

Technological Change, Skill Demand, and Wage Inequality: Evidence from Indonesia

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Summary. — This study provides empirical evidence of the impact that technological progress has on wage inequality in Indonesia. The share of educated workers and their skill premiums have recently increased. A supply–demand analysis, using labor force survey data during 1990–2009, shows that both the between- and within-industry shifts of labor demand that favored skilled workers contributed to the widening wage inequality since the early 2000s. Evidence from firm-level data in the manufacturing sector indicates that the diffusion of foreign technologies through imports and foreign direct investment caused demand to shift toward more skilled labor and increased wage inequality.

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1. INTRODUCTION

What effects do technology and education have on wage inequality? In recent years, there has been a rapid expansion in education and technological progress in many developing countries. While these economies emphasize the positive role of education and transfers of foreign technology in their economic growth, some economists contend that technological progress may exacerbate wage inequality due to its varied impact on workers based on their level of education.

They point out that technology may affect relative wages by shifting labor demand away from the least skilled group. Since most developing economies are dominated by low-skilled workers, this shift in labor demand could cause a drastic change in their labor markets. As argued by the skill-biased technological change hypothesis, demand for educated and skilled workers increases when skill-complementary technologies permeate the workplace.¹

A large body of literature investigates the impact of technological changes on relative labor demand and wage inequality in advanced countries. Though wage inequality is also a pressing issue in developing countries, there is scant literature on the subject. We, therefore, briefly review important papers in this field and explain how our study can contribute to the literature.

Katz and Murphy (1992) use a simple supply–demand framework to explain changes in the wage structure of the United States in 1980s. Their study demonstrates that changes in the relative wage structure, being greater than what a simple supply–demand model would predict, could be traced to an increased demand for more skilled workers. Berman, Bound, and Griliches (1994) confirm that the greater employment of non-production workers in the United States was driven mostly by increased demand from within industries and that this demand change was correlated with investments in computers and research and development (R&D). A sizeable portion of the demand shift within each industry, rather than between industries, may be attributed to technological changes that favor more skilled workers.

The increased utilization of computers and workplace organization are designated as driving forces behind the long-run

increase in the relative demand for skilled workers. Autor *et al.* (1998) show that growth in computer utilization exerted a positive effect on skill upgrading and that this relationship has accelerated in more recent decades. Autor *et al.* (2003) contend that the type of work is a key factor in the growing demand for skilled workers and explain how the recent development of computer technology is associated with an increase in upper-tail wage premiums (for example, 90th-to-50th percentile ratio; p_{90}/p_{50}). Computers have three impacts on workers corresponding to their tasks: Computers complement those who perform non-routine tasks, such as management and analysis; they replace those who carry out routine tasks; and they have a limited impact on manual workers. A study by Bresnahan, Brynjolfsson, and Hitt (2002) uses detailed firm-level data to examine the effects of information technology and workplace organization on skill-biased technological change. Additionally, it shows that a greater permeation of technology throughout particular workplace environments increases the effect of information technology on skilled labor employment.

Evidence of an association between technological change and wage inequality can also be observed for other advanced countries. Machin and Van Reenen (1998) extend the analysis to six OECD countries, finding that R&D expenditure and computer investments were positively associated with skill upgrading. Berman, Bound, and Machin (1998) find that, with progressing technology, skill upgrading occurred within similar industries in twelve OECD countries, suggesting pervasive skill-biased technological change.

A number of papers raise questions regarding the extent of skill-biased technological change and its impacts on wage structure. Card and DiNardo (2002) insist that skill-biased

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technological change should be considered as an episodic event rather than a secular trend; as evidence, they point out the stabilization of wage inequality in the 1990s, when computer technology continued to develop. They conclude that non-market factors, such as the minimum wage and labor unions, had a more important role in explaining the rising inequality.

Lee (1999) supports Card and DiNardo's (2002) claim by showing that increasing wage inequality in the 1980s in the United States was associated with a decline in the real value of the federal minimum wage. Lemieux (2006) suggests that skill-biased technological change is illusory because of the compositional change in the labor force and measurement errors in the data. If unobserved skills are more dispersed among older and more educated workers, residual inequality could be higher in a labor force where these workers are more common. Western and Rosenfeld (2011) present a decline in union membership as a source of increased wage inequality. Their analysis shows that the decline in labor unionization rates from 34% of male workers in 1973 to 8% in 2007 contributed to 20–30% of the increased wage inequality in the United States.

In response to this “revisionist” literature focusing on non-market factors, Autor, Katz, and Kearney (2008) claim that skill-biased technological change is still the major source of increasing inequality in the long run. They point out that decreased overall wage inequality in the 1990s hides a strong, persistent rise in inequality in the upper half of the distribution, which polarizes U.S. earnings. According to their new framework, non-market factors affecting lower tail (p50/p10) inequality cannot explain increased inequality in the upper tail (p90/p50). Goldin and Katz (2009) further extend the supply–demand framework and examine the evolution of wage differentials from 1890 to 2005. They claim that even with immigration flows and institutional changes during wartime in the 1940s and late 1970s, the college premium in the United States was still mainly determined by the relative supply and demand for college workers.

There are a limited but growing number of empirical studies on the relationship between technological change and wage inequality in developing countries. Berman, Somanathan, and Tan (2005) find evidence of skill-biased technological change in India in the 1990s using panel data disaggregated by industry and state. Kijima (2006) also points out that returns to skills, produced by skill-biased technological changes within industries, are a driving force of increasing income inequality in India. Harrison (2008) presents firm-level evidence supporting skill-biased technology adoption in Brazil. Bustos (2011) observes the positive association between skill upgrading within firms and relative demand for skilled labor in Argentina. Chen, Ge, and Lai (2010) also find that wage inequality in China is driven by foreign direct investment, implying that the transfer of foreign technology in an important source of wage inequality in developing countries.

This paper empirically examines the implications that technological changes have for wage inequality in Indonesia, one of the largest and fastest-growing developing economies with some 240 million people. We are especially interested in the role of foreign technology and trade on said inequality. Indonesia is a labor abundant country with relatively low wages that attracts many multinational companies. Hence, it provides an excellent opportunity to examine the impact of trade and foreign direct investment (FDI) on the demand for skilled labor. Indonesia's exposure to international trade and direct investment increased significantly in the last decade. FDI net inflows have shown rapid growth since the Asian financial

crisis, increasing from –2.8% of GDP in 2000 to 2.3% in 2012, according to the World Bank's *World Development Indicators* data (World Bank, 2013). The country's trade share also began rising in 2003 after its collapse during the crisis. An increase in international trade and FDI is expected to have significant effects on wage premiums and the relative demand for skilled workers by means of various mechanisms, including relative demand shifts across sectors and technology upgrades.

While previous studies, such as Alatas and Bourguignon's (2005), highlight that Indonesia has been known for successful growth without an increase in income inequality, other studies address the recent reversal in this trend.² Several factors such as increasing unemployment, changing labor market institutions, rising rice prices, and regressive fuel subsidies are cited as sources of the rising income inequality. However, a limited quantity of literature analyzes the role of skill-biased technological change in creating this inequality.

A recent World Bank report by Di Gropello & Sakellariou (2010) examines skill-biased technological change and reports no clear evidence of skill upgrading in Indonesia. They find that the share of skilled labor in employment and total wage bills did not increase in the manufacturing sector during 1975–2005. They also observe that most changes in labor demand occurred between industries, suggesting little evidence of a demand shift toward skilled labor. It would be interesting to investigate whether any significant change has occurred in the wage inequality trend in the last few years, during which the economy has increased its exposure to foreign trade and investment.

We find evidence that the wage inequality trend began to reverse around 2003, when all decreasing inequality indexes started to soar. We also find, based on extended data and available Indonesian surveys from after 2005, that demand shifted toward skilled workers as wage inequality rose. We then carefully examine whether the demand shift is related to technological progress. Our regression results, using firm-level manufacturing survey data, show that the increased demand for skilled labor was associated with transfers of foreign technology through FDI and imported materials. Our findings imply that trade and foreign technology could increase wage inequality by shifting demand toward more skilled workers.

The remainder of this paper is organized as follows: Section 2 describes both trends in various wage inequality measures and overall characteristics of the Indonesian labor market. Section 3 analyzes the Indonesian Labor Force Survey using a supply–demand framework and a within/between decomposition of industry demand shifts. Section 4 is devoted to the analysis of the relationship between technology transfers and skill upgrading in the manufacturing sector. Section 5 concludes.

2. OVERVIEW OF CHANGING WAGE INEQUALITY IN INDONESIA

In contrast to many other developing countries, Indonesia experienced declining wage inequality during its rapid development period. However, in recent years, wage inequality has been rising. Figure 1 shows the median, 10th percentile, and 90th percentile of the real monthly wage distribution among full-time wage workers in the 1990–2009 period. The National Labor Force Survey of Indonesia (from which the aforementioned data were gathered) is conducted annually. The sample size varies from over 65,000 households in 1990 to about 299,000 in 2009. The survey provides detailed

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