MONOPOLY POWER AND TERMS OF TRADE

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ABSTRACT

The Prebisch-Singer (PS) theory predicts that terms of trade worsen for developing countries producing primary commodities as income increases, given low income elasticity of demand for primary products and market power of industrialized countries. Due to problems of defining the correct price index no pure empirical test of the PS hypothesis exists. This paper uses experimental methods to test the basic premise of the PS hypothesis. The experiments do not support the PS hypothesis. The monopolist is unable to exploit its market power and terms of trade do not worsen for the primary producers as income increases.

1. INTRODUCTION^{1,2}

Low income elasticity of demand was a key ingredient in the development of the Prebisch-Singer “Theory of Unequal Exchange” (Prebisch, 1949, cited in Love, 1987; and Singer, 1950). According to the theory income growth leads to a deterioration in the developing countries’ terms of trade (ToT) as the share of the income spent on primary products declines. Moreover, the associated deterioration in welfare is exacerbated due to differences in market structure. Since primary products are sold in competitive markets, the benefits of technical advance are transferred to the industrialized countries (ICs) through lower

prices for primary products. Over time, the ICs benefit from growth in production due to the fall in the prices of primary products, relative to those of manufactured products. However, with market power on the part of ICs, technical advance in industrial production benefits the ICs relatively more because technological progress does not reduce prices for manufactured products to the same degree.³

The Prebisch-Singer (PS) hypothesis generated a lot of controversy. A large empirical literature noted that their empirical evidence in particular was subject to numerous problems. One problem was the choice of the initial and the terminal year.⁴ Another was the valuation of primary products at cif (cost-insurance-freight) and fob (free on board) prices.⁵ Then there are the problems of quality and weight changes, technological change, and the availability and quality of substitutes and complements that are not controlled for in the data. As a result, it is extremely difficult to test the basic premise of the PS hypothesis using field data.

In this paper we use experimental methods to test the basic premise of the PS hypothesis. With these methods it is possible to control variables that cannot be controlled in the field. Valuations of the commodities can be held constant and the problem of exogenous factors influencing supply and demand conditions in the initial or terminal year, can be eliminated. There are no changes in qualities and/or weights of products. The players in the experiments are trading fictitious commodities of constant quality, reflected by induced valuations (see Smith, 1976) for the commodities that do not change over time.

The experimental results do not support the PS hypothesis. The monopolist is unable to exploit its market power and terms of trade for the developing countries improve as income grows. The experimental results contradict the theoretical predictions.⁶

In the remaining paper, Section 2 describes the experimental design, Section 3 presents the experimental results and Section 4 concludes.

2. THE EXPERIMENTAL DESIGN

The Environment

We test the basic premise of the Prebisch-Singer hypothesis: Given the low income elasticity of demand for primary products and the 'market-power' of the ICs does an increase in income result in a worsening of TOT for the primary product producers (the less developed countries, or LDCs)?

There are four LDCs and one IC in the experimental design. The LDCs are not allowed to communicate and hence there is no room for explicit collusion.

The IC is a monopsony in the primary product market (henceforth market X) and a monopoly in the manufactured product market (henceforth market Y). Despite the fact that the main interest of this study is the net barter terms of trade, i.e. the number of units of good X exchanged for good Y, experimental money is introduced in all designs. Money is used because it helps the process of equilibration and it serves as a medium of exchange.⁷ This last feature is especially important, since without money problems of indivisibility of commodities occur.

A set of utility functions, reflecting inelastic income elasticity of demand for primary products is derived from fairly general Engel curves, where as income increases a decreasing proportion is spent on X. From the Engel curves, the Marshallian demand is derived and then the expenditure function. Subsequently, via the indirect utility function the direct utility function is derived.⁸ If subjects are maximizing their profits in the experimental setting, they are behaving as if they have the preferences defined above.⁹

Payoffs are derived from both the utility of holding goods X and Y and from the amount of money held at the end of each period, i.e. including profits from trading.

A developing country thus maximizes:

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

and an industrialized country maximizes:

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

Wx_i is the resource endowments of good X for a developing country. Wy_j is the resource endowment of the industrialized country. The final allocation has to be non-negative, i.e. x_i, y_i, x_j and $y_j > 0$. The budget constraint (as noted earlier M_i is chosen such that it is not binding) is for the LDC:

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

and for the industrialized country:

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

Assuming price taking behavior, a more stringent result than the equality of the marginal rate of substitution (MRS_{xy}) and the price ratio (p_x/p_y) is 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 is possible to test whether in each market prices converge to the equilibrium and not just whether relative prices (i.e. terms of trade) converge.

One possible problem in the experimental design is that subjects can go bankrupt. To avoid this, subjects were given a starting capital of \$5.¹⁰ Subjects were also trained several times without salient rewards to improve their understanding of the institution.

Parameterization

A linear transformation of the general utility function described above is chosen, with the following parameters values: $\alpha = 0.9$, $\beta = 0.8$, $\gamma = 2000$, $\delta = 100$ ¹¹.

$$u(x, y) = \delta + \gamma * \alpha * y^{1-\beta} * (\alpha^{-1/\beta} - x^{-(1-\beta)/\beta})^\beta \quad (5)$$

The choice of the parameter β , the income elasticity of demand, is especially important. We chose 0.8 for the laboratory market, the parameter Prebisch used for the numerical example in his original paper (1959).

Up to a certain point all income is spent on the primary product, X. In this region, where $Y = 0$, preferences can be represented by a lexicographic preference ordering. The same choice behavior is observed if an individual cares only about good X. The following functional form was chosen, with $\eta = 300$ and $\mu = 0.25$, to represent such preferences.

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

The payoff tables for different combinations of final holdings of x and y , as well as two tables with the marginal utilities of x and y , respectively (given certain holdings of the other commodity), are given to the subjects (see Appendix 1 for an example). All three tables are given to the subjects 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.

The Experimental Design

Four LDCs face a single industrial country (monopoly/monopsony). Four experiments were conducted, each experiment consisted of a ‘trainer’,¹² an inexperienced and an experienced session. The sessions with inexperienced and experienced subjects consisted of a low income phase (1) followed by a high income phase (2). After the trainer, subjects participate in two more sessions, first as inexperienced, then as experienced subjects. For our purposes only the data from experienced subjects is used.¹³

Table 1. Experimental Design.

All four experiments featured a single industrialized country and four developing countries.		
	Phase 1	Phase 2
Trainer	Low Income	No second phase
Inexperienced	Low Income	High Income
Experienced	Low Income	High Income

In the second phase the endowment (of both the IC and the LDCs) is doubled in order to achieve a substantial effect on the equilibrium predictions and to study the effect of lower income elasticity of demand for the primary product (X). The endowments are chosen to be $W_x = 5$ (10) for the LDCs and $W_y = 10$ (20) for the IC in phase 1 (2).

Table 2 gives an overview of the parameterization of the experiments as well as the allocations, prices, and trading quantities which would occur given a competitive equilibrium. Table 3 gives the effect of market power in the two phases for the Industrialized and Developing countries.

Table 2. Endowments and Competitive Equilibrium.

Endowment		Prices		Terms of Trade	Trading Volume	
W_x	W_y	P_x	P_y	ToT	Q_x	Q_y
5	10	74–105	89–137	0.54–1.18	4	8
(10)	(20)	(37–43)	(67–82)	(0.45–0.64)	(8)	(16)

Numbers in parentheses are values for phase 2, when the resource endowments (W_x and W_y) are doubled.

Table 3. The Effect of Market Power.

Phase	Prices		Industrialized Country				Developing Countries				Surplus	
	p_x	p_y	x_j	y_j	$u(x, y)$	Payoff	x_i	y_i	$u(x, y)$	Payoff	Total	CE
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

“Payoff” is the utility of the final holding of x and $y - u(x, y)$ – plus the trade surplus.
CE = surplus in the competitive equilibrium.

Trading Institution

The multiple unit double auction mechanism (MUDA)¹⁴ trading institution is used. MUDA is chosen for two reasons, first, it allows simultaneous trading in multiple markets and, second, the double auction mechanism has good convergence properties. This is particularly important because it is difficult to reach a General Equilibrium in two distinct markets at the same time.¹⁵

Subjects are not allowed to cancel bids or asks. However, in all experiments subjects are in the position of a trader, i.e. they can 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 sell more units than the equilibrium quantity. Overtrading can be observed because of both the sequential character of the double auction and the interlinked demands in the two markets.

For the analysis of prices, all transaction prices are taken into account. However, net quantities are reported, i.e. sales net of purchases by LDCs in market X and purchases net of sales by LDCs in market Y.

Common Features of the Data Analysis

Due to the introduction of money into the system, and as utility is expressed in monetary terms, separate equilibrium predictions for both markets can be derived. The market for the primary product (market X) is analyzed first. This is followed by the analysis of the market for manufactured products (market Y).

The following econometric model is used to analyze the change in prices over time.¹⁶

$$p_t = \alpha + \beta * p_{t-1} + \gamma * f[T(t) - T(t-1)] + \varepsilon_t \quad (7)$$

Where 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 $EQ + \alpha/(1 - \beta)$. $\alpha = 0$ 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 $\beta \geq 1$, the model does not converge to any particular point; $\beta < 0$ implies that prices overshoot the equilibrium (but eventually converge if the absolute value is less than one); $1 > \beta > 0$ implies convergence at a constant rate to an equilibrium from one direction. $\gamma > (<) 0$ indicates that prices shift upward (downward) when the period changes.

Terms of trade are calculated as the ratio of the average transaction price in the primary product market (X) divided by the average transaction price in the manufactured good 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 1 and 2. Statistical tests are therefore conducted for all experiments within each design.

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.

3. EXPERIMENTAL RESULTS

According to the monopoly/monopsony model, the IC should be able to lower prices in market X and to increase prices in market Y (compared to the competitive equilibrium). Consequently, the terms of trade are expected to be substantially worse than in the competitive equilibrium (see Table 6, which also contains the experimental results).

Summary of Results

All subjects in the role of the IC are able to raise the price in their output market substantially above the competitive level, though not always to the level predicted by the monopoly model. Prices in market Y usually decrease from

phase 1 to phase 2, contradicting the monopoly model. Terms of trade (ToT) are usually below the competitive equilibrium, but above the level predicted by the monopoly model. ToT for the experienced subjects increase in three cases. Earnings of ICs are between the competitive level and the monopoly level. Earnings of LDCs are usually below the competitive level.

The Market for Primary Products

The monopsony model predicts that prices in market X should be lower than the competitive equilibrium¹⁷ and decrease, but the monopoly fails to exploit its market power. The average contract prices are displayed in Fig. 1.

In the beginning of phase 1 in market X, prices are volatile in some experiments, but stabilize in later periods. Prices are generally within the competitive range at the end of phase 1, with the exception of one experiment. At the end of phase 2, prices are above the competitive equilibrium in two experiments. Only in experiment 1 are prices consistently close to the monopsony prediction. In experiment 3, prices are close to the monopsony prediction in phase 1, but substantially above the competitive level in phase 2.

Convergence

In phase 1, all asymptotic predictions are within the competitive range or below, but in all but one case above the monopsony prediction.¹⁸ The lower end of the competitive equilibrium and the monopsony prediction differ by only a small amount. Convergence to either cannot be rejected in all but one case (where prices are at the upper end of the competitive range).¹⁹ In experiment 1, prices converge to *below* the monopsony level,²⁰ but the difference is small.

The asymptotic predictions for phase 2 are usually above the competitive equilibrium, and the difference in two cases is significant.²¹ The exception is again experiment 1, where prices are below the competitive equilibrium and not significantly different from the monopsony prediction. β is positive and less than one, indicating convergence towards the equilibrium from one side. In most cases, β is significant²² and γ not. This indicates that prices in market X do not shift at the beginning of periods.²³

Market for Manufactured Products

In the market for manufactured products, the IC has market power as a seller. The price predictions of the monopoly model substantially exceed the competitive equilibrium.²⁴

Fig. 1. Average Contract Prices Market X (Primary Product).

Table 4. Tests for Convergence – Market X (Primary Product).

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: 74 EQ in phase 2: 37			
	Coefficient	Coefficient Value	Standard Deviation
Experiment 1 Phase 1	Alpha	-12.24	3.27
	Beta	0.29	0.14
	Gamma	-13.57	16.81
	Asymptote	56.78	
Experiment 1 Phase 2	Alpha	-3.95	1.20
	Beta	0.64	0.11
	Gamma	10.77	7.37
	Asymptote	32.08	
Experiment 2 Phase 1	Alpha	6.43	4.56
	Beta	0.74	0.10
	Gamma	36.04	29.15
	Asymptote	98.67	
Experiment 2 Phase 2	Alpha	0.71	0.54
	Beta	0.86	0.06
	Gamma	-4.72	5.32
	Asymptote	47.92	
Experiment 3 Phase 1	Alpha	-1.22	4.36
	Beta	0.11	0.11
	Gamma	-42.88	55.45
	Asymptote	72.63	
Experiment 3 Phase 2	Alpha	5.88	1.20
	Beta	0.81	0.04
	Gamma	22.70	4.78
	Asymptote	74.05	
Experiment 4 Phase 1	Alpha	21.09	6.14
	Beta	0.20	0.12
	Gamma	46.39	57.64
	Asymptote	100.43	
Experiment 4 Phase 2	Alpha	11.39	3.20
	Beta	0.50	0.10
	Gamma	75.73	23.78
	Asymptote	65.61

Fig. 2. Average Contract Prices Market Y (Manufactured Product).

The average contract prices (Fig. 2) in all periods are above the high end of the competitive range, but below the monopoly level. Prices stay fairly close to the monopoly prediction only in phase 1 of experiment 3. Prices slowly but consistently fall in the second phase of that experiment. Figure 3 displays the typical problem a monopoly faces. In period one of experiment 4, the monopolist 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 LDCs that they can acquire units at a lower price. In period two, only two units are sold at high prices, afterwards prices drop again substantially. In period three the monopolist holds out for a long time until finally the LDCs buy at fairly high prices. From then on average prices drop, since only one or two units are sold at high prices. In phase 2, even this ceases to work after period three, and only by holding out for a long time in period eight is the monopolist able to raise the price of at least one unit per period to higher levels.

The patterns of contract prices provides some insights into buyer behavior. When the monopolist tries to price-discriminate some buyers 'learn' that the monopolist sells cheaper, and subsequently 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.

Convergence

Generally, prices converge from above to a level at, or above, the competitive equilibrium. For purposes of analysis of convergence, the equilibrium prediction used to calculate the differences was the high end of the competitive price range. This is done as prices tend to be above the competitive equilibrium²⁵ in all the experiments. A significant α implies that prices are different from the initial equilibrium prediction (EQ).

The asymptotic prediction is always above the competitive equilibrium and always below the monopoly level. Prices are, in most cases, significantly different from both.²⁶ The coefficient β is always positive and less than one and usually significant,²⁷ indicating convergence of prices to levels between the competitive and the monopoly prediction, γ is always positive and usually significant,²⁸ indicating an upward shift of prices in market Y at the beginning of periods. This pattern is quite typical, as is seen in Fig. 3. The only exception is experiment 3, where prices are extremely stable until the last two periods of the second phase. The pattern of prices of this 'outlier' is displayed in Fig. 4.

Table 5. Tests for Convergence -Market Y (Manufactured Product).

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			
	Coefficient	Coefficient Value	Standard Deviation
Experiment 1	Alpha	9.68	43.36
Phase 1	Beta	0.82	0.21
	Gamma	408.25	92.73
	Asymptote	192.02	
Experiment 1	Alpha	17.54	8.58
Phase 2	Beta	0.66	0.07
	Gamma	530.70	56.42
	Asymptote	132.91	
Experiment 2	Alpha	88.32	21.58
Phase 1	Beta	0.37	0.11
	Gamma	463.68	77.52
	Asymptote	277.31	
Experiment 2	Alpha	16.14	5.12
Phase 2	Beta	0.58	0.04
	Gamma	767.30	39.62
	Asymptote	119.99	
Experiment 3	Alpha	247.74	85.08
Phase 1	Beta	0.34	0.21
	Gamma	99.29	102.02
	Asymptote	514.48	
Experiment 3	Alpha	21.91	30.76
Phase 2	Beta	0.88	0.09
	Gamma	135.62	83.23
	Asymptote	269.01	
Experiment 4	Alpha	34.54	22.83
Phase 1	Beta	0.55	0.09
	Gamma	1154	168.18
	Asymptote	213.66	
Experiment 4	Alpha	33.33	12.20
Phase 2	Beta	0.35	0.07
	Gamma	1180	135.11
	Asymptote	132.94

Fig. 3. Experiment 4, Prices in Both Markets (typical).

Fig. 4. Experiment 3, Prices in Both Markets (outlier).

An explanation for the general decrease of prices and their shift at the beginning of a period is the specific structure of the supply and demand. Profitable trades can occur well above the competitive equilibrium, but not substantially below it. The marginal value of X decreases rapidly with the number of units a country holds.²⁹ Figure 5 shows the supply and demand curves for X in phase 1 and 2, given that the market for manufactured products is already in equilibrium (i.e. every country holds two units of Y).³⁰

This feature is important to explain the evolution of prices. Transactions are profitable for both trading partners at prices well above the competitive equilibrium, but not at prices substantially below. The range of profitable prices becomes rapidly smaller as units of X are traded, also decreasing the asymmetry in the distribution of surplus.

Terms of Trade

The terms of trade (ToT) are almost always below the competitive equilibrium, but above the monopoly prediction (Fig. 6). ToT are below the competitive equilibrium in phase 1 in almost all periods. In three experiments ToT are fairly close to the monopoly prediction at the end of phase 1. In phase 2, the ToT are stable and halfway between the low end of the competitive equilibrium and the monopoly prediction.

The ToT presented in Table 6 are computed as the ratio of the average price in the last three periods. Both the monopoly and the competitive model predict that the ToT should worsen. However, ToT increase in three experiments against the prediction of both the competitive and the monopoly model.

Experiment 4 is the outlier, and only because the last periods of each phase differ from earlier periods. ToT in experiment 4 increase during phase 1 (ToT in the final three periods are higher than in all other periods) and drop drastically in the last three periods of phase 2 (before this they had never been below the competitive equilibrium).

Table 6. Terms of Trade.

	Competitive		Monopoly –				
			Monopsony	Experiment 1	Experiment 2	Experiment 3	Experiment 4
	Low	High					
Phase 1	0.54	1.18	0.11	0.17	0.25	0.14	0.47
Phase 2	0.45	0.64	0.04	0.20	0.27	0.25	0.22

Fig. 5. Supply and Demand – Market X.

Y-Market is an equilibrium, i.e. each country holds 2 units of Y in phase 1 and 4 units of Y in phase 2.

Fig. 6. Terms of Trade.

Trading Volume and Efficiencies

The theoretical model predicts that the IC should exert its market power by reducing the quantity in market Y, its output market. The predicted quantity is reduced (relative to the competitive equilibrium) from 8 to 4 in phase 1 and from 16 to 4 in phase 2. The quantity traded is close to the monopoly prediction in phase 1.³¹

In phase 2, the quantity traded is close to the monopoly prediction in experiment 3 (where prices were highest). In other cases the quantity traded is around 8. The effect of restricting output and increasing price is best seen in experiment 4: In phase 2, the monopolist sold on an average 12 units during the first 8 periods at a price around 150 Shillings. In the last two periods it 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. However, the quantities purchased by the monopsonist vary substantially across different experiments. In experiment 3 the monopsonist purchases up to 10 units in phase 1 and 25 units in phase 2. This also explains why prices exceed the competitive equilibrium in phase 2. Quantities in all the other experiments are fairly close to the equilibrium prediction of 4 in phase 1 and 8 in phase 2. In phase 2, experiment 1 is the exception. In this experiment the monopsonist paid prices very close to the monopsony level, but at the expense of quantity purchased. The average quantity purchased is only four units.

Due to the deadweight loss, the monopoly model predicts efficiencies of 95% (of the competitive equilibrium) in phase 1 and 88% in phase 2. Efficiencies are particularly low in experiment 3, in which the monopsonist purchased 'too many' units at a high price in market X and also charged the highest price as monopolist in market Y. Efficiencies in that experiment 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 1, and often greater in phase 2.³²

Earnings

Earnings are defined as the sum of the redemption values for the final holding of X and Y plus (or minus) the trade surplus.³³ The values in the text are the average earnings in the last three periods of each phase.

The competitive model³⁴ predicts that the IC will earn 1960 in phase 1 and 2580 in phase 2, less than in the monopoly model (3560 and 4636). The earnings of each LDC predicted by the competitive model (960 in phase 1, 1310

in phase 2) are higher than those in the monopoly model (488 and 559). In all experiments the average earnings realized by LDCs are lower than the competitive equilibrium and almost always³⁵ higher than the monopoly prediction.

The earnings of the monopolists are always below the monopoly prediction but usually above the competitive equilibrium.³⁶ Experiment 3 is the exception, where, in the last four periods in phase 2, earnings of the monopsonist are below the competitive equilibrium. This is the case because the IC purchased a greater number of units of X at a higher price than is predicted by the competitive model.

CONCLUSION

Industrialized countries are unable to keep prices below the competitive equilibrium as monopsonists in market X. At the same time, as monopolists in market Y they are able to charge higher prices than the competitive equilibrium. The buyers, unlike the sellers, cannot exploit their market power in this environment, whereas the sellers are able to do so. Terms of trade are usually between the competitive range and the monopoly level. Terms of trade increase from phase 1 to phase 2, contradicting the monopoly model. The single industrialized country is unable to exploit its market power to the full extent.

The pure prediction of the Prebisch-Singer (PS) theory of unequal exchange does not hold. The monopsonistic industrialized country is unable to lower prices of the primary product. However, it alters the ToT in its favor as it is able to increase the price of the manufactured good as monopolist. The PS thus tends to overstate the effect on ToT in this setting. In addition, ToT improve as income increases thus contradicting the PS theory.

NOTES

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2. The original research for this paper, including the theoretical model, the experimental design, the experiments and the statistical analysis, was carried out by Michelitsch as part of a Ph.D. thesis (Michelitsch (1993)).

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

4. Prebisch analyzed the terms of trade of the United Kingdom for the period 1876-1880 to 1946-1947. 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 1973 (Balassa, 1989, p. 1653).

5. The ratio of fob to cif prices could show that the terms of trade improve for both trading partners if transportation costs decline.

6. It is important to note that terms of trade *do* worsen significantly in all cases using a similar experimental setting *without* market power on the part of industrialized countries. See Michelitsch (1993).

7. Money is an "obvious feature of any well-functioning market process." Noussair, Plott, Riezman (1995, p. 3). 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. The exchange rate (from experimental money to dollars) is private information.

8. For the exact procedure and parameterization see Michelitsch (1993).

9. For details on induced preferences see Smith (1976).

10. This is done as experimental subjects can not be asked to pay debts they accumulate in an experiment. The subjects receive their payoffs at the end of a series of experiments. This made it unlikely that the total payoff over all experiments is negative, and indeed the lowest payoff was greater than \$9.

11. Note, that this utility function can only be derived for an interior solution ($x > 0$, $y > 0$).

12. 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. For a discussion on how the trainer was run see Appendix 2.

13. 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 experiment. 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.

14. For a description of MUDA see Plott (1991). 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 double auction 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).

15. For a test of the competitive model in multiple markets (but additively separable demand) see Noussair, Plott, Riezman (1992). The authors report that in their multi-market environment only the qualitative predictions of the competitive model hold. Michelitsch (1993) reports similar results with interlinked market akin to this environment but with a competitive design.

16. Other models allowing for a change of prices over time were also considered. Let t denote the observation number (counted from the beginning of the experiment) and T the period number. The model $P_t = \alpha + \beta \cdot \exp(-t) + \varepsilon_t$ assumes a constant rate of convergence from one observation to the next where α is the asymptotic equilibrium

prediction. A significant coefficient on $\exp(-t)$ indicates that prices change over time (they increase if β is negative, decrease if β is positive). The model $P_t = \alpha + \beta \cdot \exp(-T) + \varepsilon_t$ 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 "saw-tooth" form was a common pattern observed in many experiments.

17. The competitive range in phase 1 (2) 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. Figures use CEL for the low end of the competitive range and CEH for its high end.

18. Detailed results using as starting point the lower end of the competitive equilibrium range in phase 1 and its higher end in phase 2 are in Table 4. For experiment 1, with lower prices, the results presented for phase 2 also use the lower end of the competitive range.

19. The following abbreviations are used in the footnotes. E4P1X represents experiment 4, phase 1, market X. In E4P1X prices converge into the competitive range and are significantly different from the monopsony prediction.

20. Significance level of 1%.

21. Prices are significantly greater than the high end of the competitive range, in experiments 3 and 4.

22. The exceptions are E1P1X, E3P1X and E4P1X.

23. The exceptions are E3P2X and E4P2X ($\gamma > 0$).

24. The competitive equilibrium in phase 1 (2) is 89–137 (67–82), the monopoly prediction is 599 (705).

25. The choice of EQ in the equation ($p_t = P_t - EQ$) does not affect the asymptotic equilibrium prediction. It only affects the value and standard deviation of α . In the one case where the asymptotic equilibrium prediction 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.

26. α is not significantly different from zero in E1P1Y and E3P2Y (using the monopoly prediction) and E1P2Y and E3P2Y (using the competitive equilibrium).

27. The only exception is E3P1Y.

28. The only exception occurs in experiment 3.

29. X and Y are complements, i.e. the marginal value of X increases with the number of units of Y. However, the rapidly decreasing marginal utility of X is a feature of the demand and applies for any specific holding of Y.

30. Note that both supply and demand curves shift as units of X are traded. However, 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.

31. The average quantity traded is 4.2. During the last three periods, quantities are close to the competitive prediction of 8 only in one case (experiment 4, phase 1, market Y). In this case the average contract price is also the lowest.

32. Efficiency can drop drastically, for example, in the last period of experiment 2, phase 2 efficiency drops from 94 to 80% after the average contract price in market Y increased from 141 to 198.

33. Trade surplus in this environment is defined as revenues from sales minus expenditures on purchases. The reason for using earnings for comparisons rather than just trade surplus is 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.

34. For better comparison with the monopoly model, the high end of the competitive earnings range from the point of view of the industrialized country (i.e. the low end from the point of view of LDCs) is presented in this section.

35. Three exceptions occur in period 1 and 3 of experiment 3 and period 3 of experiment 4, both in phase 1.

36. Earnings are within the competitive range in only 4 periods of 40 in phase 1, and in 3 periods of 30 (excluding experiment 3, discussed below) in phase 2.

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Appendix 1. Marginal Value Table – Market Y (Manufactured Product).

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	23	19	17	15	14	12	11	11	0	0	0	0	0	0	0	0	0	0	0	0	0
2	430	102	67	51	41	35	31	27	25	23	21	19	0	0	0	0	0	0	0	0	0	0	0	0	0
3	537	124	81	61	50	43	37	33	30	27	25	24	18	17	16	15	15	14	13	13	12	12	11	11	11
4	598	137	90	68	56	47	41	37	33	30	28	26	22	21	20	19	18	17	16	15	15	14	14	13	13
5	639	147	96	73	59	51	44	39	36	33	30	28	24	23	22	21	20	19	18	17	16	16	15	15	14
6	667	154	101	76	62	53	46	41	37	34	32	29	26	25	23	22	21	20	19	18	18	17	16	16	15
7	689	160	104	79	65	55	48	43	39	36	33	31	28	26	24	23	22	21	20	19	19	18	17	17	16
8	705	165	108	82	67	57	50	44	40	37	34	31	29	27	25	24	23	22	21	20	19	19	18	17	17
9	718	169	110	84	68	58	51	45	41	38	35	32	29	28	26	25	24	22	22	21	20	19	18	18	17
10	728	173	113	86	70	60	52	46	42	38	35	33	30	28	27	25	24	23	22	21	20	20	19	18	18
11	737	176	115	87	71	61	53	47	43	39	36	34	31	29	27	26	25	24	23	22	21	20	19	19	18
12	743	179	117	89	72	62	54	48	43	40	37	34	31	30	28	26	25	24	23	22	21	20	20	19	18
13	749	181	118	90	73	62	55	49	44	40	37	35	32	30	28	27	26	24	23	22	21	21	20	19	19
14	754	183	120	91	74	63	55	49	45	41	38	35	32	30	29	27	26	25	24	23	22	21	20	20	19
15	758	186	121	92	75	64	56	50	45	41	38	35	33	31	29	28	26	25	24	23	22	21	20	20	19
16	761	187	122	93	76	65	56	50	46	42	38	36	33	31	29	28	27	25	24	23	22	21	21	20	19
17	763	189	123	94	77	65	57	51	46	42	39	36	33	31	30	28	27	26	24	23	23	22	21	20	20
18	766	191	125	95	77	66	58	51	46	42	39	36	34	32	30	28	27	26	25	24	23	22	21	20	20
19	767	192	126	95	78	66	58	52	47	43	39	37	34	32	30	29	27	26	25	24	23	22	21	21	20
20	769	194	126	96	78	67	58	52	47	43	40	37	34	32	30	29	27	26	25	24	23	22	21	21	20
21	770	195	127	97	79	67	59	52	47	43	40	37	35	33	31	29	28	26	25	24	23	22	22	21	20
22	771	196	128	97	80	68	59	53	48	44	40	37	35	33	31	29	28	27	25	24	23	23	22	21	20
23	772	198	129	98	80	68	60	53	48	44	41	38	35	33	31	29	28	27	26	25	24	23	22	21	20
24	772	199	130	99	80	68	60	53	48	44	41	38	35	33	31	30	28	27	26	25	24	23	22	21	21
25	772	200	130	99	81	69	60	54	49	44	41	38	35	33	31	30	28	27	26	25	24	23	22	21	21
26	773	201	131	100	81	69	60	54	49	45	41	38	36	33	32	30	29	27	26	25	24	23	22	21	21
27	773	202	132	100	82	69	61	54	49	45	41	38	36	34	32	30	29	27	26	25	24	23	22	22	21

28	772	203	132	101	82	70	61	54	49	45	42	39	36	34	32	30	29	28	26	25	24	23	23	22	21
29	772	203	133	101	82	70	61	55	49	45	42	39	36	34	32	31	29	28	27	25	24	24	23	22	21
30	772	204	133	101	83	70	62	55	50	45	42	39	36	34	32	31	29	28	27	26	25	24	23	22	21
31	771	205	134	102	83	71	62	55	50	46	42	39	37	34	32	31	29	28	27	26	25	24	23	22	21
32	771	206	134	102	83	71	62	55	50	46	42	39	37	35	33	31	29	28	27	26	25	24	23	22	21
33	770	207	135	103	84	71	62	55	50	46	42	39	37	35	33	31	30	28	27	26	25	24	23	22	22
34	770	207	135	103	84	71	62	56	50	46	43	40	37	35	33	31	30	28	27	26	25	24	23	22	22
35	769	208	136	103	84	72	63	56	51	46	43	40	37	35	33	31	30	28	27	26	25	24	23	22	22
36	768	209	136	104	85	72	63	56	51	46	43	40	37	35	33	31	30	28	27	26	25	24	23	22	22
37	768	209	137	104	85	72	63	56	51	47	43	40	37	35	33	31	30	29	27	26	25	24	23	23	22
38	767	210	137	104	85	72	63	56	51	47	43	40	37	35	33	32	30	29	27	26	25	24	23	23	22
39	766	210	137	104	85	73	63	57	51	47	43	40	38	35	33	32	30	29	27	26	25	24	23	23	22
40	765	211	138	105	85	73	64	57	51	47	43	40	38	35	33	32	30	29	28	26	25	24	24	23	22
41	764	212	138	105	86	73	64	57	51	47	43	40	38	35	34	32	30	29	28	26	25	24	24	23	22
42	763	212	138	105	86	73	64	57	52	47	44	40	38	36	34	32	30	29	28	27	25	25	24	23	22
43	762	213	139	106	86	73	64	57	52	47	44	41	38	36	34	32	30	29	28	27	26	25	24	23	22
44	761	213	139	106	86	73	64	57	52	47	44	41	38	36	34	32	30	29	28	27	26	25	24	23	22
45	760	214	139	106	87	74	64	57	52	47	44	41	38	36	34	32	31	29	28	27	26	25	24	23	22
46	759	214	140	106	87	74	65	58	52	48	44	41	38	36	34	32	31	29	28	27	26	25	24	23	22
47	758	215	140	106	87	74	65	58	52	48	44	41	38	36	34	32	31	29	28	27	26	25	24	23	22
48	757	215	140	107	87	74	65	58	52	48	44	41	38	36	34	32	31	29	28	27	26	25	24	23	22
49	756	216	141	107	87	74	65	58	52	48	44	41	38	36	34	32	31	29	28	27	26	25	24	23	22
50	755	216	141	107	87	74	65	58	52	48	44	41	39	36	34	32	31	29	28	27	26	25	24	23	22

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?

APPENDIX 2

Trainer session

Subjects received L-shaped squares which allowed them to 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. After the computerized training program, subjects participated in three to six training periods with exactly the 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. During the training periods, subjects had extensive opportunity to ask questions as well as to check their accounting. During the first two periods of the trainer the accounting of all subjects was checked, later only questions answered. The accounting was verified before subjects came back for the subsequent session.