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Do terms of trade have to worsen for developing countries? How low-income elasticity of demand affects the terms of trade in a laboratory market, in combination with the effect of market power

Michelitsch, Roland, Ph.D.

The University of Arizona, 1993

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Do Terms of Trade have to worsen
for developing countries?

How low income elasticity of demand affects the
terms of trade in a laboratory market,
in combination with the effect of market power.

by
Roland Michelitsch

A Dissertation Submitted to the Faculty of the

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In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

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How low income elasticity of demand affects the terms of

trade in a laboratory market in combination with the

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SIGNED: _____

A handwritten signature in cursive script, appearing to read "K. S. ...", is written over a horizontal line.

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To
Carmini

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ABSTRACT

A laboratory economy was created to test the influence of both market power and low income elasticity of demand on the terms of trade. The Prebisch-Singer "Theory of Unequal Exchange" predicts that terms of trade worsen for developing countries, due to low income elasticity of demand for their primary product exports. A model is presented to show that, ceteris paribus, the terms of trade improve with population growth and differential technological progress.

The effect of market power on the terms of trade was analyzed by comparing a 'competitive' market, a primary commodity cartel, and an industrial monopoly. The competitive (price taker) model predicts declining prices in both markets and worsening terms of trade as production grows. The cartel model predicts higher prices of the primary product, which increase as income grows, lower prices of the manufactured product, and better and improving terms of trade. The monopoly model predicts lower prices for primary commodities, higher and increasing prices in the market for manufactured products, and lower and worsening terms of trade.

Experimental Results:

Trading occurred in a multiple-unit double auction.

Prices usually converge from above in both markets. Only sellers succeed in exploiting their market power, buyers fail

to do so. In the competitive design, prices in both markets generally converge to the competitive equilibrium. The terms of trade worsen in all experiments as income grows (caused by the low income elasticity of demand), confirming the prediction of the Prebisch-Singer model.

The commodity cartels increase primary export prices, but cannot stop the decline of prices when income increases. They cannot decrease prices of the manufactured product. Terms of trade for the cartels are usually better and do not always worsen. Earnings of industrialized countries facing the cartel are lower than competitive, but earnings of the cartel members are not significantly higher.

The single industrial country fails to lower prices for primary products, but can charge higher prices for manufactured products. Terms of trade usually improve as income grows, contradicting both the competitive and the cartel model. When the monopoly faces a cartel, a substantial deadweight loss occurs.

1.

INTRODUCTION

This study created an economy in the laboratory that had some of the salient characteristics of an international economy. In this context, the interaction between market power and specific demand structures was analyzed. In the laboratory, market variables, which cannot be controlled in the international economy, can be held constant. This feature allows the investigation of the influence of specific factors on the terms of trade.

In the experimental setup the agents are industrialized countries and developing countries¹. Each country has consumption bundles of two commodities, X (the primary product) and Y (the manufactured product). Values of X and Y are derived from a specified preference structure and a resource endowment.

This experiment is not an attempt to re-create an international economic system. Nevertheless, important questions and theories can be studied in an environment much simpler than the world economy. If a theory cannot account for the data generated in the laboratory, the question arises

¹ For an attempt to capture the important features of an industry see Hong/Plott (1980): "Rate filing policies for inland water transportation: an experimental approach". Noussair/Plott/Riezman (1992): "An Experimental Investigation of the Patterns of International Trade" try to create a laboratory economy with some of the prominent features of an international economic system.

why the theory did not work and the theory may have to be modified or rejected. However, if the theory can explain the data generated in the experimental economy, results must be interpreted with the caveat that conditions are more favorable in the laboratory than in the field, especially because of the complexity of the world economy.

The less developed countries (LDCs) lag far behind industrialized countries in virtually all economic indicators. This gap is widening over time, at least in terms of absolute differences. GNP per capita -- admittedly only one of the important indicators of development -- differs dramatically. For 1990, GNP per capita was \$350 in the low-income countries and \$19,590 in the high income countries. Growth rates from 1965 to 1990 were 3% and 2.3% respectively². If those growth rates continued, the LDCs would catch up to the developed countries only in the year 2580.

From the late 1940s until the late 1960s dualistic models were used to explain the problems of LDCs and to derive policy implications for development (Lewis, Ranis and Fei, Jorgenson). The economy contained a modern capitalist exchange sector and a indigenous ('traditional') noncapitalist sector. Development was equated to moving resources from the traditional sector to the modern sector. This strategy

² Social Indicators of Development 1991-92, p. xvi and xvii.

followed from the alleged low marginal productivity of labor in the traditional sector. Total output of the economy can be increased by moving resources from the traditional to the modern sector until marginal productivities are the same in both sectors.

The goal of development policy thus is to facilitate movement of resources. Most analysts equated the capitalist sector with industry and the noncapitalist sector with traditional (subsistence) agriculture³. The potential positive role of agriculture in the development process was largely neglected. This view was reinforced by the empirical observation that agriculture's share in the economy declines during the course of the development, reflecting the low income elasticity of demand for food products. The view that the income elasticity is less than unity has been given the name "Engel's Law", after the German economist Ernst Engel, who observed as early as 1857 that "the poorer a family is, the greater the proportion of the total expenditures which must be used to procure food"⁴.

³ However, Lewis himself pointed out that this is not necessarily the case. See Staatz/Eicher (1990): "Agricultural Development Ideas in Historical Perspective", p. 5.

⁴ Engel as quoted in Schumpeter (1954): "History of Economic Analysis", p. 961.

1.1. The Theory of Unequal Exchange

Low income elasticity of demand was a key ingredient in the development of the Prebisch-Singer "Theory of Unequal Exchange". At approximately the same time, Raul Prebisch⁵ and Hans Singer⁶ developed an argument to show why terms of trade for the producers of primary commodities worsen over time. Prebisch saw industrialization as a necessary part of the process of improvement in per capita income. In Prebisch's view, a country specializing in the production of primary products (usually seen as the area of comparative advantage of LDCs) will be worse off than a country specializing in industrial products. The relative share of income spent on primary products has to decline because the income elasticity of demand for primary products is less than unity. Over time, the industrialized countries reap the fruits of growth in production because of the fall in the prices of primary products relative to those of manufactured products. Technical advance in primary production "defeats its own purpose"⁷ since at least part of the benefits are transferred

⁵ Raul Prebisch (1949): "ECLA Economic Survey 59, as cited in Love (1987): Raul Prebisch and the Origins of the Doctrine of Unequal Exchange", p. 90.

⁶ Singer (1950): "The Distribution of Gains Between Investing and Borrowing Countries", AER Papers and Proceedings 40 no. 2 (May 1950).

⁷ Prebisch (1959): "Commercial Policy in the Underdeveloped Countries", p. 252.

to the industrialized countries through lower prices for primary products. Technical advance in industrial production, on the other hand, benefits the industrialized countries relatively more because technological progress does not reduce prices for manufactured products to the same degree.

The policy implication Prebisch derived from this theory of unequal exchange was that an LDC should form manufacturing industries instead of following comparative advantage in the production of primary products. Pursuit of comparative advantage was myopic because the LDCs necessarily would lose in the long run from deterioration in the terms of trade.

1.2. Other Factors Affecting Terms of Trade

The development of the terms of trade is not affected only by the income elasticity of demand. Several other factors play an important role. To point out just a few, consider the following commodity market equilibrium condition:

$$Q_D(m, Pop, P) = Q_S(MC, P) \quad (1)$$

Q_D , the quantity demanded, is a function of nominal income (m), population (Pop) and price (P). Q_S , the quantity supplied, is a function of marginal costs (MC) and price.

The partial derivatives have the following signs:

$$\frac{\partial Q_S}{\partial P}, \frac{\partial Q_D}{\partial m}, \frac{\partial Q_D}{\partial POP} > 0; \quad \frac{\partial Q_D}{\partial P}, \frac{\partial Q_S}{\partial MC} < 0 \quad (2)$$

The signs are derived from the following assumptions: the supply curve is upward sloping, i.e. the quantity supplied increases as the price increases; demand increases as income increases, reflecting a "normal good" with positive income elasticity of demand; demand increases with population growth; the demand curve is downward sloping, i.e. the quantity demanded decreases as the price increases; and an increase in marginal costs shifts the supply curve upward to the left.

Taking total derivatives of both sides and rearranging terms leads to the following equation:

$$\left(\frac{\partial Q_S}{\partial P} - \frac{\partial Q_D}{\partial P} \right) * dP = \frac{\partial Q_D}{\partial m} * dm + \frac{\partial Q_D}{\partial POP} * dPOP - \frac{\partial Q_S}{\partial MC} * dMC \quad (3)$$

The coefficient on dP is greater than zero. The left hand side, the "change in price", is affected by the price elasticities of supply and demand.

The right hand side indicates the factors which influence price. The first term reflects the income effect on demand. As income increases, demand increases, given the assumption of a normal good. The partial derivative of the quantity demanded with respect to income is included in the income

elasticity of demand, the central parameter in the Prebisch-Singer theory. The higher the income elasticity of demand, the greater the (positive) change in price for that commodity (the importance of the income distribution is ignored in this model).

The second term shows the influence of population growth on demand. As population increases, total demand increases (this model does not account for the effects of demographic structure on demand). The third term accounts for the effects of technological change. As marginal costs decrease, the supply curve shifts to the right.

Equation (3) allows for a more detailed analysis of the terms of trade. "Terms of trade" refers to the net barter terms of trade (namely the relation between the unit price of the primary product and the unit price of the manufactured product). From equation (3) the following result for terms of trade can be derived (PP stands for primary products, MF for manufactured products):

$$dToT = \frac{dP^{PP}}{dP^{MF}} = \frac{\left[\frac{\partial Q_D^{PP}}{\partial P^{PP}} - \frac{\partial Q_S^{PP}}{\partial P^{PP}} \right]^{-1} \left[\frac{\partial Q_D^{PP}}{\partial m} * dm + \frac{\partial Q_D^{PP}}{\partial Pop} * dPop - \frac{\partial Q_S^{PP}}{\partial MC^{PP}} * dMC^{PP} \right]}{\left[\frac{\partial Q_D^{MF}}{\partial P^{MF}} - \frac{\partial Q_S^{MF}}{\partial P^{MF}} \right]^{-1} \left[\frac{\partial Q_D^{MF}}{\partial m} * dm + \frac{\partial Q_D^{MF}}{\partial Pop} * dPop - \frac{\partial Q_S^{MF}}{\partial MC^{MF}} * dMC^{MF} \right]} \quad (4)$$

Change in the development of the terms of trade depends

not only on the income elasticities of demand, but also on the price elasticities of supply and demand, population growth and technological progress. Technological progress for manufactured products often is assumed to be faster, which would tend to improve the terms of trade. Population growth usually is assumed to have a greater effect on demand for primary products than on demand for manufactured products, thus improving the terms of trade.

Assuming no change in population and in technology ($dPop = 0$ and $dMC = 0$), equation (4) simplifies to:

$$dT_{OT} = \frac{dP^{PP}}{dP^{MF}} = \frac{\left(\left[\frac{\partial Q_D^{PP}}{\partial P^{PP}} - \frac{\partial Q_S^{PP}}{\partial P^{PP}} \right]^{-1} * \left[\frac{\partial Q_D^{PP}}{\partial m} * dm \right] \right)}{\left(\left[\frac{\partial Q_D^{MF}}{\partial P^{MF}} - \frac{\partial Q_S^{MF}}{\partial P^{MF}} \right]^{-1} * \left[\frac{\partial Q_D^{MF}}{\partial m} * dm \right] \right)} \quad (5)$$

Rearranging leads to:

$$dT_{OT} = \frac{dP^{PP}}{dP^{MF}} = \frac{\left(\frac{\partial Q_S^{PP}}{\partial P^{PP}} * \frac{P^{PP}}{Q_S^{PP}} - \frac{\partial Q_D^{PP}}{\partial P^{PP}} * \frac{P^{PP}}{Q_D^{PP}} \right)^{-1} * P^{PP} * \frac{\partial Q_D^{PP}}{\partial m} * \frac{m}{Q_D^{PP}} * dm}{\left(\frac{\partial Q_S^{MF}}{\partial P^{MF}} * \frac{P^{MF}}{Q_S^{MF}} - \frac{\partial Q_D^{MF}}{\partial P^{MF}} * \frac{P^{MF}}{Q_D^{MF}} \right)^{-1} * P^{MF} * \frac{\partial Q_D^{MF}}{\partial m} * \frac{m}{Q_D^{MF}} * dm} \quad (6)$$

Let ϵ_s (ϵ_D) denote the price elasticity of supply (demand), ϵ_I the income elasticity of demand and ϵ_{TOT} the elasticity of terms of trade. Equation (6) simplifies to:

$$\epsilon_{TOT} = \frac{dTOT}{TOT} = \frac{\partial P^{PP}}{\partial P^{MF}} * \frac{P^{MF}}{P^{PP}} = \frac{(\epsilon_S^{PP} - \epsilon_D^{PP})^{-1} * \epsilon_I^{PP}}{(\epsilon_S^{MF} - \epsilon_D^{MF})^{-1} * \epsilon_I^{MF}} \quad (7)$$

Thus, *ceteris paribus*, an income elasticity of demand for primary products (manufactured products) of less (greater) than unity leads to a deterioration in terms of trade.

1.3. Empirical Analysis of the Terms of Trade

Prebisch and Singer supported their hypothesis about deterioration of the terms of trade with empirical data. Prebisch analyzed the terms of trade of the United Kingdom for the period 1876-80 to 1946-47. Great Britain was mainly an exporter of manufactured products and importer of primary products. Terms of trade thus were expected to improve for Great Britain. Singer cited data for the time after 1950, excluding petroleum after 1973⁸.

Numerous problems arise in evaluating the development of the terms of trade over time and authors differ about the behavior of the terms of trade for primary products.

One problem for empirical estimation is the choice of the initial and the terminal year. Singer was criticized for using 1950 as an initial year because prices were unusually

⁸ Both cited in Balassa (1989): "Outward Orientation", p. 1653.

high at the beginning of the Korean war. He was further criticized for using a terminal year when prices for nonfuel primary products were generally low (due to the negative impact of the first oil price shock on economic activity)⁹. Subsequent studies have shown inconclusive results or reached the opposite conclusion -- terms of trade improved for primary products¹⁰.

Another problem for estimation is that imports of primary products are usually valued at cif (cost-insurance-freight) prices, whereas exports are valued at fob (free on board) prices. Prebisch, for example, used the ratio of fob export unit values to cif import unit values to estimate the terms of trade for Great Britain. This procedure was criticized by Ellsworth¹¹, who pointed out that the improvement of terms of trade for Great Britain between 1876 and 1905 is explained by a reduction of transportation costs (which affected cif but not fob prices). If transportation costs are taken into account, the terms of trade even improved slightly for primary

⁹ See Balassa (1989): "Outward Orientation" p. 1653ff, also for the subsequent paragraph.

¹⁰ Maizels (1963): "Industrial growth and world trade"; Spraos (1980): "The statistical debate on the net barter terms of trade between primary commodities and manufactures"; all cited in Balassa (1989): "Outward Orientation".

¹¹ Ellsworth (1956): "The terms of trade between primary producing and industrial countries".

products¹².

A further difficulty in evaluating the terms of trade is the changing quality of products over time. Quality improvements tend to favor manufactured products: "copper remains copper, cotton remains cotton, and wheat remains wheat, while an automobile, a rubber tire, a radio, an antibiotic, either did not exist at all or was entirely different, less durable, and an infinitely less serviceable commodity in earlier periods"¹³. This view is exaggerated, since the quality of some primary products has improved. In some cases quality of manufactured products has deteriorated (for instance in terms of durability).

Unit values are usually derived as a ratio of value to weight. This procedure also favors manufactured goods, since there has been a shift over time to lighter materials. The best example for changes in quality and weight is probably the computer industry, where 6 pounds of computer in 1950 are not comparable to a present-class notebook computer with a 486 processor. Technological progress in the computer industry (or decrease in marginal costs) was probably faster than in any other industry. The model developed above predicts

¹² The ratio of fob to cif prices could show that the terms of trade improve for both trading partners in the event of transportation costs declines.

¹³ Haberler (1961): "Terms of trade and economic development"

correctly a decrease in the relative price of computers. Yet prices per unit weight need not show a decline.

This phenomenon leads to the problem of indices. An index is needed to take care of the problems of quality and weight changes over time and to represent a "general" price level for manufactured and for primary products, respectively. Therefore, prices of individual commodities have to be weighted. The choice of such indices is difficult and quite subjective. Several indices have been used in empirical studies¹⁴ and yield conflicting results, i.e., a negative trend in the terms of trade with one index is reverted to a positive trend with a different index¹⁵.

More difficulties arise because many variables cannot be controlled. Technological change and the availability and quality of substitutes and complements can have a major impact on (relative) prices. Any shock affecting supply and demand (like political situations, wars, drought, population growth) makes the determination of influences on the terms of trade difficult.

¹⁴ For instance the U.N. price index for the world exports of primary products other than petroleum, the World Bank's index for thirty-three nonfuel commodities, with further adjustments for quality changes.

¹⁵ Balassa (1989): "Outward Orientation", p. 1654.

1.4. Market Power

Another reason cited for the poor performance of LDCs is the market power of the "center" (the industrialized countries). Prebisch pointed out that the United Kingdom was the "world's principal dynamic center"¹⁶ in the 19th century, a role later taken over by the United States. During and immediately following World War II, when the Prebisch-Singer theory was developed, the United States played a central role as trading partner for the Latin American countries¹⁷. Even though the U.S. dominance did not last long¹⁸, it influenced policy suggestions and political action substantially, especially in Latin America. Today, concern about market power focusses more on transnational corporations (TNCs). Intensification of intra-regional trade¹⁹ and the formation of cartels for primary products were suggested as ways to counterbalance market power of the center.

Several commodity cartels have been established, the most

¹⁶ Prebisch (1959): "Commercial Policy in the Underdeveloped Countries", p. 266

¹⁷ Sheahan (1987): "Patterns of Development in Latin America", p. 163

¹⁸ Bairoch (1975): "The Economic Development of the Third World since 1900", p. 103

¹⁹ for instance through the formation of a Central American Common Market, the Latin American Free Trade Association (LAFTA) and the Andean Group; see Furtado (1976): "Economic Development of Latin America", p. 154

famous of which is the Organization of Petroleum Exporting Countries (OPEC). OPEC faced favorable conditions for establishing a cartel: demand for oil was inelastic, at least in the short run; when OPEC was formed, a large proportion of production was controlled by a few countries; and oil is a relatively homogenous commodity with little room for competition in terms of offering higher quality. Nevertheless, OPEC did not maintain output share and price at the high levels of 1973. OPEC's share in world production fell from 68% in 1973 to 40% in 1985. Nominal prices fell from a peak of \$34 in 1980 to \$13 by 1986²⁰.

Some authors argue that the increase in prices was not caused necessarily by the formation of the cartel but maybe by a failure of the property right system for oil²¹.

At the end of the Second World War, international oil companies controlled the production and marketing of oil from the Persian Gulf countries²². They owned the oil but did not have ownership of the reserves. Thus a property right failure

²⁰ Balassa (1989): "Outward Orientation", p. 1661.

²¹ Smith (1984): "Property Rights in Natural Resources: Institutions and Ideologies", p. 413. OPEC was formed in 1960, long before the first oil price shock. Prices for Persian Gulf oil fell from \$2.22 per barrel in 1947 to \$1.10 in 1969. OPEC also never succeeded in establishing a controlled production quota system.

²² See Smith (1984): "Property Rights in Natural Resources: Institutions and Ideologies".

occurred, where companies acted according to the "rule of capture", not taking into account the future value of reserves. For the oil companies the value of reserves was zero, providing them with an incentive to flood the world market with oil.

Starting in the 1970s production decisions were made by the owners of the reserves. This change provided an incentive to reduce production from previous levels under rule of capture, causing an increase in prices. As Smith points out: "None of us knows whether OPEC, as a price-rigging cartel, had any effect on this price increase. But we do know that each member of OPEC had an independent competitive market incentive to lower output."²³

Numerous commodities have been considered for cartellization, including copper, tin, bauxite, phosphates, rubber, tropical timber, coffee, tea, cocoa, bananas and metals.²⁴ Cartels to "stabilize" prices include the International Coffee Agreement (ICA), the Intergovernmental Council of Copper Exporting Countries (CIPEC), and the Union of Banana Exporting Countries (UPEB). The ICA "may have

²³ Smith (1984): "Property Rights in Natural Resources: Institutions and Ideologies", p. 414.

²⁴ Balassa (1989): "Outward Orientation", p. 1660, citing several sources.

raised prices somewhat"²⁵, but this might have been caused by Brazil unilaterally reducing its output so as to maximize profits²⁶. Despite the presence of several cartels none of them has completely achieved their goals. One might even argue that "thus far, there have been no successful cartels ..."²⁷.

1.5. The Advantages of an Experimental Examination of the Development of Terms of Trade

The main advantage of the application of experimental methods is the possibility to control variables which cannot be controlled in the field. Valuations of the commodities can be held constant, so the problem of special factors influencing supply and demand conditions in the initial or terminal year does not arise. There are no fluctuations in the transportation cost, since such costs can be held constant (at zero) in an experimental market. There are no changes in qualities and/or weights of products. The actors in the experiments are trading fictitious commodities of constant quality over time, reflected by induced valuations for the

²⁵ Balassa (1989): "Outward Orientation", p. 1661.

²⁶ See Van Duyne (1975): "Commodity Cartels", p. 608f, who argues that Brazil, with 34% share of the world production, sets prices, prices for other coffees adjust to clear the market and Brazil supplies the residual demand.

²⁷ Balassa (1989): "Outward Orientation", p. 1661.

commodities which do not change over time.

In an experimental market conditions favorable for the cartel can be established. The homogenous (fictitious) product has no substitutes and a small number of producers who control the entire production. There is no threat of entry -- in the experimental market, high prices do not attract new producers (usually a major problem for a cartel). Communication among producers can be established at very low "cost" by convening before each period and by typing messages and sending them through a computer network. The agreements cannot be monitored by the industrialized countries.

Cheating on an agreement can be observed by all producers of the commodity (even though monitoring is "costly"). However, the incentive structure stays the same, a multi-person prisoner's dilemma game. It is in the best interest of each single producer to let the other producers cut back their production to keep up the price; this single producer then can increase production to maximize profits. At the same time, if all producers follow this strategy and increase production all are worse off than with the profit maximizing quantity for the cartel.

2.

THE THEORETICAL MODEL

There are two goods in the laboratory economy, good X (the primary commodity) and good Y (the manufactured commodity). Developing countries are endowed with a certain amount of the primary product, Wx_1 . Industrialized countries are endowed with a certain amount of the manufactured commodity, Wy_1 .

Valuations are derived starting from the assumption of an income elasticity of demand for primary products of less than unity. This feature can be represented by Engel curves which reflect that as income grows a relatively smaller proportion of that income is spent on primary commodities (X). One Engel curve in parameterized form which is relatively general is the following:

$$E_x = \alpha * p_x^{1-\beta} * m^\beta \quad (1)$$

E_x is the expenditure (as a function of prices and income) on good X, α and β are parameters, p_x is the price of good X and m is the income. An additional condition is that E_x has to be less than or equal to m (at most all income can be spent on good X). For the region where E_x would be greater than m -- according to this formulation -- E_x is assumed to be equal to m . This reflects for instance lexicographic preferences in that region: up to a certain level of income

all this income is spent on good X (the primary product, for example food).

The Marshallian demand for good X is simply E_x divided by p_x , thus:

$$x = \alpha * p_x^{-\beta} * m^\beta \quad (2)$$

One property of the expenditure function (as a function of prices and utility)¹, $e(p_x, p_y, u)$, is that the partial derivative with respect to p_x is equal to the Marshallian demand:

$$\frac{\partial e(p_x, p_y, u)}{\partial p_x} = x(p_x, p_y, m) = \alpha * p_x^{-\beta} * m^\beta \quad (3)$$

Acknowledging the equality of m and $e(p_x, p_y, u)$ at the optimum, results in:

$$\frac{\partial e(p_x, p_y, u)}{\partial p_x} * e(p_x, p_y, u)^{-\beta} = \alpha * p_x^{-\beta} \quad (4)$$

Integrating (holding p_y and u constant) gives the following result:

¹ Note that the expenditure function is different from E_x , the Engel curve, which is a function of prices and income.

$$e(p_x, p_y, u)^{(1-\beta)} = \alpha * p_x^{1-\beta} + K \quad (5)$$

K is a constant of integration. Note that K has to be a function of p_y and u . From homogeneity of degree one in prices of the expenditure function it follows that the coefficient on p_y has to be equal to the coefficient on p_x , namely $(1 - \beta)$:

$$K = \theta(p_y, u) = p_y^{1-\beta} * \phi(u) \quad (6)$$

Any function of u with a positive first derivative would represent the same preferences, one simple possibility is $\phi(u) = u$. Using again the equality of $e(p_x, p_y, u)$ and m , as well as the equality of the direct utility function $u(x, y)$ and the indirect utility function $v(p_x, p_y, m)$ the following equations can be derived:

$$e(p_x, p_y, u) = [\alpha * p_x^{1-\beta} + p_y^{1-\beta} * u]^{\frac{1}{1-\beta}} = m \quad (7)$$

$$u = \left(\frac{m}{p_y}\right)^{1-\beta} - \alpha * \left(\frac{p_x}{p_y}\right)^{1-\beta} = v(p_x, p_y, m) \quad (8)$$

From the Marshallian demand function and the budget constraint:

$$p_x * x + p_y * y = m \quad (9)$$

it follows that:

$$\left(\frac{p_x}{p_y} \right) = \frac{y}{\left(\frac{x}{\alpha} \right)^{\frac{1}{\beta}} - x} \quad (10)$$

$$\left(\frac{m}{p_y} \right) = y * \frac{\left(\frac{x}{\alpha} \right)^{\frac{1}{\beta}}}{\left(\frac{x}{\alpha} \right)^{\frac{1}{\beta}} - x} \quad (11)$$

Thus one of the possible induced utility functions (any function thereof with a strictly positive first derivative will produce the same preferences) has the following format:

$$u(x, y) = \alpha * y^{1-\beta} * \left[\alpha^{-\frac{1}{\beta}} - x^{-\frac{1-\beta}{\beta}} \right]^{\beta} \quad (12)$$

This is the utility function only for an interior solution, i.e. both x and y are positive. As pointed out earlier, up to a certain point (for example minimal food consumption for survival) all income is spent on good X , thus, in this region, preferences can be represented by a

lexicographic preference ordering.

For an interior solution, the marginal utilities of x respectively y are:

$$u_x = \alpha * (1-\beta) * x^{-\frac{1}{\beta}} * y^{1-\beta} * \left[\alpha^{-\frac{1}{\beta}} - x^{-\frac{1-\beta}{\beta}} \right]^{\beta-1} \quad (13)$$

$$u_y = \alpha * (1-\beta) * y^{-\beta} * \left[\alpha^{-\frac{1}{\beta}} - x^{-\frac{1-\beta}{\beta}} \right]^{\beta} \quad (14)$$

Thus the marginal rate of substitution between x and y is:

$$MRS_{xy} = \frac{u_x}{u_y} = \frac{x^{-\frac{1}{\beta}} * y}{\alpha^{-\frac{1}{\beta}} - x^{-\frac{1-\beta}{\beta}}} = \frac{y}{\left(\frac{x}{\alpha} \right)^{\frac{1}{\beta}} - x} \quad (15)$$

In equilibrium the marginal rate of substitution has to be equal to the price ratio p_x/p_y , using this condition and the budget constraint (equation 9) closes the circle back to the Marshallian demand for good X .

From the Marshallian demand the income elasticity of demand for good X can be derived, it is simply:

$$\epsilon_I^x = \frac{\partial X}{\partial m} * \frac{m}{X} = \beta \quad (16)$$

Thus the parameter β has to be less than one in order to

fulfill the condition that income elasticity for primary products is smaller than unity. Note that the expenditure on good Y is the residual expenditure: income minus expenditure on good X. Marshallian Demand for good Y is thus:

$$y = \frac{m}{p_y} - \alpha * p_x^{(1-\beta)} * p_y^{-1} * m^\beta \quad (17)$$

The income elasticity of demand for good Y is consequently:

$$\epsilon_I^y = \frac{m^{1-\beta} - \alpha * p_x^{(1-\beta)} * \beta}{m^{1-\beta} - \alpha * p_x^{(1-\beta)}} = \frac{m - \beta * p_x * X}{m - p_x * X} \quad (18)$$

3. THE EXPERIMENTAL DESIGN

3.1. Environment

In all designs four developing countries participated. In some designs (I and II) only one industrialized country participated, which is then a monopsony in the X market and a monopoly in the Y market. In other designs (III and IV) there were also four industrialized countries. Despite the fact that the main interest of this study are the net barter terms of trade, in other words how many units of good X are exchanged for good Y, experimental money has been introduced in all designs. In every period, each agent (i) is endowed with a certain amount of money, M_i . This amount should not be regarded as a budget constraint. It is sufficient to cover all reasonable transactions. It can be viewed as (relatively) unlimited borrowing for purchases. This experimental money had real value in the sense that at the end of the experiment all experimental currency was exchanged into dollars, as payoff for the participation in the experiments. The exchange rate from experimental money to dollars is known only privately to the acting agents. Varying the nominal payoffs and the exchange rate, as well as the money endowment by multiplying them with the same factor is also useful for disguising an identical environment when agents are brought back as experienced subjects. The main reasoning for introducing money was that it helps the process of

equilibration¹ and it serves as a medium of exchange. This last feature is especially important, since without money problems of indivisibility of commodities would occur. Note that with the introduction of money the maximization problem changes slightly, since payoff is derived from both utility (from holding good X and good Y at the end of a period) as well as from trading. Thus a developing country will maximize:

$$\Pi_i = u(x_i, y_i) + p_x * (Wx_i - x_i) - p_y * y_i \quad (1)$$

An industrialized country will maximize:

$$\Pi_j = u(x_j, y_j) - p_x * x_j + p_y * (Wy_j - y_j) \quad (2)$$

Wx_i (Wy_j) is the resource endowment with good X (Y) of a developing (industrialized) country.

The constraints to the maximization problems are non-negativity of the final allocation, x_i and y_i (respectively x_j and y_j). In addition to that, there are the budget constraints (as noted earlier, M_i is chosen such that it is not binding) for the developing countries:

¹ Money is an "obvious feature of any well-functioning market process". Noussair/Plott/Riezman (1992): "An Experimental Investigation of the Patterns of International Trade", p. 3

$$M_i \geq p_y * y_i - p_x * (Wx_i - x_i) \quad (3)$$

and for the industrialized country (or countries):

$$M_j \geq p_x * x_j - p_y * (Wy_j - y_j) \quad (4)$$

Assuming price taking behavior (p_x and p_y are seen as constant by both countries), a somewhat more stringent result than the equality of the marginal rate of substitution (MRS_{xy}) and the price ratio (p_x/p_y) can be derived for the competitive equilibrium. Since utility is expressed in monetary terms, in equilibrium the marginal utility of x (u_x) has to equal the price of x (p_x) and the marginal utility of y (u_y) has to equal the price of y (p_y). Therefore it was possible to test separately in each market whether prices converged to the equilibrium.

One problem that arises in this experimental design is that participants can go bankrupt. Two measures helped to avoid incentive problems (since experimental subjects can not be asked to pay debts they accumulated in the experiment). Subjects were given a starting capital of \$5 which they could lose by making poor decisions (in this case if they pay more for a good than its marginal utility to them) and subjects only received their payoffs at the end of a series of experiments, which made it very unlikely that the total payoff over all experiments was negative, and indeed the lowest

payoff was more than \$9.

In addition to that subjects were trained several times, in the beginning without salient rewards.

3.2. Parameterization

The same preferences can be represented by any strictly increasing transformation of the utility function presented in equation (19). For the experiments a linear transformation of the form:

$$u(x, y) = \delta + \gamma * \alpha * y^{1-\beta} * \left[\alpha^{-\frac{1}{\beta}} - x^{-\frac{1-\beta}{\beta}} \right]^{\beta} \quad (5)$$

was chosen. The parameters were chosen to be:

$\alpha = 0.9$, $\beta = 0.8$, $\gamma = 2000$, $\delta = 100$. The choice of the parameter β is especially important. It is the income elasticity of demand. Estimates of the income elasticity of demand for primary products differ vastly. For the laboratory market 0.8 was chosen, the parameter Prebisch's used for the numerical example in his original paper². Note that this utility function can only be derived for an interior solution (i.e. $x > 0$ and $y > 0$). As mentioned earlier, up to a certain point all income is spent on the primary product, X. In this region, where y equals zero, preferences can be represented by

² Prebisch (1959): "Commercial Policy in the Underdeveloped Countries", p. 253

a lexicographic preference ordering. The same choice behavior would be observed if an individual only cares about good X. The following functional form was chosen to represent these preferences:

$$u(x, y) = \eta * x^\mu \quad (6)$$

with the parameters $\eta = 300$ and $\mu = 0.25$. Utility was set to zero (reflecting for instance starvation) where X was zero. See the appendix for a table with the payoffs for different combinations of final holdings of x and y as well as two tables with the marginal utilities of x respectively y, given certain holdings of the other commodity. All three of these were given to the subjects and explained to them during the training session and again at the beginning of each experiment. All payoffs are in experimental Shillings, which are converted into U.S. dollars at a certain rate. The only difference between the tables used in the training session and the ones used in the subsequent experiments is that they are multiplied by a constant factor to avoid the fixation on an equilibrium price of a previous experiment. Multiplying the conversion rate by the same factor as the payoff table leaves the environment unchanged, except for the equilibrium prices which vary by the same factor.

The following four different designs were chosen:

TABLE 1.: Experimental Designs		
	Four Developing Countries Without Communication	Four Developing Countries With Communication
Single Industrialized Country	Design I (4 Experiments)	Design II (1 Experiment)
Four Industrialized Countries	Design III (4 Experiments)	Design IV (4 Experiments)
Phases within designs I, III and IV:		
	Phase 1	Phase 2
Trainer	Low Income	No second phase
Inexperienced	Low Income	High Income
Experienced	Low Income	High Income
In design II, subjects who had gained experience in designs I and IV participated in a first (low income) and second (high income) phase.		

In design I, the four developing countries face a single industrial country (monopoly/monopsony); in design II, the four developing countries form a cartel and face a single industrial country; in design III, the four developing countries face four industrialized countries. Neither side has market power; in design IV, the four developing countries form a cartel and face four industrialized countries.

Four experiments were conducted in designs I, III and IV. Each experiment consisted of a 'trainer', an inexperienced and

Each experiment consisted of a 'trainer', an inexperienced and an experienced session. The one experiment in design II was conducted with subjects who had gained experience in designs I and IV.

The sessions with inexperienced and experienced subjects in designs I, III, and IV and the one experiment in design II consisted of a low income phase, followed by a high income phase.

Trainer: The trainer was used to familiarize subjects with the trading institution, the payoff tables and the accounting procedures. To learn the trading institution, subjects went through a computerized training program, which allowed them to trade with computerized traders. Subjects received L-shaped squares, which allowed them to easily identify profitable trades in each market, given their current holding of X and Y. These squares provided the following information: "It is profitable to buy below ...", pointing to the marginal value of an additional unit in that market. "It is profitable to sell above ...", pointing to the marginal value of the last unit owned. Copies of the squares are printed in the appendix. After the computerized training program subjects participated in three to six training periods with the exact same features as the actual two experiments in which they participated during the subsequent two sessions. They did not receive any payoff for the first round of the

trainer. Subjects also had the possibility to practice the communication option the MUDA software offers for subjects in design IV, in which communication is allowed. However, during the trainer in design IV the subjects were not allowed to talk before each period. This was done because oral communication was thought of as not needing practice. During the training periods subjects had extensive opportunity to ask questions as well as to check the correctness of their accounting. During the first two periods of the trainer the accounting of all subjects was checked, later only questions answered. However, the accounting was verified before subjects came back for the subsequent session.

Data from the practice sessions was not evaluated, the only purpose of the trainer was to prepare the subjects for the subsequent sessions of the experiment.

3.3. Different Designs and the Competitive Equilibrium

After the trainer, subjects participated in two more sessions, first as inexperienced, then as experienced subjects. As mentioned above these experiments utilized the same payoff tables as in the five periods at the end of the training session, except for the fact that the payoff tables and the conversion rate from experimental Shillings to U.S. dollars were multiplied by the same factor (for the second session by a factor of two, for the last session by a factor

of 0.5^3).

Both inexperienced and experienced subject groups went through two phases. In the second one, the endowment (of both the industrialized country and the LDCs) was doubled in order to achieve a substantial effect on the equilibrium predictions, due to the lower income elasticity of demand for the primary product (X). The endowments were chosen to be originally $W_x = 5$ (second phase: $W_x = 10$) for the LDCs and $W_y = 10$ (20) for the industrialized country (IC) in designs I and II. When the number of ICs is increased from one to four, not everything else can be held constant. It was chosen to hold the competitive equilibrium allocation per country constant (namely $A_x = 4$ and $A_y = 2$ in the first phase and twice the amount in the second phase), which also fixes the equilibrium price ratio. However, the endowments per country (W_x resp. W_y) have to be adjusted. They were $W_x = 8$ (16) for LDCs and $W_y = 4$ (8) for industrialized countries in designs III and IV. The only difference between designs I and II (as well as between III and IV) is the possibility for the LDCs to form non-binding agreements.

Table 2. gives an overview of the parameterization of different experiments as well as the allocations, prices, and

³ Except for experiment 1 in design I: the payoff tables for the third session were not ready then. Subjects received therefore the same payoff tables as in the trainer.

trading quantities which would occur given a competitive equilibrium in which all agents act as price takers.

Des.	Wx	Wy	Ax	Ay	Px	Py	ToT	Qx	Qy
I	5	10	4	2	74-	89-	0.54-	4	8
II	(10)	(20)			105	137	1.18	(8)	(16)
III	8	4	(8)	(4)	(37	(67	(0.45	16	8
IV	(16)	(8)			43)	82)	0.64)	(32)	(16)

The numbers in parentheses are the values for phase two, when the resource endowments (Wx resp. Wy) are doubled.

3.4. The Effects of Market Power

In table 3. the different results when a country (or multiple countries) uses its (their) market power are presented. In design I, the case of the industrialized country (IC) using its monopoly power is displayed. In design II, both the IC and the LDCs with the possibility to form a cartel can potentially exert market power. Multiple equilibria are possible. The following two extremes can be compared. The case where the industrialized country exerts its market power and the LDCs act as price takers is the one presented in design I.

The maximization problem for the cartel is the following:

$$\frac{\text{Max.}}{\text{w. r. t. } x_i, y_i} \sum_{i=1}^4 u(x_i, y_i) + p_x * (Wx_i - x_i) + p_y * y_i \quad (7)$$

Note that both p_x and p_y are also functions of the sum of both x_i and y_i .

Table 3. contains the results if in design II the LDCs act as cartel, and the industrialized country acts as a price taker.

For design IV the results for a cartel of the LDCs versus price taking industrialized countries is presented. The abbreviations TSP for total surplus and CESP for surplus in the competitive equilibrium have been used.

The problematic incentive structure for the cartel is very well illustrated. For instance in design II, phase one the price the cartel charges for selling one unit of good X is 531. However, only one of the four LDCs can sell this unit, the marginal cost of which is only 74. Thus there is a very strong incentive for the LDCs to undercut the price. At a price of 36 for the Y good it would be profitable for any single LDC to purchase 6 more units. The optimal outcome for a single LDC is if all the other LDCs restrict their purchases in the Y market to keep the price of Y low and this single LDC maximizes its profit given these sales decisions.

TABLE 3.: THE EFFECTS OF MARKET POWER

		Prices		Industrialized Country (-ies)				Developing Countries				Surplus	
Design	Phase	p_x	p_y	x_i	y_j	$u(x,y)$	Payoff	x_i	y_i	$u(x,y)$	Payoff	TSP	CESP
I	1	64	599	4	6	1420	3560	4	1	1023	488	5512	5800
	2	27	705	8	16	2032	4636	8	1	1210	559	6872	7820
II	1	531	36	1	2	531	288	5 4	2 2	3) 1234 1) 1160	1162 1619	5393	5800
	2	461	27	2	7	1114	543	10 10 9	4 3 3	1) 1633 1) 1547 2) 1517	1525 1466 1897	7328	7820
III	1	90	113	4	2	1160	1028	4	2	1160	1292	9280	9280
	2	40	75	8	4	1564	1542	8	4	1564	1586	1251	12512
IV	1	358	67	2	2	889	307	6	2	1291	1873	8720	9280
	2	431	35	2	5	1048	291	14	3	1637	2394	1074	12512

- Design I shows the effect of the IC exercising its monopoly power.
- Design II shows the effect of a successful cartel. Not all LDCs end up with the same final allocation.
The number with parenthesis in the utility column for the LDCs indicates how many countries end up with this final allocation.
- Design III shows the result in the competitive equilibrium.
- Design IV shows the effect of a successful cartel when there are four ICs.

3.4.1. The Effect of the Cartel on the Terms of Trade

One important result is that the cartel could potentially counter the worsening of the terms of trade. In design II, with the cartel exerting its market power, the terms of trade improve from 14.75 to 17.04. In design IV they increase from 5.34 to 12.29. In all other cases (under both competitive equilibrium and the monopoly assumption) the terms of trade worsen for the LDCs. Table 4. shows the terms of trade in different designs.

For the competitive equilibrium a price range is possible. In the top row of Design III, the terms of trade if prices are at the midpoint of this range are displayed, below (in parentheses) the limits for the terms of trade are presented.

Design	Phase	Competitive Equilibrium	Monopoly	Cartel
I	1	0.79	0.11	
	2	0.54	0.04	
II	1	0.79	0.11	14.75
	2	0.54	0.04	17.04
III	1	0.79 (0.54-1.18)		
	2	0.54 (0.45-0.64)		
IV	1	0.79		5.34
	2	0.54		12.29

3.5. Trading Institution

Trading Institution was the multiple unit double auction mechanism (MUDA), developed at Caltech by Charles Plott and his co-workers⁴. The reason for choosing MUDA is the possibility to trade simultaneously in multiple markets and that the double auction mechanism has good convergence properties, which is particularly important because it is more difficult to reach a General Equilibrium, respectively to attain two interdependent equilibria in distinct markets at the same time.

Other experiments have shown that even less than four agents on each side of the market are enough to ensure convergence to the competitive equilibrium in a double auction market⁵. "A substantial body of evidence suggests that markets organized under double-auction trading rules converge "rapidly" to a CE price when there are as few as four sellers and four buyers."⁶ However, previous experiments with double auctions usually involved either single markets or markets for

⁴ For a description of MUDA see Plott (1991): "A Computerized Laboratory Market System And Research Support System For The Multiple Unit Double Auction".

⁵ Smith/Williams [1992]: "The Boundaries of Competitive Price Theory", p. 36

⁶ Ibid., p. 33

which demand was additively separable⁷.

A transaction in the double auction can be initiated by either buyers or sellers. Buyers can submit a bid which is higher than the standing bid. This bid becomes the standing bid. If a seller accepts the bid a transaction takes place with the price equal to the standing bid. Alternatively, a buyer can accept the standing offer, in which case a transaction takes place with the price equal to the standing offer. A seller can submit an offer which is lower than the standing offer. This offer becomes the standing offer.

The message space in the double auction is more or less equivalent for buyers and sellers (in contrast for instance with a posted offer institution, which resembles a retail market and in which sellers announce offer prices and buyers accept or not). The double auction therefore does not offer a structural advantage to either side of the market, i.e. prices tend to converge to the competitive equilibrium (and not to stay above or below it). Whether the convergence is from above or from below can usually not be predicted in cases where the surplus is evenly distributed. In asymmetric cases convergence is more likely from the side with the larger

⁷ For a test of the competitive model in multiple markets (but additively separable demand) see Noussair/Plott/Riezman (1992): "An Experimental Investigation of the Patterns of International Trade". The authors report that in their multi-market environment only the qualitative predictions of the competitive model hold.

surplus⁸.

Subjects were not allowed to cancel bids or asks. However, subjects were in all experiments in the position of a trader, i.e. they were able to buy and sell units in both markets. This feature essentially enables subjects to erase their own offer or bid by accepting it. The reason for putting subjects in the role of a trader was to ease the process of equilibration. In this complex environment it is possible to "overshoot" the equilibrium by for instance selling more units than the equilibrium quantity. The following example and graph 5. shall clarify this possibility, which arises because of both the sequential character of the double auction and the interlinked demand in the two markets. Suppose that prices in both markets are within the equilibrium range, for instance in phase one, at 100 in both markets. The supply and demand curves (S_0 and D_0 respectively) indicate the initial position of a developing country, endowed with 8 units of X and no unit of Y. At a price of 100 it is profitable to sell up to seven units of X, more than the equilibrium quantity of four. Suppose the country sells six units of X. Holding two units of X and no units of Y it is profitable to buy two units of Y at a price of 100. Since the marginal

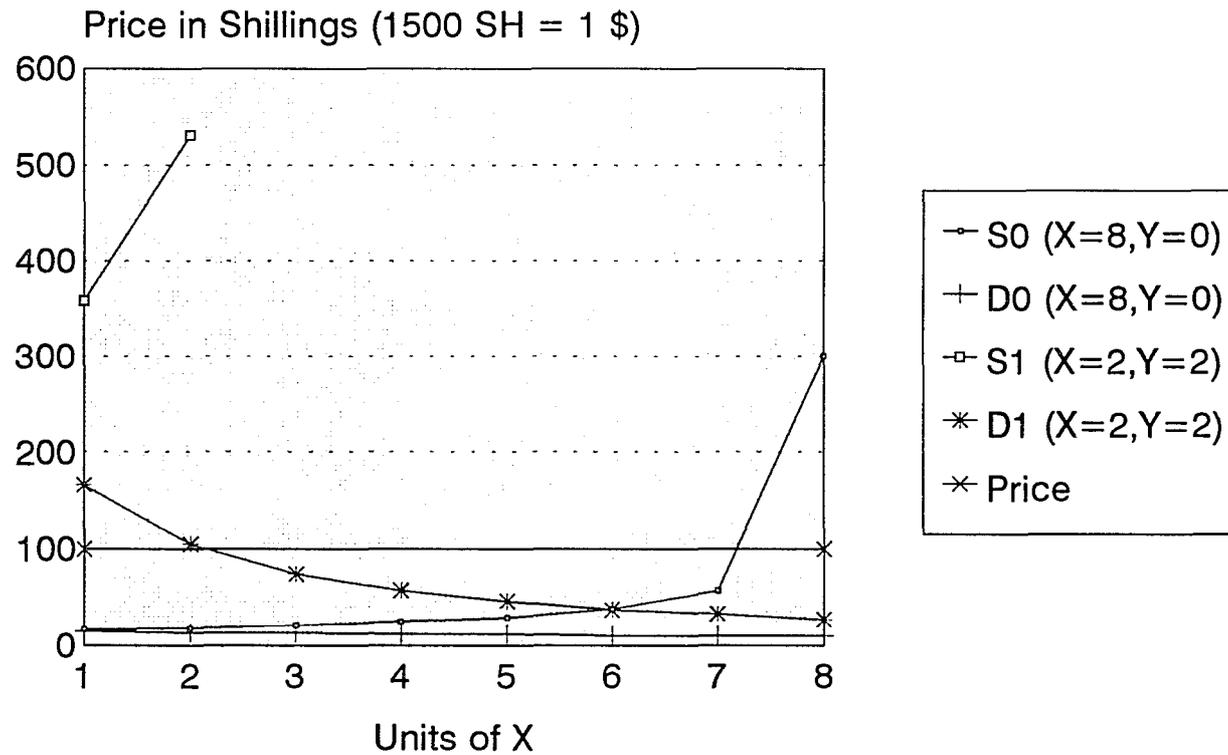
⁸ When all the surplus accrues to one side, any deviation of prices has to be in that direction. For an example see Smith/Williams (1992): "The Boundaries of Competitive Price Theory", p. 42 ff.

value of X increases with the amount of Y a country holds it is now profitable to buy two units of X. After this transaction, the country possesses four units of X and two units of Y, the equilibrium quantities. The country has exploited all potential gains from trade at these prices (or any prices within the equilibrium range). It has done so by acting both as a seller and a buyer of X. Likewise a sequence of profitable trades is possible in which a country acts both as a buyer and seller of Y⁹. For the analysis of prices all transaction prices were taken into account. However, net quantities are reported, i.e. sales (purchases) by developing countries minus purchases (sales) by developing countries in market X (Y).

⁹ At these prices buying three units of Y is profitable, then selling four units of X and selling one unit of Y.

Graph 5.: Sequential Evolution of Supply and Demand

Market X, Example for a Developing Country



Example: The country sells 6 units of X, then buys 2 units of Y, then buys 2 units of X

4. PREVIOUS EXPERIMENTAL RESULTS

MUDA has been used before in a General Equilibrium context¹. The application which is closest to this study is Noussair, Plott, Riezman (1992), henceforth NPR. NPR study very complex environments, with two countries, two inputs (supposedly labor and capital), for which distinct markets exist in every country and two outputs which are traded internationally. In addition to that, they have "producers", who transform inputs into output and trade those outputs, and "consumers", who derive utility from consuming these final outputs. NPR analyze whether the economy they create resembles more closely the Autarky model or the Competitive Equilibrium model. The Autarky model proposes that domestic production is also consumed domestically and derives its predictions from this premise. The Competitive Equilibrium model suggests that countries specialize according to their respective comparative advantage. Further predictions derived from this latter model are that the output prices of the internationally traded commodities equalize and that the input prices would equal their marginal revenue product. NPR come to the conclusion that the exact predictions derived from both

¹ For applications of MUDA in a General Equilibrium framework see Lian/Plott (1991): "General Equilibrium, Macroeconomics and Money in a Laboratory Experimental Environment" and Noussair/Plott/Riezman (1992): "An Experimental Investigation of the Patterns of International Trade".

models have to be rejected, which they explain by the vast number of predictions generated by each model. However, the qualitative predictions of the Competitive Equilibrium model hold. "Market prices and quantities are observed moving in the direction of the competitive equilibrium [...]. Factor price equalization is observed." (NPR, Abstract).

In some respects the NPR environment is much more complex than the current study (e.g. existence of input markets, production taking place, separation of producers and consumers), in other respects this study adds new features (e.g. a demand structure which is not additively separable, increased number of countries) and asks different questions. The importance of the NPR study is best summarized by the following: "The overall conclusion is that experiments of this level of complexity can be successfully implemented with modern technology and that these complicated and interdependent systems, when observed experimentally, have many of the properties that competitive theory suggests should exist." (NPR, Abstract).

5.

HYPOTHESES

The following hypotheses were under investigation:

H1: Under the absence of market power (design III) the competitive equilibrium is reached, at least with experienced subjects. Note that this hypothesis is not as trivial as it sounds. This is a general equilibrium model, in which simultaneous equilibria have to be attained in distinct markets. NPR have shown that the general equilibrium model predicts fairly well in terms of qualitative results. However, the exact quantitative forecasts could -- in most cases -- not be attained. One further complication is the specific demand structure, namely interdependent (and not additively separable) demand. Thus for attaining the competitive equilibrium (CE) enough time (10 periods in each phase) has to be granted. It is very likely that subjects need experience to attain the CE.

H2: In design I the monopoly will exert its market power. It will pay the monopsonist price (P_{ms}) in the X market and charge the monopoly price (P_{mp}) in the Y market.

The industrial country (IC) as monopsony will succeed to lower² the price of the X good to P_{ms} . The equilibrium

² In comparison to the competitive equilibrium (CE). All the following comparisons refer to the CE as well.

trading volume will not be affected. The industrial country's market power is -- due to the demand structure -- greater as seller of the Y good, thus a greater effect on the price in that market is to be expected, the trading volume will decrease. The experimental investigation will show to what extent the IC will succeed to extract monopoly rents. Due to the unknown structure of demand and to the possibility of the LDCs to underreveal demand -- features commonly present in the field -- the success of the monopoly is not certain.

H3: In designs II and IV the cartel will be able to charge the monopoly price (P_{mp}) in the X market and to pay the monopsonist price (P_{ms}) in the Y market.

It is likely that the LDCs will use their possibility to communicate to increase the price of good X to P_{mp} and to lower the price of good Y to P_{ms} .

Note, however, that each individual agent has an incentive to cheat. Thus the cartel might eventually break down. Especially the continuous double auction provides so many opportunities to violate the agreement, that such a breakdown might occur relatively fast.

H4: The terms of trade will worsen for LDCs in designs I and III. As a consequence of hypotheses one and two the terms of trade will worsen for developing countries when there is no

possibility for the LDCs to communicate.

H5: The possibility to form a cartel will impede the decline of the terms of trade.

In designs II and IV the cartel will be able to initially avert the deterioration of the terms of trade. As mentioned above, due to the incentive for each individual cartel member to cheat on the agreement, eventually also in these designs the terms of trade might worsen.

H6: The terms of trade will be better in design IV than in design III (the competitive equilibrium).

Because of the market power the cartel has, the terms of trade for the cartel will be better than for the developing countries in the competitive equilibrium.

H7: The terms of trade will be worse in design I than in design III.

Due to market power the terms of trade for the LDCs facing a monopsony (in the X-market) and monopoly (in the Y-market) will be worse than in the competitive equilibrium.

6.

EXPERIMENTAL RESULTS

Subjects were recruited from undergraduate economics classes at the University of Arizona. Each participant was paid \$20 for showing up on time for all three sessions of the experiment¹. Subjects earned, in addition to that, salient rewards, depending on their decisions, ranging from about \$10 to \$85. For each subject group all sessions took place within one week.

6.1. Common Features of the Data Analysis

For each design, the data analysis was split into several parts. Due to the introduction of money into the system and because utility is expressed in monetary terms, separate equilibrium predictions for both markets could be derived. The market for the primary product (market X) was analyzed first, followed by the analysis of the market for manufactured products (market Y).

The following econometric model was used to analyze the change in prices over time².

¹ In a few cases the experiments lasted for longer than the subjects were recruited for. In those cases subjects were paid additional \$5 for their commitment to stay longer.

² All models considered allowed for a change of prices over time. Let the abbreviations t and T denote observation number (counted from the beginning of the experiment) and period number, respectively. The model $P_t = \alpha + \beta \cdot \exp(-t) + \epsilon_t$ assumes a constant rate of convergence from one observation to the next. α is the asymptotic equilibrium prediction. A

$$p_t = \alpha + \beta * p_{t-1} + \gamma * f[T(t) - T(t-1)] + \epsilon_t$$

p_t is defined as the difference between the transaction price, P_t , and the equilibrium prediction (EQ). The function $f[T(t) - T(t-1)]$ allows for a shift of prices at the beginning of the period. The functional form considered was $f(.) = [(T(t) - T(t-1))/T(t)]$. This functional form implies that the shift decreases with the number of periods. Using prices lagged by one period as independent variable substantially reduces the (positive) autocorrelation.

The parameters of the model can be interpreted as follows. The asymptotic equilibrium prediction is defined by $EQ + \alpha/(1-\beta)$. α equal to zero indicates convergence to the equilibrium prediction EQ. The choice of EQ does not affect the asymptotic prediction, it only changes the value and the standard error of the estimated constant term α . If the absolute value of β is greater or equal to one, the model

significant coefficient on $\exp(-t)$ indicates that prices change over time (they increase if β is negative, decrease if β is positive). The model $P_t = \alpha + \beta * \exp(-T) + \epsilon_t$ assumes that prices are constant within a period and change at a constant rate across periods. The coefficients have similar interpretations as in the previous model. In both models β was usually positive and significant, indicating a decrease of prices both within a period and across periods.

Neither model predicted very accurately (very low R^2), since they failed to take into account simultaneously the change in price across periods and across transactions. A decrease of this form, comparable to the shape of a saw blade, was a common pattern observed in many experiments.

explodes, i.e. it does not converge to any particular point. β less than zero implies that prices overshoot the equilibrium (but eventually converge if the absolute value is less than one). β greater than zero (and less than one) implies convergence at a constant rate to an equilibrium from one direction. γ greater (less) than zero indicates that prices shift upward (downward) when the period changes.

Terms of trade were calculated as the ratio of the average transaction price in market X divided by the average transaction price in market Y. For the statistical analysis only one measure of the terms of trade per phase of an experiment was used, namely the ratio of the average of the contract prices in the last three periods in market X and Y. This procedure reduces each experiment to two observations, namely the final terms of trade for phase one and two. Statistical tests were therefore conducted for all experiments within each design, not for single experiments, i.e. the unit of observation was the experiment.

In all cases the competitive equilibrium is not a specific price but a range of prices. Prices were said to be at the competitive equilibrium if either of the following hypotheses could not be rejected:

a) $\alpha = 0$, against the alternative $\alpha > 0$, when the high endpoint of the competitive range entered the statistical model as equilibrium prediction (EQ).

b) $\alpha = 0$, against the alternative $\alpha < 0$, when the low endpoint of the competitive range was used for EQ.

If the asymptotic equilibrium prediction (which is independent of the choice of EQ) is within the competitive range, neither hypothesis can be rejected. If the high (low) end of the equilibrium range is entered as EQ and the result is that α is greater (less) than zero it is not necessary to test the other hypothesis.

Experiments in four different designs were conducted. In all designs there were four developing countries, the number of industrialized countries was a treatment variable. Design I is called the monopoly design. In this design, only one country is initially endowed with the manufactured product. Design II is called the monopoly/cartel design. The only difference from design I is that the developing countries are allowed to communicate. Design III is called the competitive design, in which four industrialized countries face four developing countries. Design IV is called the cartel design. The only difference from design III is that the developing countries are allowed to communicate. In designs I, III and IV four experiments were conducted, in design II only one experiment. The discussion of results starts with design III, since in this design the competitive theory is given its "best shot". Subsequently, design IV, I and II are discussed (in that order), followed by a comparison of designs.

Each experiment consisted of two phases, phase one with 'low income' and phase two with 'high income'. The following examples shall illustrate the abbreviations used in the text. D4P1XE3Y represents design IV, phase one, experienced subjects, experiment 3, market Y. This annotation was shortened to D4XE3 in tables and graphs, when the titles made clear in which market and which phase of the experiment the observation occurred. D3P2IE1X represents design III, phase two, inexperienced subjects, experiment 1, market X. In many cases the behavior of inexperienced subjects in phase one (henceforth called 'completely inexperienced subjects') differs from the behavior in other phases of the experiment.

7. THE COMPETITIVE DESIGN: DESIGN III

The "competitive" design (design III) has four industrialized countries and four developing countries. Neither side of the market is allowed to communicate, except for submitting and accepting bids and offers. The expected results were that prices would converge to the competitive equilibrium in the market for primary products (market X) and the market for manufactured products (market Y). In the second phase of the experiment, world income (respectively production) was doubled in comparison with the first phase. The competitive equilibrium prediction is that prices of primary products in the second phase decrease more than prices of manufactured products, due to the fact that the income elasticity of demand for primary products is less than unity. Therefore, terms of trade for primary products are expected to worsen.

7.1. The Market for Primary Products (Market X)

In the competitive design the four developing countries are each endowed with eight units of the primary commodity. In the second phase the endowment is doubled. In the competitive equilibrium each developing country sells four (phase two: eight) units of the primary product, at a price between 74 and 105 (phase two: 37 to 43) Shillings.

Table 6. contains the average contract prices in each

period, both for experiments with inexperienced and experienced subjects. In graph 7. the average contract prices of experiments with experienced subjects are displayed.

Results: Prices in the "competitive" design are in general higher than the competitive level, decrease over time, but shift upward at the beginning of periods. One possible explanation for this phenomenon is the asymmetric distribution of surplus between buyers and sellers. Two experiments converge to the competitive equilibrium (CE) with experienced subjects. The result that inexperienced subjects in phase two never reach the CE suggests that a lot of learning is necessary in such a complex environment with two markets and interlinked demand. Even with experienced subjects, prices do not always attain the competitive equilibrium in ten periods. Prices in market X at the end of the second phase are for all subject groups lower than at the end of the first phase, as predicted by the competitive model.

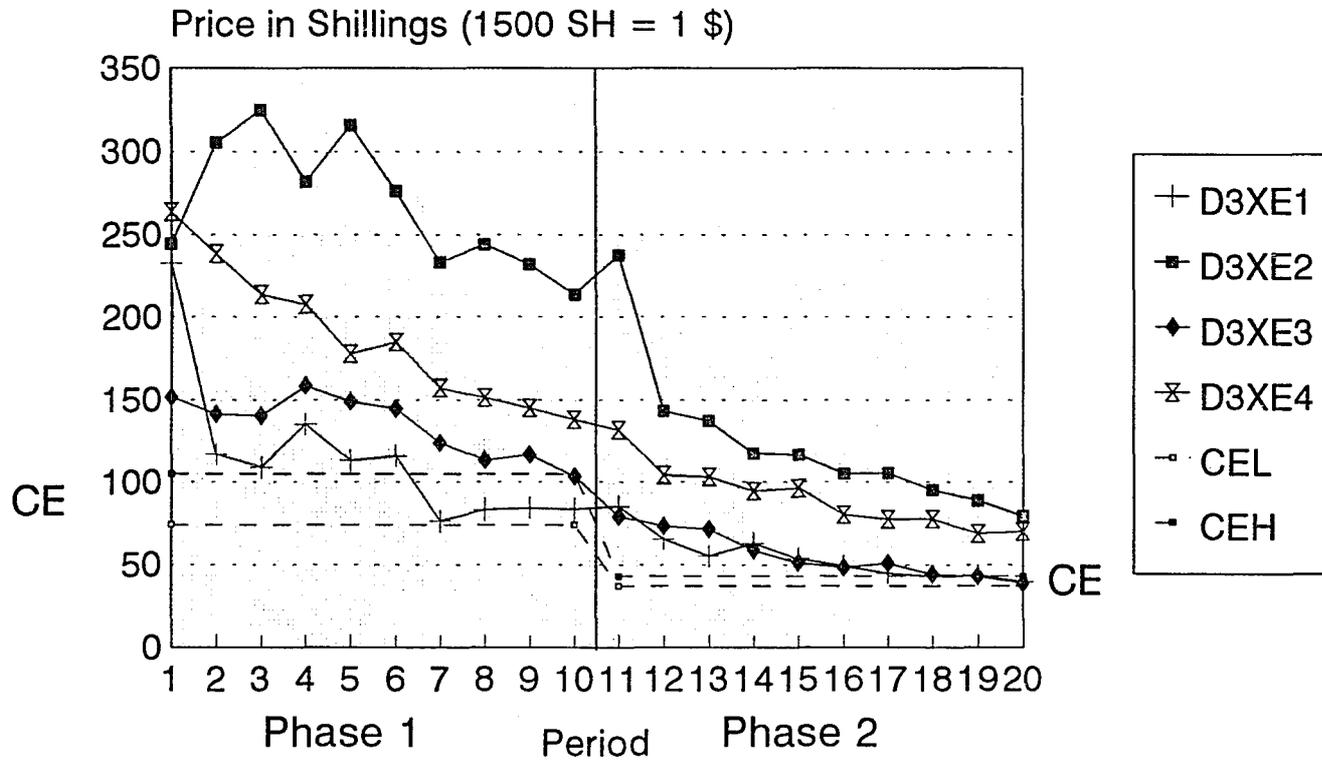
Prices decrease over time, with the exception of two experiments with completely inexperienced subjects. In experiment 2 with experienced subjects in phase one, prices are clearly higher than in all other experiments, they also stay well above the competitive equilibrium until the end of that phase.

Table 6.: Average Contract Prices: Design III, Market X

	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4
Phase 1	1	35	233	80	244	43	151	85	264
	2	100	117	73	305	55	141	92	238
	3	83	109	105	325	63	140	100	214
	4	80	135	114	282	54	158	108	208
	5	91	113	116	316	47	149	109	178
	6	86	116	142	276	59	145	126	185
	7	75	76	138	233	57	124	122	157
	8	81	83	153	244	80	113	122	151
	9	75	84	171	232	46	117	125	145
	10	102	84	162	214	60	103	138	138
Phase 2	11	77	85	112	238	59	79	122	132
	12	63	65	129	143	61	73	98	104
	13	73	55	104	137	57	71	92	103
	14	82	63	71	117	51	59	94	95
	15	66	53	93	117	50	51	88	96
	16	71	49	93	105	50	48	78	80
	17	53	45	103	106	49	51	76	77
	18	50	43	95	95	51	44	79	78
	19	51	43	94	89	50	43	77	69
	20	47	40	98	79	48	39	99	70

Graph 7.: Average Contract Prices

Design III, Market X (Primary Product), Experienced Subjects



Among experienced subjects prices were always at or above the competitive equilibrium, never below. Whenever average contract prices are above the competitive equilibrium they show a general tendency to decrease, at least with experienced subjects.

7.1.1. Test for Convergence

The general result is that prices converge from above to a level at or above the competitive equilibrium. Prices usually decrease, but shift upward at the beginning of a period.

In all cases, the equilibrium prediction used to calculate the differences was the high end of the competitive price range (CEH), since prices tended to be above the competitive equilibrium¹. Table 8. contains the results of the regressions. A significant coefficient α implies that prices are different from the initial equilibrium prediction (EQ).

¹ As mentioned earlier, the choice of EQ in the equation ($p_t = P_t - EQ$) does not affect the asymptotic equilibrium prediction (ASY), only the value of the coefficient α and its standard deviation. In the one case where ASY was below the competitive range a second regression was conducted with EQ equal to the low end of the competitive range to test whether α was significantly different from zero.

Table 8.: Results of Test for Convergence							
Design III, Market X (Primary Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ; \text{Asymptote} = EQ + \text{Alpha}/(1-\text{Beta})$							
EQ in phase 1: 105				EQ in phase 2: 43			
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.De
D3IE1	Alpha	-12.70	3.46	D3XE1	Alpha	0.00	4.04
Ph. 1	Beta	0.40	0.06	Ph. 1	Beta	0.56	0.05
	Gamma	-8.76	64.88		Gamma	185.51	75.24
	Asympt.	83.72			Asympt.	105.00	
D3IE1	Alpha	5.02	1.55	D3XE1	Alpha	0.21	0.46
Ph. 2	Beta	0.70	0.04	Ph. 2	Beta	0.89	0.02
	Gamma	209.58	34.05		Gamma	126.66	9.86
	Asympt.	59.70			Asympt.	44.84	
D3IE2	Alpha	13.47	5.14	D3XE2	Alpha	29.20	10.19
Ph. 1	Beta	0.45	0.07	Ph. 1	Beta	0.75	0.05
	Gamma	-119.99	86.63		Gamma	706.73	83.29
	Asympt.	129.34			Asympt.	222.83	
D3IE2	Alpha	27.33	3.72	D3XE2	Alpha	4.37	2.29
Ph. 2	Beta	0.48	0.05	Ph. 2	Beta	0.90	0.02
	Gamma	75.04	49.48		Gamma	308.59	28.91
	Asympt.	95.20			Asympt.	85.07	
D3IE3	Alpha	-22.54	3.56	D3XE3	Alpha	13.16	3.30
Ph. 1	Beta	0.52	0.07	Ph. 1	Beta	0.54	0.07
	Gamma	-69.89	25.88		Gamma	85.80	40.62
	Asympt.	57.63			Asympt.	133.67	
D3IE3	Alpha	8.82	1.75	D3XE3	Alpha	1.02	1.00
Ph. 2	Beta	0.07	0.06	Ph. 2	Beta	0.80	0.03
	Gamma	10.81	37.08		Gamma	175.39	20.46
	Asympt.	52.44			Asympt.	48.08	
D3IE4	Alpha	1.90	2.88	D3XE4	Alpha	8.14	4.51
Ph. 1	Beta	0.43	0.07	Ph. 1	Beta	0.81	0.04
	Gamma	165.22	45.68		Gamma	349.08	39.27
	Asympt.	108.32			Asympt.	148.06	
D3IE4	Alpha	16.68	2.87	D3XE4	Alpha	8.52	2.25
Ph. 2	Beta	0.57	0.05	Ph. 2	Beta	0.78	0.04
	Gamma	153.49	33.48		Gamma	121.12	20.16
	Asympt.	81.60			Asympt.	81.88	

α was usually greater than zero. The only exceptions occurred with completely inexperienced subjects². In all other cases α was significantly greater than zero among inexperienced subjects, suggesting that without experience prices do not converge to the competitive equilibrium³. Among experienced subjects, α is in most cases not significant, indicating that prices do converge to the competitive equilibrium. The exceptions are experiment 2 (both phases) and experiment 3 (phase one). In all cases the coefficient β was positive and less than one⁴, indicating convergence to an equilibrium from one side. In all but one case β was significant. The asymptotic equilibrium prediction among experienced subjects is always above the high end of the competitive range.

In most cases the coefficient γ is significant and positive, indicating a positive shift of prices at the beginning of periods, which decreases over time. Thus prices decrease both within and across periods. Among experienced

² D3P1IE1X and D3P1IE3X. In the first case prices converge to the competitive equilibrium range, in the second case they are significantly below (when EQ is set to the low end of the competitive range $\alpha = -7.79$, Std. Dev. = 1.90).

³ All results are reported at a significance level of 1%.

⁴ β ranged from 0.06 to 0.90.

subjects, γ is usually positive and significant⁵. The only cases with γ less than zero (indicating a negative shift of prices) occur with completely inexperienced subjects⁶.

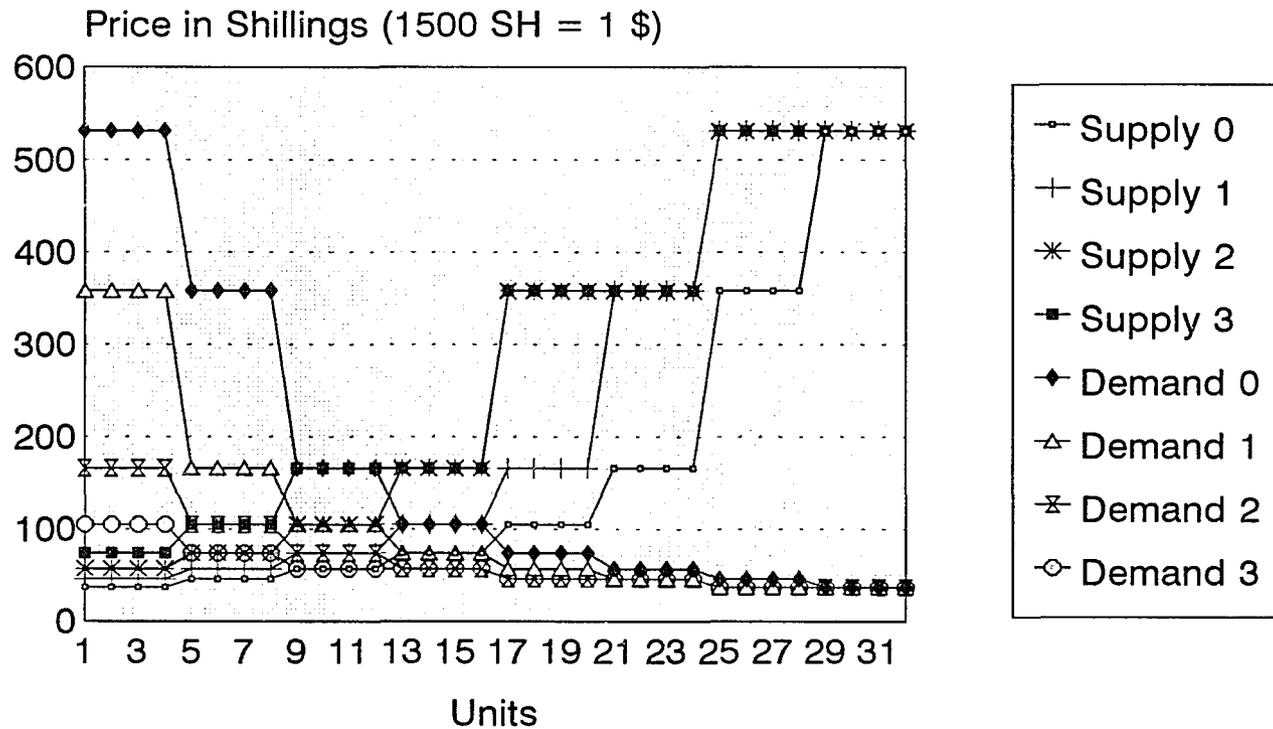
One possible explanation for both the general decrease of prices and the shift at the beginning of a period is the specific structure of supply and demand. Profitable trades can occur well above the competitive equilibrium, but not substantially below it. The first unit of X is extremely valuable. The marginal value of X decreases rapidly with the number of units a country holds (for any constant holding of Y). X and Y are complements, i.e. the marginal value of X increases with the number of units of Y. Graph 9. shows the supply and demand curves for X in phase one, given that the market for manufactured products is already in equilibrium (i.e. every country holds two units of Y). Both supply and demand curves shift as units of X are traded. To show this effect the curves have been graphed after each country has traded none, one, two and three units of X, respectively. The upward shift of the supply curve is negligible compared to the huge downward shift of the demand curve as units of X are traded.

⁵ The only exception is D3P1XE1X.

⁶ D3P1IE1X, D3P1IE2X and D3P1IE3X, in the first two cases it is not significant. In two cases with inexperienced subjects in phase two (D3P2IE2X and D3P2IE3X) the coefficient is not significant.

Graph 9.: Supply and Demand Curves, Market X

Y-Market is in Equilibrium (every country holds 2 Y)



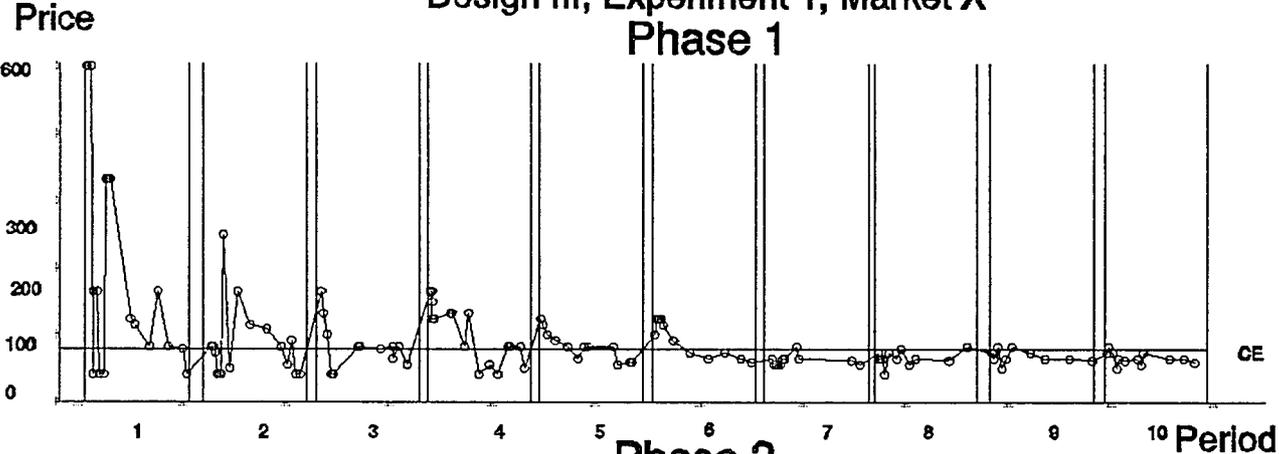
Supply and demand after each country has traded 0, 1, 2, and 3 units.

This feature is important to explain the evolution of prices. Graph 10. shows the typical pattern of contract prices, which occurred in experiment 3 with experienced subjects. Transactions are profitable for both trading partners at prices well above the competitive equilibrium (CE), but not at prices substantially below CE. The range of profitable prices becomes smaller as units of X are traded, also decreasing the asymmetry in the distribution of surplus. However, subjects "learn" that prices decrease at the end of a period, which might explain why the deviation from the equilibrium at the beginning of a period decays. The fact that prices do not necessarily attain the competitive equilibrium within ten periods could also be explained by risk averse behavior. If subjects fear that they might not be able to purchase units of X at a cheaper price at the end of the period, it is rational for them to pay more to secure at least the first extremely valuable unit of X.

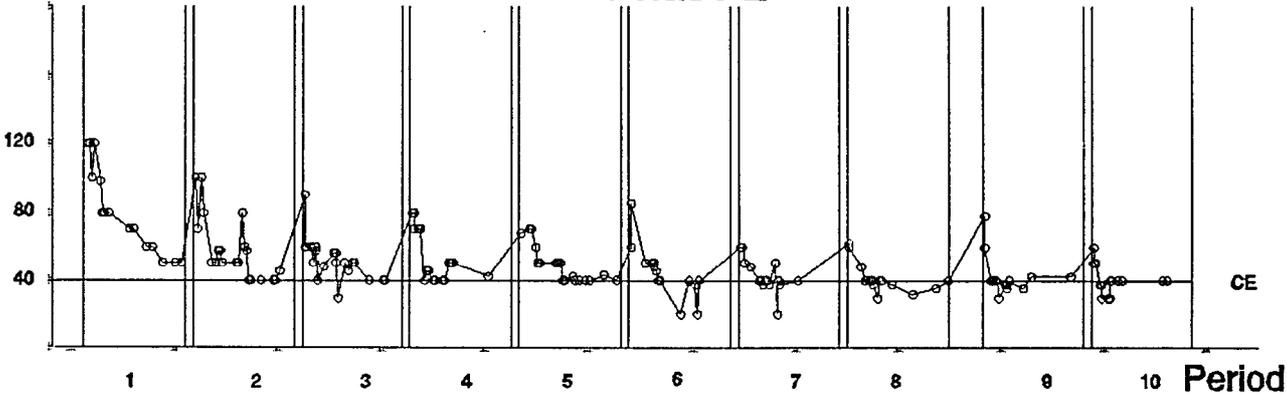
Graph 10.: Pattern of Contract Prices

Design III, Experiment 1, Market X

Phase 1



Phase 2



7.2. The Market for Manufactured Products (Market Y)

Each industrialized country was initially endowed with four (phase two: eight) units of the manufactured product (Y). The price range of the competitive equilibrium is 89 to 137 (phase two 67 to 82) Shillings. The marginal value of Y decreases with the number of units a country holds. However, this decrease is not as pronounced as in the X-market. Supply and demand curves for Y also shift as units of X and Y are traded. Profitable trades can also occur at prices well above the competitive equilibrium, but the "margin of error", is also smaller below the competitive equilibrium. The range for profitable trades becomes smaller as units of Y are traded, and the asymmetry in the distribution of surplus decreases.

Table 11. contains average contract prices per period and graph 12. displays them for experienced subjects.

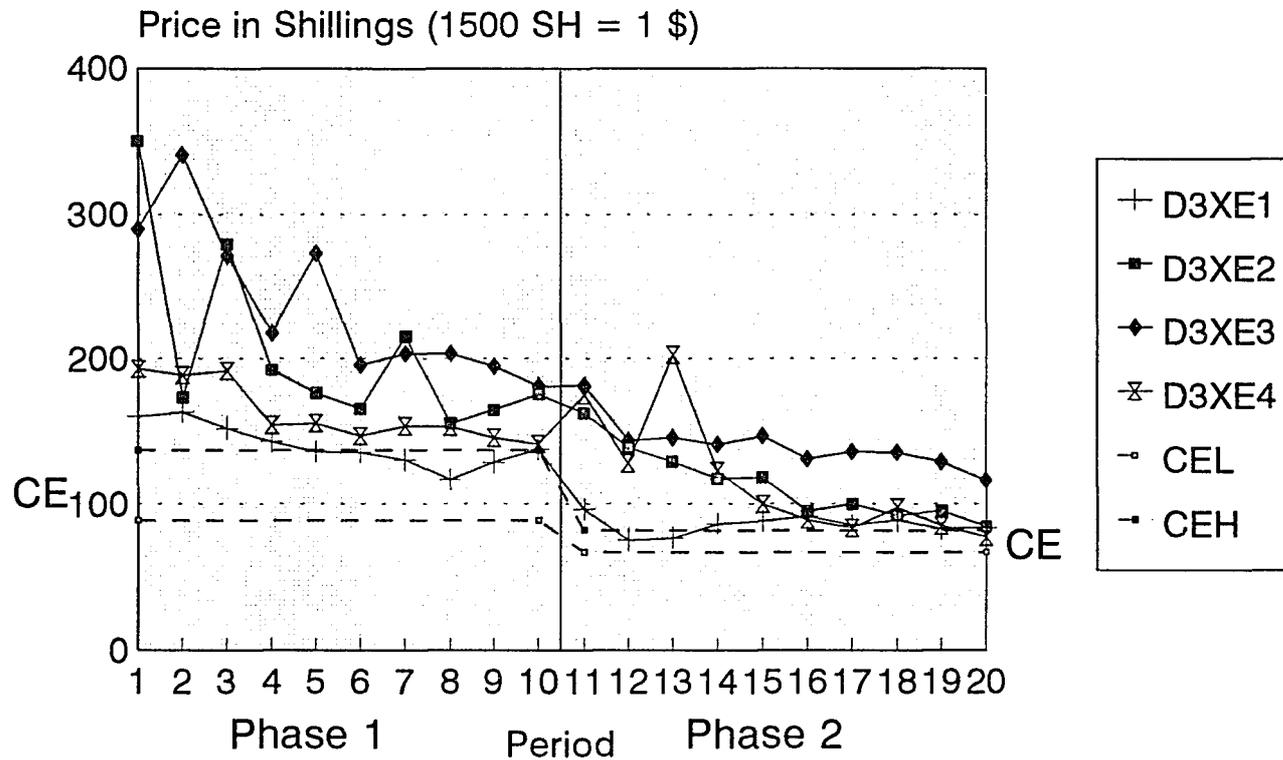
Results: In market Y prices tend to start out above CEH, decrease over time and shift upward at the beginning of periods, thus displaying the same saw-like pattern as in market X. A possible explanation is the same as in market X, the margin of error is mainly above the competitive equilibrium and decreases as units are traded. A lot of learning is necessary until prices converge (from above) in this complex environment, but among experienced subjects prices generally converge to the high end of the competitive range.

Table 11.: Average Contract Prices: Design III, Market Y

	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4
Phase 1	1	195	160	47	350	103	290	230	193
	2	95	163	110	173	116	341	216	189
	3	135	152	77	280	127	272	202	192
	4	152	143	118	192	105	218	188	154
	5	167	136	126	176	137	273	210	155
	6	131	135	125	166	182	196	204	147
	7	116	130	172	215	163	204	190	153
	8	136	117	137	155	185	204	209	153
	9	114	129	113	165	167	195	186	146
	10	128	138	119	176	181	181	177	141
Phase 2	11	144	96	159	162	150	181	198	175
	12	84	75	128	139	203	144	153	128
	13	112	77	97	129	193	146	132	203
	14	146	86	119	118	150	141	139	123
	15	123	88	110	118	145	147	126	100
	16	129	92	102	95	157	131	114	89
	17	99	86	95	100	138	136	122	84
	18	93	89	93	92	138	136	104	98
	19	121	83	98	95	144	129	98	85
	20	93	84	86	85	125	116	92	78

Graph 12.: Average Contract Prices

Design III, Market Y (Manufactured Product), Experienced Subjects



With the exception of completely inexperienced subjects in experiment 2, average contract prices are never below the competitive equilibrium. With very few exceptions, all with completely inexperienced subjects, average contract prices are always above the midpoint of the competitive range. Prices generally decrease across periods.

7.2.1. Test for Convergence

The equilibrium prediction used to calculate the differences was the high end of the competitive range (CEH). Table 13. contains the regression results. α is usually positive, but in most cases with experienced subjects it is not significant⁷. The conclusion is that prices converge to the high end of the equilibrium range or higher. The only exception among experienced subjects is the second phase of experiment 3, where prices do not converge to the competitive equilibrium. Among inexperienced subjects in phase two, α is always positive and significant, suggesting that inexperienced subjects fail to adjust prices downward in the second price.

⁷ The only cases when α is negative occur with completely inexperienced subjects and with experienced subjects in experiment 1 (both phases). In all these cases α is not significant.

Table 13.: Results of Test for Convergence							
Design III, Market Y (Manufactured Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ; \text{Asymptote} = EQ + \text{Alpha}/(1-\text{Beta})$							
EQ in phase 1: 137				EQ in phase 2: 82			
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.Dev.
D3IE1	Alpha	3.52	9.25	D3XE1	Alpha	-3.88	7.36
Ph. 1	Beta	0.16	0.11	Ph. 1	Beta	0.04	0.12
	Gamma	-33.11	120.95		Gamma	261.42	82.11
	Asympt.	141.19			Asympt.	132.95	
D3IE1	Alpha	18.93	5.60	D3XE1	Alpha	-2.57	2.16
Ph. 2	Beta	0.19	0.07	Ph. 2	Beta	0.47	0.07
	Gamma	343.35	78.62		Gamma	236.55	32.85
	Asympt.	105.41			Asympt.	77.13	
D3IE2	Alpha	-14.96	9.03	D3XE2	Alpha	12.15	9.09
Ph. 1	Beta	0.15	0.09	Ph. 1	Beta	0.50	0.08
	Gamma	-144.42	133.35		Gamma	720.38	99.56
	Asympt.	119.49			Asympt.	161.36	
D3IE2	Alpha	8.54	3.40	D3XE2	Alpha	5.86	2.82
Ph. 2	Beta	0.43	0.06	Ph. 2	Beta	0.68	0.06
	Gamma	372.84	49.64		Gamma	220.69	33.15
	Asympt.	97.06			Asympt.	100.38	
D3IE3	Alpha	-0.10	5.76	D3XE3	Alpha	22.98	13.52
Ph. 1	Beta	0.40	0.10	Ph. 1	Beta	0.52	0.09
	Gamma	273.01	72.09		Gamma	757.11	114.86
	Asympt.	136.84			Asympt.	184.52	
D3IE3	Alpha	24.86	7.09	D3XE3	Alpha	25.40	4.73
Ph. 2	Beta	0.43	0.06	Ph. 2	Beta	0.45	0.06
	Gamma	756.79	78.96		Gamma	295.32	45.55
	Asympt.	125.66			Asympt.	128.09	
D3IE4	Alpha	28.45	9.07	D3XE4	Alpha	10.86	6.19
Ph. 1	Beta	0.27	0.09	Ph. 1	Beta	0.25	0.11
	Gamma	587.60	75.58		Gamma	250.91	64.18
	Asympt.	175.72			Asympt.	151.54	
D3IE4	Alpha	16.63	5.38	D3XE4	Alpha	23.35	10.30
Ph. 2	Beta	0.40	0.06	Ph. 2	Beta	0.07	0.08
	Gamma	618.89	74.36		Gamma	133.48	158.72
	Asympt.	109.92			Asympt.	107.22	

The asymptotic equilibrium prediction is usually above CEH, the only exceptions occur with completely inexperienced subjects and with experienced subjects in experiment 1 (both phases). In all cases the coefficient β was positive and less than one, indicating convergence to an equilibrium from one side. In all but five cases β is significant⁸.

The coefficient γ is usually positive and significant⁹, indicating that prices shift upward at the beginning of periods.

7.3. Terms of Trade

Table 14. contains the terms of trade (ToT), computed as the ratio of the average prices per period. Graph 15. displays the evolution of the ToT for experienced subjects. The equilibrium range for the ToT is fairly large in phase one (0.54 to 1.18) and narrows in phase two (0.45 to 0.64).

The ToT worsen for all experienced subject groups, even though the values of the ToT are very much affected by the bargaining power of different groups.

⁸ β ranged from 0.04 to 0.68. It is not significant in experiments D3P1IE1Y, D3P1IE2Y, D3P1XE1Y D3P1XE4Y and D3P2XE4Y.

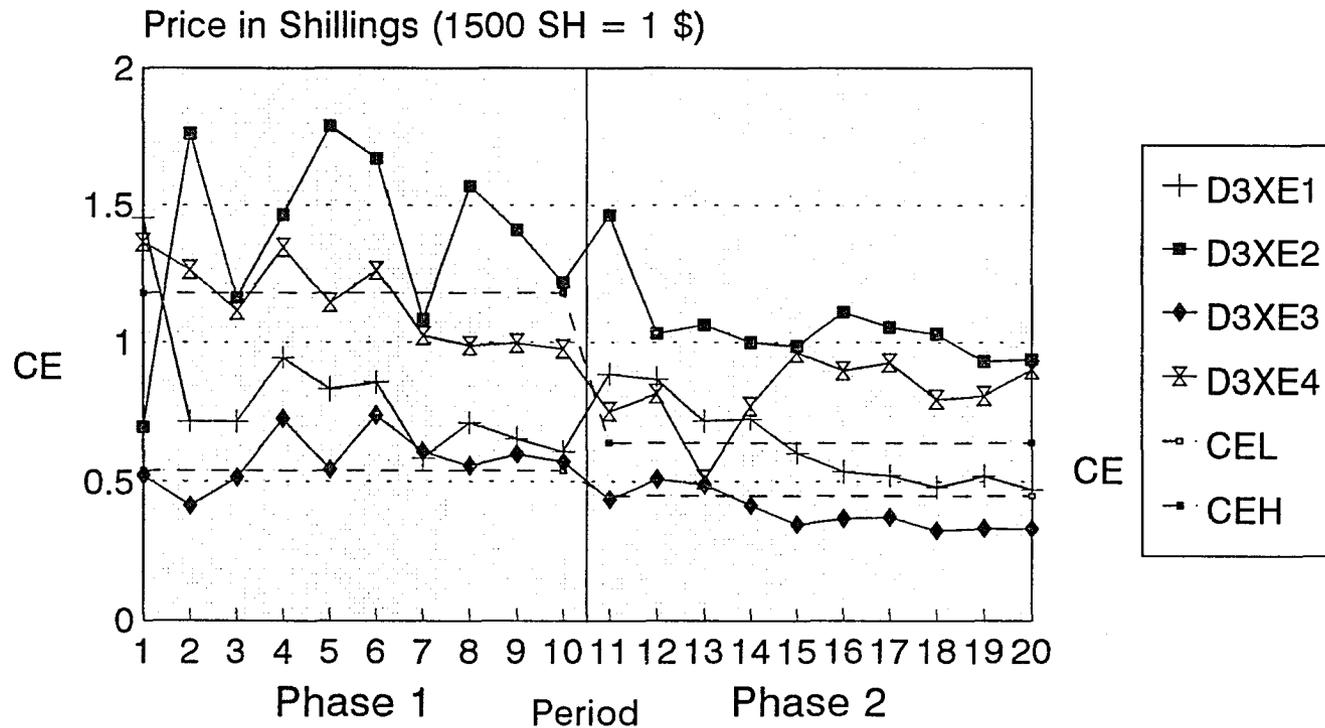
⁹ With the exception of two cases with completely inexperienced subjects, where γ is negative but insignificant, and D3P2XE4Y where γ is insignificant.

Table 14.: Terms of Trade: Design III

	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4
Phase 1	1	0.18	1.45	1.72	0.70	0.42	0.52	0.37	1.37
	2	1.05	0.72	0.66	1.76	0.48	0.41	0.42	1.26
	3	0.61	0.72	1.37	1.16	0.49	0.52	0.49	1.11
	4	0.53	0.95	0.96	1.46	0.52	0.73	0.58	1.35
	5	0.55	0.83	0.92	1.79	0.35	0.54	0.52	1.14
	6	0.66	0.85	1.13	1.67	0.32	0.74	0.61	1.26
	7	0.65	0.59	0.80	1.08	0.35	0.61	0.64	1.02
	8	0.59	0.71	1.12	1.57	0.43	0.56	0.59	0.99
	9	0.66	0.65	1.51	1.41	0.27	0.60	0.67	1.00
	10	0.80	0.61	1.36	1.22	0.33	0.57	0.78	0.98
Phase 2	11	0.53	0.89	0.70	1.46	0.39	0.44	0.61	0.75
	12	0.75	0.87	1.01	1.03	0.30	0.51	0.64	0.82
	13	0.65	0.72	1.06	1.06	0.29	0.49	0.70	0.51
	14	0.56	0.73	0.59	1.00	0.34	0.42	0.68	0.77
	15	0.54	0.60	0.85	0.99	0.34	0.35	0.70	0.96
	16	0.55	0.54	0.91	1.11	0.32	0.37	0.68	0.90
	17	0.53	0.52	1.09	1.06	0.36	0.37	0.62	0.93
	18	0.54	0.48	1.02	1.03	0.37	0.33	0.76	0.80
	19	0.43	0.52	0.96	0.93	0.35	0.33	0.78	0.81
	20	0.51	0.47	1.14	0.94	0.39	0.33	1.08	0.90

Graph 15.: Terms of Trade

Design III, Experienced Subjects



In phase one, the ToT are usually within the competitive range, in phase two they are in only one experiment within the narrow equilibrium range, but on average they are at the high end of the range.

The ToT seem not to follow a clear upward or downward trend but generally stabilize within the last few periods of a phase.

In phase one with experienced subjects, the ToT in three experiments clearly converge into the competitive range, all observations on ToT in the last four periods of phase one are within that range. Experiment 2 is the exception, in which the ToT are in most periods above the competitive equilibrium (CE), in the last period they are very close to the CE (1.22 compared to 1.18). In experiment 2, in which prices in market X had been higher than in other experiments, the ToT also vary substantially across periods.

In phase two, the ToT are always above the CE in experiments 2 and 4¹⁰. After the fourth period of phase two, ToT are always at the CE in experiment 1 and in experiment 3 they are always below the CE.

The ToT vary substantially among subject groups, they depend heavily on the bargaining power of subject groups. In most periods they are highest in experiment 2, second highest

¹⁰ With the exception of period 3 in experiment 4.

in experiment 4, and lowest in experiment 3. This ranking is the same for experienced and inexperienced subjects.

7.3.1. Do Terms of Trade worsen in the Competitive Design?

The hypothesis that the terms of trade are equal to the competitive equilibrium cannot be rejected. Terms of trade were computed as ratio of the average prices in the last three periods. In phase one the mean (0.898) is within the competitive range (0.54-1.18). In phase two the mean (0.656) is not significantly different from the high endpoint of the competitive range (0.64)¹¹.

Even though prices do not reach competitive levels in the two different markets, the terms of trade do. The explanation for this conundrum is quite simple. In both markets, prices tend to be above the high endpoint of the competitive range (or at least converge from above). Since the terms of trade are the ratio of the two prices, these two effects cancel each other out¹².

¹¹ The alternative hypothesis was that they are higher. Since there are only four observations for terms of trade in each phase, significance levels of 10% or better are reported. The result among inexperienced subjects is the same. The means are 0.754 and 0.668 in phase one and two, respectively. For phase two the t-values are below 0.2, both for inexperienced and experienced subjects.

¹² However, the efficiencies (realized compared to potential surplus) are expected to be affected, since prices in both markets are too high. This aspect will be covered later.

To test the hypothesis the terms of trade worsen as income increases, a paired t-test was conducted. Only the terms of trade for experienced subjects were analyzed, especially because of the enormous amount of learning necessary in this environment.

TABLE 16.: Terms of Trade Comparison of Phases, Design III								
	Experiment							
	INEXPERIENCED				EXPERIENCED			
Ph.	E1	E2	E3	E4	E1	E2	E3	E4
1	0.69	1.31	0.34	0.68	0.65	1.38	0.58	0.99
2	0.48	1.04	0.37	0.79	0.49	0.97	0.33	0.83

Terms of trade do decrease significantly among experienced subjects, they decrease in all cases with experienced subjects.

7.4. Trading Volume and Efficiencies

The net trading volume was generally below the competitive equilibrium, especially in experiments where prices had been above the competitive equilibrium. Among inexperienced subjects, the net trading volume is usually substantially less than the total quantity traded. Even though the net trading volume does often not increase with experience, efficiencies do. Almost all possible gains from trade are realized at the end of the experiment.

The average net trading volume in period one ranged from 10.8 to 18.1 in market X (equilibrium 16) and from 5.9 to 7.8 in market Y (equilibrium 8). In phase two it ranged from 18.8 to 31.3 (equilibrium 32) in market X and 10.3 to 14.4 in market Y (equilibrium 16). Quantities generally stay below the competitive equilibrium, even at the end of the phase with experienced subjects¹³. In experiments where average prices are higher than the competitive equilibrium the quantity is lower¹⁴. But even if the price is at the competitive equilibrium, the trading volume can fall short of it¹⁵. The total trading volume, including the trades among one side of

¹³ 16, 14, 13, 11 and 33, 22, 27 20 in market X; 8, 9, 7, 7 and 13, 13, 13, 16 in market Y, phase one and two respectively.

¹⁴ For example in experiment 2, market X, both phases.

¹⁵ For example in experiment 3, market X, both phases.

the market, was substantially higher. Especially in market X the difference is relatively high, on average up to six units per period, in several periods more than ten. In almost all cases the difference decreases with experience, indicating that with more training fewer equilibrating trades are necessary.

Efficiency is defined as the total surplus (earnings) generated in the system as a percentage of maximum attainable surplus. That is, if all gains from trade are exploited and the market is in equilibrium efficiency is 100%. Even though full efficiency was not achieved in any period of any experiment in this (or any other) design, efficiency is usually fairly high in the competitive design. Among experienced subjects average efficiency was 94% and 95% in phase one and two, respectively¹⁶. In most cases efficiency increased over time. In the last period average efficiency was for experienced subjects 96% in both phases¹⁷. Experience also increases efficiency¹⁸.

¹⁶ Inexperienced subjects: 88% and 93%.

¹⁷ Inexperienced subjects: 92% in phase one, 95% in phase two.

¹⁸ In seven out of eight cases efficiency in the last period is higher among experienced subjects.

7.5. Earnings

Earnings are in most cases higher among experienced subjects¹⁹ and generally increase towards the end of a phase. On average they are within the equilibrium range, even though in individual experiments they are above or below.

Earnings are defined as the sum of redemption values for the final holding of X and Y plus (or minus) the trade surplus²⁰. The values discussed in the text are the average earnings in the last three periods of each phase. See table 17. for earnings per period.

For industrialized countries in phase one earnings are in most cases within the competitive range (918 to 1138), only in experiment 2 are they below. In phase two they are below the equilibrium (1488 to 1596) in experiments 2 and 4, in experiment 3 they are above.

¹⁹ In all experiments in phase one earnings increase for developing countries, in all experiments in phase two earnings increase for industrialized countries. The latter result supports the finding that prices in market X stayed above the equilibrium among inexperienced subjects, even at the end of phase two. In several cases earnings increase for both sides of the market, indicating that efficiency increases with experience.

²⁰ Trade surplus is defined as revenues from sales minus expenditures on purchases. The reason for using earnings for comparisons and not trade surplus was that the latter is not very meaningful. A country can generate a high trade surplus by selling all its units and nevertheless not be in a very good position, because the redemption value is zero. This situation is comparable to a developing country exporting food while part of the population is starving.

Table 17.: Earnings of Industrialized Countries: Design III											
Earnings of Industrialized Countries, Design III, Phase 1										Averages	
	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4	D3IAV	D3XAV
CEL 918	1	970	528	699	849	682	987	1056	625	852	747
	2	537	962	854	523	1079	1049	1141	699	903	808
	3	931	990	591	388	959	1037	1018	700	875	779
	4	880	789	945	379	1129	825	968	724	980	679
	5	851	922	856	601	1207	1024	1008	780	980	831
CEH 1138	6	873	914	704	480	1173	945	930	815	920	788
	7	1032	980	934	780	1044	1030	1046	870	1014	915
	8	1049	994	783	602	1090	1052	1054	887	994	883
	9	946	1061	644	726	796	1007	984	908	843	925
	10	926	1086	769	673	1141	1055	975	891	953	926
	AVGL3	974	1047	732	667	1009	1038	1005	895	930	912
	AVGALL	899	922	778	600	1030	1001	1018	790	931	828
Earnings of Industrialized Countries, Design III, Phase 2										Averages	
	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4	D3IAV	D3XAV
CEL 1488	11	1342	1299	1362	888	1605	1490	1363	1230	1418	1227
	12	1252	1325	1158	1192	1675	1560	1479	1335	1391	1353
	13	1307	1421	1160	1156	1670	1486	1369	1288	1376	1338
	14	1298	1362	1351	1175	1649	1582	1395	1325	1423	1361
	15	1508	1459	1304	1202	1533	1643	1407	1288	1438	1398
CEH 1596	16	1414	1479	1312	1204	1604	1667	1406	1337	1434	1421
	17	1495	1516	1244	1156	1580	1742	1440	1319	1440	1433
	18	1488	1523	1270	1246	1589	1656	1367	1380	1428	1451
	19	1510	1539	1247	1279	1639	1651	1381	1396	1444	1466
	20	1514	1568	1236	1311	1571	1650	1367	1354	1422	1471
	AVGL3	1504	1543	1251	1279	1600	1652	1372	1376	1432	1463
	AVGALL	1413	1449	1264	1181	1612	1613	1397	1325	1421	1392
Earnings of Developing Countries, Design III, Phase 1										Averages	
	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4	D3IAV	D3XAV
CEL 1182	1	760	1627	1131	1075	1128	1262	1074	1633	1023	1399
	2	1230	1194	1093	1487	900	1176	1025	1515	1062	1343
	3	1021	1168	1415	1755	942	1203	1138	1526	1129	1413
	4	989	1336	1009	1663	1055	1349	1167	1524	1055	1468
	5	1202	1242	1008	1540	880	1251	1204	1446	1073	1370
CEH 1402	6	1061	1236	1129	1628	1046	1295	1217	1319	1113	1370
	7	1120	1084	1076	1403	1073	1181	1224	1389	1123	1264
	8	1014	1125	1168	1490	1075	1174	1193	1354	1112	1286
	9	1124	1128	1459	1289	1066	1228	1273	1323	1231	1242
	10	1192	1112	1266	1594	1033	1204	1251	1311	1185	1305
	AVGL3	1110	1121	1297	1458	1058	1202	1239	1329	1176	1277
	AVGALL	1071	1225	1175	1492	1020	1232	1176	1434	1111	1346
Earnings of Developing Countries, Design III, Phase 2										Averages	
	Period	D3IE1	D3XE1	D3IE2	D3XE2	D3IE3	D3XE3	D3IE4	D3XE4	D3IAV	D3XAV
CEL 1532	11	1449	1563	1388	1851	1380	1499	1569	1626	1446	1634
	12	1641	1598	1450	1806	1262	1508	1508	1630	1465	1635
	13	1591	1492	1581	1798	1307	1555	1569	1632	1512	1619
	14	1612	1667	1427	1779	1345	1480	1563	1605	1487	1633
	15	1343	1442	1476	1810	1432	1419	1643	1747	1474	1604
CEH 1640	16	1406	1232	1672	1676	1378	1407	1615	1651	1518	1492
	17	1430	1386	1512	1846	1434	1330	1631	1677	1502	1560
	18	1334	1375	1685	1740	1423	1401	1674	1608	1529	1531
	19	1393	1392	1580	1727	1401	1426	1690	1625	1516	1542
	20	1402	1369	1700	1695	1452	1436	1639	1667	1548	1542
	AVGL3	1376	1379	1655	1720	1425	1421	1668	1633	1531	1538
	AVGALL	1460	1452	1547	1772	1381	1446	1610	1647	1500	1579

AVGL3: Average earnings during the last 3 periods of one phase.
AVGALL: Average earnings during the whole experiment.
D3IAV (D3XAV): Earnings averaged over all experiments with inexperienced (experienced) subjects.
CEL (CEH) Predictions by the competitive model.

In the second phase, average earnings of industrialized countries increase in all experiments when subjects gain experience.

Earnings of developing countries in phase one increase with experience in all experiments. Among experienced subjects they are in phase one below the equilibrium (1182 to 1402) in experiment 1 and above the equilibrium in experiment 2. In phase two among experienced subjects, earnings are below the equilibrium (1532 to 1640) in experiments 1 and 3, above in experiment 2. None of the results is significantly below the low end of the competitive range.

7.6. Summary for Design III

Prices in the "competitive" design do not always converge to the competitive equilibrium within ten periods, even though a double auction is used as market institution. Convergence to the competitive equilibrium is more likely among experienced subjects. Prices in both markets decrease both within and across periods and are generally above the competitive equilibrium. This result could be due to the specific structure of supply and demand, which leaves a lot of room for profitable trades above, but not below the competitive equilibrium. Consequently, in all experiments with experienced subjects prices converged from above, a result quite untypical for a double auction. They converged

to either the high end of the competitive range or above. In the primary product market, prices in phase one stayed above the competitive equilibrium in two out of four experiments, even when subjects were experienced. In phase two prices remain significantly above the equilibrium in only one experiment. In the market for manufactured products prices remained above the equilibrium in only one experiment in phase two. The effect of inflated prices is a drop in efficiency, but the magnitude of the decrease is moderate. Efficiencies increase, as prices decrease, with experience. In the last period of experiments with experienced subjects, they averaged 96%. The earnings of both developing and industrialized countries were on average at the low end of the equilibrium range.

The terms of trade (ToT) are not too much affected by the aberrant behavior of prices, since prices in both markets tend to be too high. However, prices in the market for primary products seemed to exceed the equilibrium by more than in the manufactured product market. In period two the ToT are at the high end of the competitive equilibrium. ToT vary substantially among the different subject groups, affected by the relative bargaining strength of the groups. However, in all experiments with experienced subjects they do worsen for developing countries.

8. THE "CARTEL" DESIGN: DESIGN IV

In the cartel design, as opposed to the competitive design, the developing countries are allowed to communicate. Communication was possible both before and during each period. Before each period the subjects in the role of developing countries had two minutes for oral communication in a separate room. During each period subjects were allowed to send messages via computer¹. The communication was essentially unrestricted².

In general, all cartel groups immediately realized the opportunity to influence prices as sellers in the market for primary products. However, they only realized much later (if at all) that they were also able to influence prices as buyers. Most groups only agreed to set high prices, but quota restrictions were rarely discussed. In one experiment subjects came up with the idea to separate the market for

¹ In the training session, subjects were instructed how to send messages but oral communication was not possible. Since oral communication is much faster and more convenient, and also because time is valuable during a period (while sending a message one might miss a profitable opportunity to trade), rarely messages were sent.

² Subjects were not allowed to agree on side-payments, to reveal their identity number as trader, and to make physical threats. The reason for implementing the last rule was not because threats and violent actions do not occur in the world economy. One country might well decide to invade another one because the former is not satisfied with the output quota of the latter. However, allowing threats would have made it impossible to conduct the experiments because of objections by the Human Subjects Commission .

primary products into bilateral bargaining in the sense that each one of them was assigned a particular counterpart³. Several groups "agreed to cheat" by agreeing not to offer below a certain price, but granted everyone to accept bids from the other side⁴. In many groups subjects agreed to lower prices at the end of a period.

Some groups did not agree at all on "maximum" prices they were willing to pay in the market for manufactured products, or if they did it was rather in the form of recommendations than in firm agreements. As will be discussed later, these lax agreements might have been the reason why subjects did not succeed in exploiting their market power as buyers in the same manner as they did as sellers⁵. In experiment 3 the inability of the cartel to influence prices in the market for manufactured products was particularly evident. It seemed

³ The agreement was that for instance subject seven would exclusively sell to subject four, subject six would exclusively sell to subject three etc. This agreement was soon abandoned, once some subjects started to cheat on it. Cheating occurred in many cases.

⁴ The cartel members did not want to show the other side that they were also willing to sell cheaper. In MUDA the transaction price is not displayed, but the standing offer is. Therefore accepting bids 'hides' low transaction prices in this case. They could be viewed by calling up the period statistic, which is 'costly' because while doing so a subject cannot trade).

⁵ It is possible to conduct intragroup comparisons, since the same group of people who form the sellers' cartel in market X can form a buyers' cartel in market Y.

almost as if the group which was not able to communicate was able to form a (sellers') cartel in market Y. However, this tacit collusion eventually broke down. At the end of the second phase in the experienced session, prices in market Y were indistinguishable from other groups, but until then this group of industrialized countries had kept prices above those of all other groups⁶.

8.1. The Market for Primary Products

The cartel model predicts that prices increase substantially compared to the high end of the equilibrium range⁷ and rise from phase one to phase two. Table 18. contains the average contract prices in market X for both inexperienced and experienced subjects, in graph 19. the results for experienced subjects are graphed.

⁶ Subjects in this experiment were asked to fill out a questionnaire after the experiment was over. Two of the four subjects realized that it was beneficial for them "... not to undersell each other". One subject stated "... there was a basic understanding between the four of us that we shouldn't go above or below certain prices". This tacit collusion was successful for a long time, it broke down in the second phase with experienced subjects. Apparently only two subjects consciously influenced the market and the other two followed along.

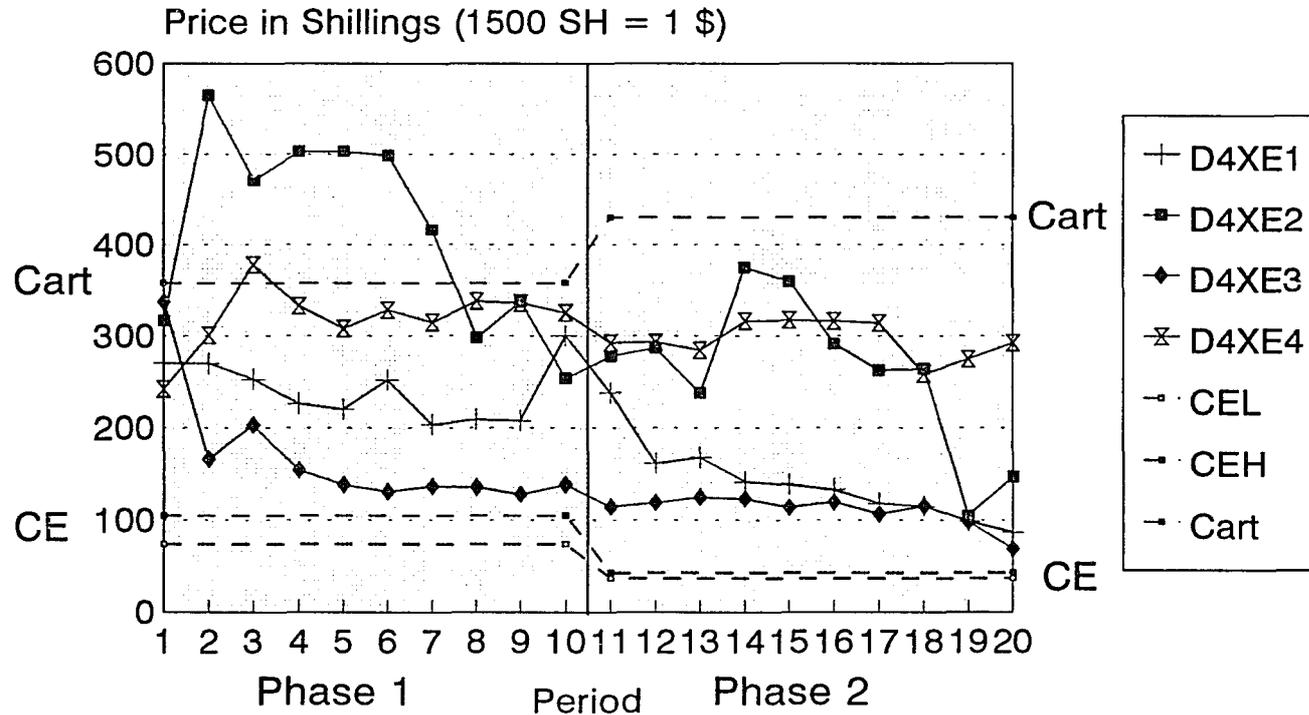
⁷ The price predictions for the cartel are 358 in phase one (CEH: 105) and 431 (CEH: 43) in phase two.

Table 18.: Average Contract Prices: Design IV, Market X

	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4
Phase 1	1	126	270	369	317	263	337	111	242
	2	159	270	392	565	247	166	121	301
	3	183	253	366	472	189	203	157	378
	4	150	226	388	503	168	154	161	333
	5	175	220	340	503	151	138	174	308
	6	164	252	350	499	150	131	179	328
	7	180	204	369	417	171	137	193	315
	8	168	209	354	298	240	136	200	338
	9	175	208	348	338	253	128	228	336
	10	174	300	351	254	388	138	229	325
Phase 2	11	156	238	378	278	282	114	151	292
	12	153	162	303	287	196	119	164	293
	13	151	168	345	238	200	125	164	284
	14	158	142	339	375	298	123	141	316
	15	155	139	427	360	151	114	133	317
	16	151	133	313	292	187	120	102	316
	17	141	118	336	263	138	107	134	314
	18	135	115	275	264	135	115	128	259
	19	121	99	270	105	98	98	142	275
	20	169	87	218	147	90	69	136	293

Graph 19.: Average Contract Prices

Design IV, Market X (Primary Product), Experienced



Results: All cartel groups can increase prices above the competitive level, but not to the prediction of the cartel model. Prices generally decrease over time, but usually remain above CEH, and shift upward at the beginning of periods. Prices at the end of the second phase are in all experiments lower than at the end of the first phase, thus contradicting the cartel model.

In this laboratory market the cartel faces much more favorable conditions than in the field. The performance of the cartel is therefore expected to be at least as good as in the field. There are no substitutes for its product nor can substitutes be developed if high prices prevail for a long period of time (which would result in the long run elasticity of demand being greater than the short run elasticity). Another facilitating factor is that in this laboratory environment the cartel was not threatened by the entry of competitors.

In most experiments prices of primary products are fairly stable. The only exception is experiment 2, in which prices in phase one are even above the cartel level: In that experiment the sellers' cartel in market X seems to work best, but prices sometimes drop drastically. How much a well functioning cartel can influence prices can best be seen in the change from period 8 to 9 of the second phase. The cartel group decided to abandon their agreements and subsequently the

average contract price plummeted by 60%. In the next period this group managed to increase the price of X again, but not to previous levels.

8.1.1. Test for Convergence

Prices usually converge to values between the competitive and the cartel level. They generally shift upward at the beginning of periods. Table 20. contains a summary of the results.

Prices converge in all cases to levels below the cartel prediction⁸, but they always remain above the high end of the competitive range⁹. In D4P1XE3X prices would eventually have converged to CEH (even though until the end they are clearly above). β is usually significant¹⁰ and always positive but less than one, indicating convergence from one side.

⁸ Only in experiment 2, phase one, the difference is not significant. The α - values of the regression with EQ equal to the cartel prediction are -4.20 (Std. Dev. 8.53) and -13.96 (Std. Dev. 12.42) for inexperienced and experienced subjects, respectively.

⁹ The table below contains results from the regression using EQ = CEH. In all cases the asymptotic prediction is above CEH. In several phases of experiment 2 the significance level is only 1.2%.

¹⁰ The exceptions are D4P1IE2X, D4P2IE1X, and D4P1IE3X (in the last case the significance level is 2.2%).

Table 20.: Results of Test for Convergence							
Design IV, Market X (Primary Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ$; Asymptote = $EQ + Alpha/(1-Beta)$							
EQ in phase 1: 105				EQ in phase 2: 43			
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.Dev.
D4IE1	Alpha	31.60	6.47	D4XE1	Alpha	78.21	13.94
Ph. 1	Beta	0.40	0.09	Ph. 1	Beta	0.39	0.09
	Gamma	194.49	48.32		Gamma	93.02	92.56
	Asympt.	157.94			Asympt.	234.01	
D4IE1	Alpha	104.23	10.47	D4XE1	Alpha	53.38	7.42
Ph. 2	Beta	0.01	0.08	Ph. 2	Beta	0.41	0.06
	Gamma	34.36	118.89		Gamma	244.46	99.51
	Asympt.	147.89			Asympt.	133.11	
D4IE2	Alpha	211.05	32.14	D4XE2	Alpha	67.45	28.20
Ph. 1	Beta	0.15	0.12	Ph. 1	Beta	0.68	0.09
	Gamma	186.10	106.61		Gamma	503.10	127.12
	Asympt.	353.06			Asympt.	314.63	
D4IE2	Alpha	48.51	20.85	D4XE2	Alpha	31.48	13.55
Ph. 2	Beta	0.77	0.07	Ph. 2	Beta	0.68	0.06
	Gamma	711.76	106.58		Gamma	837.41	101.51
	Asympt.	255.99			Asympt.	141.85	
D4IE3	Alpha	70.14	12.14	D4XE3	Alpha	7.28	8.13
Ph. 1	Beta	0.23	0.10	Ph. 1	Beta	0.65	0.06
	Gamma	107.05	124.30		Gamma	744.91	102.62
	Asympt.	196.14			Asympt.	125.72	
D4IE3	Alpha	36.72	9.22	D4XE3	Alpha	9.35	3.34
Ph. 2	Beta	0.67	0.05	Ph. 2	Beta	0.82	0.05
	Gamma	377.42	105.23		Gamma	85.03	20.16
	Asympt.	154.65			Asympt.	95.78	
D4IE4	Alpha	27.74	7.19	D4XE4	Alpha	99.79	20.77
Ph. 1	Beta	0.50	0.08	Ph. 1	Beta	0.48	0.09
	Gamma	291.13	72.31		Gamma	470.81	75.85
	Asympt.	160.58			Asympt.	296.11	
D4IE4	Alpha	17.11	5.27	D4XE4	Alpha	118.87	23.33
Ph. 2	Beta	0.78	0.05	Ph. 2	Beta	0.50	0.09
	Gamma	321.98	37.37		Gamma	317.94	82.47
	Asympt.	119.13			Asympt.	279.00	

γ is always positive, indicating a shift at the beginning of periods which decreases over time and is often significant¹¹.

8.2. The Market for Manufactured Products

In the market for manufactured products the cartel is on the buyers' side. If it functions perfectly, it works like a monopsony and can lower the prices -- compared to the low end of the competitive range (CEL) -- in the Y market¹². Table 21. contains the average contract prices and the results for experienced subjects are displayed in graph 22..

Results: Average contract prices do generally not decrease below CEL¹³. On the contrary, in a substantial number of cases they are above CEH! Prices in one experiment are substantially above the competitive equilibrium and also above prices in other experiments, indicating that four sellers are not always enough to render a market competitive. Among experienced subjects, prices usually converge from above to the competitive equilibrium at the end of a phase.

¹¹ The only exceptions occur with completely inexperienced subjects and in experiment 1.

¹² The price predictions for the cartel are 67 (CEL = 89) in phase one and 35 in phase two (CEL = 67).

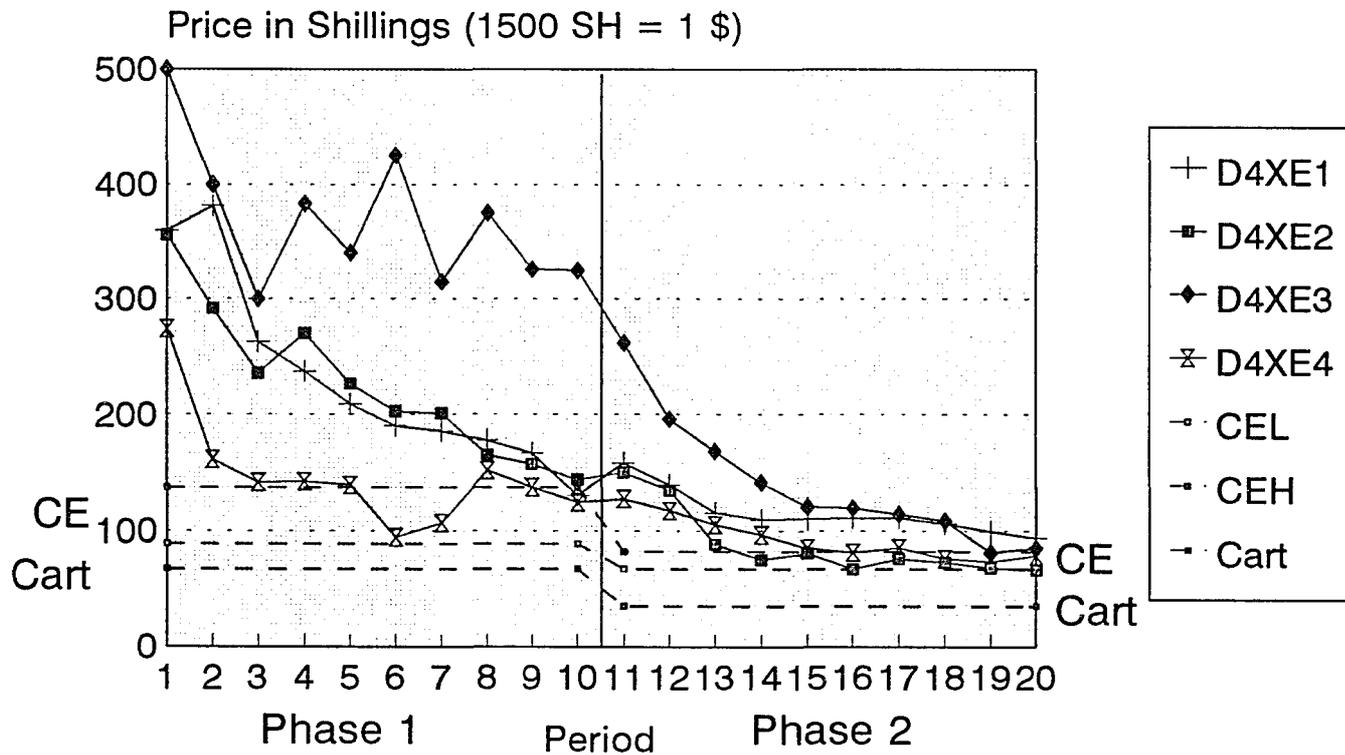
¹³ The only exceptions are D4P1IE4Y (completely inexperienced subjects), and in the last period of D4P2XE2Y the average contract price is 66 (CEL = 67!).

Table 21.: Average Contract Prices: Design IV, Market Y

	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4
Phase 1	1	133	360	168	356	540	500	72	274
	2	144	381	217	292	440	400	77	161
	3	141	263	188	236	424	300	148	142
	4	200	237	215	270	456	383	99	142
	5	160	209	207	226	536	340	121	139
	6	138	190	177	203	463	425	57	94
	7	158	185	153	201	494	315	105	107
	8	145	177	155	165	463	375	92	152
	9	131	167	175	157	449	326	62	137
	10	133	130	165	144	533	325	83	125
Phase 2	11	123	158	165	150	378	262	96	127
	12	127	139	157	135	363	196	102	117
	13	140	115	136	88	298	168	92	105
	14	125	109	134	75	369	141	96	96
	15	119	110	131	81	303	121	79	85
	16	106	111	142	67	306	119	88	81
	17	101	111	138	76	161	114	82	85
	18	96	106	138	73	342	108	86	76
	19	97	99	137	68	237	82	80	73
	20	93	94	130	66	287	85	81	78

Graph 22.: Average Contract Prices

Design IV, Market Y (Manufactured Product), Experienced Subjects



The conclusion is that the buyers' cartel completely fails to exert its market power. Prices at the end of phase one are almost always higher than at the end of phase two, as predicted by both the cartel and the competitive model.

8.2.1. Test for Convergence

Table 23. contains the summary of the regression results. The asymptotic prediction is in only three cases¹⁴ within the competitive range. In all other cases it is above the high end of the competitive range. Among experienced subjects α is significant in experiment 3, phase one and experiment 1, phase two¹⁵. Prices converge only in experiments 2 and 4 to the competitive equilibrium. β is almost always positive¹⁶ and less than one, indicating convergence from above. γ is usually positive, indicating that prices shift upward at the beginning of periods¹⁷.

¹⁴ D4P1IE4Y, D4P2XE2Y and D4P1XE4Y

¹⁵ The significance levels in the other phases of these experiments are 2.2% in D4P1XE1Y and 1.6% in D4P2XE3Y.

¹⁶ The only exception is D4P1XE3Y, the experiment in which the industrialized countries charged substantially higher prices than in all other experiments. The negative coefficient indicates that prices overshoot the equilibrium, which seems to explain the behavior of prices in that experiment fairly well.

¹⁷ γ is negative in D4P2IE4Y. γ is usually not significant in the first phase (except D4P1XE4Y), but it is in the second phase (except D4P2XE1Y).

Table 23.: Results of Test for Convergence							
Design IV, Market Y (Manufactured Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ$; Asymptote = $EQ + Alpha/(1-Beta)$							
EQ in phase 1: 137				EQ in phase 2: 82			
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.Dev.
D4IE1	Alpha	2.88	4.01	D4XE1	Alpha	24.59	11.93
Ph. 1	Beta	0.45	0.09	Ph. 1	Beta	0.66	0.09
	Gamma	81.49	53.08		Gamma	59.08	109.82
	Asympt.	142.23			Asympt.	210.37	
D4IE1	Alpha	7.49	3.09	D4XE1	Alpha	13.59	2.68
Ph. 2	Beta	0.69	0.06	Ph. 2	Beta	0.56	0.06
	Gamma	187.12	34.69		Gamma	1.25	31.49
	Asympt.	105.81			Asympt.	112.73	
D4IE2	Alpha	37.36	7.18	D4XE2	Alpha	7.38	6.67
Ph. 1	Beta	0.21	0.10	Ph. 1	Beta	0.81	0.06
	Gamma	93.83	61.36		Gamma	166.82	54.19
	Asympt.	184.11			Asympt.	176.04	
D4IE2	Alpha	13.69	4.82	D4XE2	Alpha	-1.65	1.63
Ph. 2	Beta	0.73	0.07	Ph. 2	Beta	0.80	0.04
	Gamma	126.68	23.14		Gamma	219.60	30.28
	Asympt.	132.19			Asympt.	73.72	
D4IE3	Alpha	269.09	47.96	D4XE3	Alpha	245.42	41.20
Ph. 1	Beta	0.21	0.13	Ph. 1	Beta	-0.11	0.17
	Gamma	271.51	160.74		Gamma	134.76	176.89
	Asympt.	479.11			Asympt.	357.58	
D4IE3	Alpha	62.80	23.30	D4XE3	Alpha	12.19	5.73
Ph. 2	Beta	0.59	0.10	Ph. 2	Beta	0.54	0.07
	Gamma	398.40	94.94		Gamma	331.17	65.50
	Asympt.	236.24			Asympt.	108.70	
D4IE4	Alpha	-31.81	7.17	D4XE4	Alpha	-2.39	4.75
Ph. 1	Beta	0.33	0.11	Ph. 1	Beta	0.35	0.08
	Gamma	32.09	59.03		Gamma	20.66	53.64
	Asympt.	89.62			Asympt.	133.33	
D4IE4	Alpha	5.85	2.36	D4XE4	Alpha	1.53	2.45
Ph. 2	Beta	0.12	0.09	Ph. 2	Beta	0.50	0.08
	Gamma	-69.55	34.43		Gamma	154.66	34.79
	Asympt.	88.66			Asympt.	85.04	

8.3. Terms of Trade

Table 24. contains the terms of trade (ToT) for both inexperienced and experienced subjects, graph 25. displays the results for experienced subjects.

Results: The cartels do not obtain terms of trade predicted by the cartel model. However, they usually improve the ToT beyond the competitive level. The question whether cartels improve the ToT when income increases, as predicted by the cartel model, remains unanswered: the results are inconclusive.

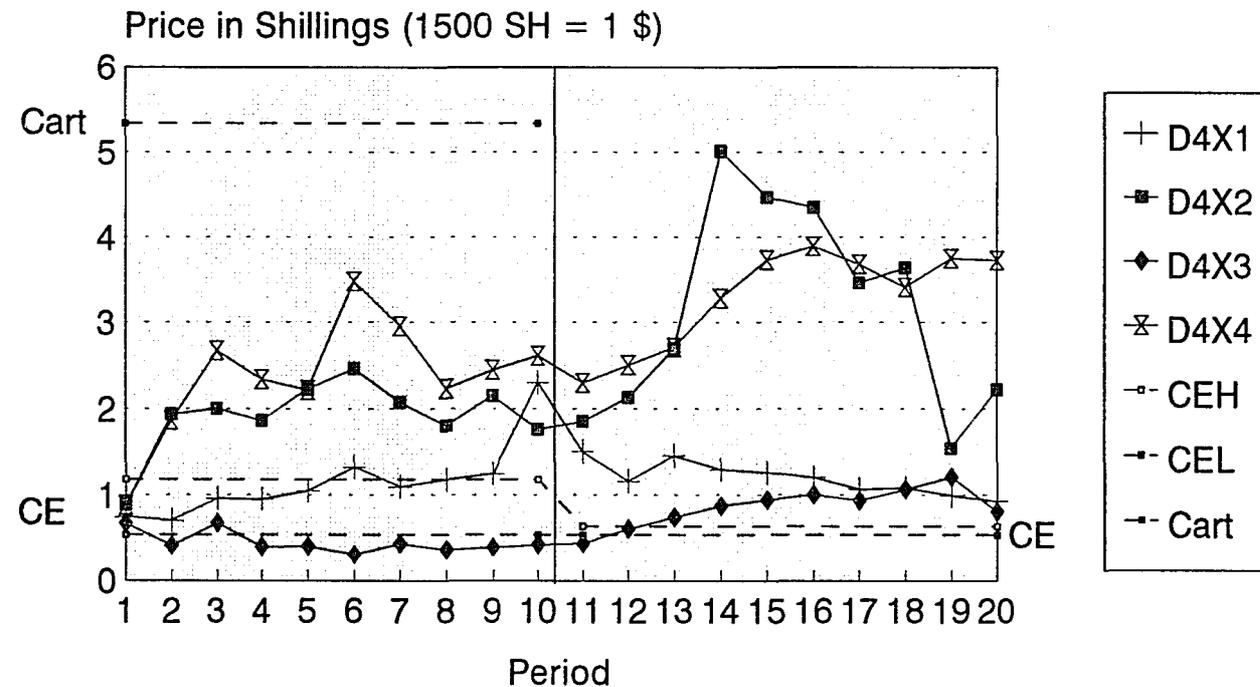
The terms of trade were in all cases far below the cartel prediction. The bargaining strength of specific subject groups plays an important role in this design. The characteristics of experiment 3, in which the industrialized countries managed to charge extremely high prices for the manufactured product, are completely different from the other experiments. In experiment 3, the ToT are in several periods below the low end of the competitive range, especially in phase one with both inexperienced and experienced subjects and again at the end of phase two with inexperienced subjects. The ToT increase within the second phase with experienced subjects, but until the very end of that phase they are below the ToT in all other experiments.

Table 24.: Terms of Trade: Design IV

	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4
Phase 1	1	0.95	0.75	2.20	0.89	0.49	0.67	1.54	0.88
	2	1.11	0.71	1.81	1.94	0.56	0.42	1.57	1.87
	3	1.30	0.96	1.95	2.00	0.45	0.68	1.06	2.67
	4	0.75	0.95	1.80	1.86	0.37	0.40	1.62	2.34
	5	1.10	1.05	1.64	2.22	0.28	0.41	1.44	2.21
	6	1.19	1.33	1.97	2.46	0.33	0.31	3.13	3.48
	7	1.14	1.10	2.42	2.07	0.35	0.43	1.83	2.96
	8	1.16	1.18	2.28	1.81	0.52	0.36	2.17	2.23
	9	1.34	1.25	1.99	2.15	0.56	0.39	3.65	2.45
	10	1.31	2.30	2.13	1.76	0.73	0.43	2.75	2.61
Phase 2	11	1.27	1.51	2.30	1.85	0.75	0.44	1.57	2.30
	12	1.21	1.16	1.93	2.13	0.54	0.61	1.61	2.50
	13	1.08	1.46	2.53	2.69	0.67	0.74	1.79	2.71
	14	1.26	1.29	2.53	5.01	0.81	0.87	1.47	3.28
	15	1.30	1.26	3.26	4.47	0.50	0.95	1.68	3.73
	16	1.42	1.21	2.20	4.35	0.61	1.01	1.16	3.89
	17	1.39	1.07	2.43	3.46	0.86	0.94	1.63	3.68
	18	1.42	1.08	1.99	3.64	0.40	1.07	1.48	3.41
	19	1.24	0.99	1.97	1.54	0.41	1.21	1.77	3.75
	20	1.82	0.93	1.68	2.22	0.31	0.81	1.69	3.73

Graph 25.: Terms of Trade

Design IV, Experienced Subjects



Phase 1 Phase 2
 CEH (CEL) = High (low) end of competitive range, Cart = Cartel (Phase 2: 12.29)

This result suggests that with only four subjects in the role of industrialized countries tacit collusion can be successful and communication is not indispensable. In experiment 1, the ToT rise slowly but quite steadily in the first phase and decrease in the second phase (with experienced subjects). Experiments 2 and 4 resemble most closely 'typical' cartels. In both experiments the ToT in phase one (with experienced subjects) start out in the competitive range and increase subsequently when the cartel starts to function. A common pattern is that the ToT decrease after reaching high levels, presumably because when the ToT are favorable the incentive to cheat is also greatest. However, the drastic drop in terms of trade between periods eight and nine of the second phase of experiment 2 has a different explanation. When the cartel group in that experiment decided abandon their agreements, the result was a major drop in prices for the primary product (prices in the Y market stayed the same, since the buyers' cartel had not worked anyway), and the ToT plummeted.

At the end of each phase, the ToT (computed as ratio of the average contract prices within the last three periods) are significantly below the cartel level, both with inexperienced and experienced subjects (even at $\alpha = 1\%$). The ToT are not significantly above the high end of the competitive range in

phase one, but they are in phase two¹⁸. This result is due to the 'outlier', experiment 3. In all other experiments the ToT are above the high end of the competitive range by a wide margin.

The conclusion is therefore that the terms of trade are generally higher than the CE. Even though the cartels fail to keep prices down in the market for manufactured products, overall they improve the terms of trade -- unless the industrialized countries successfully collude.

8.3.1. Do Terms of Trade worsen in the Cartel Design?

As discussed in the theoretical part, a perfectly functioning cartel should not only be able to avert the worsening of the terms of trade, it should even be able to improve the terms of trade as income increases! Table 26. contains the terms of trade of the different experiments.

¹⁸ Because of the low power of the test with only four observations (8 when inexperienced and experienced subjects are pooled), $\alpha = 10\%$ was chosen as level of significance. Results are significant, for both experienced and inexperienced subjects. In all cases the alternative hypothesis was that ToT are above CEH.

Table 26.: Terms of Trade: Comparison of Phases, Design IV								
	Experiment							
	Inexperienced				Experienced			
Ph.	E1	E2	E3	E4	E1	E2	E3	E4
1	1.27	2.11	0.61	2.80	1.37	1.91	0.39	2.45
2	1.50	1.86	0.37	1.63	1.00	2.28	1.00	3.58

Terms of trade in phase one and two, do not differ significantly. In three of the experiments with inexperienced subjects they decrease, in three of the experiments with experienced subjects they increase. This result is important, because it is apparently possible for a cartel to avert worsening terms of trade.

8.4. Trading Volume and Efficiencies

The trading volume in market X in phase one was generally much lower than in the competitive equilibrium (16), but close to the cartel prediction (8)¹⁹. In phase two, the average

¹⁹ It averaged less than 9 units (range: 5.5 to 11.5) units.

trading volume (14) is substantially less than the competitive prediction (32), but more than predicted by the cartel model (8). However, in experiments 2 and 4 the average trading volume is only 8.8, almost equal to the cartel prediction. Other than in the competitive design, there is almost no trade among members of one side of the market²⁰. In market Y both the competitive and the cartel model predict a trading volume of 8 in phase one. The quantities actually traded were somewhat less (on average 6). However, by the end of phase one, the trading volume is only in experiment 3²¹ substantially below 8. In phase two, the competitive model predicts a trading volume of 16, the cartel model predicts 12. In most experiments the quantity traded is closer to the cartel than to the competitive prediction²².

Efficiencies are in general lower than in the competitive design. There is no clear upward trend, on the contrary, efficiency sometimes decreases substantially at the end of a phase. Efficiency is also much more volatile than in the competitive design, it sometimes drops by twenty percentage

²⁰ Since the cartel voluntarily restricts trade, the quantities traded do not overshoot the equilibrium and reversing equilibrating trades are not necessary.

²¹ In experiment 3 the industrialized countries were able to collude tacitly.

²² Average quantity traded is between 10 and 13. The exceptions are experiment 3 with inexperienced subjects (4) and experiment 2 with experienced subjects (18).

points from one period to the next. The activity of the cartel can cause a substantial dead weight loss²³.

8.5. Earnings

Table 27. contains the average earnings for each period of each experiment and the average of the last three periods of the experiments. The earnings of industrialized countries are generally below the low end of the competitive equilibrium range (918 in phase one and 1488 in phase two) but above the level predicted by the cartel model during the whole experiment. The only exception is again experiment 3, in which the industrialized countries earn the competitive level in several periods in phase one. During the last three periods, the average earnings of industrialized countries in all experiments are below CEL.

In phase one, earnings of developing countries are below the competitive range (1182-1402) in experiment 3, within it in experiment 1, and above it in experiments 2 and 4, both for inexperienced and experienced subjects in each case. This result reflects both the importance of relative bargaining strength of different groups, and that cartels are not always able to increase their earnings.

²³ With experienced subjects efficiencies in the last period of phase one and two, respectively, range from 54% to 90% and from 82 to 97%.

Table 27.: Earnings of Industrialized Countries: Design IV											
Earnings of Industrialized Countries: Design IV, Phase 1										Averages	
	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4	D4IAV	D4XAV
CEL 918	1	784	670	301	657	1096	490	662	759	711	644
	2	559	971	485	429	963	1078	684	554	673	758
	3	707	707	387	526	866	764	862	361	706	589
	4	708	653	334	494	1167	1045	691	471	725	666
CEH 1138	5	641	544	401	345	1167	1043	719	466	732	599
	6	792	545	383	438	1115	688	585	405	719	569
	7	673	670	281	518	903	921	655	364	628	618
CART 307	8	794	598	383	541	747	1082	613	444	634	666
	9	795	621	417	561	604	804	534	461	587	612
	10	634	261	383	596	600	624	577	474	548	489
	AVGL3	741	493	394	566	651	837	575	460	590	589
	AVGALL	709	624	375	510	923	874	658	476	666	621
Earnings of Industrialized Countries: Design IV, Phase 2										Averages	
	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4	D4IAV	D4XAV
CEL 1488	11	1066	781	668	859	906	1361	1008	688	912	922
	12	1086	995	591	767	1039	1192	972	726	922	920
	13	999	915	668	877	995	1119	1002	718	916	907
	14	1059	999	656	444	912	1029	1070	603	924	769
CEH 1596	15	1038	919	597	548	1111	1214	1113	612	965	823
	16	1157	1051	714	537	840	1018	1215	607	982	803
	17	1013	1034	700	742	1029	1041	1019	625	940	860
CART 291	18	1024	1107	751	678	1141	1135	1132	765	1012	921
	19	1092	1174	716	1021	1291	1167	1066	692	1041	1013
	20	751	1184	924	938	1429	1310	978	655	1020	1022
	AVGL3	955	1155	797	879	1287	1204	1059	704	1024	985
	AVGALL	1028	1016	698	741	1069	1158	1057	669	963	896
Earnings of Developing Countries: Design IV, Phase 1										Averages	
	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4	D4IAV	D4XAV
CEL 1182	1	1234	1318	1388	1482	422	1544	1309	1385	1088	1432
	2	1169	726	1401	1251	1059	1132	1297	1490	1231	1150
	3	1195	1250	1573	1283	1261	1421	1161	1499	1297	1363
	4	1196	1310	1633	1211	1014	949	1417	1673	1315	1285
CEH 1402	5	1242	1485	1698	1319	993	1121	1334	1733	1317	1414
	6	1192	1482	1756	1410	1037	802	1420	1736	1351	1357
	7	1259	1440	1723	1326	1033	1166	1479	1836	1373	1442
CART 1873	8	1376	1474	1616	1627	1134	1118	1598	1623	1431	1460
	9	1400	1367	1688	1391	926	1140	1516	1534	1382	1358
	10	1405	994	1570	1337	1058	1009	1424	1609	1364	1237
	AVGL3	1394	1278	1624	1451	1039	1089	1513	1589	1392	1352
	AVGALL	1267	1284	1604	1363	994	1140	1396	1612	1315	1350
Earnings of Developing Countries: Design IV, Phase 2										Averages	
	Period	D4IE1	D4XE1	D4IE2	D4XE2	D4IE3	D4XE3	D4IE4	D4XE4	D4IAV	D4XAV
CEL 1532	11	1826	2021	1998	1689	1428	1445	1693	2069	1736	1806
	12	1766	1955	2129	1763	1660	1464	1677	1997	1808	1795
	13	1498	2062	2012	1829	1634	1413	1879	1923	1756	1806
	14	1548	1930	1993	1616	1570	1505	1849	1902	1740	1738
CEH 1640	15	1802	1854	2008	1666	1458	1655	1675	1913	1736	1772
	16	1746	1733	1914	1970	1939	1553	1762	2110	1840	1841
	17	1899	1912	1967	1906	1886	1506	1763	2024	1879	1837
CART 2394	18	1711	1824	1906	2081	1270	1659	1819	2047	1677	1902
	19	1624	1843	1820	1828	1449	1855	1796	1983	1672	1877
	20	2007	1780	1916	2091	1401	1651	1781	1920	1776	1860
	AVGL3	1781	1815	1881	2000	1373	1721	1798	1983	1708	1880
AVGALL	1743	1891	1966	1844	1569	1570	1769	1988	1762	1823	
AVGL3: Average earnings during the last 3 periods of one phase.											
AVGALL: Average earnings during the whole experiment.											
D4IAV (D4XAV): Earnings averaged over all experiments with inexperienced (experienced) subjects.											
CEL (CEH): Predictions by the competitive model; CART: Predictions by the cartel model.											

In phase two, the last three periods' earnings of developing countries are almost always above the high end of the competitive range, the exception is experiment 3 with inexperienced subjects. Even though subjects never earn cartel payoffs (1873 and 2394 in phase one and two, respectively), especially in experiments 2 and 4 they come very close.

The conclusion is that market power can be successfully used by the cartel members. Especially in phase two, when the competitive model predicts that the income of developing countries increases by substantially less than that of the industrialized countries (because of the worsening terms of trade) the cartel can improve the developing countries' earnings.

8.6. Summary for Design IV

The members of the commodity cartel are able to substantially increase the prices of the primary commodity. They do so mainly with price agreements, often without making agreements on quotas. Cheating occurs by selling at prices cheaper than the ones agreed upon. Under the favorable conditions of the laboratory market (no entry, no substitutes, small number of agents) the sellers' cartel successfully increases prices in the primary product market.

In the market for manufactured products the cartel has

the opportunity to exert market power as a buyers' cartel, but it fails lower the prices below the competitive equilibrium. In most cases, prices in that market are even above the high end of the competitive range, indicating that the buyers' cartel does not succeed at all to control prices. In one case the group of four industrialized countries is able to increase prices by tacitly colluding. This result suggests that, even in a double auction, four sellers are not necessarily enough to insure convergence to the competitive equilibrium. One possible explanation is that they observe that joint action (by the commodity cartel) can increase prices and try to do the same without the possibility to communicate. Most cartel groups immediately realized the possibility to influence prices as sellers, only sometimes and much later did they also gain the insight that they might also exert market power as buyers. The fact that only sellers are able to influence the market might be due to cultural differences, since in our society buyers often take prices as given. Another possible interpretation is that with this specific supply and demand structure it is much more profitable to influence prices as seller.

Even though the cartel only works reasonably well in the primary product market, the terms of trade usually increase beyond the competitive level. Prices never increase from phase one to phase two in the market for primary products, as

the cartel model predicts, but the final terms of trade increase in half the experiments. The cartel has apparently the potential to avert decrease of the terms of trade, but does not always succeed.

The cartel mainly affects the trading volume in the market for primary products, not in the market for manufactured products. This result conforms with the theoretical prediction. Efficiencies are lower than in the competitive design and also more volatile, the cartel causes some deadweight loss.

The cartel members usually succeed to improve their earnings beyond the competitive equilibrium, but not to the levels predicted by the cartel model. The industrialized countries suffer, and their earnings decrease well below the competitive level, with the exception of the first phase of experiment 3, in which the industrialized countries are able to collude tacitly.

9. THE MONOPOLY DESIGN: DESIGN I

In the "monopoly" design (design I) the four developing countries are facing a single industrialized country, which is in the role of a monopsony in the primary product market and in the role of a monopoly in the manufactured product market. According to the monopoly/monopsony model, the industrialized country should be able to lower prices in market X and to increase prices in market Y (compared to the competitive equilibrium, CE). Consequently, the terms of trade are expected to be substantially worse than in the competitive equilibrium.

In general, all subjects in the role of the industrialized country were able to raise the price in their output market substantially above the competitive level, usually though not to the level predicted by the monopoly model. Experienced subjects charge higher prices in the market for manufactured products. Prices in market Y usually decrease from phase one to phase two, contradicting the monopoly model. In the market for primary products the monopsonies fail to exploit their market power. Especially in phase two prices are often even above the CE. The terms of trade are usually below the CE, but above the level predicted by the monopoly model. ToT always decrease among inexperienced subjects from phase one to phase two, contradicting both the competitive and the monopoly model.

Among experienced subjects however, they increase in three cases. Earnings of experienced industrialized countries are usually above the competitive level and below the monopoly level. Earnings of developing countries are usually below the competitive level.

9.1. The Market for Primary Products

The monopsony model predicts that prices decrease in market X compared to the competitive equilibrium¹, however the difference is by far not as pronounced as in market Y. Table 28. contains the average contract prices for both inexperienced and experienced subjects, in graph 29. they are displayed for experienced subjects only.

Results: Prices in market X are in many cases very volatile at the beginning of phase one, but stabilize afterwards. At the end of phase one, prices are generally within the competitive range, with the exception of one experiment. At the end of phase two, prices are above the competitive equilibrium in two experiments. Prices are in only one experiment consistently close to the monopsony prediction.

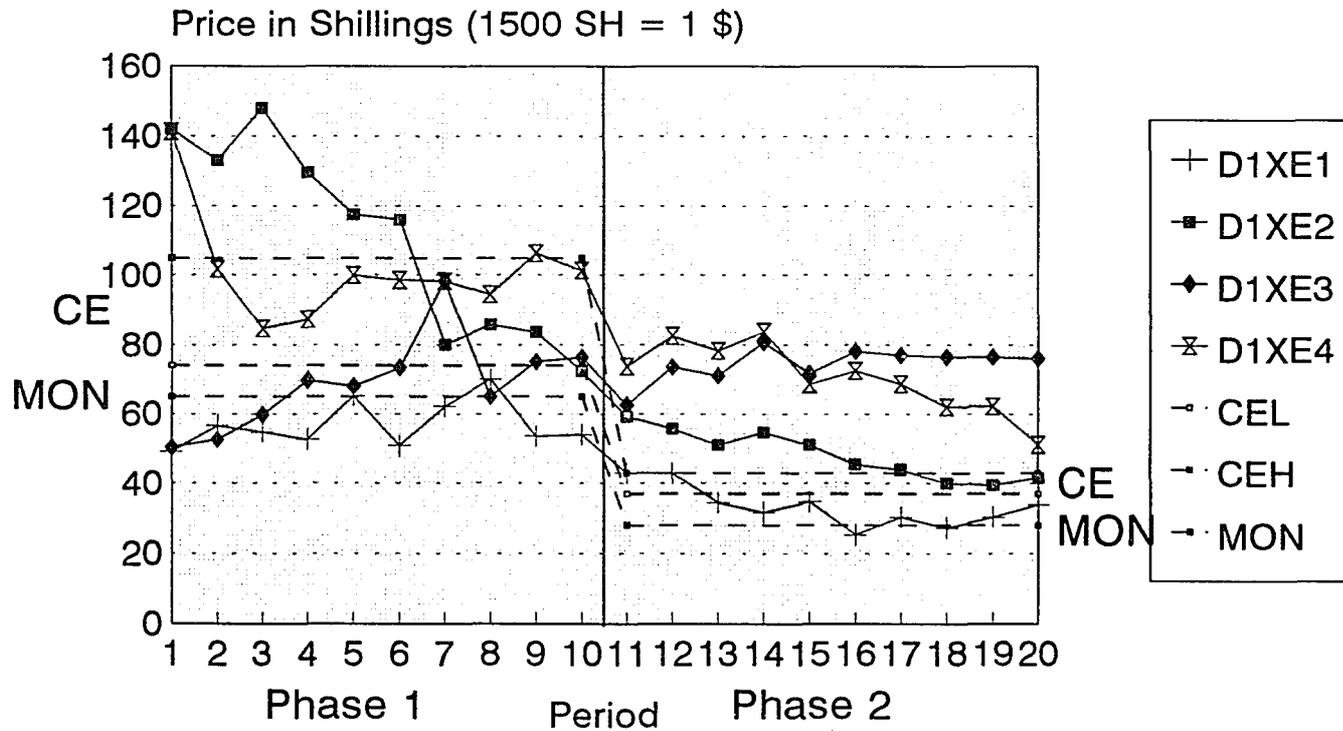
¹ The competitive range in phase one (two) is 74-105 (37-43), the monopsony model predicts 64 (27), thus in both phases only 10 Shillings below the low end of the competitive range.

Table 28.: Average Contract Prices: Design I, Market X

	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4
Phase 1	1	26	49	48	142	27	50	61	141
	2	28	57	53	133	30	53	77	102
	3	32	55	45	148	38	60	72	85
	4	35	53	67	130	40	70	70	87
	5	48	65	65	118	39	68	69	100
	6	49	51	66	116	41	73	60	99
	7	56	62	78	80	49	98	43	98
	8	45	70	73	86	65	65	66	95
	9	40	54	76	84	88	75	71	106
	10	50	54	85	72	72	76	73	101
Phase 2	11	22	43	49	59	39	63	29	74
	12	27	43	61	56	47	74	42	83
	13	27	35	53	51	62	71	45	78
	14	25	32	53	55	49	81	52	84
	15	34	35	54	51	50	72	46	69
	16	29	25	56	46	44	78	59	72
	17	24	30	58	44	48	77	25	69
	18	25	27	59	40	45	76	47	62
	19	26	30	56	40	46	76	47	62
	20	28	34	50	42	48	76	49	51

Graph 29.: Average Contract Prices

Design I, Market X (Primary Product), Experienced Subjects



Only experiment 1 (with both inexperienced and experienced subjects) supports the monopsony prediction throughout the experiment. In experiment 3, prices are close to the monopsony prediction in phase one, but substantially above even the competitive level in phase two. With experienced subjects, prices are initially well above the competitive level, but are at the end of phase one in all cases (including inexperienced subjects) at the CE. At the end of phase two, they are at the CE in experiment 2 and only slightly above in experiment 4.

9.1.1.1. Test for Convergence

All asymptotic predictions in phase one are either within the competitive range or below (CEL), in phase two they are above the high end (CEH), except for experiment 1. Table 30. contains therefore the results using (EQ = CEL) in phase one and (EQ = CEH) in phase two².

Whether prices converge in phase one to CEL or to the monopsony prediction cannot be clearly distinguished, in most cases convergence to either cannot be rejected³.

² For experiment 1 the results for EQ = CEL are presented.

³ In D1P1XE1X prices converge into the competitive range and are significantly different from the monopsony prediction.

Table 30.: Results of Test for Convergence							
Design I, Market X (Primary Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ$; Asymptote = $EQ + Alpha/(1-Beta)$							
The equilibrium prediction EQ is mentioned in parentheses.							
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.Dev.
D1IE1	Alpha	-4.62	3.26	D1XE1	Alpha	-12.24	3.27
Ph. 1	Beta	0.83	0.09	Ph. 1	Beta	0.29	0.14
	Gamma	-3.43	9.04		Gamma	-13.57	16.81
	Asympt.	46.19	(EQ = 74)		Asympt.	56.78	(EQ = 74)
D1IE1	Alpha	-8.54	1.38	D1XE1	Alpha	-3.95	1.20
Ph. 2	Beta	0.16	0.12	Ph. 2	Beta	0.64	0.11
	Gamma	0.16	6.76		Gamma	10.77	7.37
	Asympt.	26.87	(EQ = 37)		Asympt.	32.08	(EQ = 37)
D1IE2	Alpha	-1.23	2.35	D1XE2	Alpha	6.43	4.56
Ph. 1	Beta	0.46	0.14	Ph. 1	Beta	0.74	0.10
	Gamma	-23.68	20.57		Gamma	36.04	29.15
	Asympt.	71.72	(EQ = 74)		Asympt.	98.67	(EQ = 74)
D1IE2	Alpha	7.26	1.35	D1XE2	Alpha	0.71	0.54
Ph. 2	Beta	0.31	0.10	Ph. 2	Beta	0.86	0.06
	Gamma	33.98	8.93		Gamma	-4.72	5.32
	Asympt.	53.46	(EQ = 43)		Asympt.	47.92	(EQ = 43)
D1IE3	Alpha	-5.58	2.76	D1XE3	Alpha	-1.22	4.36
Ph. 1	Beta	0.66	0.08	Ph. 1	Beta	0.11	0.11
	Gamma	-82.40	27.12		Gamma	-42.88	55.45
	Asympt.	57.37	(EQ = 74)		Asympt.	72.63	(EQ = 74)
D1IE3	Alpha	4.67	1.55	D1XE3	Alpha	5.88	1.20
Ph. 2	Beta	0.00	0.07	Ph. 2	Beta	0.81	0.04
	Gamma	1.26	27.98		Gamma	22.70	4.78
	Asympt.	47.69	(43)		Asympt.	74.05	(EQ = 43)
D1IE4	Alpha	-2.31	3.42	D1XE4	Alpha	21.09	6.14
Ph. 1	Beta	0.26	0.09	Ph. 1	Beta	0.20	0.12
	Gamma	-175	44.63		Gamma	46.39	57.64
	Asympt.	70.89	(EQ = 74)		Asympt.	100.43	(EQ = 74)
D1IE4	Alpha	0.69	0.90	D1XE4	Alpha	11.39	3.20
Ph. 2	Beta	0.69	0.06	Ph. 2	Beta	0.50	0.10
	Gamma	-20.27	15.50		Gamma	75.73	23.78
	Asympt.	45.21	(EQ = 43)		Asympt.	65.61	(EQ = 43)

Prices converge only in experiment 1 consistently to the monopsony level⁴. The asymptotic predictions for phase two are usually above CEH, the difference is often significant⁵. The exception is again experiment 1, where they are in both cases below CEL and not significantly different from the monopsony prediction. β is always positive and less than one, indicating convergence to an equilibrium from one side. β is in most cases significant⁶. γ is usually not significant, indicating that in design I prices in market X do not shift at the beginning of periods⁷.

9.2. The Market for Manufactured Products

Table 31. contains the average contract prices of both inexperienced and experienced subjects, graph 32. displays the results for experienced subjects.

⁴ In experiment 1 with experienced subjects, prices converge to even below the competitive level. Using the monopoly prediction for EQ, the hypothesis ($\alpha=0$) is rejected at a significance level of 1%.

⁵ Prices are significantly greater than CEH in experiments 2 and 3 with inexperienced subjects and in experiments 3 and 4 with experienced subjects.

⁶ The exceptions are D1P2IE1X, D1P2IE3X, D1P1XE1X, D1P1XE3X and D1P1XE4X.

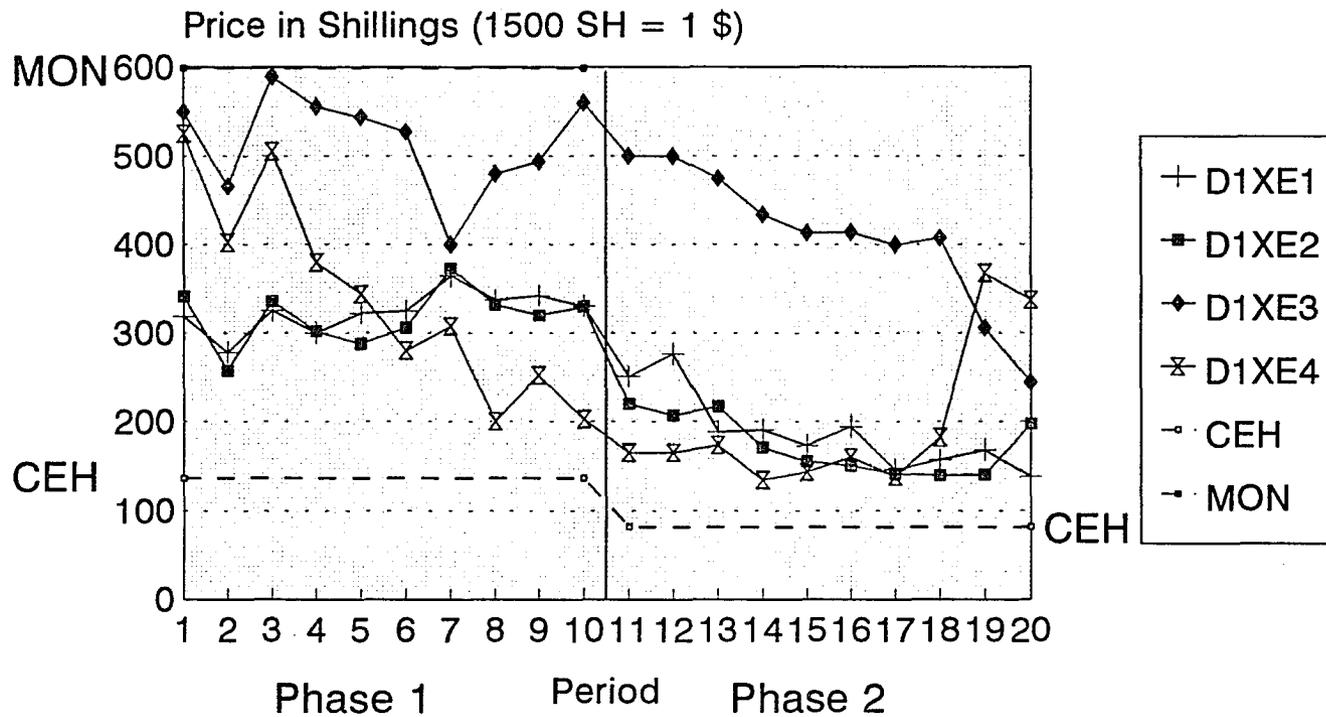
⁷ The exceptions are D1P1IE3X, D1P1IE4X ($\gamma < 0$), D1P2IE2X, D1P2XE3X and D1P2XE4X ($\gamma > 0$). Prices only shift downwards with completely inexperienced subjects.

Table 31.: Average Contract Prices: Design I, Market Y

	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4
Phase 1	1	45	319	219	341	143	550	110	526
	2	128	278	185	258	155	466	132	402
	3	138	326	173	336	171	590	153	506
	4	153	300	159	302	229	556	193	380
	5	172	323	160	288	224	544	189	344
	6	194	325	187	306	209	528	214	280
	7	206	365	152	373	208	400	195	308
	8	250	338	166	332	300	480	161	200
	9	270	343	153	320	268	494	164	252
	10	228	331	149	330	243	560	159	202
Phase 2	11	261	251	145	220	256	500	210	165
	12	242	277	109	207	284	500	200	166
	13	224	189	105	217	263	475	151	174
	14	229	191	133	171	290	434	160	135
	15	228	174	121	156	335	413	166	144
	16	199	194	127	151	309	414	189	160
	17	238	146	137	142	323	400	215	139
	18	197	158	114	140	346	408	156	182
	19	182	169	119	141	363	306	184	368
	20	178	139	109	198	320	244	251	338

Graph 32.: Average Contract Prices

Design I, Market Y (Manufactured Product), Experienced Subjects



Monopoly Prediction: 705 in phase 2

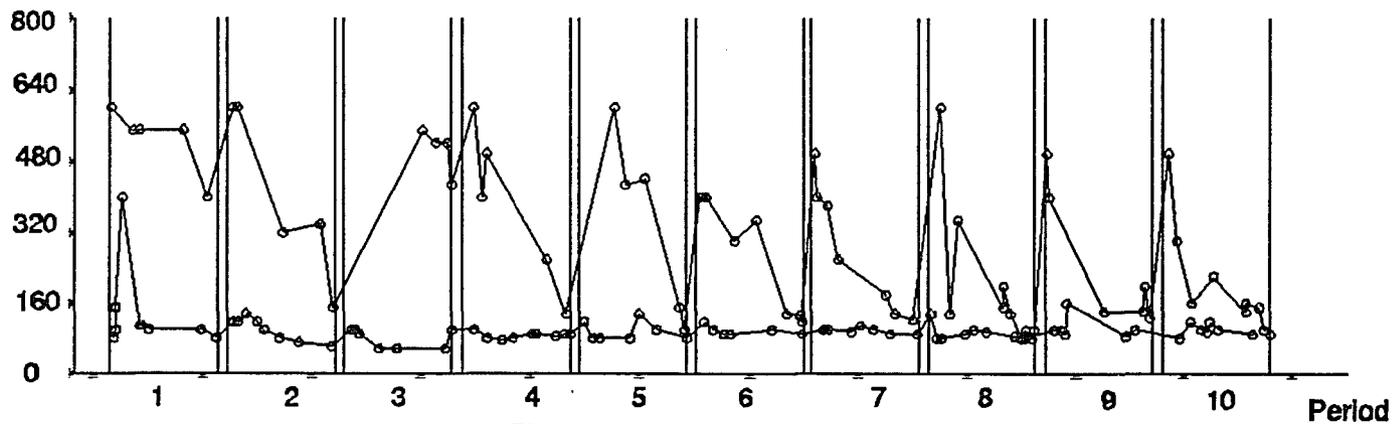
In the market for manufactured products the industrialized country has market power as a seller. The predictions of the monopoly model exceed the CE by far⁸.

Results: The average contract prices are in all periods above the high end of the competitive range (CEH). However, they are also in all periods below the monopoly prediction. Among experienced subjects, prices are always higher than among inexperienced subjects in phase one, suggesting that the industrialized countries have to 'learn' how to exploit their market power. The fact that a subject can exploit market power as a buyer does not necessarily lead to the conclusion that he can do so as a seller.

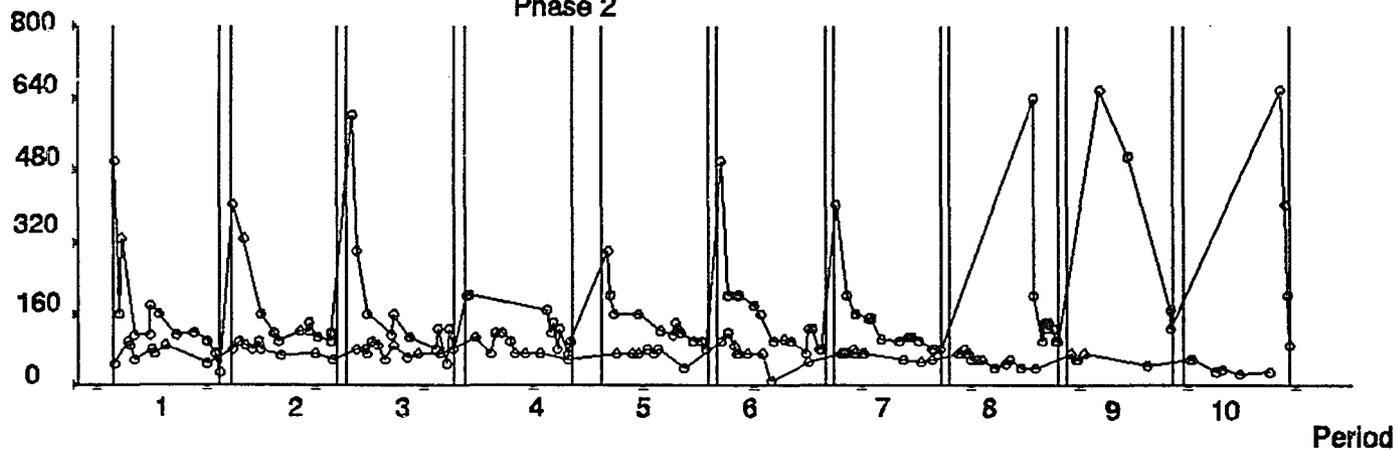
Prices stay fairly close to the monopoly prediction only in phase one of experiment 3 (with experienced subjects). Prices slowly but consistently fall in the second phase of that experiment. In experiment 4 they start out fairly high, but eventually fall below the levels of all other experiments with experienced subjects. Graph 33. displays the problem a monopoly faces. In period one, the monopolist in experiment 4 charges prices relatively close to the (single price) monopoly level and sells four units. The monopolist then sells one unit for substantially less, which reveals to the developing countries that they can acquire units cheaper.

⁸ The competitive equilibrium in phase one (two) is 89-137 (67-82), the monopoly prediction is 599 (705).

Graph 33.: Design I, Experiment 4, Both Markets (Y above X)
Phase 1



Phase 2



In period two, only two units are sold at high prices, afterwards prices drop again substantially. In period three the monopolist has to hold out very long until finally the developing countries buy at fairly high prices, but from then on average prices drop, since only one or two units are sold at high prices. In phase two, even that ceases to work after period three, and only by holding out for a long time in period eight can the monopolist raise the price of at least one unit per period to very high levels.

The patterns of contract prices provide several insights. The fact that experienced monopolists charge always more than inexperienced monopolists indicates that it is necessary to 'learn' the shape of the demand curve and how to use that information. But obviously that is not enough, especially when the monopolist tries to price-discriminate. Buyers 'learn' that the monopolist sells cheaper, and withhold their demand until the seller concedes. Not all buyers however take the 'risk' to wait until the end of the period, since it is possible to be excluded from the market because of the time constraint.

9.2.1. Test for Convergence

Table 34. contains the summary of the regression results. The asymptotic prediction is always above CEH and always below the monopoly level.

Table 34.: Results of Test for Convergence							
Design I, Market Y (Manufactured Product)							
Results of the model $p(t) = a + b * p(t-1) + c * [T(t)-T(t-1)]/T$							
$p(t) = P(t) - EQ$; Asymptote = $EQ + Alpha/(1-Beta)$							
EQ in phase 1: 137				EQ in phase 2: 82			
Inexperienced				Experienced			
		Coeff.	Std.Dev.			Coeff.	Std.Dev.
D1IE1	Alpha	34.29	25.27	D1XE1	Alpha	9.68	43.36
Ph. 1	Beta	0.81	0.09	Ph. 1	Beta	0.82	0.21
	Gamma	198.92	120.56		Gamma	408.25	92.73
	Asympt.	321.75			Asympt.	192.02	
D1IE1	Alpha	105.11	33.61	D1XE1	Alpha	17.54	8.58
Ph. 2	Beta	0.62	0.09	Ph. 2	Beta	0.66	0.07
	Gamma	564.15	89.60		Gamma	530.70	56.42
	Asympt.	360.38			Asympt.	132.91	
D1IE2	Alpha	3.13	5.24	D1XE2	Alpha	88.32	21.58
Ph. 1	Beta	0.55	0.08	Ph. 1	Beta	0.37	0.11
	Gamma	370.18	52.31		Gamma	463.68	77.52
	Asympt.	143.94			Asympt.	277.31	
D1IE2	Alpha	16.76	4.73	D1XE2	Alpha	16.14	5.12
Ph. 2	Beta	0.28	0.06	Ph. 2	Beta	0.58	0.04
	Gamma	712.36	64.02		Gamma	767.30	39.62
	Asympt.	105.43			Asympt.	119.99	
D1IE3	Alpha	43.57	14.86	D1XE3	Alpha	247.74	85.08
Ph. 1	Beta	0.47	0.14	Ph. 1	Beta	0.34	0.21
	Gamma	20.24	79.53		Gamma	99.29	102.02
	Asympt.	219.22			Asympt.	514.48	
D1IE3	Alpha	107.08	33.81	D1XE3	Alpha	21.97	30.76
Ph. 2	Beta	0.49	0.14	Ph. 2	Beta	0.88	0.09
	Gamma	195.65	110.60		Gamma	135.62	83.23
	Asympt.	291.71			Asympt.	269.01	
D1IE4	Alpha	12.07	5.98	D1XE4	Alpha	34.54	22.83
Ph. 1	Beta	0.44	0.11	Ph. 1	Beta	0.55	0.09
	Gamma	113.59	54.87		Gamma	1154	168.18
	Asympt.	158.41			Asympt.	213.66	
D1IE4	Alpha	76.98	11.87	D1XE4	Alpha	33.33	12.20
Ph. 2	Beta	0.16	0.10	Ph. 2	Beta	0.35	0.07
	Gamma	365.97	85.75		Gamma	1180	135.11
	Asympt.	173.17			Asympt.	132.94	

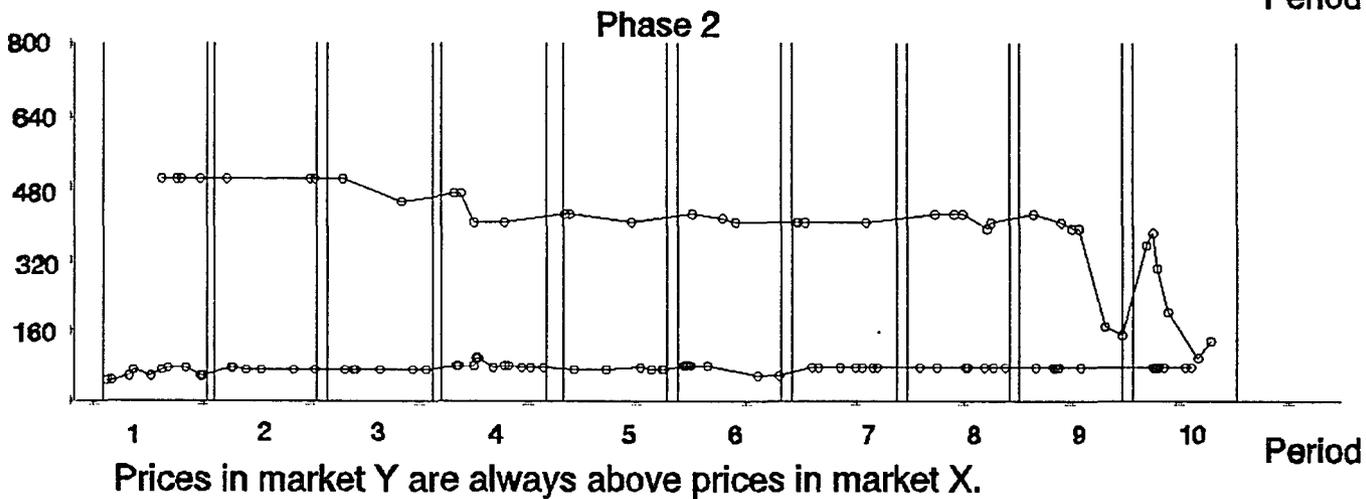
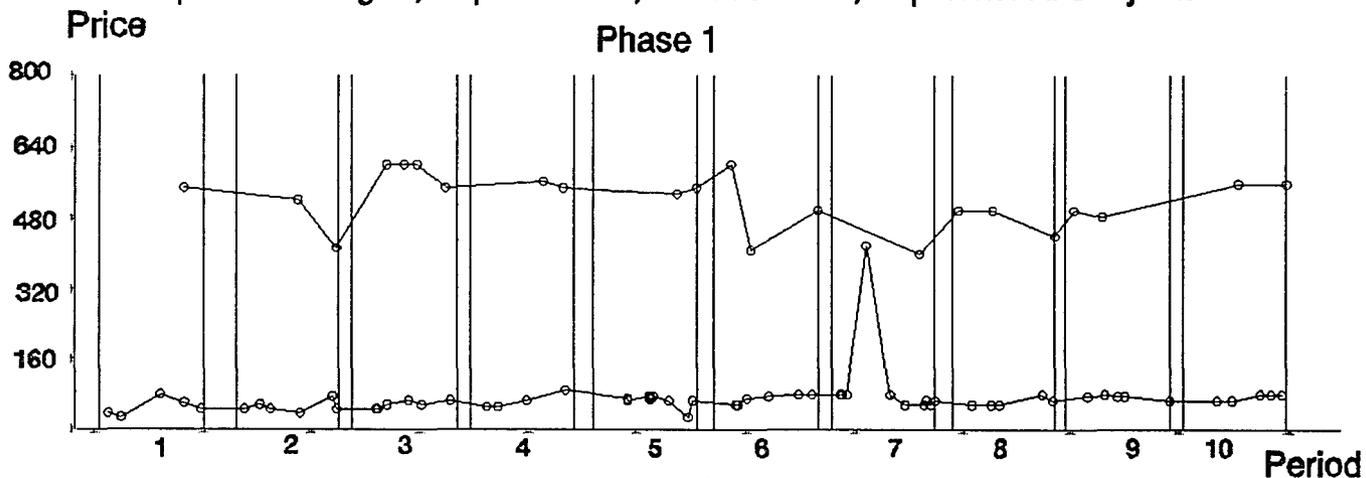
Prices are in most cases significantly different from both CEH and the monopoly prediction⁹. β is always positive and less than one and usually significant¹⁰, indicating convergence of prices to levels between the competitive and the monopoly prediction. γ is always positive and usually significant¹¹, indicating an upward shift of prices in market Y at the beginning of periods. This pattern was quite typical, as can be seen in graph 33. The only exception was experiment 3, in which prices were extremely stable until the last two periods of the second phase. The pattern of prices of this 'outlier' is displayed in graph 35.

⁹ Among experienced subject α is not significantly different from zero in D1P1XE1Y and D1P2XE3Y (using the monopoly prediction) respectively D1P2XE1Y, D1P2XE3Y.

¹⁰ The exceptions are D1P2IE4Y and D1P1XE3Y.

¹¹ The only exceptions occur in experiment 3 and with completely inexperienced subjects.

Graph 35.: Design I, Experiment 3, Both Markets, Experienced Subjects



9.3. Terms of Trade

Table 36. contains the terms of trade (ToT) for both inexperienced and experienced subjects, graph 37. displays the results for experienced subjects.

Results: The ToT are in general below the low end of the competitive range (CEL), but above the monopoly prediction.

Even though both models predict that the ToT worsen from phase one to phase two, in the experiments they only decrease among inexperienced subjects, in three cases among experienced subjects they increase.

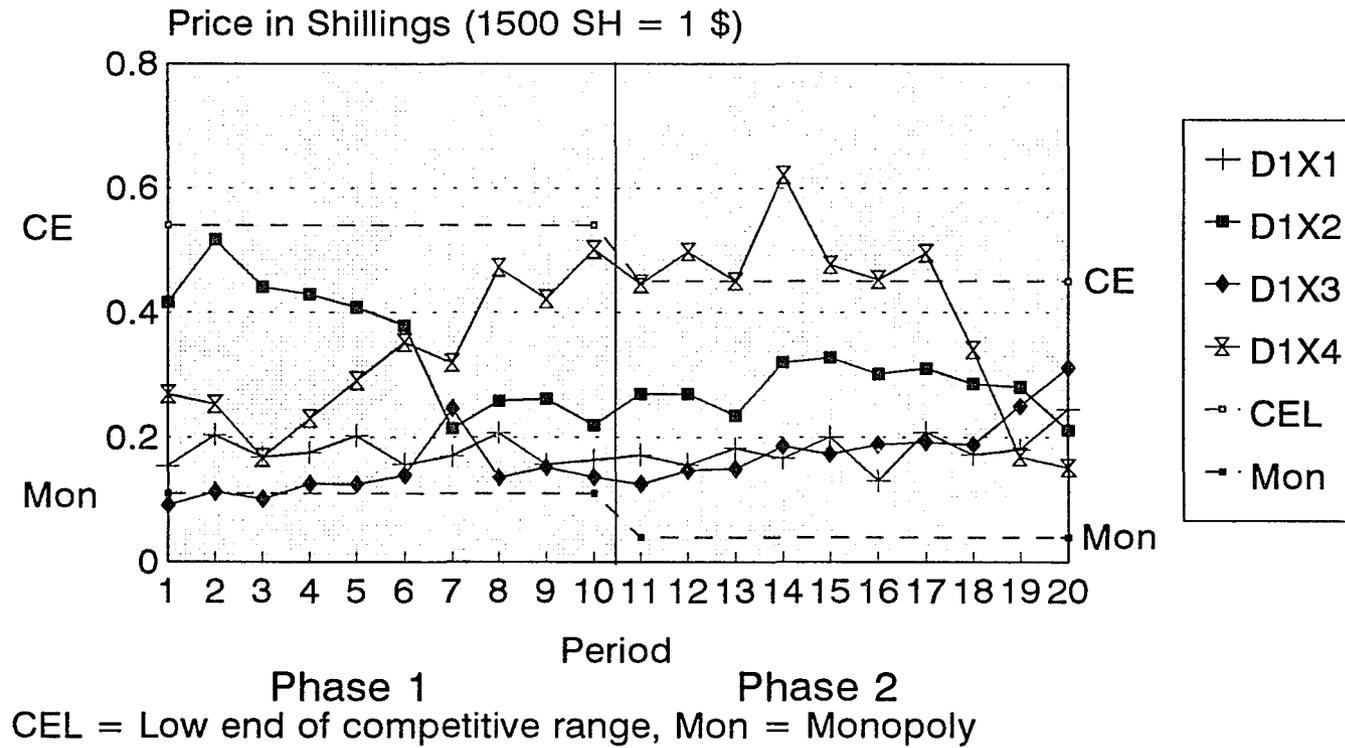
The ToT are in almost all periods (always with experienced subjects) below the low end of the competitive range (CEL) in phase one. In three experiments with experienced subjects, they are fairly close to the monopoly prediction at the end of phase one. In phase two, the ToT are usually quite stable and about halfway between CEL and the monopoly prediction. At the end of each phase the ToT are significantly above CEL and significantly below the monopoly prediction.

Table 36.: Terms of Trade: Design I

	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4
Phase 1	1	0.57	0.15	0.22	0.42	0.19	0.09	0.56	0.27
	2	0.22	0.20	0.28	0.52	0.20	0.11	0.58	0.25
	3	0.23	0.17	0.26	0.44	0.22	0.10	0.47	0.17
	4	0.23	0.18	0.42	0.43	0.18	0.13	0.36	0.23
	5	0.28	0.20	0.41	0.41	0.17	0.13	0.36	0.29
	6	0.25	0.16	0.35	0.38	0.20	0.14	0.28	0.35
	7	0.27	0.17	0.52	0.21	0.24	0.25	0.22	0.32
	8	0.18	0.21	0.44	0.26	0.22	0.14	0.41	0.47
	9	0.15	0.16	0.50	0.26	0.33	0.15	0.43	0.42
	10	0.22	0.16	0.57	0.22	0.30	0.14	0.46	0.50
Phase 2	11	0.08	0.17	0.33	0.27	0.15	0.13	0.14	0.45
	12	0.11	0.16	0.56	0.27	0.16	0.15	0.21	0.50
	13	0.12	0.18	0.50	0.24	0.24	0.15	0.30	0.45
	14	0.11	0.17	0.40	0.32	0.17	0.19	0.33	0.62
	15	0.15	0.20	0.45	0.33	0.15	0.17	0.27	0.48
	16	0.15	0.13	0.44	0.30	0.14	0.19	0.31	0.45
	17	0.10	0.21	0.42	0.31	0.15	0.19	0.12	0.50
	18	0.13	0.17	0.52	0.29	0.13	0.19	0.30	0.34
	19	0.14	0.18	0.47	0.28	0.13	0.25	0.26	0.17
	20	0.16	0.25	0.46	0.21	0.15	0.31	0.20	0.15

Graph 37.: Terms of Trade

Design I, Experienced Subjects



9.3.1. Do Terms of Trade worsen in the Monopoly Design?

Both the monopoly and the competitive model predict that the ToT worsen in design I. Table 38. contains the ToT (computed as ratio of the average price in the last three periods).

Table 38.: Terms of Trade: Comparison of Phases, Design I								
	Experiment							
	Inexperienced				Experienced			
Ph.	E1	E2	E3	E4	E1	E2	E3	E4
1	0.18	0.50	0.28	0.43	0.17	0.25	0.14	0.47
2	0.14	0.48	0.14	0.26	0.20	0.27	0.25	0.22

The ToT only decrease among inexperienced subjects. Among experienced subjects, they increase in three experiments, contradicting both the competitive and the monopoly model. The final ToT decrease only in experiment 4. The ToT in that experiment increased during phase one (the ToT in the final three periods are higher than in all other periods) and dropped drastically in the last three periods of the second phase, before that the had never been below 0.45

9.4. Trading Volume and Efficiencies

The theoretical solution is that the industrialized country exerts its market power mainly by reducing the quantity in market Y, its output market. Sales are reduced (compared to the competitive equilibrium) from 8 to 4 in phase one and from 16 to 4 in phase two. In phase one, the quantity traded is usually very close to the monopoly prediction¹². In phase two, the quantity traded is only in experiment 3 (in which prices had been highest) close to the monopoly prediction, in most other cases it is around 8. The effect of restricting output and increasing price can best be seen in experiment 4. In phase two, the monopolist had sold around 12 units during the first 8 periods, usually at a price around 150 Shillings. In the last two periods he restricted sales to the monopoly level and increased the price to about 350.

Both the competitive and the monopsony model predict the same trading volume in the primary product market (4 respectively 8 in phase two). The quantities actually purchased by the monopsonist vary substantially among different experiments. The (experienced) monopsonist in experiment 3 purchased up to 10 units in phase one and up to

¹² The average quantity traded is 5 among inexperienced subjects and 4.2 among experienced subjects. During the last three periods, quantities are only in three cases (D1P1IE2Y, D1P1IE4Y AND D1P1XE4Y) close to the competitive prediction of 8. In those cases the average contract prices had also been lowest.

25 (!) units in phase two, which also explains why prices exceeded by far the competitive equilibrium in phase two. The quantities are in all other experiments fairly close to the the prediction of 4 in phase one¹³ and 8 in phase two. In phase two, experiment 1 is the exception. In this experiment the monopsonist had paid prices very close to the monopsony level, but apparently at the expense of quantity purchased. On average, he only bought four units.

The monopoly model predicts efficiencies of 95% in phase one and 88% in phase two, due to the deadweight loss. Efficiencies are particularly low in experiment 3, in which the monopsonist had bought 'too many' units at too high a price in market X and had charged the highest price as monopolist in market Y. Efficiencies in that experiment (experienced subjects) range from 77 to 87% during the last three periods of both phases. In the other experiments, efficiencies are around the level predicted by the monopoly model at the end of phase one, and often even above that level in phase two. However, efficiency sometimes drops by ten percentage points or more from one period to the next, sometimes due to increased prices in market Y¹⁴.

¹³ At least with experienced subjects. Completely inexperienced monopsonists often purchased less.

¹⁴ For example in the last period of D1P2XE2, efficiency drops from 94 to 80%, after the average contract price in market Y had increased from 141 to 198.

9.5. Earnings

Table 39. contains the earnings realized by industrialized and developing countries in different periods. The earnings of the industrialized country predicted by the competitive model (phase one: CEH = 1960, phase two: CEH = 2580)¹⁵ are substantially lower than earnings predicted by the monopoly model (3560 and 4636). The earnings of developing countries predicted by the competitive model (phase one: CEL = 960, phase 2: CEL = 1310)¹⁶ are substantially higher than those predicted by the monopoly model (488 and 559). The average earnings realized by developing countries are always¹⁷ higher than the monopoly prediction and lower than CEL. The earnings of the monopolists are always below the monopoly prediction, but almost always above CEH¹⁸.

¹⁵ Earnings cannot be compared to design III (1138 and 1596), since the equilibrium prediction is the same price range, but a higher output in market Y: The monopoly sells all units which are sold by four countries in the competitive design.

¹⁶ In design III, due to the lower trading volume per country (only one instead of four units), the low range for earnings is 1182 and 1532 in phase one and two, respectively.

¹⁷ i.e. in all experiments and all periods

¹⁸ Earnings are below CEH (but above CEL) in only 4 periods of 40 in phase one, and in 3 periods of 30 (without experiment 3) in phase two (5 of 70 when inexperienced subjects are included).

Table 39.: Average Earnings per Period, Design I											
Earnings of Industrialized Countries: Design I, Phase 1										Averages	
	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4	D1IAV	D1XAV
CEH 1960	1	180	2730	1865	3060	1476	1812	1512	3052	1258	2664
	2	979	2528	1660	2688	1800	2280	1826	2896	1566	2598
	3	729	1981	2280	2512	2059	3622	1899	3098	1741	2803
	4	1516	1764	1612	2380	2246	2400	1842	2924	1804	2367
	5	1671	2405	2066	2368	2351	2264	2290	2734	2094	2443
	6	999	1686	2084	2442	2226	2854	2188	2782	1874	2441
MON 3560	7	1975	2321	2132	2278	1995	1902	1588	2734	1922	2309
	8	1561	2293	2116	2412	2556	2658	1807	2400	2010	2441
	9	1844	2597	2023	2100	1779	2114	2216	2438	1965	2312
	10	1978	2462	1987	2470	2213	2292	1481	2380	1915	2401
	AVGL3	1794	2451	2042	2327	2182	2355	1834	2406	1963	2385
	AVGALL	1343	2277	1982	2471	2070	2420	1865	2744	1815	2478
Earnings of Industrialized Countries: Design I, Phase 2										Averages	
	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4	D1IAV	D1XAV
CEH 2580	11	2767	2861	3233	3210	3208	3602	2818	3176	3006	3212
	12	2559	2950	2515	3310	2720	2426	3290	3004	2771	2923
	13	2703	2894	2738	2874	2974	1954	2648	3138	2766	2715
	14	3083	2763	3058	2862	4327	2530	2988	2444	3364	2650
	15	2785	2789	2876	2886	2692	1974	3018	2980	2843	2657
	16	2911	2395	2849	3004	2879	2388	3410	3212	3012	2750
MON 4636	17	2629	2858	3055	2816	2695	2180	2998	3104	2844	2740
	18	2740	2899	2909	2820	2947	2286	3719	3146	3079	2788
	19	2687	2701	2779	2742	3314	2028	3318	2972	3024	2611
	20	2652	2698	2840	2472	2635	2070	2710	2884	2709	2531
	AVGL3	2693	2766	2843	2678	2965	2128	3249	3001	2937	2643
	AVGALL	2751	2781	2885	2900	3039	2344	3091	3006	2942	2758
Earnings of Developing Countries: Design I, Phase 1										Averages	
	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4	D1IAV	D1XAV
CEL 960	1	812	747	817	636	671	479	780	608	770	618
	2	842	764	878	722	773	548	845	652	834	671
	3	832	689	787	768	857	251	747	450	806	539
	4	817	789	920	776	817	498	785	663	834	681
	5	809	750	911	789	708	544	648	710	769	698
	6	687	621	864	779	713	522	739	739	751	665
MON 488	7	763	658	909	634	763	518	811	726	812	634
	8	653	753	888	770	752	589	881	814	793	731
	9	737	722	932	739	775	589	860	802	826	713
	10	765	746	941	754	719	564	870	839	824	726
	AVGL3	718	740	920	754	748	581	870	818	814	723
	AVGALL	772	724	885	737	755	510	796	700	802	668
Earnings of Developing Countries: Design I, Phase 2										Averages	
	Period	D1IE1	D1XE1	D1IE2	D1XE2	D1IE3	D1XE3	D1IE4	D1XE4	D1IAV	D1XAV
CEL 1310	11	842	838	1126	1034	987	804	908	1105	966	945
	12	1023	983	1277	1043	1011	919	1004	1142	1079	1021
	13	1025	1055	1233	1062	950	867	1162	1105	1093	1022
	14	1002	1040	1170	1126	760	1029	1107	1253	1010	1112
	15	1025	1080	1208	1149	868	1007	1098	1166	1049	1100
	16	1033	1063	1202	1136	989	1071	966	1093	1047	1090
MON 559	17	1027	1134	1172	1166	863	1078	918	1159	995	1134
	18	1052	1106	1219	1162	848	1071	989	1096	1027	1108
	19	1070	1098	1225	1150	856	1050	1009	973	1040	1068
	20	1081	1139	1227	948	817	1180	878	980	1001	1062
	AVGL3	1068	1114	1224	1087	840	1100	959	1016	1022	1079
	AVGALL	1018	1053	1206	1097	895	1007	1004	1107	1031	1066
AVGL3: Average earnings during the last 3 periods of one phase.											
AVGALL: Average earnings during the whole experiment											
D1IAV (D1XAV): Earnings averaged over all experiments with inexperienced (experienced) subjects.											
CEL (CEH): Predictions by the competitive model; MON: Prediction by the monopoly model.											

The major exception is experiment 3 with experienced subjects, in which in phase two earnings of the monopsonist after the first period are always below CEH, in the last four periods even below CEL. In experiment 3 the subject in the role of the industrialized country had purchased more units of X at a higher price than predicted by the competitive model.

Earnings for industrialized (developing) countries usually increase (decrease) with experience in phase one and decrease (increase) with experience in phase two.

9.6. Summary for Design I

The industrialized countries usually fail to force prices below the competitive equilibrium as monopsonists in market X, especially in phase two they are sometimes even higher than the competitive equilibrium. At the same time however, they are able to charge prices which are higher than the competitive equilibrium as monopolists in market Y. The conclusion is the same as in design IV, in this particular environment sellers can exploit their market power, buyers cannot. This result might be due to cultural differences, since in our society buyers can often not influence the price. This fact might influence behavior in the sense that, when subjects are in the role of both seller and buyer, they feel more 'powerful' as seller. However, the results might also be driven by the fact that in this particular environment the

market power was 'greater' as seller.

The terms of trade are usually below the competitive range, but above the monopoly level. Among experienced subjects they usually increase from phase one to phase two, contradicting both the competitive and the monopoly model.

The analysis of earnings also points in the same direction: The single industrialized country can exploit its market power to some extent, but cannot take full advantage of it.

10. CARTEL VERSUS MONOPOLY: DESIGN II

Only one experiment was conducted in design II. All subjects had participated in other designs. The monopolist with the highest total earnings in design I participated as industrialized country. From each experiment in design IV, the subject who had earned the most as cartel member was invited back as developing country¹.

If the cartel functions perfectly it can act as a monopoly. There is no unique equilibrium prediction, the extremes are the monopoly prediction for design I and the prediction if the cartel acts as monopoly and the industrialized country as price taker (see table 3.).

During the first 6 periods of phase one, contract prices in market X were approximately equal to the competitive equilibrium and the trading volume (5-7) even higher than the competitive prediction (4). The usual pattern was that the cartel members started with high bids and then underbid each other, especially towards the end of the period. These actions were not entirely cheating, since the cartel had agreed to lower prices in the last minute or thirty seconds of a period, but prices usually went below the values agreed upon.

¹ The highest earner from experiment four did not show up and was replaced by the second highest earner in experiment 4.

At the same time, contract prices in market Y (500-530) were fairly close to the monopoly prediction (599). The trading volume however was substantially less than even the monopoly prediction (4), only one or two units were traded in periods one through seven. Most cartel members withheld their demand, but some of them cheated by violating the agreement not to buy at those high prices.

At the end of phase one the picture changed completely. The cartel members finally decided to not let the monopolist exploit them any more and trade broke down.

From period 7 of phase one to period 1 of phase two, only one trade occurred in market X, at a price of 529 -- practically at the cartel prediction of 531! Finally the cartel started to sell X again, at prices well above the competitive level, but also below the cartel prediction. Trade was restricted to one or two units, in several periods of phase two the cartel did not sell at all. This is presumably also the reason why the mail facility was extensively used during this part of the experiment. Since subjects were not trading, they had time to send messages.

No transaction took place in market Y from period 8 of the first phase to period one of the second phase. Finally the monopolist 'gave in' and sold units of Y much cheaper. Units of Y are completely worthless for the monopolist when he is not able to purchase X, since he 'starves' without the

primary product (i.e. his redemption value is zero). The monopolist managed nevertheless to keep the price of Y above 90 in all periods, higher than the competitive equilibrium. The monopolist tried twice to raise the price to previous levels, with the effect that he only sold one unit (by accepting an offer of 150), respectively none when he tried to raise the price to 500 and more. In all other periods of phase two, the trading volume in market Y (7-15) was fairly high, usually at or above the competitive equilibrium.

Terms of trade are not available for several periods, since no trades occurred in one or both markets. When available, they are almost at the monopoly level in phase one and substantially above the competitive level at the end of phase two.

The earnings of the industrialized country are initially at or above the competitive level. They drop to zero in several periods, namely when the industrialized country is not able to buy or sell units. In phase two they are always below the competitive equilibrium.

The average earnings of the developing countries are -- with one exception in phase two -- below the competitive equilibrium. Even though the developing countries are able to charge higher than competitive prices in phase two, due to the fact that they also pay higher than competitive prices and because the trading volume in market X is very low, they do

not succeed in raising their earnings.

The efficiency is generally very low. When trade brakes down, it is only around 30%. The maximum (average) efficiency in phase one is 78% (58%), in phase two it is 92% (67%).

13.1. Summary for Design II

When the 'best' monopoly faces the 'best' cartel members the result is a power struggle, which in the end does not benefit either side. Initially the monopoly is more successful, it can charge almost monopoly prices in market Y and keep prices in market X down at the competitive level. The monopoly can however not raise its earnings much beyond the competitive level, due to the low trading volume in market Y. When both sides try to exploit their market power, trade breaks down. The cartel succeeds afterwards in charging prices in excess of the competitive equilibrium, but so does the monopoly. Earnings of both sides are below the competitive prediction. The terms of trade are in phase one close to the monopoly prediction, in phase two above the competitive level. Efficiency is in general very low.

The overall conclusion is, that a (market) power struggle does not pay: both sides lose and the competitive equilibrium would be a Pareto-improvement.

11. COMPARISON OF DESIGNS

The single experiment in design II will be discussed, but not enter the statistical analysis. The analysis will focus on prices in market X, followed by prices in market Y and the terms of trade. Useful comparisons of earnings can only be conducted between designs III and IV.

11.1. The Market for Primary Products

Table 40. contains the average contract prices in market X, they are displayed for experienced subjects in graph 41. On average, prices in market X are in all periods highest in the cartel design, second highest in the competitive design and lowest in the monopoly design¹. Prices in design II resemble those in the monopoly design in the first phase, and at the end of the second phase those in the cartel design. In design I, the inability of the monopsonies to control prices in market X is apparent: Mean prices in phase one are in the competitive range², in phase two they are above, but still lower than in the 'competitive' design.

¹ The ranking is the same for inexperienced subjects. In phase one, prices among experienced subjects are, in all designs, higher than among inexperienced subjects.

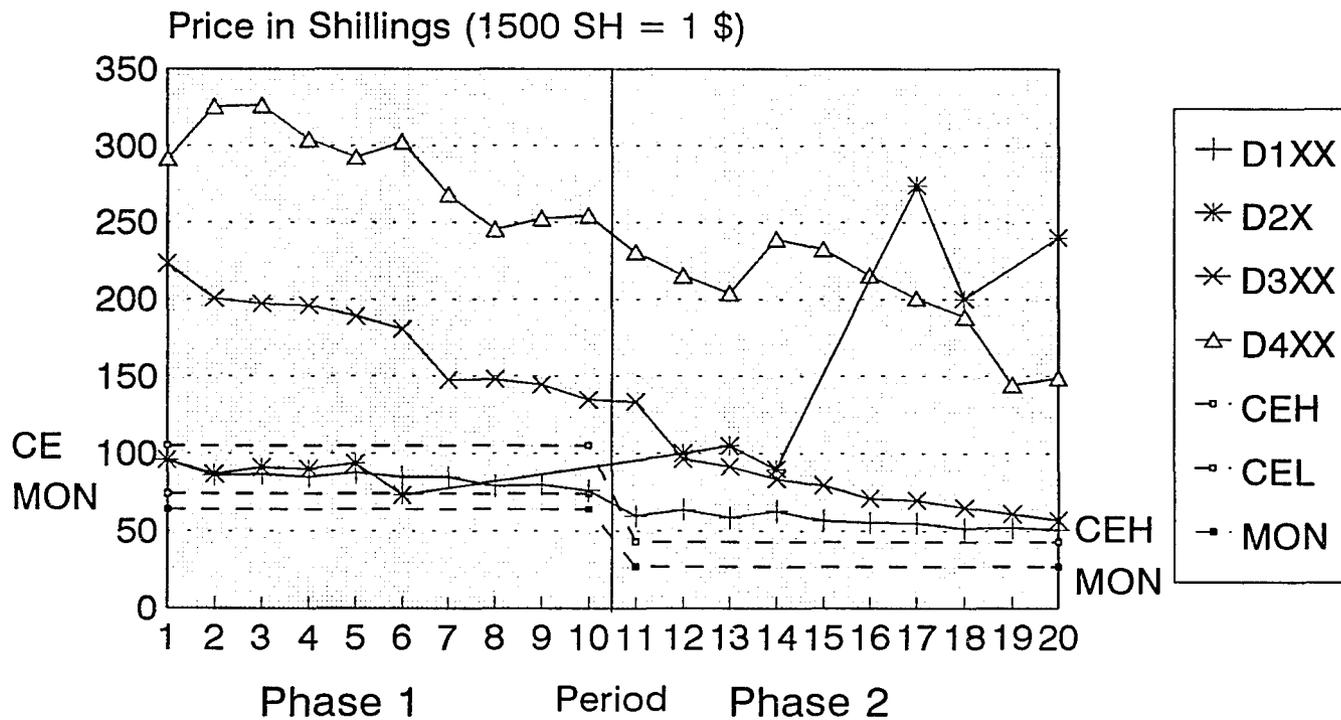
² Among experienced subjects, among inexperienced subjects they are below.

Table 40.: Average Contract Prices: Market X								
Phase	Period	D1I	D1X	D2	D3I	D3X	D4I	D4X
1	1	40	96	96	61	223	217	292
	2	47	86	87	80	200	230	325
	3	47	87	91	88	197	224	326
	4	53	85	90	89	196	217	304
	5	55	88	94	91	189	210	292
	6	54	85	73	103	180	211	302
	7	57	85	NA	98	148	228	268
	8	62	79	529	109	148	240	245
	9	69	80	NA	104	144	251	252
	10	70	76	NA	115	135	285	254
2	11	35	60	NA	92	133	242	230
	12	44	64	100	88	96	204	215
	13	47	59	105	81	92	215	204
	14	45	63	90	74	83	234	239
	15	46	57	NA	74	79	216	232
	16	47	55	NA	73	71	188	215
	17	39	55	274	70	70	187	200
	18	44	51	200	69	65	168	188
	19	44	52	NA	68	61	158	144
	20	44	51	240	73	57	153	149

The abbreviation I denotes inexperienced, X experienced.

Graph 41.: Average Contract Prices

All Designs, Market X (Primary Product), Experienced Subjects



Design II: One contract in period 8 (529) omitted. Cartel predictions: 358 (ph. 1) and 431 (ph. 2)

Average prices decrease in all designs; the decline is more pronounced in designs III and IV. Prices in phase two are generally lower.

11.1.1. Statistical Comparison of Prices in Market X

The average of all contract prices in the last three periods of each phase entered the analysis. Table 42. summarizes the observations.

Table 42.: Average Contract Prices, Market X Comparison of Designs								
Phase One								
Design	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	45	78	74	70	57	81	72	100
III	87	162	60	128	84	228	111	145
IV	173	351	291	217	213	295	134	334
Phase Two								
Design	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	26	55	47	48	31	40	76	58
III	50	96	50	77	42	87	42	72
IV	143	251	103	135	100	157	91	272

Prices in market X are in both phases (always) significantly³ higher in the cartel design than in both other designs, and they are usually significantly higher in the competitive design than in the monopoly design. The difference between the latter is not significant in phase two, among experienced subjects⁴. It reflects the fact that on average the monopsonies in market X did not succeed in lowering the prices compared to the competitive equilibrium!

Market power does influence the contract prices in market X, however, the results are much stronger when market power is on the sellers' side. This result might be due to the fact that sellers can increase prices substantially by withholding only a few units, whereas for buyers it is much more difficult to lower prices.

³ Both a t-test and a Wilcoxon rank-sum test were conducted, for experienced subjects, inexperienced subjects and both pooled. The results of the t-test and the Wilcoxon test were generally the same, except for minor differences in the level of significance. In all cases a significance level of 10% is reported.

⁴ Several factors could explain why the result is not significant: First, the low power of the test (only four observations entered the analysis), second the substantial variation among subject groups and third the small difference between the competitive and the monopoly level.

11.2. The Market for Manufactured Products

Table 43. contains the average contract prices in market Y, they are displayed for experienced subjects in graph 44. Prices in all designs are on average above the high end of the competitive range (CEH), both among inexperienced and experienced subjects. Mean prices in the monopoly design are higher than in both design III and IV⁵. In design II, prices in phase one are even higher than in design I, but drop to the levels of the competitive design in phase two. The buyers' cartel initially fails to lower prices. They are always higher than in the competitive design, except for the second phase with experienced subjects.

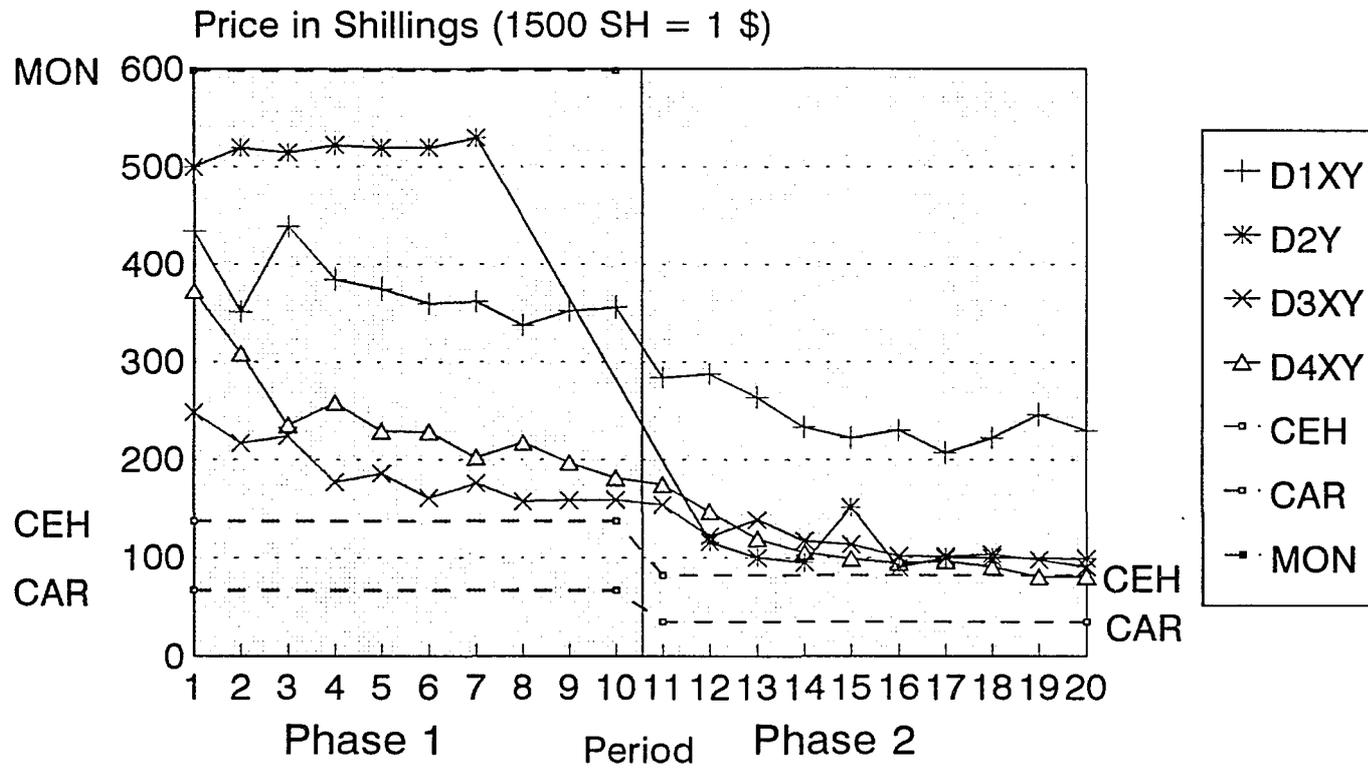
⁵ However, completely inexperienced monopolists do not succeed in raising prices above those in other designs.

Table 43.: Average Contract Prices: Market Y								
Phase	Period	D1I	D1X	D2	D3I	D3X	D4I	D4X
1	1	129	434	500	143	248	228	373
	2	150	351	520	134	216	219	309
	3	158	439	515	135	224	225	235
	4	183	385	523	141	177	243	258
	5	186	375	520	160	185	256	229
	6	201	360	520	161	161	209	228
	7	190	362	530	160	176	227	202
	8	219	337	NA	167	157	214	217
	9	214	352	NA	145	158	204	197
	10	195	356	NA	151	159	229	181
2	11	218	284	NA	163	154	190	174
	12	209	287	116	142	121	187	147
	13	186	264	100	134	138	166	119
	14	203	233	95	139	117	181	105
	15	212	222	151	126	113	158	99
	16	206	230	90	125	102	161	95
	17	228	207	100	113	101	121	97
	18	203	222	100	107	104	165	91
	19	212	246	NA	115	98	138	81
	20	214	230	99	99	91	147	81

The abbreviation I denotes inexperienced, X experienced.

Graph 44.: Average Contract Prices

All Designs, Market Y (Manufactured Product), Experienced Subjects



11.2.1. Statistical Comparison of Prices in Market Y

The average of all contract prices in the last three periods of each phase entered the analysis. Table 45. summarizes the observations.

Table 45.: Average Contract Prices, Market Y Comparison of Designs								
Phase One								
Design	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	245	155	270	161	337	328	505	214
III	127	123	178	189	129	165	193	147
IV	136	166	477	78	156	154	341	136
Phase Two								
Design	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	185	114	346	179	154	151	308	258
III	103	92	135	98	85	90	127	86
IV	95	135	277	82	100	69	91	76

Average prices in the monopoly design are significantly higher than those in the two other designs -- at least among experienced subjects⁶. The mean prices in the competitive design and the cartel design do not differ significantly -- the buyers' cartel fails to lower prices in the market for

⁶ Prices in design I with inexperienced subjects are significantly higher than in design III.

manufactured products.

The conclusion is the same as for market X, market power does influence prices. However, in this environment market power is only exploited when it is on the seller's side.

11.3. Terms of Trade

Table 46. contains the average terms of trade (ToT), they are displayed for experienced subjects in graph 47.

The mean ToT are in all periods (both with experienced⁷ and inexperienced subjects) highest in the cartel design, second highest in the competitive design and lowest in the monopoly design. In design II they are close to the monopoly level in phase one, at the end of phase two they are close to the ToT realized in design IV.

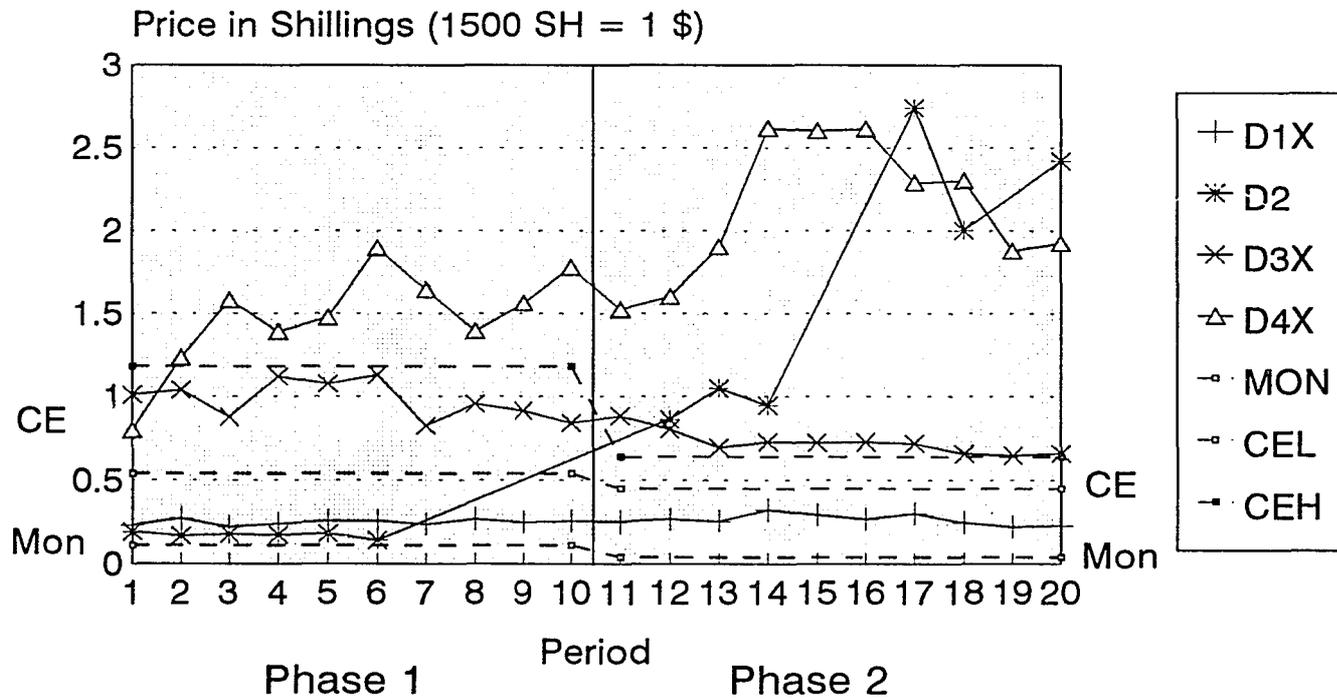
⁷ With the exception of period 1, phase one with experienced subjects.

Table 46.: Terms of Trade								
Phase	Period	D1I	D1X	D2	D3I	D3X	D4I	D4X
1	1	0.38	0.23	0.19	0.67	1.01	1.30	0.80
	2	0.32	0.27	0.17	0.65	1.04	1.26	1.23
	3	0.30	0.22	0.18	0.74	0.88	1.19	1.58
	4	0.30	0.24	0.17	0.65	1.12	1.14	1.39
	5	0.31	0.26	0.18	0.58	1.08	1.11	1.47
	6	0.27	0.26	0.14	0.68	1.13	1.65	1.89
	7	0.31	0.24	NA	0.61	0.83	1.43	1.64
	8	0.31	0.27	NA	0.68	0.96	1.53	1.39
	9	0.35	0.25	NA	0.78	0.91	1.89	1.56
	10	0.38	0.25	NA	0.82	0.84	1.73	1.78
2	11	0.18	0.25	NA	0.56	0.88	1.47	1.52
	12	0.26	0.27	0.86	0.68	0.81	1.32	1.60
	13	0.29	0.25	1.05	0.68	0.69	1.52	1.90
	14	0.25	0.32	0.95	0.54	0.73	1.52	2.62
	15	0.25	0.29	NA	0.61	0.73	1.68	2.60
	16	0.26	0.27	NA	0.62	0.73	1.35	2.61
	17	0.20	0.30	2.74	0.65	0.72	1.58	2.29
	18	0.27	0.25	2.00	0.67	0.66	1.32	2.30
	19	0.25	0.22	NA	0.63	0.65	1.35	1.87
	20	0.24	0.23	2.42	0.78	0.66	1.38	1.92

The abbreviation I denotes inexperienced, X experienced.

Graph 47.: Terms of Trade

All Designs, Experienced Subjects



Cartel Prediction: Design II: 14.75 (17.04), Design IV: 5.34 (12.29) in phase one (two).

11.3.1. Statistical Comparison of the Terms of Trade

The ratio of the mean contract prices in the last three periods in markets X and Y of each phase entered the analysis. Table 48. summarizes the observations.

Table 48.: Average Terms of Trade Comparison of Designs								
Phase One								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	0.18	0.50	0.28	0.43	0.17	0.25	0.14	0.47
III	0.69	1.31	0.34	0.68	0.65	1.38	0.58	0.99
IV	1.27	2.11	0.61	2.80	1.37	1.91	0.39	2.45
Phase Two								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
I	0.14	0.48	0.14	0.26	0.20	0.27	0.25	0.22
III	0.48	1.04	0.37	0.79	0.49	0.97	0.33	0.83
IV	1.50	1.86	0.37	1.63	1.00	2.28	1.00	3.58

The ToT in design I are significantly lower than in both other designs⁸. The average ToT in design IV are always higher than in design III, but the difference in phase one is only significant if the observations from inexperienced and

⁸ Both with inexperienced and experienced subjects, and both in phase one and phase two.

experienced subject groups are pooled⁹. In phase two they are significantly higher.

11.4. Earnings in Designs III and IV

The average earnings of developing and industrialized countries during the last three periods entered the analysis.

The observations for industrialized countries are summarized in table 49.

Table 49.: Average Earnings Comparison of Designs III and IV								
Industrialized Countries								
Phase One								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
III	974	732	1009	1005	1047	667	1038	895
IV	741	394	651	575	493	566	837	460
Phase Two								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
III	1504	1251	1600	1372	1543	1279	1652	1376
IV	955	797	1287	1059	1155	879	1204	704

The earnings of industrialized countries are significantly higher in design III than in design IV. The cartel of primary producers takes away profits from the

⁹ The mean ToT are 70% (inexperienced: 125%) higher in design IV, but due to both the large differences among subject groups and to the low power of the test the hypothesis that they are equal cannot be rejected.

industrialized countries.

The observations for developing countries are summarized in table 50.

Table 50.: Average Earnings Comparison of Designs III and IV								
Developing Countries								
Phase One								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
III	1110	1297	1058	1239	1121	1458	1202	1329
IV	1394	1624	1039	1513	1278	1451	1089	1589
Phase Two								
Des.	Inexperienced				Experienced			
	E1	E2	E3	E4	E1	E2	E3	E4
III	1376	1655	1425	1668	1379	1720	1421	1633
IV	1781	1881	1373	1798	1815	2000	1721	1983

The earnings of developing countries are in general higher in design III than in design IV, but the difference is not always significant¹⁰. The main reason for the insignificant results is the 'outlier' experiment 3 in the cartel design, in which earnings of developing countries were always below those in all other designs. The conclusion is therefore that the developing countries can increase their

¹⁰ They are significant using the t-test (not with the Wilcoxon rank-sum test) among inexperienced subjects in phase one and among experienced subjects in phase two.

earnings by forming a cartel, unless the industrialized countries counter-react.

11.5. Conclusions from the Comparison of Designs

Both industrialized countries and developing countries are able to exploit their market power, however, only their market power as sellers. The monopoly raises prices in market Y, but fails to lower prices as monopsony in market X. The cartel of primary producers raises prices in market X, but fails to lower prices in the market for manufactured products. The terms of trade are clearly altered in favor of the side with market power. Earnings of the cartel members usually increase compared to the competitive design, but the decrease of profits of industrialized countries is much more pronounced, due to the additional deadweight loss the cartel causes.

12.

SUMMARY

The "Theory of Unequal Exchange", developed by Raul Prebisch and Hans Singer states that developing countries have to be worse off in the long run, if they concentrate on the production of primary commodities. One of the main reasons cited is that the income elasticity of demand for primary products is less than unity, which, *ceteris paribus*, causes the terms of trade to worsen as income grows. The model developed in the theoretical sections shows that, *ceteris paribus*, the terms of trade improve with population growth (under the assumption that population growth has a larger impact on demand for primary than on manufactured products). They also improve if technological progress is faster in the production of manufactured products. There is no conclusive evidence whether terms of trade in the field actually improve or worsen in the long run, because of the difficulties with analyzing the terms of trade with field data (particularly changing supply and demand structure, changing transportation costs, changing quality and weight of the products and the choice of price indices). These difficulties are at the same time the advantages of analyzing the terms of trade in a laboratory economy.

Terms of trade are also affected by market power. The alleged monopoly position of the producers of manufactured products and the policy suggestion to form cartels of primary

producers were the motivation for the experimental design.

This study has created a laboratory economy with some of the prominent features of the world economy to test the hypothesis if the terms of trade for the producers of primary products worsen, given a specific demand structure (low income elasticity of demand). It has also analyzed the effect of market power on the terms of trade, by comparing a 'competitive' market to one, where the developing countries are able to form a cartel and one, where a single industrialized country is a monopoly in the manufactured product market and a monopsony in the market for primary products.

Induced valuations have been derived, using fairly general Engel curves as starting point. The competitive model, which is derived from the assumption that all countries act as price takers, predicts that as production grows prices in both markets decline. The decline of the price of the primary product is more pronounced, causing the terms of trade to worsen. According to the cartel model, the primary producers maximize their joint profits. It predicts higher prices of the primary product, which increase as income grows, and lower prices of the manufactured product. It also predicts better and improving terms of trade. In the monopoly model, the single industrialized country acts as monopsony in the primary product market and as monopoly in the market for

manufactured products. It predicts lower prices for primary commodities and higher and increasing prices in the market for manufactured products. The monopoly model also predicts lower and worsening terms of trade.

The general conclusion is that, in most markets, prices converge from above. This result might be driven by the specific structure of demand and supply, which allows for profitable trades well above the competitive equilibrium, but not much below. Another possible interpretation are cultural influences. In the U.S. buyers often act as price takers. Judging from the discussions of the cartel groups, it seems to be more apparent that sellers can influence prices. This hypothesis is also supported by the finding that usually only sellers succeed in exploiting their market power, buyers fail to do so. In single-market experiments with symmetric distribution of surplus convergence from above or below can usually not be predicted in a double auction. It remains to be tested if the results of this study are due only to the asymmetric distribution of surplus or also to the double-role of subjects as both buyer and seller.

The experimental results led to the following conclusions concerning the hypotheses:

H1: Under the absence of market power (design III) the competitive equilibrium is reached, at least with experienced subjects. The experimental results support hypothesis 1.

H2: In design I the monopoly will exert market power. It will pay the monopsonist price in market X and charge the monopoly price in market Y. Hypothesis 2 is clearly rejected in market X. The quantitative prediction for the price in market Y is also clearly rejected, however, the qualitative prediction of higher prices holds.

H3: In designs II and IV the cartel will charge the monopoly price in market X and pay the monopsonist price in the market Y. Hypothesis 3 is clearly rejected for market Y. In design IV (and at the end of the second phase in design II) the qualitative prediction of higher prices holds, but the quantitative prediction is clearly rejected.

H4: The terms of trade will worsen for LDCs in designs I and III. Hypothesis 4 is supported in design III, however, in design I the terms of trade improve in most cases.

H5: The possibility to form a cartel will impede the decline of the terms of trade. Hypothesis 5 is supported by the results. In design IV, the terms of trade usually improve.

H6: The terms of trade will be better in design IV than in design III (the competitive equilibrium). The results support hypothesis 6.

H7: The terms of trade will be worse in design I than in design III. The results support hypothesis 7.

In the competitive design, in which the subjects have no possibility to communicate other than submitting and accepting bids and offers, prices in both markets generally converge to the competitive equilibrium, sometimes they remain above. Convergence to the competitive equilibrium is better among experienced subjects. The terms of trade are at the competitive equilibrium, they worsen in all experiments as income grows.

The primary producers in the cartel design are able to form agreements. Subjects usually agreed on setting prices, often not on setting quotas as well. They usually realized immediately that setting prices as sellers in the market for primary products was profitable, whereas they either did not make agreements in the market for manufactured products, or those agreements came later and were less rigorously discussed. Prices of the primary product are substantially higher than in the competitive equilibrium (and those realized in the 'competitive' design), even though usually not as high as predicted by the cartel model. They decrease in all experiments as production grows, contradicting the cartel model. Prices of the manufactured product remain at or even above (especially in one experiment) the competitive level; the buyers' cartel is not able to lower them. Prices are not clearly distinguishable from the 'competitive' design. The terms of trade are usually better than the

competitive level, but clearly worse than the cartel prediction. There is no conclusive evidence whether terms of trade improve or worsen as income grows; in half the experiments they do, and in the other half they do not. The result suggests at least that the cartel of primary producers has the possibility to avert the worsening of the terms of trade, given the favorable conditions of the laboratory markets. The earnings of the cartel members are usually higher than those of the developing countries in the 'competitive' design, but the decrease of profits of industrialized countries is much more pronounced, due to the additional deadweight loss the cartel causes.

In the monopoly design, the single industrialized country in the position of a monopsonist fails to lower prices for primary products below the competitive equilibrium. However, as a monopoly it charges higher than competitive prices for manufactured products. The terms of trade in the monopoly design are usually lower than the competitive equilibrium, but higher than the monopoly prediction. They often improve as income grows, contradicting the competitive and the monopoly model.

When the monopoly faced a cartel of primary producers, the result was a power struggle, which in the end benefitted neither side. Initially the monopolist was more successful, later the cartel. Usually, however, both parties earned less

than in the competitive equilibrium.

12.1. Conclusions

The result of the competitive design supports the Prebisch-Singer "Theory of Unequal Exchange". Given the specific demand structure, namely income elasticity of less than one for primary products, the terms of trade do worsen when income increases. In the laboratory economy it was possible to hold all other conditions constant. Whether terms of trade also worsen in the field cannot be concluded from this study. Important factors present in the field are missing, like population growth or differential technological progress for the production of manufactured relative to primary products. It is not clear if the assumption that the income elasticity of demand is less than unity holds for all primary products.

The policy suggestion to form cartels to keep the terms of trade from worsening was successful in this environment. Since the conditions a cartel faces in the laboratory environment are substantially more favorable than in the field, it would seem more likely that a cartel fails in the field. Most (sellers') cartels did not succeed in raising prices to the cartel level; presumably a cartel in the field would therefore also not be able to so. However, since all cartels in the laboratory succeeded in raising prices above

the competitive level, it seems reasonable to assume that cartels in the field would also raise prices somewhat.

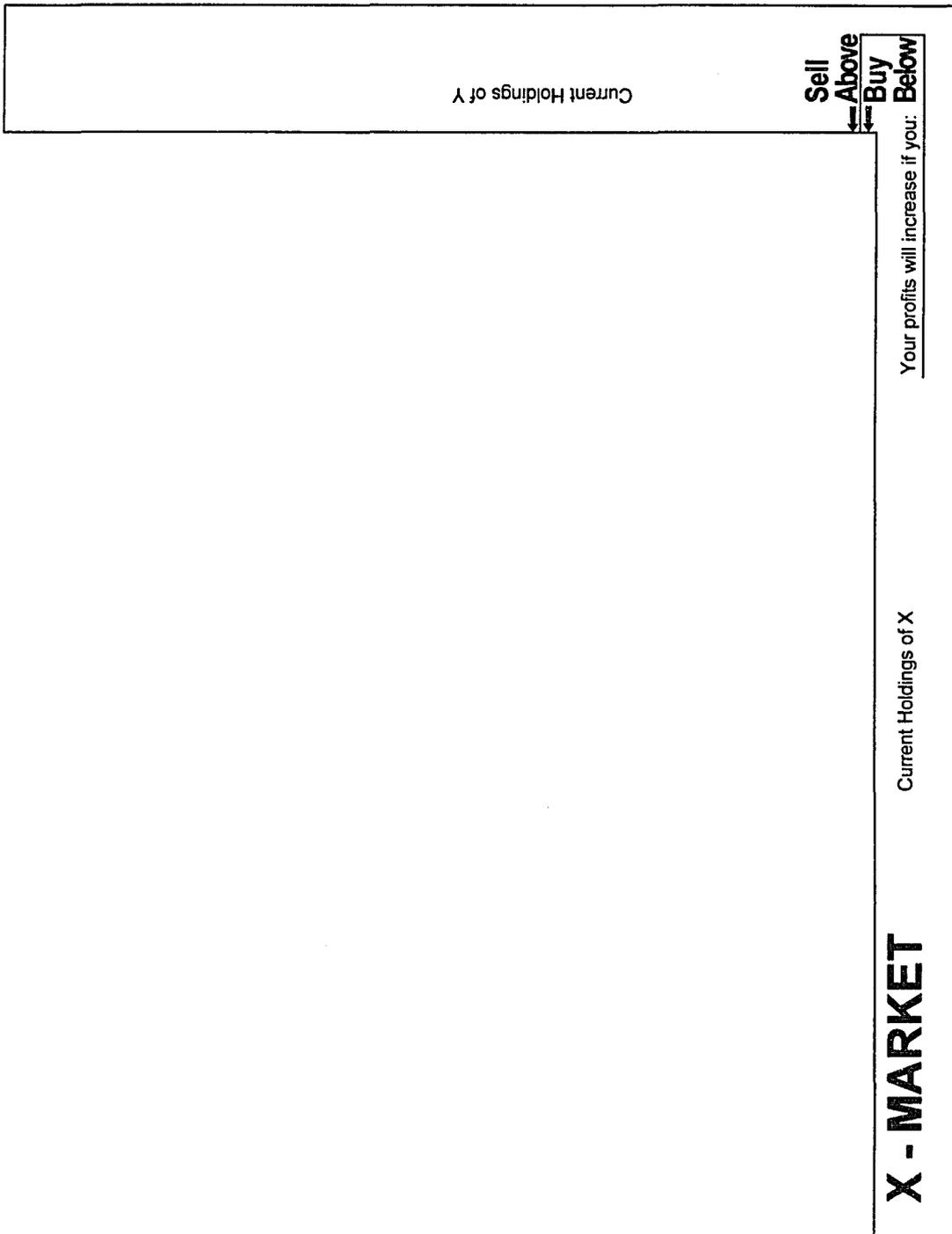
Industrial monopolies succeeded in raising prices of manufactured products. There is reason for concern if one believes the argument that industrialized countries (or transnational corporations) act as monopolies.

APPENDIX I: HANDOUTS

X \ Y	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	300	475	531	567	595	617	637	653	668	682	694	706	716	726	736	745	753	761	769	776	783	789	796	802	808	814
2	357	787	889	956	1006	1048	1083	1114	1141	1166	1188	1209	1229	1247	1264	1280	1296	1310	1324	1338	1350	1363	1374	1386	1397	1407
3	395	932	1055	1136	1197	1247	1290	1327	1361	1391	1418	1443	1467	1489	1510	1529	1548	1566	1583	1599	1614	1629	1643	1657	1670	1683
4	424	1023	1160	1249	1317	1373	1420	1461	1498	1532	1562	1590	1616	1641	1664	1686	1706	1726	1745	1762	1780	1796	1812	1827	1842	1856
5	449	1087	1234	1330	1403	1462	1513	1557	1596	1632	1665	1695	1723	1749	1774	1797	1819	1840	1860	1879	1897	1915	1932	1948	1964	1979
6	470	1137	1291	1392	1468	1531	1584	1630	1672	1709	1743	1775	1804	1832	1858	1882	1905	1927	1948	1968	1988	2006	2024	2041	2058	2074
7	488	1177	1337	1441	1521	1585	1641	1689	1732	1771	1806	1839	1870	1898	1925	1950	1974	1997	2019	2040	2060	2079	2098	2116	2133	2149
8	505	1210	1374	1482	1564	1631	1688	1737	1782	1822	1858	1892	1924	1953	1981	2007	2032	2055	2078	2099	2120	2140	2159	2177	2195	2212
9	520	1237	1407	1517	1601	1669	1728	1779	1824	1865	1903	1937	1970	2000	2028	2055	2080	2105	2128	2150	2171	2191	2211	2230	2248	2265
10	533	1262	1434	1547	1633	1703	1762	1814	1861	1903	1941	1977	2009	2040	2069	2097	2123	2147	2171	2193	2215	2236	2256	2275	2293	2311
11	546	1283	1459	1574	1661	1732	1793	1846	1893	1936	1975	2011	2044	2076	2105	2133	2159	2185	2209	2231	2253	2275	2295	2315	2333	2352
12	558	1302	1480	1597	1686	1758	1820	1873	1921	1965	2005	2041	2075	2107	2137	2165	2192	2218	2242	2265	2288	2309	2330	2350	2369	2388
13	570	1319	1500	1618	1708	1781	1844	1898	1947	1991	2031	2069	2103	2135	2166	2195	2222	2248	2272	2296	2319	2340	2361	2382	2401	2420
14	580	1334	1517	1637	1728	1803	1866	1921	1970	2015	2056	2093	2128	2161	2192	2221	2248	2275	2300	2324	2347	2369	2390	2410	2430	2449
15	590	1348	1534	1655	1747	1822	1886	1942	1992	2037	2078	2116	2151	2184	2216	2245	2273	2299	2325	2349	2372	2394	2416	2436	2456	2476
16	600	1361	1548	1671	1764	1840	1904	1961	2011	2057	2098	2137	2172	2206	2237	2267	2295	2322	2347	2372	2395	2418	2439	2460	2481	2500
17	609	1373	1562	1685	1779	1856	1921	1978	2029	2075	2117	2156	2192	2226	2257	2287	2316	2343	2369	2393	2417	2440	2461	2482	2503	2523
18	618	1384	1574	1699	1794	1871	1937	1994	2045	2092	2134	2173	2210	2244	2276	2306	2335	2362	2388	2413	2437	2460	2482	2503	2524	2543
19	626	1394	1586	1712	1807	1885	1951	2009	2061	2108	2150	2190	2227	2261	2293	2324	2353	2380	2406	2431	2455	2478	2501	2522	2543	2563
20	634	1403	1597	1724	1820	1898	1965	2023	2075	2122	2166	2205	2242	2277	2309	2340	2369	2397	2423	2448	2473	2496	2518	2540	2561	2581
21	642	1412	1607	1735	1831	1911	1978	2037	2089	2136	2180	2220	2257	2292	2325	2355	2385	2413	2439	2465	2489	2512	2535	2557	2578	2598
22	650	1421	1617	1745	1843	1922	1990	2049	2102	2149	2193	2233	2271	2306	2339	2370	2399	2427	2454	2480	2504	2528	2551	2572	2594	2614
23	657	1429	1626	1755	1853	1933	2001	2061	2114	2162	2206	2246	2284	2319	2352	2384	2413	2441	2468	2494	2519	2542	2565	2587	2609	2629
24	664	1436	1635	1764	1863	1943	2012	2072	2125	2173	2218	2258	2296	2332	2365	2396	2426	2455	2482	2508	2532	2556	2579	2601	2623	2643
25	671	1443	1643	1773	1872	1953	2022	2082	2136	2184	2229	2270	2308	2343	2377	2409	2439	2467	2494	2520	2545	2569	2592	2615	2636	2657
26	677	1450	1651	1782	1881	1963	2032	2092	2146	2195	2240	2281	2319	2355	2388	2420	2450	2479	2506	2533	2558	2582	2605	2627	2649	2670
27	684	1456	1658	1790	1890	1971	2041	2102	2156	2205	2250	2291	2330	2366	2399	2431	2462	2490	2518	2544	2569	2594	2617	2639	2661	2682
28	690	1463	1665	1797	1898	1980	2050	2111	2165	2214	2259	2301	2340	2376	2410	2442	2472	2501	2529	2555	2581	2605	2628	2651	2673	2694
29	696	1468	1672	1805	1906	1988	2058	2119	2174	2223	2269	2310	2349	2386	2420	2452	2482	2512	2539	2566	2591	2616	2639	2662	2684	2705
30	702	1474	1678	1812	1913	1996	2066	2128	2183	2232	2278	2320	2358	2395	2429	2462	2492	2521	2549	2576	2601	2626	2650	2672	2694	2716
31	708	1479	1684	1818	1920	2003	2074	2136	2191	2241	2286	2328	2367	2404	2438	2471	2502	2531	2559	2586	2611	2636	2660	2682	2704	2726
32	714	1484	1690	1825	1927	2010	2081	2143	2199	2249	2294	2337	2376	2412	2447	2480	2511	2540	2568	2595	2621	2645	2669	2692	2714	2736
33	719	1489	1696	1831	1933	2017	2088	2151	2206	2256	2302	2345	2384	2421	2455	2488	2519	2549	2577	2604	2630	2654	2678	2701	2724	2745
34	724	1494	1702	1837	1940	2024	2095	2158	2213	2264	2310	2352	2392	2429	2463	2496	2527	2557	2585	2612	2638	2663	2687	2710	2733	2754
35	730	1499	1707	1843	1946	2030	2102	2166	2220	2271	2317	2360	2399	2436	2471	2504	2535	2565	2594	2621	2647	2672	2696	2719	2741	2763
36	735	1503	1712	1848	1952	2036	2108	2171	2227	2278	2324	2367	2407	2444	2479	2512	2543	2573	2601	2629	2655	2680	2704	2727	2750	2771
37	740	1507	1717	1853	1957	2042	2114	2177	2233	2284	2331	2374	2414	2451	2486	2519	2551	2580	2609	2636	2662	2688	2712	2735	2758	2779
38	745	1512	1722	1858	1963	2048	2120	2183	2240	2291	2337	2380	2420	2458	2493	2526	2558	2588	2616	2644	2670	2695	2719	2743	2765	2787
39	750	1516	1726	1863	1968	2053	2126	2189	2246	2297	2344	2387	2427	2464	2500	2533	2565	2595	2623	2651	2677	2702	2727	2750	2773	2795
40	754	1519	1731	1868	1973	2058	2131	2195	2252	2303	2350	2393	2433	2471	2506	2540	2571	2602	2630	2658	2684	2710	2734	2757	2780	2802
41	759	1523	1735	1873	1978	2064	2137	2200	2257	2309	2356	2399	2439	2477	2513	2546	2578	2608	2637	2665	2691	2716	2741	2764	2787	2809
42	764	1527	1739	1877	1983	2069	2142	2206	2263	2314	2361	2405	2445	2483	2519	2552	2584	2615	2643	2671	2698	2723	2748	2771	2794	2816
43	768	1530	1743	1882	1987	2073	2147	2211	2268	2320	2367	2411	2451	2489	2525	2558	2590	2621	2650	2677	2704	2730	2754	2778	2801	2823
44	773	1534	1747	1886	1992	2078	2152	2216	2273	2325	2372	2416	2457	2495	2531	2564	2596	2627	2656	2684	2710	2736	2760	2784	2807	2829
45	777	1537	1751	1890	1996	2083	2156	2221	2278	2330	2378	2421	2462	2500	2536	2570	2602	2633	2662	2690	2716	2742	2767	2790	2813	2836
46	781	1540	1754	1894	2000	2087	2161	2226	2283	2335	2383	2427	2467	2506	2542	2576	2608	2638	2667	2695	2722	2748	2773	2796	2820	2842
47	785	1543	1758	1898	2005	2092	2165	2230	2288	2340	2388	2432	2473	2511	2547	2581	2613	2644	2673	2701	2728	2754	2778	2802	2825	2848
48	790	1546	1762	1902	2009	2096	2170	2235	2292	2345	2393	2437	2478	2516	2552	2586	2618	2649	2678	2707	2733	2759	2784	2808	2831	2854
49	794	1549	1765	1906	2013	2100	2174	2239	2297	2349	2397	2441	2483	2521	2557	2591	2624	2654	2684	2712	2739	2765	2790	2814	2837	

X \ Y	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
0	300	475	531	567	595	617	637	653	668	682	694	706	716	726	736	745	753	761	769	776	783	789	796	802	808	814
1	57	312	358	389	411	431	446	461	473	484	494	503	513	521	528	535	543	549	555	562	567	574	578	584	589	593
2	38	145	166	180	191	199	207	213	220	225	230	234	238	242	246	249	252	256	259	261	264	266	269	271	273	276
3	29	91	105	113	120	126	130	134	137	141	144	147	149	152	154	157	158	160	162	163	166	167	169	170	172	173
4	25	64	74	81	86	89	93	96	98	100	103	105	107	108	110	111	113	114	115	117	117	119	120	121	122	123
5	21	50	57	62	65	69	71	73	76	77	78	80	81	83	84	85	86	87	88	89	91	91	92	93	94	95
6	18	40	46	49	53	54	57	59	60	62	63	64	66	66	67	68	69	70	71	72	72	73	74	75	75	75
7	17	33	37	41	43	46	47	48	50	51	52	53	54	55	56	57	58	58	59	59	60	61	61	61	62	63
8	15	27	33	35	37	38	40	42	42	43	45	45	46	47	47	48	48	50	50	51	51	51	52	53	53	53
9	13	25	27	30	32	34	34	35	37	38	38	40	39	40	41	42	43	42	43	43	44	44	45	45	45	46
10	13	21	25	27	28	29	31	32	32	33	34	34	35	36	36	36	36	38	38	38	38	39	39	40	40	41
11	12	19	21	23	25	26	27	27	28	29	30	30	31	31	32	32	33	33	33	34	35	34	35	35	36	36
12	12	17	20	21	22	23	24	25	26	26	26	28	28	28	29	30	30	30	30	31	31	31	31	31	32	32
13	10	15	17	19	20	22	22	23	23	24	25	24	25	26	26	26	26	27	28	28	28	29	29	29	29	29
14	10	14	17	18	19	19	20	21	22	22	23	23	23	24	24	25	24	25	24	25	25	25	26	26	26	27
15	10	13	14	16	17	18	18	19	19	20	20	21	21	22	21	22	22	23	22	23	23	24	23	24	25	24
16	9	12	14	14	15	16	17	17	18	18	19	19	20	20	20	21	21	21	22	21	22	22	22	22	22	23
17	9	11	12	14	15	15	16	16	16	17	17	17	18	18	19	19	19	19	19	20	20	20	21	21	21	20
18	8	10	12	13	13	14	14	15	16	16	16	17	17	17	18	18	18	18	18	18	18	18	19	19	19	20
19	8	9	11	12	13	13	14	14	14	14	16	15	15	16	16	16	17	17	17	17	18	18	17	18	18	18
20	8	9	10	11	11	13	13	14	14	14	14	15	15	15	16	15	16	16	16	17	16	16	17	17	17	17
21	8	9	10	10	12	11	12	12	13	13	13	13	14	14	14	15	14	14	15	15	16	16	16	15	16	16
22	7	8	9	10	10	11	11	12	12	13	13	13	13	13	13	14	14	14	14	15	14	14	15	15	15	15
23	7	7	9	9	10	10	11	11	11	11	12	12	12	13	13	12	13	14	14	14	13	14	14	14	14	14
24	7	7	8	9	9	10	10	10	11	11	11	12	12	12	11	12	13	13	12	12	12	13	13	14	13	14
25	6	7	8	9	9	10	10	10	10	11	11	11	11	12	11	11	11	12	12	13	13	13	13	12	13	13
26	7	6	7	8	9	8	9	10	10	10	10	10	11	11	11	11	12	11	12	11	12	11	12	12	12	12
27	6	7	7	7	8	9	9	9	9	9	9	10	10	10	10	11	11	10	11	11	11	12	11	12	12	12
28	6	5	7	8	8	8	8	8	9	9	10	9	9	10	10	10	10	11	10	11	10	11	11	11	11	11
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30	6	5	6	6	7	7	8	8	8	9	8	8	9	9	9	9	10	10	10	10	10	10	10	10	10	10
31	6	5	6	7	7	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
32	5	5	6	6	6	7	7	8	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
33	5	5	6	6	7	7	7	7	8	8	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
34	6	5	5	6	6	6	6	7	7	7	7	8	7	7	8	8	8	8	8	8	8	8	8	8	8	8
35	5	4	5	5	6	6	6	7	7	7	7	7	8	8	8	8	8	8	7	8	8	8	8	8	8	8
36	5	4	5	5	5	6	6	6	6	6	6	7	7	7	7	7	7	7	8	7	8	7	8	8	8	8
37	5	5	5	5	6	6	6	6	7	7	6	6	6	6	7	7	7	7	8	7	8	8	7	8	7	8
38	5	4	4	5	5	5	6	6	6	6	7	7	7	6	7	7	7	7	7	7	7	7	8	7	8	8
39	4	3	5	5	5	5	5	6	6	6	6	6	6	7	6	7	6	7	7	7	7	7	8	7	7	7
40	5	4	4	5	5	6	6	5	5	6	6	6	6	6	7	6	7	6	7	7	7	6	7	7	7	7
41	5	4	4	4	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	7	6	6	7	7	7	7
42	4	3	4	5	4	4	5	5	5	6	6	6	6	6	6	6	6	6	6	7	6	6	7	6	7	7
43	5	4	4	4	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	7	6	6	6	6	6	6
44	4	3	4	4	4	5	4	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	7
45	4	3	3	4	4	4	5	5	5	5	5	5	6	6	6	6	6	5	5	5	6	6	6	6	6	6
46	4	3	4	4	5	5	4	4	5	5	5	5	5	5	5	5	6	6	6	6	6	6	5	6	5	6
47	5	3	4	4	4	4	5	5	4	5	5	5	5	5	5	5	5	5	5	6	5	5	6	6	6	6
48	4	3	3	4	4	4	4	4	5	4	4	4	5	5	5	5	6	5	6	6	6	6	6	6	6	5
49	4	3	3	3	3	3	4	4	4	4	5	5	4	5	5	5	5	6	5	5	5	5	5	5	5	6

X-MARKET: Use the device for the X-market on this sheet.
 Column to the left: How many units of X do you have?
 Row on top: How many units of Y do you have?



Current Holdings of Y

Sell
← Above
← Buy
Below

Your profits will increase if you:

X - MARKET

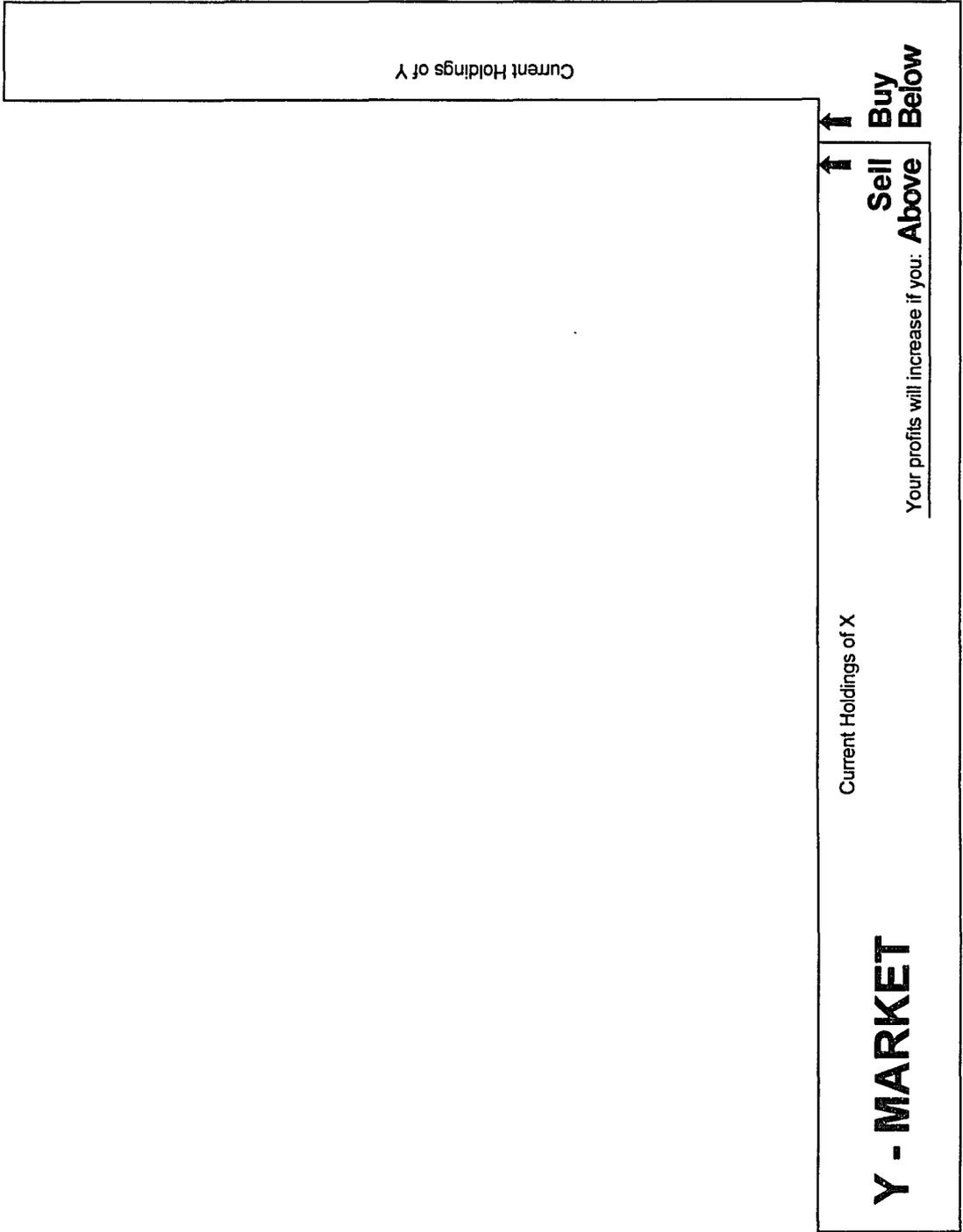
Current Holdings of X

X \ Y	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	175	56	36	28	22	20	16	15	14	12	12	10	10	10	9	8	8	8	7	7	6	6	6	6	6
2	430	102	67	50	42	35	31	27	25	22	21	20	18	17	16	16	14	14	14	12	13	11	12	11	10
3	537	123	81	61	50	43	37	34	30	27	25	24	22	21	19	19	18	17	16	15	15	14	14	13	13
4	599	137	89	68	56	47	41	37	34	30	28	26	25	23	22	20	20	19	17	18	16	16	15	15	14
5	638	147	96	73	59	51	44	39	36	33	30	28	26	25	23	22	21	20	19	18	18	17	16	16	15
6	667	154	101	76	63	53	46	42	37	34	32	29	28	26	24	23	22	21	20	18	18	17	17	17	16
7	689	160	104	80	64	56	48	43	39	35	33	31	28	27	25	24	23	22	21	20	19	19	18	17	16
8	705	164	108	82	67	57	49	45	40	36	34	32	29	28	26	25	23	23	21	21	20	19	18	18	17
9	717	170	110	84	68	59	51	45	41	38	34	33	30	28	27	25	25	23	22	21	20	20	19	18	17
10	729	172	113	86	70	59	52	47	42	38	36	32	31	29	28	26	24	24	22	22	21	20	19	18	18
11	737	176	115	87	71	61	53	47	43	39	36	33	32	29	28	26	26	24	22	22	22	20	20	18	19
12	744	178	117	89	72	62	53	48	44	40	36	34	32	30	28	27	26	24	23	23	21	21	20	19	19
13	749	181	118	90	73	63	54	49	44	40	38	34	32	31	29	27	26	24	24	23	21	21	21	19	19
14	754	183	120	91	75	63	55	49	45	41	37	35	33	31	29	27	27	25	24	23	22	21	20	20	19
15	758	186	121	92	75	64	56	50	45	41	38	35	33	32	29	28	26	26	24	23	22	22	20	20	20
16	761	187	123	93	76	64	57	50	46	41	39	35	34	31	30	28	27	25	25	23	23	21	21	21	19
17	764	189	123	94	77	65	57	51	46	42	39	36	34	31	30	29	27	26	24	24	23	21	21	21	20
18	766	190	125	95	77	66	57	51	47	42	39	37	34	32	30	29	27	26	25	24	23	22	21	21	19
19	768	192	126	95	78	66	58	52	47	42	40	37	34	32	31	29	27	26	25	24	23	23	21	21	20
20	769	194	127	96	78	67	58	52	47	44	39	37	35	32	31	29	28	26	25	25	23	22	22	21	20
21	770	195	128	96	80	67	59	52	47	44	40	37	35	33	30	30	28	26	26	24	23	23	22	21	20
22	771	196	128	98	79	68	59	53	47	44	40	38	35	33	31	29	28	27	26	24	24	23	21	22	20
23	772	197	129	98	80	68	60	53	48	44	40	38	35	33	32	29	28	27	26	25	23	23	22	22	20
24	772	199	129	99	80	69	60	53	48	45	40	38	36	33	31	30	29	27	26	24	24	23	22	22	20
25	772	200	130	99	81	69	60	54	48	45	41	38	35	34	32	30	29	27	26	25	24	23	23	21	21
26	773	201	131	99	82	69	60	54	49	45	41	38	36	33	32	30	28	27	27	25	24	23	22	22	21
27	772	202	132	100	81	70	61	54	49	45	41	39	36	33	32	31	28	28	26	25	25	23	22	22	21
28	773	202	132	101	82	70	61	54	49	45	42	39	36	34	32	30	29	28	26	26	24	23	23	22	21
29	772	204	133	101	82	70	61	55	49	46	41	39	37	34	32	30	30	27	27	25	25	23	23	22	21
30	772	204	134	101	83	70	62	55	49	46	42	38	37	34	33	30	29	28	27	25	25	24	22	22	22
31	771	205	134	102	83	71	62	55	50	45	42	39	37	34	33	31	29	28	27	25	25	24	22	22	22
32	770	206	135	102	83	71	62	56	50	45	43	39	36	35	33	31	29	28	27	26	24	24	23	22	22
33	770	207	135	102	84	71	63	55	50	46	43	39	37	34	33	31	30	28	27	26	24	24	23	23	21
34	770	208	135	103	84	71	63	55	51	46	42	40	37	34	33	31	30	28	27	26	25	24	23	23	21
35	769	208	136	103	84	72	62	56	51	46	43	39	37	35	33	31	30	29	27	26	25	24	23	22	22
36	768	209	136	104	84	72	63	56	51	46	43	40	37	35	33	31	30	28	28	26	25	24	23	23	21
37	767	210	136	104	85	72	63	56	51	47	43	40	37	35	33	32	29	29	27	26	26	24	23	23	21
38	767	210	136	105	85	72	63	57	51	46	43	40	38	35	33	32	30	28	28	26	25	24	24	22	22
39	766	210	137	105	85	73	63	57	51	47	43	40	37	36	33	32	30	28	28	26	25	25	23	23	22
40	765	212	137	105	85	73	64	57	51	47	43	40	38	35	34	31	31	28	28	26	26	24	23	23	22
41	764	212	138	105	86	73	63	57	52	47	43	40	38	36	33	32	30	29	28	26	25	25	23	23	22
42	763	212	138	106	86	73	64	57	51	47	44	40	38	36	33	32	31	28	28	27	25	25	23	23	22
43	762	213	139	105	86	74	64	57	52	47	44	40	38	36	33	32	31	29	27	27	26	24	24	23	22
44	761	213	139	106	86	74	64	57	52	47	44	41	38	36	33	32	31	29	28	26	26	24	24	23	22
45	760	214	139	106	87	73	65	57	52	48	43	41	38	36	34	32	31	29	28	26	26	25	23	23	23
46	759	214	140	106	87	74	65	57	52	48	44	40	39	36	34	32	30	29	28	27	26	25	23	24	22
47	758	215	140	107	87	73	65	58	52	48	44	41	38	36	34	32	31	29	28	27	26	24	24	23	23
48	756	216	140	107	87	74	65	57	53	48	44	41	38	36	34	32	31	29	29	26	26	25	24	23	23
49	755	216	141	107	87	74	65	58	52	48	44	42	38	36	34	33	30	30	28	27	26	25	24	23	22
50	754	216	141	107	88	74	65	58	53	48	44	41	39	36	34	33	31	29	28	27	26	25	24	23	23

Y-MARKET: Use the device for the Y-market on this sheet.

Column to the left: How many units of X do you have?

Row on top: How many units of Y do you have?



REFERENCES

Bairoch, Paul: "The Economic Development of the Third World since 1900". London: Methuen, 1975

Balassa, Bela: "Outward Orientation". In: Handbook of Development Economics. Hollis Chenery and T.N. Srinivasan (Eds.), Volume II, North Holland, 1988

Bruton, Henry: "Import Substitution". In: Handbook of Development Economics. Hollis Chenery and T.N. Srinivasan (Eds.), Volume II, North Holland, 1988

Ellsworth, P.T.: "The Terms of Trade between Primary Producing and Industrial Countries". Inter-American Economic Affairs, 10:47-65, 1956

Furtado, Celso: "Economic Development of Latin America", Cambridge University Press, 1976

Haberler, G.: "Terms of Trade and Economic Development". In: Ellis, H., ed.: Economic Development of Latin America. New York: St. Martins's Press, 1961

Jorgenson, Dale W.: "The Development of a Dual Economy". Economic Journal 71. June 1961, 309-34

Lian, P. and Plott, Charles R.: "General Equilibrium, Macroeconomics and Money in a Laboratory Experimental Environment". mimeo, 1991

Lewis, W. Arthur: "Economic Development with Unlimited Supplies of Labor". Manchester School of Economic And Social Studies 22(2): 139-91, 1954

Love, Joseph L.: "Raul Prebisch and the Origins of the Doctrine of Unequal Exchange". In: Latin America's economic development. Lynne Rienner Publishers. Boulder, Colorado 1987

Maizels, A.: "Industrial Growth and World Trade". Cambridge University Press, 1963

Noussair, Charles; Charles Plott and Raymond Riezman: "An Experimental Investigation of the Patterns of International Trade". Social Science Working Paper 799, California Institute of Technology, May 1992

Plott, Charles R.: "A Computerized Laboratory Market System and Research Support Systems for the Multiple Unit Double Auction". Social Science Working Paper 783, California Institute of Technology, November 1991

Prebisch, Raul: "Commercial Policy in the Underdeveloped Countries". American Economic Review 49, May 1959

Ranis, Gustav and John C.H. Fei: "A Theory of Economic Development". American Economic Review 51 (4), 1961: 533-46

Schumpeter, Joseph A.: "History of Economic Analysis". New York, Oxford University Press, 1954

Sheahan, John: "Patterns of Development in Latin America". Princeton University Press, 1987

Singer, Hans W.: "The Distribution of Gains Between Investing and Borrowing Countries". AER Papers and Proceedings 40, no. 2, May 1950

Social Indicators of Development. The World Bank. Johns Hopkins University Press, 1991-92

Smith, Vernon L.: "Property Rights in Natural Resources: Institutions and Ideologies". In: Anthony Scott. Oxford University Press, 1984

Smith, Vernon L.: "The Boundaries of Competitive Price Theory": Convergence, Expectations and Transaction Costs. In: Advances in Behavioral Economics, Volume 2, Edited by Leonard Green and John H. Kagel. Ablex Publishing Corporation, Norwood N.J., 1992

Spraos, John: "The Statistical Debate on the Net Barter Terms of Trade between Primary Commodities and Manufactures". The Economic Journal 90, March 1980

Staatz, John M. and Carl K. Eicher: "Agricultural Development Ideas in Historical Perspective". In: Eicher, Carl K. and John M. Staatz (Editors): "Agricultural Development in the Third World". Johns Hopkins University Press, 1990

Van Duyne, Carl: "Commodity Cartels and the Theory of Derived Demand". Kyklos, Vol. 28, 1975, Fasc. 3, 597-612