The Effects of Information Communication Technology on the Terms of Trade between North-South Countries: A Structural Economic Dynamic Approach

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Abstract

Information Communication Technology has been identified as a major determinant of international competitiveness between nations in recent years, through increased labor productivity. Depending on the choice of techniques, process innovations may also result in increasing differences in income per capita between developed and underdeveloped countries. Following a structural economic dynamic approach, this paper examines the potential impact of Information Communication Technology on the terms of trade between North-South countries and presents two particular scenarios.

Keywords: Information Communication Technology; Terms of Trade; North-South.

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1. Introduction

In discussions of the ever-widening gap between developed and underdeveloped regions, one factor that has received repeated attention is the decline in the share of consumer expenditure on Southern goods. The usual explanation for this phenomenon is Engel's law relating to the difference between the income elasticity of demand for industrial products and that for primary products. Prebisch (1950, 1959, and 1963), for instance, argues that the South typically exports primary products while the North exports industrial products. Engel's law implies a lower income elasticity of demand for primary products.

Despite the fact that Engel's law constitutes the most evident abiding causal mechanism blocking rapid growth for poor regions, Prebisch (references above) and Singer (1950) referred to another mechanism that involves a continuous deterioration in the terms of trade as a constraint on Southern development[1]. A country whose terms of trade are worsening loses some of its productivity gains, leaking them to the rest of the world. In this paper we intend to show that Information Communication Technology [ICT] substantially affects this issue. Considering that terms of trade vary through time according to changes in productivity in the sectors of specialization, relative to changes in productivity in other sectors, ICT provides the possibility of reversing the continuous deterioration of the Southern terms of trade. This will happen if gains in productivity from ICT are limited to those sectors in which the advanced countries have comparative advantage.

[1] These authors acknowledge two other supplementary causal mechanisms for the problems faced by poor countries: capital dependence and the market power of transnational agribusiness.

In this case the ratio between productivity growth in the exporting sectors of developed countries and productivity growth in the home-market sectors happens to be larger than this same ratio in underdeveloped countries. Hence, due to ICT, the terms of trade will worsen for developed countries. And the terms of trade will deteriorate even further, the heavier the concentration of technical improvements in the exporting sectors. This situation corresponds to the case that the underdeveloped countries achieve gains since the productivity increases that take place in the exporting sectors of the developed countries are leaked abroad. If, however, the effects of ICT are widespread, it is reasonable to assume that productivity will increase evenly across all sectors of developed economies. In this case, the developed countries gain not only from these technical improvements but also from being able to retain the productivity increases that take place in their exporting industries.

Concerning the U.S. economy, Gordon (2000, p. 72) reported that "the New Economy, defined as the post-1995 acceleration in the rate of technical change in information technology together with the development of the Internet, has been both a great success and a profound disappointment. The New Economy has created a dynamic explosion of productivity growth in the durable manufacturing sector (...). However, the New Economy has meant little to the 88 percent of the economy outside durable manufacturing." Acemoglu (2002, p. 9) points out that "(...) despite the acceleration in skill bias, we are most likely not in the midst of a 'Technological Revolution'; what has changed is not necessarily the overall rate of progress, but the types of technology that are being developed."

On the other hand, for some authors ICT has been the primary force behind the sharp recent gains in productivity growth. Labor productivity reflects increases in the amount of capital per hour worked (referred to as capital deepening) and growth in labor quality and multifactor productivity. According to this line of thought, ICT is a fundamental industrial revolution which has a widespread impact over different sectors of the economy. According to Jorgenson & Stiroh (2000, p. 127) "It could be argued that this represents a new paradigm. In this view the diffusion of IT improves business practices, generates spillover benefits, and raises productivity throughout the economy". In this regard, the role of innovation and the diffusion of technology seem of crucial importance.

In this paper, following these lines of investigation, and based on the ideas of Pasinetti (1981,1993), we intend to study the effects of ICT on North-South international relations using a structural economic dynamic approach. We provide simulations relating to two particular scenarios. In the first scenario the productivity gains from ICT are confined to one sector. In the second, ICT is treated as an industrial revolution, having a widespread effect over both types of economies. Our aim is to analyze the impact of ICT on the terms of trade between developed and underdeveloped countries.

This paper is structured as follows. In Section 2 we discuss the determination of the terms of trade following a Pasinettian approach. Section 3 focuses on the effects of ICT on the terms of trade involving two situations: in the first, the productivity gains are limited to one sector and, in the second, they are widespread throughout the economy. Section 4 presents our conclusions.

2. The Determination of the Terms of Trade: A Pasinettian Approach

One issue that has been pursued by a number of scholars is why the terms of trade have been worsening – as it seems they have been – for the primary-product countries (normally underdeveloped countries), at a time when the largest increases in productivity are taking place in manufactured-product countries (the industrially advanced countries).

When dealing with free trade and international diffusion of technical progress, Pasinetti (1981, 1993) considers a hypothetical case of two countries, one advanced and one underdeveloped, denoted respectively by A and U, which produce the same set of commodities with different methods of production[2]. According to Pasinetti the dynamics of the terms of trade depend on changes in productivity in the specialized sectors of the two nations relative to changes in productivity in the other sectors. Whether the terms of trade improve or worsen depends on comparative international changes in productivity and have no relation to the fact that in one country overall productivity may be growing faster or slower than in another. This means, for example, that the faster-growing nation might well be the one which, besides keeping all productivity increases to itself, also absorbs some of the smaller productivity increases achieved in the other countries.

Let R_A and R_U be the (weighted) average rates of change of productivity in A and in U respectively for those commodities that are produced in both countries (and are mobile, so that they have the same price both in A and in U), and let ρ_A and ρ_U be the

[2] Araujo & Teixeira (2004) formally extended Pasinetti's model to consider international flow of commodities.

(weighted) average rates of change of productivity for specialized commodities in countries *A* and *U*, respectively. Then the prices of exports from *A*, relative to the prices of imports from *U*, i.e. the terms of trade, will worsen, improve, or remain unchanged over time according to whether:

$$\frac{\rho_A}{R_A} > \frac{\rho_U}{R_U} \tag{1}$$

$$\frac{\rho_A}{R_A} < \frac{\rho_U}{R_U} \tag{2}$$

$$\frac{\rho_A}{R_A} = \frac{\rho_U}{R_U} \tag{3}$$

Corresponding to each of the above situations, over time, international trade:

(i) will cause leakage of some productivity gains from country *A* to country *U*.

(ii) will cause leakage of some productivity gains from country *U* to country *A*.

(iii) will keep all productivity gains inside the country of origin.

The situation expressed in (ii) is the usual explanation for the secular deterioration in the terms of trade for the South. The traditional argument is that workers in poor regions do not obtain gains in real wages commensurate with growth in their productivity, whilst those in rich regions do. The productivity gains of workers in poor regions are thus passed on to consumers in rich regions via lower prices, whilst workers in rich regions capture productivity increases through growth in real wages,

which means that productivity increases in rich regions are not passed on to poor regions in the form of lower prices for the products of the North[3].

In the next section we analyze the possibility that ICT might (or might not) reverse the continuous deterioration of the terms of trade for the South.

3. The Effects of Information Communication Technology on the Terms of Trade

The two most common views associated with ICT are that the resulting structural changes are limited to a few sectors or that they are widespread throughout the economy. If the productivity gains from ICT are limited to a few sectors, there arises the possibility of reversing the downward trend in the Southern terms of trade. However if the effects of ICT are widespread, it is reasonable to assume that productivity will increase evenly across all sectors of the developed economy. In this case, the developed countries would gain not only from these technical improvements, but also from being able to retain the productivity increases that take place in their exporting industries.

In order to assess the effects of ICT on the terms of trade, let us consider two particular scenarios. In the first, the productivity gains from ICT are limited to one sector and, in the second, they are widespread throughout the economy. These scenarios, considered from the points of view of countries *U* and *A*, assume that both countries produce and consume the same two consumer and capital goods but with different structures of production and patterns of demand. The technical knowledge of the average employee is such that per capita productivity in country *A* is ten times

[3] For an interesting comparison between the import substitution paradigm and the export-oriented approach see Bruton (1998) and Edwards (1993). Ardeni & Wright's (1992) reappraisal of the Prebisch-Singer hypothesis of the deterioration in the terms of trade sheds light on earlier discussion of this matter.

greater than in country *U*, which implies that the real per capita income at the disposal of the average employee is ten times greater in *A* than in *U*. As pointed out by Pasinetti (1993), this gives rise to particular changes in demand.

When technical progress takes place at exactly the same rate in the production of commodity *i* and in the production of capital good *ki* for this commodity, (when $\rho_i = \rho_{ki}$) we face Harrod-neutral[4] technical progress. In this case, sectoral capital output ratios remain constant, although the technical coefficients are changing all the time. Technical progress is neutral with reference to the capital intensity of the production process. The proportion of the quantity of labor used directly to the quantity of labor locked up in capital goods remains unchanged through time. One of the characteristics of 'capital intensity neutral' technical progress is that it entails the use of more physical capital per person.

The hypothesis of constant sectoral capital-output ratios requires that in each sector the capital intensity of the production processes remain constant over time. The empirical relevance of the constancy of these ratios turns out to be a test of the kind of technical progress that the traditional economies experience. On the other hand, ICT has been the primary force behind the recent sharp gains in productivity growth in the advanced economies. Labor productivity reflects increases in the amount of capital per hour worked and growth in labor quality and multifactor productivity.

[4] It is important to notice that Harrod's (1948) concept of neutral technical progress deals with the change in the production functions which, at a given level of marginal product, leaves the capital/output ratio unchanged. His definition of 'neutrality' is a technical relation that meets the test of constancy of income shares. The way we introduce 'neutrality' here does not refer to the distribution of income between wages and profits. However, it is not difficult to see that it takes the same benchmark.

Acemoglu (2002) points out the existence of a consensus that recent technical change favors more skilled workers, replaces tasks previously performed by the unskilled, and exacerbates inequality. He argues that capital skills were intrinsically complementary until the early 20th century and that the advances of ICT favor more-skilled workers in the late 20th century. In other words, the demand for skills has increased faster during the past thirty years than previously.

Technologies of the past were skill-replacing (unskilled-biased) because the technological frontier then only enabled the invention of skill-replacing techniques. He also argues that models based on a single skill index (one type of skill or many types of skills that are perfect substitutes) are unable to explain the current situation. He conjectures that recent technological developments are likely to have affected the organization of the labor market and may have had a large effect on the structure of wages[5].

Let R_U be the (weighted) average rate of change of productivity in U. The weights a_1, a_2, a_{k1} and a_{k2} are established according to the participation of each sector in

[5] It is interesting to notice that Tinbergen (1975, p. 61), in his pioneering study, mentioned that "Increasingly we get the feeling that technological development is not simply something given, but that may be guided, within limits". Furthermore, the idea that technology affects the organisation of production and institutions was dramatically stressed by Marx (1992, pp.80-81) in his famous statement on hand mills and steam engines. According to Marx: "The hand mill gives you society with the feudal lords and the steam engine gives you society with the industrial capitalist". Sivanandan (1997,p.20) goes as far as to claim that "the microchip gives you society with the global capitalism." For a critique of this naive determinism see Hrynyshyn (2002).

national income. The rate of change of productivity in each of the sectors is denoted by $\rho_1, \rho_2, \rho_{k1}$ and ρ_{k2}. Accordingly R_U can be written as:

$$R_U = \rho_1 a_1 + \rho_2 a_2 + \rho_{k1} a_{k1} + \rho_{k2} a_{k2} \tag{4}$$

where $\sum_{i=1}^{2}(a_i + a_{ki}) = 1$. If we consider Harrod-neutral technical progress, that is $\rho_1 = \rho_{k1}$ and $\rho_2 = \rho_{k2}$, we can rewrite R_U as:

$$R_U = \rho_1(a_1 + a_{k1}) + \rho_2(a_2 + a_{k2}) \tag{5}$$

As we are assuming that country *U* specializes in producing the consumer good 1 and capital good *k*1, the average rate of change of productivity for those commodities for which country *U* has specialized, ρ_U, may be written as:

$$\rho_U = \rho_1 b_1 + \rho_{k1} b_{k1} \tag{6}$$

where b_1 and b_{k1} are the weights associated with the internal and external demand for commodity 1 and capital good *k*1 respectively, with $b_1 + b_{k1} = 1$. Considering that $\rho_1 = \rho_{k1}$ due to the Harrod-neutral technical progress, we obtain:

$$\rho_U = \rho_1(b_1 + b_{k1}) = \rho_1 \tag{7}$$

Adopting the same procedure in relation to country *A* we conclude that the (weighted) average rate of change of productivity in *A* can be written as:

$$R_A = \hat{\rho}_1 \hat{a}_1 + \hat{\rho}_2 \hat{a}_2 + \hat{\rho}_{k1} \hat{a}_{k1} + \hat{\rho}_{k2} \hat{a}_{k2} \tag{8}$$

The weights $\hat{a}_1$, $\hat{a}_2$, $\hat{a}_{k1}$ and $\hat{a}_{k2}$ are established according to the participation of each sector in national income and $\sum_{i=1}^{2}(\hat{a}_i + \hat{a}_{ki}) = 1$. The rate of change of productivity in each of the sectors is denoted by $\hat{\rho}_1, \hat{\rho}_2, \hat{\rho}_{k1}$ and $\hat{\rho}_{k2}$. Considering Harrod-neutral technical progress:

$$R_A = \hat{\rho}_1(\hat{a}_1 + \hat{a}_{k1}) + \rho_2(\hat{a}_2 + \hat{a}_{k2}) \tag{9}$$

As we are considering that country *A* specializes in producing consumer good 2 and capital good *k*2, the average rate of productivity change for those commodities for which country *A* has specialized, ρ_A, may be written as:

$$\rho_A = \hat{\rho}_2\hat{b}_2 + \hat{\rho}_{k2}\hat{b}_{k2} \tag{10}$$

Due to the Harrod-neutral technical progress we can write the above expression as:

$$\rho_A = \hat{\rho}_2(\hat{b}_2 + \hat{b}_{k2}) = \hat{\rho}_2 \tag{11}$$

Note that $\hat{b}_2 + \hat{b}_{k2} = 1$. As pointed out in the previous section, the dynamics of the terms of trade, and thus the direction in which productivity may be leaking, depends on ratios of rates of change. For country *U* this ratio is given by:

$$\frac{\rho_U}{R_U} = \frac{\rho_1}{\rho_1(a_1 + a_{k1}) + \rho_2(a_2 + a_{k2})} \tag{12}$$

In the case of country *A* this ratio is given by:

$$\frac{\rho_A}{R_A} = \frac{\hat{\rho}_2}{\hat{\rho}_1(\hat{a}_1 + \hat{a}_{k1}) + \hat{\rho}_2(\hat{a}_2 + \hat{a}_{k2})} \tag{13}$$

Now we are in a position to compare the dynamics of the terms of trade according to the cases expressed by (1), (2) and (3).

First Scenario:

In underdeveloped countries, productivity growth in export industries relative to productivity growth in home-market industries happens to be larger than in industrial countries. We can represent this fact as $\rho_1 > \rho_2$. This is considered one of the facts that explain why the terms of trade have been worsening for the underdeveloped countries.

In terms of our numerical illustration let us represent this assuming that $\rho_1 = \rho_{k1} = 0.0025$ and $\rho_2 = \rho_{k2} = 0.0015$. In what follows we assume that ICT has no impact on the productivity of underdeveloped countries. Of course we are not considering the possibility of learning new techniques from abroad, which is a useful simplification in this analysis but should be considered in future inquiries[6].

In order to determine the ratio of rates of change it is necessary to assume a particular composition of demand. For country *U*, it is reasonable to assume that the demand composition concentrates on the commodity that represents the fulfillment of basic needs according to the income level of the underdeveloped country. Assuming that the demand composition in country U implies that $a_1 + a_{k1} = 0.75$ and $a_2 + a_{k2} = 0.25$, we conclude that $\frac{\rho_U}{R_U} = 1.10619$.

Let us assume that the effects of ICT are limited to the exporting sector in the advanced country. This implies rates of productivity as follows: $\hat{\rho}_1 = \hat{\rho}_{k1} = 0.002$ and $\hat{\rho}_2 = \hat{\rho}_{k2} = 0.004$. The rate of productivity change in the specialized sector of the advanced country is twice this rate in the other sectors. Note that this represents a new situation in the evolving patterns of productivity in advanced countries since the usual situation was that the productivity was increasing at roughly the same rate in these countries. Further, let us assume that the composition of demand in country *A* is given as $\hat{a}_1 + \hat{a}_{k1} = 0.25$ and $\hat{a}_2 + \hat{a}_{k2} = 0.75$, representing a demand composition concentrated on the specialized good. This yields $\frac{\rho_A}{R_A} = 1.14286$.

[6] The possibility of learning new techniques from abroad is considered by Oda (1999, p. 208).

Hence we conclude that $\frac{\rho_A}{R_A} > \frac{\rho_U}{R_U}$, which means that international trade causes leakage of some productivity gains from country *A* to country *U*. In this case, the terms of trade are worsening for the advanced country. And, due to ICT, the terms of trade will worsen even further, the heavier their concentration of technical improvements in the export industries. In this case the underdeveloped countries gain since the productivity increases that take place in the exporting sectors of the developed countries are leaked abroad[7].

Second Scenario:

In this second scenario let us assume that the underdeveloped country is characterized by the same parameters as in the previous scenario. This is reasonable, since we are assuming that ICT has no impact on the productivity of underdeveloped countries. Concerning the advanced country, let us assume that the effects of ICT are widespread over all its sectors. This assumption may be represented by the following rates of technical progress: $\hat{\rho}_1 = \hat{\rho}_{k1} = 0.004$ and $\hat{\rho}_2 = \hat{\rho}_{k2} = 0.004$. Considering that

[7] Despite the fact that technical progress entailed by ICT may lead to the improvement of the Southern terms of trade, it does not mean that it will reverse the widening gap between the two regions. As pointed out by Dutt (1996, p.87) "studies connecting the terms of trade deterioration to uneven development may have focused on the wrong issue: those interested in the uneven development process who try to show that the Southern terms of trade deteriorated may be barking up the wrong tree. By the same token, studies denying that this deterioration has occurred have not proved that there has been no uneven development."

$\hat{a}_1 + \hat{a}_{k1} = 0.25$ and $\hat{a}_2 + \hat{a}_{k2} = 0.75$, we conclude that $\frac{\rho_A}{R_A} = 1$, which implies that $\frac{\rho_A}{R_A} < \frac{\rho_U}{R_U}$.

This corresponds to the traditional case reported in the literature, which implies deterioration in the underdeveloped country's terms of trade. Clearly, the effects of ICT cannot reverse the secular downward trend of the Southern terms of trade.

One could argue that international diffusion of technical progress (technological spillover or shared learning) from developed to underdeveloped countries mitigate the negative effects of the deterioration of the terms of the trade for the latter, thus reducing the technological gap. Learning, however, has proved to be more difficult. Acemoglu (2002, p. 63) reported that "(...) new technologies developed in the rich economies are typically 'too skill-biased' for less developed countries, the recent acceleration in skill bias could have negative implications for these countries".

In this context, the investment-specific nature of technological progress in ICT, added to the deterioration in the terms of trade, makes the economic development in the South a daunting task!

4. Concluding Remarks

It is widely acknowledged in the current literature that the nature of technological progress and international trade has changed dramatically in the last three decades. The globalization of production is frequently portrayed as a process that is unfolding with no center and no discernible power structure, ruled by ICT and independent of the nation state. According to Hummels, Ishii & Yi (2001, pp.75-76):

"One of the most important changes involves the increasing interconnectedness of production process in a vertical trading chain that stretches across many countries, with each country specializing in particular stages of a good production sequence".

Of course, there are many different ways to view and to model the impact of increasing vertical specialization of production, trade patterns and welfare consequences in the New Economy. However, it is certain that recent technological innovation has had different impacts on performances of North and South countries, with few exceptions. We may say that differences in economic institutions, in technological dependence and in terms of trade, result in impressive productive and welfare consequences in the North but nothing equivalent is observed in the South. In other words, the dual capitalism of Prebisch with all of its contradictions remains.

Amable & Petit (2001,p.7), commenting on the diversity of capitalism, argue that: "This diversity is not seen as something that is accidental or temporary, but as the consequence of mechanisms that can be grouped under the generic title of 'institutional complementarities'." To attain real success in this period of the New Economy requires a mixture of the United States and Scandinavian institutions. Needless to say, any trend toward such an ideal configuration is an unrealistic expectation for the South. Actually, the 'diversity of capitalism' is a core concept of the Structuralist School of the 50's. Certainly, some institutions have changed but the economic dynamics, technological dependence, deterioration in the terms of trade of underdeveloped countries and the nature of the dual configuration are still very much present. This is no surprise. A deeper probing into fundamental causes may well be required to understand why the

second scenario of this paper prevails and why the effects of ICT cannot reverse the ever-widening gap between rich and poor countries.

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