

# How Does Labor Demand React to Changes in the Supply of Skills? Evidence from Schooling Reforms

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## Abstract

It is widely documented that the college-high school wage differential in the US and many European countries began to rise rapidly starting from the 1980s and the upward trend continued in the past few decades. The large increase in the college wage premium was accompanied by a large secular rise in the relative supply of college workers at the same time. The leading hypothesis explaining this phenomenon is the skill-biased technology change (SBTC). The SBTC argues that constant and exogenous arrival of new technologies that are more complementary to skilled workers causes labor demand for skilled workers to rise relative to that of unskilled workers (Katz and Murphy, 1992; Autor, Katz, and Kearney, 2008). Another set of papers suggests that the shift in the relative labor demand curve is a response to the shift in relative supply (Acemoglu, 1998; Beaudry and Green, 2003; Acemoglu, 2007). A common feature to these models is that, instead of imposing exogenous and stable shift in labor demand as in the SBTC literature, technology choice is endogenous (either in the form of adoption or invention). An inflow of skilled workers increases return to using more skill-complementary technology, making firms more likely to upgrade their technology and the long-run relative labor demand curve potentially upward-sloping.

While predictions from the endogenous technology change hypothesis are shown to be consistent with the empirical facts, few existing studies have produced convincing evidence on the causal impact of changes to the supply of skills on the demand for skills. One difficulty is that supply changes may be endogenous to changes in wages and production structure. Another challenge is to separately identify endogenous demand shifts from exogenous demand shifts, both of which have similar predictions on wages. The ideal experiment would be to have two isolated labor markets with identical skill compositions, one receiving a shock in the supply of skilled labor and the other one does not. Both labor markets could be subject to the exogenous labor demand shocks, whereas only the treatment market could experience endogenous demand shifts. However, aggregated supply of skills has been going up for the past several decades in almost everywhere in developed countries. When all markets experience an increase in the supply of skills, implications from exogenous and endogenous demand shifts are quite similar.

In this paper, we examine how much the labor demand curve shifts in response to shifts in the supply. We overcome the empirical challenges by exploiting exogenous shocks to the supply of skilled labor through two education reforms in Norway. The main reform we consider is the establishment of several new regional colleges in different cities at different times through the 1970s. Municipalities with a new college had more rapid growth of the share of skilled workers over time than a set of control cities without any new college, perhaps due to a reduction in the cost of going to college for

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people living in the area. The timing and geographic location of the roll-out of new college openings are determined by the central government and are unlikely to correlate with prevailing local labor demand conditions. As a second reform, we use the compulsory school reform as a shock to the supply of middle-skilled workers. The compulsory schooling reform, implemented in different cities at different time through the 1960s, mandates a minimum education of 9 years, up from 7 years of compulsory schooling prior to the reform. Contrary to the college reform where the shift is at the top of the distribution of skills, the compulsory school reform mainly affects the bottom of the skill distribution.

We start by building a simple model of endogenous technology adoption to motivate our empirical study. In the model, firms in a local and competitive market face two technology choices, one of which is more complementary to skilled worker than the other. The choice of technology is costly, and is more costly for using the skill-biased technology. In this economy, firms initially choose the equilibrium technology that is not skill-biased. When the shock to the supply of skilled workers is large enough, the new equilibrium technology becomes the skill-biased technology. As a result of the technology change, the long-run labor demand curve may be upward-sloping, predicting an increased wage of skilled workers along with increased supply.

Our empirical analysis draws on several large and long panel data containing firm-level information on production structure and individual-level information on social and economic backgrounds of all adult individuals in Norway. Our main firm-level data spans from 1967 to 1990, covering the entire periods of the college reform and majority of periods of the compulsory schooling reform. During this period, at the aggregate level there has been a dramatic increase in the share of college educated workers. From the early 1980s the college premium begins to rise following a drop in the 1970s, consistent with a exogenous SBTC taking place starting in the 1980s. We then provide some reduced form estimates that are consistent with predictions from the model of technology adoption. In specific, we estimate the short and long run reduced-form effects of the reforms on a range of firm and city-level outcomes. Our preferred specification uses the method proposed by Abadie, Diamond, and Hainmueller (2010) to construct an optimal synthetic control group for each municipality with a college opening, whose pre-treatment trends match the treated municipality's more closely than those of an arbitrarily selected set of municipalities. Our main results are also robust to alternative identification strategy which exploits the spatial and time variation of the reform in a difference-in-difference type of regression setting. Under our preferred specification, we find that, in comparison with the control municipality, the opening of a new college in the 1970s increases the share of skilled labor in the city with a new college. Despite the positive shock to the supply of skilled workers, the municipalities with new college openings also have higher wages, value-added output per worker and share of high-skilled industry. All of these estimates are suggestive of a skill-biased demand shift.

To quantify the effect of supply shock on technology change, we estimate production functions using the firm-level panel data, controlling for firm and year fixed effects. Parameters describing labor productivity is allowed to vary either by implementation of the reform or by a flexible function characterizing time relative to the reform. These parameters are meant to capture any technology change as a result of the reform. We estimate both Cobb-Douglas and the more general translog production functions, with capital and three types of labor (high skilled, middle skilled and low skilled) as inputs. Besides the fixed effects model, to make sure that unobserved productivity shocks do not bias our estimates, we also follow Levinsohn and Petrin (2003) and use intermediate inputs to proxy for unobserved productivity shocks. We find that the college reform has large, gradual and persistent impacts on the productivity of skilled workers. Output elasticity of skilled labor begins to increase by about 5% from 3 to 5 years after the reform and 8% increase by 8 years into the reform. Relative to the productivity before the college was established, the productivity of skilled labor has doubled. The productivity for the middle and low-skilled labor is, however, largely unchanged due to the reform. Taken together, our evidence suggests that an increase in the supply of skilled workers leads to skilled-biased demand shift. In a simulation exercise performed at the end of the paper, we show that the simulated technology-upgrading effects are sufficiently strong to overcome wage losses resulting from the positive supply shock. Turning to the compulsory school reform, we do not find any significant effects on productivity for any type of labor. Pushing the bottom of the skill distribution from 7 to 9 years of education does not appear to induce firms to upgrade their

technologies.

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