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Pro-competitive effect, division of labor, and firm productivity

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HIGHLIGHTS

- This study constructs a general oligopolistic equilibrium model with the division of labor.
- A pro-competitive policy weakens the division of labor and hence reduces firm productivity.
- The policy promotes an increase in workers' welfare and a decrease in firm owners' welfare.
- The policy reduces total output and aggregate welfare.

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ABSTRACT

This study constructs a general oligopolistic equilibrium model in which Smith's (1776) famous theory of the division of labor under vertical specialization is embedded. We demonstrate that a pro-competitive government policy weakens the division of labor and hence reduces firm productivity, total output, and aggregate welfare. In addition, the policy promotes an increase in workers' welfare and a decrease in firm owners' welfare.

1. Introduction

Division of labor is an important aspect of firms' behavior. Using the example of a pin factory, Smith (1776) shows that a deeper division of labor increases firm productivity.[2]

Ethier (1982) rationalizes the pin factory argument in a monopolistically competitive model based on the framework of Krugman (1980). Here, he relies on average costs falling with horizontal specialization as the variety of intermediate inputs increases. However, division of labor under vertical specialization has received little attention in theoretical literature. Chaney and Ossa (2013) emphasize the importance of division of labor under vertical specialization. They embed the pin factory into Krugman's (1979) monopolistic competition model and show that an increase in market size promotes a deeper division of labor, thereby increasing firm productivity.[3] In their model, division of labor is measured as the (optimal) number of teams in a firm's production chains.

However, Chaney and Ossa (2013) do not analyze strategic interaction among firms, because their model is based on Krugman's (1979) monopolistic competition model in which this does not take place. To investigate this strategic interaction, we construct a simplified general oligopolistic equilibrium (GOLE) model that includes intra-firm division of labor under vertical specialization.[4]

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2 Smith describes the now well-known example of division of labor in a pin factory, stating that "one man draws out the wire; another straightens it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head (…)".

3 Krugman (1979) differs from Krugman (1980). The latter assumes CES preferences, so the elasticity of demand is constant, whereas the former assumes that preferences are additively separable and that the elasticity of demand falls as individual consumption rises.

4 Kamei (2013) investigates the relationship between trade liberalization and division of labor within a GOLE framework with free entry of firms, and shows that trade liberalization promotes an increase in firm productivity and total output. This study considers a pro-competitive policy within a GOLE framework without free entry.

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We show that a pro-competitive government policy, which implies an increase in the number of firms, has the effect of reducing the number of teams in the production chain, firm productivity, and total output. The reasoning is as follows. First, the pro-competitive policy promotes competition among firms, and hence raises wages. The higher wages reduce a firm's demand for labor, causing the number of teams to decline. Finally, the reduction in the number of teams reduces the firm's productivity and total output.

Furthermore, we investigate the relationship between a pro-competitive policy and the distribution of welfare. Here, we show that a pro-competitive policy promotes a decrease in the firm owner's welfare, an increase in the worker's welfare, and a decrease in aggregate welfare.

The remainder of this paper is structured as follows. Section 2 describes our basic model. In this section, we also derive the equilibrium wage, optimal number of teams, firm profit, and total output. In Section 3, we show that a pro-competitive policy reduces the optimal number of teams in a firm, as well as a firm's productivity, total output, and aggregate welfare. In addition, we investigate the welfare distribution between workers and firm owners. Section 4 concludes the paper.

2. Model

In this section, we develop a simplified GOLE model that includes the division of labor, following the formulation of Chaney and Ossa (2013). Our GOLE model is based on that of Neary (2002, 2009).

2.1. Preferences

We first define consumer behavior. There is a continuum of sectors, $z \in [0, 1]$. Sector z produces goods $x(z)$ with a price of $p(z)$. We assume an aggregate utility function, as follows:

$$U = \int_0^1 \ln x(z)dz, \tag{1}$$

with a budget constraint of

$$\int_0^1 p(z)x(z)dz = I. \tag{2}$$

The inverse demand function is derived from utility maximization, as follows:

$$p(z) = \frac{1}{\lambda x(z)}, \tag{3}$$

where λ is the marginal utility of income. In addition, we normalize λ to 1, which is customary in studies using the GOLE approach.[5]

2.2. Production

Next, we define firm behavior. We assume all sectors are symmetric. Each production sector contains n identical firms, denoted as $n(z) = n > 1$.[6] The firms compete according to the Cournot competition model within their sector. The output of each firm in sector z is denoted by $y(z)$, and the total output in sector z is denoted by $x(z)$: $x(z) = ny(z)$. Wages are denoted as w. The profit of each firm in sector z, $\pi(z)$, is defined as follows:

$$\pi(z) = p(z)y(z) - TC(z), \tag{4}$$

where $TC(z)$ represents the total cost to each firm in sector z. Hence, we can derive the profit maximizing condition from Eqs. (3) and (4), as follows:

$$\frac{\partial \pi(z)}{\partial y(z)} = 0 \Leftrightarrow \frac{n-1}{n^2 y(z)} = \frac{\partial TC(z)}{\partial y(z)}, \tag{5}$$

where the LHS of Eq. (5) represents the marginal revenue of each firm.

2.3. Division of labor

Here we define production costs. Each firm performs a set number of sequenced tasks to produce a final good, including the acquisition of raw materials early on in the sequence. We assume the length of the segment is normalized to 2, which is the production chain. If tasks from 0 to $\omega_1 \in [0, 2]$ are performed, the firm produces intermediate good ω_1. Similarly, tasks from ω_1 to $\omega_2 \in [\omega_1, 2]$ produce intermediate good ω_2, and so on. To produce the final good, a firm must perform tasks $\omega > \omega_1$. One complete iteration of sequenced tasks is required to produce one unit of the final good.[7]

To produce final goods, firms organize teams on the production chain and assign each team tasks. The total number of teams is denoted as t. Each team acquires a core competence, $c \in [0, 2]$, on the production chain, which requires f units of labor before a team can perform its tasks. In addition, firms determine the core competence for each team, c. We express the labor requirements for a team that produces a unit of intermediate good ω_2 as follows:

$$l(\omega_1, \omega_2) = \frac{1}{2} \int_{\omega_1}^{\omega_2} |c - \omega|^{\gamma} d\omega, \tag{6}$$

where $\gamma > 0$. Teams are symmetric, which implies that γ and f are the same across teams. Hence, the firm's total cost in sector z, $TC(z)$, is derived as follows:

$$TC(z) = wt(z)\left(f + y(z) \int_0^{\frac{1}{t(z)}} \omega^{\gamma} d\omega\right) \tag{7}$$

$$= w\left(t(z)f + \frac{y(z)t(z)^{-\gamma}}{1+\gamma}\right). \tag{8}$$

From Eq. (7), a firm in sector z derives the optimal number of teams, $\tilde{t}(z)$, that minimizes $TC(z)$, given $y(z)$:

$$\tilde{t}(z) = \left[\frac{\gamma}{\gamma+1} \frac{y(z)}{f}\right]^{\frac{1}{\gamma+1}}. \tag{9}$$

Substituting Eq. (9) into Eq. (7), we can derive the total cost for the optimal number of teams of a firm in sector z, $\tilde{TC}(z)$, as follows:

$$\tilde{TC}(z) = wy(z)^{\frac{1}{\gamma+1}} f^{\frac{\gamma}{\gamma+1}} \left(\frac{1+\gamma}{\gamma}\right)^{\frac{\gamma}{1+\gamma}}. \tag{10}$$

We partially differentiate Eq. (10) by $y(z)$, and hence obtain the following:

$$\frac{\partial \tilde{TC}(z)}{\partial y(z)} = \frac{wy(z)^{-\frac{\gamma}{1+\gamma}} f^{\frac{\gamma}{1+\gamma}}}{\gamma^{\frac{\gamma}{1+\gamma}} (1+\gamma)^{\frac{1}{1+\gamma}}}. \tag{11}$$

[5] See Neary (2002, 2009).

[6] This kind of approach has been adopted in a number of applications using the GOLE framework. See, for example, Bastos and Kreickemeier (2009).

[7] The description of the production process is similar to that in Dixit and Grossman (1982).