ARTICLE IN PRESS

Economic Modelling xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/econmod

Population growth and the wage skill premium☆

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ARTICLE INFO

JEL:
O30
O41
J31

Keywords:
Population growth
Endogenous economic growth
Skill premium

ABSTRACT

We develop a general equilibrium directed technical change model with growth of skilled and unskilled labour in order to analyse the effect of heterogeneous population growth on the skill premium. Heterogeneous population growth generates a non-monotonic and non-linear relationship between the skill premium and the demographic variables, which may help explain different conflicting patterns of the skill premium across history and amongst countries. In a quantitative exercise on the US economy for almost all the 20th century, we show that the model can replicate the observed data on skill premium. We extend the quantitative exercise to consider that the R & D productivity depends on population ageing and this improved the fit of the replication of the skill-premium pattern.

1. Introduction

We investigate the consequences of population growth for the relative wage rate of skilled labour (i.e., the skill premium). In particular, we seek to explain the observed skill premium by building a directed technical change growth model with age specific heterogeneity of households. We do so because population ageing, especially in the most developed countries, has become an important factor in the economic and social debate (e.g., Bloom et al., 2004, 2010; The Economist, 2009, 2011; Prettner, 2013).

The skill premium, defined as the ratio of skilled labour wage to unskilled labour wage, has undergone dramatic changes in the United States economy since the beginning of the 20^{th} century: for example, in the postwar United States (US) economy it fell during the end of the 1970 s and early 1980 s and increased throughout the 1980 s, 1990 s, and 2000 s. The most popular explanation for this increase in the skill premium is the skill-biased technological change (SBTC) - e.g., Bound and Johnson (1992), Katz and Kevin (1992), Juhn et al. (1993). The argument is that technological-knowledge change induces an increase in the relative demand of skilled labour that exceeds the increase in the (exogenous) relative supply, thus increasing the skill premium. Acemoglu (1998), Acemoglu (2002) and Acemoglu and Zilibotti (2001) enhance this literature by considering that technological-knowledge change responds to shifts in labour endowments. When the supply of a type of labour increases, the market for technologies that complement it broadens, and this creates additional incentives for R & D aimed at those technologies. Consequently, technological-knowledge change steers toward those technologies, which, in turn, increases the demand for the complementary type of labour. Thus, the SBTC explanation interprets the rise in the skill premium as a direct consequence of the (exogenous) increase in the relative supply of skilled labour. In a recent work, Mallick and Sousa (2017) have used US manufacturing data to show that technology has in fact favoured skilled workers since the 1980 s and that productivity differences lead to increases in the relative demand for skilled workers when skilled and unskilled labour are imperfect substitutes.

However, in addition to the relationship between the skill premium and the (exogenous) relative supply of skilled labour, through technological-knowledge bias, there are other demographic changes associated with the fertility and the mortality rates that are not considered by the standard SBTC literature. For example, decreases in mortality due to advances in medical science increase the rate of population growth, but decreases in fertility reduce it and in addition contribute to population ageing (e.g., Preston et al., 2001; Harper and Leeson, 2009; Prettner, 2013).

Moreover, there are diverging paths of the skill premium amongst countries (other than the United States). For example, the Netherlands experienced a reduction in the skill premium with a simultaneous increase in the relative skilled labour supply between the early 1980s and mid-1990s (Acemoglu, 2003). Similarly, in Mexico wage inequality

☆ We are grateful to the journal editor, Sushanta Mallick, and to two anonymous Referees for their valuable comments. We also acknowledge financial support from FCT, Portugal, and FEDER/COMPETE 2020, through grant UID/ECO/04007/2013 (POCI-01-0145-FEDER-007659).

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http://dx.doi.org/10.1016/j.econmod.2017.08.019
Received 17 February 2017; Received in revised form 14 June 2017; Accepted 19 August 2017
0264-9993/

fell between 1994 and 2002, while in the same period the relative amount of skilled workers increased (Robertson, 2004). In the Czech Republic and in Hungary the skill premium increased between 1993 and 2004, but the relative employment of skilled workers fell (Crinò, 2005). And in Canada, the rise in the skill premium in the 1990 s was accompanied by stability in the relative supply of skilled labour (Acemoglu, 2003).

Although the theoretical SBTC models can examine the wage-inequality effects of changes in demographic patterns as represented by population size, they are unable to analyse the wage-inequality consequences of population growth and ageing because they assume that economies are populated by representative households that live forever. This paper contributes to the wage-inequality literature by considering, on the one hand, the technological-knowledge bias in line with the standard SBTC literature and, on the other hand and in addition, the observed demographic changes associated with the fertility and the mortality rates. It thus provides an alternative explanation for the trends observed in the skill premium in the United States: a change in the skill premium induced by the effect of changes in the share of skilled labour, in the fertility rate and in the mortality rate on the endogenous allocation of skilled labour between sectors. Indeed, the US economy share of (skilled) R & D labour grew over time. That is, we are particularly interested in analysing the extent to which the above demographic change can account for the dynamics of the skill premium. Our model is able to capture the dynamic interaction between the skill premium and the relative supply of skilled labour and, accordingly, we also extend He and Liu (2008), who provide a unified framework in which the dynamics of the relative supply of skilled labor and the skill premium arise as an equilibrium outcome driven by measured investment-specific technological change. Since we incorporate heterogenous population growth in a traditional directed technical change framework, this can be viewed as a semi-endogenous version of the original framework to study the skill premium.

To examine our research questions, we develop a general equilibrium directed technical change growth model, with the following assumptions: two sectors (skilled and unskilled), which can be substitutes or complements to produce the unique final good; the R & D effort is determined as the outcome of market forces assuming profit maximizing firms; and, in contrast to the representative agent assumption, we introduce overlapping generations in the spirit of Buiter (1988) –and also the continuous-time infinite-horizon “perpetual youth” model (e.g., Acemoglu, 2009, Ch.9) –to the Jones (1995) case, since there the population size has to grow. In the presence of an age-heterogeneous population, the growth rate of aggregate consumption is obtained by integrating over different generations (e.g., Prettner, 2013). To sum up, we have extended: (i) the standard directed technical change setup in order to consider population growth – i.e., instead of the usual lab-equipment setup, we use the knowledge-driven one (e.g., Acemoglu, 2009, Ch. 15); (ii) the directed technical change setup with population growth in order to include the fertility and the mortality rates – i.e., our knowledge-driven setup meets fertility and mortality rates; (iii) the directed technical change setup in order to include the overlapping generations framework in the spirit of Buiter (1988) and the continuous-time infinite-horizon “perpetual youth” framework (e.g., Acemoglu, 2009, Ch. 9).

Our model suggests that the introduction of two different types of labour (skilled and unskilled), with distinct fertility and mortality rates, changes the key determinants of consumption growth at the individual level, but not at the aggregate level. The model also suggests that the effect of an increase in the growth rate of each type of labour on the skill premium is ambiguous. In particular, the skill premium is no longer monotonically dependent on the relative supply of skilled labour. The observed changes in the skill premium in the postwar US economy reveal, in a quantitative exercise which incorporates demographic changes, that during the end of the late 1970s and early 1980s there was a decrease in the skilled labour demand in R & D relative to the skilled-labour demand in the final-goods sector. This implies the increase in the relative supply of skilled labour in the final-good sector and thus the reduction in both the skill premium and the growth rate of output per labour. Then, the economy is pushed away and, in the subsequent period, the relative supply of skilled labour in the final-good sector starts falling. Therefore, both the skill premium and the growth rate of output per labour increase when the shock occurs in either the fertility or the longevity rates.

Our paper is closely related to Acemoglu (2002), Prettner (2013), Schafer (2014) and Bohm et al. (2015). The first is the original contribution on Directed Technical Change but does not consider demographic dynamics, as in our case. Prettner (2013) studies the consequences of population ageing in endogenous growth models frameworks but without considering Directed Technical change, as we do. Schafer (2014) considers an overlapping generations directed technical change setup that includes fertility decline, scale invariant growth, and non-renewable natural resources as an essential input to produce machines in order to analyse the interaction between population dynamics, technological-knowledge bias, and natural resource depletion. In the context of this model, the skilled and unskilled households' composition is endogenous, and skilled and unskilled households' fertility is inversely related to wages and education. Also through a directed technical change model, Bohm et al. (2015) show that unskilled workers lose in terms of consumption and income in the short-run with the expansion of higher education, but eventually gain in the long-run. Moreover, due to adverse general equilibrium effects, policies aimed at expanding the skills of unskilled workers make them only moderately better off, and they benefit most from redistribution. In our model, we do not consider the effects induced by natural resources, endogenous human-capital accumulation and government interventions.

Our paper is also related to the empirical studies of Eris (2010) and Peng et al. (2017), as well as the theoretical ones of Elgin and Tumen (2012) and Choi and Shin (2015). Eris (2010) analyses the relationship between growth and population heterogeneity along ethnic, linguistic, religious, and socio-economic class lines, using cross-section data from 72 countries, and finds support for the inclusion of population heterogeneity as a theory when proxied by fragmentation indices. Peng et al. (2017) use panel data from nine European countries over the period 1970–2007 to analyse the impact of information and communication technology on the demand for older workers, observing a decrease in the demand for older workers in the 1970 s and 1980 s and concluding that such impact is skill-biased. Elgin and Tumen (2012) show theoretically that when there is a reduction in the degree of increasing returns to human capital in production technologies, developed economies tend to direct their productive efforts toward human capital-oriented technologies that support an ageing population, such that sustained economic growth can coexist with a declining population. Choi and Shin (2015) develop an overlapping generations model with endogenous human-capital accumulation to examine the effect of population ageing on economic growth in Korea, concluding that population ageing reduces the growth of labour supply and raises the growth of capital stock, thus leading to capital deepening.

This paper is organized as follows. Section 2 describes the theoretical model, by looking at the consumption side (Section 2.1), the production side (Section 2.2), the steady-state growth rate (Section 2.3), and the steady-state skill premium (Section 2.4). Section 3 performs the quantitative analysis. Finally, Section 4 draws conclusions and highlights scope for further research.