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Discrimination: A Threat to Economic Growth

Deriving a Neoclassical Growth Model with Human Capital Barriers

Erika Hansson and Ebba Wallin

Lund University School of Economics and Management

Department of Economics

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Supervisor: Pontus Hansson

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Abstract

This paper was set out to examine how discrimination lower incentives to attain human capital throughout different societal sectors and, thus, how human capital barriers affect economic growth. We aim to derive a generalized theoretical framework that is applicable to any group facing discrimination. Our secondary purpose is to apply the generalized theoretical framework to women and men in Sweden from the period 1965 to 2015 in order to concretize the model and test it in practice. A general neoclassical growth model is constructed, which includes discrimination causing barriers to human capital accumulation. The barriers to human capital attainment affect the *discriminated groups'* decision to acquire human capital. The discrimination consists of *occupation-specific wage differences*, *wage differences when holding the same level of education*, *discrimination in the schooling sector*, *over-education*, and *socioeconomic differences*. Relevant data on wages, occupation, and education are collected from Statistics Sweden, while data on national accounts are collected from Penn World Tables. When applying the model to the Swedish sample, findings suggest that changing discrimination accounts for 43 percent of the growth in output per worker. A decline in discrimination is discovered when estimating the model. Further, the estimated output per worker is in line with the actual output per worker observed in the period, suggesting that the model is appropriate. The results support the common view that human capital is a source of economic growth.

Keywords: Discrimination, Human Capital, Neoclassical Growth Model, Education

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1. Introduction

Protection against discrimination is constituted in the United Nations declarations of Human Rights. Multiple countries have anti-discrimination regulations, such as the Civil Rights Act in the U.S., and the Promotion of Equality and Prevention of Unfair Discrimination Act in South Africa. In 1979 in Sweden, the Equality Act was established (Landsorganisationen, 2013)[1], and Sweden has continually been at the top of the European Institute's Gender-Equality Index (European Institute for Gender Equality, 2021). Globally, however, the situation is not as bright as in the case of Sweden. For example, in Madagascar, women are not allowed to work at night. In the U.S., only 18 percent of the cases reported to the Equal Employment Opportunity Commission are processed, and in India, crimes against members of the Dalit community often go uninvestigated as crimes targeted at this group are not taken seriously (Amnesty International, n.d.). Discrimination is still persistent worldwide, and inequalities are rising (United Nations, 2014). The consequences of discrimination affect the individual's mental and material well-being. In addition, discrimination can threaten economic development, considering it prevents an efficient allocation of human capital (Hsieh, Hurst, Jones & Klenow, 2019). Therefore, our study will focus on discrimination and its effects on economic growth.

Talent is assumed to be equally distributed across different sections of society, implying that all groups should have equal possibilities to attain education and hold specific occupations (Hsieh et al., 2019). Although an equal distribution of talent exists, an equal distribution of educational possibilities does not, implying that inefficient allocation of talent and missed opportunities for economic development occur. Different types of discrimination affect the unequal distribution of possibilities (Hsieh et al., 2019). An efficient allocation of talent can be considered a state where every person is positioned where he or she performs best, a state that is impossible to reach when some individuals face human capital barriers in the form of discrimination (Strensze, 2013). Barriers to human capital influence the economy negatively because human capital is emphasized as a source of economic growth by, for example, Lucas (1988) and Mankiw, Romer, and Weil (1992).

Developing countries exhibit that economic gains from educating females are more extensive than from educating males, both in higher productivity and faster growth (Wolfensohn, 1995).

[1]The Swedish Trade Union Confederation.

Educating females reduces fertility, increases life expectancy, and has a significant positive relationship with children's educational attainment (Knowles, Lorgelly & Owen, 2002; Wolfensohn, 1995). In the U.S., Mexican origin families are the most disadvantaged in terms of educational challenges. Higher poverty rates, lower educational attainment amongst parents, and language barriers create an unfavorable environment for educational success (Ackert, Ansari, Crosnoe & Ressler, 2019). Talented individuals are disadvantaged, hence, efficiency losses such as inefficient allocation of talent appear. A similar situation exists for refugee groups. Students with refugee backgrounds face fewer opportunities to access higher education and reduced possibilities to attain education at prestigious institutions (Mifsud, Naylor, Nguyen, Rizzo & Terry, 2019).

Further, the material possessions a child is born with determine how one's talent is developed. If there are costs associated with attaining education, such as tuition or different opportunity costs, wealthier families will find education cheaper in terms of utility. As a result, untalented individuals from more prosperous families will be educated while talented individuals with disadvantaged backgrounds will lose out, creating economic losses (Chiu, 1998).

1.1 Purpose

In light of human capital's importance for economic development and the potential barriers preventing its accumulation, our study aims to explore the relationship further by creating a generalized model. The model explains how discrimination affects different sections of society's ability to gain human capital and how discrimination affects economic growth. We construct the theoretical framework as a neoclassical growth model, inspired by the model created by Mankiw, Romer, and Weil (1992). Our model incorporates two groups: the *reference group* and the *discriminated group*. The *discriminated group* comprises the group of interest facing human capital barriers, while the *reference group* comprises the remainder of society. In the model, five different components of discrimination causing human capital barriers are included. The five components are *occupation-specific wage differences, wage differences when holding the same level of education, discrimination in the schooling sector, over-education,* and *socioeconomic differences*.

Our secondary purpose is to exemplify the usage of the theoretical model by applying it to women and men in Sweden from 1965 to 2015. Data on education, wages, and occupations are collected and digitalized from Statistics Sweden (SCB) to carry out the estimations. Data on national accounts are collected from Penn World Tables, version 10.0 (Feenstra, Inklar & Timmer, 2021).

1.2 Definition of Discrimination

The term discrimination is used throughout the paper to describe different human capital barriers affecting economic development. The concept of discrimination embodies a wide range of different types of injustice affecting various groups. There is, for example, discrimination in the legal system, in the health sector, and in the labor market. Discrimination is of different types and is targeted at, for example, specific age groups, different nationalities, sex, or people with different disabilities (U.S. Equal Employment Opportunity Commission, n.d.). When considering the effects of discrimination on the economy, discrimination in the labor market and human capital attainment is often of the most interest (Hsieh et al., 2019). Hsieh et al. (2019) found that human capital barriers had the most significant effect on economic growth, justifying a focus on discrimination affecting human capital. Thus, our paper's human capital barriers are *occupation-specific wage differences, wage differences when holding the same level of education, discrimination in the schooling sector, over-education,* and *socioeconomic differences*. However, we are well aware that discrimination can be of many other types and have consequences on the individual's mental and material well-being.

1.3 Structural Overview

A portrayal of the current opinion on human capital barriers and their influence on the economy commences our analysis. Section 2, covering previous research, will primarily focus on different human capital barriers. Our model aims to explain how different barriers to accumulating human capital affect economic development, and thus, the barriers discussed in Section 2, Previous Research, are of interest. Further, in Section 3, the theoretical framework and the derivation of the model are introduced. Data and estimations are presented in Section 4, followed by the results of the estimates and discussion in Section 5. Lastly, our conclusions are explained and presented in Section 6.

2. Previous Research

The effects of human capital on economic growth have frequently been discussed in the macroeconomic literature since Becker (1962) initially founded the human capital accumulation theory. Whereas most studies promote a positive relationship between human capital and economic growth (see, for example, Hawkes & Ugur, 2012; Pelinescu, 2015; Schultz, 1963), the area of inefficient allocation of talent as a result of human capital barriers has not been explored to the same extent. Several dimensions such as gender inequality, parental attitudes, discrimination in the schooling sector, and wealth can capture human capital barriers and inefficient allocation of talent (Guironnet & Peypoch, 2007; Hsieh et al., 2019; Silva & Klasen, 2021; Weir, 2010). The literature review will touch upon these elements to advocate for the content of our measure of human capital barriers and the contribution and importance to the already existing research.

2.1 Parents' Attitudes

A substantial factor to include when addressing human capital in terms of education is parents' attitudes towards school. Parents' attitudes and perceptions are mostly unobservable, but they might be correlated with observable variables and are essential to investigate. The risk of a correlation like this could potentially result in omitted variable bias (Weir, 2010). Weir's (2010) research suggests that differences in attitudes could be one component of explaining parents' enrolment decisions for their children and recommend using social policies to influence and improve the attitude. Melnick and Fiene (1990) have another take on parents' attitudes towards school and underline the importance of involving parents to a greater extent in school activities, which would give a more positive attitude. Parents' positive attitude results in higher achievement scores for their children, interpreted as higher human capital. Despite different angles, both Melnick and Fiene (1990) and Weir (2010) agree that parents' attitudes have a crucial impact on the students' schooling effectiveness. Gorman (1998) includes social class when addressing families' resistance and conformity to schooling and declares how the middle class takes for granted that their children want to attend a university or college education. Parents of the middle class make great sacrifices to guarantee attendance and put effort into shaping their children's education. The results from working-class parents were more diversified and broad, stretching from a similar approach demonstrated by middle-class families to rejection of higher education.

Parents' attitudes are not necessarily a discrimination component but can be a barrier to human capital accumulation since it captures an underlying socioeconomic effect that affects the precondition to attaining human capital. However, parents' attitudes could have a discriminating impact if the parents treat their children differently depending on, for example, the child's gender (Altonji & Blank, 1999).

2.2 Occupational Choice

Cuberes and Teignier (2016) investigate the quantitative effects of gender gaps on income and aggregated productivity by simulating an occupational choice model. Cuberes and Teignier (2016) designed their model to uncover the negative impact on aggregate productivity and income per capita resulting from gender inequality in the allocation of talent. The model includes exogenous labor frictions that only concern women. While men are unrestricted to choose an occupation based on their talent, women's choice of profession is limited and therefore independent from their initial endowment of entrepreneurial talent, causing frictions in the labor market. These frictions would then reduce both aggregated productivity and income per capita. Their model predicted a 10 percent drop in income per capita if all women were excluded from entrepreneurship, arguing for a significant effect on the allocation of resources due to gender inequality. The results align with Silva's and Klasen's (2021) research on how gender inequality barriers affect economic growth. Silva and Klasen (2021) argue in the same sense as Cuberes and Teignier (2016) that if women do not have access to the labor market, the economic efficiency will decrease. However, Silva and Klasen (2021) take the analysis one step further by explaining the restrictions of gender discrimination in the labor market, which will misallocate talent and lower incentives for female human capital establishment. Silva and Klasen (2021) conclude that falling discrimination would cause increased efficiency due to a more optimal matching mechanism between individual ability and occupation.

2.3 Over-education

A factor creating frictions in the labor market is over-education, described by Guironnet and Peypoch (2007) as a mismatch between workers and employers. Over-education leads to inefficiency in the economy and is interpreted by Guironnet and Peypoch (2007) as a state where the employee's level of qualification exceeds the requirements for their job. Guironnet's and Peypoch's (2007) findings show that the education surplus decreased in

France from 1987 to 1999 for intermediate and higher occupations but increased for the least skilled jobs. The increase depends on a higher imbalance between salaries and required qualifications leading to a degradation of aggregate productivity (Guironnet & Peypoch, 2007).

2.4 Discrimination in the Schooling Sector

Hsieh et al. (2019) follow Becker's (1957) taste-based discrimination theory where a firm's utility declines as a worker from a group the employer dislikes is hired. Hsieh et al. (2019) extend the theory by replacing the firm with a school that "sells" educational goods to students, who use them as inputs in their human capital. The school owner's utility depends on which groups buy the educational goods, whereas the utility declines when the school provides it to groups the owner dislikes. Hence, discrimination and inequality towards specific groups in the schooling sector are formed. Mifsud et al. (2019) investigate the structural inequality of refugees and how the inequality affects their participation in higher education and identify structural inequality as vertical and horizontal barriers. Students from refugee backgrounds face vertical barriers in fewer opportunities to access higher education and horizontal barriers in reduced possibilities to attain education at prestigious institutions (Mifsud et al., 2019).

2.5 Human Capital Barriers in Previous Research

Discrimination in the labor market can take different forms and is described as a tax on individual earnings in the article "*Allocation of talent and U.S. economic growth*" by Hsieh et al. (2019). The tax is modeled together with human capital barriers, which also is created as a tax, and group-specific preferences with the ambition to reveal how some groups do not pursue their comparative advantage even though they are innately talented. The authors use an occupational-specific Roy model, whereas the outcome leads to a misallocation of talent, yielding economically aggregated and individual consequences. Hsieh et al. (2019) tested the model on four groups: black men, white men, black women, and white women. Their results show how market GDP per person has had substantially slower growth from the 1960s to 2010 than it would have had without human capital barriers and labor market discrimination. The decline in human capital barriers and labor market discrimination accounted for 42 percent of economic growth during the examined period in market GDP per person and 38 percent in market earnings per person. Group-specific preferences showed only a modest

effect on growth in real earnings per person. In contrast, the declined tax (human capital barriers and labor market discrimination) was the most significant determinant of earnings growth, mainly for women, due to increased gender equality from the 1960s. Hsieh et al. (2019) discovered that falling human capital barriers against women accounted for 33 percent of total GDP per person gains.

Further, Knowles, et al. (2002) investigate the effect of gender inequality on the economy in the article "*Are educational gender gaps a brake on economic development? some cross-country empirical evidence".* Unlike Cuberes and Teignier (2016) and Hsieh et al. (2019), who use occupational specific models, Knowles et al. (2002) use cross-country data and focus on human capital, which consists of three components: health capital (measured as life expectancy[2]), male and female education. Knowles et al. (2002) emanate from a neoclassical growth MRW-model (Mankiw-Romer-Weil model) to obtain the long-run effects of female and male schooling on labor productivity in different countries. Knowles et al. (2002) use a Cobb-Douglas production function, including health capital and female and male education, to investigate the aggregated effects, whereas the variables are modeled separately. The result shows that countries with a higher level of education for females will have a higher level of labor productivity which is in line with the World Bank's view that female education makes a more outstanding contribution to labor productivity than male education does (Knowles et al., 2002).

3. Theoretical Framework

Section 3 presents how the underlying theoretical framework was derived and how it diverges from previous studies. Second, a model specification is displayed, followed by a specification of the measure discrimination and its components. Last, the steady-state equations of the production function's main elements are presented.

3.1 Deriving the Theoretical Framework

The underlying theoretical framework of our analysis is inspired by the article of Hsieh et al. (2019), with some restrictions and modifications. Hsieh et al. (2019) build their model from a household production function, including an employer and an educational side. Instead, our

[2] Life expectancy (according to Wheeler, 1980; Barro and Lee, 1994; Barro and Sala-i-Martin 1995; Knowles and Owen 1995, 1997 cited in Knowles et al. 2002) is a common proxy for the health component of human capital in the literature on economic growth.

model emanates from a modified production function, similar to Knowles et al.'s (2002), which will be explained more in detail in Section 3.2. According to Hsieh et al. (2019), the variable that gives the most considerable economic impact is human capital barriers. Their measure of human capital barriers is calculated from a specific program specializing in deriving different taxes[3].

Following Hsieh et al. (2019), our focus lies on where discrimination had the most significant effect on the economy: human capital barriers, which we will model as a tax. We aim to clarify and simplify the usage of a tax of this kind with the ambition to make it easily applicable to different societal groups. A user-friendly tool is created by focusing on selected components, regarded as of great importance by previous studies. To fulfill the second purpose of our study, we will, in Section 4, impose the tax on women in Sweden from 1965 to 2015.

Our model is inspired by Knowles et al.'s. (2002) MRW-model, but has been modified in the sense that education for males and females has been replaced by human capital for two groups (in our example, women and men). The health stock included in Knowles et al. (2002) production function is not considered in our model as the variable appears to partly proxying from unmeasured country-specific effects. Further, our model does not include a cross-country macroeconomic index as Knowles et al. (2002) do, but it could be extended if such a comparison is wished to be done. Guironnet and Peypoch's (2007) measure of over-education shows how the mismatch between skills and requirements leads to inefficiency in the economy. We have modeled a similar interpretation of friction as a component in our estimate of human capital barriers but instead, focus on the *discriminated group* within specific occupations. To capture the socioeconomic effect on human capital barriers, we have, just as Melnick and Fiene (1990), Gorman (1998), and Weir (2010), constructed a variable for it. The variable focuses on parents' assets and attitudes and positively correlates with human capital. We also include wage differences based on occupation and level of education in the measure of discrimination, see section 3.2.

3.2 Model Specification

Our model follows an MRW-style neoclassical growth model, taking the population growth, savings rate, and technological growth as exogenous (Mankiw, Romer & Weil, 1992). We

[3] See Hsieh et al. (2019a) Supplement to "The allocation of talent and U.S. economic growth", Appendix C D.3.

broaden the concept of human capital to illustrate the *reference group's* human capital versus the *discriminated group's* human capital. Equation (1) illustrates the aggregate production function where Y is real output, K denotes the capital stock, H_D the *discriminated group's* human capital, H_R the *reference group's* human capital, A the level of technology, and L the labor force.

$$Y = K^{\alpha} H_D^{\beta_D} H_R^{\beta_R} (AL)^{1-\alpha-\beta_D-\beta_R} \tag{1}$$

α, β_D, β_R may vary across countries and time, although it is not accounted for in our model due to the ambition to create a generalized model. However, such a specification is possible if desired. It is assumed that $\alpha + \beta_D + \beta_R < 1$, implying a decreasing return to all types of capital. $0 < \alpha < 1, 0 < \beta_D < 1$ and $0 < \beta_R < 1$. β_D and β_R are assumed to be equal since it is reasonable to assume the return to schooling to be equal across groups. L and A grows exogenously at rate n and g, see equations (2) and (3).

$$L_t = L_0 e^{nt} \tag{2}$$

$$A_t = A_0 e^{gt} \tag{3}$$

K, H_D and, H_R are accumulated according to equations (4) to (6). Note that equation (5) includes our measure of human capital barriers, τ. Index D denotes the *discriminated group,* while index R denotes the *reference group*.

$$\dot{K} = s_k Y - \delta K \tag{4}$$

$$\dot{H}_D = s_{hD} Y(1 - \tau) - \delta H_D \tag{5}$$

$$\dot{H}_R = s_{hR} Y - \delta H_R \tag{6}$$

Equation (1) can be written in quantities per unit of effective labor, denoted by lower case letters, see equation (7).

$$y = k^{\alpha} h_D^{\beta_D} h_R^{\beta_R} \tag{7}$$

Accumulation of capital per unit of effective labor, the *discriminated group's* human capital per unit of effective labor, and the r*eference group's* human capital per unit of effective labor are given by equations (8) to (10)[4].

$$\dot{k} = s_k y_t - (n + g + \delta)k_t \tag{8}$$

$$\dot{h}_D = s_{hD} y_t (1 - \tau) - (n + g + \delta)h_D \tag{9}$$

$$\dot{h}_R = s_{hR} y_t - (n + g + \delta)h_R \tag{10}$$

s_k, s_{hD} and s_{hR} are the fractions of real output invested in physical capital, the *discriminated group's* education, and the *reference group's* education. δ is the rate of depreciation, assumed to be constant[5], n and g represent the growth rate of the labor force and the growth rate of technology. The economy's long-term growth rate equals the growth rate of technology, *g*.

3.3 Discrimination in the Model

To include discrimination in the model, we construct the variable τ[6]. τ denotes the barriers to human capital attainment that the *discriminated group* faces, see equation (11). τ incorporate *socioeconomic differences,* Ω*, discrimination in the schooling sector, U, over-education amongst the discriminated individuals,* θ*, differences in return to education in the form of wage, M,* and *differences in occupation-specific wages, W.* Further, the components of τ will be explained in detail.

$$\tau = (1 - WM)\frac{1}{U\Omega}\theta \tag{11}$$

W is the relative wages between the *discriminated group* and the *reference group* in a specific occupation, and *M* captures the difference in wages between the groups when holding the same level of education.

$$W = \frac{1}{O}\sum w_O \tag{12}$$

$$M = \frac{1}{E}\sum m_E \tag{13}$$

[4] For details on calculations, see Appendix 1.
[5] The rate of depreciation is the same for human capital and real capital, a simplifying assumption.
[6] $0 \leq \tau \leq 1$, where 1 = highest level of human capital barriers and 0 = no human capital barriers.

The variables' purpose is to capture the wage gaps that individuals from *discriminated groups* can expect after completing a particular level of education or choosing a specific occupation. If a lower rate of return of education is expected, the incentives to attain a certain education are lowered. The lowered incentives also apply when choosing a specific occupation. *W* and *M* are the sums of *all* relative wages for a specific year based on occupation, w_O, and education level, m_E.

$$w_O = \left(\frac{w_{DO}}{w_{RO}}\right) \tag{14}$$

$$m_E = \left(\frac{m_{DE}}{m_{RE}}\right) \tag{15}$$

Subscript *R* denotes the *reference group*, *D* the *discriminated group*, *O* a specific occupation, and subscript *E* denotes the level of education, see equations (12) to (15).

Discrimination in the schooling sector is expressed through the variable *U,* and is partially inspired by Becker's (1957) taste-based discrimination theory, which is also found in Hsieh et al.'s (2019) theoretical framework. *U* describes the utility that the schooling sector gains from educating individuals from the *discriminated group*. The variable consists of the education sector's profit, π , from educating discriminated individuals and the dislike, *d*, causing lower utility when the educator teaches a student from a disliked group. The utility of the schooling sector is modeled in equation (16), where *I* is the income and *Z* is the cost[7].

$$U_{school} = (\pi - d\ ) = (I - Z - d\ ) \tag{16}$$

Socioeconomic differences include parents' attitudes and the family's economic preconditions. An individual with access to high-quality education will have enhanced talent development. If the training is costly, individuals from wealthier families will find education relatively cheaper, making less talented children from more fortunate families attain education. In comparison, talented children from poorer families are disadvantaged (Chiu, 1998). Further, there is evidence suggesting that the parents' social class and attitude towards education influence the children's behavior (Gorman, 1998) and that the parents' level of education, especially the mother's, has a positive relationship with the child's level of

[7] To make sure that the schooling sector has a positive utility $\pi > d$.

education (Black, Devereux & Salvanes, 2005). The socioeconomic variable is denoted Ω, depending positively on the parents' attitude, σ, and the family's assets, *a*, see equation (17).

$$\Omega = \sigma a \tag{17}$$

The variable capturing *over-education*, θ, demonstrates the friction occurring when an individual is forced to hold a position requiring lower qualifications than the competence the individual has. Over-education causes frictions, creating inefficiency in the economy (Guironnet & Peypoch, 2007). It is more common for women than men to be over-educated, while it is more common for men to be under-educated, causing women to have a lower return on education (Johansson & Katz, 2007). Further, over-education is more common amongst immigrants than natives (Andersson Joona, Gupta & Wadensjö, 2014). The variable capturing over-education depends on unemployment, u_{DO}, and level of education, E_{DO}, see equation (18).

$$\theta = \frac{u_{DO}}{E_{DO}} \tag{18}$$

Subscript *D* denotes the *discriminated group* while subscript *O* denotes occupation.

3.4 Steady-State

In steady-state, equation (8) to (10) gives the following values[8]:

$$k^* = \left(\frac{(s_{hD}(1-\tau))^{\beta_D} s_k^{(1-\beta_D-\beta_R)} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \tag{19}$$

$$h_D^* = \left(\frac{(s_{hD}(1-\tau))^{(1-\alpha-\beta_R)} s_k^{\alpha} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \tag{20}$$

$$h_R^* = \left(\frac{(s_{hD}(1-\tau))^{\beta_D} s_k^{\alpha} s_{hR}^{(1-\alpha-\beta_D)}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \tag{21}$$

Where $\eta = 1 - \alpha - \beta_D - \beta_R$. By substituting equations (3) and (19) to (21) into equation (7) and taking natural logarithms, we obtain equation (22), expressing steady-state output per worker. Equation (22) is our empirical specification, our base model, and will be used for estimation.

[8] For details on calculations, see Appendix 1.

$$ln(\frac{Y}{L})^{*} = lnA_0 + gt + \frac{\alpha}{\eta}lns_k + \frac{\beta_D}{\eta}lns_{hD}(1 - \tau) + \frac{\beta_R}{\eta}lns_{hR} - \frac{1-\eta}{\eta}ln(n + g + \delta) \quad (22)$$

The base model shows the dependence between economic growth per worker and the variables: discrimination, τ, the fraction of real output invested in human capital for the *discriminated group*, s_{hD}, the fraction of real output invested in human capital for the *reference group*, s_{hR}, and the fraction of real output invested in physical capital, s_k. The equation expresses a negative correlation with the discrimination component. The remaining components: technology, *A*, affect the economic growth per worker positively, and the rate of depreciation, δ, affects economic growth negatively. However, the labor force growth, *n,* and the rate of productivity, *g*, have a two-parted effect on the economy.

4. Data

To estimate and test our base model in practice, the framework is applied to Sweden from 1965 to 2015. Every fifth year is considered, e.g., 1965, 1970, 1975. Section 4 begins with presenting data on parameters included in the model. Second, data on national accounts and fundamental growth variables, such as capital stock, the growth rate of the labor force, and real output, are introduced. Lastly, data on the different components of discrimination are presented.

The *discriminated group* is women, while the *reference group* is men. Following Mankiw, Romer, and Weil (1992), $g + \delta$ is assumed to equal 0.05. In Sweden, the growth has been, on average, 2.4 percent per year (SCB, 2017a). Therefore, *g* is assumed to equal 0.024 and δ 0.026. α is assumed to equal ⅓. In line with Mankiw, Romer, and Weil (1992), β is assumed to equal ⅓. Hence, β_D and β_R are assumed to equal ⅙. The parameters are presented in Table 1.

Table 1: *Parameters*

Parameter	Description	Value
β_D	Return to education *discriminated group*	1/6
β_R	Return to education *reference group*	1/6
g	Growth rate in productivity	0.024
δ	Depreciation of human capital and physical capital	0.026
α	Diminishing marginal return	1/3

Data on real output, capital stock, the labor force's growth rate, the fraction of real output invested in physical capital, and human capital is from Penn World Tables, version 10.0, constructed by Feenstra, Inklar, and Timmer (2021). The database is annual and covers the period 1950-2019 for 183 countries. Real output, *Y,* is denoted *rgdpna* in the database and measures real GDP at constant 2017 national prices. Capital stock, *K,* measures capital stock at constant 2017 national prices and is called *rnna* in the database. The growth rate of the labor force, *n*, is retrieved by calculating the population growth, population is denoted *pop* in the database. The notation for human capital, *H,* in the database is *hc* and is based on years of schooling and returns to education. The fraction of real output invested in physical capital, s_k, denoted *csh_i* in the database, is the share of gross capital formation at current PPPs[9].

To proxy technical efficiency, *A,* we use Hall's and Jones' (1999) estimates on *lnA*. We make the same assumption regarding technical efficiency as Knowles et al.'s. (2002) paper. Measuring technical efficiency is troublesome and thus, using the proxy provided by Hall and Jones (1999) is an appropriate solution. Knowles et al. (2002) conducted similar reasoning and assessed that some technical efficiency proxy is better than none. Based on the data provided by Hall and Jones (1999), and ours and Knowles et al.'s. (2002) considerations of the difficulties in measuring the unobservable technical efficiency, we deem the index to be a

[9] The variables are described in Appendix 3.

suitable answer to the issue. We desire, however, that the index problem can be solved in future research.

Data on educational costs is from SCB and is the total cost of schooling in Sweden per year. SCB has published data on educational costs from 2000 and onward, see Appendix 2 for more information regarding data sources. The average growth rate of educational expenses is calculated from 2000 to 2015 and used to estimate the educational cost before 2000, where data on educational costs are missing. In our estimations, we assume that s_{hD} is equal to s_{hR}. The assumption is made because we believe the educational costs per gender to be approximately proportional to the distribution of males versus females in the population. Thus, s_{hD} and s_{hR} are equal to half of the total educational costs divided by real output, *Y*.

Data for estimating different components of τ are collected from SCB's published population and housing censuses, see Appendix 2. The censuses report statistics on, for example, employment, living, and family composition. We estimate the wage ratio between the *discriminated group* versus the *reference group* in a particular occupation, w_o , by creating different occupational categories and distributing the data on employment provided by the censuses, see Table 2.

Table 2: *Occupational categories*

Occupational Category	Example
Immerse tertiary education required	Engineers, physicists, teachers & lawyers
Tertiary education required	Bank clerks, marketers, purchasers & police
Administration and customer service	Postmen, doormen & traffic control
Service, care, and resale	Salespersons, conductors, chefs & waiters
Agriculture and forestry	Farmers, huntsmen & arborists
Construction and manufacturing	Tailors, upholsters, welders & bricklayers
Machine production and transportation	Miners, train drivers & stonecutters
Limited education required	Lighthouse keepers, kitcheners & cleaners
Military	Officers & soldiers

The data on wages used for estimation is in the form of the median wage. For 1980 and 1995, data on median wages and occupations are missing. To solve the issue with missing data, the average wage growth is calculated from 1975 to 1985 and 1990 to 1996. We use the growth rates to obtain estimated values for median wages.

The wage ratio between the *discriminated group* versus the *reference group* for the same years of schooling, m_E, is estimated using data from SCB, see Appendix 2. The databases display the population categorized into six groups depending on their level of education and the associated median wages. The six groups are:

- Pre-high school education (shorter than 9 years in total)
- Pre-high school education (9-10 years in total)
- High school (12-13 years in total)
- Post-high school education (shorter than 2 years, max 14 years in total)
- Post-high school education (more than 2 years, at least 14 years in total)
- P.h.d education or more

SCB has published data on education, and associated median wages from 1990 and onwards, we also found data for 1971. To circumvent the gaps, the average growth in wages from the year 1971 to the year 1990 is calculated. After calculating the growth rate, the median wages for the years 1965, 1970, 1975, 1980, and 1985 are estimated, and thus the gaps are filled.

5. Results and Analysis

To estimate and evaluate the base model, it is applied to women and men in Sweden from 1965 to 2015. We make this application to demonstrate an example of usage of the model. Section 5 presents the results of the application and provides a discussion about them. Firstly, the development of discrimination, τ, is presented and analyzed. Secondly, a presentation of the results of our base model and a comparison with the actual observed data follows. Further, the base model is compared to a model where discrimination, τ, is kept constant and a model without any discrimination. Lastly, our results are set in the broader concept and contrasted with previous research.

5.1 Discrimination

In our estimations, the primary variable of interest is τ, the variable capturing discrimination. The variable is estimated according to equation (11). Some components of the variable are unobservable and, thus, difficult to estimate. As a result, we estimate τ based on data provided for m_E, the wage ratio between the *discriminated group* versus the *reference group* when holding the same level of education, and w_o, the wage ratio between the *discriminated group* versus the *reference group* in a certain occupation. The values for τ are reported in Table 3. In the period investigated, discrimination decreased from 0.54 in 1965 to 0.19 in 2015, which equals a 46 percent decrease. Thus, barriers to human capital accumulation facing women in Sweden decreased over the years but still exist.

The most dramatic change in discrimination happened between 1990 to 1995. Both m_E and w_O changed considerably with approximately 15 versus 9 percentage points between these years. In the years following 1995, both m_E and w_O remain similar, which we can observe in the relatively stable value of τ, see Table 3.

Table 3: *Discrimination*

Year	Discrimination, τ
1965	0.54
1970	0.54
1975	0.47
1980	0.46
1985	0.45
1990	0.40
1995	0.21
2000	0.24
2005	0.23
2010	0.22
2015	0.19

The increase in m_E implies that the return to education for women increased between 1990 to 1995. During the 1990s in Sweden, women passed men in the level of education, the amount of unpaid work performed by women decreased, and new reforms on childcare and parental leave were implemented, raising the incentives for women to work (Statens Offentliga Utredningar, 2005)[10]. The developments can possibly explain the decrease in discrimination. However, some of the consequences of the new reforms had likely a lagged effect because changes in behavior take time to implement. The financial crisis in Sweden could have somewhat opposed the lagged effect at that time. When a larger part of the population behaves in a non-Ricardian manner, which is likely the case during a crisis when the population is economically constrained, economic and social reforms have more pronounced effects (Romer, 2019). However, although the incentives to work increased due to the new reforms, the rate of return on education for women remained lower than for men during the 1990s (Statens Offentliga Utredningar, 2005).

The unobservable aspects of discrimination, *socioeconomic differences,* Ω *, discrimination in the schooling sector, U,* and *over-education amongst the discriminated individuals,* θ*,* cannot be estimated. However, the potential impact of the components can be discussed. The component *socioeconomic differences,* Ω, have likely risen in the investigated period, causing τ to fall. Since the 1950s, the population identifying as the working class has decreased, and the middle class has increased (Engström, 2004). A larger middle class will both increase parents' assets, *a,* and parents' attitudes, σ, see section 2.1. Thus, it is reasonable to assume that *socioeconomic differences,* Ω, have risen. Further, admittance to universities and tertiary studies in Sweden is handled by a public authority that bases its decisions on grades and prior knowledge (Swedish Council for Higher Education, n.d.). Reasonably, this system gives fewer possibilities for discrimination, suggesting that *discrimination in the schooling sector, U*, is low in Sweden.

Gender discrimination when recruiting employees is not allowed in Sweden (Diskrimingeringsombudsmannen, 2021)[11], and quota allocation by gender is discussed actively (Svenska Dagbladet, 2022)[12]. Therefore, *over-education*, θ, is assumed to have decreased amongst women in the investigated period. However, if immigrants in Sweden

[10] The Swedish government's official investigations.
[11] Equality Ombudsman.
[12] A Swedish newspaper.

were considered the *discriminated group*, the situation would likely be different as long-term unemployment in Sweden today is at high levels, both for people with academic and non-academic backgrounds, especially among immigrants (Regeringskansliet, 2021[13]; Saco, 2021). Since we believe that the unobservable aspects have caused discrimination, τ, to decline in the investigated period, it is reasonable to assume that discrimination would have fallen even more, see Table 3, if the unobservable components were estimated.

5.2 Output per Worker Base Model

The results obtained when estimating the base model, using equation (22), are reported in column 3 in Table 4.

Table 4: *Comparing output per worker data with output per worker model in USD*

Year	Output per worker observed data	Output per worker base model
1965	20 916	18 158
1970	23 733	17 969
1975	26 496	27 109
1980	27 908	28 491
1985	30 647	29 737
1990	33 659	32 691
1995	33 732	40 183
2000	40 030	40 253
2005	44 778	33 982
2010	47 082	38 322
2015	50 413	47 219

We report the estimations alongside the actual output per worker given by data collected from Penn World Tables, version 10.0. Our model's output per worker grew by 1.9 percent on average per year over the half-century considered. According to the model, this observed growth can be due to five sources. First, growth can be due to the changing growth rate of the labor force (changing n). Second, due to changing fraction of real output invested in physical

[13] The Swedish government offices.

capital (changing s_k). Third, growth in the fraction of real output invested in the reference group's education (changing s_{hR}), causing higher human capital amongst the *reference group*. Fourth, growth in the fraction of real output invested in the *discriminated group's* education (changing s_{hR}), making the human capital level higher amongst the *discriminated group*. Lastly, the growth in output per worker can be due to lower discrimination (lower τ), causing less extensive human capital barriers, which is the primary focus of our analysis.

The base model's predicted output per worker is not too far from the observed data. For example, in 2000, the predicted output per worker was within 0.56 percent of the actual data. The values given by the model are also close to the observed output per worker in the years 1975, 1980, 1985, and 1990[14]. However, in 1970, 1995, 2005, and 2010, the predicted values deviate more from the observed ones[15]. We observe one of the more significant deviations in 1995, when the observed output per worker was 19 percent lower than the value predicted by the model. A reasonable explanation for the deviation is the banking- and financial crisis in Sweden during the early 1990s. The model predicts output per worker in a steady-state, thus, periods of crisis and conjunctural fluctuations are difficult to capture. Also, in 1995, there was low discrimination in the model, further amplifying the deviation. The relatively low predicted values in 1970 and 2005 are partially due to low fractions of output invested in physical capital, s_k. In the early 2000s, investment inflows declined considerably in the EU. The most significant decline occurred in Sweden, the Netherlands, Denmark, and Germany (United Nations, 2005). Moreover, between 1965 to 1970, discrimination remained at a similar level. The almost non-existing development in τ, see Table 3, can explain some of the low growth in output per worker presented by the base model in the period.

5.3 Keeping Discrimination Constant versus no Discrimination

The model is estimated again to determine how much the change in discrimination has affected the economic growth, keeping τ constant at the level exhibited in 1965 while letting the other variables evolve with time. When performing the estimation with a constant τ, equation (23) is used. The results from performing the estimation are presented in Table 5,

[14] The output per worker predicted by the model is within 2.3 percent in 1975, 2.1 percent in 1980, 3.0 percent in 1985 and 2.9 percent in 1990.
[15] The output per worker predicted by the model deviates with 24 percent in 1970 and 2005, 19 percent in 1995 and 6.3 percent in 2010.

column 3. In addition, Table 5 includes estimations when τ equals zero, see column 4, "Output per worker when τ equals zero". When τ equals zero, our empirical specification takes the form of equation (24). The estimations in column 4 show output per worker if there is no discrimination. Hence, the difference between output per worker in our base model and output per worker when τ equals zero are the economic losses due to discrimination.

$$ln(\frac{Y}{L})^{*} = lnA_{0} + gt + \frac{\alpha}{\eta}lns_{k} + \frac{\beta_{D}}{\eta}lns_{hD}(1 - \tau_{1965}) + \frac{\beta_{R}}{\eta}lns_{hR} - \frac{1-\eta}{\eta}ln(n + g + \delta) \quad (23)$$

$$ln(\frac{Y}{L})^{*} = lnA_{0} + gt + \frac{\alpha}{\eta}lns_{k} + \frac{\beta_{D}}{\eta}lns_{hD} + \frac{\beta_{R}}{\eta}lns_{hR} - \frac{1-\eta}{\eta}ln(n + g + \delta) \quad (24)$$

The change in discrimination, changing τ, accounts for 43 percent of growth from 1965 to 2015 in output per worker. Declining human capital barriers in the period of interest have allowed women to allocate their comparative advantages more efficiently. Hence, it leads to a more efficient allocation of talent. An increasing difference between the values is displayed when comparing columns 2 and 3 in Table 5, output per worker in the base model versus output per worker when τ is kept constant.

Table 5: *Output per worker in USD base model, keeping* τ *constant and when* τ *equals zero*

Year	Output per worker base model	Output per worker when keeping τ constant	Output per worker when τ equals zero
1965	18 158	18 158	26 882
1970	17 969	17 913	26 520
1975	27 109	25 243	37 370
1980	28 491	26 257	38 872
1985	29 737	27 076	40 085
1990	32 691	28 519	42 221
1995	40 183	30 434	45 057
2000	40 253	31 094	46 033
2005	33 982	26 137	38 694
2010	38 322	29 259	43 317
2015	47 219	35 520	52 586

The escalating difference comes naturally since the barriers to human capital accumulation have decreased. The increase in difference is the most significant from 1990 to 1995. In 1990, the two values deviated by 13 percent, whereas they deviated by 24 percent in 1995. During these five years, the most dramatic decrease in discrimination takes place, see section 5.1.

Further, in a model with no discrimination, see Table 5, column 4, the output per worker would be 11 percent higher in 2015 than in the base model. The difference between the output levels created by equation (22) versus equation (24) describes the losses in output per worker when women face human capital barriers in Sweden. The two different values for output per worker are converging over the years, with a more dramatic change happening between the years 1990 to 1995. The faster convergence is likely due to the same reasons discussed above. That is, women's education and incentives to work rose. From 1995 onwards, differences in output per worker in the base model and the model without discrimination vary between 11.3 percent to 14.4 percent.

Figure 1 shows the output per worker coming from the three levels of τ presented in Table 5, equations (22) to (24).

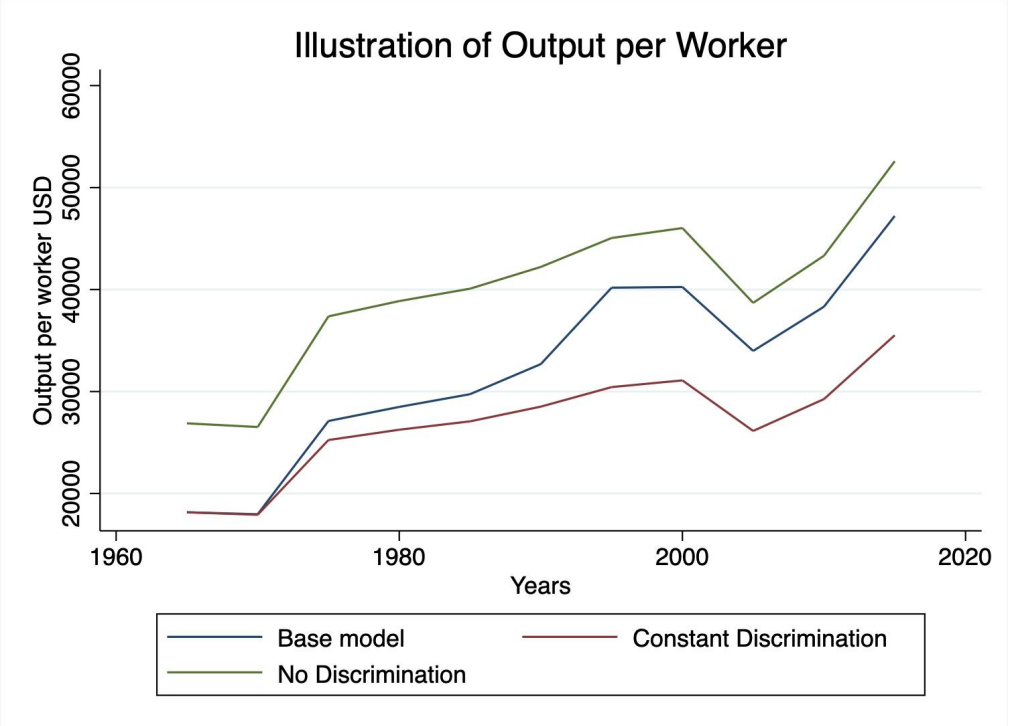

Figure 1: *Output per worker in USD. The blue curve illustrates the base model, the green curve shows* τ *equal zero and the red curve presents* τ *constant.*

The green curve shows the output per worker when there is no discrimination. The blue curve shows the output per worker when letting τ evolve with time, the base model, and the red curve shows the output per worker when τ is kept constant. All curves show upward-moving trends but with differing slopes and intercepts. In 2005, a decline in output per worker was present on all curves. The decline is presumably due to the low investments and hence, the low fraction of real output invested in physical capital discussed in section 5.2.

During the observed years, the fall in discrimination can explain a considerable part of the growth in output per worker. However, most productivity gains from reducing discrimination against women have already occurred in the half-century investigated. In 2015, the green and blue curves displayed in Figure 1 were relatively close to one another, suggesting that falling discrimination will have a weakened impact on growth in the future due to higher equality in the socioeconomic dimension discussed in this study.

6. Conclusion

The study aimed to explain how discrimination affects economic growth through society's ability to gain human capital. A generalized neoclassical growth model was constructed with the ambition to explain the effects. Our secondary purpose was to test the model in practice by applying the model to two groups in Sweden: women as the *discriminated group* and men as the *reference group*, from 1965 to 2015. Barriers to human capital accumulation were imposed on the *discriminated group* and aimed to capture five components; *the return to education in wage, M, occupational-specific wages, W, over-education,* θ*, a socioeconomic factor,* Ω*,* and *discrimination in the schooling sector, U.*

The results showed a decrease in discrimination by 46 percent from 1965 to 2015, meaning that the human capital accumulation has become more equal between men and women during the last half-century. The estimations from the base model demonstrated an average growth of 1.9 percent in output per worker per year over the investigated period. The base model, see equation (22), includes five components that could explain the growth, whereas discrimination is the main target in our study. Comparing the results from the base model with the observed data, the estimations moved in a similar trend. However, due to decreased investment inflows in physical capital in 1970 and 2005, the base model predicts relatively low values in output per worker in those particular years. In the early 1990s, the Swedish

financial crisis generated a fall in the observed data on output per worker, explaining why it was 19 percent lower than the value in the base model in 1995. From 1995 and forward, there is a distinct drop in discrimination displayed in Table 2, which can be explained by an increase in women's incentives to work due to the implementation of social reforms involving childcare and parental leave. The financial crisis could have amplified the effects as economic and social reforms tend to have a more distinct effect when the population demonstrates a non-Ricardian behavior (Romer, 2019).

We modified the base model in two contrasting ways, keeping discrimination constant with levels from 1965, portraying an unequal society, and setting the measure of discrimination equal to zero, presenting a society with no discrimination, see equations (23), (24), and Figure 1. In line with Hsieh et al.'s (2019) findings that declining barriers to human capital accumulation could explain a significant part of the gains in market GDP per person in the U.S., we found that declining discrimination in human capital barriers explains 43 percent of the growth in output per worker in Sweden. Although our study focuses on a different country, different population groups, and partially on different types of discrimination, our results are comparatively similar to those received by Hsieh et al. (2019). However, a more significant part of the increased output can be explained by falling discrimination in our model than Hsieh et al. (2019). In addition to human capital frictions, their model includes labor market frictions and preferences. The differing frictions included in our versus Hsieh et al.'s. (2019) model could explain some of our results' variance, but of course, variance is also due to different underlying calculations in their and our model.

According to our results, discrimination accounts for consequential economic losses and is hence of great importance when investigating the efficiency of an economy. An individual exposed to discrimination is prevented from practicing their comparative advantage. Thus, it is crucial to increase the incentives by lowering discrimination so that individuals can maximize their utility freely. The discrimination aspect is essential for decision-makers, and our model could be incorporated into economic tools for further usage. Our estimations reflected human capital barriers toward women in Sweden from 1965 to 2015 but could be generalized and extended to apply to any socioeconomic group in any country. Area of usage could, for example, be immigration, wealth status, ethnic groups, or age discrimination in different places and at different times. Further extensions, such as cross-country studies similar to Knowles et al. (2002), are also possible.

Even though some components in the measure of human capital barriers are not measurable, creating disadvantages in the model, such as *discrimination in the schooling sector*, *socioeconomic differences*, and *over-education*, they are still essential to evaluate as they might bias significant observable variables (Weir, 2010). In our measure of discrimination, the unobservable variables are all assumed to cause discrimination to decline in different ways. An even more significant fall in discrimination would probably have shown if we had estimated the unobservable variables. When creating a generalized model, aspects of matter could go unnoticed and lead to misjudgment in estimations. However, extending and modifying the model accurately towards the direction one wishes to investigate, such as specifying a particular index mentioned in the paragraph above, could avoid skewness.

The derived neoclassical growth model emphasizes the importance of considering discrimination as it negatively affects the allocation of talent in an economy and, thus, conduct as a threat to economic efficiency. Our model shows that Sweden, one of the top-performing countries on the European Institute's Gender-Equality Index (European Institute for Gender Equality, 2021), has increased economic efficiency by lowering human capital barriers for women during the last half-century. Discrimination is still a fact globally. Our study concludes the value of promoting equality, as discrimination has a negative effect on the economy and individuals' well-being.

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Appendix

Appendix 1: *Calculations*

Deriving k, h_D, and h_R in steady-state:

Capital:

$$s_k k^{\alpha} h_D^{\beta_D} h_R^{\beta_R} = (n + g + \delta)k_t$$

$$k^* = \left(\frac{s_k h_D^{\beta_D} h_R^{\beta_R}}{(n+g+\delta)}\right)^{\frac{1}{1-\alpha}}$$

Human capital discriminated group:

$$s_{hD} k^{\alpha} h_D^{\beta_D} h_R^{\beta_R} (1 - \tau) = (n + g + \delta)h_D$$

$$h_D^* = \left(\frac{s_{hD} k^{\alpha} h_R^{\beta_R} (1-\tau)}{(n+g+\delta)}\right)^{\frac{1}{1-\beta_D}}$$

Human capital reference group:

$$s_{hR} k^{\alpha} h_D^{\beta_D} h_R^{\beta_R} = (n + g + \delta)h_R$$

$$h_R^* = \left(\frac{s_{hR} k^{\alpha} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\frac{1}{1-\beta_R}}$$

How to go from steady-state to equations (19) to (21).

Step 1: Insert h_R^* into k^* and solve for k^*:

$$k^* = \left(\frac{s_k h_D^{\beta_D} \left(\frac{s_{hR} k^{\alpha} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\frac{\beta_R}{1-\beta_R}}}{(n+g+\delta)}\right)^{\frac{1}{1-\alpha}}$$

$$k^* = \frac{s_k^{1/1-\alpha} s_{hR}^{\frac{\beta_R}{1-\beta_R}\frac{1}{1-\alpha}} h_D^{\frac{\beta_D}{1-\alpha} + \frac{\beta_D \beta_R}{(1-\beta_R)(1-\alpha)}} k^{\frac{\alpha\beta_R}{1-\beta_R}\frac{1}{1-\alpha}}}{(n+g+\delta)^{\frac{1}{1-\alpha} + \frac{\beta_R}{1-\beta_R}\frac{1}{1-\alpha}}}$$

$$k^{*\frac{(1-\beta_R-\alpha)}{(1-\beta_R)(1-\alpha)}} = \frac{s_k^{1/1-\alpha} s_{hR}^{\frac{\beta_R}{1-\beta_R}\frac{1}{1-\alpha}} h_D^{\frac{\beta_D}{(1-\beta_R)(1-\alpha)}}}{(n+g+\delta)^{\frac{1}{(1-\alpha)(1-\beta_R)}}}$$

$$k^* = \left(\frac{s_k^{1-\beta_R} s_{hR}^{\beta_R} h_D^{\beta_D}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R)}$$

Step 2: Insert k^* into h_R^* and solve for h_R^*:

$$h_R^* = \left(\frac{s_{hR} \left(\frac{s_k^{1-\beta_R} s_{hR}^{\beta_R} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\alpha/(1-\alpha-\beta_R)} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\frac{1}{1-\beta_R}}$$

$$h_R^* = \frac{s_k^{\frac{\alpha(1-\beta_R)}{(1-\alpha-\beta_R)(1-\beta_R)}} s_{hR}^{\frac{1}{1-\beta_R}+\frac{\beta_R\alpha}{1-\alpha-\beta_R}\frac{1}{1-\beta_R}} h_D^{\frac{\beta_D\alpha}{(1-\alpha-\beta_R)}\frac{1}{1-\beta_R}+\frac{\beta_D}{(1-\beta_R)}}}{(n+g+\delta)^{\frac{1}{1-\beta_R}+\frac{\alpha}{(1-\alpha-\beta_R)}\frac{1}{1-\beta_R}}}$$

$$h_R^* = \frac{s_k^{\frac{\alpha}{(1-\alpha-\beta_R)}} s_{hR}^{\frac{1-\alpha-\beta_R+\beta_R\alpha}{(1-\alpha-\beta_R)(1-\beta_R)}} h_D^{\frac{\beta_D}{(1-\alpha-\beta_R)}}}{(n+g+\delta)^{\frac{1}{(1-\alpha-\beta_R)}}}$$

$$h_R^* = \left(\frac{s_{hR}^{(1-\alpha)} s_k^{\alpha} h_D^{\beta_D}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R)}$$

Step 3: Insert k^* and h_R^* into h_D^* solve for h_D^* and obtain equation (20):

$$h_D^* = \left(\frac{s_{hD}\left(\frac{s_k^{1-\beta_R}\beta_R s_{hR}^{\beta_R} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\alpha/(1-\alpha-\beta_R)}\left(\frac{s_{hR}^{(1-\alpha)} s^{\alpha} h_D^{\beta_D}}{(n+g+\delta)}\right)^{\beta_R/(1-\alpha-\beta_R)}(1-\tau)}{(n+g+\delta)}\right)^{\frac{1}{1-\beta_D}}$$

$$h_D^* = \frac{(s_{hD}(1-\tau))^{\frac{1}{1-\beta_D}} s_k^{\frac{\alpha(1-\beta_R)}{(1-\alpha-\beta_R)(1-\beta_D)}+\frac{\alpha\beta_R}{(1-\alpha-\beta_R)(1-\beta_D)}} s_{hR}^{\frac{\beta_R}{(1-\alpha-\beta_R)(1-\beta_D)}} h_D^{\frac{\beta_D\alpha}{(1-\alpha-\beta_R)}\frac{1}{1-\beta_D}+\frac{\beta_R\beta_D}{(1-\alpha-\beta_R)(1-\beta_D))}}}{(n+g+\delta)^{\frac{1}{1-\beta_D}+\frac{\alpha}{(1-\alpha-\beta_R)}\frac{1}{1-\beta_D}+\frac{\beta_R}{(1-\alpha-\beta_R)}\frac{1}{1-\beta_D}}}$$

$$h_D^{*\frac{1-\alpha-\beta_D-\beta_R}{(1-\alpha-\beta_R)(1-\beta_D)}} = \frac{(s_{hD}(1-\tau))^{\frac{1}{1-\beta_D}} s_k^{\frac{\alpha}{(1-\alpha-\beta_R)(1-\beta_D)}} s_{hR}^{\frac{\beta_R}{(1-\alpha-\beta_R)(1-\beta_D)}}}{(n+g+\delta)^{\frac{1}{(1-\alpha-\beta_R)(1-\beta_D)}}}$$

$$h_D^* = \left(\frac{(s_{hD}(1-\tau))^{(1-\alpha-\beta_R)} s_k^{\alpha} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_D-\beta_R)}$$

$$h_D^* = \left(\frac{(s_{hD}(1-\tau))^{(1-\alpha-\beta_R)} s_k^{\alpha} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \tag{20}$$

Step 4: Insert h_D^* into k^* solve for k^* and obtain equation (19):

$$k^* = \left(\frac{s_k^{1-\beta_R}\beta_R s_{hR}^{\beta_R}\left(\frac{(s_{hD}(1-\tau))^{(1-\alpha-\beta_R)} s_k^{\alpha} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{\beta_D/(1-\alpha-\beta_D-\beta_R)}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R)}$$

$$k^* = \frac{(s_{hD}(1-\tau))^{\frac{\beta_D}{(1-\alpha-\beta_R-\beta_D)}} s_k^{\frac{(1-\beta_D-\beta_R)}{(1-\alpha-\beta_D-\beta_R)}} s_{hR}^{\frac{\beta_R}{(1-\alpha-\beta_R-\beta_D)}}}{(n+g+\delta)^{\frac{1}{(1-\alpha-\beta_R-\beta_D)}}}$$

$$k^* = \left(\frac{(s_{hD}(1-\tau))^{\beta_D} s_k^{(1-\beta_D-\beta_R)} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R-\beta_D)}$$

$$k^* = \left(\frac{(s_{hD}(1-\tau))^{\beta_D} s_k^{(1-\beta_D-\beta_R)} s_{hR}^{\beta_R}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \tag{19}$$

Step 5: Insert h_D^* into h_R^* solve for h_R^* and obatin equation (21):

$$h_R^* = \left(\frac{s_{hR}^{(1-\alpha)} s_k^{\alpha} \left(\frac{(s_{hD}(1-\tau))^{(1-\alpha-\beta_R)\alpha} s_k^{\alpha\beta_R} s_{hR}^{\alpha\beta_D/(1-\alpha-\beta_D-\beta_R)}}{(n+g+\delta)}\right)^{\beta_D/(1-\alpha-\beta_D-\beta_R)}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R)}$$

$$h_R^* = \frac{s_{hR}^{\frac{(1-\alpha)}{(1-\alpha-\beta_R)}+\frac{\beta_R\beta_D}{(1-\alpha-\beta_R-\beta_D)(1-\alpha-\beta_R)}} (s_{hD}(1-\tau))^{\frac{\beta_D(1-\alpha-\beta_R)}{(1-\alpha-\beta_R-\beta_D)(1-\alpha-\beta_R)}} s_k^{\frac{\alpha}{(1-\alpha-\beta_R)}+\frac{\alpha\beta_D}{(1-\alpha-\beta_R)(1-\alpha-\beta_D-\beta_R)}}}{(n+g+\delta)^{\frac{1}{1-\alpha-\beta_R}+\frac{\beta_D}{(1-\alpha-\beta_R-\beta_D)}\frac{1}{1-\alpha-\beta_R}}}$$

$$h_R^* = \left(\frac{s_{hR}^{(1-\alpha-\beta_D)} (s_{hD}(1-\tau))^{\beta_D\alpha} s_k^{\alpha}}{(n+g+\delta)}\right)^{1/(1-\alpha-\beta_R-\beta_D)}$$

$$h_R^* = \left(\frac{(s_{hD}(1-\tau))^{\beta_D\alpha} s_k^{\alpha} s_{hR}^{(1-\alpha-\beta_D)}}{(n+g+\delta)}\right)^{\frac{1}{\eta}} \qquad (21)$$

Appendix 2: *Data Sources*

Data on educational costs:

- Data on educational costs for the year 2000 is collected from SCB's report *Educational expenditure 2000-2004* (SCB, 2005). The relevant data can be found in table 1, page 34, in column 2 on the last row.
- Data on educational costs for the year 2005 is collected from SCB's report *Educational expenditure 2002-2006* (SCB, 2007). The relevant data can be found in table 1, page 27, in column 8 on row 3.
- Data on educational costs for the year 2010 is collected from SCB's report *Costs for educational system 2008-2012* (SCB, 2013). The relevant data can be found in table 1, page 30, in column 6 on row 3.
- Data on educational costs for the year 2015 is collected from SCB's report *Costs for educational system 2011-2015* (SCB, 2016). The relevant data can be found in table 1, page 30, in column 10 on row 3.

Data on wages and occupation:

- Data on median wages for different occupations year 1965 is collected from SCB's population and housing census in 1965, part 9 (SCB, 1965). The relevant data can be found in table 17, pages 122 to 139, in columns 5 and 11. Median wages are collected for each occupation and are later categorized into different occupational

categories, see table 1.

- Data on median wages for different occupations year 1970 is collected from SCB's population and housing census in 1970, part 11 (SCB, 1970). The relevant data can be found in table 3, pages 42 to 55, in column 15. Median wages are collected for each occupation and are later categorized into different occupational categories, see table 1.
- Data on median wages for different occupations year 1975 is collected from SCB's population and housing census in 1975, part 8 (SCB, 1975). The relevant data can be found in table 6, pages 151 to 152, in column 2. Median wages are collected for each occupation and are later categorized into different occupational categories, see table 1.
- Data on median wages for different occupations year 1985 is collected from SCB's population and housing census in 1985, part 8 (SCB, 1985). The relevant data can be found in table 2, pages 34 to 45, in column 6. Median wages are collected for each occupation and are later categorized into different occupational categories, see table 1.
- Data on median wages for different occupations year 1990 is collected from SCB's population and housing census in 1990, part 6 (SCB, 1990). The relevant data can be found in table 2, pages 33 to 44, column 6. Median wages are collected for each occupation and are later categorized into different occupational categories, see table 1.
- Data on median wages for different occupations year 1996 to 2013 is collected from SCB's statistical database (https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__AM__AM0110__AM0110D/TidsserieYrke/) (SCB, 2014).
- Data on median wages for different occupations year 2015 is collected from SCB's statistical database (https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__AM__AM0110__AM0110D/TidsserieYrkeSSYK12/) (SCB, 2017b).

Data on wages and education:

- Data on median wages for different levels of education year 1971 is collected from SCB's report *Education, employment status and income 1971* (SCB, 1973). The

relevant data can be found in table 5, page 15, in columns 8 and 10 on row 4.

- Data on median wages for different levels of education year 1990 is collected from SCB's population and housing census in 1990, part six (SCB, 1990). The relevant data can be found in table 3, page 25, in columns 10 and 11, rows 4 to 9.
- Data on median wages for different levels of education year 1995 to 2015 is collected from SCB's statistical database (https://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__AM__AM0110__AM0110D/TidsserieUtbniva/table/tableViewLayout1/) (SCB, 2021).

Data on technical efficiency:

- Data on the proxy for technical efficiency is collected from Hall and Jones's (1999) estimates (https://web.stanford.edu/~chadj/HallJones400.asc).

Appendix 3: *Variables*

Notation	Description
Y	Real output
y	Effective real output
K	Capital stock
k	Effective capital stock
H_D	Human capital *discriminated group*
h_D	Effective human capital *discriminated group*
H_R	Human capital *reference group*
h_R	Effective human capital *reference group*
A	Technical efficiency
L	Labor force
n	Growth rate labor force
g	Growth rate technology

s_k	Fraction of real output invested in physical capital
s_{hD}	Fraction of real output invested in the *discriminated group's* education
s_{hR}	Fraction of real output invested in the *reference group's* education
δ	Rate of depreciation
τ	Barrier to human capital attainment
W	Wage ratio *discriminated group* versus *reference group* accumulated across all occupations
w_O	Wage ratio *discriminated group* versus *reference group* in a specific occupation
M	Wage ratio *discriminated group* versus *reference group* for same years of schooling accumulated
m_E	Wage ratio *discriminated group* versus *reference group* for same years of schooling
U	Discrimination in the schooling sector
π	Schooling sector's profit
d	Schooling sector's dislike of certain groups
I	Schooling sector's income
Z	Schooling sector's cost
Ω	Socioeconomic variable
σ	Parents' attitude towards schooling
a	Family's assets
θ	Over-education
u_{DO}	Unemployment
E_{DO}	Level of education