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“Technological Improvements and Comparative Advantage Reconsidered”

by

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Technological Improvements and Comparative Advantage Reconsidered

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Abstract

Given a world consisting of two countries, two commodities, and two consumers, this paper analyzes the potential effects of the current global trend of shifting world productions with regards to consumer goods. When technological improvements occur in a developing country, would terms of trade remain favorable for a developed country? Would both countries benefit? Instances where one or both countries benefit are feasible. However the developed country may lose as a result of an improvement in the production of the good that previously had been exported by the developed country.

JEL Classifications: F0, F1, O, O1, O3, D51

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Technological Improvements and Comparative Advantage Reconsidered

I. Introduction

World production is dramatically changing, shifting from the United States to China. This phenomenon occurs over the spectrum of all goods and services and includes not only furniture, textile, kitchenware, car tires, and the like but also precision machine tools, networking gears, electronic circuit boards, heavy electric appliances, petrochemicals, and microchips. The present paper analyses the potential effects of this global trend utilizing a simple model with two countries, two goods, and two representative agents.

The foundations for free trade theory were established by giants such as Smith (1776), Ricardo (1817), and Mill (1844). For a defense of free trade, see for example, Friedman (2000), Douglas (2003), Bhagwati (2004), and Wolf (2004). For a balanced approach see Sen (2000), and Stiglitz (2003). Johnson and Stafford (1993), Gomory and Baumol. (2000) and Samuelson (1972, 2004) provide examples where free trade leads to one party losing from trade. The current paper revisits the issue by applying a simple model of income in kinds.

This paper investigates the effects of various increases in endowments or technological improvements by one country on its own welfare and the welfare of its trading partners. The paper derives the equilibrium bundles of consumption and explores what happens, for instance, to U.S. citizens if Chinese technology continues to advance in various directions. It is shown that if China acquires more endowments that favor the production of the good in which it has had a comparative advantage (or if China improved its technology in a good in which it has had a comparative advantage), the people of the U.S. and China would benefit from this improvement but the terms of trade would change in favor of the United States. The utility of people in both countries also rises.¹

However, the interesting case is technological improvement, or the positive endowment shock, occurring in an industry in which the U.S. previously dominated the U.S.-Chinese trade market. If the U.S. continues to export that good, even after the technological improvement in China, it will lose out as the Chinese terms of trade have changed favorably. Furthermore, technological improvement in China's productivity permits China to export goods that it initially imported, thereby significantly increasing its benefit while the benefits to the U.S. are smaller as compared with the pre-technological improvement in China. It may still be beneficial for the United States to trade with China in comparison with the autarkic, no-trade equilibrium.

Furthermore, when transportation costs are included, such positive endowment shocks, or technological improvements in China's productivity, may cause trade to cease, thus causing substantial losses to the U.S. In this scenario, where transportation costs are high and may lead to autarky, calls for interventionist government policies by the developed country occur (e.g. externality models). These policies are able to justify the imposition of interventionist measures including tariffs, quotas, and export subsidies which subsequently hurt the developing country. The ultimate outcome is a loss-loss situation as both developing and developed countries would be hurt.

This paper offers an analysis of the various potential terms of trade which the United States and other developed countries may face in the future. At the present time, many developing nations are rapidly becoming major players in the international market; they are negotiating better terms of trade, which are unfavorable to developed countries. The model presented considers the implications of the policies adopted by the developed countries in response to these technological advancements. With border security and proposals for a guest-worker program gaining prominence in Congress' agenda, it is vital that the U.S. and other

developed countries such as Germany and Japan—in their effort to cope with undocumented workers—do not overlook legal immigration.² The model presented supports the argument forcefully proposed by Becker (2005) who asks U.S. policy makers the question: Since the U.S. still has a major advantage in attracting skilled workers (as it is the preferred destination of the vast majority), why not take advantage of potential Indian and Chinese immigrants' preferences to come to the U.S. rather than force them to look elsewhere? The analysis may be helpful in understanding the effects of industrialization on international trade in many economics courses.³

The remainder of the paper is organized as follows: Section II presents the model and derives the conditions for circumstances where the two countries benefit and conditions when only the country who acquired the improved technology gains while the other country losses. Section III offers further discussions and concludes the paper.

II. The Model

Assume two representative individuals who reside in two countries with identically ordinal utility functions over two goods, X and Y, of the Cobb-Douglas type:

$$U_i = AX_i^a Y_i^b$$

Since utility functions are ordinal, without loss of generality, assume that A, a, and β are equal to one. Thus, the utility function can be written in a more simplified way:

$$U_i = X_i Y_i, \quad i = 1, 2$$

Assume that the two residents of the two countries differ in their income levels, including in-kinds income, i.e., $\bar{X}_1 \neq \bar{X}_2$ and $\bar{Y}_1 \neq \bar{Y}_2$. Since the initial levels of feasible bundles are different while their preferences are identical, both parties can benefit from trade. Assuming both have the same negotiation powers, the competitive equilibrium will be reached at the

relative competitive price $(P_X/P_Y)^*$, which is the terms of trade between the internal price ratios of the two countries.

The first aim of the analysis below is to find the bundles of final consumptions of the two representative individuals and their utility levels after trade. Each individual in each country is maximizing his utility subject to the in-kinds income constraint that he is facing.

$$(1) \quad \text{Max } U_i = X_i Y_i,$$

Subject to,

$$(2) \quad P_X X_i + P_Y Y_i = P_X \bar{X}_i + P_Y \bar{Y}_i$$

The First Order Condition (F.O.C.) leads to:

$$(3) \quad MU_X/MU_Y = Y_i / X_i = P_X / P_Y.$$

Or, alternatively,

$$(3') \quad P_X X_i = P_Y Y_i$$

Substituting back into the budget constraint yield:

$$(4) \quad X_i = \bar{X}_i/2 + (P_Y/2P_X) \bar{Y}_i$$

The excess demand curve is defined as:

$$(5) \quad X_i - \bar{X}_i = [P_Y/2P_X] \bar{Y}_i - \bar{X}_i/2.$$

Clearing the competitive market conditions imply:

$$(6) \quad X_1 - \bar{X}_1 = \bar{X}_2 - X_2. \text{ Assuming } X_1 > \bar{X}_1 \text{ and } \bar{X}_2 > X_2.$$

Equations (5) and (6) lead to the derivation of the perfectly competitive equilibrium price ratio, P_Y/P_X as follows:

$$(7) \quad (P_Y/P_X)^* = (\bar{X}_1 + \bar{X}_2) / (\bar{Y}_1 + \bar{Y}_2)$$

Equations (7), (4), (3') and (1) allow for the derivation of the utility level of an individual at equilibrium:

$$(8) \quad U_1 = \{[(\bar{X}_1^2/4) + \bar{X}_1 \bar{Y}_1(\bar{X}_1 + \bar{X}_2)/2(\bar{Y}_1 + \bar{Y}_1) + \\ + [(\bar{X}_1 + \bar{X}_2)/(\bar{Y}_1 + \bar{Y}_2)]^2[(\bar{Y}_1)^2/4]\}[(\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)]$$

Define the optimal price ratio, $(P_Y/P_X)^* = (\bar{X}_1 + \bar{X}_2)/(\bar{Y}_1 + \bar{Y}_2) = e$, the last equation can be written as:

$$(8') \quad U_1 = [(\bar{X}_1)^2/4](1/e) + (\bar{X}_1 \bar{Y}_1)/2 + e[(\bar{Y}_1)^2/4].$$

Next, the effect in-kind income's change due to the technological improvement on the utilities of the two parties will be investigated. Taking the derivatives of the last expression with respect to \bar{X}_1 , \bar{X}_2 , \bar{Y}_1 , and \bar{Y}_2 , one can study the effects of these parameters on the utility function.

$$(9) \quad ?U_1/?\bar{X}_1 = (\bar{X}_1/2)(1/e) + [(\bar{X}_1)^2/4](dU_1/de)(de/d\bar{X}_1) + \\ + (\bar{Y}_1/2) + (dU_1/de)(de/d\bar{X}_1) [(\bar{Y}_1)^2/4] \\ = (\bar{X}_1/2)(1/e) + [(\bar{X}_1)^2/4] [-(1/e^2)][1/(\bar{Y}_1 + \bar{Y}_2)] + (\bar{Y}_1)/2 + [(\bar{Y}_1)^2/4][1/(\bar{Y}_1 + \bar{Y}_2)] \\ = (\bar{X}_1/2)[(\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)] - \\ - [(\bar{X}_1)^2/4][(\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)^2] + \bar{Y}_1 + [(\bar{Y}_1)^2/4][1/(\bar{Y}_1 + \bar{Y}_2)] \\ = [\bar{X}_1(\bar{Y}_1 + \bar{Y}_2)/[2(\bar{X}_1 + \bar{X}_2)][1 - \bar{X}_1/2(\bar{X}_1 + \bar{X}_2)] + (\bar{Y}_1)/2 + [(\bar{Y}_1)^2/4][1/(\bar{Y}_1 + \bar{Y}_2)] > 0$$

Q.E.D.

Using symmetry, the derivative of U_1 with respect to \bar{Y}_1 can be derived and concluded that:

$$?U_1/?\bar{Y}_1 > 0$$

A further interesting question is how an additional quantity received by a rival country will affect the utility of its counterparts (cross effect).

$$(10) \quad ?U_1/?\bar{X}_2 = [(\bar{X}_1)^2/4](?U_1/?e) ?e/?\bar{X}_2 + [(\bar{Y}_1)^2/4](?U_1/?e) ?e/?\bar{X}_2 \\ = -[(\bar{X}_1)^2/4][(\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)^2] + (\bar{Y}_1)^2/[4(\bar{Y}_1 + \bar{Y}_2)]$$

$$= [(\bar{Y}_1 + \bar{Y}_2)/4][(\bar{Y}_1)^2/(\bar{Y}_1 + \bar{Y}_2)^2 - [(\bar{X}_1)^2/(\bar{X}_1 + \bar{X}_2)^2]$$

$$= [(\bar{Y}_1 + \bar{Y}_2)/4][(\bar{Y}_1/(\bar{Y}_1 + \bar{Y}_2) + \bar{X}_1/(\bar{X}_1 + \bar{X}_2)][(\bar{Y}_1/(\bar{Y}_1 + \bar{Y}_2) - \bar{X}_1/(\bar{X}_1 + \bar{X}_2)]$$

Thus,

$$\text{If } (\bar{Y}_1/(\bar{Y}_1 + \bar{Y}_2) > \bar{X}_1/(\bar{X}_1 + \bar{X}_2) \quad \text{then } \partial U_1/\partial \bar{X}_2 > 0$$

$$\text{If } (\bar{Y}_1/(\bar{Y}_1 + \bar{Y}_2) < \bar{X}_1/(\bar{X}_1 + \bar{X}_2) \quad \text{then } \partial U_1/\partial \bar{X}_2 < 0$$

If, $(\bar{Y}_1/\bar{X}_1) > (\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)$, or equivalently,

$$\text{if } \bar{Y}_1/\bar{X}_1 \gg \bar{Y}_2/\bar{X}_2 \quad \text{then } \partial U_1/\partial \bar{X}_2 > 0$$

This is the case when the representative individual of country 1 is selling or exporting Good Y and buys or imports Good X. Recall that this is indeed what happens as both individuals have the same utility functions but a different initial allocation of resources X_i and Y_i .

The implication for the case presented is very important for international economists. If one country indeed improves its technology in the production of good X, or equivalently in this model, it acquires more endowments that favor the production of good X, a good which initially before the technological improvements is exported, and as a result its production of good X increases. Its partner country benefits from this improvement which is due to the change in the terms of trade in favor of the partner country. Since both $\partial U_i/\partial \bar{X}_i$ and $\partial U_i/\partial \bar{Y}_i$ are greater than zero, the country with the increased endowment or with the improved technology benefits from it and shares the benefits with its trade partner.

However, in the opposite scenario, which has an utmost importance and has not received appropriate attention in the literature, where: $(\bar{Y}_1/\bar{X}_1) < (\bar{Y}_1 + \bar{Y}_2)/(\bar{X}_1 + \bar{X}_2)$, is guaranteed as long as: $(\bar{Y}_1/\bar{X}_1) \ll \bar{Y}_2/\bar{X}_2$, then $\partial U_1/\partial \bar{X}_2 < 0$.

In this last case, where the technological improvement in one country occurs in the good that was initially imported by that country, the welfare of the exporter country decreases.

Furthermore, if the technological improvement increases to the point where the country switches its initially imported good to become its exported good, the benefit to that country is larger while the benefit to the other country decreases. It is still beneficial for the losing country to trade with its counterpart under the new circumstances, as compared to the autarky, no-trade equilibrium.

III. Conclusion

The paper derives the equilibrium bundles of consumption, and explores what happens to a country (i.e. the U.S.) if another country's technology (i.e. China) continues to advance in various industries. Using a simple model of two countries, two goods, and two representative agents, the paper provides a few scenarios; among them one where the more developed country prior to the technological changes loses from the introduction of a positive endowment shock or more advanced technologies in the other country. Furthermore, when transportation costs are included, such positive endowment shocks by that country may lead to autarky, a situation that would reduce the welfare of both countries. In this scenario, calls for interventionist policies by the losing country justify imposing barriers to trade such as tariffs and quotas, as well as exports subsidies, as is the case with negative externalities. This conclusion is in line with Samuelson (2004) who stated that technological improvements may reduce the welfare of at least one of the trading countries.

Notes

1. Adams, Gangnes and Shachmurove (2006) evaluate the factors responsible for the competitiveness of China in the world economy and relative to its East Asian rivals.
2. For example, in the U.S. only 140,000 green cards are issued annually. As a result, scientists, engineers and other highly skilled workers have to wait years before receiving a green card that would allow them to stay permanently. Another two examples include Japan and Germany which have rapidly aging (and soon to be declining) populations that are not sympathetic (especially Japan) to absorbing many immigrants. See Becker, (2005).
3. As one of the referees to this paper points out, one interesting policy implication that could come out of the paper is the U.S. favoring certain policies that may cause countries such as China and India to increase the exports of products that they were originally exporting. The U.S. would try to dissuade these countries from exporting products that would compete with its exports.

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