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**How Barriers to International Trade Affect TFP**

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# How Barriers to International Trade Affect TFP\*

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## Abstract

We ask how barriers to international trade affect TFP when there are monopoly rights in the import–competing industries. Holmes and Schmitz (1995) show that without barriers to trade TFP in these industries is as large as possible. We study the general case of finite barriers to trade. We find that binding quotas lead to the use of inefficient technology in the import–competing industries. In addition, finite quotas or tariffs imply that the import–competing industries produce larger than efficient quantities, if they produce at all. For both of these reasons, barriers to international trade reduce TFP.

*Keywords:* TFP; Monopoly Rights; Quota; Tariff.

*JEL classification:* EO0; EO4.

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# 1 Introduction

There are big cross-country differences in total factor productivity (TFP henceforth). For example, Hall and Jones (1999) estimate that in 1998 TFP in the U.S. was 10 times larger than in China. Why do rich countries have so much larger TFPs than poor countries? Parente and Prescott (1999) argue that monopoly rights over the use of inefficient technologies reduce TFP and that insider groups in poor countries have stronger monopoly rights than in rich countries. Parente and Prescott (2000) and Schmitz (2005) provide evidence for this view.

In this paper, we ask whether barriers to international trade can reduce TFP when there are insider groups and monopoly rights in the tradable-goods industries. The existing view due to Holmes and Schmitz (1995) is that free international trade implies the largest possible aggregate TFP, but they only considered the extreme cases ‘free trade’ and ‘no trade’. Here, we also consider the intermediate cases of positive but finite quotas and tariffs.<sup>1</sup>

We develop a theoretical model of a small open economy with insider groups and monopoly rights in the import-competing industries. We find that under a binding quota, these sectors use inefficient technology and they produce larger than efficient quantities. As a result, TFP decreases. We also find that a tariff reduces TFP by less than a quota: if the import-competing industries produce at all, then they still produce larger than efficient quantities, but they now use the efficient technology.

Our findings are consistent with the empirical evidence that openness fosters the catch up of per-capita GDP and TFP; see, for example, Sachs and Warner (1995), Wacziarg and Welch (2003), and Alcalá and Ciccone (2004). The measures of openness typically used in the literature have many dimensions. One key dimension is the barriers to international trade we consider here. Our findings are also consistent with the empirical evidence that quotas are particularly bad for TFP; see, for example, Baily (1993), Baily and Gersbach

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<sup>1</sup>Quotas are quantity restrictions and tariffs are taxes on imports. Note that no trade corresponds to a zero quota and free trade corresponds to a zero tariff.

(1995), Muendler (2002), and Kim (2000).

We organize the paper as follows. In Sections 2, we lay out the economic environment and define the equilibrium. In Section 3, we characterize the equilibrium. In Section 4, we conclude. All proofs are in the Appendix.

## 2 Model

We start with the description of the environment. Consider a small–open economy with one period.<sup>2</sup> There are an “agricultural” good  $a$  and many differentiated “manufactured” goods  $m_i$ ,  $i \in [0, 1]$ . There is a measure one of individuals, each of which is endowed with one unit of productive time and possibly with the membership in an insider group. In particular, for each  $i \in [0, 1]$  there is an interval of length  $\lambda_0 \in (0, 1)$  of identical insiders of type  $i$ . Individuals that are not insiders are identical outsiders, so there is a rectangle of measure  $1 - \lambda_0$  of outsiders. The subscript  $\iota \in \{i, o\}$  indicates an individual’s type. All types have identical preferences represented by  $\left(a^{\frac{\sigma-1}{\sigma}} + \int_0^1 m_i^{\frac{\sigma-1}{\sigma}} di\right)^{\frac{\sigma}{\sigma-1}}$ . We assume that the demand for the differentiated goods is inelastic, that is,  $\sigma \in (0, 1)$ .

The technology in the agricultural sector is described by  $A \leq N_a$ , where  $A$  is the production and  $N_a$  is the labor allocated to the agricultural sector. In each manufacturing industry  $i$ , there are three technologies described by  $M_{ik} \leq \pi_k N_{ik}$ , where  $M_{ik}$  and  $N_{ik}$  are the production and the labor with technology  $k \in \{0, 1, 2\}$  and  $1 = \pi_0 < \pi_1 < \pi_2$ . Any individual can use the  $\pi_0$  technology. In contrast, only the insiders of each manufacturing sector can use the  $\pi_1$  technology (“monopoly rights”). Any group of individuals can use the  $\pi_2$  technology if it pays a fixed cost  $c$ . Which technology is used in each manufacturing industry is decided in a three–stage game.

In the first stage, the insiders choose whether to leave their insider group. Leaving is voluntary and insiders who leave can work anywhere else. If all insiders of a manufacturing industry leave, then the insider group dissolves and every individual can use the  $\pi_2$  technology there without paying  $c$ . Afterwards, production and consumption take place

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<sup>2</sup>Our environment combines elements of Holmes and Schmitz (1995) and Parente and Prescott (1999).

and the game ends. If some insiders stay, then they are committed to working in this industry and the game continues. The insider group then decide whether to accept new members. We assume that if there are several group sizes  $\lambda_i \in [0, 1]$  with the same insider utility, then the group picks the largest one.

In the second stage, a group of outsiders can enter the  $i$ -th manufacturing industry. If it does enter, then only its members can use the  $\pi_2$  technology the outsider group chooses the price of the industry output while the insider group chooses how efficiently it wants to operate the  $\pi_1$  technology,  $\pi_i \in [0, \pi_1]$ . The demand for the outsider group's product equals the total demand minus the insider group's product,  $\pi_i \lambda_i$ , minus the imports,  $M_i^*$ . The outsider group has as many members as it takes to produce this demand with the  $\pi_2$  technology. Afterwards, production and consumption take place and the game ends. If no outsider group enters the game continues.

In the third stage the  $i$ -th insider group again chooses  $\pi_i \in [0, \pi_1]$ .<sup>3</sup> The outsiders decide whether or not to produce the manufacturing good with the  $\pi_0$  technology. Afterwards, production and consumption take place and the game ends.

We now turn to the equilibrium definition. There are markets for all final goods and types of labor. The final goods are tradable in the world market and the economy is small and open in that it takes the relative final goods prices in the world market as given. Labor is mobile within the country, but it is not traded in the world market. We use the agricultural good in the world market as the numeraire and denote the remaining relative prices by  $p_a$ ,  $p_{mi}^*$ ,  $p_{mi}$ ,  $w_o$ , and  $w_i$ . The superscript  $*$  indicates relative prices from the world market. We will only consider equilibria with free trade of the agricultural good, so  $p_a = 1$  in equilibrium.

Given the strategic choices in the different stages, profit maximization implies that the wages equal the marginal products, so  $w_o = 1$ . Each individual takes prices and wages as given and maximizes its utility function subject to its budget constraint, implying the individual demand functions  $a_i = w_i / [1 + \int_0^1 p_{mj}^{1-\sigma} dj]$  and  $m_{ii} = p_{mi}^{-\sigma} w_i / [1 + \int_0^1 p_{mj}^{1-\sigma} dj]$ .

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<sup>3</sup>Schmitz (2005) documents that the productivity with which a technology is operated depends on working arrangements and work rules.

Adding the individual demands for  $m_i$  gives the aggregate demand:  $D(p_{mi}) = [1 - \int_0^1 \lambda_j dj + \int_0^1 \lambda_j w_j dj] / [p_{mi}^\sigma (1 + \int_0^1 p_{mj}^{1-\sigma} dj)]$ .

We now turn to the three stages. If the outsiders enter in stages 3, they earn their marginal product  $p_{mi}\pi_0 = p_{mi}$ . They enter if and only if this is at least as large as the outsider wage  $w_o = 1$ . Since some outsiders must work in agriculture,  $p_{mi} \leq 1$  in equilibrium. The members of the  $i$ -th insider group also earn their marginal products,  $w_i = p_{mi}\pi_i$ . The group chooses  $\pi_i \in [0, \pi_1]$  so as to maximize the utility of its representative member subject to its given group size, to  $w_i = p_{mi}\pi_i$ , and to the total demand for this manufactured good. Since all prices but that of its own product are given to the group, this is equivalent to:

$$\begin{aligned} \max_{\pi_i} p_{mi}(\pi_i)\pi_i \quad \text{s.t.} \quad p_{mi}(\pi_i) &= [D(1)/(\lambda_i\pi_i + M_i^*)]^{\frac{1}{\sigma}} \quad \text{if } \pi_i \geq [D(1) - M_i^*]\lambda_i^{-1}, \\ p_{mi}(\pi_i) &= 1 \quad \text{if } \pi_i < [D(1) - M_i^*]\lambda_i^{-1}. \end{aligned} \quad (1)$$

In the first case, the group's production  $\lambda_i\pi$  would exceed demand if  $p_{mi} = 1$ , so  $p_{mi} < 1$  and only the insiders produce  $m_i$ . In the second case, the group's production falls short of demand if  $p_{mi} = 1$ . Since  $p_{mi} \leq 1$ ,  $p_{mi} = 1$  and some outsiders produce too.

We continue with stage 2. If an outsider group enters the  $i$ -th manufacturing industry, then it chooses  $p_{mi}$  to maximize profits subject to its members producing with the  $\pi_2$  technology and to the demand for their production, which equals total demand minus the insider group's product minus imports. Given any choice of  $p_{mi}$ , it is optimal for the insider group to produce as much as possible,  $\lambda_i\pi_1$ . Thus, the outsider group solves

$$\max_{p_{mi}} (p_{mi} - \pi_2^{-1}) [D(p_{mi}) - (\lambda_i\pi_1 + M_i^*)]. \quad (2)$$

The outsider group enters if and only if the resulting profit exceeds the entry costs  $c$ .

We finish with stage 1. The insiders stay in their groups if and only if their wage in manufacturing exceeds what they could earn in agriculture:  $w_o = 1 < p_{mi}\pi_i$ . They accept new members if the initial size  $\lambda_0$  falls short of the minimum  $\lambda_i$  that deters entry in stage

2 or if their maximum production in stage 3 is smaller than total demand at  $p_{mi} = 1$ :  $\lambda_i \pi_1 < D(1) - M_i^*$ .

For us to be able to talk about a quota  $Q$  or a tariff  $\tau$  on manufactured goods, the domestic economy needs to import them under free trade. We therefore assume that it has a comparative advantage in the agricultural good:

**Assumption 1** *The relative world market price of all  $m_i$  is given by  $p_m^* \in (0, \pi_2^{-1})$ .*

We also assume that the revenues  $(p_m - p_m^*)Q$  and  $\tau M^*$  from the trade barriers are thrown away. None of our results would change if, instead, they were lump-sum rebated.

We study symmetric subgame-perfect equilibria in which the insiders behave identically and the insider groups do too. We can then drop the index  $i$  except when distinguishing the insiders from outsiders. We start with a binding quota on the imports of manufactured goods,  $M^* = Q$ , in which case  $p_m$  is determined domestically.

**Definition 1** *A symmetric, subgame-perfect equilibrium under a binding quota are prices  $(p_a, p_m, w_o, w_i)$ , an allocation  $(A, N_a, M_0, N_0, M_1, N_1, M_2, N_2, a_o, a_i, m_o, m_i)$ , net imports  $(A^*, M^*)$ , and group choices  $(\lambda, \pi)$  such that: (i)  $M^* = Q$ ; (ii)  $p_a = 1$ ; (iii) wages equal marginal products,  $w_o = 1$  and  $w_i = p_m \pi$ ; (iv)  $\lambda$  and  $\pi$  solve the problems of the representative insider group at stages 1 and 3; (v)  $M_2 = \pi_2 N_2$  and  $M_0 = N_0$  solve the entry problems at stages 2 and 3; (vi)  $(a_\iota, m_\iota)$  solves the problem of the representative agent of type  $\iota \in \{o, i\}$ ; (vii) markets clear.*

We continue with a tariff on manufactured goods. If the tariff is small, then the manufactured goods are imported and  $p_m = (1 + \tau)p_m^*$  is given to the domestic economy. If the tariff is large it shuts down trade while  $p_m < (1 + \tau)p_m^*$  is determined domestically.

**Definition 2** *A symmetric, subgame-perfect equilibrium under a tariff are prices  $(p_a, p_m, w_o, w_i)$ , allocations  $(A, N_a, M_0, N_0, M_1, N_1, M_2, N_2, a_o, a_i, m_o, m_i)$ , net imports  $(A^*, M^*)$ , and group choices  $(\lambda, \pi)$  such that: (i)  $p_m = (1 + \tau)p_m^*$  or  $A^* = M^* = 0$  and  $p_m$  is determined domestically; (ii)–(vii) as in Definition 1.*

### 3 Equilibrium

We first characterize the equilibrium under a binding quota. The relative price of a typical manufactured good is then determined domestically, so the corresponding insider group can manipulate it by producing inefficiently and thereby restricting its output. Since the demand for manufactured goods is assumed inelastic here, this results in an increase in the relative price that more than compensates for the decrease in the marginal product of labor, so income increases. The group therefore stays together and produces  $m$  with the inefficient  $\pi_1$  technology. The next proposition formalizes this intuitive argument.

**Proposition 1** *Let Assumption 1 hold and  $Q \in [0, 1/2)$  be a quota on manufactured goods. If*

$$\lambda_0 \leq (1 - 2Q)(1 + \pi_1)^{-1} \quad \text{and} \quad c > 2^{-\frac{1}{\sigma}} \sigma (1 - \sigma)^{\frac{1-\sigma}{\sigma}} [(2^{-1} - Q) \pi_1 + Q]^{-\frac{1-\sigma}{\sigma}}, \quad (3)$$

*then there is a unique equilibrium in which the quota binds. In this equilibrium the domestic economy produces all final goods;  $\lambda \geq \lambda_0$ ;  $\pi \leq \pi_1$ .*

We now turn to TFP, which is defined as the residual that would result if aggregate output at international prices was produced from aggregate labor. Since our economy is small and all goods are traded, the world-market prices are also the international prices. Moreover, since aggregate labor equals one,  $TFP = A + p_m^* M$ . We can see that the maximum TFP of 1 obtains when the domestic economy produces only  $a$ . If it also produces  $m$ , then TFP is smaller than 1.

**Proposition 2** *Let Assumption 1 and Conditions (3) hold and  $Q \in [0, 1/2)$  be a quota on manufactured goods. In equilibrium  $TFP < 1$  and TFP increases when  $Q$  increases.*

We now characterize the equilibrium under a tariff. In the interesting case in which the tariff does not completely shut down international trade, the domestic economy imports the manufactured goods and  $p_m = (1 + \tau)p_m^*$  is given to it. So a typical insider group can no longer manipulate  $p_m$ . It therefore dissolves, so that its members can work in

agriculture or use the  $\pi_2$  technology. As a result, manufactured goods are produced with the most productive technology, if they are produced at all.

**Proposition 3** *Let Assumption 1 hold and  $\tau$  be a tariff on manufactured goods. (i) If  $\tau \in [0, (1 - p_m^* \pi_2)/(p_m^* \pi_2))$ , then there is a unique equilibrium. In this equilibrium the insider groups dissolve; the domestic economy produces only the agricultural good. (ii) If  $\tau = (1 - p_m^* \pi_2)/(p_m^* \pi_2)$ , then there is continuum of equilibria. In almost all equilibria the domestic economy produces all final goods and uses the  $\pi_2$  technology to produce the manufactured goods; it exports agricultural goods and imports manufactured goods. (iii) If  $\tau \in ((1 - p_m^* \pi_2)/(p_m^* \pi_2)^{-1}, \infty)$ ,  $\lambda_0 \leq (1 + \pi_1)^{-1}$ , and  $c > 2^{-1} \sigma (1 - \sigma)^{\frac{1-\sigma}{\sigma}} \pi_1^{\frac{\sigma-1}{\sigma}}$ , then the equilibrium is as under a zero quota (closed economy).*

The equilibrium with a positive tariff has the same qualitative properties as the equilibrium with a zero tariff, except for relatively large tariffs, which increase the relative price of manufactured goods by so much that the economy starts producing manufactured goods. In particular, in case (ii) all individuals are indifferent between producing and not producing manufactured goods. An equilibrium in which manufactured goods are imported then still exists. In case (iii), all individuals strictly prefer to produce manufactured goods. An equilibrium in which manufactured goods are imported no longer exists. We now turn to analyze TFP under a tariff.

**Proposition 4** *Let Assumption 1 hold and  $\tau$  be a tariff on manufactured goods. (i) If  $\tau \in [0, (1 - p_m^* \pi_2)/(p_m^* \pi_2))$ , then  $TFP = 1$ ; a reduction in  $\tau$  does not affect TFP. (ii) If  $\tau = (1 - p_m^* \pi_2)/(p_m^* \pi_2)$ , then in almost all equilibria  $TFP < 1$ ; a reduction in  $\tau$  increases TFP. (iii) If  $\tau \in ((1 - p_m^* \pi_2)/(p_m^* \pi_2)^{-1}, \infty)$  and conditions (3) hold for  $Q = 0$ , then  $TFP < 1$ ; a reduction in  $\tau$  such that  $\tau$  remains in case (iii) does not affect TFP.*

As long as the tariff does not shut down international trade, TFP is smaller under the tariff than under free trade only in case (ii). This is the usual misallocation effect: a tariff distorts the efficient allocation of the factors of production, so the import-competing industries produce too much. This effect shows up for only one tariff value here because our production function is linear in labor.

In sum, we find that when there are monopoly rights in the import-competing industries binding quotas and tariffs affect TFP in different ways: (i) under a quota the import-competing industries use inefficient technologies and they may operate them inefficiently; under a tariff that does not shut down international trade the import-competing industries use efficient technologies and they operate them efficiently, if they produce at all; (ii) an increase in the quota has a quantitatively larger effect on TFP than an equivalent decrease in the tariff for a large range of tariff values.<sup>4</sup>

Baily (1993) and Baily and Gersbach (1995) provide supportive evidence for finding (i). They study the services and manufacturing industries of Germany, Japan, and the USA and find strong positive correlations between the level of TFP and the degree to which domestic firms are exposed to the competition with the international productivity leaders. The key factor determining exposure is quotas (which they call non-tariff barriers), whereas tariffs are not important. Muendler (2002) provides supportive evidence for finding (ii). He studies a sample of medium-sized to large Brazilian manufacturers before, during, and after Brazil's trade liberalization 1986–98. Using market penetration as a proxy for quotas, Muendler finds that an increase in quotas had a much larger effect on TFP than an equivalent decrease in tariffs. Kim (2000) also provides supportive evidence for prediction (ii). He studies the Korean manufacturing industries during 1963–83 and 1966–88, respectively. Using coverage ratios (the percentage of imported goods with quantity restrictions) as a rough measure of quotas, he finds that quotas had a statistically significant negative effect on TFP growth, whereas tariffs did not.<sup>5</sup>

The Korean evidence is also consistent with having the monopoly power in the goods market. In independent work, Traca (2001) studies an endogenous growth model with a monopolist in the import-competing industry. He shows that more restrictive quotas

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<sup>4</sup>Note that these differences between quotas and tariffs are reminiscent of Bhagwati's (1965) result that the two are not equivalent when there monopoly power in the goods market. However, we need monopoly power in the labor market for our result. The reason is that a goods-market monopolist could increase the relative price directly, so there would be no incentive to produce inefficiently.

<sup>5</sup>There are other studies that document that TFP or labor productivity increased after trade liberalizations, but do not distinguish between quotas and tariffs; see Cavalcanti Ferreira and Rossi (2003) and Pavcnik (2002) and the references therein.

reduces the growth rates of productivity and output along the balanced growth path, whereas tariffs have no effect. The main difference between his work and our's is that he focuses on the effect of trade barriers on R&D whereas we focus on their effect on technology adoption. Coe et al. (1997) report that “almost the entire R&D activity in the world economy is concentrated in the industrial countries”. This suggests using his model for the industrial countries and our model for rest.

## 4 Conclusion

In this paper, we have shown that barriers to international trade can reduce TFP if insider groups in the import-competing industries have monopoly rights over the use of inefficient technologies. The existing view due to Holmes and Schmitz (1995) is that international trade makes monopoly rights ineffective and leads to efficient production. We have shown that this is only the case if there are no barriers to international trade at all. Specifically, we find that under a binding quota, the import-competing sectors use inefficient technology and they produce larger than efficient quantities. As a result, TFP decreases. We also find that a tariff reduces TFP by less than a quota: if the import-competing industries produce at all, then they still produce larger than efficient quantities, but they now use the efficient technology.

## References

- Alcalá, Francisco and Antonio Ciccone**, “Trade and Productivity,” *Quarterly Journal of Economics*, 2004, 119, 613–646.
- Baily, Martin N.**, “Competition, Regulation, and Efficiency in Service Industries,” *Brookings Papers on Economic Activity*, 1993, *Microeconomics*, 71–103.
- **and Hans Gersbach**, “Efficiency in Manufacturing and the Need for Global Competition,” *Brookings Papers on Economic Activity*, 1995, *Microeconomics*, 307–347.

- Bhagwati, Jagdish N.**, “On the Equivalence of Tariffs and Quotas,” in Richard F. Caves et al., ed., *Trade, Growth, and the Balance of Payments*, Chicago: Rand-McNally, 1965.
- Cavalcanti Ferreira, Pedro and José Luis Rossi**, “New Evidence on Trade Liberalization and Productivity Growth,” *International Economic Review*, 2003, *44*, 1383–1405.
- Coe, David T., Elhanan Helpman, and Alexander W. Hoffmaister**, “North–South R & D Spillovers,” *Economic Journal*, 1997, *107*.
- Hall, Robert and Charles I. Jones**, “Why Do Some Countries Produce So Much More Output Per Worker Than Others?,” *Quarterly Journal of Economics*, 1999, *114*, 83–116.
- Holmes, Thomas J. and James A. Schmitz Jr.**, “Resistance to New Technology and Trade Between Areas,” *Federal Reserve Bank of Minneapolis Quarterly Review*, 1995, *19*, 2–17.
- Kim, Euysung**, “Trade Liberalization and Productivity Growth in Korean Manufacturing Industries: Price Protection, Market Power, and Scale Efficiency,” *Journal of Development Economics*, 2000, *62*, 55–83.
- Muendler, Marc-Andreas**, “Trade, Technology, and Productivity: A Study of Brazilian Manufactures, 1986–1998,” Manuscript, University of California, San Diego 2002.
- Parente, Stephen L. and Edward C. Prescott**, “Monopoly Rights: a Barrier to Riches,” *American Economic Review*, 1999, *89*, 1216–33.
- and ———, *Barriers to Riches*, Cambridge, MA: MIT Press, 2000.
- Pavcnik, Nina**, “Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants,” *Review of Economic Studies*, 2002, *69*, 245–276.
- Sachs, Jeffrey D. and Alejandro Warner**, “Economic Reform and the Process of Global Integration,” *Brookings Papers on Economic Activity*, 1995, *1*, 1–95.
- Teixeira, Arilton**, “Effects of Trade Policy on Technology Adoption.” PhD dissertation, University of Minnesota 1999.
- Traca, Daniel A.**, “Quantitative Restrictions, Market Power, and Productivity Growth,” *Journal of Development Economics*, 2001, *65*, 95–111.
- Wacziarg, Romain and Karen Horn Welch**, “Trade Liberalization and Growth: New Evidence,” Working Paper 10152, NBER 2003.

# Appendix

**Proof of Proposition 1.** We start with stage 3. Imposing symmetric equilibrium and using that  $\sigma < 1$  and  $w_i = p_m \pi_i$ , the solution to (1) is to choose the smallest  $\pi_i$  such that  $p_{mi} = 1$ .

Next, we determine the productivity  $\pi_i \in [0, 1]$  with which the representative insider group operates the  $\pi_1$  technology. In symmetric equilibrium,  $\lambda_i = \lambda$ ,  $\pi_i = \pi$ , and  $p_{mi} = p_m = 1$ . Thus, the demand for the manufactured good reduces to  $D(1) = (1 - \lambda + \lambda\pi)2^{-1}$ . If the group's maximal production  $\lambda\pi_1$  exceeds  $D$ , then it chooses  $\pi \in [0, \pi_1]$  such that its actual production equals  $D$ . This implies:

$$\lambda\pi = 1 - \lambda - 2Q < \lambda\pi_1. \quad (4)$$

If the group's maximal production does not exceed  $D$ , then it produces with  $\pi_1$ . At this stage this includes the case that production falls short of demand:  $D(1) - Q \geq \lambda\pi_1$ .

We now turn to stage 2. Using that the productivity chosen in equilibrium must satisfy  $\lambda\pi = 1 - \lambda - 2Q$ , we can write (2), the problem of the outsider group after it has entered, as:

$$\max_{p_m} (p_m - \pi_2^{-1}) [p_m^{-\sigma} (1 - \lambda - Q) - (\lambda\pi_1 + Q)]. \quad (5)$$

There is no closed-form solution to this problem. However, it is possible to derive a sufficient condition for no entry by considering the case of zero marginal costs, that is, by replacing  $\pi_2^{-1}$  by 0 in (5). Clearly, if it is not optimal to enter with zero marginal costs, it is not optimal to enter when marginal costs equal  $\pi_2^{-1}$ . Computing the maximum profits with zero marginal costs, we find a sufficient condition for no entry:

$$c \geq \sigma(1 - \sigma)^{\frac{1-\sigma}{\sigma}} (1 - \lambda - Q)^{\frac{1}{\sigma}} (\lambda\pi_1 + Q)^{-\frac{1-\sigma}{\sigma}}. \quad (6)$$

We finish with stage 1. First,  $D(1) - Q \geq \lambda\pi_1$  cannot hold with strict inequality, be-

cause if it did the insiders' wage would equal its maximum while the group could increase its size. Thus,  $\lambda \geq (1 - 2Q)(1 + \pi_1)^{-1}$  and condition (3) ensures that  $\lambda \geq \lambda_0$  so the insider group never wants to expel members. Second, for a given group size the insiders earn  $p_m \pi_1$  if entry occurs in stage 2. For the same group size the insiders can earn a higher wage in stage 3 if entry does not occur in stage 2. This follows because producing with  $\pi_1$  in stage 3 would already give them higher income than they earn in stage 2 because in stage 3 they are the only domestic producers. Consequently the group will choose  $\lambda$  such that entry does not occur at stage 2. Third, condition (3) ensures that inequality (6) holds strictly for  $\lambda = 1/2 - Q$ . Thus, there exists a smallest  $\lambda \in [[2(1 + \pi_1)^{-1}](1/2 - Q), (1/2 - Q))$  such that nobody enters at stages 2 and 3. Fourth, we need to check that the utility of the representative insider is higher in the group than outside, given all other groups stay together. If he leaves, he earns the outsider wage. If he stays, he produces with  $\pi \in [0, \pi_1]$  at a relative price that makes the outsiders indifferent between working in agriculture and in this manufacturing industry with the  $\pi_0$  technology. Since  $\lambda < 1/2 - Q$ , (4) implies that  $\pi > \pi_0 = 1$ , so he is better off in the group. **QED.**

**Proof of Proposition 2.** We start by noting that  $TFP = 1 - \lambda + p_m^* \pi \lambda$ . The first statement of the proposition follows from Assumption 1 because  $p_m^* \pi \leq p_m^* \pi_1 < p_m^* \pi_2 < 1$ . We continue with the second statement. To show that  $TFP$  increases as  $Q$  increases, we need to show that  $\pi \lambda$  decreases as  $Q$  increases. Consider an increase in  $Q$  from  $Q_1$  to  $Q_2$  and call  $\lambda_2$  the value of  $\lambda$  for which  $\lambda(Q_1)\pi_1 + Q_1 = \lambda_2\pi_1 + Q_2$ . Using (5) and that  $-(\lambda + Q) = -(\pi_1\lambda + Q) + (\pi_1 - 1)\lambda$ , we can see that if  $\lambda(Q_1)$  deters entry when the quota equals  $Q_1$ , then  $\lambda_2$  deters entry when the quota equals  $Q_2$ . Since the sum of the maximum group product and the quota remains the same, it must be that in equilibrium  $\lambda(Q_2) \leq \lambda_2$ . So, it remains to be shown that  $\lambda(Q_2)\pi(Q_2) < \lambda(Q_1)\pi(Q_1)$ . If the opposite was true, then we would have:

$$\frac{1 - \lambda(Q_2) + \pi(Q_2)\lambda(Q_2)}{2p_m^\sigma} - [\lambda(Q_2)\pi_1 + Q_2] > \frac{1 - \lambda(Q_1) + \pi(Q_1)\lambda(Q_1)}{2p_m^\sigma} - [\lambda(Q_1)\pi_1 + Q_1].$$

Since for  $Q_1$  the entrant was indifferent between entering or not, for  $Q_2$  it would strictly prefer to enter. This is a contradiction. **QED.**

**Proof of Proposition 3.** The marginal product in agriculture equals 1, so  $w_o = 1$ . The highest marginal product in manufacturing in units of the agricultural good is  $p_m^*(1 + \tau)\pi_2$ .

In case (i),  $\tau \in [0, (1 - p_m^*\pi_2)/(p_m^*\pi_2))$ . Since Assumption 1 implies that  $p_m^*\pi_2 < 1$  the marginal product in agriculture is then strictly larger than that in manufacturing. Thus, the groups dissolve and all individuals work in agriculture. The economy exports the agricultural good and imports its whole consumption of manufactured goods.

In case (ii),  $\tau = (1 - p_m^*\pi_2)/(p_m^*\pi_2)$  and the marginal product in agriculture equals that in manufacturing if the  $\pi_2$  technology is used. If they stayed in their groups and used the  $\pi_1$  technology, then the insiders would earn a lower marginal product than in agriculture. Thus, the insider groups dissolve. Total income and the total consumptions of agricultural and manufactured goods are as in the first case but productions change as individuals allocate labor to the manufacturing industries.

In case (iii),  $\tau \in (1 - p_m^*\pi_2)/(p_m^*\pi_2), \infty)$ . If there was an equilibrium in which the manufactured goods are imported, then the groups would dissolve and the wage in manufacturing would equal  $(1 + \tau)p_m^*\pi_2$ . This would be larger than the outsider wage, so every individual would want to produce in manufacturing, contradicting that the manufactured goods are imported. Thus, the equilibrium is the same as under a zero quota. **QED.**