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Skill-biased technological change, endogenous labor supply and growth: A model and calibration to Poland and the US

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ABSTRACT

In this paper skill-biased technological change is linked with endogenous labor supply in a growth model. Elastic labor supply allows us to explain how the observed increasing unemployment of unskilled workers is caused by skill-biased technological change. Using empirical data on wages and education, we construct the time series for the skill-biased technology for Poland and the US. The empirical relevance of the model is tested by calibrating it to empirical data for Poland over the period 1996–2006 and for the US over the period 1992–2008. Our numerical analysis shows that if the skill-biased technological change is not followed by the growth of total factor productivity, then output, physical capital stock and consumption decline. With only two necessary inputs, namely the share of skilled workers in total population and the technology adopted by firms, this model allows to simulate the future behavior of the labor market.

1. Introduction

Skill-biased technological change, which has led to a strong increase of the skill premium and sometimes also to the rise in unemployment of unskilled workers, is debated extensively in the economic literature.[2] The phenomenon of increased non-production worker share in the wage bill in OECD countries in the context of skill-biased technological change (SBTC) was studied among others by Machin and Van Reenen (1998) and Berman et al. (1998). Berman et al. (1998, p. 1246) found that "SBTC was pervasive over the past two decades, occurring simultaneously in most, if not in all, developed countries". This change occurred in the US as well as in other developed countries and the most affected industries were the skill-intensive ones, namely machinery, electrical machinery and printing and publishing (Berman et al., 1998). They state that less skilled workers sometimes also face increased unemployment. A very similar pattern can be observed in Transition Economies, which also face skill-biased technological change and increasing unemployment of unskilled workers.[3]

Even though that skill-biased technological change has an impact on unemployment of the unskilled workers, the literature usually assumes that labor supply is inelastic. However, Machin and Van Reenen (1998, p. 1217) state: "We cannot

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1 The views expressed in this paper are those of the authors and do not necessarily reflect the opinions of the National Bank of Poland.

2 A review of the literature can be found in Acemoglu (2002) and Machin (2008). Esposito and Steher (2007) provide a literature overview focusing on Transition Economies.

3 Focusing on the period 1995–2003 and using data at the 14 industries level (DA-DN code) Esposito and Steher (2007) find evidence of SBTC in Transition Economies. However, there is a sector bias as SBTC was concentrated in the skill-intensive and medium skill industries in Hungary and Poland. Another study, performed by Lorentowicz et al. (2005) at a higher disaggregation level (23 ISIC industries) in the period 1994–2002 links FDI with an increase of skilled labor share and wage inequality in Poland.

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deduce the full effect of technology on labor market structure without also closing the model by looking at the supply side effects and the non-manufacturing sector, which is beyond the scope of this paper''.

We aim to enrich the literature by including the SBTC process in a growth model with endogenous labor supply and exogenous neutral technological change. Further on, we include the exogenously changing share of skilled workers in the production function. We model a household which consists of skilled and unskilled workers, who optimally choose how much to work and how much leisure to have. Nobody gets unemployed in the neoclassical sense and household members share the income and do not suffer when they do not work. Under the assumption of elastic labor supply our model explains the observed decreasing labor supply of unskilled workers and links it to skill-biased technological change. The increasing skill premium makes it less valuable for the unskilled to work. We calibrate the model and test its empirical relevance using data for Poland and for the US. Poland made a fast transition towards a market economy and it is the largest economy in Central and Eastern Europe. The US are the most developed economy.

The paper is organized as follows. We model the production function with skilled and unskilled labor and solve the household labor supply problem in Section 2. In Section 3 we provide empirical evidence for skill-biased technological change and calculate its time series for Poland and the US. In Section 4 the model is calibrated and a numerical analysis is performed. This allows to test the model's empirical relevance. Section 5 concludes the paper.

2. The model

We consider an economy populated by an infinite number of households and firms. The economy is perfectly competitive and everybody is a price taker. Households consist of skilled and unskilled workers who provide a fraction of their time to the production of a representative good. Throughout the paper skill-biased technological change and total factor productivity growth are strictly exogenous.

2.1. The productive sector

We set up the productive sector based on the specification of Caselli and Coleman (2006):

$$y = k^{\alpha}[(A_u L_u)^{\sigma} + (A_s L_s)^{\sigma}]^{(1-\alpha)/\sigma}. \tag{2.1}$$

Here L_u is unskilled labor and L_s is skilled labor. The elasticity of substitution between skilled and unskilled workers is $\epsilon = 1/(1-\sigma)$ and lies in the range $(1, 2)$ (see Autor et al., 1998).

In addition to the Caselli and Coleman (2006) model, we allow the workers to decide how much labor they supply and put the model in a growth framework. The households live infinitely. Each household consists of an exogenously given fraction u of unskilled workers and a fraction $1-u$ of skilled workers. Each type of worker is endowed with one unit of time. The unskilled (skilled) worker devotes a fraction of time $l(h)$ to work and the residual $1-l(1-h)$ to leisure. In aggregate terms, when N denotes the total available labor force, the labor input of unskilled workers is uNl and of skilled workers $(1-u)Nh$. We divide the production function by N and get output in per capita terms:

$$y = k^{\alpha}[(A_u ul)^{\sigma} + (A_s(1-u)h)^{\sigma}]^{(1-\alpha)/\sigma}. \tag{2.2}$$

First, we present the production function in a form which is convenient for the further analysis:

$$y = A^{1-\alpha}k^{\alpha}[(\phi ul)^{\sigma} + ((1-\phi)(1-u)h)^{\sigma}]^{(1-\alpha)/\sigma}. \tag{2.3}$$

A denotes total factor productivity and ϕ and $1-\phi$ denotes the productivity of unskilled and skilled labor,[4] respectively. After profit maximization, thus differentiation of Eq. (2.3) with respect to the inputs ul, $(1-u)h$ and k, we obtain the wages and interest rate in equilibrium:

$$w_l = (1-\alpha)A^{1-\alpha}k^{\alpha}[(\phi ul)^{\sigma} + ((1-\phi)(1-u)h)^{\sigma}]^{(1-\alpha)/\sigma-1}\phi^{\sigma}(ul)^{\sigma-1} \tag{2.4}$$

$$w_h = (1-\alpha)A^{1-\alpha}k^{\alpha}[(\phi ul)^{\sigma} + ((1-\phi)(1-u)h)^{\sigma}]^{(1-\alpha)/\sigma-1}(1-\phi)^{\sigma}((1-u)h)^{\sigma-1} \tag{2.5}$$

$$r = \alpha A^{1-\alpha}k^{\alpha-1}[(\phi ul)^{\sigma} + ((1-\phi)(1-u)h)^{\sigma}]^{(1-\alpha)/\sigma}. \tag{2.6}$$

Besides the capital input the firms also need the labor input of skilled and unskilled workers. During the process of skill-biased technological change firms adopt technologies which make skilled workers more productive. This has an effect on the skill premium, which we obtain by dividing the skilled workers' wage w_h by the unskilled workers' wage w_l:

$$\frac{w_h}{w_l} = \left(\frac{1-\phi}{\phi}\right)^{\sigma}\left(\frac{1-u}{u}\frac{h}{l}\right)^{\sigma-1}. \tag{2.7}$$

As usual in this kind of models, the skill premium is increasing in $1-\phi$ and decreasing in $(1-u)h$.

[4] Another way to think about ϕ is the ''erosion effect'' proposed by Galor and Moav (2000). New technology makes some of the old skills obsolete. Skilled workers are able to exploit technological change better than unskilled ones. Due to technological change the skilled workers become more productive, while unskilled workers lose productivity.