Skilled labor market flexibility, technological change and the gains from differentiated goods trade

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Discussion Paper No.24-04
2025 年 2 月

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Abstract

This paper examines a differentiated goods trade model in which firms are operated by skilled workers. It analyzes the effects of skilled labor-saving technological change. While the adoption of such technology typically benefits all in the long run under flexible labor market conditions, this study highlights a key exception: when a country's skilled labor market is rigid and firms cannot adopt the new technology, its skilled workers may lose from trade if its trading partner successfully implements and adapts to the technological change.

Keywords: international trade; monopolistic competition; labor market institution; technological change
JEL classification: F12, F16, J24, J31, J41, D33

1. Introduction

Interest in international differences in labor market institutions has grown over the past several decades. These institutions encompass minimum wage laws, employment protection legislation, unions and collective bargaining, and mandated benefits such as family-related leave. Betcherman (2012) examines the impact of labor market institutions, focusing on these four aspects, and suggests that while they play a role in redistribution, their effects on efficiency and productivity remain ambiguous.

Given the diversity of labor market institutions across countries, the rapid globalization since the late twentieth century has likely had uneven effects on labor markets. Globalization has produced varied outcomes for countries engaged in international trade. For instance, Baccini et al. (2022) distinguish between liberal market economies (LMEs) and coordinated market economies (CMEs), which differ in wage-setting mechanisms and state vocational training. Their findings suggest that CMEs experience a milder impact from trade compared to LMEs.

Theoretical studies have explored how globalization affects economies with different labor market institutions. Davis (1998a) examines how U.S. wages are influenced by European unemployment, concluding that trade between flexible-wage America and rigid-wage Europe raises U.S. wages to European levels while increasing European unemployment. Davis (1998b) further investigates how technological change affects wage disparities between skilled and unskilled workers under different labor market institutions. Tang (2012) analyzes how labor market conditions shape comparative advantage through workers' skill acquisition, showing that countries with protective labor markets encourage firm-specific skill development, leading to specialization in firm-specific skill-intensive goods. Davidson and Matusz (2004) develop a job search model explaining unemployment, demonstrating how cross-country differences in job creation and job turnover rates influence autarky prices and drive international trade.

Labor market institutions vary significantly across countries. For example, while the U.S. labor market is relatively flexible, Japan's labor market remains rigid, particularly for skilled or core workers under its lifetime employment system. Miura (2001) highlights the persistence of traditional Japanese employment structures, showing that asymmetric deregulation has deepened the divide between regular and atypical workers, reinforcing labor market segmentation.

This study is motivated by Japan's experience but applies more broadly to economies with a distinct skilled-unskilled labor divide and rigid skilled labor markets. The central question is how globalization—specifically, international trade—affects economies with varying degrees of labor market flexibility when skilled labor-saving technology becomes available. The analysis focuses on a scenario in which the home country has an inflexible skilled labor market, while its trading partner has a more flexible one. The key finding is that under such asymmetry, home skilled workers may lose from trade because domestic firms, unable to adopt the new technology, cannot reallocate skilled labor efficiently. Meanwhile, home unskilled workers and all foreign workers continue to benefit from trade. The remainder of the paper is structured as follows. Section 2 presents a general equilibrium model focusing on skilled workers in monopolistically competitive firms producing differentiated goods. Section 3 examines the effects of technological innovation that reduces firms' reliance on skilled labor. Section 4 explores the impact of international trade, comparing three different cases of skilled labor market flexibility. The final section concludes.

2. The basic skilled worker model

Assumptions

There are two types of goods in the economy – differentiated goods, produced in the 'modern (M)' sector, and homogeneous goods, produced in the 'traditional (T)' sector. All consumers are assumed to have the same preferences. These preferences are described by the following two-tier structure:

$$U = M^{\mu}T^{1-\mu} \ (0 < \mu < 1) \tag{1a}$$

$$M = \left[\int_0^n m(i)^{\rho} di\right]^{\frac{1}{\rho}} \ (0 < \rho < 1) \tag{1b}$$

The upper tier (1a) is a Cobb-Douglas function of the consumption of an aggregate of differentiated varieties (M) and the homogeneous good (T). The second tier defines M as a constant elasticity of substitution (CES) function, where $m(i)$ is the consumption of each manufactured variety i. M is therefore a CES composite of the total mass of varieties, n. The elasticity of substitution between any differentiated goods is $1/(1-\rho) \equiv \sigma \ (\sigma > 1)$.

On the production side, a firm in the modern sector producing a particular variety requires a fixed number (F) of skilled workers and c units of unskilled workers per unit output.[1] The firm thus faces increasing returns to scale. Its total cost for producing a given amount (q) is then

$$C(q) = Fw + cq, \tag{2}$$

where w is the wage of skilled workers and that of unskilled workers is set equal to one. It is assumed that this industry is monopolistically competitive.

The traditional sector is a constant returns to scale sector using only unskilled labor as a factor of production. A unit of unskilled worker produces a unit of traditional goods. Therefore, the total cost of producing a given amount of traditional goods (q^T) is

$$C_T(q^T) = q^T, \tag{3}$$

The total amount of skilled workers in the economy is S and that of unskilled workers is L. They are also consumers.

Consumer behavior

For a given income I, and a given price $p(i)$ for each variety, the consumer's problem is to maximize her utility, subject to the budget constraint

$$\int_0^n p(i)m(i)di + p^T T = I, \tag{4}$$

where $p(i)$ is the price of variety i of the differentiated good and p^T is the price of the homogeneous good. Since the preference for differentiated varieties and the homogeneous good are separable, and the second tier is homothetic in $m(i)$, the problem can be solved in two steps. The first step is to choose $m(i)$. That is, consumers should choose $m(i)$ to minimize the cost of consuming M. This implies minimizing expenditure

$$\int_0^n p(i)m(i)di, \tag{5}$$

subject to

$$\left[\int_0^n m(i)^{\rho} di\right]^{\frac{1}{\rho}} = M. \tag{6}$$

[1] This formulation was used by Forslid and Ottaviano (2003) in their economic geography model of footloose entrepreneurs.

Then standard result of demand function for variety j is

$$m(j) = p(j)^{-\sigma} G^{\sigma-1} \mu I, \tag{7}$$

where σ becomes the price elasticity of demand, and G is called the price index:

$$G \equiv \left[\int_0^n p(i)^{\frac{\rho}{\rho-1}} di \right]^{\frac{\rho-1}{\rho}} = \left[\int_0^n p(i)^{1-\sigma} di \right]^{\frac{1}{1-\sigma}}. \tag{8}$$

The second step is to allocate the expenditure between M and T. The demand for the homogeneous good is then

$$T = \frac{(1-\mu)I}{p^T}. \tag{9}$$

Firm behavior

In the modern sector, because of the infinite number of potential varieties and increasing returns to scale at the firm level, each firm becomes a sole producer of a differentiated variety. The first-order condition of profit maximization is then the equalization of marginal revenue and marginal costs. Since the demand elasticity that each firm faces is σ, firms will exhibit the following mark-up pricing behavior

$$p\left(1 - \frac{1}{\sigma}\right) = c, \tag{10}$$

and the corresponding price index of differentiated goods is

$$G = n^{\frac{1}{1-\sigma}} p. \tag{11}$$

(Hereafter, i is dropped to focus on a typical firm.) Operating profit per firm (π), which is shared by the skilled workers, is $pq - cq$ or

$$\pi = \frac{cq}{\sigma-1}. \tag{12}$$

In the traditional sector, perfect competition leads to marginal cost pricing. Hence, $p^T = 1$.

Equilibrium

Equilibrium requires clearing of the markets of goods and factors. Market clearing in the differentiated goods require

$$\mu p^{-\sigma} G^{\sigma-1} Y = q, \tag{13}$$

where the aggregate income (Y) is

$$Y = n\pi + L. \tag{14}$$

Turning to the clearing of labor markets, full employment of the skilled workers implies that the total mass of modern sector firms is fixed at

$$n = \frac{S}{F}. \tag{15}$$

Since each firm employs cq unskilled workers, full employment of the unskilled workers requires

$$ncq + (1-\mu)Y = L, \tag{16}$$

which is also the market clearing condition of the traditional good.

Solving the above equilibrium conditions, we obtain the constant equilibrium M sector firm size

$$q = \frac{\mu LF(\sigma-1)}{cS(\sigma-\mu)}, \tag{17}$$

and equilibrium per firm profit is

$$\pi = \frac{\mu LF}{S(\sigma-\mu)}, \tag{18}$$

which is shared by the skilled workers. Then the real wage of a skilled worker is

$$\omega_S^A = \frac{\pi/_F}{G^\mu} = \frac{\frac{\mu L}{S(\sigma-\mu)}}{G^\mu}, \tag{19a}$$

And that of an unskilled worker is

$$\omega_U^A = \frac{1}{G^\mu}, \tag{19b}$$

where superscript A stands for autarky, and subscripts S and U stand for skilled and unskilled, respectively.[2]

4. Response to technological innovation in autarky

4.1 The case with skilled labor market flexibility

Assumption of technological innovation

Suppose an innovation occurs due to information technology development that enables the M firms to operate with fewer skilled workers. Specifically, suppose adoption of the new technology realizes $F' < F$.

Equilibrium under flexible skilled labor market

Now if the skilled labor market is flexible in the sense that the skilled workers can move to other firms or be employed by new firms, in the new equilibrium,

$$n' = \frac{S}{F'} > \frac{S}{F}, \tag{20}$$

$$G' = n'^{\frac{1}{1-\sigma}} p < n^{\frac{1}{\sigma-1}} p, \tag{21}$$

$$q' = \frac{\mu L F'(\sigma-1)}{cS(\sigma-\mu)} < \frac{\mu L F(\sigma-1)}{cS(\sigma-\mu)}, \tag{22}$$

and

$$\pi' = \frac{\mu L F'(\sigma-1)}{S(\sigma-\mu)} < \frac{\mu L F(\sigma-1)}{S(\sigma-\mu)}. \tag{23}$$

Therefore, in the new equilibrium, the total mass of M sector firms/variety increases while individual prices (p) remain unchanged, which are reflected in the lower price index. Specifically, the real wages are

$$\omega_S^{A'} = \frac{\pi'/_{F'}}{G'^\mu} = \frac{\pi/_F}{G'^\mu} > \omega_S^A, \tag{24a}$$

and

$$\omega_U^{A'} = \frac{1}{G'^\mu} > \omega_U^A, \tag{24b}$$

for skilled and unskilled workers, respectively. Both skilled and unskilled workers enjoy higher real wages generated by the increased mass of M sector varieties.

4.2 The case with no skilled labor market flexibility

When skilled labor market flexibility is absent—meaning skilled workers are bound to their existing firms with no mobility or opportunity to transition to new workplaces—firms cannot reduce skilled labor employment, nor can new firms hire them. As a result, no new firms or product varieties emerge in the M sector. Consequently, despite the availability of skilled labor-saving technology, the economy remains unchanged.

[2] Although it is not necessary for the subsequent analyses, the condition for the skilled wage exceeding the unskilled wage is $\mu L > S(\sigma - \mu)$.

5. Trade and response to technological innovation

5.1 Assumptions

As emphasized earlier, the technological innovation examined in this paper allows M sector firms to operate with fewer skilled workers. This section analyzes the outcomes when two identical countries engage in trade, considering three different scenarios.

1. No Skilled Labor Market Flexibility in Either Country: In this case, skilled labor remains immobile, preventing M sector firms in both countries from adopting the new technology.
2. Full Skilled Labor Market Flexibility in Both Countries: Here, skilled labor is mobile, allowing M sector firms in both countries to implement the technology and reduce their skilled labor employment.
3. Asymmetric Skilled Labor Market Flexibility: In this scenario, the home country (Home) has no skilled labor mobility, while the foreign country (Foreign) does. As a result, only M firms in Foreign can adopt the technology and reduce skilled employment.

The settings for these three cases are summarized in Table 1.

Table 1: Skilled labor market flexibility

	Home	Foreign
Case 1	No	No
Case 2	Yes	Yes
Case 3	No	Yes

Throughout the following analyses, international trade costs are ignored. Costless trade of traditional goods implies that $p^T = 1$ holds internationally, and that unskilled wage is equal to one in Home and Foreign.

5.2 Case 1: Neither country has skilled labor market flexibility

Trading equilibrium

Clearing of the differentiated goods markets requires

$$\mu p^{-\sigma} G^{\sigma-1}(Y + Y^*) = q = q^*, \tag{25}$$

where

$$Y = n\pi + L, \tag{26a}$$

and

$$Y^* = n^*\pi^* + L. \tag{26b}$$

Asterisks are used hereafter to denote variables of Foreign. Market clearing of the homogeneous good requires its global demand to equal global supply, that is,

$$(1-\mu)(Y + Y^*) = 2L - ncq - n^*cq^*, \tag{27}$$

which also implies full employment of unskilled workers. Due to symmetry, this reduces to (16) in the autarky case.

Full employment of the skilled workers implies that the total mass of firms is fixed at

$$n = n^* = \frac{S}{F}. \tag{28}$$

Then the welfare levels of the skilled and unskilled workers in case 1 are

$$\omega_S^1 = \omega_S^{1^*} = \frac{\pi/F}{G^\mu} = \frac{\frac{\mu L}{S(\sigma-\mu)}}{G^\mu}, \tag{29a}$$

and

$$\omega_U^1 = \omega_U^{1^*} = \frac{1}{G^\mu}, \tag{29b}$$

respectively, where

$$G = \left(\frac{2S}{F}\right)^{\frac{1}{1-\sigma}} \frac{\sigma c}{\sigma - 1}. \tag{30}$$

Gains from trade

In comparison to the autarky case with no adoption of technological innovation, both skilled and unskilled workers in Home and Foreign still equally gain from trade because they can consume more varieties through trade. That is,

$$\frac{\omega_S^1}{\omega_S^A} = \frac{\omega_S^{1^*}}{\omega_S^{A^*}} = \frac{\omega_U^1}{\omega_U^A} = \frac{\omega_U^{1^*}}{\omega_U^{A^*}} = 2^{\frac{\mu}{\sigma-1}} > 1. \tag{31}$$

5.3 Case 2: Both countries have skilled labor market flexibility

Trading equilibrium

Market clearing conditions of the two goods and that of the unskilled workers are the same as in case 1. Noting that the fixed costs of the M sector firms are now reduced to $F'(< F)$, full employment of the skilled workers implies that the total mass of firms is fixed at

$$n = n^* = \frac{S}{F'}. \tag{32}$$

Therefore, M sector firms/varieties increase in both countries. Solving (25), (26a), (26b) and (27) using (32), we have

$$q = q^* = \frac{\mu(\sigma-1)}{\sigma-\mu} \cdot \frac{LF'}{cS}, \tag{33}$$

and

$$\pi = \pi^* = \frac{\mu L F'}{S(\sigma-\mu)}. \tag{34}$$

The welfare levels of the skilled and unskilled workers in case 2 are then

$$\omega_S^2 = \omega_S^{2^*} = \frac{\pi/F'}{G^\mu} = \frac{\frac{\mu L}{S(\sigma-\mu)}}{G^\mu}, \tag{35a}$$

and

$$\omega_U^2 = \omega_U^{2^*} = \frac{1}{G^\mu}, \tag{35b}$$

respectively, where

$$G = \left(\frac{2S}{F'}\right)^{\frac{1}{1-\sigma}} \frac{\sigma c}{\sigma - 1} < \left(\frac{2S}{F}\right)^{\frac{1}{1-\sigma}} \frac{\sigma c}{\sigma - 1}. \tag{36}$$

Gains from trade

In comparison to the autarky case with no adoption of technological innovation, both skilled and unskilled workers in Home and Foreign gain by being able to consume more varieties through trade, but the gains are larger than those of Case 1, because the modern sector firm increases in both countries, making use of the technological innovation. That is,

$$\frac{\omega_S^2}{\omega_S^A} = \frac{\omega_S^{2^*}}{\omega_S^{A^*}} = \frac{\omega_U^2}{\omega_U^A} = \frac{\omega_U^{2^*}}{\omega_U^{A^*}} = \left(2\,\frac{F}{F'}\right)^{\frac{\mu}{\sigma-1}} > \frac{\omega_S^1}{\omega_S^A} = \frac{\omega_U^1}{\omega_U^A} = 2^{\frac{\mu}{\sigma-1}} > 1. \tag{37}$$

5.4 Case 3: Only one country (Foreign) has skilled labor market flexibility

Trading equilibrium

Market clearing conditions of the two goods and that of the unskilled workers are the same as in case 1. Noting that the fixed costs of the M sector firms are now reduced to $F'(<F)$ only in Foreign, full employment of skilled workers leads to the mass of M sector firms in Home and Foreign to be

$$n = \frac{S}{F}, \tag{38a}$$

and

$$n^* = \frac{S}{F'}, \tag{39b}$$

respectively. That is, while the M sector firms/varieties increases in Foreign, it remains unchanged from the autarky level in Home. Solving (25), (26a), (26b), and (27) using (38a) and (38b), we have

$$q = q^* = \frac{\mu(\sigma-1)}{\sigma-\mu} \cdot \frac{2L}{c\left(\frac{S}{F}+\frac{S}{F'}\right)}, \tag{40}$$

and

$$\pi = \pi^* = \frac{\mu L}{S(\sigma-\mu)} \cdot \frac{2FF'}{F+F'}. \tag{41}$$

Therefore, skilled real wages in Home and Foreign in Case 3 are

$$\omega_S^3 = \frac{\pi/_F}{G^\mu} = \frac{\frac{\mu L}{S(\sigma-\mu)}}{G^\mu} \cdot \frac{2F'}{F+F'}, \tag{42a}$$

and

$$\omega_S^{3^*} = \frac{\pi/_{F'}}{G^\mu} = \frac{\frac{\mu L}{S(\sigma-\mu)}}{G^\mu} \cdot \frac{2F}{F+F'}, \tag{42b}$$

respectively, where

$$G = \left[\frac{S(F+F')}{FF'}\right]^{\frac{1}{1-\sigma}} \frac{\sigma c}{\sigma-1}. \tag{43}$$

Here, unlike the previous cases, note that $\omega_S^{3^*} > \omega_S^3$. Unskilled real wages in Home and Foreign are

$$\omega_U^3 = \omega_U^{3^*} = \frac{1}{G^\mu}. \tag{44}$$

Gains and losses from trade

Comparing (42b) and (19a), the gains from trade in Case 3 for the Foreign skilled workers is

$$\frac{\omega_S^{3^*}}{\omega_S^{A^*}} = \left(\frac{F+F'}{F'}\right)^{\frac{\mu}{\sigma-1}} \cdot \frac{2F}{F+F'} > 1. \tag{45}$$

Further, comparing the three cases and autarky,

$$\omega_S^{3^*} > \omega_S^{2^*} > \omega_S^{1^*} > \omega_S^A. \tag{46}$$

As for Home skilled workers,

$$\omega_S^2 > \omega_S^1 > \omega_S^3. \tag{47}$$

In Home, where there is no flexibility in the skilled labor market, per firm output and correspondingly per firm operating profit decreases compared to the autarkic equilibrium. Therefore, in Home, the skilled workers who share the profits may not gain from trade. Specifically, Home skilled workers do not gain from trade when $\omega_S^3 \leq \omega_S^A$, or

$$2\left(\frac{F'}{F+F'}\right)^{\frac{\sigma-1-\mu}{\sigma-1}} \leq 1. \tag{48}$$

The graph of (48) in Figure 1 shows that the larger σ and/or the smaller μ, the higher chance of Home skilled workers losing from trade in case 3. The possibility of Home's skilled workers losing from trade can be explained as follows. In Foreign, firms in the modern sector adopt the new

technology, increasing their number and absorbing more unskilled workers. This shift reduces output in Foreign's traditional sector, which is then offset by an expansion of Home's traditional sector. As Home's traditional sector grows by employing more unskilled workers, each modern sector firm in Home shrinks, leading to lower per-firm profits and reduced earnings for skilled workers.

The lack of skilled labor market flexibility in Home results in de-industrialization, potentially lowering the welfare of Home's skilled workers compared to autarky. Meanwhile, unskilled workers benefit unambiguously due to the greater availability of differentiated goods through trade:

$$\frac{\omega_U^3}{\omega_U^A} = \frac{\omega_U^{3^*}}{\omega_U^{A^*}} = \left(\frac{F+F'}{F'}\right)^{\frac{\mu}{\sigma-1}} > 1. \tag{49}$$

Further, comparing the results of the three cases and the autarky case, the order of the level of welfare of the unskilled workers is

$$\omega_U^2 = \omega_U^{2^*} > \omega_U^3 = \omega_U^{3^*} > \omega_U^1 = \omega_U^{1^*} > \omega_U^A. \tag{50}$$

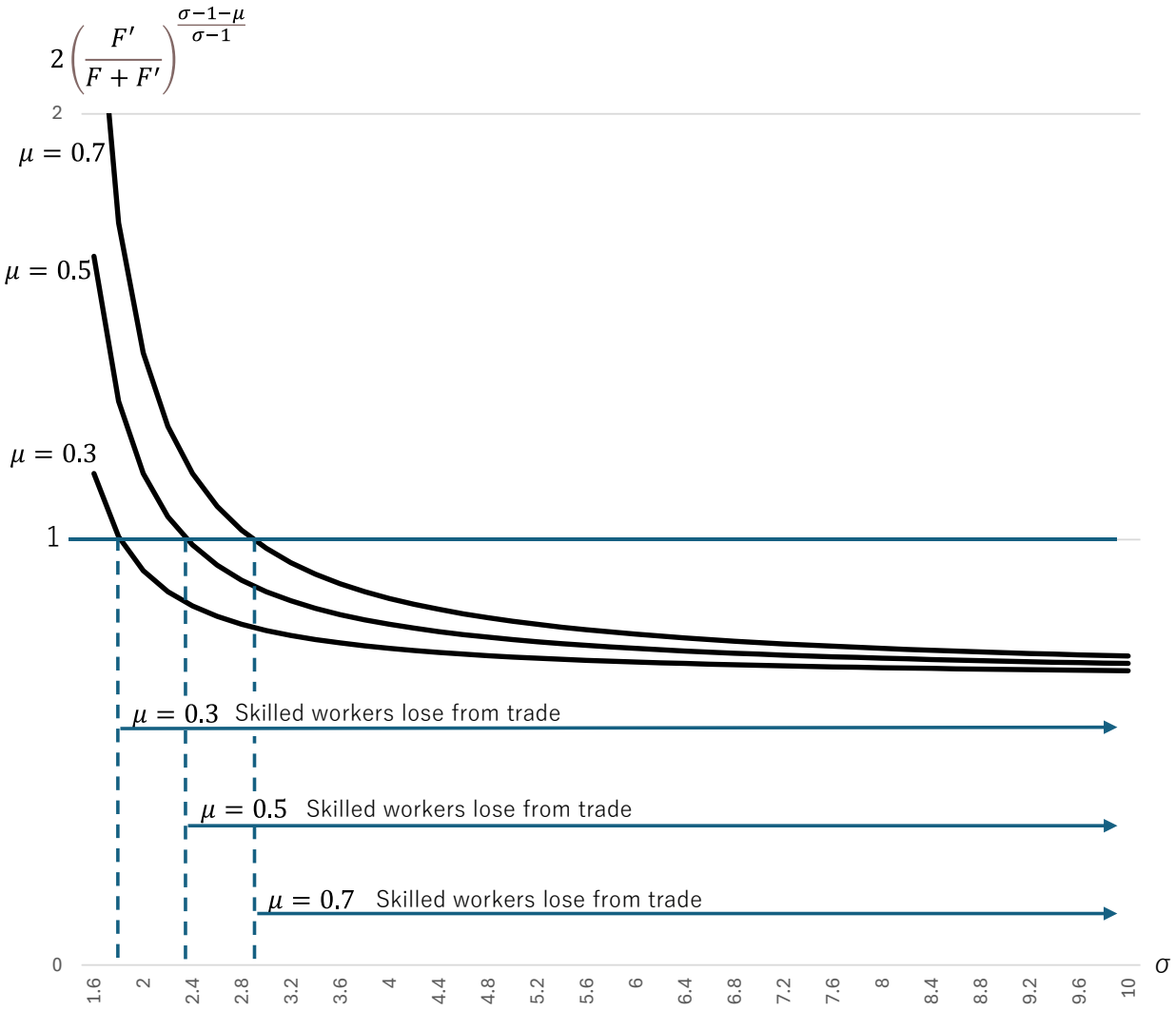

Figure 1: Condition for Home skilled workers' gains and losses from trade in Case 3

Concluding comments

Labor market institutions vary significantly across countries, and this diversity suggests that globalization has had varying impacts on economies engaged in international trade. This paper examined the flexibility of skilled labor markets, particularly focusing on the interfirm mobility of workers essential for firms competing through product differentiation. The information and communication technology revolution enabled firms to operate more efficiently with fewer skilled, white-collar workers. However, the global adoption of labor-saving technologies cannot be assumed to have occurred uniformly. In countries with more rigid labor markets, firms may have struggled to reduce employment and leverage new technologies effectively.

Japan's experience since the late 1990s provides a particularly relevant case study of these dynamics. The challenges faced by Japanese firms and their former white-collar workers over the past three decades illustrate the adverse effects of globalization when labor markets fail to adapt. While technological advancements transformed the way skilled workers operate in many parts of the world, those in countries that did not embrace these changes found themselves at a competitive disadvantage, losing out in the face of international trade.

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