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The Effects of Skill-Biased Technical Change on Productivity Flattening and Hours Worked

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The Effects of Skill-Biased Technical Change on Productivity Flattening and Hours Worked

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Contents

Abstract

In a structural macroeconometric analysis based on comprehensive micro data, we examine the role of skill-biased technical change for the flattening of productivity growth and effects on hours worked. The results show that more than 60 percent of the slowdown in productivity growth in Germany since the early 2000s can be explained by the SBTC development. Furthermore, skill-biased technology shocks reduce hours worked, while skill-neutral technology shocks have a positive effect in the long run.

Zusammenfassung

Wir untersuchen, welche Rolle der qualifikationsverzerrte technologische Fortschritt (SBTC) für das schwache Produktivitätswachstum spielt und welchen Einfluss er auf das Arbeitsvolumen hat. Hierfür nutzen wir ein strukturelles makroökonometrisches Modell sowie umfassende Mikrodaten. Die Ergebnisse zeigen, dass die SBTC-Entwicklung mehr als 60 Prozent der Verlangsamung des Produktivitätswachstums in Deutschland seit den frühen 2000er Jahren erklärt. Außerdem reduzieren SBTC-Schocks das Arbeitsvolumen, wohingegen qualifikationsneutrale Technologieschocks langfristig positive Effekte haben.

JEL classification: C32, E24, J24

Keywords: productivity, hours, SBTC, SVAR

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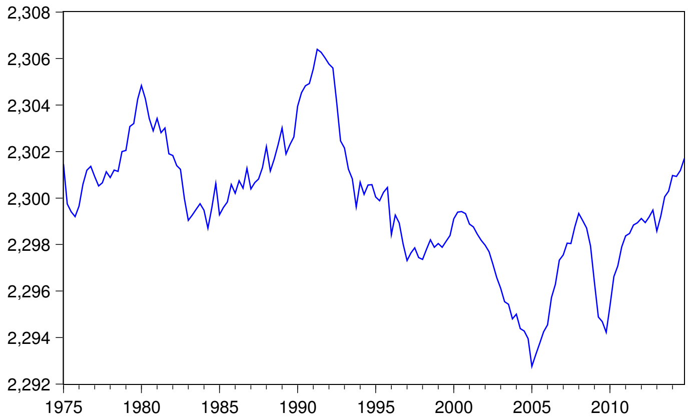
1 Introduction

The flattening of productivity growth is intensely discussed as a global phenomenon (e.g., Summers (2015), Gordon (2016)), where the focus is on technical change, besides demographics and the great recession. Additionally, an unsettled debate addresses the employment effects of technical change (e.g., Gali (1999), Christiano et al. (2004)). We examine both questions together, stressing a particular role of skill-biased technical change (SBTC). Indeed, SBTC has been identified as a major driving force of labour market inequalities mostly since the 1990s (e.g., Acemoglu (2002)). Our analysis benefits from large-sample high-quality labour market data available for Germany, one of the major countries with a past rise in inequality and weakening of productivity. We discriminate skill-neutral and skill-biased technology shocks in a structural Vector Autoregression (VAR) setting with long-run restrictions and find them to have opposing effects on hours worked. SBTC has substantially flattened since the early 2000s, explaining more than half of the drop in productivity growth rates.

2 Variable Selection and Data

We use total hours from the IAB working time accounts. Our data range from 1975Q1 to 2014Q4, where we could rely on overlapping German and West German macroeconomic time series in 1991, providing a factor for adjusting the level shift after 1992Q1 due to the German reunification. Hours is a holistic measure of labour market activity considering both the number of workers and the employees' working time. Figure 1 shows the log $\times$ 100 of seasonally adjusted hours worked by all dependent workers. It clearly mirrors the downturn of the German labour market over the 1990s and the recovery since 2005, interrupted only temporarily by the Great Recession.

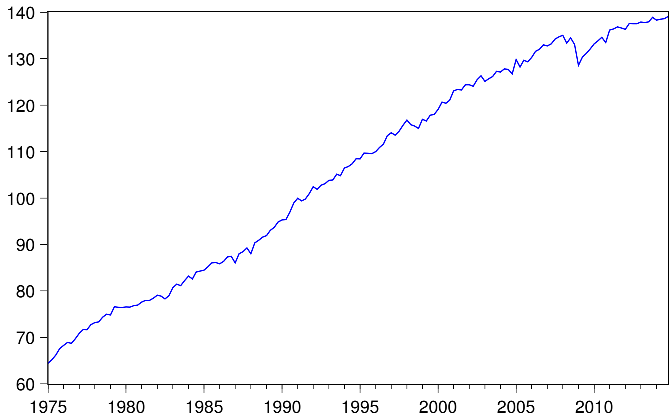
Figure 1: Seasonally adjusted hours worked by all dependent workers, log $\times$ 100



Source: IAB working time accounts.

A seasonally adjusted productivity time series measured in terms of real gross domestic product (GDP) per hours worked is obtained from destatis. Figure 2 shows the development of productivity after taking logs and multiplying by 100. Beyond the Great Recession of 2008/2009, we observe a clear flattening of productivity growth from about 2001 onwards.

Figure 2: Seasonally adjusted productivity: GDP per hour worked, log $\times$ 100



Source: destatis.

We explicitly model SBTC in order to disentangle the productivity effects of SBT shocks (i.e. shocks favoring the skilled over unskilled workers) from skill-neutral technology shocks. For measuring SBTC we use the theoretical framework of a growth model with horizontal innovation that endogenizes the bias of new technologies (see e.g. Gancia and Zilibotti (2009) or Acemoglu (2002)), allowing to infer SBTC from observable variables and estimable parameters:

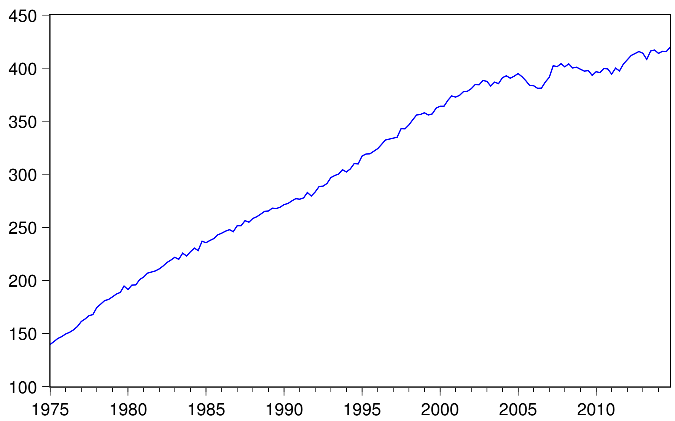
$$ln\left(\frac{A_H}{A_L}\right) = \frac{\sigma}{\sigma - 1}\left[ln\left(\frac{w_H}{w_L}\right) + \frac{1}{\sigma}ln\left(\frac{H}{L}\right)\right], \tag{1}$$

where A_L and A_H are the factor-augmenting technology terms of low-education and high-education labour supplied inelastically at time t, $L(t)$ and $H(t)$ denote the respective number of workers, w_H and w_L the average wages, and σ is the elasticity of substitution between the two factors. Equation (1) requires observations of the skill premium and the relative factor supply, which we obtain from the Sample of Integrated Labour Market Biographies (SIAB). This data set provides detailed information about an individual's (un)employment history on the German labour market.

When determining labour supply, we count all employees and unemployed (including participants of active labour market policy measures) with completed vocational training or higher education as being high-skilled and all workers without degree as being low-skilled. While this classification seems to differ from the usual college vs. no college perspective, for the German case we find it appropriate due to the special role of the dual system of vocational training (Müller and Wolbers (2003)). Indeed, it comprises the main part of jobs that require a college degree in other countries. Shifts in the labour supply variables in 1992 (reunification) and 2005 (statistical effects of the Hartz reforms) were adjusted in autoregressive integrated moving average (ARIMA) models with dummies. To calculate the skill premium, we run monthly Mincer-type regressions of wage on age, squared age, seniority, squared seniority and dummies for gender, nationality and East-Germany. Note that variables such as education, sectors or firm size are left out in the regressions since alongside these dimensions SBTC unfolds its distortive character. The residuals from the regressions are used to calculate w_H and w_L. We take a standard value of $\sigma = 1.7$, for Germany e.g. found by Möller (2000).

Figure 3 shows the development of SBTC after seasonally adjusting, converting the monthly into quarterly data and multiplying by 100. SBTC is steepest through the 1990s but markedly flattens in the subsequent decade. This could be explained by the phasing out of the first wave of computerisation and the fact that the new digitalisation wave did not yet start (compare Beaudry et al. (2010) for technology waves). We will show below that the flattening is a major reason behind the much-discussed weakening of productivity growth.

Figure 3: Skill-Biased Technical Change



Notes: SBTC measured according to (1). Source: SIAB.

3 Model and Identification

Our model needs to fulfill several requirements: First, we are interested in the response of hours and productivity to (skill-biased) technology shocks *over time*, so the model needs to be dynamic. Second, we want to isolate skill-neutral from skill-biased technology shocks. This requires a structural model identified on economic grounds. Third, since technology shocks can be discriminated by their steady-state-effects, the dynamic model must formally incorporate the long run.

Augmented Dickey-Fuller (ADF) tests confirm that our variables should be treated as non-stationary. This leads to modelling the variables in first differences (Δ). In order to capture very general dynamic interactions of the variables without imposing strong structural assumptions a priori we start with a VAR of lag length q:

$$\Delta y_t = c + \sum_{i=1}^{q} A_i \Delta y_{t-i} + u_t \ , \tag{2}$$

where y_t contains the $n = 3$ endogenous variables SBTC, productivity (p) and hours worked (h). A_i are $n \times n$ coefficient matrices and u_t is n-dimensional white noise. We allow for a $n \times 1$ vector of constants c.

The VAR in (2) represents the reduced form of an underlying structural system. The correlated residuals in u_t are not economically interpretable, but usually specified as linear combinations of structural shocks. Under the standard assumption of zero cross-correlations between the different structural shocks, $n(n-1)/2 = 3$ restrictions are needed for identifying the structural form.

We are interested in the effects of skill-neutral and skill-biased technology shocks. The remaining innovation is assumed to have no long-run impact on productivity and SBTC. This is in line with the standards in the growth literature stating that the only long-term drivers of productivity are technology shocks. By definition, SBTC is driven only by SBT shocks in the long run, but not by the normal, i.e. skill-neutral, technology shock. Examples are the widespread usage of computers and robotics at workplaces or other skill-complementing or low-skill replacing technologies. The three restrictions lead to a triangular matrix of long-run impacts.

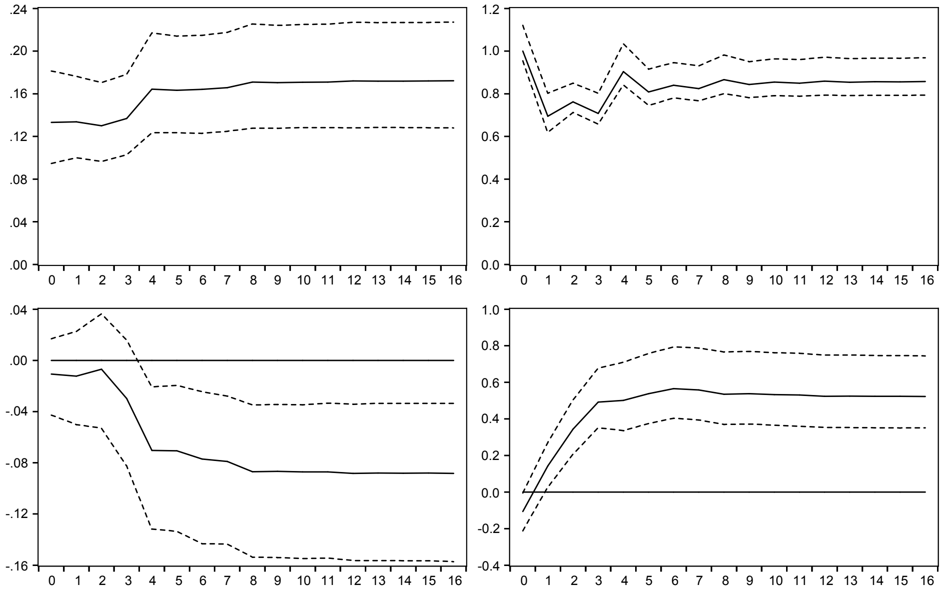
4 Results

We choose the optimal lag length $q = 4$ according to AIC and secure parsimony by sequentially excluding the A_i-elements that lead to worse AIC values. From the structural model, we estimate impulse responses and 2/3 confidence intervals using the Hall bootstrap with 2.000 replications, as shown in Figure 4 for a horizon of 16 quarters. We consider 1 unit shocks. Since all variables were multiplied by 100, this implies a technology shock connected to an immediate 1 percent productivity impact and a SBT shock connected to an immediate 1 percent impact on SBTC (i.e., the relation of the factor-augmenting technology terms of the high- and low-skilled).

As expected, SBT shocks increase productivity (Figure 4, upper left panel). However, hours worked are clearly reduced (lower left panel). This is consistent with high-skilled workers being more productive than low-skilled workers: Then, if the relative demand for high-skilled is increased, less hours are required for producing a given output. The income effect of SBTC seems not to offset the displacement or substitution effect (Moore and Ranjan (2005)). Put differently, if less productive workers are substituted with more productive ones following an SBT shock, total hours decrease while their production impact rises.

(Skill-neutral) technology shocks naturally increase productivity (upper right panel). Notably, we also find a clear increase of hours worked (lower right panel). The effect following a 1 percent technology shock is insignificant in the short run but increases until the third

Figure 4: Responses of p and h to skill-biased and skill-neutral technology shocks



Notes: The solid line shows the responses of productivity (upper panels) and hours (lower panels) to 1% skill-biased (left panels) and skill-neutral (right panels) technology shocks up to 16 quarters. The dotted lines denote 2/3 confidence intervals.

quarter to about 0.5 percent. It is in line with results from Christiano et al. (2004), amongst others, but stands in contrast to the persistent negative effects reported in Gali (1999) and subsequent literature. Note that these latter results are based on a single technology shock that implicitly captures both skill-neutral and skill-biased technology shocks (compare also Balleer and van Rens (2013)). Since the hours effect of the latter has been shown to be negative above, responses to overall (intermingled) technology shocks will be smaller than to skill-neutral shocks. Indeed, if we eliminate SBTC from the system and thus estimate a small standard model, the response of hours to the technology shock is insignificant in the long run. However, the positive hours effect reached in the larger model is more in line with standard search and matching theory where plain productivity shocks foster vacancy creation and therefore employment. This emphasizes the advantage of an approach that disentangles skill-neutral and skill-biased technology shocks.

Finally, we calculate the contribution of the flattening of SBTC to the decrease in productivity growth since about 2001. SBTC rose from 1975 until 2000 on average by 2.27 points per quarter, afterwards only by 0.82 points. We can hypothetically neutralise this weakening by additional shocks of $2.27 - 0.82 = +1.45$ per quarter since 2001. (Note that the shocks have to be scaled down slightly since the long-run impulse response of SBTC to a SBT-unit-shock is 1.13.) Applying the total impulse response of productivity to SBT shocks, 0.17, we find that productivity growth would have been 0.22 percentage points higher per quarter (or 0.88 percentage points per year) if SBTC had not flattened. This explains a substantial part of the average growth rate difference of productivity before and since 2001, which amounts to 1.44 percentage points per year.

5 Conclusion

We analysed the effects of SBTC on productivity flattening and hours worked. More than 60 percent of the slowdown in productivity growth in Germany since the early 2000s can be explained by the SBTC development. Furthermore, SBT shocks reduce hours worked, while skill-neutral technology shocks have a positive effect in the long run. In disentangling the effects of skill-biased and skill-neutral technology shocks, our analysis contributes to a more comprehensive understanding of the relationship of technology and the labour market. Moreover, the results on SBTC can be taken as a warning signal for the current wave of intelligent and interconnected digitalisation. According to research results for Germany, this will raise the qualification needs (Wolter et al. (2016)). To the extent the development is connected to an essentially skill-biased technical change, there is a risk of negative employment effects. This underlines the key role of qualification. On the other hand, according to our results a new wave of SBTC would contribute to overcome the worldwide productivity slack.

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