Contract enforcement, division of labor, and the pattern of trade

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Abstract

This paper analyzes the impact of imperfect contract enforcement on the extent of the division of labor and the pattern of trade. We consider a world economy comprising two large countries, with a continuum of goods and one factor of production, labor. Each good is characterized by its complexity, defined as the number of elementary tasks that must be performed to produce one unit. There are increasing returns to scale in the performance of each task, which creates gains from the division of labor. When contracts are not perfectly enforced, the trade-off between these gains and transaction costs pins down the size of productive teams across sectors in each country. When the two countries open up to trade, the country where teams are larger under autarky — in efficiency units of labor — specializes in the more complex goods. In our model, it is the country where the product of institutional quality and workers' productivity is larger. Institutions and productivity levels are complementary sources of comparative advantage. Our model predicts that when institutional improvement and productivity gains occur in developed countries, all countries gain; but that when they occur in developing countries, developed countries might be hurt.

Keywords Contract enforcement, Division of labor, Ricardian comparative advantage

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"One cannot take enforcement for granted. It is (and has always been) the critical obstacle to increasing specialization and division of labor"; NORTH [1990]

1 Introduction

This paper proposes a simple theory of international trade in the presence of imperfect contract enforcement. The core of the theory lies in the impact of the quality of contract enforcement on the size of productive teams. The two key elements of the theory are: (*i*) gains from the division of labor; and (*ii*) transaction costs. Gains from the division of labor depend on the complexity of the production process, which is a function of an industry's technology. Transaction costs depend on the quality of institutions and workers' productivity, which are characteristics of countries. When contracts are not perfectly enforced, the trade-off between these two forces pins down the size of productive teams across industries in each country. When countries open up to trade, the endogenous differences in the optimal organization of production across countries determine the pattern of trade.

Fourteen years ago, NORTH [1990] noted: "For 200 years, the gains from trade made possible by increasing specialization and division of labor have been the corner stone of economic theory. [...] But the many economists who built this approach into an elegant body of economic theory did so without regard to the costliness of this exchange process". Since then, economists have been catching up. Transaction costs, and the institutions that cope with them, have now received a great deal of attention in topics as diverse as: the organization of the firm, political economy, economic growth, and international trade.[2] The main contribution of this paper is to develop a theory of international trade that incorporates both institutions and their impact on the efficient organization of production. By offering a closer look at the economic role of institutions, our theory is able to generate new predictions on the determinants of international trade.

Section 2 illustrates some of the main ideas of our analysis through a simple example. The formal set-up of the model is described in section 3. We consider an economy with a continuum of goods and one productive factor, labor. The production of every good requires that a set of elementary tasks be performed. Like in SMITH [1776]'s pin factory, there are increasing returns to scale in the performance of each task: before

[2] See e.g. WILLIAMSON [1979], DIXIT [1996], ACEMOGLU et al. [2001] and LEVCHENKO [2003], respectively.

being able to perform a task, workers must spend a fixed amount of time learning it. Goods differ in their "complexity", defined as the number of elementary tasks that must be performed to produce one unit. The more complex a good is, the longer it takes to learn how to perform all tasks, and the larger are the gains from the division of labor.

In each industry, contracts organize productive activities by assigning elementary tasks to workers. But, their enforcement is imperfect. If the contract of a worker is enforced, she performs her tasks in accordance with the terms of her contract; otherwise, she does not perform at all. A key parameter of the model is the probability with which a given contract is enforced. This probability is assumed identical across industries and aims to capture the "quality of institutions", that is the efficiency of the judicial system and/or the level of trust, in a given country.

Section 4 characterizes the efficient organization of production in a closed economy. Our analysis of team size, defined as the number of workers that cooperate on each unit of a given good, builds on previous works by Becker and Murphy [1992] and Kremer [1993]. It predicts that team size increases with the quality of institutions and the complexity of the goods, but decreases with the productivity of the workforce.

Section 5 analyzes the pattern of trade between two countries, which share the same technology, but differ in the quality of their institutions and the productivity of their workers. Because there are increasing returns to scale in the performance of each task, the country where teams are larger under autarky — in efficiency units of labor — specializes in the more complex goods under free trade. In our model, it is the country where the product of institutional quality and workers' productivity is larger. Like better institutions, a higher absolute productivity level confers comparative advantage in the more complex sectors. Institutions and productivity levels are complementary sources of comparative advantage. Our model predicts in particular that developed countries specialize in the more complex sectors, and developing countries in the less complex sectors. In turn, international trade decreases average team size in developing countries, while increasing it in developed countries.

Section 6 discusses the welfare impacts of institutional improvement and productivity gains in the two countries. When institutional improvement and productivity gains occur in the developed country, both countries gain. But when they occur in the developing country, the developed country might be harmed. Our results echo the analysis of technological progress in Krugman [1986].

Section 7 extends our model to discuss the choice between family and anonymous firms. Family firms are characterized by higher levels of trust between their members; but, their size is bounded by the number of family members. We show that firms are family-run in the less complex industries, and anonymous in the more complex industries. Under autarky, the proportion of family firms decreases with the quality of institutions and increases with workers' productivity. When the two countries open up to trade, differences in the prevalence of family firms across countries are sharpened. The proportion of family firms decreases in the developed country and increases in the developing country.

Our paper is related to the literature on international trade and institutions. In most of this literature, the quality of institutions is modeled as a tax parameter imposed on "institutionally dependent" sectors; see Berkowitz et al. [2003] for a recent example. Differences in these tax parameters across countries create the pattern of comparative advantage. This "Ricardian view" has been criticized by Levchenko [2003], who argues that institutional differences are better modeled within the Grossman-Hart-Moore framework of contract incompleteness. However, new views on how to model institutions have not changed the starting point of the analysis. There exist sectors which depend more on institutions than others; then, efficient international specialization implies that these sectors should be located in the country with better institutions.[3] But, there is nothing in the analysis to determine what these sectors are. Our paper fills this gap. In our model, the "institutionally dependent" industries are the more complex ones: larger gains from the division of labor imply more workers per team, and so more contracts to be enforced.

From a theoretical point of view, our paper is also related to the recent literature on international trade and organizations, see e.g. Antras [2003], Antras and Helpman [2004] and Marin and Verdier [2003]. Like the previous authors, we propose a model that endogenizes the efficient organization of production in a global general equilibrium.[4] But while they focus on the allocation of property rights or authority within firms, we focus on the extent of the division of labor.

[3] Recent papers along these lines include: Matsuyama [2004], where the country with a better credit market specializes in sectors subject to bigger agency problems; Vogel [2004], where the country with a better monitoring technology specializes in sectors more subject to moral hazard; and Nunn [2004], where the country with better ex post enforcement specializes in sectors subject to bigger hold-up problems.

[4] See Legros and Newman [2000] and Grossman and Helpman [2002] for earlier closed-economy models in this field.

Finally, our paper is related to Grossman and Maggi [2000] which shows that not only aggregate factor endowments, but also the dispersion of these factors across workers can be a source of comparative advantage. This paper shows that when there are gains from the division of labor and imperfect contract enforcement, the factor endowment of a representative worker, i.e. her productivity, also matters for the pattern of trade.

2 A simple example

Some of the main ideas of our analysis are best illustrated by a simple example. Consider an island economy with two sectors: pins and computers. The island is populated by many identical workers, each able to work for 300 days. In each industry, producing one unit of output requires many complementary tasks to be performed; and whatever the task is, it takes a worker 1 day to learn it and 1 more day to perform it.[5] But, computers are more *complex* than pins: it takes 10 tasks to produce a pin, against 100 to produce a computer.

In both industries, goods can be produced by teams of either 1 or 2 workers. For each worker, there is a contract that stipulates her assignment of tasks. However, such contracts are not perfectly enforced. Only 90% of the workers fulfill their contractual obligations; the remaining 10% do not perform any tasks. Given the technological and institutional constraints of the island, what is the efficient team size in the pin and computer industries, respectively?

Consider first the pin industry. If there is 1 worker per team, then this worker needs 10 training days to learn how to produce a pin from the beginning to the end. Instead, if there are 2 workers per team, then each worker may specialize in only 5 tasks, and spend 5 more days producing rather than learning. The 5 days that are saved for production by adding an extra worker captures the gains from the division of labor. What are the associated transaction costs? While a team with a single worker has a 90% chance to produce, a team with 2 specialized workers needs both of them to be honest, and so produces with probability 81%. Specialization increases the number of contracts that need to be simultaneously enforced, which reduces the expected output of each team. In the pin industry, this latter effect is dominant. If teams are of size 1, each worker may produce for $300-10=290$ days, with probability 90%. If teams are of size 2, each worker may produce for $300-5=295$ days,

[5] In other words, it takes 3 days for a given worker to perform the same task twice.

but with probability 81%. Since $0.9 \times 290 = 261 > 0.81 \times 295 = 238.95$, the efficient team size in the pin industry is equal to 1.

Let us now turn to the computer industry. If there are 2 workers per team, then each worker may save 50 training days. While there are gains from the division of labor in both industries, these gains are 10 times larger in the computer industry. Thus for given transaction costs, its teams ought to be larger. Indeed, in a team of size 1, each worker may produce for $300 - 100 = 200$ days, with probability 90%; in a team of size 2, each worker may produce for $300 - 50 = 250$ days, with probability 81%. Since $0.9 \times 200 = 180 < 0.81 \times 250 = 202.5$, the efficient team size in the computer industry is equal to 2.

This, in a nutshell, explains why the division of labor should be more extensive in the more complex industries. What does this example tell us about differences in team size across countries? Two things: (*i*) countries with worse institutions should have smaller teams; and (*ii*) countries with higher productivity levels should have smaller teams. To see this, suppose that the *quality of institutions* in the island goes down. A given contract is now enforced with a 50% chance. In this case, gains from the division of labor are unchanged, but transaction costs go up, and so team size decreases. Since $0.5 \times 200 = 100 > 0.25 \times 250 = 62.5$, the efficient team size in the computer industry goes down from 2 to 1. Similarly, suppose that *workers' productivity* goes up. The same 300 working days are now worth 600 days. Then, team size also decreases from 2 to 1 in the computer industry, since $0.9 \times 500 = 450 > 0.81 \times 550 = 445.5$. Again, gains from the division of labor are unchanged, but transaction costs go up — there is more to lose when contracts are not enforced — and so team size decreases.

Suppose now that the island opens up to trade. Its trading partner shares the same technology, but differs in the quality of its institutions and the productivity of its workforce. Which of the two islands, if any, should specialize in the computer industry? Our answer is simple: it is the island where teams are larger in *efficiency units* under autarky, i.e. the island where the number of working days per team is larger.

In the first island, we know that teams in the pin industry comprise 1 worker, endowed with 300 working days. Hence, there are 300 efficiency units per team in this sector. Similarly, teams in the computer industry comprise 2 workers, and so $2 \times 300 = 600$ efficiency units. Let us assume that in the second island, there are 300 efficiency units per team in both industries. This may correspond to one of these two cases: (*i*) workers in the second island are as productive as workers in the first island, but worse institutions have lead to teams of size 1 in both sectors; or (*ii*) workers in the second island are half as productive, but better institutions have lead to teams of size 2. In any case, the first island has a comparative advantage in the computer industry.

To see this, let us define a_p^1 and a_c^1 as the average number of days necessary to produce one pin and one computer in the first island. Since there is 1 worker per team in the pin industry, we have: $a_p^1 = \frac{300}{\frac{290 \times 0.9}{10}} = 11.5$. In the computer industry, there are 2 workers per team and so: $a_c^1 = \frac{600}{\frac{500 \times 0.81}{100}} = 148$. In turn, the relative unit labor requirement is given by: $\frac{a_c^1}{a_p^1} = 12.8$. Now, let us define a_p^2 and a_c^2 as the average number of days necessary to produce one pin and one computer in the second island. Similar computation leads to: $\frac{a_c^2}{a_p^2} = 14.5 > 12.8 = \frac{a_c^1}{a_p^1}$. The pattern of trade follows. In the island where teams are larger in efficiency units, fixed learning costs can be spread over larger amounts of output. As a result, this island produces and exports computers, where learning costs are larger.

This simple example illustrates two important ideas: (*i*) differences in institutions and productivity levels lead to differences in the optimal organization of production across countries; and (*ii*) these endogenous differences confer distinct comparative advantages. In particular, the country with larger teams in efficiency units has a comparative advantage in the more complex goods. This is an important observation, but by no means the end of the story. One fundamental question remains: what is the country with larger teams in efficiency units? The previous example only suggests that it might be the country with better institutions or lower productivity levels, because it has more workers per team; or on the contrary, the country with higher productivity levels, because workers have larger endowments in efficiency units. In order to give a satisfactory answer to this question, we need a formal model to which we now turn.

3 Set-up of the model

3.1 Technology

We consider an economy with a continuum of goods $z \in (0, \overline{z})$, and one productive factor, labor. In every sector, a continuum of elementary tasks $s \in S_z$ must be performed to produce one unit of good z. Following Becker and Murphy [1992], "must be performed" is modeled by a Leontief technology:

$$q_z = \min_{s \in S_z} q(s) \tag{1}$$

where q_z is the output of good z, and $q(s)$ the output of each task $s \in S_z$. The measure of S_z captures the "complexity" of the production process in sector z. The more complex a good is, the more elementary tasks are required in its production. For notational convenience, we assume that goods can be indexed so that in each sector, the measure of S_z is equal to z.

The economy is populated by a continuum of workers of mass L, each endowed with h units of labor. The parameter h captures the productivity of a representative worker in this economy. There are increasing returns to scale in the performance of each elementary task. If a worker spends $l(s)$ units of labor performing task s, her associated output $q(s)$ is given by:

$$q(s) = \max\{l(s) - k(s), 0\} \tag{2}$$

We interpret the fixed overhead cost $k(s) > 0$ as the time necessary to learn how to perform task s. In the rest of this paper, we assume that $k(s)$ is identical across tasks, and normalize it to one. Hence, the total learning costs in sector z are equal to $\int_{s \in S_z} k(s)ds = z$. The more complex a good is, the longer it takes to learn how to produce it, and the larger are the gains from the division of labor.[6]

3.2 Institutions

We focus on a single, but crucial, function of institutions: contract enforcement. For each worker i, there exists a contract that stipulates her output, $q^i(s)$, on every elementary task $s \in S_z$. However, workers are free to fulfill or ignore their contractual obligations. Suppose for simplicity that shirking is a binary decision: worker i either performs all tasks or none.[7] She will not shirk on her contract if and only if $c^i \leq \pi^i$, where c^i is her cost of effort and π^i the expected present discounted value of her future punishments. The latter value may depend on worker i's discount factor and moral costs, the ability of her employer to monitor and fire

[6] We have modeled complexity in terms of the number of tasks necessary to produce one unit of output. All tasks are identical, but more complex goods require more tasks. Alternatively, we could assume that all goods require the same number of tasks, but that some tasks take more time to be learnt than others. Then, more complex goods would be the ones associated with more complicated tasks. The two approaches are equivalent. In both cases, total learning costs determine the magnitude of the gains from specialization.

[7] Even if workers have the possibility to shirk only on a subset of tasks, shirkers may always prefer to shirk all the way. In the spirit of Bernheim and Whinston [1990], this would be true for example in a repeated game where enforcement depends on the trigger strategy of the employer. Since the employer always punishes as much as possible, the employee always shirks as much as possible.

her, or the legal sanctions imposed by a well-functioning state law. In this paper, we will not delve further into the origins of the enforcement mechanism.[8] Instead, we simply assume that better institutions — either formal or informal — increase π^i for all $i \in L$, and so increase the probability that a contract is enforced.

Formally, we call $F(.)$ the distribution of $\pi^i - c^i$ over the population of workers, and assume that $\pi^i - c^i$ is not observed by prospective employers. Thus contracts are randomly assigned across workers and independently enforced with probability: $1 - F(0) = e^{-\frac{1}{\theta}}$.[9] The parameter $\theta \geq 0$ measures the quality of institutions, which aims to capture both the efficiency of the judicial system and/or the level of trust in a given country. When $\theta = 0$, institutions are completely inefficient and contracts are never enforced. When $\theta = \infty$, institutions are perfect, and like in the neoclassical benchmark, contracts are always enforced. From a technical point of view, we treat imperfect contract enforcement as an additional technological constraint: θ is an exogenous parameter, not a control variable.[10]

4 The closed economy

4.1 Efficient organization of production

In the previous section, we have described the technological and institutional constraints of our economy. We now analyze how to organize production efficiently subject to these constraints. We first consider the maximization program of a benevolent social planner; and then show that the optimal organization can be decentralized through a competitive equilibrium with atomistic firms.

Let us call L_z the mass of workers in industry z. The objective of the social planner is to maximize total output per worker in each industry, conditional on L_z. The social planner has one control variable per industry: *team size*, which corresponds to the number of workers that cooperate on each unit of good z. Given the team size N, each team member specializes in $\frac{z}{N}$ tasks, in order to minimize learning costs, and allocates her time uniformly across these tasks.[11]

[8] See e.g. Greif [1994] for an explicit model with second-party enforcement, Acemoglu and Verdier [1998] for an explicit model with third-party enforcement, and Dixit [2004] for an analysis of their interaction.

[9] The arbitrary choice of "$e^{-\frac{1}{\theta}}$" rather than "θ" simplifies the analytical expressions of section 4.

[10] The situation where employers can offer higher wages in order to improve contract enforcement is discussed in section 8.

[11] For simplicity, the allocation of tasks within each team is exogenously given. This

Let us call $\widehat{q}_z$ the *potential* output per worker, that is the quantity of good z that they can produce were all contracts to be enforced. The Leontief technology implies that:

$$\widehat{q}_z = \frac{1}{L_z} \min_{s \in S_z} \left[\int_{i \in L_z} q^i(s) di \right] \tag{3}$$

When the team size in industry z is N, each worker has $h - \frac{z}{N}$ units of labor available to perform $\frac{z}{N}$ tasks, and hence $q^i(s) = \frac{h - \frac{z}{N}}{\frac{z}{N}} = \frac{hN}{z} - 1$ for all i and s. Since 1 out of N workers perform a given task s in each team, the potential output per worker is in turn given by:

$$\widehat{q}_z = \frac{h}{z} - \frac{1}{N} \tag{4}$$

As team size increases, workers become more specialized — learning costs per worker decrease — and the number of potential units that each worker is able to produce increases.[12]

However, the Leontief technology also implies that a given team produces if and only if all its members perform. When labor contracts are independently enforced with probability $e^{-\frac{1}{\theta}}$, this means that a team of size N only produces with probability $e^{-\frac{N}{\theta}}$. Since the output per worker is equal to $\widehat{q}_z$ if all contracts are enforced and zero otherwise, the expected output per worker in each team is given by $e^{-\frac{N}{\theta}} \widehat{q}_z$. In turn, the total output per worker in industry z is equal to $e^{-\frac{N}{\theta}} \widehat{q}_z$, by the law of large numbers. Specialization increases the number of contracts that need to be simultaneously enforced, and so reduces the expected output of each team.

Let us now determine the efficient team size, N_z, in industry z. By definition, N_z must solve:

$$\max_N e^{-\frac{N}{\theta}} \left(\frac{h}{z} - \frac{1}{N} \right) \tag{5}$$

The first-order condition is given by:

$$\frac{z}{N_z^2} = \frac{1}{\theta} \left(h - \frac{z}{N_z} \right) \tag{6}$$

assumption is relaxed in a previous version of the paper. When the social planner also controls the allocation of tasks, the analysis is slightly more complicated, but does not provide any further insights with regards to the only variable of interest, team size.

[12] In particular, potential output per worker is maximized when N is infinite and every worker only learns an infinitesimal task. When contracts are perfectly enforced, efficiency requires each skill to be used as intensively as possible. This is in the spirit of Rosen [1983].

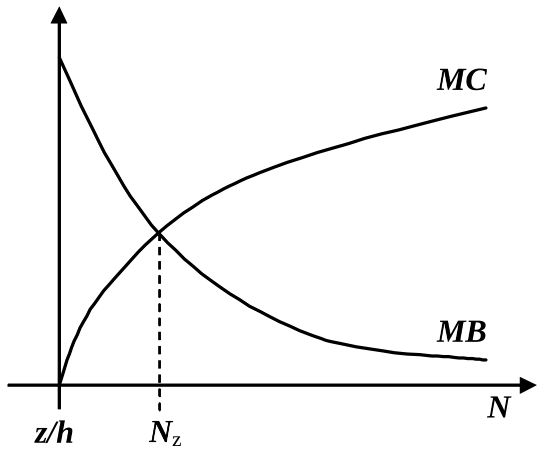

Figure 1: Efficient team size

Graphically, it can be described as in figure 1. $MB = \frac{z}{N^2}$ represents the marginal benefit of increasing team size. It is equal to the extra units of labor that workers are able to spend performing tasks, rather than learning them. $MC = \frac{1}{\theta}\left(h - \frac{z}{N}\right)$ represents the marginal cost of increasing team size. It is equal to the extra units of labor that are lost when labor contracts are not enforced. Because more specialization implies more labor contracts to be enforced, increasing team size decreases the probability that potential units get produced, and hence the expected output per worker. Equation (6) states that when team size is efficient, marginal gains from the division of labor are equal to the transaction costs they create.

Finally, we solve equation (6) explicitly. In our model, N_z is uniquely determined as a function of the good's complexity, the quality of the country's institutions and its workers' productivity:

$$N_z = \frac{z}{2h}\left(1 + \sqrt{1 + \frac{4\theta h}{z}}\right) \tag{7}$$

Equation (7) implies in particular that the size of a typical team in industry z does not depend on the mass of workers in that industry. Thus, there are constant returns to scale at the industry level: the output of an industry doubles when it doubles its employment. This further implies the existence of a perfectly competitive equilibrium with atomistic firms. This equilibrium entails efficient resource allocation, and hence efficient team size.

4.2 Determinants of team size

From equation (7), we obtain that:

Proposition 1 *Team size:*
(*i*) *increases with the quality of institutions;*
(*ii*) *increases with the complexity of industries;*
(*iii*) *decreases with workers' productivity.*

In our model, team size depends on the trade-off between gains from specialization and transaction costs. Graphically, the MB curve captures the marginal gains of increasing team size, and the MC curve its marginal costs. When the quality of institutions improves, transaction costs decrease at the margin — MC shifts down — and team size increases. Similarly, as the complexity of an industry increases, marginal gains from specialization increase — MB shifts up — and transaction costs decrease at the margin — MC shifts down,[13] which both increase team size. Since N_z only depends on z and h through their ratio, an increase in workers' productivity is equivalent to a decrease in the good's complexity. As a result, team size must decrease with the productivity of the labor force.

The trade-off that determines team size in our model is in the spirit of Becker and Murphy [1992], who emphasize "increasing returns from concentrating on a narrower set of tasks" and "coordination costs". Our three exogenous parameters — institutional quality, complexity and productivity — can all be reinterpreted in these terms. Nevertheless, our predictions are distinct from theirs. In particular, proposition 1 predicts that productivity gains decrease specialization by increasing transaction costs at the margin. By contrast, Becker and Murphy [1992] predict that an increase in "knowledge", which is equivalent to an increase in productivity, raises specialization by increasing the marginal gains from the division of labor. This relationship between knowledge and the gains from the division of labor is admittedly *ad hoc*, but "necessary if [their] model is to explain why economic development and the growth in knowledge raise specialization and the division of labor". Does it mean that our model is inconsistent with centuries of joint increase in specialization and productivity? Not necessarily, if one also thinks of economic development as an increase in the complexity of the production process.

[13] More complex goods are associated with larger learning costs. So, when complexity increases, potential output decreases, and the loss of expected output associated with a marginal increase in team size decreases as well.

Suppose that centuries of technological innovations have made goods relatively more complex: $\frac{z}{h}$ has increased. Then, our model also predicts an increase in specialization over time.[14]

From a mathematical point of view, the quality of institutions plays a role similar in our model to that of skill levels in KREMER [1993]. In his "O-Ring Theory", higher skill levels increase the probability that a given task is performed, and so lead to the adoption of more complicated technologies. Here, better institutions increase the probability that a given contract is enforced, and so enhance the Smithian division of labor. Though close formally, our model and KREMER [1993] lead to very different predictions on the distribution of team size across countries. The "O-Ring Theory" predicts that rich countries, with high-skilled workers, should have larger teams. Our model suggests that there is no simple relationship between team size and development: rich countries, with better institutions *and* more productive workers, may have larger or smaller teams.[15]

5 The open economy

We consider a world comprising two countries, North and South. The technology, described by equations (1) and (2), is the same in the two countries. North and South only differ in the quality of their institutions, θ and θ^*, and the productivity of their workers, h and h^*. Asterisks denote variables relating to the South.

5.1 The pattern of comparative advantage

Let us first describe the production possibility frontiers (PPFs) of the two countries in reduced form, as in DORNBUSCH et al. [1977]. We call $a(z)$ the average labor requirement of one unit of good z in the North:

$$a(z) = \frac{hL_z}{\widehat{q}_z e^{-\frac{N_z}{\theta}} L_z} = \frac{zhN_z e^{\frac{N_z}{\theta}}}{(hN_z - z)} \tag{8}$$

[14]Interestingly, our model may also rationalize the reemergence of smaller units of production in the manufacturing sectors that occurred over the last thirty years; see LOVEMAN and SENGENBERGER [1991]. One can think of the introduction of computers as an increase in workers' productivity, which has decreased $\frac{z}{h}$, and in turn the efficient team size. Put (too) simply, the industrial revolution is a z-revolution and the IT revolution an h-revolution, hence their opposite effects on team size.

[15]If we assume, like KREMER [1993], that team size is positively correlated with firm size, then this ambiguity does not seem inconsistent with the data. As KUMAR et al. [2002] note: "the "stylized" fact that richer countries have larger firms seems true only when we examine the obvious difference between the size of firms in really poor countries where there is little industry to speak of, and those in rich developed countries, and when we do not correct for differences in institutions".

where N_z is the efficient team size under autarky in sector z;[16] see equation (7). Similarly, we call $a^*(z)$ the average labor requirement of one unit of good z in the South.

Since efficient production implies constant returns to scale at the industry level, the PPFs of North and South are completely characterized by the constant unit labor requirements — $a(z)$ and $a^*(z)$ — in each industry. The relative unit labor requirement is given by:

$$A(z) = \frac{a^*(z)}{a(z)} = \frac{h^* N_z^* e^{\frac{N_z^*}{\theta^*}} (hN_z - z)}{hN_z e^{\frac{N_z}{\theta}} (h^* N_z^* - z)} \tag{9}$$

In the next lemma, we describe how institutions and workers' productivity endogenously determine the pattern of comparative advantage between the two countries:

Lemma 1 *$A(z)$ is strictly increasing in z if and only if $\theta h > \theta^* h^*$*

Proof. See Appendix. ■

The intuition behind lemma 1 is as follows. When the complexity of a good increases, it affects the unit labor requirement in two ways. First, it directly increases the average labor cost of a potential unit, $AC = \frac{zhN_z}{hN_z - z}$; secondly, it increases team size. However, when team size is efficient, the latter is only a second-order effect. Thus, the increase in $a(z)$ only depends on the increase in AC, and hence on the teams' workforce, measured in efficiency units, hN_z. When hN_z is larger, workers' output on each task is larger. As a result, increasing the magnitude of fixed costs lowers their output relatively less, and in turn, raises AC relatively less. Since the same reasoning applies to $a^*(z)$, the increase in unit labor requirements is relatively smaller in the country where the teams' workforce is larger under autarky. From equation (7), we know that this is the country where the product of institutional quality and workers' productivity is larger.

Because there are increasing returns to scale in the performance of each task, the country where teams are larger under autarky — in efficiency units of labor — has a comparative advantage in the more complex goods. Hence, institutional quality and productivity levels, which both increase hN_z, are independent sources of comparative advantage.

[16] By definition, when the North is on its PPF, team size minimizes the average labor cost — and so maximizes the total output per worker — in each sector, conditional on L_z.

However, it is important to note that they determine the pattern of comparative advantage in two very different ways.

The quality of institutions, θ, only has an indirect effect on the pattern of comparative advantage, through its impact on the efficient team size, N_z. If team size was exogenously given, then differences in institutions across countries would have no effect on the pattern of trade. Formally, the monotonicity of $A(z)$ would be independent of θ; see equation (9). It is the endogenous response of team size that makes institutions a source of comparative advantage.

By contrast, workers' productivity, h, has both a direct and an indirect effect on the pattern of comparative advantage. Besides its impact on N_z, it mechanically increases the teams' workforce in efficiency units. Thus, even if N_z was exogenously given, cross-country differences in productivity levels would still affect the pattern of comparative advantage. When workers are more productive, they spend a smaller fraction of their time learning, and so unit labor requirements are lower; see equation (8). Furthermore, this decrease is not uniform across goods. In the more complex sectors, learning costs are more important and the decrease in unit labor requirements is larger. As a result, the country with more productive workers is relatively more efficient in the more complex industries. Does the endogeneity of team size affect this pattern? The answer is no. When team size is endogenous, higher productivity levels also decrease N_z, but equation (7) guarantees that this indirect effect is always dominated by the direct effect: hN_z increases with h.

At this point, it is worth emphasizing two important results of our analysis. First, it predicts that a higher *absolute* productivity level confers *comparative* advantage in the more complex sectors. Unlike standard Ricardian models, an increase in workers' productivity, h, is not equivalent to an increase in country size, L. Even if they share the same technology and institutions, a country with one billion workers and a country with one hundred million workers, each of them ten times more productive, are economically distinct trading partners, with distinct comparative advantage. Secondly, it predicts that institutional quality and productivity levels have *complementary* effects on the pattern of comparative advantage. Since θ and h affect $A(z)$ through their product, institutional improvements have larger effects in countries with more productive workers. Similarly, productivity gains have larger effects in countries with better institutions.

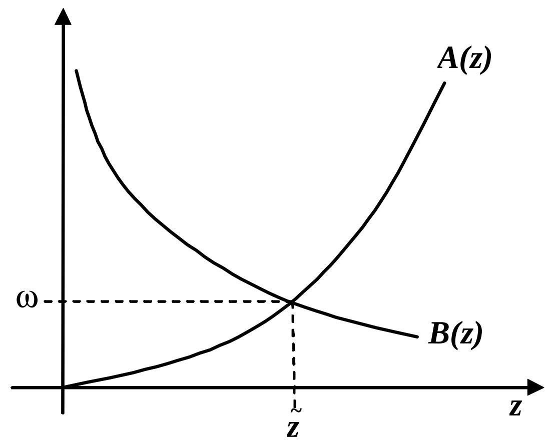

Figure 2: The pattern of trade

5.2 The impact of trade

In the rest of this paper, we assume without loss of generality that the North has a comparative advantage in the more complex industries:

$$\theta h > \theta^* h^* \tag{10}$$

Let us call $\omega = \frac{w}{w^*}$ the ratio of the Northern wage to the Southern wage, both expressed in units of labor. Since $A(.)$ is strictly increasing in z, there exists a cut-off good $\widetilde{z}$ such that $\omega = A(\widetilde{z})$. By construction, all goods $z \geq \widetilde{z}$ are efficiently produced in the North, and all goods $z \leq \widetilde{z}$ in the South.

In order to complete our analysis, we need to describe the demand side. Following DORNBUSCH et al. [1977], we assume that both countries have identical Cobb-Douglas preferences. Thus, each good receives a constant share of expenditure. The share of income spent on Southern goods, $S(\widetilde{z})$, increases with the number of goods it produces, and so increases with $\widetilde{z}$. The trade balance equilibrium is given by: $\omega = \frac{h^* L^* [1 - S(\widetilde{z})]}{hLS(\widetilde{z})} = B(\widetilde{z})$. This condition and efficient international specialization jointly determine the relative wage and the pattern of trade; see figure 2. An increase in the range of goods produced in the South raises Southern exports and lowers its imports. Hence, trade balance equilibrium requires the ratio of the Northern wage to the Southern wage to go down. On the supply-side, efficient specialization requires the reverse.

We summarize our findings in the following proposition:

Proposition 2 *North produces and exports the more complex goods; South produces and exports the less complex ones.*

The welfare impact of trade is straightforward. Let us call p_z the price of good z.[17] While the real wage $\frac{w}{p_z}$ does not change for goods still produced in the North in the trade equilibrium, it goes up for goods produced in the South (otherwise, they would still be produced in the North). The same reasoning applies to the real wage $\frac{w^*}{p_z}$ in the South. Thus, both countries gain from trade.

The pattern of specialization between developed and developing countries also is clear. Countries with worse institutions *and* less productive workers specialize in the less complex goods. Hence, our analysis may shed a new light on the higher share of employment in primary sectors in developing countries. As Kremer [1993] notes: "it is not surprising that [developing countries] have a larger share of food in consumption, but given the possibility of trade, it is not clear why they have a larger share of agriculture in production".[18] Still, countries among the richest 5% in the world have 5% of their population working in the agricultural sector, against 90% in the poorest 5%; see Restuccia et al. [2003].

If productivity levels are the same in the two countries, then proposition 2 predicts that the country with better institutions specializes in the "institutionally dependent" industries. This is in the spirit of the previous literature on international trade and institutions. One novel aspect of this model, however, is that it endogenously identifies the "institutionally dependent" industries. These are the more complex ones because larger gains from the division of labor imply more workers per team in equilibrium, and so more contracts to be enforced.

By combining propositions 1 and 2, we can also analyze the impact of trade on team size. The prediction is again unambiguous: international trade decreases average team size in developing countries, while increasing it in developed countries. In our model, trade does not change *how* goods are produced in each country. Technological and institutional constraints fully characterize the efficient team size; see equation (7). But, by changing *which* goods are produced, trade affects the overall distribution of team size in the two countries. When the two countries open

[17] Constant returns to scale at the industry level imply that: $p_z = wa(z)$ if good z is produced in the North, and $w^*a^*(z)$ if it is produced in the South.

[18] The alternative explanation given by Kremer [1993] is based on sequential production. In his model, less-skilled workers should perform the first tasks, when mistakes are less costly.

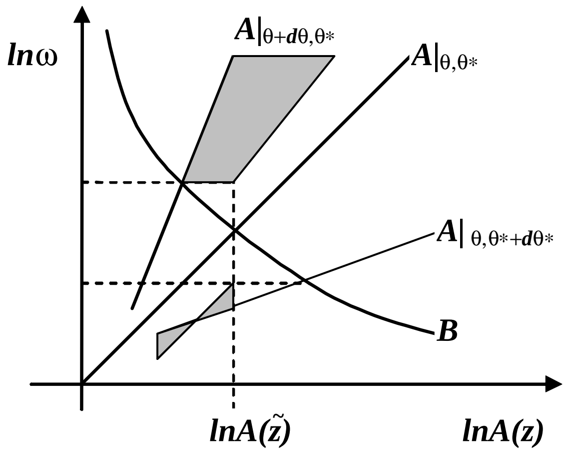

Figure 3: Institutional improvements at home and abroad

up to trade, North specializes in industries where teams are relatively larger and South in those where they are relatively smaller. As a result, average team size increases in the North and decreases in the South.

6 Comparative statics

For a given pattern of comparative advantage, as captured by $A(z)$, our model is formally equivalent to DORNBUSCH et al. [1977]. This implies that changes in relative country size, demand shifts, and unilateral transfers, which all leave $A(z)$ unchanged, have the same effects in our model as in theirs. In this section, we perform two new exercises in comparative statics. We ask: (i) what is the impact of institutional improvement in the two countries? and (ii) what is the impact of productivity gains?

6.1 Institutional improvement

We follow the graphical analysis used by KRUGMAN [1986] to discuss technological change. In figure 3, we plot the efficient specialization condition, $\omega = A(z)$, and the trade balance equilibrium, $\omega = B(z)$, with $\ln \omega$ on the vertical axis and $\ln A(z)$ on the horizontal axis. The efficient specialization condition now is represented by the 45 degree line.

Let us first consider an increase in the quality of institutions in the North. Since institutions only affect unit labor requirements, the trade balance — B schedule — is unchanged. However, the A schedule shifts up, with the gains in $\ln A(z)$ being larger in the more complex industries. The formal argument relies on the envelope theorem. Since the efficient team size minimizes unit labor requirements, we have:

$$\frac{d\ln A(z)}{d\theta} = \frac{\partial \ln A(z)}{\partial \theta} = \frac{N_z}{\theta^2} \tag{11}$$

which is strictly increasing in z by proposition 1. The new schedule $A_{\theta+d\theta,\theta^*}$ is represented in figure 3. Institutional improvement is biased towards "institutionally dependent" sectors, just as technological progress is biased towards "technologically intense sectors" in Krugman [1986]. Hence, the same welfare analysis applies. In the North, welfare increases as the real wage $\frac{w}{p_z}$ goes up for all goods. Northern goods become cheaper because unit labor requirements decrease; and southern goods become cheaper because the relative wage ω increases. In the South, the situation is *a priori* more subtle. As ω increases, South's share of world income decreases. However, the real wage in the South, $\frac{w^*}{p_z}$, cannot go down. It is unchanged for goods whose production remains in the South; and it increases for goods whose production goes from the South to the North (otherwise they would still be produced in the South). The key to the analysis is that $\frac{w^*}{p_z}$ also goes up for goods whose production remains in the North. Indeed, the net effect of an increase in θ is an improvement of the South's terms of trade. Because institutional improvement is biased towards the more complex sectors, the percent increase in ω, which is lower than the percent decrease in unit labor requirements for the cut-off good $\widetilde{z}$, is also lower for all goods more complex than $\widetilde{z}$; see figure 3.

The welfare analysis of an improvement of institutions in the South is similar. The schedule, $A_{\theta,\theta^*+d\theta^*}$, associated with a marginal improvement in the quality of Southern institutions is represented in figure 3. Again, institutional improvement is biased towards the more complex sectors.[19] Clearly, the South now gains. What happens to the North? The real wage $\frac{w}{p_z}$ cannot decrease for goods initially produced in the North. It is unchanged if the production remains in the North; and it increases if the production switches to the South because of lower labor costs in this country. However, $\frac{w}{p_z}$ may decrease for goods which are initially produced in the South. While the percent decrease in ω is lower than the percent decrease in unit labor requirements for industries close to $\widetilde{z}$, it is higher for the less complex ones; see figure 3. As a result, welfare in the North may decrease.

We summarize our results in the following proposition:

[19] Formally, the envelope theorem implies: $\frac{d\ln A(z)}{d\theta^*} = \frac{\partial \ln A(z)}{\partial \theta^*} = -\frac{N_z^*}{\theta^{*2}}$.

Proposition 3 (i) *Institutional improvement in the North increases welfare in both countries.*

(ii) *Institutional improvement in the South increases welfare in this country, but may decrease welfare in the North.*

Our welfare analysis of institutional change echoes Krugman's analysis of technological change. When the institutional gap between the two countries increases, welfare goes up in both countries. But when this gap narrows, the country with better institutions might be hurt. However, our model is more than a reinterpretation of KRUGMAN [1986] in institutional terms. Unlike "technologically intense" sectors in KRUGMAN [1986], "institutionally dependent" sectors are endogenous in our model. Differences in the gains from the division of labor imply differences in team size, and in turn differences in the dependence on contract enforcement across sectors.

6.2 Productivity gains

Unlike DORNBUSCH et al. [1977], across the board productivity gains in one country are not equivalent to a change in $\frac{L^*}{L}$. In our model, workers' productivity, like institutions, affect team size, and so unit labor requirements.

An increase in the workers' productivity in one country has two distinct effects. Like an increase in the quality of its institutions, it leads to an increase of its comparative advantage, which is biased towards the more complex industries. But, unlike institutional improvement, productivity gains affect the trade balance. Increasing the productivity of one country creates an excess of its labor supply, which tends to decrease its relative wage. The welfare impact of productivity gains in the two countries are described in proposition 4:

Proposition 4 (i) *Productivity gains in the North increase welfare in both countries.*

(ii) *If the terms of trade effect is large enough, productivity gains in the South increase welfare in both countries. Otherwise, they increase welfare in the South, but may decrease welfare in the North.*

Proof. See Appendix. ■

When productivity gains occur in the North, the terms of trade effect does not affect our qualitative results: both countries still win. In the South, any decrease in ω further increases the real wage $\frac{w^*}{p_z}$; in the North, any decrease in ω is always smaller than the increase in h, and the real wage per worker $\frac{wh}{p_z}$ increases as well. When productivity gains occur in the South, the terms of trade effect may affect our qualitative results. Indeed, if the relative wage ω increases, North unambiguously wins.

7 Family versus anonymous firms

Up to this point, we have focused on one organizational variable: the size of productive teams. In practice, there are many others. For example, all team members may or may not be monitored within a single factory; and all team members may or may not belong to the same family. In this section, we consider the latter situation and add the possibility for productive teams to organize themselves either as "family" or as "anonymous" firms.

The prevalence of family firms seems to vary greatly from one country to another. FUKUYAMA [1995] expresses the view that these cross-country differences reflect differences in levels of trust: "It would appear no accident that three high-trust societies, Japan, Germany, and the United States, pioneered the development of large scale professionally managed enterprises. Low-trust societies like France, Italy, and noncommunist Chinese states including Taiwan and Hong Kong, by contrast, were relatively late in moving beyond large family businesses to modern corporations." In this section, we formally investigate this idea, and show how the trade-off that determines team size — gains from the division of labor versus transaction costs — may also shed light on the choice between family and anonymous firms across countries and industries.

We now assume that the population is partitioned in families of size N_f. We say that a productive team is a family firm if all team members belong to the same family. Otherwise, we say that it is an anonymous firm. Working in a family firm increases the punishment faced by every worker if she decides to shirk: $\pi_f^i > \pi^i$. The moral costs of cheating on a family member may be higher, or family members may have additional punishment tools available outside of the market place. In any case, since the distribution of the π_f^is first-order stochastically dominates the distribution of the π^is, the probability that any given contract is enforced must be higher within the family firm: $e^{-\frac{1}{\theta_f}} > e^{-\frac{1}{\theta}}$. The rest of the model is unchanged.

First, we reconsider the case of a closed economy. In which sectors should we observe family and anonymous firms respectively? In our model, the efficient organization of production depends on the trade-off between gains from the division of labor and transaction costs. This was true when we discussed team size in section 4 and it remains true here. For family firms, gains from specialization are limited by the size of the family,[20] but transaction costs are relatively low. For anonymous firms, gains from specialization are *a priori* unlimited, but transaction costs are relatively high. Therefore, one should expect to observe family firms in industries where gains from the division of labor are small, and anonymous firms in those where they are large. This is the intuition behind proposition 5:

Proposition 5 *Firms are family-run in the less complex industries, and anonymous in the more complex industries.*

Proof. See Appendix. ■

As Ben-Porath [1980] put it: "The transactional advantage of the family cannot compensate for the fact that within its confines the returns from impersonal specialization and division of labor are not fully realizable". In our model, the total learning costs, z, captures the extent of these returns in each industry. When they are small, e.g. in the agricultural sector, firms are family-run; but, when gains from the division of labor become large enough, family firms are no longer observed.

Next, we consider the impact of the quality of institutions and workers' productivity on the proportion of family firms. Our findings are presented in proposition 6:

Proposition 6 *The proportion of family firms:*
(*i*) *decreases with the quality of institutions;*
(*ii*) *increases with workers' productivity.*

Proof. See Appendix. ■

The proof of our first claim is trivial. When θ increases, the output of anonymous firms increases in every industry. But, the output of family firms remains unchanged. This mechanically decreases the number of industries in which family firms are efficient. Thus, an immediate prediction of our model is that *ceteris paribus*, trust should increase the prevalence of anonymous firms in a given country; this rationalizes the verbal arguments of Fukuyama [1995]. The intuition behind the second claim is the same as for proposition 1. As far as the maximization of total output per worker is concerned, z and h only matter through

[20] A family firm may decide to hire a stranger, but if it does, we assume that it becomes an anonymous firm. In other words, whenever team size goes beyond the family size, the quality of contract enforcement goes down from θ_f to θ. This is in the spirit of Dixit [2004], chapter 3; extending exchanges beyond a critical (social) distance decreases the quality of relation-based governance.

their ratio; see equation (5). Thus, an increase in workers' productivity must have the same effect on the choice between family and anonymous firms as a decrease in complexity. From proposition 5, we know that this extends the range of industries in which family firms are present.

Finally, we can use our model to discuss the impact of international trade on the prevalence of family firms. Suppose again that the world economy is made of two countries, North and South. We restrict ourselves to the case where the organization of family firms is identical across countries. Namely, we assume that the size of the families, N_f, the quality of contract enforcement, θ_f, and the productivity of the workers, h, are the same in the two countries. North and South only differ in the quality of their institutions with $\theta > \theta^*$. Our findings are presented in proposition 7:

Proposition 7 *When the two countries open up to trade, the proportion of family firms decreases in the country with better institutions and increases in the country with worse institutions.*

Proof. See Appendix. ■

The addition of family firms does not affect the pattern of comparative advantage; the country with better institutions still has a comparative advantage in the more complex industries. As a result, the pattern of international specialization remains the same as in section 5. North produces and exports the more complex goods; South produces and exports the less complex ones. Since family firms are present in the less complex industries under autarky, this destroys family firms in the North and anonymous firms in the South. Proposition 7 follows.

8 Concluding remarks

This paper analyzes the impact of imperfect contract enforcement on the division of labor and the pattern of trade. When contracts are not perfectly enforced, the trade-off between gains from the division of labor and transaction costs pins down team size across sectors in each country. Under autarky, the model predicts that team size increases with the quality of institutions and the complexity of the goods, but decreases with the productivity of the labor force.

When the two countries open up to trade, the country where teams are larger under autarky — in efficiency units of labor — specializes in the more complex goods. In our model, it is the country where the product of institutional quality and workers' productivity is larger. Like better institutions, a higher absolute productivity level confers comparative advantage in the more complex sectors. Institutions and productivity levels are complementary sources of comparative advantage.

The model unambiguously predicts that developed countries specialize in the more complex sectors, and developing countries in the less complex sectors. In turn, international trade decreases team size and the proportion of anonymous firms in developing countries, while increasing them in developed countries. The model also predicts that when institutional improvement and productivity gains occur in developed countries, all countries gain; but that when they occur in developing countries, developed countries might be hurt.

In our model, the probability that a worker performs is exogenous. It is interpreted throughout the paper as a measure of institutional quality. This is a natural interpretation, but by no means the only one. Health quality is a possible alternative. Indeed, a high probability that a worker performs may simply reflect a high proportion of people in good shape. We think of such alternatives as a richness of the model. Our theory of international trade applies whenever countries differ in the probability that a worker performs, whatever the origins of these differences are. One could imagine further variations of our analytical framework based on labor market regulations and credit market imperfections.

Though useful, the assumption that the quality of contract enforcement is exogenous is a strong one. In practice, employers may well take the quality of their judicial system as given, but still try to improve the trustworthiness of their workers by offering efficiency wages. Intrinsically dishonest workers would still shirk, but the probability that a given contract gets enforced would certainly increase. Endogenizing the quality of contract enforcement has a very appealing feature in a closed economy. In equilibrium, it implies that enforcement, and hence wages, differ across sectors. In the more complex industries where teams are larger, contract enforcement is more important, and so wages must be larger. This simple idea provides an appealing theoretical foundation for the employer size-wage effect; see Brown and Medoff [1989]. Its implications on the pattern of international specialization in an open economy are left for future research.

Another interesting extension of our model concerns offshoring. In section 5, we implicitly assume that all teams are national teams; within each team, all workers are from the same country. But if teams can hire workers of different countries, they may gain by assigning complicated jobs — with large fixed costs — to workers of the developed country and simple jobs — with small fixed costs — to workers of the developing country. If it is the case, in which industries should we observe offshoring? Are the welfare effects of offshoring any different from those of trade? Do institutional improvement and productivity gains in the developing country enhance offshoring? These questions are also left for future research.

The introduction of nontraded goods, transport costs and tariffs are other possible extensions of our analysis. Since our model simplifies into Dornbusch et al. [1977] for a given pattern of comparative advantage, they are all straightforward. Their main contribution with regards to Dornbusch et al. [1977] would be to identify the goods which are not traded. In our model, developing countries would export the least complex goods, developed countries would export the most complex goods and goods in an intermediate range would not be traded.

Finally, we have developed a model of "family-run" firms, where all workers are from the same family. It would be interesting to extend our model in order to discuss "family-owned" firms, see e.g. Burkart et al. [2003], which has been the main focus of the empirical literature. One possibility would be to modify our technology so that the division of labor matters at the managerial level; the smaller the set of tasks assigned to a manager is, the more efficient she would be, and so the more productive would be the workers below her. Within such a framework, we conjecture that the trade-off which determines the choice between family and anonymous firms — and hence our results — would remain the same.

9 Appendix

9.1 Proof of lemma 1

Lemma 1 *$A(z)$ is strictly increasing in z if and only if $\theta h > \theta^* h^*$*
Proof. Let us write the derivative of $A(z)$ with respect to z as:

$$A'(z) = \frac{\frac{da^*}{dz}a - a^*\frac{da}{dz}}{a^2} \tag{12}$$

Since N_z and N_z^* minimize $a(z)$ and $a^*(z)$ respectively, we can use the envelope theorem and write:

$$A'(z) = \frac{\frac{\partial a^*}{\partial z}a - a^*\frac{\partial a}{\partial z}}{a^2} \tag{13}$$

Then, simple algebra leads to:

$$A'(z) = \lambda(hN_z - h^*N_z^*) \tag{14}$$

with $\lambda = \frac{h^*N_z^* e^{\frac{N_z^*}{\theta^*} - \frac{N_z}{\theta}}}{hN_z(h^*N_z^* - z)^2} > 0$. Our claim directly follows from (7). ■

9.2 Proof of proposition 4

Proposition 4 (i) *Productivity gains in the North increases welfare in both countries.*

(ii) *If the terms of trade effect is large enough, productivity gains in the South increase welfare in both countries. Otherwise, they increase welfare in the South, but may decrease welfare in the North.*
Proof. Let us start with claim (i). Suppose that productivity increases in the North. The envelope theorem implies:

$$\frac{d\ln A(z)}{dh} = \frac{\partial \ln A(z)}{\partial h} = \frac{1}{h\left[\frac{hN_z}{z} - 1\right]} \tag{15}$$

which by (7), is positive and strictly increasing in z. In figure 3, A shifts up, with the gains in $\ln A(z)$ being larger in the more complex industries. with a bias towards the most complex industries. In the meantime, B shifts down since $\omega = \frac{h^*L^*[1-S(\tilde{z})]}{hLS(\tilde{z})}$ is decreasing in h. How do these two effects affect welfare in the North and in the South? We start by showing that North always gains. Since productivity has changed in the North, we need to consider the changes in the real income $\frac{wh}{p_z}$ for all goods, instead of the real wage $\frac{w}{p_z}$.[21] It clearly goes up for Northern goods,

[21] Of course, these two measures of welfare are equivalent when, like in the previous section, h is constant.

either initially produced in the North or in the South. Since unit labor requirements go down, $\frac{w}{p_z}$ increases, and *a fortiori* $\frac{wh}{p_z}$. The situation is more subtle for goods whose production remains in the South. Since unit labor requirements are unchanged, $\frac{wh}{p_z}$ increases if and only if the labor endowment of Northern workers in units of Southern labor, ωh, increases. Since an increase in h lowers unit labor requirements and increases labor endowments in the North, it increases the share of Northern goods, which increases in turn $\omega h = \frac{h^* L^* [1 - S(\widetilde{z})]}{LS(\widetilde{z})}$. Hence, North unambiguously gains. Let us now consider South. Since Southern productivity is unchanged, we can still focus on $\frac{w^*}{p_z}$. We know from the analysis of institutional improvements that without the terms of trade effect, productivity gains in the North increases welfare in the South. But, the terms of trade effect makes goods produced in the North even cheaper in terms of Southern labor. So, welfare increases in South as well.

Let us turn to claim (ii). Suppose that h^* increases. Once again, the envelope theorem implies:

$$\frac{d \ln A(z)}{dh^*} = \frac{\partial \ln A(z)}{\partial h^*} = -\frac{1}{h^* \left[\frac{h^* N_z^*}{z} - 1\right]}$$

which by (7), is negative and strictly decreasing in z. We can analyze the welfare impact in the South like we have analyzed the welfare impact of an increase of h in the North. The same formal argument implies that $\frac{w^* h^*}{p_z}$ increase for all goods. Similarly, we can still focus on $\frac{w}{p_z}$ in the North. From the analysis of institutional improvements, we know that without the terms of trade effect, productivity gains in the South decrease $\frac{w}{p_z}$ in the least complex industries. However, if the terms of trade effect is so large that ω increases, this can no longer be true. In this situation, the decrease in unit labor requirements abroad implies that North unambiguously wins as well. ∎

9.3 Proof of proposition 5

Proposition 5 *Firms are family-run in the less complex industries, and anonymous in the more complex industries.*

Proof. For each industry, we need to compare the maximum expected output per worker when firms are family-run, Q_f, and when they are anonymous, Q_a. In order to express Q_f and Q_a, we introduce a few notations. We call $Q_z(N, \widetilde{\theta}) = e^{-\frac{N}{\theta}} \left(h - \frac{z}{N}\right)$ the expected output per worker, when team size is N and the quality of contract enforcement is $\widetilde{\theta} \in \{\theta_f, \theta\}$. Similarly, we call $N_z(\widetilde{\theta})$ the associated efficient team size. By definition, $Q_a = Q_z(N_z(\theta), \theta)$ and $Q_f = \max_{N \le N_f} Q_z(N, \theta_f)$.

First, we consider the less complex industries z such that $N_z(\theta) < N_f$. Since $\theta_f > \theta$, we have:

$$Q_a < Q_z(N_z(\theta), \theta_f) \leq Q_f$$

As a result, efficiency requires family firms in those sectors.

Let us now consider the more complex industries z such that $N_z(\theta) \geq N_f$. From section 3, we know that $Q_z(N, \theta_f)$ is strictly increasing in N for all $N \leq N_z(\theta_f)$. Since $N_z(\theta_f) > N_z(\theta) \geq N_f$, the maximum expected output per worker of a family firm $Q_f = Q_z(N_f, \theta_f)$. Now, let us show that $\exists! z_f$ such that $Q_f > Q_a$ for all $z < z_f$ and $Q_f < Q_a$ for all $z > z_f$. We proceed in two steps. First, we remark that for $N_z(\theta) = N_f$, we have:

$$Q_f = Q_z(N_f, \theta_f) > Q_z(N_z(\theta), \theta) = Q_a \tag{16}$$

Secondly, we compute the derivatives of Q_f and Q_a with respect to z:

$$\begin{cases} \frac{dQ_f}{dz} = -\frac{1}{N_f} e^{-\frac{N_f}{\theta_f}} \\ \frac{dQ_a}{dz} = -\frac{1}{N_z(\theta)} e^{-\frac{N_z(\theta)}{\theta}} \end{cases}$$

where the last equality comes from the envelope theorem. Since $N_z(\theta) \geq N_f$ and $\theta_f > \theta$, the slope of Q_f is steeper:

$$\left| \frac{dQ_f}{dz} \right| > \left| \frac{dQ_a}{dz} \right| \tag{17}$$

The two inequalities (16) and (17) imply the existence and uniqueness of z_f. ■

9.4 Proof of proposition 6

Proposition 6 *The proportion of family firms:*
(i) decreases with the quality of institutions;
(ii) increases with workers' productivity.

Proof. In the proof of proposition 5, we have shown that there exists a unique z_f such that:

$$e^{-\frac{N_f}{\theta_f}} (h - \frac{z_f}{N_f}) = e^{-\frac{N_{z_f}(\theta)}{\theta}} (h - \frac{z_f}{N_{z_f}(\theta)}) \tag{18}$$

Let us first differentiate this expression with respect to θ and z_f:

$$-\frac{1}{N_f} e^{-\frac{N_f}{\theta_f}} dz_f = -\frac{1}{N_{z_f}(\theta)} e^{-\frac{N_{z_f}(\theta)}{\theta}} dz_f + \frac{1}{\theta^2} e^{-\frac{N_{z_f}(\theta)}{\theta}} (hN_{z_f}(\theta) - z_f) d\theta \tag{19}$$

where the RHS comes from the envelope theorem. After rearrangements, we obtain:

$$\frac{dz_f}{d\theta} = -\frac{1}{\theta^2}\frac{e^{-\frac{N_{z_f}(\theta)}{\theta}}(hN_{z_f}(\theta) - z_f)}{\left(\frac{1}{N_f}e^{-\frac{N_f}{\theta_f}} - \frac{1}{N_{z_f}(\theta)}e^{-\frac{N_{z_f}(\theta)}{\theta}}\right)} < 0 \tag{20}$$

since $N_{z_f} > N_f$ and $\theta_f > \theta$. Claim (i) follows.

Let us now rewrite equation (18) as:

$$e^{-\frac{N_f}{\theta_f}}(1 - \frac{z_f}{hN_f}) = e^{-\frac{N_{z_f}(\theta)}{\theta}}(1 - \frac{z_f}{hN_{z_f}(\theta)}) \tag{21}$$

The envelope theorem implies:

$$\left(\frac{1}{N_f}e^{-\frac{N_f}{\theta_f}} - \frac{1}{N_{z_f}(\theta)}e^{-\frac{N_{z_f}(\theta)}{\theta}}\right) \times d\left(\frac{z_f}{h}\right) = 0 \tag{22}$$

and thus $d\left(\frac{z_f}{h}\right) = 0$. Claim (ii) follows. ■

9.5 Proof of proposition 7

Proposition 7 *When the two countries open up to trade, the proportion of family firms decreases in the country with better institutions and increases in the country with worse institutions.*

Proof. Let us call z_f and z_f^* the cut-off industries in the North and in the South, respectively. From proposition 6, we know that $z_f < z_f^*$. First, we show that the relative unit labor requirement, $A(z)$, is increasing in z. We need to distinguish three different cases. If $z \geq z_f^*$, then firms are anonymous in both countries; $A(z) = \frac{h^* N_z^* e^{\frac{N_z^*}{\theta^*}}(hN_z - z)}{hN_z e^{\frac{N_z}{\theta}}(h^* N_z^* - z)}$, which is increasing in z by lemma 1. If $z \leq z_f$, then firms are family-run in both countries; and by assumption, $A(z) = 1$. Finally, if $z_f < z < z_f^*$, firms are anonymous in the North and family-run in the South. In this case, all family firms must have size N_f in the South since:

$$N_z^*(\theta_f) = N_z(\theta_f) > N_z > N_f \tag{23}$$

where the last inequality comes from the fact that $z > z_f$. As a consequence, $A(z) = \frac{h^* N_f e^{\frac{N_f}{\theta_f}}(hN_z - z)}{hN_z e^{\frac{N_z}{\theta}}(h^* N_f - z)}$, which implies

$$A'(z) = \lambda(N_z - N_f) \tag{24}$$

with $\lambda = \frac{hN_f e^{\frac{N_f}{\theta_f} - \frac{N_z}{\theta}}}{N_z(h^* N_z^* - z)^2} > 0$. (23) and (24) guarantee that $A(z)$ is also increasing in z over this last interval.

The rest of the analysis is similar to the one of section 5. Since $A(z)$ is increasing in z, efficient international specialization implies that: North produces and exports the more complex goods; and South produces and exports the less complex ones. But from proposition 5, we know that family firms are only present in the less complex industries. Our claim follows. ■

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