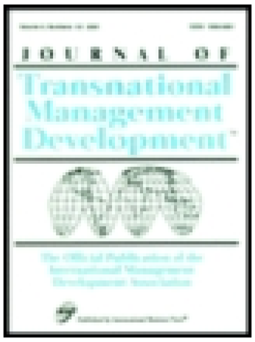

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An Economic Perspective

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Uncertainty, the Lemon Problem, Asymmetric Information and Countertrade: An Economic Perspective

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ABSTRACT. A review of the International Trade literature suggests that uncertainty caused by the lack of perfect information and/or asymmetric information provides a motivation for countertrade (Hennart, 1990; Mirus & Yeung, 1986; Yavas & Vardiabasis, 1988). After presenting the most prevalent forms and examples of countertrade, this study shows how uncertainty can lead to some of the most common forms of countertrade; counterpurchase, buyback and offset. The paper compares and contrasts two strategies facing the management team of a profit-maximizing firm. The standard neoclassical mathematical model developed and presented shows that countertrade strategy may be superior to standard money-mediated trade strategy when there is uncertainty. Therefore, countertrade (particularly, buyback, counterpurchase and offset) may be a rational response to conditions that restrict standard trade. As such, countertrade can supplement standard money-mediated trade and contribute to the growth of international business. *[Article copies available for a fee from The Haworth Document Delivery Service: 1-800-342-9678. E-mail address: <getinfo@haworthpressinc.com> Website: <http://www.haworthpressinc.com>]*

KEYWORDS. Countertrade, uncertainty, asymmetric information

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INTRODUCTION

Countertrade (CT) is a generic term for parallel business transactions, linking sellers and buyers in reciprocal commitments that usually lie outside the realm of typical money-mediated trade. Some common forms of CT transactions include barter, counterpurchase, compensation, buyback, clearing arrangements, offset and switch trading. Because of its unprecedented spread in recent years, CT has come to attract considerable attention. Many U.S. corporations have found it difficult to conduct business with firms and governments in other countries without relying on CT. IBM, GM, Boeing, General Dynamics and Procter & Gamble are among the more familiar of these firms. The official trade statistics do not differentiate CT from money-mediated trade, making it very difficult to obtain the true figure on CT. Nevertheless, even skeptics agree that CT constitutes more than 10% of world trade today, up from 2% just two decades ago (Miramon, 1986; Van Hoof, 1991). Park (1990) and Howard and Yeakel (1990) also provides more recent estimates for CT ranging from 8% to 30% of total world trade.

As CT has grown in importance, many economists have argued that various forms of CT are inefficient and cumbersome for the marketing of products on a world scale mainly because of the need to spend a considerable amount of time disposing of goods (Howard & Yeakel, 1990; Girling, 1992; Korth, 1987; Yavas & Vardiabasis, 1988). In addition, Rabino and Shah (1987) showed that CT may involve a significant increase in business risk. Since the spread of CT at the expense of normal commercial trade is inconsistent with established trade theory, some questions have been raised: Why has CT become so important? Why would the world economy create a breeding ground for such "non standard" types of purchasing? Is CT a fad or is it here to stay?

Earlier studies on CT (Alexandrides & Bowers, 1987; Elderkin & Norquist, 1987; Vardiabasis, 1985; Verzariu, 1984, 1985) have attempted to standardize the terminology by classifying together various forms of CT transactions. Another line of early research dealt with the motivations of both firms and countries for engaging in CT. Different motivations were found for different CT arrangements, strengthening the case for a more "micro" approach (Caves & Marin, 1992; Kogut, 1986; Korth, 1987; Mirus & Yeung, 1986; Vardiabasis & Yavas, 1988). It was argued that CT would help conserve scarce foreign exchange (Verzariu, 1987); circumvent foreign exchange repatriation restrictions (Cho, 1988); open up new markets (Alexandrides & Bowers, 1987; Vardiabasis & Yavas, 1986; Zurawicki, 1988) and help overcome trade restrictions (Hennart, 1990). Later investigations supported the finding that CT was more popular in less developed countries and in centrally planned economies (Rabino & Shah, 1987). The rapid transition toward market economies in Eastern European countries seemed to have contributed to the upsurge of CT. Thus, CT appears to be not only a North-South, but also an East-West form of exchange.

Since the above studies have been relied upon for explaining CT, a short digression may be in order. Many less developed countries (LDCs) started to experience difficulties in the 70's, marked by a gradual deterioration in their capacity to finance imports. The most notable manifestation of these difficulties was a worsening of trade balance that coincided with the growth of the Eurodollar market fostered by oil shocks. The result was a heavy dependence by LDCs on private financial intermediaries. Sizable debt service payments and continuing ambitious import-substitution development programs created an extreme scarcity of foreign exchange. In addition, debt crises contributed to a dramatic rise in the level of consumer prices that, often, was not fully reflected in exchange rates. CT is said to have offered an alternative to debtor nations to continue with their programs within their foreign exchange limitations (DeMarines, 1985; Elderkin & Norquist, 1987; Girling, 1992; Samonis, 1990; Vardiabasis, 1985; Yavas, Freed & Bilici, 1996). Huszagh and Barksdale (1986) stressed the role of CT in eliminating exchange valuations in monetary terms, thus reducing a firm's transaction exposure. Lecraw (1989) found a higher rate of CT success if an importer faced a disequilibrium exchange rate, foreign exchange constraints, and barriers in export markets. Yavas, Freed and Bilici (1996) argued that lack of liquidity may provide a motivation for international barter.

Based on the findings of these studies, some researchers recommended corporate strategies to exploit CT opportunities (Beltramo, 1986; Vardiabasis & Yavas, 1986; Verzariu, 1987). However, when data became available and some hypotheses were tested empirically (Mirus & Yeung, 1987; Hennart, 1990), the results raised serious doubts about some of the more common explanations given for the emergence and growing importance of CT. For example, the hypothesis that CT offers a way to hide price cuts and/or to inflate sales (Neale & Sercu, 1991, 1993) was not supported. Also, the role played by the shortage of hard currency along with exchange control policies (predominant among the explanations for LDCs for requiring CT) was critically questioned. It was pointed out that while pure barter avoids the use of foreign exchange, not all CT transactions involve barter. In other forms of CT, the need for money may be reduced but it does not disappear entirely. In fact, two common forms of CT, counterpurchase and buyback are both money-mediated transactions (Hennart, 1990). Another widely held rationale for CT, that CT would improve balance of payments, did not go unchallenged either. Mirus and Yeung (1987) found that many forms of CT had either negative or neutral effects on the balance of payments.

Therefore, the search for motives for CT has taken another route. Recent studies emphasize attempts to lower transaction costs in international exchanges. Mirus and Yeung (1986), Yavas and Freed (1992) and Yavas (1994) have advanced the hypothesis that market imperfections may provide a motivation for international barter. The observation that the economies of many LDCs are less diversified and more dependent on certain goods reinforces motives for CT. Besides lack of well developed financial markets, institutional restrictions affect the allocation of resources and contribute to differential costs thereby providing incentives for CT. Mirus and Yeung (1986, 1991) and Hennart (1990) argue that such market imperfections as information asymmetry, lack of forward and future markets, and ownership constraints can explain CT. As Holmstrom and Milgrom (1987) pointed out, only recently have there been systematic efforts within the economics profession to investigate non-market types of arrangements. Other examples include the analysis of imperfect information in a principal agent relationship subject to a "moral hazard" (Holmstrom, 1979), and Akerlof (1970), which was one of the pioneering studies linking quality differences and uncertainty. Also, Spence (1973) and Yavas (1994) explored the effect of market failure due to information asymmetry.

The assumption typically made in much of the established trade theory is that the firms engaged in international trade are single-activity firms and that there is no reason for these firms to use anything but the money-mediated exchange mechanism. Furthermore, these firms armed with perfect information, operate on their optimum production frontiers. As Dunning (1995) observes, trade theory assumes that exchanging goods and services in the open market is costless. This assumption implies, of course, that both parties to an exchange transaction have complete and symmetrical information regarding the characteristics and quality of the goods and services involved. In other words, there is complete honesty and transparency and absence of opportunism (Dunning, 1995). Therefore, there is no place in this scenario for different non-market type arrangements (hierarchies, alliances, networks, governments . . ., etc.) for the market is the best way of organizing resources. The existence and growing importance of alternative forms of organizing economic activity, however, point to the fact that sometimes other forms may be necessary to complement (if not permanently replace) markets and help them operate more efficiently. One aspect of the changing world environment, Dunning observes, is the significance of micro-organizational costs and benefits.

One of the reasons for the increased organizational costs is:

> . . . more specialization . . . tends to raise a firm's coordination costs, by increasing the number and specificity of tasks and of information links. It may also raise transaction costs, as the likelihood of information asymmetry and opportunistic behavior increases. (Dunning, 1995, p. 176)

The problem of increased costs is even more pronounced in the international transactions due to such factors as:

> . . . lack of information about, or unfamiliarity with, foreign markets, or uncertainty about institutions, organizational structures, business customs, and actions of foreign governments. (Dunning, 1995, p. 177)

The question which has largely been ignored is if and how such market failures affect demand and supply conditions. The present study attempts to contribute to the understanding of a market failure under conditions of uncertainty. The objective of this paper is to show that CT may be a rational response to conditions that restrict standard money-mediated trade. Therefore, far from being inefficient, CT may fulfill a very important function in increasing the volume of international trade. This is not to suggest that the role played by CT is permanent. Quite the contrary, as the impediments to money-mediated trade are removed, CT might decline in importance. Viewed from this perspective, CT may be a temporary phenomenon that will disappear as world markets become more integrated, efficient and complete.

The next section, which draws on Yavas and Vardiabasis (1988), defines CT, establishes its importance and discusses the various forms it takes. Later in the paper, benefits of CT are shown using a standard neoclassical mathematical model. However, we relax the standard assumption dealing with perfect information and introduce uncertainty. Standard neoclassical production function is used for a mathematical proof.

COUNTERTRADE: DIFFERENT TYPES

CT is an umbrella term for a variety of international transactions that differ from each other with respect to (1) the length of time necessary to complete the transactions, (2) the type(s) of goods involved, and (3) the type of financial arrangement involved (Yavas & Vardiabasis, 1988). Many firms in developed countries including some major U.S. firms such as General Electric, General Motors, McDonnell Douglas, Northrop and Levi Strauss & Co. have all used CT. For example, McDonnell Douglas sold planes to Yugoslavia in exchange for canned hams and tools. The United States traded 14,000 tons of surplus dairy products to Jamaica in exchange for 400,000 tons of bauxite. Japan helped finance an aluminum plant in Brazil in exchange for finished aluminum.

Other than the common feature of explicit linkage of transactions between the seller and the buyer, these forms of CT are quite different. Some of the more prevalent forms of CT are explained below.

Pure barter is both parties agreeing simultaneously to exchange goods. Pure barter is relatively rare primarily because it is very difficult to decide and agree upon the relative value of traded goods. An example of pure barter is the help of the Reagan administration in 1982 to the newly elected, friendly government of Jamaica by swapping bauxite for surplus dairy products. Another example is the agreement by which PepsiCo sent syrup to 37 bottling plants in the former Soviet Union in exchange for Stolichnaya Vodka which Pepsi sold in the U.S.

The second form of commercial CT is *counterpurchase,* also called parallel barter. This form of CT is probably the most common. It involves two parties signing two separate contracts that specify the goods and services to be exchanged at different times. Since the goods are often not of equal value, some amount of cash is usually involved. Counterpurchase involves an initial export, but the exporter receiving back goods that are unrelated to items exporter produces. An example of counterpurchase is the sale of Rolls Royce jet parts to Finland in return for Rolls Royce buying Finnish TV sets and other Finnish goods.

Compensation (or buy-back when the contract period is long) involves the sale of technology, equipment or expertise with the obligation of the exporting firm to take partial or full payment in resulting products. In other words, a company sets up a plant in another country and agrees to buy all or part of its output. The gas pipeline from Siberia is an example where Russian gas is exchanged for European technology. Other examples include but not limited to Goodyear's contract to send China materials and training for a printing plant in exchange for finished labels.

Offset arrangements are frequently found in the defense-related sector and in the sale of large-scale, high-priced items such as aircraft and are designed to "offset" the negative effects of large purchases from abroad on the current account of a country. Under this arrangement, the exporter sells final products and undertakes the obligation to buy from the importing country certain components that could be used in the production processes of the exporting country's final product. For example, Caterpillar built ship engines which were sold to an Australian firm for use in the production of high speed ferries. Caterpillar then assisted the Australian firm in selling the finished product to the Philippines, thereby generating foreign exchange which allowed the Australian company to pay Caterpillar. Another example of offset is General Dynamics' F-16 fighter plane production project in Turkey.

Switch Trade is probably the most complicated form of CT. It typically involves a third party, due in part to the inability of one of the original parties to find a buyer for the goods bartered.

Finally, *clearing* is a long term barter arrangement between two governments. An example is the deal made by Canada and Mexico to swap electrical transmission for petroleum.

Clearly, there are important differences among various forms of CT. Each CT deal, therefore, needs to be examined individually (Hennart, 1990). Furthermore, the expected effects of a CT deal depend on the form(s) it takes. The reader is referred to Girling (1992) and Hennart (1990) for a summary of effects of various forms of CT on such factors as employment, new market penetration and new technology acquisition.

COUNTERTRADE: A REACTION TO MARKET IMPERFECTIONS

In their attempt to explain CT using standard economic theory, Mirus and Yeung (1986) refer to "market imperfections."

> The results suggest that Countertrade is a rational economic response to differential transaction costs, information asymmetry, incomplete markets, and political and ownership constraints that lead to principal agency problems. (Mirus & Yeung, 1986)

In other words, CT is seen as a response to conditions that inhibit, or at least do not promote, standard money-mediated trade. Consider a common CT deal between a DC firm and an LDC government. An example might be an arms deal between the U.S. firm, General Dynamics and the Turkish Government involving the F-16 fighter plane production and/or assembly worth 4.3 billion dollars. The deal is complex, involving direct and indirect offset, technology transfer and investment, and buy-back. The direct offset commitment requires the three consortium partners, General Dynamics, General Electric and Westinghouse to generate more than $200 million of component purchases by 1994. The partners are also required, under the indirect offset agreement, to generate $127 million of the investment credits and $1.14 billion of procurement. Under the buy-back agreement, General Dynamics is committed to purchasing $82 million worth of components produced in Turkey (Yavas & Vardiabasis, 1987). It has been argued that indigenous arms production reduces LDC dependence on other countries, creates jobs, promotes technology transfer, helps the balance of payments by promoting exports and generating investments, and improves skill levels (Harbin, 1984). It has also been pointed out that CT, as direct and/or indirect offset, is used by many LDCs to revitalize their economy while building up their defense. This is thought to be particularly relevant during times of economic recession (Harbin, 1984).

While all of the reasons provided above may be relevant, none explains satisfactorily why they arranged a specific CT deal involving technology transfer, offset, export promotions and buy-back. Consider an alternate scenario: The LDC in question, as a recipient of a technology package, is at a disadvantageous position vis a vis the technology supplier since it has less information about the quality of the technology to be supplied. In other words, when the supplier is not also the final user of the technology, it may not be in its interest to provide what the recipient wants. In particular, when costs increase with quality, the supplier will be inclined to provide a lower quality technology package. Asking the supplier to buy back some components to be produced using the technology provided could then be sensible. The result is a CT transaction. Thus, information asymmetry resulting from uncertainty, not shortage of hard currency, has caused CT. This is sometimes called the "lemon problem." The lemon problem may occur for a number of reasons; the seller may have superior information regarding the quality and future value of the good to be produced using the technology provided by the seller, or the seller may have marketing information not available to anyone else due to the seller's technological superiority, or information about product demand and plant capacity elsewhere. In addition, if the LDC based firm lacks a marketing system (knowledge about marketing costs and channels at the international level) for the good in question, CT may become a viable marketing alternative.

To illustrate another aspect of the information asymmetry, suppose that a buy-back contract is agreed upon, according to which the DC firm is to purchase millions of dollars worth of components to be produced in the LDC. Since these components are to be used as inputs in further production, the question arises about how to value these components. The DC firm would be in a much better position to know the value of the components since this is related to their marginal physical product in farther production (Mirus & Yeung, 1987). Then, there is the possibility that the DC firm might try to understate the value of the components to lower their prices. These problems called "informational asymmetry-moral-hazard" might be overcome by a contract that specifies physical quantities rather than valuation. Such a contract would help align interests of both parties involved.

There is yet another aspect of the information asymmetry. Lack of information by the LDC also acts to increase the risk associated with new products. Since the economies of the LDCs are less diversified than the DCs, the risk of new projects may not be offset in the portfolio theory context. The firms in DCs are in a better position to take more of the risk in their trade with the LDC firms. Unless DC firms are willing to take and diversify away more of the risk of the trade with the LDC partners, international trade will be limited. Again, CT may be seen not as inefficient and hindering international trade, but quite the contrary, as efficiency improving and promoting trade.

ASYMMETRIC INFORMATION: AN EXAMPLE

This section formalizes the analysis of the previous section by presenting a mathematical model that approximates the behavior of the management team of a profit maximizing firm in an LDC, operating under uncertainty about the quality of the technology offered by a DC. The management team will consider the profitability of two different strategies:

1. The "Trade-As-Usual" Strategy–Purchase/rent the technology in the open market, and then sell the resulting output, both at home and abroad.
2. The CT Strategy–acquire the technology in exchange for some of the output to be produced by using said technology.

Clearly, the management team will choose the more profitable of these two strategies. If uncertainty about the quality of the technology becomes sufficiently large, and/or if the terms at which the technology can be acquired become more favorable, then the CT strategy may be preferred. To focus on the uncertainty issue, we use a simple model in which management has a one-period planning horizon.[1] The firm produces a single output (which it sells both at home and abroad), using capital, labor, and imported technology.

In this model, the following notation is used:

x = quantity of output to be sold domestically

y = quantity of output to be exported

z = total quantity of output produced, i.e., $z = x + y$

p_x = price at which output is sold domestically

e_x = price elasticity of demand for that portion of the firm's output which is sold domestically

MR_x = Marginal Revenue from sale of output domestically. Note that[2] $MR_x = \partial(p_x x)/\partial x = (1+(1/e_x))p_x$

p_y = price at which output is sold abroad

e_y = price elasticity of demand for that portion of the firm's output which is exported

MR_y = Marginal Revenue from sale of exported output. Note that $MR_y = \partial\,(p_y y)/\,\partial y = (1+(1/e_y))p_y$

L = amount of labor used in production

K = amount of capital used in production

r = rental rate of capital

e_K = r-elasticity of the supply of capital

m_K = marginal factor cost of using capital = $\partial\,(rK)/\partial K$

Note that $m_K = (1 + (1/e_K))r$

w = wage rate

e_L = wage elasticity of the supply of labor

m_L = marginal factor cost of using labor = $\partial(wL)/\partial L$

Note that $m_L = (1+(1/e_L))w$

C = cost of using imported technology

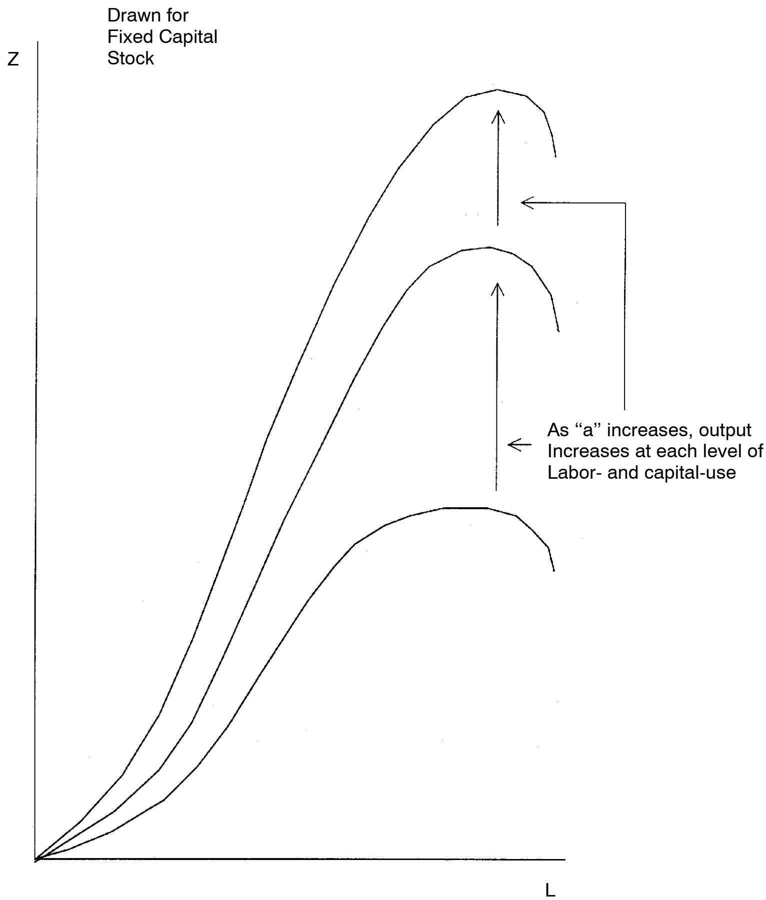
z = f(K, L, a)–the firm's production function, where "a" is a parameter which reflects the impact of imported technology upon output. The more beneficial the imported technology, the larger "a" will be (see Figure 1). Since the firm's managers may not know the value of "a," uncertainty enters our model here.[3]

Since the firm will be selling some output domestically, and exporting the rest, we can write the production function as:

$$x + y = f(K, L, a) \quad \text{or} \tag{1}$$

$$x + y - f(K, L, a) = 0 \tag{2}$$

FIGURE 1



Expressions (1) and (2) show that if we choose K, L, and the amount of output that we wish to export, then the output which remains to be sold domestically is determined by:

$$x = f(K, L, a) - y$$

Expressions (1) and (2) also show that if we choose K, L, and the amount of output that we wish to sell domestically, then the output which remains to be exported is determined by:

$$y = f(K, L, a) - x$$

While this is true, the best course of action is to choose K, L, x, and y simultaneously in a way which maximizes profit. We do this below. Note that expressions (1) and (2) imply that the marginal rate of transformation (i.e., MRT) between x and y is 1.0. This is so because "x" and "y" are just notational conventions that we have adopted to show what portion of the output is sold domestically, and what portion of it is exported.[4] If the firm is a price taker, then the fact that MRT = 1 would lead the firm to sell all output domestically (if $p_x > p_y$) or to export all output (if $p_x < p_y$). However, we do not assume that the firm is a price-taker, so that p_x and p_y will change if the firm shifts output from domestic sale to export or vice versa. Under these conditions, the firm will maximize profit by allocating output (i.e., "z") between domestic sale (i.e., "x") and export (i.e., "y") until $p_x/p_y = (1+(1/e_y))/(1+(1/e_x))$ (See Figures 2, 3, and 4).

$$x = b_x - c_x p_x \text{ or } p_x = (b_x - x)/c_x \tag{3}$$

$$y = b_y - c_y p_y \text{ or } p_y = (b_y - y)/c_y \tag{4}$$

So that the isorevenue[5] curve shown in Figure 4 has the following equation:

$$\begin{aligned} TR &= p_x x + p_y y \\ &= ((b_x - x)/c_x)x + ((b_y - y)/c_y)y \\ &= (b_x/c_x)x - (1/c_x)x^2 + (b_y/c_y)y - (1/c_y)y^2 \end{aligned} \tag{5}$$

FIGURE 2

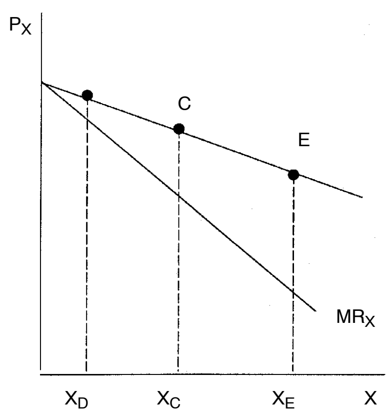
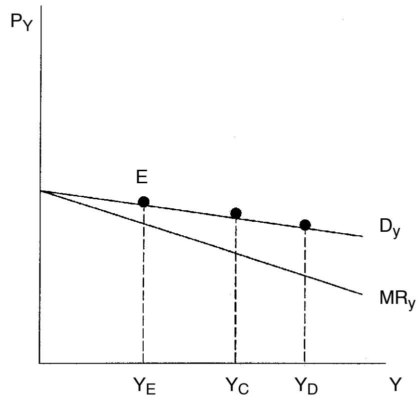


FIGURE 3



When the members of the management team consider the "Trade-As-Usual" strategy, they will attempt to identify the values of x, y, K, and L which will maximize profit[6] subject to the constraint imposed by the production function. However, the management team will not know exactly how the use of the "imported" technology will affect output. That is, they will not know the exact value of "a" in the production function. Thus, they will choose x, y, K, and L to maximize profit subject to their belief about production conditions (i.e., subject to their belief about the value of "a"). We will use a* to denote this belief about the value of "a." Then we will explain the way in which changes in the management team's belief about the value of "a" will affect the choices of x, y, K, and L. Note that the mathematical statement of the management team's decision problem is to choose the values of x, y, K, and L which will maximize:

$$V = p_x x + p_y y - rK - wL - C + \lambda_1(x + y - f(K, L, a^*)) \quad (6)$$

The appropriate first order conditions are:

$$\text{(a) } \partial V/\partial x = \partial (p_x x)/\partial x + \lambda_1 = MR_x + \lambda_1 = 0 \quad (7)$$

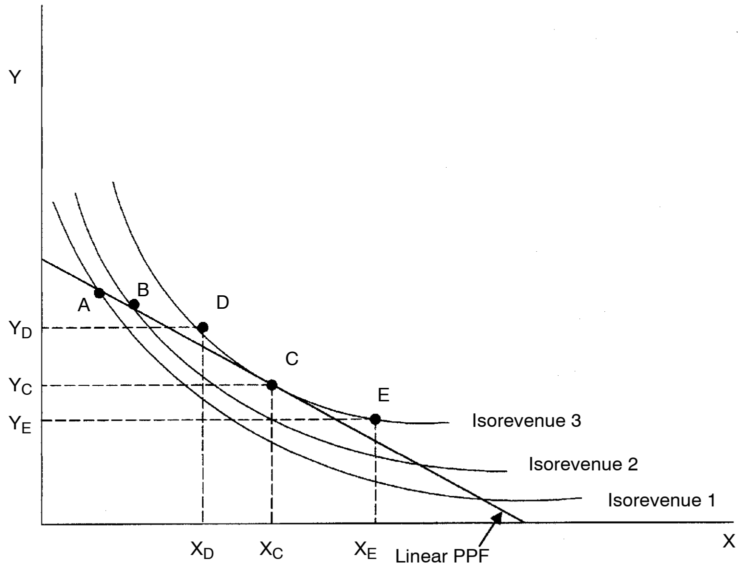
$$\text{(b) } \partial V/\partial y = \partial (p_y y)/\partial y + \lambda_1 = MR_y + \lambda_1 = 0$$

$$\text{(c) } \partial V/\partial K = \partial (rK)/\partial K + \partial_1 \partial f/\partial K = m_K + \partial_1 \partial f/\partial K = 0$$

$$\text{(d) } \partial V/\partial L = \partial (wL)/\partial L + \partial_1 \partial f/\partial L = m_L + \partial_1 \partial f/\partial L = 0$$

$$\text{(e) } \partial V/\partial \lambda_1 = x + y - f(K, L, a^*) = 0$$

FIGURE 4



If we recall from the definitions section that MR_X depends upon p_X, MRx depends upon p_y, m_K depends upon r, and m_L depends upon w, then we can use the Implicit Function Theorem[7] to solve (7) for the choice variables and the LaGrange Multiplier as functions of p_x, p_y, r, w, and a*:

$$\begin{aligned} &(a)\ x = g_1(p_x, p_y, r, w, a^*) \\ &(b)\ y = g_2(p_x, p_y, r, w, a^*) \\ &(c)\ K = g_3(p_x, p_y, r, w, a^*) \\ &(d)\ L = g_4(p_x, p_y, r, w, a^*) \\ &(e)\ \lambda_1 = g_5(p_x, p_y, r, w, a^*) \end{aligned} \tag{8}$$

Equation (8a) is the firm's profit maximizing supply of domestic output function; equation (8b) is the firm's profit maximizing supply of exported output function; equation (8c) is the firm's demand for capital function and equation (8d) is the firm's profit maximizing demand for labor function. For example, if the appropriate production function is:

$$x + y - a^*(m_1KL - m_2K^2 - m_3L^2) = 0 \tag{9}$$

and if the appropriate demand for domestic output, demand for exported output, supply of capital and supply of labor functions are:

$$\begin{aligned}
&\text{(a) } x = (n_1/n_2) - (1/n_2)p_x \\
&\text{(b) } y = (n_3/n_4) - (1/n_4)p_y \\
&\text{(c) } K = r\, n_5 \\
&\text{(d) } L = wn_6
\end{aligned} \tag{10}$$

then the corresponding versions of (8a) through (8d) are:

$$\text{(a)} \quad x = \frac{p_x - p_y}{n_2 + n_4} + \frac{v_{11}r^2 + v_{12}rw + v_{13}w^2}{v^2(2p_y - n_3)^2}\,\frac{1}{a^*} \tag{11}$$

$$\text{(b)} \quad y = \frac{p_y - p_x}{n_2 + n_4} + \frac{v_{21}r^2 + v_{22}rw + v_{23}w^2}{v^2(2p_y - n_3)^2}\,\frac{1}{a^*}$$

$$\text{(c)} \quad K = \frac{v_{31}r + v_{32}w}{v(2p_y - n_3)}\,\frac{1}{a^*}$$

$$\text{(d)} \quad L = \frac{v_{41}r + v_{42}w}{v(2p_y - n_3)}\,\frac{1}{a^*}$$

where

$$\begin{aligned}
v_{11} &= n_4(2m_1^2 - 4m_2^3 - m_1^2m_3)n_5^2 \\
v_{12} &= n_4(4m_1m_2m_3 + m_1^3 - 4m_2^2 - 4m_3^2)n_5n_6 \\
v_{13} &= n_4(2m_3m1_1^2 - m_2m_1^2 - 4m_{33})n_6^2 \\
v_{21} &= n_2(2m_1^2 - 4m_2^3 - m_1^2m_3)n_5^2 \\
v_{22} &= n_2(4m_1m_2m_3 + m_1^3 - 4m_2^2 - 4m_3^2)n_5n_6 \\
v_{23} &= n_2(2m_3m1_1^2 - m_2m_1^2 - 4m_{33})n_6^2 \\
v &= m_1^2 - 4m_2m_3 \\
v_{31} &= 2m_2n_5 \\
v_{32} &= m_1n_6 \\
v_{41} &= m_1n_5
\end{aligned}$$

$v_{42} = 2m_3n_6$

Note that (11) give the firm's supplies of output and demands for inputs (i.e., capital and labor) as functions of output prices, input prices, and the management team's belief about the effectiveness of the imported technology (as reflected by their choice of a*). This result is exactly what is implied by (8).

When we substitute (8a) through (8d) into the profit function, we obtain:

$$\begin{aligned} \text{profit} &= p_x x + p_y y - rK - wL - C \qquad (12)\\ &= p_x g_1(p_x, p_y, r, w, a^*)\\ &+ p_y g_2(p_x, p_y, r, w, a^*)\\ &- r g_3(p_x, p_y, r, w, a^*)\\ &- w g_4(p_x, p_y, r, w, a^*)\\ &= h(p_x, p_y, r, w, a^*, C) \end{aligned}$$

That is, (12) gives the firm's profit from the "Trade-As-Usual" strategy, as a function of output prices, input prices, and the management team's belief about the effectiveness of the imported technology (as reflected by their choice of a*). For example, when (10a) through (10d) are substituted into the profit function, we obtain:

$$\text{profit} = M + (N_1 - N_2)(1/a^*) \qquad (13)$$

where:

$$M = \frac{p_x^2 - 2p_xp_y + p_y^2}{n_2 + n_4} - C$$

$$N_1 = \frac{(v_{11}p_x + v_{21}p_y)r^2 + (v_{12}p_x + v_{22}p_y)rw + (v_{13}p_x + v_{23}p_y)w^2}{v^2(2p_y - n_3)^2}$$

$$N_2 = \frac{v_{31}r^2 - (v_{32} + v_{41})rw + v_{42}w^2}{v(2p_y - n_3)}$$

In (13) we suppress the dependence of profit upon p_x, p_y, r, and w because we are primarily interested in the impact of management's belief about a* upon their choice of the "Trade-As-Usual" strategy rather than the "CT" strategy. By using the composite function rule, it is easy to show that profit is an increasing function of a. This result is exactly what we would expect: if a* increases, then the firm obtains an increasing amount of output from a given level of capital and labor.

We turn now to the "CT" strategy. When pursuing this strategy, the members of the management team will choose the values of x, y, K, and L that will maximize:

$$V = p_x x - rK - wL + \lambda_1(x + y - f(K, L, a)) + \lambda_2(C - sy) \quad (14)$$

Notice that neither a $p_y y$ term nor a "C" appears in (14). This is because they are selling no output in markets abroad.[8] Rather, they are exchanging exported output for technology, as the second constraint (i.e., C = sy) suggests. In the expression C = sy the "s" term is the implicit price of output.[9] In addition, note that "a" rather than "a*" appears in the production function component of (14). This is because the willingness of the trading partner to accept output in exchange for technology removes the manager's uncertainty about the effectiveness of the technology. If the trading partner sells ineffective (or obsolete, lower quality) technology, then he or she will receive reduced payment (in output from the production process).

In the countertrade case, the appropriate first order conditions are:

$$\begin{aligned}
&(a)\ \partial v/\partial x = \partial (p_x x)\ \partial x + \lambda_1 = 0 \\
&(b)\ \partial v/\partial y = \lambda_1 - \lambda_2 s = 0 \\
&(c)\ \partial v/\partial K = \partial (rK)/\ \partial K + \lambda_1 \partial f/\partial K = 0 \\
&(d)\ \partial v/\partial L = \partial (wL)/\ \partial L + \lambda_1 df/\partial L = 0 \\
&(e)\ \partial v/\partial \lambda_1 = x + y - f(K, L, a) = 0 \\
&(f)\ \partial v/\partial \lambda_2 = C - sy = 0
\end{aligned} \quad (15)$$

By using the Implicit Function Theorem again, we can solve (15) for the choice variables x, y, K, and L and the LaGrange Multipliers as functions of p_x, r, w, and s:

$$\begin{aligned}
&(a)\ x = h_1(p_x, r, w, s) \\
&(b)\ y = C/s \\
&(c)\ K = h_3(p_x, r, w, s) \\
&(d)\ L = h_4(p_x, r, w, s) \\
&(e)\ \lambda_1 = h_5(p_x, r, w, s)
\end{aligned} \quad (16)$$

(f) $_2 = h_6(p_x, r, w, s)$

Equation (16a) is the firm's profit maximizing supply of domestic output function; equation (16c) is the firm's demand for capital function and equation (16d) is the firm's profit maximizing demand for labor function. It is again straightforward to show that if the firm's production function is given by (9) and if the appropriate demand for domestic output, supply of capital, and supply of labor functions are given by (10a), (10c), and (10d) then the corresponding versions of (16a), (16c) and (16d) are:

$$
\begin{aligned}
&\text{(a)}\quad x = p_x + ((s/C)J)^{.5}\\
&\text{(b)}\quad K = \frac{2m_3n_5r + m_1n_6w}{a(m_1^2 - 4m_2m_3)((s/C)J)^{.5}}\\
&\text{(c)}\quad L = \frac{m_1n_5r + 2m_2n_6w}{a(m_1^2 - 4m_2m_3)((s/C)J)^{.5}}
\end{aligned}
\tag{17}
$$

where

$$J = (J_1r^2 + J_2rw + J_3w^2)/J_4$$

$$J_1 = (2m_1m_3 - 4m_2m_3^2 - m_3m_1^2)n_5^2$$

$$J_2 = (m_1^3 - 4m_1m_2m_3)n_5n_6$$

$$J_3 = (m_1^2m_2 - 4m_2^2m_3)n_6^2$$

$$J_4 = a^2(m_1^2 - 4m_2m_3)^2$$

When we substitute (16a), (16c), and (16d) into the firm's profit function, we obtain:

$$
\begin{aligned}
\text{profit} &= p_xx - rK - wL \\
&= p_xh_1(p_x, r, w, s) - rh_3(p_x, r, w, s) \\
&\quad - wh_4(p_x, r, w, s)
\end{aligned}
\tag{18}
$$

That is, (18) gives the firm's profit from the "CT" strategy as a function of output prices, input prices, and the terms at which output is exchanged for technology. For example, when (17a), (17b), and (17c) are substituted into the profit function. We obtain:

$$\text{Profit} = p_x^2 + (p_x(J/C)^{.5})s^{.5} - Us^{-.5} \tag{19}$$

where

$$U = \frac{2m_3n_5r^2 + (m_1n_6 + m_1n_5)rw + 2m_2n_6w^2}{a(m_1^2 - 4m_2m_3)(J/C)^{.5}}$$

In (19) we suppress the dependence of profit upon output and input prices because we are primarily interested in the impact upon profit of the terms at which technology is exchanged for output. Via the composite function theorem, profit is an increasing function of s, as we would expect. That is, as "s" increases (given a particular level of input-use) the firm can exchange less output for the needed technology, so that it can devote more inputs to the production of output for sale domestically, thus increasing revenue and profit.

By using (13) and (19) we can identify combinations of "a*" and "s" for which the "Trade-As-Usual" strategy is preferred, for which the "CT" strategy is preferred, and for which the two strategies "tie." Specifically, the "Trade-As-Usual" strategy is preferred if:

$$p_x^2 + (p_x(J/C)^{.5})s^{.5} \square\ Us^{\square .5} < M + (N_1 \square\ N_2)(1/a^*) \qquad (20)$$

the "CT" strategy is preferred if

$$p_x^2 + (p_x(J/C)^{.5})s^{.5} \square\ Us^{\square .5} > M + (N_1 \square\ N_2)(1/a^*) \qquad (21)$$

and, the two strategies tie if

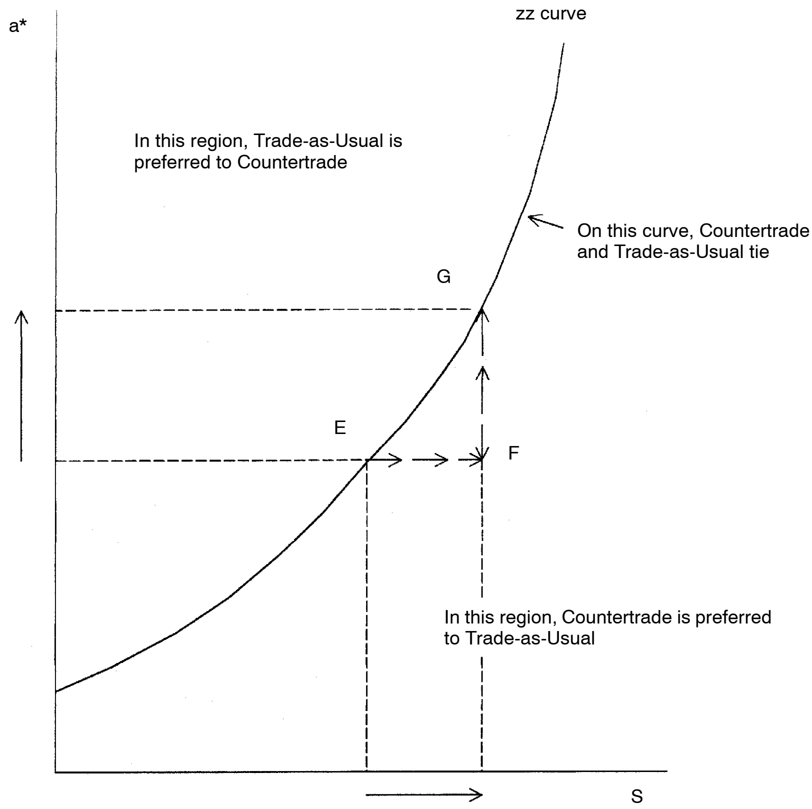
$$p_x^2 + (p_x(J/C)^{.5})s^{.5} \square\ Us^{\square .5} = M + (N_1 \square\ N_2)(1/a^*) \qquad (22)$$

These results are illustrated in Figure 5, where the "zz curve" is the locus of all combinations of a* (i.e., management's belief about the impact of imported technology upon the quantity of output which will be produced) and "s" (i.e., the implicit price at which output is exchanged for imported technology) for which "Trade-as-Usual" and "CT" are equally profitable. That is zz curve is the locus of combinations of a* and s for which equation (22) holds. Thus, the equation for the zz curve is given by:

$$a^* = (N1 \square\ N2)/(px^2 + (px(J/C)^{.5})s^{.5} \square\ Us^{\square .5} \square\ M)$$

Notice that the logic used to define the zz curve is similar to the

FIGURE 5



logic used to define IS-LM curves (e.g., the IS curve is the locus of all combinations of real income and the interest rate for which aggregate demand is equal to aggregate supply), and similar to the logic used to define Patinkin's "CC, BB, and MM curves."[10] Points below (to the right) the zz curve denote combinations of a* and s for which the "CT" strategy is preferred. To see this, suppose that the firm is originally operating at point E on the zz curve in Figure 5, so that management is indifferent between "Trade-as-Usual" and "CT." Now suppose that the trading partner agrees to supply technology to the firm in exchange for fewer units of output than it originally sought, thus increasing "s"[11], but that there is no change in management's belief about the impact of imported technology (i.e., suppose that we move to point F in Figure 5: an increase in s and no change in a*). Now, if the firm uses the "CT" strategy, it can do so by supplying less y, thus releasing resources for the production of x for domestic sale, thus increasing profit. However, the increase in s leaves the profitability of "Trade-As-Usual" unchanged, since when trading as usual the firm sells "good y" on the open market at price py, rather than countertrading "good y" at implicit prices. Therefore, at point F, countertrade will be more profitable than the "Trade-As-Usual" strategy.[12] Naturally, similar argument can be used to show that points above the zz (to the left) curve denote combinations of a* and s for which the "Trade-As-Usual" strategy is preferred.

To determine the sign of the slope of the zz curve, we consider how we must adjust a* (rather than s) to return the firm's management to a point of indifference between "Trade-As-Usual" and "CT." First note that an increase in a* means an increase in output which management believes can be produced using the imported technology and "given" quantities of other inputs. Boosting output while using the same quantities of inputs (and thus incurring the same costs) means increased profit. Hence increasing a* corresponds to increasing anticipated profit from "Trade-As-Usual." A change in a* has no impact upon the profitability of using "CT", since the impact of imported technology will be known if CT is used: this impact need not be anticipated. Second, return to point F, where "CT" is more profitable than "Trade-As-Usual." If we wish to alter a* to return to a situation in which "CT" and "Trade-As-Usual" are equally profitable, we must increase a* (thus increasing the anticipated profit from "Trade-As-Usual,") until it is equal to the new higher level of profit (due to increased s) obtained from countertrade, moving from point F to point G.[13] That is, the zz curve will have a positive slope.

We can also obtain this result with Calculus techniques:

Let Profit from countertrade = f(s) and Profit from "Trade-As-Usual = g(a*), so that combinations of s and a* on the zz curve satisfy:

$$f(s) = g(a^*) \tag{23}$$

Totally differentiating (23), we obtain

$$(\partial f(s)/\partial s)ds = (\partial g(a^*)/\partial a^*)da^*$$

so that we have:

$$da^*/ds = (\partial f(s)/\partial s)/(\partial g(a^*)/\partial a^*) \tag{24}$$

From the arguments of the previous paragraphs, we see that
$\partial f(s)/\partial s > 0$ (change in profit from the use of "CT," per unit change in s is greater than zero).
$\partial g(a^*)/\partial a^* > 0$ (change in profit from the use of "Trade-As-Usual," per unit change in a* is greater than zero). Therefore (24), which gives the slope of the zz curve, must be positive.

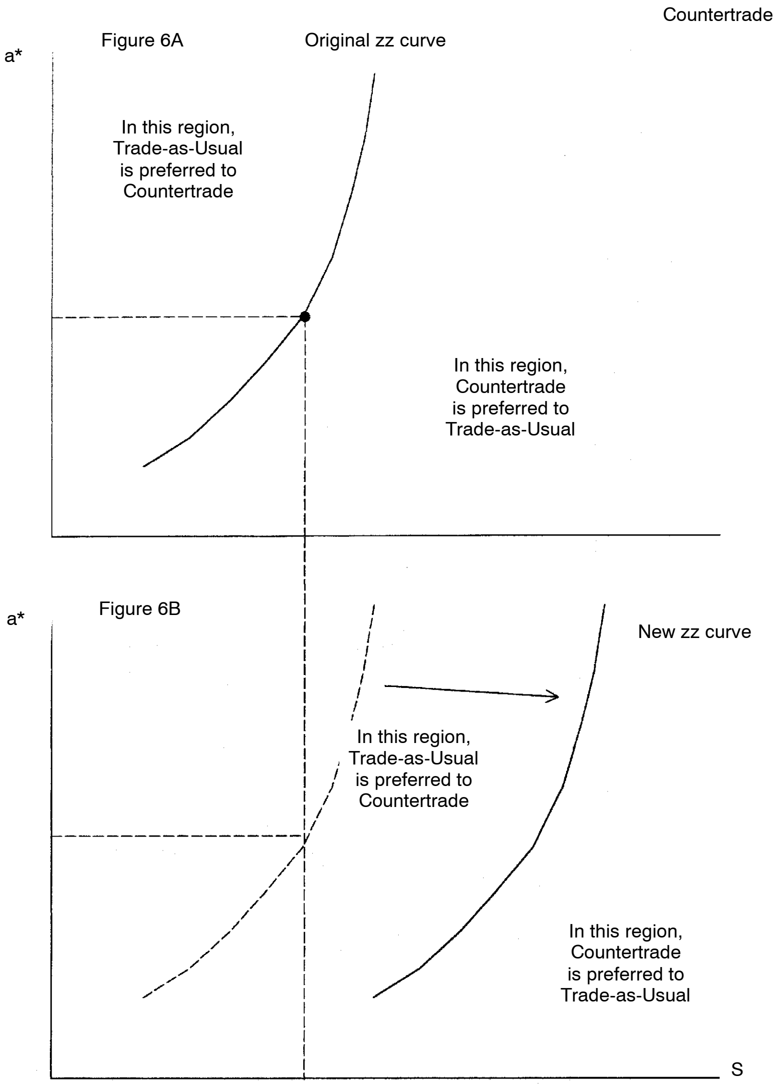
Changes in the other factors affecting profit from using "CT" and profit from "Trade-as-Usual" (e.g., w, r, the slopes and intercepts of the demand for x and demand for y functions) will shift the zz curve. For example, consider Figures 6A and 6B. Suppose that we are initially at point H in Figure 6A, so that the firm is indifferent between "CT" and "Trade-As-Usual." Next suppose that the demand for "good y" on the open market increases to the point at which the firm may set py above the value of s. Now the firm can obtain the funds needed to purchase the technology for the fewest units of "good y" by trading as usual, thus increasing its set of options and increasing the profitability of "Trade-As-Usual."[14] To illustrate this in Figure 6B, we need a new zz curve which puts point H into the region for which "Trade-As-Usual" is the most profitable strategy (i.e., the new zz curve must be to the right of the original zz curve).[15] The size and direction of the shifts will depend upon the precise form of the model being used.

SUMMARY AND CONCLUSIONS

After reviewing and summarizing the existing literature on CT, it was shown that attention has shifted from barter to other forms of CT such as buyback, counterpurchase and offset. Along with this shift, the need arose to recognize different motivations behind different types of CT transactions. As empirical studies grew in number and sophistication, some of the earlier hypotheses were shown to have very little empirical support. In particular, the view that "Countertrade is an archaic, inefficient, impractical way of doing business and that it replaces normal commercial trade" has been strongly challenged.

The main objective of the paper was to show that there may be reasons for alternatives to money mediated market exchanges. Changes in the nature of production and exchange in the last couple of

FIGURE 6


Countertrade
Figure 6A
Original zz curve
a*
In this region, Trade-as-Usual is preferred to Countertrade
In this region, Countertrade is preferred to Trade-as-Usual
Figure 6B
a*
New zz curve
In this region, Trade-as-Usual is preferred to Countertrade
In this region, Countertrade is preferred to Trade-as-Usual
S

decades have created new realities that affected decision making at the firm level. Among the changes, the most important for this paper was the increase in transaction costs due to uncertainty and informational asymmetry. To study the effects of uncertainty (and information asymmetry) on the firm's decisions, we utilized a single country economic model which was manipulated to derive the conditions under which countertrading would be preferred to the money-mediated trade strategy; the countertrade strategy would be inferior to the money-mediated trade strategy, and finally, the two strategies tie.

Furthermore, we showed what determines which particular strategy would be adopted, i.e., what parameters of the model would account for changing strategies facing the management team of a profit-maximizing firm. The most interesting result was that countertrading, to the extent that it acts to increase available information, can help increase the volume of trade and, thus, it can benefit both parties involved. CT may be used to escape uncertainty, and make a partial return to optimum profit. The upshot was that if a firm faces uncertainty and/or information asymmetry, its profit maximizing input and output mixes might be affected. Removing information constraints will enable the firm to move to a first best solution and increase its profits. Viewed from this perspective, CT, rather than representing retrogression from the present system of multilateral trade and payments, supplements money-mediated trade and thus contributes to the growth of international business. Therefore, CT, far from being inefficient and cumbersome way of doing business, may be a rational response to conditions that restrict standard trade.

ENDNOTES

1. Extension of this analysis to the production of many different goods and services using many different inputs is immediate. This model is easily extended to multi-period production. See, for example, Chapter 12 of Henderson, J. and R. Quandt, Microeconomic Theory: A Mathematical Approach, (3rd ed.), McGraw-Hill, 1980, where the authors use the technique of LaGrange Multipliers to extend the one-period models of earlier chapters to the multi-period situation.

2. To show this we proceed as follows. First, we note that we must use the "product rule" to evaluate $\partial(pxx)/\partial x$, because we are not in a perfectly competitive situation, so that p_x depends upon x. Thus, we have:

$$\text{(A) } MR_x = \partial\langle p_x x)/\partial x = p_x(\partial x/\partial x) + x(\partial p_x/\partial x)$$
$$= p_x + x(\partial px/\partial x)$$

Second, we note that, by definition, $e_x = (\partial x/\partial p_x)(p_x/x)$, so that (by the "inverse function theorem": see p. 106 of W. Fulks, Advanced Calculus (3rd. ed.), John Wiley and Sons, 1978; p. 352 of R. Buck, Advanced Calculus (3rd. ed.) McGraw-Hill, 1978; and/or p. 252 of W. Rudin, Functional Analysis, McGraw-Hill, 1973),

$1/e_x = (\partial p_x/\partial x)(x/p_x)$. Therefore, we have:

(B) $$(1/e_x)p_x = ((\partial p_x/\partial x)(x/p_x))p_x = (\partial p_x/\partial)x$$

Third, we substitute (B) into (A) obtaining

(C) $$MR_x = p_x + (1/e_x)px = (1 + (1/e_x))p_x$$

3. Notice that although the firm's manager may not know the value of "a," it is clear that "a" is not a random variable! Rather, "a" is a measure of the relationship between K and L on the one hand and z = x + y on the other hand. This relationship is defined by the physical laws that govern the production process. Since this relationship is governed by physical laws, "a" will be a constant, just like Newton's gravitational constant: "a" is clearly not random. Note also that to treat "a" as a random variable would imply that the use of unchanging quantities of K and L would lead to a randomly fluctuating amount of z, even if the firm's manager has no uncertainty about the distribution of "a." This is clearly not what we wish to imply by our choice of a production function.

4. Therefore, for example, if we are producing autos, then the autos that we export will be physically identical to the autos which we sell domestically, so that the marginal rate of transformation of autos for export into autos for domestic sale will be 1.0.

5. The isorevenue curve is the locus of all output combinations (i.e., combinations of x and y in this case) which yield the same total revenue (see p. 95 of Henderson, J. and R. Quandt, Microeconomic Theory: A Mathematical Approach (3rd. ed.), McGraw-Hill. If fixed amounts of inputs are available, then the firm must operate on or below a fixed production possibilities frontier (as shown in Figure 4). Clearly, if input-use is fixed, then total cost is fixed as well. Isorevenue curves progressively further and further from the origin correspond to progressively higher and higher levels of total revenue. Therefore, with input-use fixed, the firm can maximize profit by moving to the "mix of domestic versus export sales" which is on the highest isorevenue curve that can be attained (i.e., " . . . highest total revenue . . . "), while staying on or below the production possibilities frontier (i.e., " . . . for a specific level of total costs . . . "). See point C in Figure 4. Contrast point C with points A and B.

6. Management may have choice variables other than x, y, K, and L, yet the approach to the analysis will remain unchanged. For example, the firm may choose px, py (allowing demanders to determine x and y), K, and L.

7. See, for example, p. 150 of E. Zeidler, Nonlinear Functional Analysis and Its Application (vol. 1), Springer-Verlag, 1985; p. 283 of W. Fulks, Advanced Calculus (3rd. ed.), John Wiley and Sons, 1978; and/or p. 362 of R. Buck, Advanced Calculus (3rd. ed.), McGraw-Hill, 1978.

8. A slight extension of the following approach would enable us to handle situations in which some of the output earmarked for export is countertraded for technology, while the rest of this output is sold in export markets. We will present this extension in subsequent research.

9. For example, if the cost of the technology to be imported is $100, and if the nation which is selling the technology will accept 5 units of output for the technology, then the implicit price of output is s = $20.

10. See any macroeconomics text: for example chapters 9 and 10 of T. Dernberg, Macroeconomics, (7th ed.), McGraw Hill, 1985. Also, see D. Patinkin, Money, Interest, and Prices (2nd ed.), Harper and Row, 1965; Chapters IX through XIII.

11. For example, suppose that the cost of the imported technology is $100, and that initially the trading partner requests 20 units of "good y" in exchange for the technology. Then, initially, s is $5. Now suppose that the trading partner decides that it will ask for only 12 units of "good y" in exchange for the technology. This means that s, the implicit price of good y, increases to $8.33.

12. Notice that this argument is similar to the arguments used to demonstrate that aggregate supply exceeds aggregate demand for combinations of real income and the interest rate which lie above the IS curve, that the supply of money exceeds the demand for money for combinations of real income and the interest rate which lie above the LM curve, that the supply of bonds exceeds the demand for bonds for combinations of the price level and the interest rate which lie above Patinkin's BB curve . . ., etc. For example, consider the IS curve. If we start at a point on the IS curve and move to a point above the IS curve by increasing the interest rate while keeping aggregate supply (and thus real income) constant, then aggregate demand will fall (due to the interest rate increase), so that (with unchanged aggregate supply) we must have moved to an interest rate and real income combination for which aggregate demand is less than aggregate supply.

13. We cannot re-equate profit from countertrade and anticipated profit from "Trade-As-Usual" by reducing a*, since this will reduce the anticipated profit from "Trade-As-Usual" while leaving profit from countertrade unchanged. We could re-equate profit from countertrade and anticipated profit from "Trade-As-Usual" by reducing s to its original level, but doing this will not provide us any insight about the slope: both s and a* must be changed in order to obtain insight about the slope.

14. For example, suppose that initially the cost of the technology is $100, that the open market price of "good y" is $5 (so that 20 units of "good y" must be sold on the open market in order to obtain the funds needed to purchase the technology), that the trading partner will accept 10 units of "good y" in exchange for the technology, but that other conditions cause the firm to be indifferent between countertrade and Trade-As-Usual (i.e., the firm is on the zz curve). Now suppose that the demand for "good y" shifts to the right, enabling the firm to charge a price of $12.50 for "good y" in the open market. Now the firm can obtain the $100 needed to purchase the technology by selling only 8 units of "good y" on the open market, rather than by "countertrading" 10 units. This means that the firm has more opportunities than before (i.e., the "new" feasible set is larger than the "original" feasible set, and the "new" feasible set contains the "original" feasible set) if it adopts the "Trade-As-Usual" strategy (e.g., make only 8 units of "good y" and shift inputs to the produc-

tion of "good x," produce more "good y" than originally (since it is now selling at a higher price) selling the "excess" over and above 8 units on the open market, etc.), so the "Trade-As-Usual" strategy will be more profitable than countertrade, after the shift in the demand for "good y." That is, our original s and a* combination is now a point at which "Trade-As-Usual" is the most profitable strategy, so our "new" zz curve must put our original point in the "Trade-As-Usual" is a preferred region. That is, our new zz curve must lie to the right of our original zz curve.

15. Note that this reasoning is analogous to the reasoning used to explain shifts in IS curves, LM curves, Patinkin's CC, BB, MM curves, and so on. For example, consider the IS curve. If the nation's economy begins at an interest rate and real income combination which is ON the IS curve (i.e., aggregate demand is equal to aggregate supply), and if the nation engages in a fiscal stimulus, then (after the fiscal stimulus) our original interest rate and real income combination must be in the region for which aggregate demand exceeds aggregate supply (i.e., higher demand due to the fiscal stimulus, but same aggregate supply, since we haven't yet left our initial interest rate and real income (i.e., aggregate supply). To show this, we need a new IS curve for which our original interest rate and real income combination is in the "aggregate demand exceeds aggregate supply" region. Thus, the new IS curve must be to the right of the original IS curve.

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