Topics

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Trade Liberalization and Competition Levels

Abstract: This paper builds a general oligopolistic equilibrium model based on Neary (2009. "International Trade in General Oligopolistic Equilibrium," University of Oxford and CEPR, Working Paper) to investigate the relationship between trade liberalization and competition levels. In a closed economy, a decrease in competition negatively affects a country's welfare and reallocates factors from low marginal cost sectors to high marginal cost sectors. However, in an open economy with trade liberalization, the properties of factor reallocation give a country the incentive to adopt a beggar-thy-neighbor policy, which decreases its competition level and maximizes its own welfare under certain conditions. Hence, international coordination of competition policies could possibly increase both world welfare and trade.

Keywords: general oligopolistic equilibrium (GOLE), trade liberalization, competition policy

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1 Introduction

The integration of global markets has turned domestic competition policies into an international issue. Does a change of competition levels through domestic competition policies affect international trade and achieve the same goals as trade restrictions like tariffs? Since the average tariff rate on imports has decreased substantially, and various non-tariff restrictions have been abolished during the trade liberalization processes of past decades, this question is becoming increasingly more important as countries attempt to manage trade in pursuit of their national interests. This has generated a vast amount of literature.

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Studies on the relationship between trade and domestic competition policy can be traced back to Dixit (1984), who investigates the effect of a country's competition policy in an oligopolistic market for tradable goods but does not explicitly analyze how optimal trade and competition policies interact. Extending Dixit's work, Richardson (1999) demonstrates that the coordination of competition policies after trade liberalization will result in a less competitive outcome, and Horn and Levinsohn (2001) argue that the liberalization of international trade will possibly induce countries to use beggar-thy-neighbor competition policies to promote their own national interests at the expense of others. Based on Brander and Spencer (1985), Rysman (2001) and De Stefano and Rysman (2010) show that a country can benefit by suppressing competition in its oligopolistic export market.

While these works, which are based on strategic trade models, demonstrate the possible substitutability of tariffs by competition policy on tradable markets to pursue national interests, they have a major weakness in that they use partial equilibrium frameworks. In work more closely related to this paper, Francois and Horn (2006) examine antitrust rules in a two-country general equilibrium trade model. As stated in Francois and Horn (2006), partial equilibrium "may be appropriate when the concern is with a regulatory problem in a particular sector. But when the focus is on the establishment of a general competition policy stance, such as when formulating merger guidelines, it is clearly much less adequate." In addition to this, a general equilibrium model allows for the study of the interaction between product markets and factor markets. A regulatory problem will have cross-sector effects through factor markets, and using a general equilibrium model will provide some interesting insight into competition policy as shown in this paper.

There exists another strand of literature that studies the effect of competition policies on non-tradable markets. Yano (2001) investigates the dynamic effect of competition policies on trade balances and demonstrates that the suppression of competition in a non-tradable market will benefit a trade surplus country but at the cost of its trading partner. The work of Yano (2001) has been further developed by Yano and Dei (2003), Takahashi (2005), Yano and Honryo (2010), and Yano and Honryo (2011). Although those studies all use a general equilibrium framework, they only consider the change of competition levels in non-tradable sectors and most assume a setting of a trade imbalance.

The aim of this paper is to study the change of competition levels on tradable markets and any welfare effect of competition level changes after trade liberalization. We build a multi-sector general oligopolistic equilibrium model based on Neary (2009); however, unlike Neary (2009), we do not use the number of firms as the competition level indicator. Instead, the price-cost margin (PCM) is used to describe a firm's market power. Further, rather than allowing for an arbitrary and identical number of firms in each sector, as in

Neary (2009), this paper assumes that the number of firms in each sector is determined by government competition policy, which sets the markup and the profit level of firms. Different from partial equilibrium models that do not allow changes in factor prices, we show that a decrease in competition levels in a closed-economy general equilibrium model lowers factor prices and thus reallocates factors from low marginal cost sectors to high marginal cost sectors, which increases outputs in high marginal sectors while decreasing outputs in low marginal sectors. In a closed economy, a decrease in competition levels also lowers the country's welfare because of the distortion caused by low competition levels. However, in an open economy with trade liberalization, the factor reallocation effect gives countries extra trade advantages in high marginal cost sectors because of higher output and may increase countries' income relative to their trading partners. When the initial markup is small and the sectoral marginal costs of two countries engaged in trade are negatively correlated, the benefit from the income increase outweighs the loss from the distortion caused by low competition levels, leading countries to decrease their competition levels to maximize their own welfare. In an extreme case shown in this paper, no matter what the initial markup is, two countries engaged in trade always have an incentive to decrease their competition level which creates a prisoner's dilemma. On the other hand, it is also possible for countries to increase their competition levels after trade liberalization. For example, when the sectoral marginal costs are positively correlated, two countries will always have an incentive to increase their competition level after trade liberalization under certain conditions. We also extend the analysis of competitive advantage in Neary (2003). Although Neary (2003) shows that competition level affects a country's resource allocation, trade patterns, and trade volumes, little is said about its welfare effects. We show that competition does not always increase a country's welfare. Its effect depends on the country's trading partners, and it is possible to have a competitive disadvantage after trade liberalization.

Two general policy recommendations emerge from this paper. First, in an open economy, lowering the competition level may create trade advantages and improve the welfare of the whole economy. However, it may not be easy to successfully implement this strategy. In the model, we show that a decrease in competition levels shifts income from the factor owners to the recipients of the profits. Without an appropriate redistribution mechanism, this policy possibly creates a severe income inequality problem. Second, since, as shown in our model, the choice of competition policies after trade liberalization depends on trading partners, we argue that liberal trade policies and tight competition policies are not substitutes. The interaction between trade liberalization and competition policies has been an important issue for the World Trade

Organization (WTO). In 1996, as a result of the Ministerial Conference in Singapore, the WTO established a working group to study how domestic and international competition policy instruments, such as antitrust or competition laws, interact with international trade. However, in July 2004, the General Council of the WTO decided that any interaction between trade and competition policies would not be discussed during the Doha Round. In spite of this, this paper shows that international coordination of competition policies could possibly increase both world welfare and trade.

The paper is organized as follows. Section 2 sets up the general oligopolistic equilibrium model. Section 3 solves the equilibrium for a closed economy and shows that a change in competition levels alters both the income distribution and the factor allocation throughout sectors. Having derived some interesting characteristics of a competition policy, in Section 4, we study an open economy with two countries and three sectors. This provides us the main results about the relationship between trade liberalization and competition levels. At the end of Section 4, a simple quantitative example is solved for an open economy. Finally, Section 5 draws conclusions and discusses further possible study.

2 General model of oligopolistic competition

There is a continuum economy with an infinite number of types of products, $z \in [0,1]$, and an infinite number of identical individuals, $k \in [0,1]$. Each type of product is produced in only one sector, so there are also an infinite number of sectors in the economy.

2.1 Demand

All the individuals have the same labor endowment, L, and the same quadratic utility function, $u(x(z,k)) = ax(z,k) - \frac{b}{2}x(z,k)^2$, where $x(z,k)$ is individual k's consumption of product z and $a, b > 0$. An individual's income is denoted by I_k, $k \in [0,1]$ and has two parts. Individuals receive not only wage income, wL, from the labor market, but also profit income, $\pi(k)$, from the shares of firms they own. The consumer's problem is as follows:

$$\max \int_0^1 \left[ax(z,k) - \frac{b}{2}x(z,k)^2 \right] dz$$

$$s.t. \int_0^1 p(z)x(z,k)dz \le I_k$$

Assume that $\lambda(k)$ is the Lagrange multiplier and from the first-order conditions of the consumer's problem,

$$p(z) = \frac{1}{\lambda(k)}[a - bx(z,k)],$$

$$\lambda(k) = \frac{a\int_0^1 p(z)dz - bI_k}{\int_0^1 p(z)^2 dz}.$$

The aggregate demand for product z is

$$x(z) = \int_0^1 x(z,k)dk = \int_0^1 \left(\frac{a}{b} - \frac{\lambda(k)p(z)}{b}\right)dk = \frac{a}{b} - \frac{p(z)}{b}\lambda \qquad [1]$$

where $\lambda = \int_0^1 \lambda(k)dk = \frac{a\int_0^1 p(z)dz - b\int_0^1 I_k dk}{\int_0^1 p(z)^2 dz}$.

2.2 Supply

For the supply side of the economy, the labor requirement function for sector z is $l(z) = \alpha(z)y(z)$, where $l(z)$ is labor input, $y(z)$ is output, and $\alpha(z)$ is marginal labor input, which is constant within each sector but is different across sectors. The market in each sector is imperfectly competitive, and firms in each sector are homogeneous and follow the model of Cournot competition. Assuming there are $n(z)$ homogeneous firms with output $y(z)$ in sector z, from the model of Cournot competition we have

$$p(z) - w\alpha(z) = \frac{y(z)}{\left(-\frac{\partial x(z)}{\partial p(z)}\right)}.$$

From the aggregate demand eq. [1], we know that $\frac{\partial x(z)}{\partial p(z)} = -\frac{\lambda}{b}$. Hence, under the model of Cournot competition,

$$p(z) - w\alpha(z) = \frac{by(z)}{\lambda}. \qquad [2]$$

Combining this equation with the aggregate demand equation $x(z) = \frac{a}{b} - \frac{p(z)}{b}\lambda = n(z)y(z)$ and normalizing $\lambda = 1$, the firm's output is given by $y(z) = \frac{a - w\alpha(z)}{b(n(z)+1)}$ and the aggregate supply in sector z is $\frac{n(z)(a - w\alpha(z))}{b(n(z)+1)}$.

2.3 Entry and exit of firms and competition policy

The entry and exit strategy of firms in this economy follows Hopenhayn (1992). Since firms are homogeneous, each firm produces after its productivity is realized. Instead of assuming a sunk cost, we assume there is a threshold level M that is decided by the competition policy of the economy. In each period, the markup $m(z) = p(z) - w\alpha(z)$ for every firm cannot exceed this level. The government competition policy is defined as follows.

Definition 1 *A competition policy in the economy is a markup threshold level M. For each sector z, markup $m(z) \leq M$.*

It can easily be shown that in every sector the profit level of firms, which is denoted by $\pi(z)$, is related to the markup $m(z)$ since $\pi(z) = \frac{m^2(z)}{b}$. Therefore, the competition policy in our economy also defines a threshold level of profit $\bar{\Pi} = \frac{M^2}{b}$ and for each sector z, the profit level of firms $\pi(z) \leq \bar{\Pi}$. In the steady state with free entry, we can show that firms in different sectors must have the same profit level, $\bar{\Pi}$, which also means the same markup level, M. Otherwise, if the profit of firms in one sector is lower than the profit of firms in other sectors, then firms in that sector move to other more profitable sectors, which will increase the profit in that sector and decrease the profit in other sectors, until all firms in all sectors have the same profit level.

Although there are a number of ways in which a government may influence the degree of competition in the real world, in the literature, competition policies are usually related to the number of firms, reflecting industry concentration, for example, Richardson (1999), Rysman (2001), and Yano (2001). In this paper, M in Definition 1 and the number of firms, $n(z)$, are related. In the steady state with free entry, the markup for every sector in our economy is equal to M and the number of firms $n(z) = \frac{a - w\alpha(z)}{M} - 1$. We can easily show that $n(z)$ is a decreasing function of M and that, therefore, our definition of competition policy is equivalent to using the number of firms, as seen in previous literature. Since we allow free entry and exit, the number of firms, $n(z)$, is different across sectors; thus, it is more convenient to use M to control the degree of competition for the whole economy.[1] Markup is also used to define competition policies in Francois and Horn (2006).

For competition levels, since we use the PCM to measure the degree of competition, in Section 3, we show that M and competition levels are equivalent. When M increases, the PCM in this economy increases; therefore, the competition level in this economy decreases.

1 We could have different markups for different sectors by bringing additional distortions to our model, but it does not add any new insight into our analysis.

3 General equilibrium in a closed economy

To solve the equilibrium, from market clearing conditions in the labor market,

$$L = \int_0^1 n(z)l(z)dz = \int_0^1 n(z)\alpha(z)y(z)dz.$$

Since the markup for every sector in our economy is equal to M in the steady state, from eq. [2] and normalizing $\lambda = 1$, we have $m(z) = M = by(z)$. Substituting $y(z) = \frac{M}{b}$ and $n(z) = \frac{a - w\alpha(z)}{M} - 1$ into the labor market clearing condition and denoting $\int_0^1 \alpha(z)dz = \mu_\alpha$ and $\int_0^1 \alpha^2(z)dz = \sigma_\alpha^2$, the wage rate is

$$w = \frac{a\mu_\alpha - bL - M\mu_\alpha}{\sigma_\alpha^2}. \qquad [3]$$

After determining w, the number of firms, $n(z)$, can be calculated from $n(z) = \frac{a - w\alpha(z)}{M} - 1$, and $p(z)$ from $p(z) = w\alpha(z) + M$. From the consumer's budget constraint, the market clearing conditions for the goods market and $\frac{a - bx(z_1)}{a - bx(z_2)} = \frac{p(z_1)}{p(z_2)}$, the consumption level of good z by individual k is given by

$$x(z,k) = \frac{\left(a\int_0^1 p(z)^2 dz - ap(z)\int_0^1 p(z)dz + bp(z)I_k\right)}{b\int_0^1 p(z)^2 dz)}.$$

In eq. [3], the wage rate in the economy is decided not only by the labor endowment and the distribution of marginal cost but also by the competition policy, which decides the markup in each sector. The higher the markup, the lower the competition level in the economy and the lower the wage rate.

Theorem 1 *In the above closed economy*,

1. If M increases, then $\frac{w}{p(z)}$ decreases.
2. Let $\Pi = \int_0^1 n(z)\pi(z)dz$. When $n(z) \geq 1$, if M increases, then $\frac{\Pi}{wL}$ increases.
3. If M increases, for sectors with $\alpha(z) \geq \frac{\sigma_\alpha^2}{\mu_\alpha}$, then total output $Y(z) = n(z)y(z)$ increases. For sectors with $\alpha(z) < \frac{\sigma_\alpha^2}{\mu_\alpha}$, total output $Y(z)$ decreases.
4. The welfare in a closed economy is given by

$$W = \frac{a^2}{2b} - \frac{1}{2b}\left[\frac{(a\mu_\alpha - bL)^2}{\sigma_\alpha^2} + M^2\left(1 - \frac{\mu_\alpha^2}{\sigma_\alpha^2}\right)\right],$$

which is a decreasing function of M.

Proof. For Part 1 in Theorem 1, from $p(z) - w\alpha(z) = M$, we have $\frac{p(z)}{w} = \frac{M}{w} + \alpha(z)$. Since w is a decreasing function of M, $\frac{w}{p(z)}$ is a decreasing function of M. Part 1 shows that when M increases, the PCM $\frac{p(z)-w\alpha(z)}{p(z)}$ in this economy increases, and therefore, the competition level in this economy decreases.

For Part 2, $\pi(z) = \frac{M^2}{b}$ and $\Pi = \int_0^1 n(z)\pi(z)dz = \frac{M^2}{b}\int_0^1 (\frac{a-w\alpha(z)}{M} - 1)dz$. Hence we have $\frac{\Pi}{wL} = \frac{1}{bL}\left[-\left(\frac{M}{w}\right)^2 w + \left(\frac{M}{w}\right)a - M\mu_\alpha\right]$.

From $n(z) = \frac{a-w\alpha(z)}{M} - 1$, we know that $M \leq \frac{a}{2}$ when $n(z) \geq 1$. It is easy to show that if $M \leq \frac{a}{2}$, then $\frac{\Pi}{wL}$ increases when M increases.

Part 3 is obvious. Since $w = \frac{a\mu_\alpha - bL - M\mu_\alpha}{\sigma_\alpha^2}$, we have

$$p(z) = \frac{a\mu_\alpha\alpha(z) - bL\alpha(z)}{\sigma_\alpha^2} - M\left(\frac{\mu_\alpha\alpha(z)}{\sigma_\alpha^2} - 1\right). \qquad [4]$$

If M increases, for sectors with $\alpha(z) \geq \frac{\sigma_\alpha^2}{\mu_\alpha}$, $p(z)$ decreases. For sectors with $\alpha(z) < \frac{\sigma_\alpha^2}{\mu_\alpha}$, $p(z)$ increases. Since total output $Y(z)$ in sector z is a decreasing function in $p(z)$, if M increases, then output $Y(z)$ increases for sectors with $\alpha(z) \geq \frac{\sigma_\alpha^2}{\mu_\alpha}$ and decreases for sectors with $\alpha(z) < \frac{\sigma_\alpha^2}{\mu_\alpha}$.

For Part 4, welfare W in a closed economy is equal to $\int_0^1\int_0^1 \left[ax(z,k) - \frac{b}{2}x(z,k)^2\right]dzdk$. Since all individuals are identical and $x(z) = \frac{a}{b} - \frac{p(z)}{b}$, we have

$$W = \frac{a^2}{2b} - \frac{1}{2b}\int_0^1 p^2(z)dz. \qquad [5]$$

Substitute eq. [4] into eq. [5] and the expression for W is

$$W = \frac{a^2}{2b} - \frac{1}{2b}\left[\frac{(a\mu_\alpha - bL)^2}{\sigma_\alpha^2} + M^2\left(1 - \frac{\mu_\alpha^2}{\sigma_\alpha^2}\right)\right].$$

By Jensen's inequality, $\sigma_\alpha^2 > \mu_\alpha^2$, and W is a decreasing function in M. If $\alpha(z) = \alpha$ for every sector in our economy, then M will not reallocate resources and welfare does not change, as shown in Neary (2009). ■

From Theorem 1, M not only is related to the PCM, $\frac{p(z)-w\alpha(z)}{p(z)}$, which measures competition levels, but also determines two important characteristics of our economy: the ratio of wage income to profit income, which is related to income distribution, and the ratio of output in different sectors. An increase in M not only shifts income from wage income to profit income but also shifts factors from low marginal cost sectors to high marginal cost sectors.[2] Because of this factor reallocation effect, a decrease in competition will make our economy less efficient, and thus we see that welfare is a decreasing function in M. In a closed economy, the optimal level of M chosen by countries will be zero.

The intuition behind the factor reallocation effect is as follows. In our economy, firms in each sector have the same profit. When M increases, profit increases since the profit level for firms in each sector is $\frac{M^2}{b}$, and the change in profit is the same for all sectors. There are two ways to increase profit in our economy: a decrease in cost and an increase in market power. We know that the cost function is $w\alpha(z)$. The change of cost in the low marginal cost sector is smaller than the change in the high marginal cost sector. Thus, to achieve the same increase in profit, low marginal cost sectors need a larger increase in market power or a larger decrease in the number of firms than do high marginal cost sectors. Since the output of a firm in this economy is $\frac{M}{b}$, which has nothing to do with the sector's cost, a larger decrease in the number of firms means a smaller share of factors used in a sector. In other words, an increase in M shifts factors from low marginal cost sectors to high marginal cost sectors. Since labor endowment L is constant, the factor reallocation effect decreases the total output in low marginal cost sectors and increases the total output in high marginal cost sectors with an increase in M. In a partial equilibrium model where the wage rate w is exogenous, the factor reallocation effect does not exist since $p(z) = M + w\alpha(z)$, and the effect of a change in M is identical in every sector.

In the following open economy analysis, the factor reallocation effect plays an important role. Although welfare is a decreasing function in M in a closed economy, the factor reallocation effect brings out a new income effect in an open economy, which could be large enough to change the choice of competition levels following trade liberalization.

4 General equilibrium in an open economy

There are two countries, H and F, which are the same as described in Section 3. For simplicity, but without loss of generality, we assume that there are three sectors in each country and that each sector has an equal measure of one-third.

2 These results are robust to the adoption of increasing returns. Although increasing returns to scale is an important argument for higher industry concentration, it does not significantly change the two roles of M in our economy.

We consider two cases with different monotonic marginal cost distributions, as shown in Figure 1.

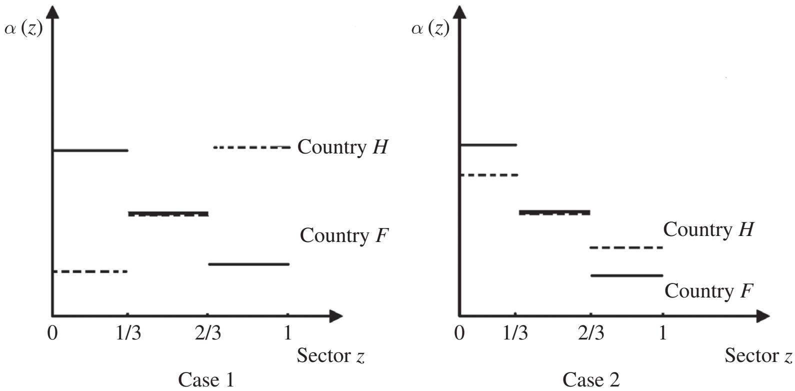

Figure 1: Monotonic marginal cost distribution: two cases

The marginal costs in country H for the three sectors are $\alpha^H(1)$, $\alpha^H(2)$, and $\alpha^H(3)$, and the marginal costs in country F are $\alpha^F(1)$, $\alpha^F(2)$, and $\alpha^F(3)$. In Case 1, country H has an upward-sloping marginal cost distribution curve, while country F has a downward-sloping marginal cost distribution curve. The marginal costs of the two countries satisfy $[\alpha^H(1) - \alpha^H(3)][\alpha^F(1) - \alpha^F(3)] < 0$. In Case 2, both country H and country F have downward-sloping marginal cost distribution curves. The marginal costs of the two countries satisfy $[\alpha^H(1) - \alpha^H(3)][\alpha^F(1) - \alpha^F(3)] > 0$. For both cases, country H has an absolute advantage in Sector 1, while country F has an absolute advantage in Sector 3. Both countries have the same marginal cost in the second sector. For simplicity, we denote $\alpha(1) = \alpha^H(1) < \alpha^F(1)$, $\alpha(3) = \alpha^F(3) < \alpha^H(3)$, and $\alpha(2) = \alpha^H(2) = \alpha^F(2)$.

The two countries have the same labor endowment, $L^H = L^F = L$. After trade liberalization, we assume that they initially have the same makeup level, or $M^H = M^F = M^*$, and that they then change their competition levels, or markup M^*, to maximize their own welfare. In the following analysis, we use country H as an example and study whether country H increases or decreases its competition level in two different cases after trade liberalization.

In terms of trade patterns, country H specializes in the first sector while country F specializes in the third sector. Both countries produce in the second sector. To obtain the same profit requires that in each country, every sector has the same markup; therefore, price equations are

$$p(1) = w^H \alpha(1) + M^H,$$

$$p(2) = w^H\alpha(2) + M^H = w^F\alpha(2) + M^F,$$

$$p(3) = w^F\alpha(3) + M^F.$$

In the first sector, from the definition of markup and properties of Cournot competition, the firms' output is

$$y^H(1) = \frac{a' - w^H\alpha(1)}{b'(n^H(1)+1)} = \frac{M^H}{b'},$$

$$y^F(1) = \frac{a' - w^F\alpha(3)}{b'(n^F(3)+1)} = \frac{M^F}{b'},$$

where $a' = \frac{2a}{\lambda^H+\lambda^F}$, $b' = \frac{b}{\lambda^H+\lambda^F}$, and $n^j(i)$, $i = 1,2,3$, $j = H,F$ is the number of firms in sector i from country j. In the second sector, both countries produce and the output of firms in countries H and F is

$$y^H(2) = \frac{a' - (n^F(2)+1)w^H\alpha(2) + n^F(2)w^F\alpha(2)}{b'(n^H(2)+n^F(2)+1)} = \frac{M^H}{b'},$$

$$y^F(2) = \frac{a' - (n^H(2)+1)w^F\alpha(2) + n^H(2)w^H\alpha(2)}{b'(n^H(2)+n^F(2)+1)} = \frac{M^H}{b'}.$$

In the second sector, from the equation for $p(2)$, there is a relationship between w^H and w^F such that

$$(w^H - w^F)\alpha(2) = M^F - M^H. \quad [6]$$

From equation $n^F(2)y^F(2) + n^H(2)y^H(2) = \frac{a'-p(2)}{b'}$, which describes aggregate demand and supply in Sector 2, we have

$$n^F(2)M^F + n^H(2)M^H = a' - w^H\alpha(2) - M^H. \quad [7]$$

Using eqs [6] and [7] together with the labor market clearing conditions in the two countries, we can solve for the wage rate in each country:

$$w^H = \frac{1}{\sum_i \alpha^2(i)}\left[a'\sum_i \alpha(i) - 6b'L - M^H\sum_i \alpha(i) + (M^H - M^F)\left(\frac{\alpha(2)\alpha(3) - \alpha^2(3)}{\alpha(2)}\right)\right],$$

$$w^F = \frac{1}{\sum_i \alpha^2(i)}\left[a'\sum_i \alpha(i) - 6b'L - M^F\sum_i \alpha(i) + (M^F - M^H)\left(\frac{\alpha(2)\alpha(1) - \alpha^2(1)}{\alpha(2)}\right)\right].$$

From these equations, country H's wage rate is not only determined by its own competition level, M^H, but is also influenced by the other country's competition level, M^F. Competition policy has global impacts through trade for these two countries. Since we normalize $\lambda^H = 1$, we need to determine the value for λ^F in the wage rate equations. For each country, the value of income should be equal to the value of expenditure, and the value of exports should be equal to the value of imports. The value for λ^F can be solved from the budget constraints, which for country H is

$$p(1)\left(\frac{a'}{b'} - \frac{p(1)}{b'}\right) + \frac{p(2)}{\alpha(2)}\left[3L^H - \alpha(1)\left(\frac{a'}{b'} - \frac{p(1)}{b'}\right)\right] = \sum_i p(i)\left(\frac{a}{b} - \frac{p(i)}{b}\right). \qquad [8]$$

Having reviewed these equations for an open economy, we shift our attention to the relationship between welfare and competition levels. We are interested in the welfare effect caused by a change of competition levels after trade liberalization. The welfare functions for countries H and F are

$$W^H = \frac{a^2}{2b} - \frac{1}{6b}\sum_{i=1}^{3} p^2(i),$$

$$W^F = \frac{a^2}{2b} - \frac{(\lambda^F)^2}{6b}\sum_{i=1}^{3} p^2(i).$$

Since $\sum_{i=1}^{3} p^2(i)$ depends on the marginal distributions in the two countries, we start our welfare analysis from Case 1 and, for simplicity, we assume $\alpha(1) = \alpha(3)$. For Case 1, we find $\sum_{i=1}^{3} p^2(i)$ using the equations for w^H and w^F, or

$$\sum_{i=1}^{3} p^2(i) = \Phi_1\left(\frac{2}{1+\lambda^F}\right)^2 + \Phi_2\left\{\frac{\alpha^2(1)}{\alpha^2(2)}\left[M^H - M^F\right]^2 + \left[(M^H)^2 + (M^F)^2\right]\right\},$$

where $\Phi_1 = \frac{\left(a\sum_{i=1}^{3}\alpha(i) - 3bL\right)^2}{\sum_{i=1}^{3}\alpha^2(i)}$ and $\Phi_2 = \frac{[\alpha(2)-\alpha(1)]^2}{\sum_{i=1}^{3}\alpha^2(i)}$. In country H, the change of M^H has two effects on welfare W^H. For the first effect, which is pro-competitive, the bracketed terms multiplied by Φ_2 increases when M^H increases and causes W^H to decrease. It is the same mechanism that causes welfare to decrease after markup increases in a closed economy. The second effect, which is possibly anti-competitive, is related to the bracketed terms multiplied by Φ_1 and depends on the change of λ^F. Multiplier λ^F measures the marginal utility of income in country F. Since we normalize $\lambda^H = 1$, an increase (decrease) in λ^F means that the income in country F decreases (increases) relative to the income in country H. The bracketed terms multiplied by Φ_1 decrease if an increase in M^H causes an increase in λ^F, which causes welfare W^H to increase. If the decrease in the bracketed terms multiplied by Φ_1 is larger than the increase in the bracketed terms multiplied by Φ_2, then welfare W^H increases when M^H increases and countries have an incentive to decrease their competition levels to achieve higher welfare. In addition, we can show that W^F and total welfare, $W^H + W^F$, decrease when λ^F increases with an increase in M^H.

Why is it possible that λ^F increases when the markup in country H increases? The answer lies in the factor reallocation effect brought about through the change of competition levels. In a closed economy, an increase in markup shifts factors from low marginal cost sectors to high marginal cost sectors. In an open economy, this effect may shift income from countries with low markups to countries with high markups under certain conditions. To demonstrate this, we assume that in Sector 2 country H is a small open economy. Since country H is small in Sector 2, an increase of output in Sector 2 does not change the world price and only increases the income of country H. The income from the first sector is denoted by $I(1)$ and is equal to $n^H(1)p(1)y^H(1)$. Substituting equations for $n^H(1)$, $p(1)$, and $y^H(1)$, we can show that

$$I(1) = \frac{(a' - w^H\alpha(1))w^H\alpha(1) + (a' - 2w^H\alpha(1))M^H - (M^H)^2}{b'}.$$

When $a' < 2w^H\alpha(1)$, the income from Sector 1 is a decreasing function of M^H. When the benefit from the increased share in Sector 2 outweighs the loss in Sector 1, the income of country H increases relative to country F, and therefore multiplier λ^F increases. When $a' > 2w^H\alpha(1)$, the income from Sector 1 increases first and then decreases when M^H increases. Therefore, in this case, the income of country H is an increasing function of M^H when M^H is small. When M^H is large, the same logic as in the case with $a' < 2w^H\alpha(1)$ is applied.

In summary, it is possible for country H to decrease its competition level after trade liberalization under certain conditions in Case 1. We formalize this intuition in the following theorem.

Theorem 2 *Case 1: When* $\alpha(1) = \alpha(3) < \alpha(2)$, *then* $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} > 0$ *after trade liberalization if initial* M^* *is small.*

Proof. From the expression for $\sum_{i=1}^{3} p^2(i)$, we have

$$\frac{\partial \sum_{i=1}^{3} p^2(i)}{\partial M^H}\Big|_{M^H=M^*} = -\Phi_1 \frac{\partial \lambda^F}{\partial M^H}\Big|_{M^H=M^*} + 2\Phi_2 M^*.$$

If $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} > \frac{2\Phi_2 M^*}{\Phi_1}$, then the welfare in country H increases after an increase in the domestic markup M^H. The term $\frac{2\Phi_2 M^*}{\Phi_1}$ is an increasing function of M^* with $\frac{2\Phi_2 M^*}{\Phi_1}|_{M^*=0} = 0$. Using the budget constraint, eq. [8], in country H, we can show that $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*}$ is a decreasing function of M^H with $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=0} > 0$. Hence, when the initial M^* is small, $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} > \frac{2\Phi_2 M^*}{\Phi_1}$, which implies that W^H increases when M^H increases. See the Appendix for details. ■

This theorem demonstrates that countries will possibly decrease competition levels in order to increase their own welfare after trade liberalization. On the other hand, as shown in Theorem 2, when the competition level in country H decreases, the welfare in country F and total welfare both decrease. Thus, a decrease in competition level in country H is a beggar-thy-neighbor policy, which maximizes a country's own welfare at the expense of others. From the proof of Theorem 2, without additional assumptions on the marginal cost distributions, we can also show that there exists a threshold level $\bar{M}$. When $M^* < \bar{M}$, $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} > 0$, while $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} < 0$ when $M^* > \bar{M}$. In other words, the optimal level of markup chosen by countries after trade liberalization is determined by $\bar{M}$. When the threshold level $\bar{M}$ is larger than the maximum level for M^*, we have the following proposition:

Proposition 1 *Case 1: When* $\alpha(1) = \alpha(3) = \rho\alpha(2)$ *and* $a > \frac{3bL}{\sum_{i=1}^{3}\alpha(i)} > \phi(\rho)a$, *then* $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} > 0$ *for any* M^* *after trade liberalization, where* $\phi(\rho)$ *is a decreasing function in* $\rho \in (0,1)$ *and* $\phi(\rho) \in (0, \frac{3}{4})$.

Proof. See the Appendix. ■

This proposition shows that it is possible for countries to adopt a beggar-thy-neighbor competition policy no matter how large the initial markup is. When decreasing their competition levels, countries H and F also face a prisoner's dilemma since they both have an incentive to increase their markups. If they increase their markups to the same level, multiplier λ^F is equal to λ^H and, as they are in a closed economy, this move will only bring inefficiency to the economy. Hence, the welfare of both countries decreases after the markup increases. If only one country increases its markup, then the welfare for the country with the larger markup will increase, while the welfare for the country with the smaller markup will decrease. It is obvious that the two countries need to cooperate when determining their competition policies to avoid a prisoner's dilemma.

In summary, the choice of competition levels after trade liberalization in Case 1 depends on two factors: the initial markup and the marginal cost difference between $\alpha(1)$ and $\alpha(2)$. A high initial M^H and a large difference between $\alpha(1)$ and $\alpha(2)$ increase a country's possibility of increasing its competition level, while a low initial M^H and a small difference between $\alpha(1)$ and $\alpha(2)$ increase a country's possibility of decreasing its competition level.

In the remainder of this section, we use Case 2 to show that whether country H decreases or increases its competition level after trade liberalization also depends on its trading partners. In Case 2, it is possible for country H to increase its competition level after trade liberalization, even when the initial markup M^H is small. Since $\alpha(1)$ is larger than $\alpha(2)$, the income effect from the factor reallocation will not induce country H to decrease its competition level as in Case 1. An increase in M^H now shifts factors from Sector 2 to Sector 1, which decreases country H's income in Sector 2. In Sector 1, following the analysis in Case 1, only when $a' > 2w^H\alpha(1)$ and the initial markup is small will the income from Sector 1 increase with an increase in M^H. If the loss from Sector 2 outweighs the possible benefit from Sector 1, country H will always have an incentive to increase its competition level after trade liberalization. The following proposition shows the conditions under which countries choose to increase their degree of competition for any initial markup.

Proposition 2 *Case 2: When* $0 < \alpha(1) - \alpha(2) = \alpha(2) - \alpha(3) < \frac{1}{10}\alpha(2)$ *and* $\frac{1}{10}a < \frac{3bL}{\sum_{i=1}^{3}\alpha(i)} < \frac{1}{2}a$*, then* $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} < 0$ *for any* M^* *after trade liberalization.*

Proof. Let $\alpha(2) = \alpha$, $\alpha(1) - \alpha(2) = x$, and $\frac{x}{\alpha} = \rho$. Since the marginal cost distribution of trading partners changes, the differentiation of $\sum_{i=1}^{3} p^2(i)$ with respect to M^H has a different form:

$$\frac{\partial \sum_{i=1}^{3} p^2(i)}{\partial M^H}|_{M^H=M^*} = -\Phi_1\left(\frac{2}{1+\lambda^F}\right)^3 \frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} + 2\Phi_2 M^*(3-2\rho).$$

From the budget constraint, eq. [8], we can derive the equation for $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*}$. The analysis for Case 2 is more complicated than that for Case 1 since λ^F is not equal to 1 before the change of M^H. To simplify the analysis, we attempt to determine the conditions that make $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} < 0$ and thus $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} < 0$ for any M^*. See the Appendix for details. ■

4.1 Simple quantitative exercise

Consider two identical countries with the marginal cost distributions as in Case 1. In the beginning, both countries are closed economies. After trade liberalization, country H increases its M and changes its competition level, while country F maintains a constant M. For parameters, assume the labor endowment for both countries is $L^H = L^F = 200$. In country H, $\alpha^H(1) = 1$, $\alpha^H(2) = 1.5$, and $\alpha^H(3) = 2$, while in country F, $\alpha^F(1) = 2$, $\alpha^F(2) = 1.5$, and $\alpha^F(3) = 1$. The two countries have the same quadratic utility function with $a = 1,000$ and $b = 2$, and the initial $M = 50$ for both. Country H gradually increases M to 60 after trade liberalization. The results are illustrated in Figure 2.

After trade liberalization, the welfare in both countries increases sharply and the PCM in Sector 2 decreases,[3] which shows the pro-competitive effect of trade liberalization. After country H lowers its competition level, welfare in country H increases, while welfare in country F decreases. Since country H increases its M, the PCM in Sector 2 for country H increases and, in the end, exceeds the level before trade liberalization. The PCM in Sector 2 for country F also shows a slight increase since a markup change in country H affects the competition level in country F through the wage rate w^F. This example also shows that if two countries have different initial M values, then the country with the higher M benefits more from trade liberalization.

5 Conclusions

This paper contributes to the literature on the relationship between trade liberalization and competition levels when competition policies are imposed on markets for tradable goods. Different from previous studies using partial equilibriums, this paper builds a general oligopolistic equilibrium model with heterogeneous sectors and free entry, which allows for the study of interactions between goods and factor markets to aid in the design of national competition policies after trade liberalization. We show that a decrease in the competition level will decrease factor prices and shift factors from low marginal cost sectors to high marginal cost sectors, providing countries extra trade advantages in high marginal cost sectors under certain conditions. When the benefit from the factor reallocation effect through the change of competition levels is larger than the

3 We see the same results for Sector 1 and Sector 3. However, they are less interesting than those for Sector 2.

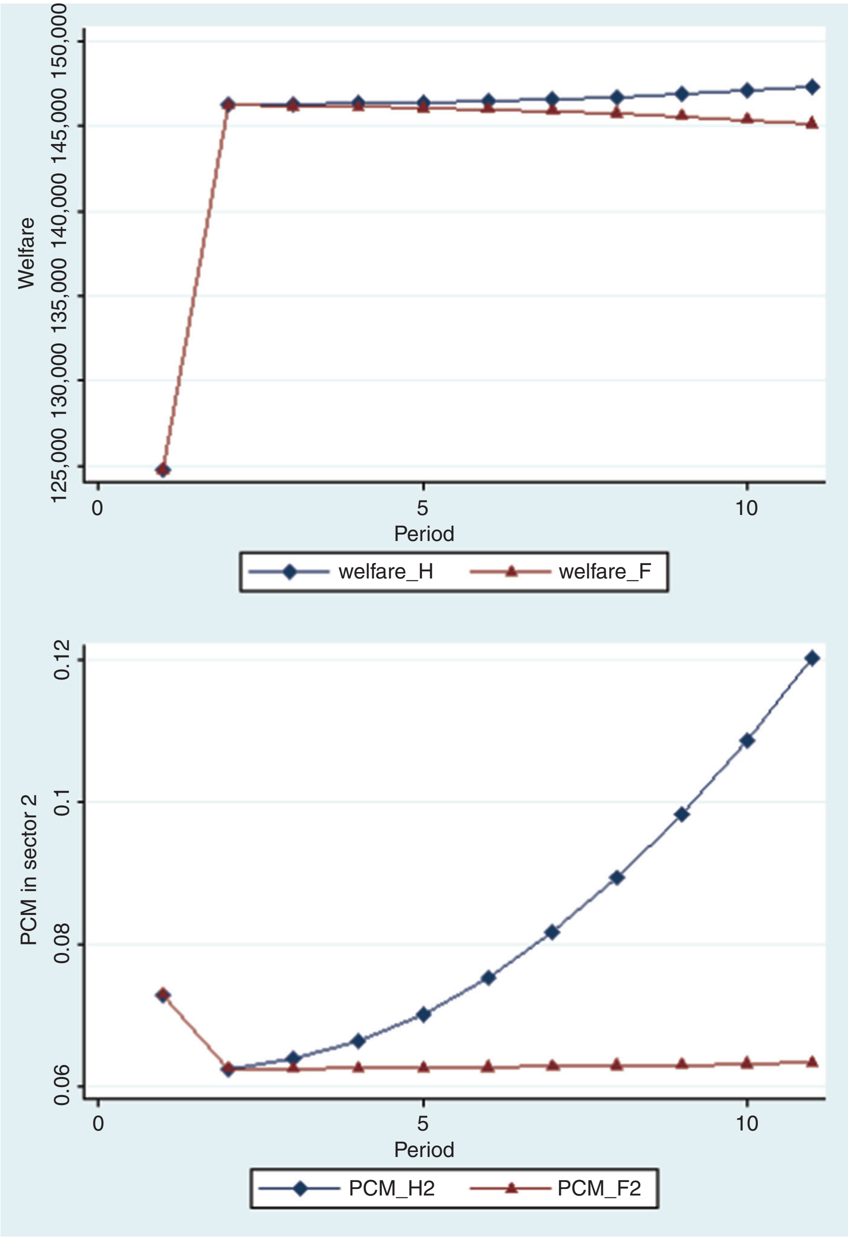

Figure 2: Numerical example results: welfare and PCM changes

cost from low competition levels, a country will adopt a beggar-thy-neighbor competition policy, which decreases its competition level to maximize its own welfare while sacrificing its trading partner's welfare. Therefore, as in previous studies, we also argue that liberal trade policies and tight competition policies are not substitutes. International coordination of competition policies could possibly promote both world welfare and trade.

Two possible improvements can be made to future work. First, introducing product differentiation and heterogeneous firms into the model would be a significant development. Second, this paper does not consider any effect of competition on productivity. If we assume that competition affects research and development (R&D) and that R&D determines productivity growth, then a dynamic model with R&D investment and changes of productivity may be of interest.

Appendix

Let us start with Case 1 and assume that $L^H = L^F = L$ and $\alpha^H(1) = \alpha^F(3) = \rho\alpha(2) = \rho\alpha$, where $0 < \rho < 1$. The welfare of country H and country F is given by

$$W^H = \frac{a^2}{2b} - \frac{1}{6b}\sum_{i=1}^{3} p^2(i),$$

$$W^F = \frac{a^2}{2b} - \frac{(\lambda^F)^2}{6b}\sum_{i=1}^{3} p^2(i).$$

We differentiate $\sum_{i=1}^{3} p^2(i)$ with respect to M^H and get

$$\frac{\partial \sum_{i=1}^{3} p^2(i)}{\partial M^H} = -\Phi_1\left(\frac{2}{1+\lambda^F}\right)^3 \frac{\partial \lambda^F}{\partial M^H} + \Phi_2\left\{2\rho^2\left[M^H - M^F\right] + 2M^H\right\},$$

where $\Phi_1 = \frac{\left(a\sum_{i=1}^{3}\alpha(i) - 3bL\right)^2}{\sum_{i=1}^{3}\alpha^2(i)}$ and $\Phi_2 = \frac{[\alpha(2)-\alpha(1)]^2}{\sum_{i=1}^{3}\alpha^2(i)}$. Initially, let $M^H = M^F = M^*$ and therefore $\lambda^F = 1$. We have

$$\frac{\partial \sum_{i=1}^{3} p^2(i)}{\partial M^H}\Big|_{M^H=M^*} = -\Phi_1 \frac{\partial \lambda^F}{\partial M^H}\Big|_{M^H=M^*} + 2\Phi_2 M^*.$$

If $\frac{\partial \lambda^F}{\partial M^H}\big|_{M^H=M^*} > \frac{2\Phi_2 M^*}{\Phi_1}$, then the welfare in the home country W^H increases when M^H increases. We can also show that if $\frac{\partial \lambda^F}{\partial M^H}\big|_{M^H=M^*} > 0$, then the welfare in the foreign country W^F always decreases when M^H increases. The only problem left now is to find the equation for $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*}$. We use the budget constraint

$$p(1)\left(\frac{a'}{b'}-\frac{p(1)}{b'}\right)+p(2)\left\{\frac{1}{\alpha(2)}\left[3L^H-\alpha(1)\left(\frac{a'}{b'}-\frac{p(1)}{b'}\right)\right]\right\}=\sum_{i=1}^{3}p(i)\left(\frac{a}{b}-\frac{p(i)}{b}\right).$$

On the right-hand side of this income and expenditure equation, we know the equation for $\sum_{i=1}^{3}p^2(i)$ and

$$\sum_{i=1}^{3}p(i)=\Phi_1\frac{2\sum_{i=1}^{3}\alpha(i)}{1+\lambda^F}+\Phi_2(M^F+M^F).$$

On the left-hand side of the income and expenditure equation, we have

$$\begin{aligned}
&p(1)\left(\frac{a'}{b'}-\frac{p(1)}{b'}\right)+p(2)\left\{\frac{1}{\alpha(2)}\left[3L^H-\alpha(1)\left(\frac{a'}{b'}-\frac{p(1)}{b'}\right)\right]\right\}\\
&=\frac{2a}{b}M^H\Phi_2+\frac{1+\lambda^F}{b}\Phi_2\left[M^HM^F\rho^2-\left(M^H\right)^2(1+\rho^2)\right]\\
&\quad+\frac{3L}{\alpha}\frac{\rho-\rho^2}{2\rho^2+1}\left(M^H-M^F\right)+\frac{3L}{\alpha}\frac{2\rho+1}{2\rho^2+1}\left[a-\frac{3bL}{\alpha}\right]\frac{2}{1+\lambda^F}.
\end{aligned}$$

Substituting this equation and equations for $\sum_{i=1}^{3}p(i)$ and $\sum_{i=1}^{3}p^2(i)$ into the budget constraint, we have

$$\begin{aligned}
0=&\,\Phi_2\left\{a+\frac{3bL}{\alpha}\frac{\rho}{1-\rho}\right\}(M^H-M^F)\\
&+M^HM^F(\lambda^F-1)\Phi_2\rho^2+\Phi_1\frac{2(1-\lambda^F)}{\left(1+\lambda^F\right)^2}\\
&-\left[\left(M^H\right)^2\lambda^F-\left(M^F\right)^2\right]\Phi_2(1+\rho^2).
\end{aligned}$$

Differentiating this equation with respect to M^H, we obtain

$$\begin{aligned}
0=&\,a\Phi_2+\frac{3bL}{\alpha}\Phi_2\frac{\rho}{1-\rho}-2M^*\Phi_2(1+\rho^2)\\
&-\left(\frac{1}{2}\Phi_1+(M^*)^2\Phi_2\right)\frac{\partial\lambda^F}{\partial M^H}|_{M^H=M^*}.
\end{aligned}$$

Therefore,

$$\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} = \frac{a\Phi_2 + \frac{3bL}{\alpha}\Phi_2\frac{\rho}{1-\rho} - 2M^*\Phi_2(1+\rho^2)}{\frac{1}{2}\Phi_1 + (M^*)^2\Phi_2}.$$

Obviously, $\frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*}$ is a decreasing function of M^* and

$$\frac{\partial \lambda^F}{\partial M^H}|_{M^H=0} = 2a\frac{\Phi_2}{\Phi_1} + \frac{6bL}{\alpha}\frac{\Phi_2}{\Phi_1}\frac{\rho}{1-\rho} > 0,$$

while $\frac{2\Phi_2 M^*}{\Phi_1}$ is an increasing function in M^* and $\frac{2\Phi_2 M^*}{\Phi_1} = 0$ when $M^* = 0$. Hence, there exists a threshold value $\bar{M}$. When M^* is less than $\bar{M}$, $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*}$ is larger than 0, while $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*}$ is less than 0 when M^* is larger than $\bar{M}$.

From the wage rate equation, we know that $M^* < a - \frac{3bL}{\sum_i \alpha(i)}$. If $\bar{M} > a - \frac{3bL}{\sum_i \alpha(i)}$, then a country will always have an incentive to increase its M. Define the function $F(M^*)$ as

$$F(M^*) = \frac{a\Phi_2 + \frac{3bL}{\alpha}\Phi_2\frac{\rho}{1-\rho} - 2M^*\Phi_2(1+\rho^2)}{\frac{1}{2}\Phi_1 + (M^*)^2\Phi_2} - \frac{2\Phi_2 M^*}{\Phi_1},$$

where $F(M^*)$ is a decreasing function of M^*. To ensure $\bar{M} > a - \frac{3bL}{\sum_i \alpha(i)}$, we must have $F(a - \frac{3bL}{\sum_i \alpha(i)}) > 0$. It can be shown that for any $0 < \rho < 1$, if $a > \frac{3bL}{\sum_{i=1}^3 \alpha(i)} > \phi(\rho)a$, then $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} > 0$ for any M^*, where

$$\phi(\rho^*) = 1 - \frac{\frac{2\rho^2+1}{1-\rho}}{\frac{2\rho^2+1}{1-\rho} + 2 + 2\rho^2 + 2\frac{(1-\rho)^2}{(2\rho+1)^2}}.$$

It is easy to show that $\phi(\rho)$ is a decreasing function of ρ and that $\phi(\rho) \in (0, \frac{3}{4})$.

For Case 2, consider $\alpha(1) > \alpha(2) > \alpha(3)$. We also assume that $\alpha(2) - \alpha(1) = \alpha(3) - \alpha(2)$. We let $\alpha(2) = \alpha$, $\alpha(1) - \alpha(2) = x$, $\frac{x}{\alpha} = \rho$, and $L^H = L^F = L$. We still have $\frac{\partial W^H}{\partial M^H}|_{M^H=M^*} = -\frac{1}{6b}\frac{\partial \sum_{i=1}^3 p^2(i)}{\partial M^H}|_{M^H=M^*}$, where

$$\frac{\partial \sum_{i=1}^{3} p^2(i)}{\partial M^H}|_{M^H=M^*} = -\Phi_1\left(\frac{2}{1+\lambda^F}\right)^3 \frac{\partial \lambda^F}{\partial M^H}|_{M^H=M^*} + 2\Phi_2 M^*(3-2\rho).$$

Different from Case 1, we need $\frac{\partial\lambda^F}{\partial M^H}|_{M^H=M^*} < \frac{2\Phi_2 M^*}{\Phi_1}(3-2\rho)(\frac{1+\lambda^F}{2})^3$ to make W^H decrease when M^H increases. Since we have different marginal cost distributions for the two countries, the budget constraint for country H is also different. We see that

$$\begin{aligned}0 = {} & aM^H\Phi_2\frac{3\rho-2\rho^2}{\rho} - aM^F\Phi_2\frac{3\rho+2\rho^2}{\rho} \\ & -\frac{3bL}{\alpha}M^H\Phi_2\frac{1+\rho}{\rho} - \frac{3bL}{\alpha}M^F\Phi_2\frac{1-\rho}{\rho} \\ & - M^H M^F(\lambda^F-1)\Phi_2(1-\rho^2) + \Phi_1\frac{2(1-\lambda^F)}{(1+\lambda^F)^2} \\ & - \Phi_2(M^H)^2(1+\rho^2)\lambda^F \ + (M^F)^2\Phi_2[1+(1+\rho)^2].\end{aligned}$$

Differentiating this equation and letting $M^H = M^F = M^*$ gives

$$\frac{\partial\lambda^F}{\partial M^H}|_{M^H=M^*} = \frac{A - 2M^*\Phi_2\left[1+(1-\rho)^2\right]\lambda^F - M^*(\lambda^F-1)\Phi_2(1-\rho^2)}{(M^*)^2\Phi_2(3-2\rho) + \Phi_1\frac{2}{(1+\lambda^F)^2}\frac{3-\lambda^F}{1+\lambda^F}},$$

where $A = a\Phi_2\frac{3\rho-2\rho^2}{\rho} - \frac{3bL}{\alpha}\Phi_2\frac{1+\rho}{\rho}$. We want to show that under certain conditions, $\frac{\partial\lambda^F}{\partial M^H}|_{M^H=M^*} < 0$ for any M^* and that therefore countries will always have an incentive to increase their competition levels. For $A < 0$. we need $\frac{3\rho-2\rho^2}{3+3\rho}a < \frac{bL}{\alpha}$. It is not difficult to show that $\frac{\partial\lambda^F}{\partial M^H}|_{M^H=M^*}$ is a decreasing function of M^* when $\lambda^F > \frac{1}{3}$. Finally, we need to show that λ^F is larger than one-third. From the budget constraint and $M^H = M^F = M^*$,

$$\begin{aligned}0 = {} & -aM^*4\rho^3 - 6\frac{bL}{\alpha}M^*\rho + (M^*)^2(3\rho^2+2\rho^3) - (M^*)^2\rho^2(3-2\rho)\lambda^F \\ & - \left[a - \frac{bL}{\alpha}\right]^2\frac{2}{1+\lambda^F} + \left[a - \frac{bL}{\alpha}\right]^2\left(\frac{2}{1+\lambda^F}\right)^2.\end{aligned}$$

The right-hand side of this equation is a decreasing function of λ^F. Since $\lambda^F > \frac{1}{3}$, we need

$$(M^*)^2\left(2\rho^2 + 2\frac{2}{3}\rho^3\right) - aM^*4\rho^3 - 6\frac{bL}{\alpha}M^*\rho + \frac{3}{4}\left[a - \frac{bL}{\alpha}\right]^2 > 0.$$

Since $M^* < a - \frac{bL}{\alpha}$, in order to make the quadratic equation in M^* larger than zero, the following two conditions must be satisfied. First, we need

$$a - \frac{bL}{\alpha} < \frac{2\rho^3 a + 3\rho \frac{bL}{\alpha}}{2\rho^2 + 2\frac{2}{3}\rho^3}.$$

When $0 < \rho < \frac{1}{10}$ and $\frac{1}{10}a < \frac{bL}{\alpha} < \frac{1}{2}a$, this equation holds. Second, we need

$$\left(a - \frac{bL}{\alpha}\right)^2 \left(2\rho^2 + 2\frac{2}{3}\rho^3\right) - a\left(a - \frac{bL}{\alpha}\right)4\rho^3 - 6\frac{bL}{\alpha}\left(a - \frac{bL}{\alpha}\right)\rho + \frac{3}{4}\left[a - \frac{bL}{\alpha}\right]^2 > 0.$$

It also can be shown that under the conditions of Proposition 2, this equation is larger than zero. Therefore $\frac{\partial \lambda^F}{\partial M^H}\Big|_{M^H = M^*} < \frac{2\Phi_2 M^*}{\Phi_1}(3 - 2\rho)\left(\frac{1+\lambda^F}{2}\right)^3$ for every M^* which means that country H always has an incentive to increase its competition level.

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