</i> (Engineering and Technology Sciences)	0.379	0.009
<i>SOCIAL</i> (Social Science)	0.197	0.007
<i>HUMAN</i> (Humanities)	0.087	0.005
<i>AGRI</i> (Agriculture)	0.040	0.004
Panel E: Employment Characteristics		
<i>PERT</i> (Permanent employment contract)	0.893	0.006
<i>PUBLIC</i> (Public sector)	0.200	0.008
<i>ACADEMIC</i> (Academic Institute)	0.584	0.009
<i>MEDIUM</i> (Medium-sized firm)	0.313	0.009
<i>LARGE</i> (Large-sized firm)	0.387	0.009
Sample Size (Observations)	2,832	

(5) Other, and (6) Unknown. If individuals without postdoctoral experience select 1 or 2, on the scale, they are classified as over-educated, while those selecting 3 on the scale are considered to be education-matched (the reference group). Similarly, if individuals with postdoctoral experience select 1, 2 or 3 on the scale, they are classified as over-educated, while those selecting 4 on the scale are considered to be education-matched. Individual claiming 5 or 6 on the scale are excluded in the regression analysis.

Groot and van den Brink (2000) noted that the following four measures of educational mismatch are used in the existing literature: (1) Direct self-assessment; (2) Indirect self-assessment; (3) Job analysis; and (4) Realized matches. The choice of measurement method is based on the availability of data. To determine whether the worker is mismatched in education, most previous studies have focused on subjective definitions such as direct self-assessment or indirect self-assessment (e.g., Duncan & Hoffman, 1981; Rumberger, 1987; Hartog & Oosterbeek, 1988;

Sicherman, 1991; Cho & Lee, 2014; Park & Shahiri, 2015). Subjective definitions are based on individual workers' self-assessments on their level of education and its utilization. Each worker is asked directly to indicate their perception regarding the difference between their actual level of education and the required level of education to perform their job for measuring educational mismatch. Objective definitions are based on expert's job analysis or realized matches. In the job analysis method, educational mismatch is defined by comparing the current educational level and the level of education required by firms for a given position. Realized matches measure the difference between years of education attained and the dominant level of education observed in the worker's current occupation. For instance, individuals are classified as over-educated if the observed number of years of education is more than one or two standard deviation from the mean in the occupation for the reference population.

Similar to most earlier studies, the current analysis also relies on individual's self-assessment of job qualifications, which provides education norms directly at the local level. Objective methods (i.e., job analysis or realized match) are difficult to be implemented on the basis of the KCDH data. A potential criticism of the procedure employed in this paper is that such measure is based on the subjective evaluation of the individuals being examined. Several existing studies, however, provides important findings concerning the reliability of self-reported measures. For instance, Jones and Sloane (2010) argued that no clear evidence exists that workers consistently overestimate or underestimate their own skills or demand regarding the extent to which their present employment position requires the level of skills they possess. Di Pietro and Urwin (2006) also claimed that the self-reported "subjective" measures of education and skill mismatch are reliable compared to the jobholder's judgment concerning the degree of utilization of workers' knowledge and skills. Chevalier (2003) particularly emphasizes that the subjective method has the advantage of adjusting the measure of over-education to the specific requirements of the job, while job analysis and realized matches methods assume that all the jobs within a given occupation have the same requirements. These assumptions are obviously

naive in those occupations where workers are hired for flexible tasks (Groot, 1996). Most importantly, as pointed out by Hartog (2000), the basic relationship between educational mismatch and wages does not appear to be influenced by the measurement method, which indicates the robustness of the results for the different types of measures. Therefore, self-reported measures are considered reliable and are viewed as capable of producing reliable results in relation to the issues examined in this paper. In other words, the individual's subjective assessment would be expected to provide the substance (important information) of this study, even though it could generally be the weakness of the study.

In the literature on educational mismatch, there are two basic empirical specifications which are considered modified specifications of the semi-logarithmic Mincer equation. The first one is the ORU (ORU is an abbreviation for Over-education, Required education, and Under-education) specification introduced by Duncan and Hoffman (1981) and the second one is the dummy variable specification introduced by Verdugo and Verdugo (1989). The ORU specification decomposes the education variable (i.e., actual years of education) into years of required education and years of surplus (i.e., years of over-education), or deficit of education (i.e., years of under-education). The Verdugo and Verdugo model defines over-education and under-education as dummy variables. The over-education and under-education dummies are typically created by the response to survey questions that directly ask workers about the comparison between their attained level of education and the level of education required for the job they hold. Due to the limitation of data availability on years of schooling, this paper considers the Verdugo and Verdugo specification in which over-education is defined as a dummy variable. Following the Verdugo and Verdugo model, the empirical model can be written as:

$$\ln Y_i = \beta X_i + \delta OVER_EDU_i + \mu_{it} \quad (1)$$

where i is the index individuals. The dependent variable $\ln Y_i$ is the log of hourly wages of the individual worker i . X_i is a vector of time-vary ingregressors including socio-demographic variables, human

capital endowments, and employment characteristics such as gender, marital status, field of study, and permanent employment contract. *OVER_EDU* is a dummy variable taking the value of 1 if a worker is over-educated in the workplace and 0 otherwise. β is vector of unknown parameters to be estimated. The coefficient δ represents the average wage effects of over-education in comparison to their adequately educated counterparts. μ_{it} is a conventional mean zero disturbance. This model is the extended version of the Mincerian wage equation. We control for a number of socio-economic characteristics (gender, age, marital status, study abroad), discipline indicators (natural science, engineering and technology, social science, humanities, agricultural science), employment characteristics (permanent employment contract, firm size), type of work (public sector, academic sector), and an indicator variable for over-education.

According to Eq. (1), over-educated workers are compared to adequately matched workers (i.e., workers with the same level of education who work in jobs that require their attained level of education). In order to explain the wage effects of over-education, it has become conventional to use assignment theory proposed by Sattinger (1993) in the over-education literature. This theory emphasizes that both individual (supply) and job (demand) characteristics of the labor market should be taken into account when explaining wage differentials. According to the assignment theory model, the actual level of productivity realized is determined by the match between acquired and required levels of human capital, although higher average human capital raises overall productivity in general. Thus, the returns to investments in human capital vary dramatically with the quality of the match between the worker and the job. If marginal productivity and wages are affected by the education level required to perform a particular job, all levels of education exceeding the required amount would be unproductive and the reward to the additional education would be zero (Bauer, 2002). In this context, over-educated workers who are working below their own level are in the case of less productive than adequately matched workers who are working at their own level, not because they on average have less education to begin with, but because

the job imposes limitations on their productivity. The lower level of the job in effect imposes a ceiling on the worker's productivity, resulting in lower wages. Consequently, an over-educated worker would earn lower wages than a similar worker with the same level of education who is adequately allocated to a job and δ would be negative: $\delta < 0$.

Another theoretical explanation stems from the human capital theory (Becker, 1964). Contrary to the Assignment Theory model, productivity and wages are solely determined by the actual level of education and, thus, the coefficient δ is expected to be zero: $\delta = 0$. This supply-side oriented approach takes into account only differences in individual characteristics when explaining wage differentials. Under such circumstances, an individual's particular level of education provides a certain level of productivity regardless of the job in which that individual works, and thus workers are rewarded according to their marginal product determined by the level of education they have accumulated rather than their job characteristics.

The conceptual framework employed in this paper is based on the assignment theory model. The current study thus attempts to examine whether the central premise of the assignment theory literature carries across to the analysis of over-education among doctorate holders in the Korean labor market. The main hypotheses addressed in this paper areas follows:

Hypothesis 1: The over-education among doctorate holders has a significant impact on wages in the Korean workplace.

Hypothesis 2: The wage returns to over-education (education under-utilization) are negative (i.e., the wage penalty).

Even though this paper does not employ longitudinal data, the hypotheses above can be tested using our nationally representative dataset, the KCDH 2012. If the assignment theory is valid in this study, then over-educated workers are under utilizing their knowledge or qualifications, resulting in a wage penalty (i.e., $\delta < 0$).

Results

The aim of this section is twofold. First, we show key findings regarding the incidence of over-education among doctorate holders at an aggregate level. Second, this study examines the wage effects of over-education among doctorate holders in the Korean labor market. The means of the reported shares of over-educated and adequately educated workers are presented in panel *B* of Table 2. The table shows that the overall proportion is approximately 44% for the share of over-educated workers and 56% for the share of adequately educated workers among Korean doctorate holders. These figures indicate that at least four out of 10 doctorate holders are over-educated in the Korean labor market. It suggests that the share of over-educated workers among doctorate holders is non-negligible in the Korean labor market, although it appears that adequately educated workers are over 50% of Korean doctorate holders.

Table 3 provides the results on the wage effects of over-education for doctorate holders in the Korean labor market. In regards to hypothesis testing for coefficients, the *F* specification test rejects the null hypothesis that all slope coefficients in each regression are different than zero at all conventional significance levels. While coefficients estimates are based on a large number of control variables, most of the empirical findings presented here are consistent with the results found in conventional wage estimations. As regards the wage effects of over-education in panel *A*, the empirical finding is in line with the previous ones in the over-education literature: the over-education (*OVER*) is typically found to have negative effects on wages: (i.e., the wage penalty). Turning to the socio-demographic characteristics in panel *B*, the results show that female doctorate holders (*FEMALE*) are paid less than their male counterparts in the Korean workplace. This result suggests that the female workers with a doctorate degree earn approximately 11.1% less than their male counterparts in the Korean workplace. Age shows the standard concave pattern with wages. Strong age effects exist with positive and negative signs on the linear (*AGE*) and quadratic terms (*AGESQ*). The job tenure (*TENURE*) is also consistent with findings of most existing studies: years of job

tenure has positive returns. In terms of fields of study in panel *C*, most variables except humanities majors (*HUMAN*) are negative and statistically significant effects on wages given the omitted group (*MEDI*; majored in medical and health sciences). Regarding employment characteristics in panel *D*, a finding is as expected for the indicator for the permanent employment (*PERT*) accounts for the wage premium. Given omitted category (*PRIVATE*; working in private sector), there exists a sizable negative wage differential in favor of doctorate holders working in public sector (*PUBLIC*) or academic institutes (*ACADEMIC*) such as a university. The wage level is significantly large who are working in relatively large firms (*MEDIUM*, *LARGE*).

Discussion

It is generally difficult to validate the means of the reported shares of over-educated workers among doctorate holders shown in panel *B* of Table 2 due to a lack of comparable information. This proportion of over-educated workers, however, appears comparable to or larger than the overall shares reported by other existing studies of graduate over-education. For instance, Green and Zhu (2010) found that the proportion of over-educated workers is ranging between 23% and 33% among U.K. graduates. This pattern is also consistent with the findings of Frenette (2004) showed that at least 30% of Canadian graduates are over-educated. For Australian graduates, Mavromaras et al. (2013) provided rates of over-education ranging between 14% and 23%. These results suggest that our findings presented in this article clearly reflect a considerable level of over-education among doctorate holders in the Korean labor market. The phenomenon of highly educated workers accepting lower quality jobs may cause troubles for jobseekers with relatively lower education levels. If doctorate holders apply for jobs that require only university graduates, university graduates will be pushed out and will instead have to be satisfied with jobs that require a college degree, resulting in college graduates applying for jobs that only require high school graduates.

As noted, our regression specification with a single dummy for over-education is a special case of

Table 3*The Wage Effects of Over-Education Among Doctorate Holders in Korea*

Variables	Coefficient	Standard Error
Panel A: Educational Mismatch		
<i>OVER_EDU</i> (Over-Education)	-0.067	0.029**
Panel B: Socio-Demographic Characteristics		
<i>FEMALE</i> (Female Workers)	-0.118	0.044***
<i>AGE</i> (Workers Age; years)	0.068	0.020***
<i>AGESQ</i> (The square of <i>AGE</i> /100)	-0.047	0.018**
<i>MARRIED1</i> (Married with a Spouse)	0.088	0.065
<i>MARRIED2</i> (Separated, Divorced, and/or Widowed)	0.145	0.136
<i>OVERSEAS</i> (Doctoral Degrees Overseas)	0.015	0.032
Panel C: Human Capital Endowments		
<i>TENURE</i> (Job Tenure; years)	0.013	0.005**
<i>TENURESQ</i> (The square of <i>TENURE</i> /100)	-0.040	0.016**
<i>SCI</i> (Natural Science)	-0.159	0.049***
<i>ENGI</i> (Engineering and Technology)	-0.112	0.044**
<i>SOCIAL</i> (Social Science)	-0.088	0.048*
<i>HUMAN</i> (Humanities)	-0.063	0.060
<i>AGRI</i> (Agriculture)	-0.196	0.074***
Panel D: : Employment Characteristics		
<i>PERT</i> (Permanent employment contract)	0.275	0.056***
<i>PUBLIC</i> (Public sector)	-0.294	0.042***
<i>ACADEMIC</i> (Academic Institute)	-0.211	0.038***
<i>MEDIUM</i> (Medium-sized firm)	0.080	0.035**
<i>LARGE</i> (Large-sized firm)	0.096	0.033***
Constant	8.208	0.469***
Sample Size (Observations)	2,832	
R-squared (R2)	0.144	
Adjusted R2	0.138	
F (19, 2696)	23.81	

Note: *** p<0.01, ** p<0.05, * p<0.1.

the Verdugo and Verdugo model which includes both dummies for over-education and under-education. In addition, the analysis is based on the OLS estimation method using a sample of full-time salaried workers with doctoral degrees. In this context, the coefficient on an over-education dummy in Eq. (1) can be interpreted as the average wage effects of being over-educated in comparison to those who are adequately educated. Therefore, the negative coefficient of over-education (*OVER*) presented in panel *A* of Table 3 means that over-educated workers earn less than adequately educated workers, but the return to over-education is not negative. This is based on the basic idea that the actual level of productivity realized is determined by the mismatch between education and job level (i.e., assignment theory), although higher-level education raises productivity in general. Specifically, our results suggest that the over-educated workers earn approximately 6.5% less than workers with the same amount of education who are working in jobs which fully utilize their education level (i.e., adequately educated workers).

Empirical evidence presented in this article basically confirms assignment theory as follows: wages are allocated based on a combination of workers' characteristics and job characteristics. According to the assignment theory, there exists a certain qualification level required for a job irrespective of the attributes of individual employees who are employed in it, and individual workers are then assigned to these jobs based on their characteristics. There is an allocation problem in assigning heterogeneous workers to jobs which differ in their complexity. If the employers' demand for different levels of qualifications is not matched by equivalent levels of supply of qualifications, some mismatch in the labor market is inevitable (Mavromaras et al., 2010). Under such circumstances, the actual level of productivity (i.e., returns to investment in education) is determined by the quality of the match between the workers and the jobs. Working in a job below one's qualification level may impose limitations on the worker's productivity (i.e., qualification under utilization of measured by over-education).

Recently, some attempts have been made towards incorporating search frictions into assignment

models, for example, Sattinger (1995). The model developed by Sattinger (1995), for instance, shows how wages can vary depending on over-qualification or under-qualification. Similar wage differences can be generated in a model of overlapping labor markets (Sattinger, 2006). Connections between mismatches and the underlying assignment problem are discussed by Allen and Van der Velden (2001), Bédoué and Giret (2011), Borghans and De Grip (2000), Green and McIntosh (2007), Hartog (2000), Mavromaras and McGuinness (2007), McGuinness (2006), and Sloane (2003).

Conclusion

Using KCDH, this study attempts to examine the incidence and wage effects of over-education among the most highly educated workers (i.e., doctorate holders) in the Korean labor market. Most prior research addressing the topic of over-education mismatch focuses on university graduates, while the analysis of microdata on doctorate holders has received relatively little attention in the literature. This asymmetry is in part due to information which has only recently available in a limit range of dataset. In this paper, we draw on a unique dataset containing information on a cohort of Korean doctorate holders in the labor market. Based on the Verdugo and Verdugo (1989) model, the main empirical specification's independent variables include individual socio-demographic, human capital, and employment characteristics (gender, age, marital status, study abroad, discipline field of study, type of work, permanent contract, and firm size), and indicator variables for over-education. The over-education measure is constructed based on the self-reported educational mismatch questions, which asks respondents directly what the level of education required by the current job is, compared to the own level of education in their view.

Overall, the major findings of this study confirm the findings of existing studies. The analysis reveals a worrisome situation in which a non-negligible proportion of doctorate holders face over-education associated with a significant wage penalty in the Korean labor workplace. Approximately 44% of doctorate holders in our sample survey consider themselves as being over-educated. The significant

wage penalty (approximately 6.5%) exists for over-educated workers compared with their adequately matched counterparts. It indicates that over-educated workers earn less than those with the same level of educational attainment but who work in jobs that fully utilize their education. From theoretical perspectives on the labor market mismatch, our results confirm the validity of the assignment theory, which asserts that the returns to additional investment in human capital appear to depend in part on the quality of the assignment of heterogeneous workers to heterogeneous jobs, and, thus, returns to investment in education are limited by how well jobs exploit workers' education.

Countries are investing in their higher education systems, and more people than ever before are completing doctoral degrees. According to a recent OECD report (OECD Science, Technology and Innovation Outlook, 2016), the number of doctoral graduates has significantly increased worldwide in the last two decades. Although the majority of graduates are still from OECD countries (about 74%), large emerging economies have also greatly expanded their higher education training capacities, including at the most advanced tertiary levels. Higher education expansion in countries was partly driven by broader rationales, like scientization, democratization, and the expansion of human rights (Schofer & Meyer, 2005). As a result, higher education systems have faced a challenge in accommodating the growth in student numbers in the existing higher education system and, further, in the labor market. In this perspective, the results presented in this paper may very well apply to other countries that have experienced a similar increase in the supply of doctorate holders.

As noted, some mismatch in the labor market is inevitable because the labor market involves complex decision-making by workers and employees and depends on many external factors. However, high and persistent labor market mismatch may be costly for workers, employers, and society at large. This study finds that many doctorate holders are employed in jobs that do not require a Ph.D. degree and in which the skills they obtained are not being fully used. According to our analysis, over-education is a more serious issue for doctorate holders since its incidence appears to be higher in Ph.D. recipients than in college

or university graduates. Our results also suggest that an over-education condition exerts a negative influence on individual returns to education (i.e., the wage penalty). Furthermore, unused skills result in a partial loss of the investment in education. A large portion of the money spent on Ph.D. education of a student that ends up in a non-Ph.D. job is wasted. The student has also wasted several years of his/her life on acquiring skills that he/she does not utilize to earn a living. These results allow policymakers to better understanding the effects of over-education and provide some useful insight into the evaluation of the career outcomes of doctoral graduates in a context where such a rapid expansion of doctoral studies has been observed.

From the societal point of view, doctorate holders represent a key element for innovation and for the generation of new knowledge in the economy (Auriol, 2010). The group of Ph.D. holders is also important from an economic perspective since they are a key factor to foster long-run economic growth in a knowledge-based economy (Romer, 1990). Considering that doctorate holders are often thought to be critical for technological progress and growth in the knowledge economy, the generally observed negative impact of over-education among doctorate holders may be costly and prevent the adoption of new technologies, even when adjustment takes places. Consistent with this perspective, if a doctorate holder cannot find a job that allows her/him to fully exploit his education and skills, this has to be considered detrimental for the society as a whole.

All of this suggests that policymakers should be more concerned about the evidence of widespread over-education, which is likely to be harmful to the welfare of employees and to the interests of employers and society. One focus of concern should be the aggregate imbalance between the stocks of doctorate holders and of Ph.D. level jobs, thus ensuing an influx of highly qualified workers into the labor market is a necessary condition for helping firms to move towards high value added product strategies (Gaeta et al., 2017). To fully exploit the productive and innovative potential of doctorate holders, employers also need to adopt human resources strategies that maximize the skills and capabilities of Ph.D. recipients. These should include efforts to improve hiring practices to ensure that there

is a good match between employees and the jobs they do. Government agencies should monitor Ph.D. level jobs and enhance data-gathering initiatives, including employer-employee surveys on job mismatch in the workplace. Such information should help employees and employers make decisions about career, education, training, and employment.

The current study has limitations that need to be acknowledged. First, the evidence presented in this paper may very well apply to other countries that have experienced a similar increase in the supply of doctorate holders. However, the results of this study indicate the need to test whether the existing results on the labor market effects of over-education for various countries because the data used in the analysis relates to only one country, namely Korea. In addition, this paper is constrained by the absence of panel data based on various longitudinal surveys which would have allowed for controls on various unobserved individual-specific characteristics, such as innate ability or employability. Future research, thus, may investigate whether the results of the wage effects of over-education among doctorate holders based on the conventional OLS estimation method are changed when one controls for unobserved individual heterogeneity using panel estimation techniques (see Bauer, 2002; and Tsai, 2010, for details).

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