Transfer Paradox in a General Equilibrium Economy: An Experimental Investigation

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Abstract: The transfer paradox, whereby a transfer of resources that influences the equilibrium price benefits the donor while harming the recipient, is a classic paradox in general equilibrium theory. This paper pursues an experimental investigation of the transfer paradox using a three-agent pure exchange economy that is predicted to have such a paradox. The results indicate that an endowment adjustment among agents influences the market price, and consequently the donors benefit from the transfer, consistent with the competitive equilibrium theory. When given an option to make a transfer, half of donor agents voluntarily decide to adjust the endowment distribution.

Keywords: experiments, transfer paradox, general equilibrium, equilibrium effects

JEL codes: C92, D51

1. Introduction

The transfer paradox is a well-known phenomenon in which an adjustment in endowments among agents may benefit the donors while harming the recipients. This paradox arises from the impact that the endowment transfer has on equilibrium prices, which alters the situation to the donors' advantage (Turner, 2016). The transfer paradox was first discussed in Leontief (1936), and has been studied by a number of scholars (e.g., Samuelson, 1947; Gale, 1974; Aumann and Peleg, 1974; Chichilnisky, 1980; Polemarchakis, 1983; Yano, 1983; Rao, 1992; Kang and Ye, 2014, 2016; Dubey and Kang, 2019). Unlike the rich body of theoretical research on the topic, surprisingly no attention has been paid to the transfer paradox in the experimental literature. This paper is the first to experimentally test the transfer paradox in a controlled environment. Two questions are examined. First, does an adjustment of endowments influence the equilibrium price in line with the competitive equilibrium prediction, thereby benefiting

the donors and hurting the recipients? Second, if yes, will donor subjects recognize that such transfers can be advantageous?

The results reveal that endowment adjustments influence the market prices as the theory suggests. This results in the donor earning a higher payoff post-adjustment. Further, when given an option to make a transfer, half of the donor agents voluntarily adjust the endowment distribution. These findings lend support to the predictive power of the competitive equilibrium theory and the possible existence of the transfer paradox in the real world.

2. Experimental Design

The experiment is designed based on Polemarchakis (1983) and Kang and Rasmusen (2016).

2.1. The Environment

There are two goods, numeraire (*x*) [units: ECU] and iron (*y*) [units: kg], in an economy. Three agents have the following Leontief payoff functions as described in row A of Table 1 (Kang and Rasmusen, 2016):[1]

$$u_i(x, y) = \min\{\lambda_i x, y\}, \text{ for } i = 1, 2, 3. \quad (1)$$

Table 1. *Parameters*

	λ_i	Initial endowment	Competitive equilibrium
A: Before transfer	$\lambda_1 = 2, \lambda_2 = 1, \lambda_3 = 3$	$(w_1, w_2, w_3) = \left(\begin{bmatrix}100\\20\end{bmatrix}, \begin{bmatrix}20\\100\end{bmatrix}, \begin{bmatrix}0\\80\end{bmatrix}\right)$	$\left(p_y, \begin{bmatrix}x_1\\y_1\end{bmatrix}, \begin{bmatrix}x_2\\y_2\end{bmatrix}, \begin{bmatrix}x_3\\y_3\end{bmatrix}\right) = \left(1, \begin{bmatrix}40\\80\end{bmatrix}, \begin{bmatrix}60\\60\end{bmatrix}, \begin{bmatrix}20\\60\end{bmatrix}\right)$
B: After transfer		$(w'_1, w'_2, w'_3) = \left(\begin{bmatrix}80\\20\end{bmatrix}, \begin{bmatrix}40\\100\end{bmatrix}, \begin{bmatrix}0\\80\end{bmatrix}\right)$	$\left(p_y, \begin{bmatrix}x_1\\y_1\end{bmatrix}, \begin{bmatrix}x_2\\y_2\end{bmatrix}, \begin{bmatrix}x_3\\y_3\end{bmatrix}\right) = \left(0.2, \begin{bmatrix}60\\120\end{bmatrix}, \begin{bmatrix}50\\50\end{bmatrix}, \begin{bmatrix}10\\30\end{bmatrix}\right)$

Notice that Agent 1 (*i*=1) is a buyer, while Agent 2 (*i*=2) and Agent 3 (*i*=3) are sellers. An important property here is that Agent 1 can *increase* their payoff *by giving away some ECUs to Agent 2*, because such a transfer sharply decreases the equilibrium price of iron (p_y [ECUs/kg]). This is an example of a strong transfer paradox. The transfer size of 20 is used in the experiment (row B of Table 1). This transfer decreases p_y from 1.0 to 0.2 ECUs/kg theoretically and increases the donor's payoff. Online Appendix I summarizes the simulation result.

2.2. The Experiment

At the start of the experiment, subjects are randomly assigned agent roles. The assigned roles are fixed throughout the experiment. The distribution of initial endowments is: $(w_1, w_2, w_3) =$

[1] This setup was chosen for simplicity. A transfer paradox can emerge with other functional forms such as Cobb-Douglas and quasilinear theoretically (Turner, 2016).

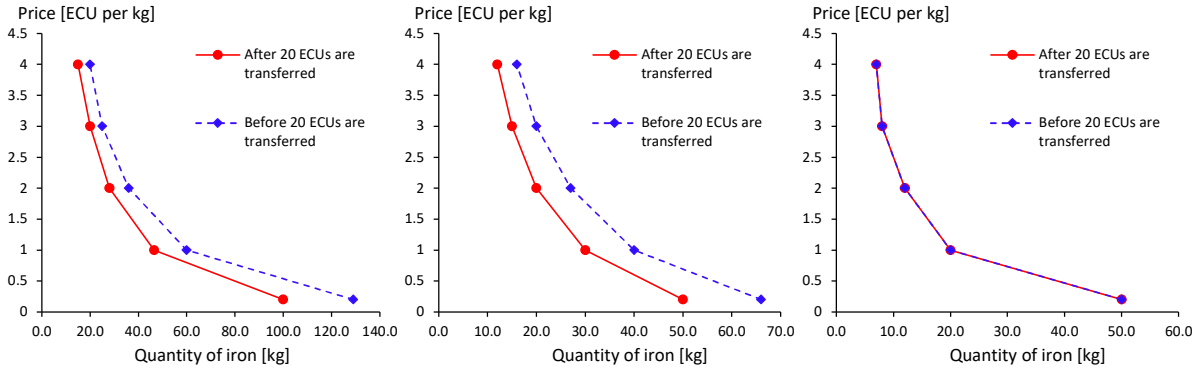
$\left(\begin{bmatrix}100\\20\end{bmatrix},\begin{bmatrix}20\\100\end{bmatrix},\begin{bmatrix}0\\80\end{bmatrix}\right)$.

The experiment consists of three parts. In Part 1, demand/supply schedules are elicited from agents under the initial endowment conditions. In Part 2, these schedules are elicited on the condition that 20 ECUs are *exogenously* transferred from Agent 1s to Agent 2s. In Part 3, Agent 1s decide whether to make such a transfer by voting.

2.2.1. Trading Rule and Structure

Trading is implemented based on the Clearinghouse (call market).[2] There are five possible prices: 0.2, 1.0, 2.0, 3.0, and 4.0 ECU(s)/kg. At the start of Part 1, Agent 1s (Agent 2s and 3s) decide how many kg of iron to buy (sell) for each price. Fig.1 reports the agents' competitive behaviors predicted by the theory. This is the only decision for agents to make in Part 1. Once all agents have completed the schedules, four trading periods are simulated, and subjects are paid based on the sum of own payoffs in these periods. In each simulated period, subjects are randomly assigned to a group that contains five Agent 1s, five Agent 2s and five Agent 3s, and the market price is selected by the computer such that the difference between the quantities demanded and supplied is minimized. Each buyer (seller) can buy (sell) the exact amount they wish and seller *i* sells $Q_D \cdot q_{s,i}/Q_S$ (buyer *j* buys $Q_S \cdot q_{d,j}/Q_D$), if the total quantity demanded Q_D is less (greater) than supplied Q_S.

Fig.1. *Schedules Predicted by Theory*



(*a*) Agent 1's demand schedule (*b*) Agent 2's supply schedule (*c*) Agent 3's supply schedule

Note: Agent 3's schedule is not affected by the transfer.

[2] Alternatively, the experiment could be designed using a multi-unit double auction format. This study, however, adopted a Clearinghouse, because the volatility of trading prices could be large under double auctions in a pure exchange economy (Gode *et al.*, 2004). How the findings from this study extend to the double auction setup remains for future research.

Part 2 proceeds the same as Part 1, except that the initial per-period endowments are changed: $(w'_1, w'_2, w'_3) = \left(w_1 - \begin{bmatrix}20\\0\end{bmatrix}, w_2 + \begin{bmatrix}20\\0\end{bmatrix}, w_3\right)$.

In Part 3, subjects have initial endowments as in Part 1. Once Part 3 begins, subjects are randomly assigned to a group of fifteen. Five Agent 1s decide whether to transfer 20 ECUs to Agent 2s by majority voting. Once Agent 1s have made the decision, all agents are informed of the transfer outcome, and then complete the demand/supply schedules (dependent on their role). The completed schedules are incentivized as these are used to determine the trading price and quantities. To reduce the design complexity, there is only one period (used for payment) in Part 3.

3. Results

Four experimental sessions, each with 30 subjects, were conducted – see online Appendix III for the procedure.

3.1. Impact of Transfer

Columns C and D of Table 2 report average elicited schedules by session. Specifically, the numbers in column C (D) are the average aggregate demands (supplies) multiplied by 1/5, i.e., the average of $q_{Agent\ 1,i}$ (the sum of the average of $q_{Agent\ 2,j}$ and the average of $q_{Agent\ 3,k}$). These numbers are comparable to the theoretical predictions summarized in Fig.1. It shows that the average schedules differ substantially from the theoretical ones (Appendix Table S.1). For example, the quantities supplied by sellers were on average smaller (larger) than the theoretical quantities when prices were low (high). In addition, individual schedules were quite heterogeneous. For instance, for 47.5% of Agent 1s, 62.5% of Agent 2s and 32.5% of Agent 3s, willingness to buy or sell did not decrease significantly as the trading price rose, unlike Fig.1, in at least one out of the three parts in the experiment – see Appendix Fig.S1.

Nevertheless, the effects of transfer are evident. The price that minimizes the excess demand was calculated in each session. The excess demands are the differences between the aggregate demands and supplies (column E of Table 2). The average market price was 0.6 ECU/kg with endowment transfer, which was lower than that without it (1.3 ECU/kg). This is consistent with the competitive equilibrium theory prediction. A look at session-level data further shows that the endowment transfer in Part 2 decreased the market price in three out of four sessions, compared with Part 1 – again see Table 2.

The effects of transfer can also be seen in the four simulated periods (which was used for payment) in each part. Due to the random matching design, any trading price was realized dependent on group composition due to the individuals' heterogeneous schedules. Nevertheless, the price of 0.2 ECUs/kg occurred significantly more frequently in these simulated periods of Part 2 than of Part 1 (see Table S.3).

How frequently did Agent 1s make the transfer in Part 3? Strikingly, 50% of Agent 1s did so in the experiment. This implies that the transfer paradox phenomenon can be initiated by human decision-makers.

Table 2 also shows that the endowment transfer benefited the donors on average (column B). However, unlike the theory, the benefits of transfer spread among the three types of agents: the recipients and third parties were both unharmed by the transfers. This was driven by the recipients' and third parties' strategic behaviors already mentioned. Having said that, this could be due to the design setup that agents had only one-time opportunities to complete the demand/supply schedule. Agents might learn efficient behaviors were they given opportunities to repeat decision making. Alternatively, this result could be due to the group size. While the impact of each agent's schedule is only 6.67% (=1/15×100%) in the experiment, it is not zero. An even larger group size might be required to eliminate the strategic behaviors of agents. Further experiments are needed to assess how transfers affect recipients' and third parties' welfare.

Result: *A transfer of 20 ECUs influenced market prices as the theory suggests, thereby benefiting the donors.*

Table 2. *Average Aggregate Demand Schedule, Average Aggregate Supply Schedule, Market Price and Payoff*

	Market price	A. Traded amount [kg]			B. Payoff [ECU]			C. Quantity demanded [kg] for the following price:					D. Quantity supplied [kg] for the following price:[#1]					E. Excess demand [kg] for the following price in a given session:				
	[ECU/kg]	Agent 1	Agent 2	Agent 3	Agent 1	Agent 2	Agent 3	0.2	1.0	2.0	3.0	4.0	0.2	1.0	2.0	3.0	4.0	0.2	1.0	2.0	3.0	4.0
Session A																						
Part 1	1.0	33.9	21.3	12.6	53.9	41.0	38.0	120.6	33.9	21.2	13.5	10.8	76.3	49.4	45.3	41.1	35.7	44.3	**-15.5**	-24.1	-27.6	-24.9
Part 2	0.2	74.3	39.4	34.9	93.4	48.0	21.0	78.7	42.2	24.4	16.5	13.1	74.3	57.5	41.3	38.4	33.1	**4.4**	-15.3	-16.9	-21.9	-20.0
Part 3 (not transferred)	--[#2]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Part 3 (transferred)	0.2	88.5	45.8	42.7	108.5	49.0	26.0	88.5	44.1	24.8	16.3	12.9	91.5	52.6	37.5	30.0	28.1	**-3.0**	-8.5	-12.7	-13.7	-15.2
Session B																						
Part 1	1.0	45.7	34.6	11.1	65.7	55.0	33.0	93.0	45.7	28.8	17.9	13.2	86.4	50.4	46.6	36.2	29.6	6.6	**-4.7**	-17.8	-18.3	-16.4
Part 2	0.2	79.4	40.2	39.2	99.4	48.0	24.0	83.7	38.9	16.8	11.3	8.1	79.4	51.0	29.9	22.3	17.8	**4.3**	-12.1	-13.1	-11.0	-9.7
Part 3 (not transferred)	0.2	96.8	55.9	40.9	116.8	44.0	25.0	99.2	51.8	24.4	16.2	11.4	96.8	63.5	45.0	33.9	30.1	**2.4**	-11.7	-20.6	-17.7	-18.7
Part 3 (transferred)	---[#2]	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
Session C																						
Part 1	0.2	89.7	53.0	36.7	109.7	47.0	22.0	89.7	47.1	19.3	14.1	7.0	90.7	53.7	39.0	30.8	27.4	**-1.0**	-6.6	-19.7	-16.7	-20.4
Part 2	1.0	44.2	26.5	17.7	64.2	67.0	53.0	94.7	44.6	20.9	16.3	10.0	79.3	44.2	30.2	21.3	18.1	15.4	**0.4**	-9.3	-5.0	-8.1
Part 3 (not transferred)	2.0	31.0	21.4	9.6	51.0	63.0	29.0	83.6	40.0	31.0	15.4	10.0	93.2	58.6	37.4	25.2	21.6	-9.6	-18.6	**-6.4**	-9.8	-11.6
Part 3 (transferred)	1.0	43.0	23.9	19.1	63.0	64.0	57.0	66.0	43.0	16.8	14.6	7.8	81.0	46.0	44.0	23.2	19.0	-15.0	**-3.0**	-27.2	-8.6	-11.2
Session D																						
Part 1	5.0	15.1	10.8	9.9	35.1	31.0	17.0	135.6	60.7	31.5	20.3	15.1	71.3	49.0	36.3	25.2	19.5	64.3	11.7	-4.8	-4.9	**-4.4**
Part 2	1.0	44.5	27.0	17.5	64.5	67.0	53.0	101.9	44.5	19.0	14.1	9.7	69.3	49.8	38.8	22.8	18.3	32.6	**-5.3**	-19.8	-8.7	-8.6
Part 3 (not transferred)	0.2	89.8	48.4	41.4	75.4	55.0	60.0	89.8	46.4	25.0	15.0	12.8	90.2	55.4	37.2	26.6	23.8	**-0.4**	-9.0	-12.2	-11.6	-11.0
Part 3 (transferred)	1.0	53.2	57.8	30.0	53.6	70.0	57.0	134.0	57.8	27.2	19.2	14.2	73.2	53.2	32.0	25.2	21.6	60.8	**4.6**	-4.8	-6.0	-7.4
All data (average market prices, traded quantities and payoffs across all sessions)																						
W/o transfer	1.3	54.5	33.3	21.9	70.2	47.1	32.8															
With transfer	0.6	63.3	37.6	30.0	80.8	57.6	39.4															

Notes: [#1] Average Agent 2's schedule plus average Agent 3's schedule.

[#2] Both the two groups decided to transfer in Session A (decided not to transfer in Session B).

3.2. What Motivated Agent 1s' Transfer Decisions?

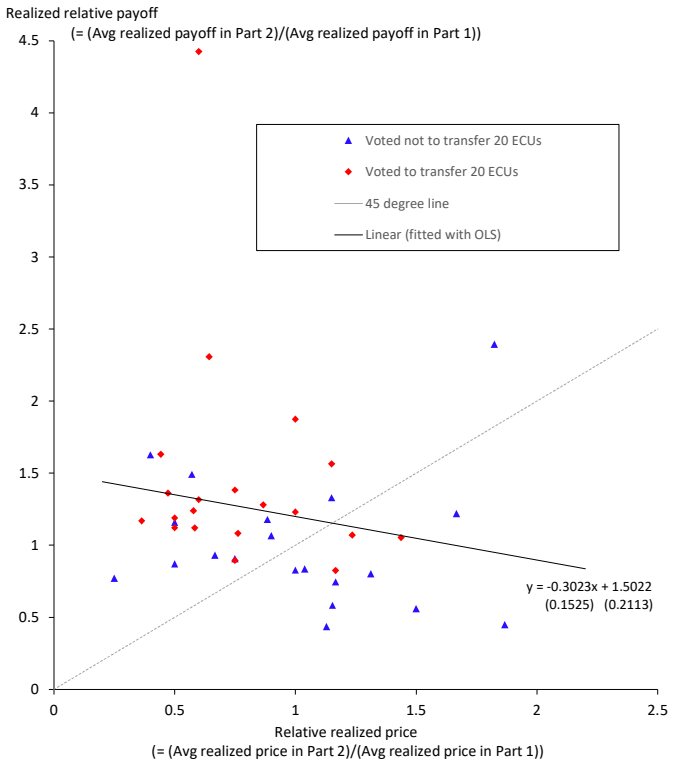
There is an inverse relationship between realized relative prices and relative payoffs of donors in Parts 1 and 2 (Fig.2). A detailed look at Fig.2 shows that the relative payoffs affected Agent 1s' transfer decisions. 69.2% of Agent 1s decided to transfer in Part 3 when the relative payoffs were greater than one. This was significantly higher than the percentage when the relative payoffs did not exceed one – whose percentage was 14.3% – at p = 0.0009 (z= -3.315, N=40) according to a two-sample test of proportions. This suggests that Agent 1s recognized the benefit of transfer.

The donors' payoff changes with the transfer can be explained by equilibrium effects. While 61.5% of Agent 1s decided to transfer in Part 3 when average realized prices dropped with forced transfer in Part 2, only 28.6% of them did so when average prices rose with transfer (Fig.2). A regression analysis confirmed the statistical significance of the equilibrium effects – see Table 3. Subjects' cognitive ability has a limited role in explaining transfer behaviors (Appendix Table S.4).

4. Conclusion

This paper showed that an adjustment in endowments among agents could influence the market price, through which the donors may benefit from the transfer.

Fig.2. *Agent 1s' Experiences, and Regime Choices*



Note: The numbers in parentheses in the linear lines are standard errors clustered by session.

Table 3. *Determinants of Agent 1s' Transfer Decisions*

Dependent variable: A dummy which equals 1 if an Agent-1 subject voted for a transfer

Independent variable:	(1)	(2)
Price diff. {=(Avg. realized price in Part 2) – (Avg. realized price in Part 1)}	-0.798** (0.333)	---
Payoff diff. {=(Avg. realized payoff in Part 2) – (Avg. realized payoff in Part 1)}	---	0.031** (0.016)
Constant	-0.807 (0.569)	-0.748 (0.701)
# observations	40	40
Pseudo R-squared	0.167	0.209

Notes: Probit regressions. Numbers in parentheses are standard errors clustered by session. *p<0.1; **p<0.05; ***p<0.01.

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References

Aumann, R., Pele, B., 1974. A note on Gale's example. *J.Math.Econ.* 1:209-211.

Chichilnisky, G., 1980. Basic goods, the effects of commodity transfers and the international economic order. *J.Dev.Econ.* 7(4):505-519.

Dubey, R., Kang, M., 2019. Transfer paradox in a stable equilibrium. *Econ. Theory Bulletin*. 7:259-269.

Gale, D., 1974. Exchange Equilibrium and Coalitions: An Example. *J.Math.Econ.* 1:63-66.

Gode, Dhananjay, Stephen Spear, and Shyam Sunder, 2004. Convergence of Double Auctions to Pareto Optimal Allocations in the Edgeworth Box. Yale ICF Working Paper 04-30.

Kang, M., Rasmusen, E., 2016. The Transfer Paradox. Working paper.

Kang, M., Ye, L., 2014. Coalition-enhancing fiscal policies in an open economy: A CES framework of Gale's transfer paradox. *J.Math.Econ.* 50:141-147.

Kang, M., Ye, L., 2014. Advantageous redistribution with three smooth CES utility functions. *J.Math.Econ.* 67:171-180.

Leontief, W., 1936. Note on the pure theory of capital transfer. In Explorations in economics, Notes and Essays Contributed in Honor of F.W.Taussig.

Polemarchakis, H., 1983. On the Transfer Paradox. *Int. Econ. Rev.* 24(3):749-760.

Rao, M., 1992. On the transfer and advantageous. *Soc. Choice Welf.* 9(2):131-139.

Samuelson, P. 1952. The Transfer Problem and Transport Costs: The Terms of Trade When Impediments Are Absent. *Econ.J.* 62(246):278-305.

Turner, S., 2016. How much trade does the transfer paradox require? working paper.

Yano, M., 1983. Welfare Aspects of the Transfer Problem. *J. Int. Econ.* 15:277-289.

NOT FOR PUBLICATION

Online Supplementary Materials to

Kamei: "Transfer Paradox in a General Equilibrium Economy: a First Experimental Investigation"*

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Appendix I: Impact of Transfers (Simulations Exercise)

This study employed a simple standard framework discussed in the theoretical literature. A three-agent pure exchange economy was selected as the basis of experiments, since the transfer paradox is theoretically a rare phenomenon in a two-agent pure exchange economy (Turner, 2016).

To my knowledge, a challenge confronted in empirically exploring the transfer paradox in realistic setups proposed by prior influential papers, such as Chichilnisky (1980, 1983), is that the set of endowments and preference parameters that lead to a paradox is usually small even in a three-agent economy.[1] For example, in the three-income-group framework of Chichilnisky (1980, 1983), restrictive Condition (C.1) [Chichilnisky, 1980, page 509] must be satisfied. In addition, the sufficient condition, (C.3) [Chichilnisky, 1983, page 239], is also restrictive.

Polemarchakis (1983) developed a nice framework for a three-agent pure exchange economy in which the set of parameters that leads to a transfer paradox is not so restrictive. Kang and Rasmusen (2016) recently provided a very useful numerical example based on Polemarchakis (1983). The experimental design of this paper (see Section 2 of the paper) is built on these two papers.

This part of the Appendix shows that the payoff of Agent 1 (the donor) is increasing with the size of transfer of ECUs to Agent 2 (t), while conversely the payoffs of Agent 2 (the recipient) and Agent 3 (the third party) are decreasing with the size of transfer, provided that $t \leq 20$. A simple setup is desired since this is the first experiment test and also the transfer paradox is a counter-intuitive phenomenon. Subjects' behaviors in a laboratory are also usefully known to be heterogeneous. For these reasons, this study uses $t = 20$ in the laboratory experiment to make the payoff benefits of the transfer theoretically large to the donor subjects (Table 1 of the paper). Subjects are unlikely to have prior knowledge about the paradox under the study.

[1] See also Rao (1992) to generalize the paradox by providing its necessary and sufficient conditions in a three-agent globally Walrasian stable economy.

Suppose that Agent 1 gives away *t* ECUs to Agent 2. The adjusted distribution of endowments is then given by:

$$w_1{}' = \begin{pmatrix} 100-t \\ 20 \end{pmatrix}; w_2{}' = \begin{pmatrix} 20+t \\ 100 \end{pmatrix}; w_3{}' = \begin{pmatrix} 0 \\ 80 \end{pmatrix}.$$

The budget condition of each agent reduces to the followings:

$$x_1 + py_1 = 100 - t + p \cdot 20. \quad \text{(A1)}$$

$$x_2 + py_2 = 20 + t + p \cdot 100. \quad \text{(A2)}$$

$$x_3 + py_3 = p \cdot 80. \quad \text{(A3)}$$

The feasibility condition in the market and the equilibrium condition of the Leontief utility functions are not affected by such a transfer and are given by the following:

$$x_1 + x_2 + x_3 = 120. \quad \text{(A4)}$$

$$y_1 + y_2 + y_3 = 200. \quad \text{(A5)}$$

$$2x_1 = y_1. \quad \text{(A6)}$$

$$x_2 = y_2. \quad \text{(A7)}$$

$$3x_3 = y_3. \quad \text{(A8)}$$

Each agent's equilibrium quantity of good *x* can thus be expressed as a function of *p* (i.e., the price of iron):

$$x_1 = \frac{100-t+20p}{1+2p}; x_2 = \frac{20+t+100p}{1+p}; x_3 = \frac{80p}{1+3p}, \quad \text{(A9)}$$

and the payoff of each agent is given by:

$$u_1 = 2x_1 = \frac{200-2t+40}{1+2p}; u_2 = x_2 = \frac{20+t+100p}{1+p}; \text{ and } u_3 = 3x_3 = \frac{240p}{1+3p}. \quad \text{(A10)}$$

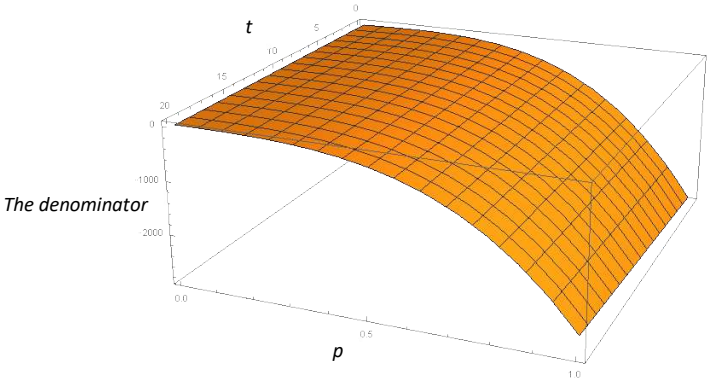
Substituting these optimal quantities to condition (A4), the following condition can be obtained for the equilibrium price:

$$\frac{100-t+20p}{1+2p} + \frac{20+t+100p}{1+p} + \frac{80p}{1+3p} = 120. \quad \text{(A11)}$$

Condition (A11) suggests that the equilibrium price depends on the size of *t*. This also suggests that the equilibrium price is monotonically decreasing in *t*. To see this, applying the Implicit Function Theorem to Condition (A11), the following derivative can be derived:

$$\frac{dp}{dt} = \frac{p(1+p)(1+2p)(1+3p)^2}{20+160p-40p^2-1440p^3-1580p^4-t-6pt-7p^2t+12p^3t+18p^4t}.$$

Notice that $\frac{dp}{dt}$ is negative if *t* is not too large because the denominator is then negative (the numerator is always positive provided that $p > 0$). The following graph shows that the denominator is always negative when $t \leq 20$:



Note: the figure was depicted using Mathematica.

Table A.1 on the next page summarizes how the equilibrium price and each agent's utility depend on *t*. For simplicity, the summary table includes the cases where *t* is a non-negative integer. It shows that the payoff of Agent 1 (Agent 2) is larger (smaller), the larger transfer she makes.

Summary: *Provided that the size of transfer t ≤ 20, the payoff of the donor (Agent 1) is increasing with the size t, and the payoffs of the recipient (Agent 2) and the third party (Agent 3) are oppositely decreasing with the size t.*

Table A.1. *The Impact of Transfer, t, on the Competitive Market Equilibrium*

t	(a) Equilibrium price *p*	(b) Allocation of good *x*: (x_1, x_2, x_3)	(c) The payoff of Agent 1 (u_1)	(d) The payoff of Agent 2 (u_2)	(f) The payoff of Agent 3 (u_3)
0	1.000	(40.00, 60.00, 20.00)	80.00	60.00	60.00
1	.967	(40.34, 59.83, 19.83)	**80.69**	*59.83*	*59.49*
2	.933	(40.71, 59.65, 19.65)	**81.41**	*59.65*	*58.94*
3	.899	(41.09, 59.45, 19.45)	**82.18**	*59.45*	*58.36*
4	.865	(41.50, 59.25, 19.25)	**83.00**	*59.25*	*57.75*
5	.831	(41.94, 59.03, 19.03)	**83.88**	*59.03*	*57.09*
6	.796	(42.41, 58.80, 18.80)	**84.82**	*58.80*	*56.39*
7	.761	(42.91, 58.54, 18.54)	**85.83**	*58.54*	*55.63*
8	.725	(43.46, 58.27, 18.27)	**86.92**	*58.27*	*54.81*
9	.690	(44.05, 57.98, 17.98)	**88.09**	*57.98*	*53.92*
10	.653	(44.69, 57.66, 17.66)	**89.38**	*57.66*	*52.97*
11	.616	(45.39, 57.30, 17.30)	**90.78**	*57.30*	*51.91*
12	.578	(46.17, 56.92, 16.92)	**92.33**	*56.92*	*50.75*
13	.540	(47.03, 56.49, 16.49)	**94.06**	*56.49*	*49.46*
14	.500	(48.00, 56.00, 16.00)	**96.00**	*56.00*	*48.00*
15	.459	(49.11, 55.45, 15.45)	**98.21**	*55.45*	*46.34*
16	.416	(50.39, 54.81, 14.81)	**100.78**	*54.81*	*44.42*
17	.371	(51.91, 54.04, 14.04)	**103.82**	*54.04*	*42.13*
18	.322	(53.79, 53.10, 13.10)	**107.58**	*53.10*	*39.31*
19	.267	(56.26, 51.87, 11.87)	**112.52**	*51.87*	*35.61*
20	.200	(60.00, 50.00, 10.00)	**120.00**	*50.00*	*30.00*
No solutions for positive competitive equilibrium price if $t \geq 21$.					

References

Chichilnisky, G., 1980. Basic goods, the effects of commodity transfers and the international economic order. *J. Dev. Econ.* 7(4): 505-519.

Chichilnisky, G., 1983. The transfer problem with Three agents once again. *J. Dev. Econ.* 13: 237-248.

Kang, M., Rasmusen, E., 2016. The Transfer Paradox. Working paper.

Polemarchakis, H., 1983. On the Transfer Paradox. *Int. Econ. Rev.* 24(3): 749-760.

Rao, M., 1992. On the transfer and advantageous. *Soc. Choice Welf.* 9(2): 131-139.

Turner, S., 2016. How much trade does the transfer paradox require? The threshold computed, Working paper.

Appendix II. Additional Figures and Tables

Fig. S.1. *Individual demand and supply schedules*

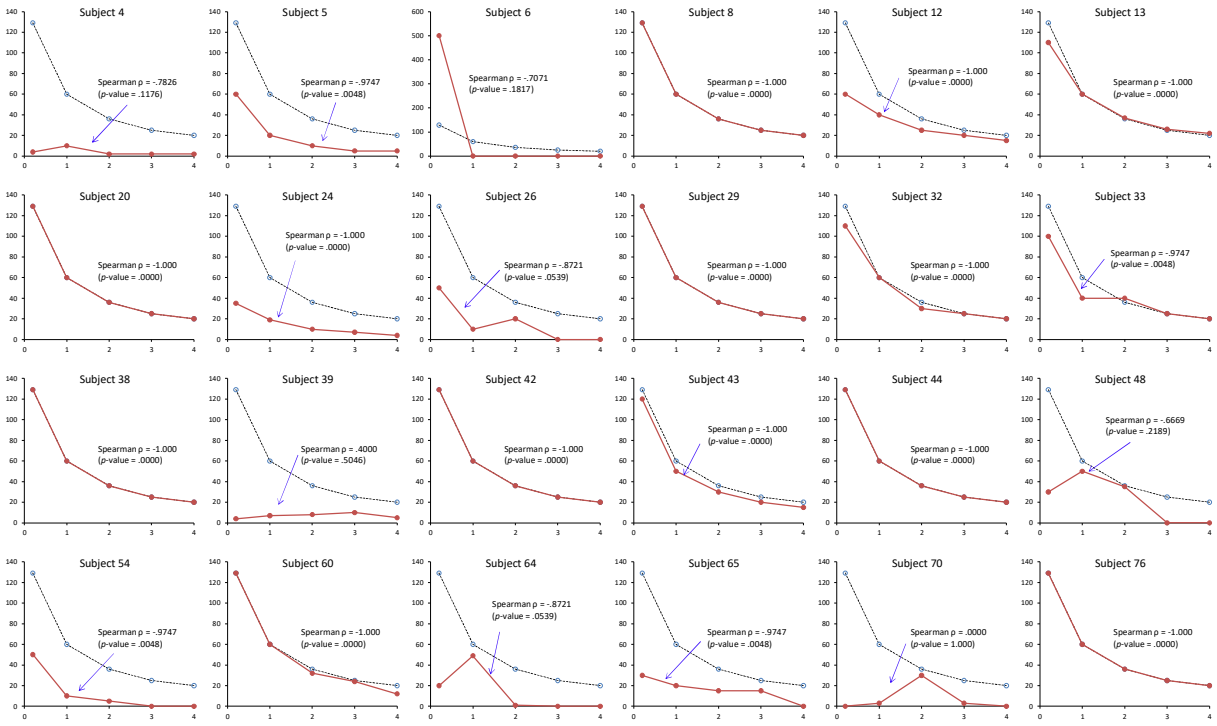
A closer look at individuals' demand and supply schedules indicates substantial heterogeneity in responses among subjects. Many subjects seemingly exhibited strategic behavior, attempting to influence the market prices.

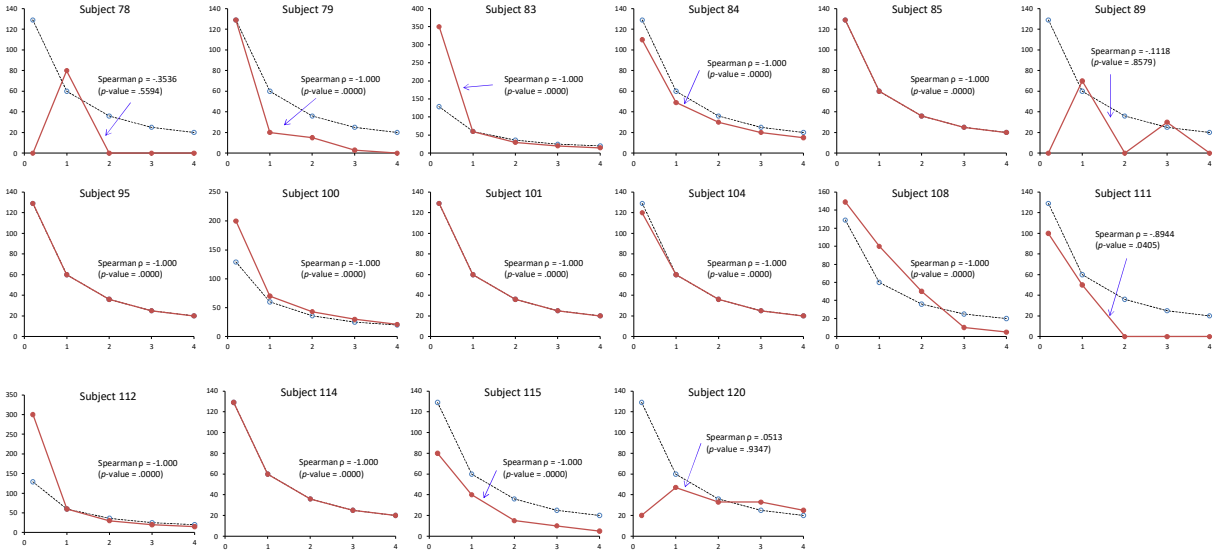
First, certain subjects' willingness to buy or sell did not decrease significantly as the trading price rises in the schedules, unlike the competitive market theory prediction (Figure 1 of the paper). This was the case for 47.5% of Agent 1s, 62.5% of Agent 2s and 32.5% of Agent 3s in at least one out of the three parts in the experiment. Each panel in Figure S.1 below includes the Spearman's ρ value and its *p*-value.

Second, some buyers (Agent 1) indicated that they would not buy anything when the purchase price is the highest. Likewise, some sellers (Agent 2 or 3) indicated that they would not sell any amount if the price is the lowest. This also contradicts agents' competitive profit maximization behaviors visible from the instructions and payoff tables distributed to the subjects. According to individual schedules included in Figure S.1 below, 47.5% of Agent 1s, 32.5% of Agent 2s and 17.5% of Agent 3s exhibited such responses in at least one out of the three parts in the experiment.

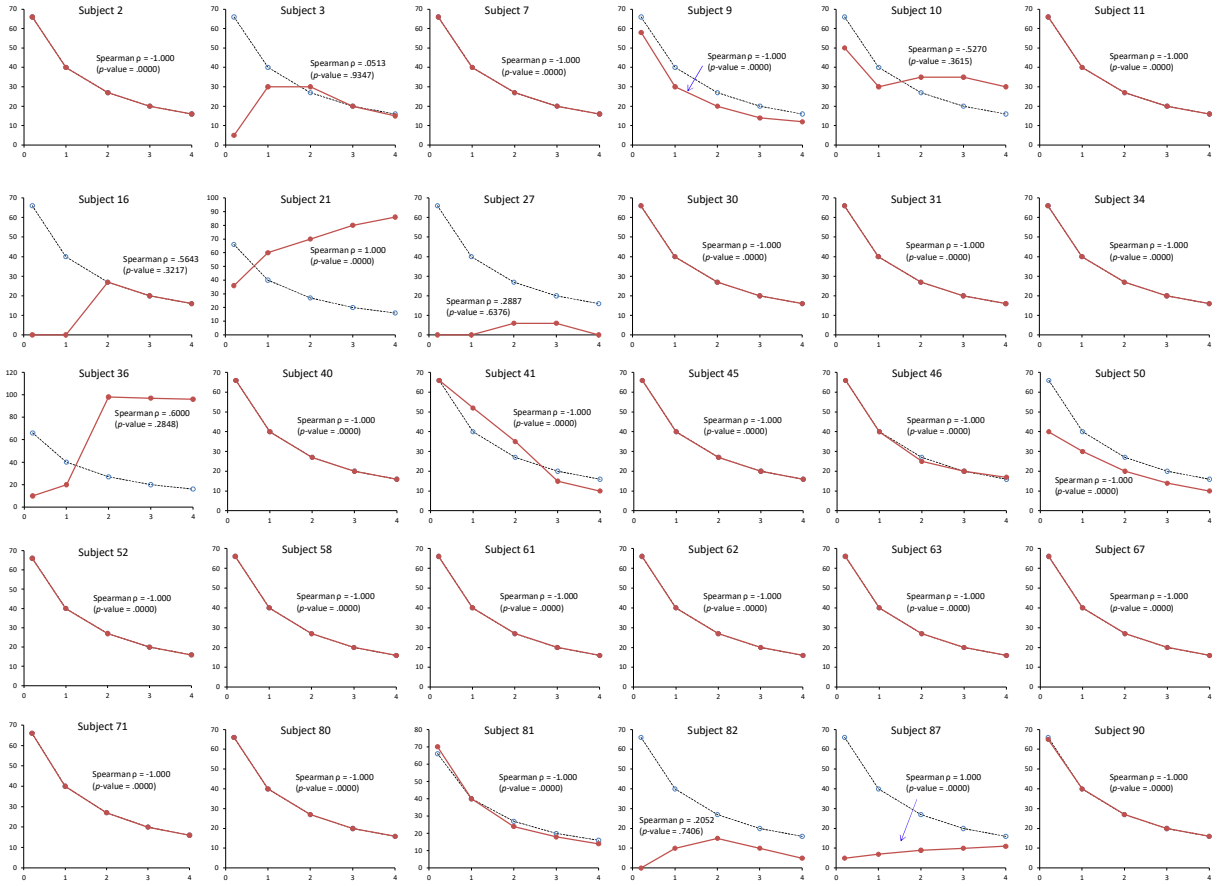
(1) Part 1

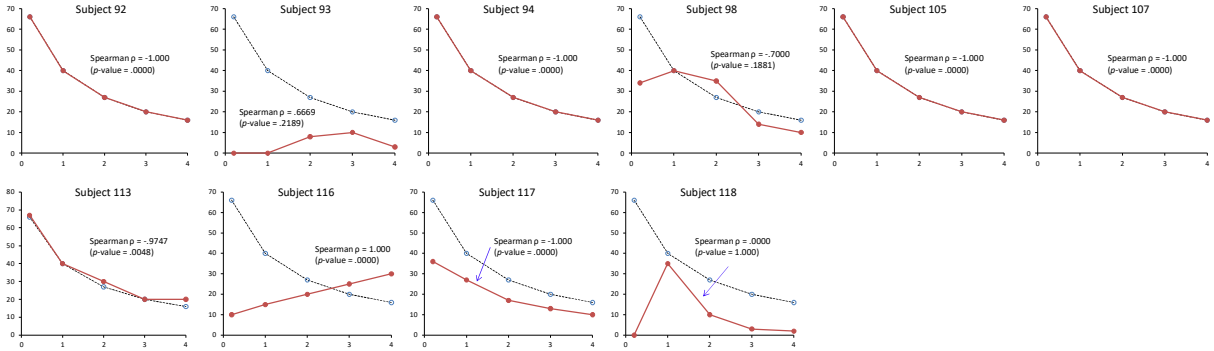
a. Agent 1 (buyer)



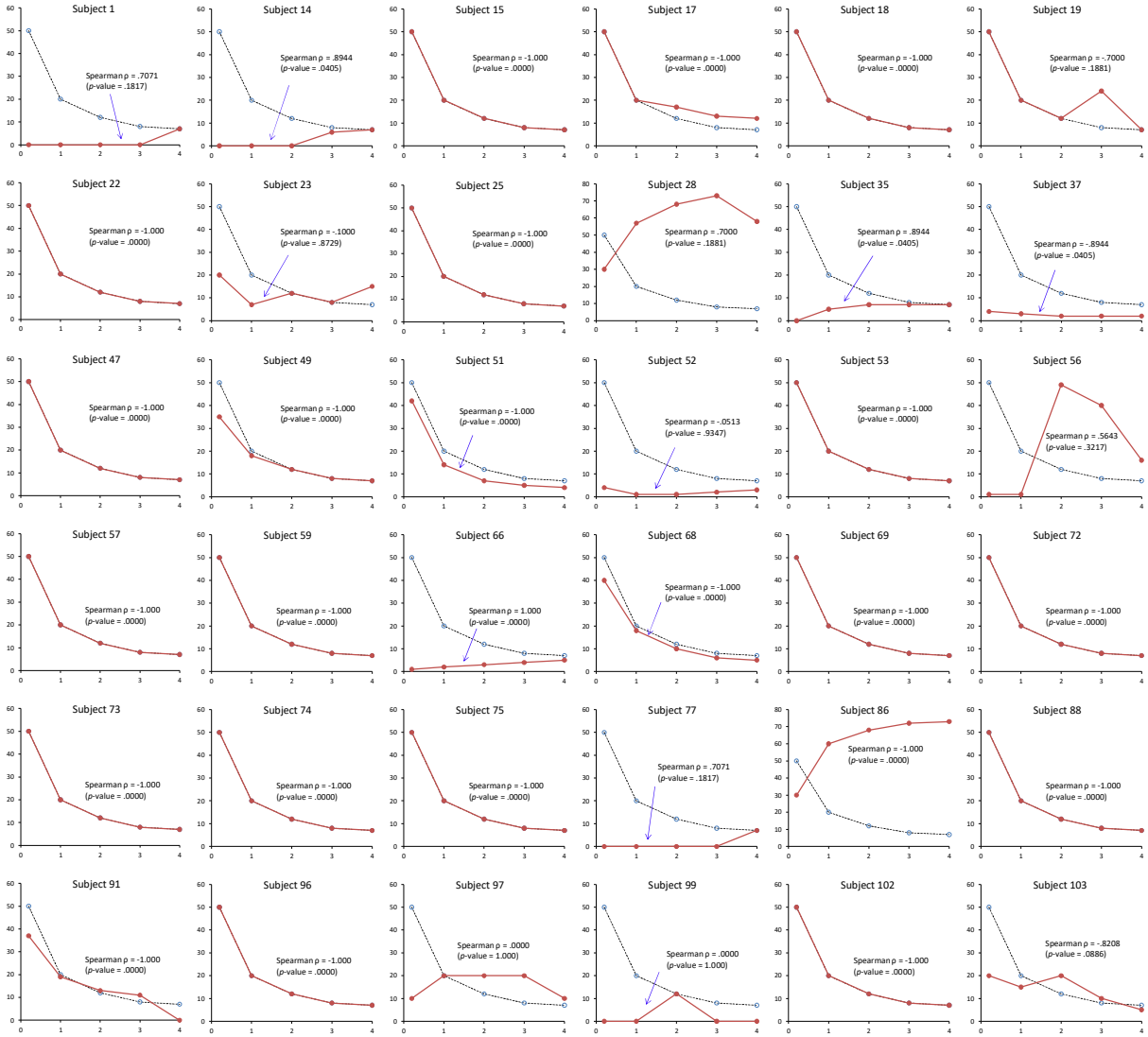


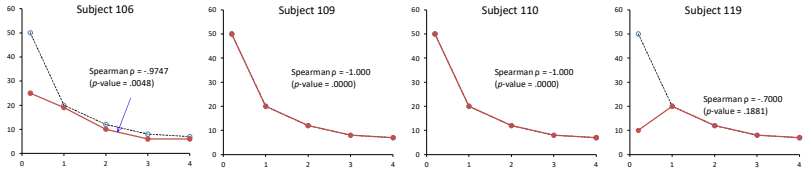
b. Agent 2 (seller)





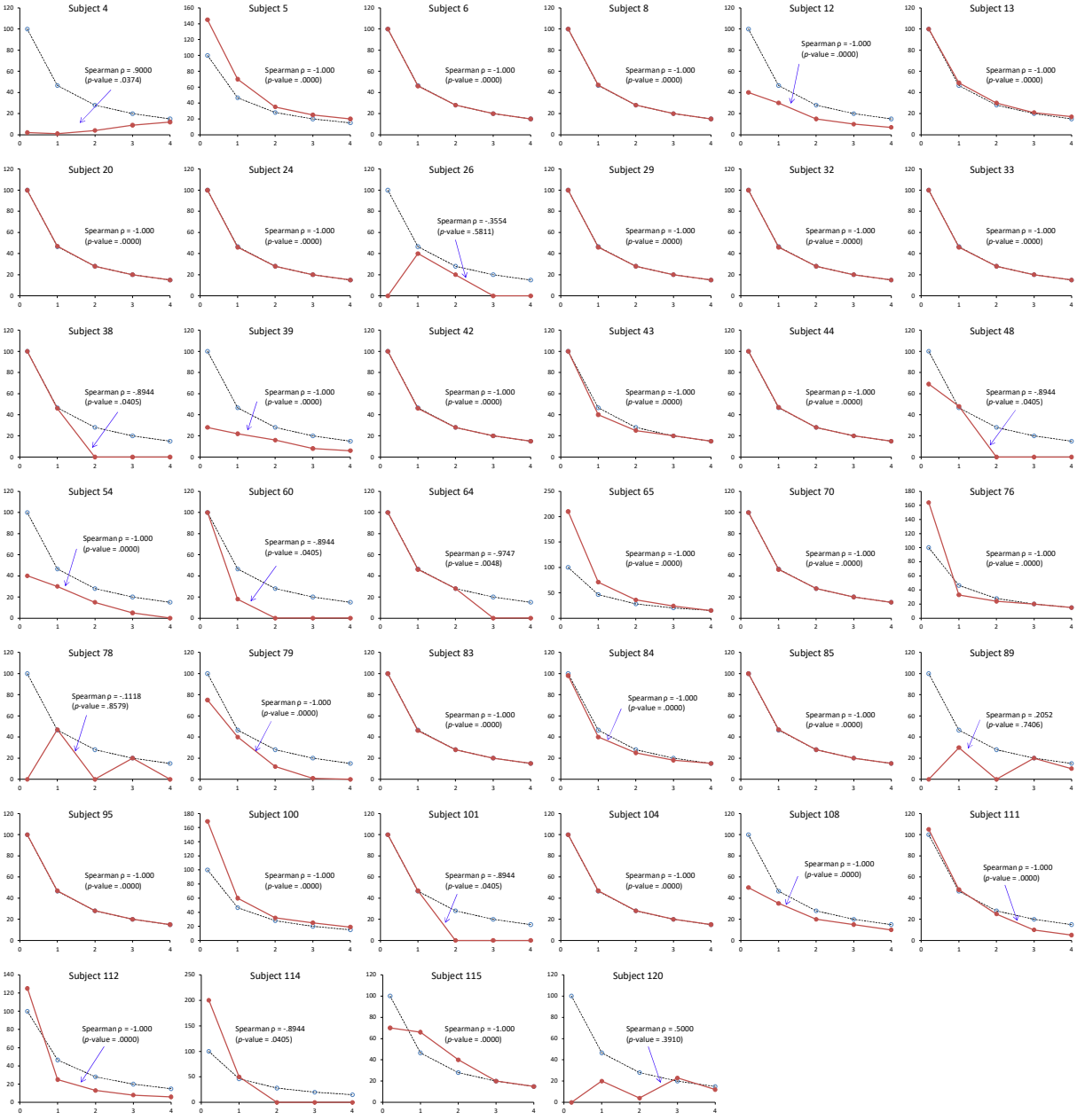
c. Agent 3 (seller)



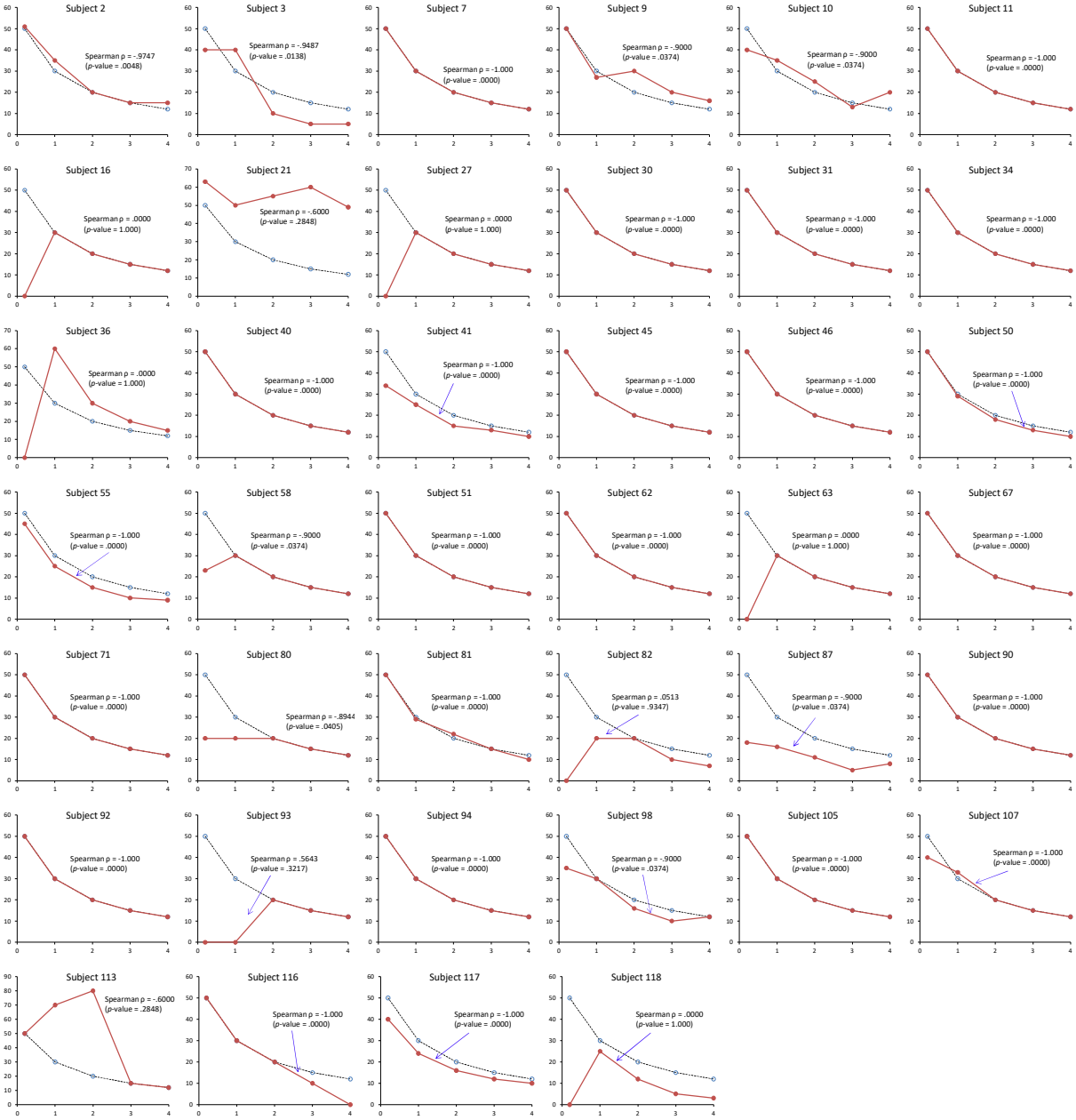


(2) Part 2

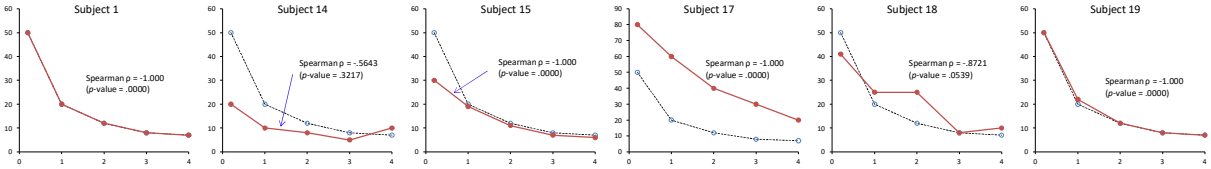
a. Agent 1 (buyer)

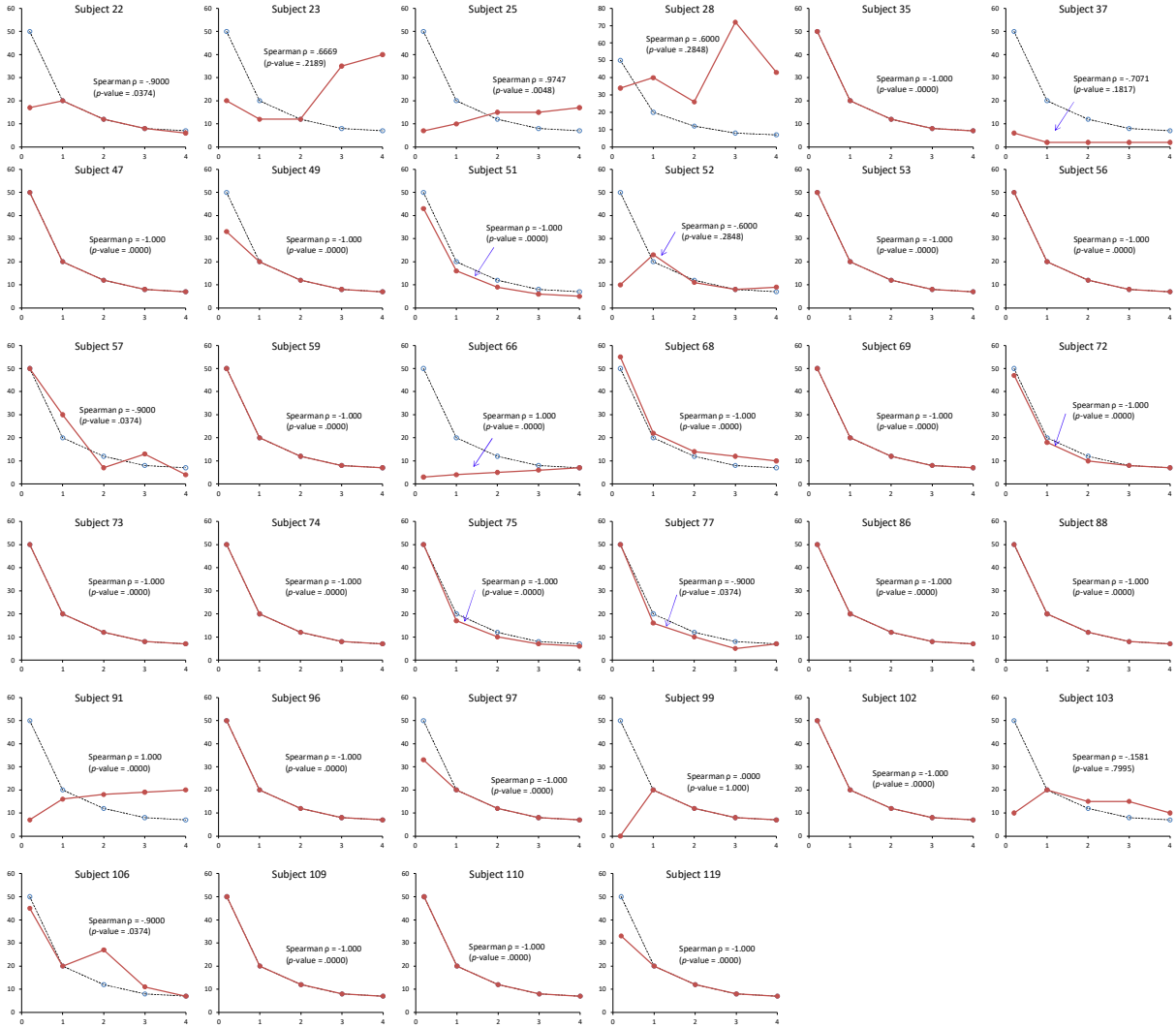


b. Agent 2 (seller)



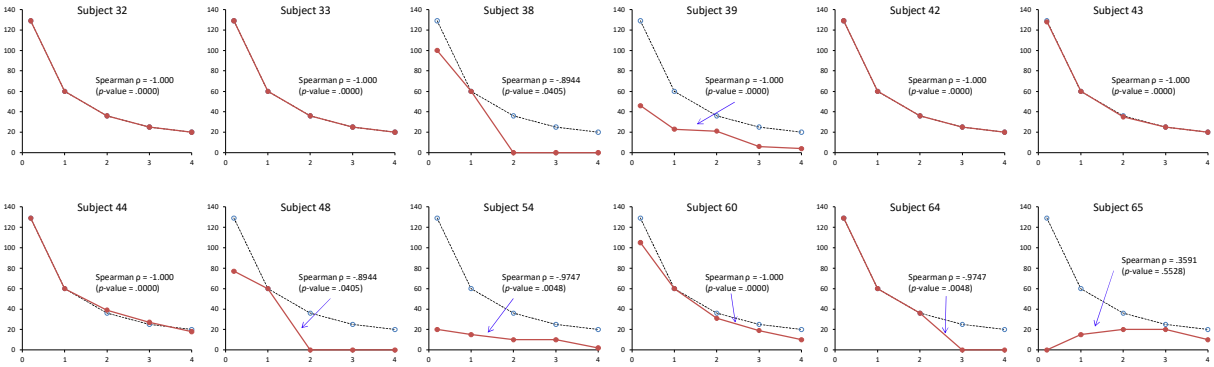
c. Agent 3 (seller)

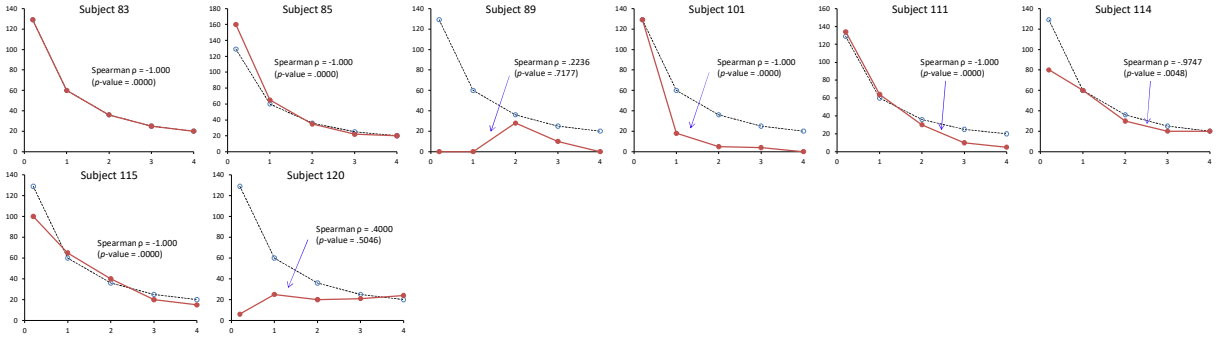




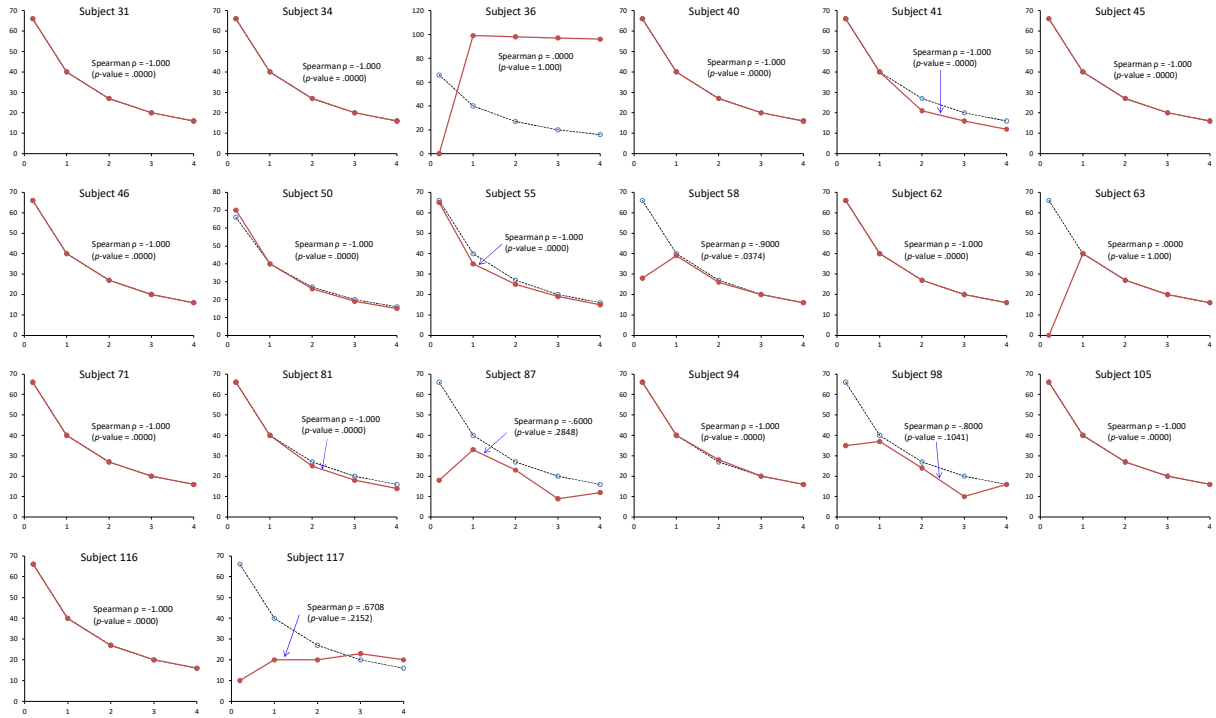
(3) Part 3 (When 20 ECUs were not transferred)

a. Agent 1 (buyer)

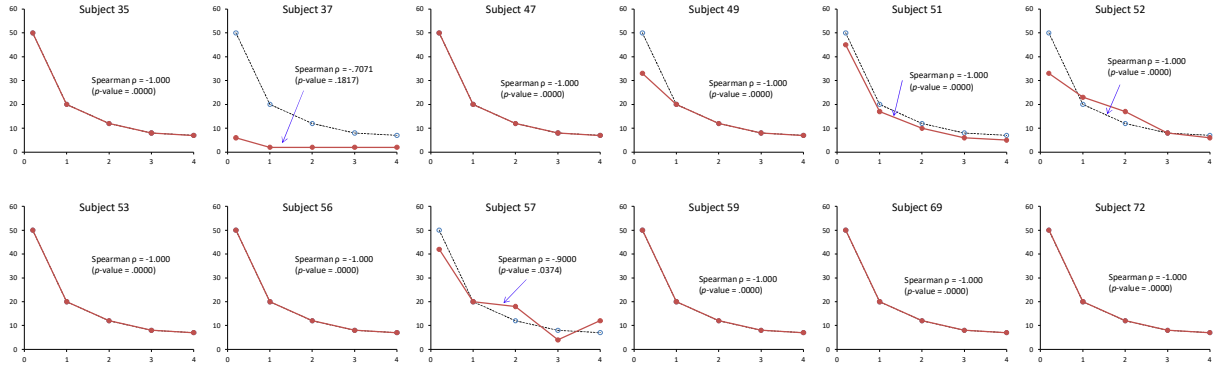


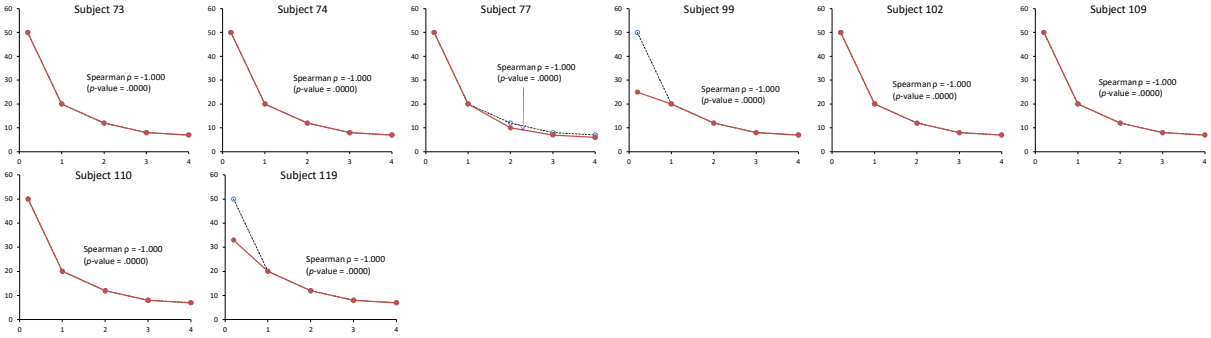


b. Agent 2 (seller)



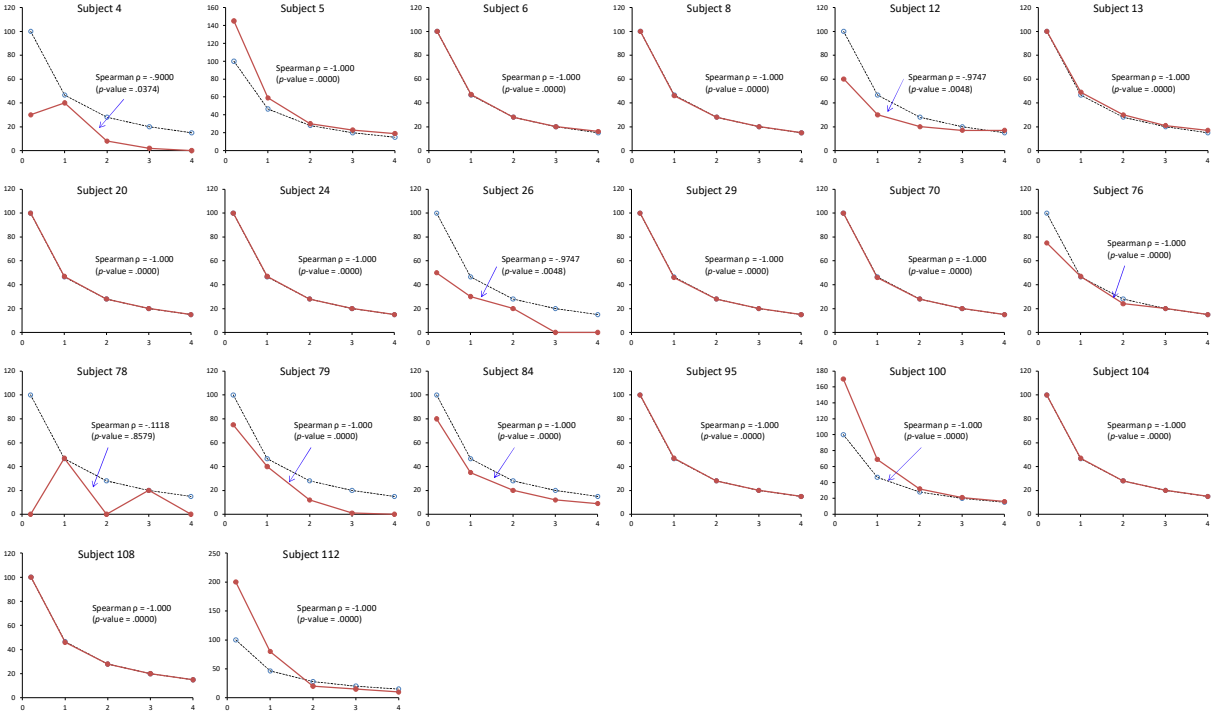
c. Agent 3 (seller)



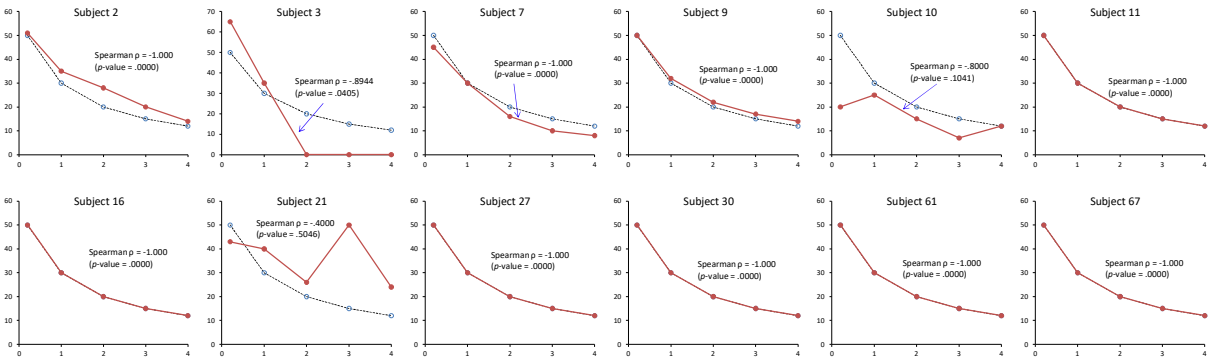


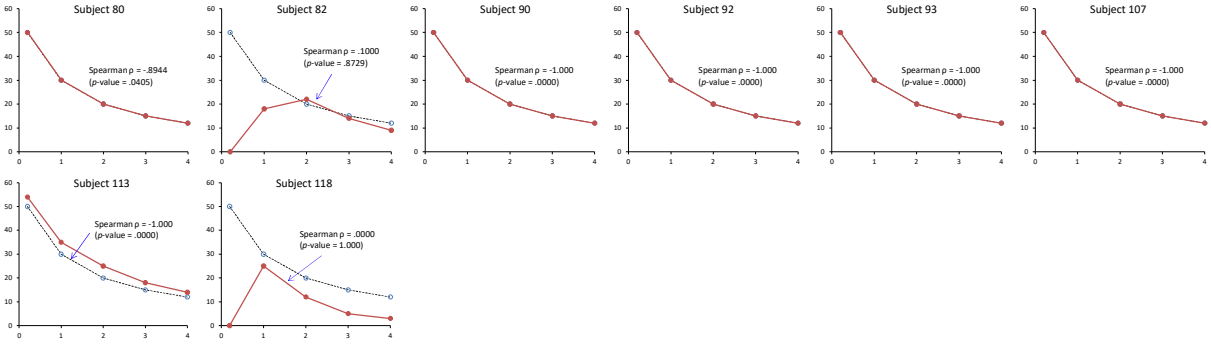
(4) Part 3 (When 20 ECUs were transferred)

a. Agent 1 (buyer)

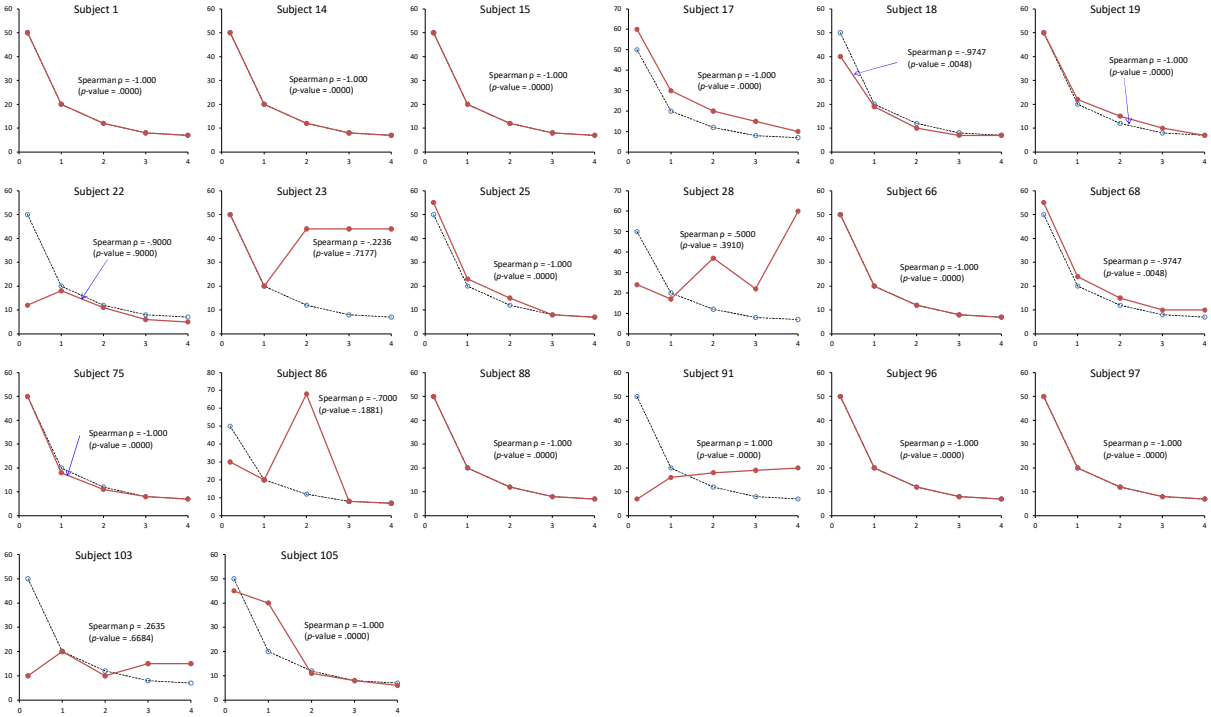


b. Agent 2 (seller)





c. Agent 3 (seller)



Notes: The horizontal axis (x-axis) indicates buying or selling prices [ECUs per kg], while the vertical axis (y-axis) indicates the quantity of iron to buy or sell [kg]. The solid connected line in each panel indicates a given subject's demand or supply schedule. The spearman's ρ correlation coefficient was calculated in each panel between the subject's schedule and price. The *p*-value in parenthesis is based on a two-sided test. As a comparison, each agent's schedule predicted by the competitive equilibrium theory was also depicted (the connected dashed line with hollow circles in each panel).

Table S.1. *Differences between Average Aggregate Schedules and Theoretically Competitive Schedules*

Numbers in bold below show the differences between schedules theoretically predicted and subjects' average aggregate schedules.

	Quantity demanded/supplied [kg] w/o transfer					Quantity demanded/supplied [kg] with transfer				
Price/kg:	0.2	1.0	2.0	3.0	4.0	Price/kg:	0.2	1.0	2.0	3.0	4.0
Theory prediction											
Buyer[#1]	129.0	60.0	36.0	25.0	20.0		100	46.5	28.0	20.0	15.0
Seller[#2]	116.0	60.0	39.0	28.0	23.0		100	50.0	32.0	23.0	19.0
Session A											
Part 1						Part 2					
Buyer[#1]	120.6	33.9	21.2	13.5	10.8		78.7	42.2	24.4	16.5	13.1
	-8.4	**-26.1**	**-14.8**	**-11.5**	**-9.2**		**-21.3**	**-4.3**	**-3.6**	**-3.5**	**-1.9**
Seller[#2]	76.3	49.4	45.3	41.1	35.7		74.3	57.5	41.3	38.4	33.1
	-39.7	**-10.6**	**6.3**	**13.1**	**12.7**		**-25.7**	**7.5**	**9.3**	**15.4**	**14.1**
Part 3 (not transferred)						Part 3 (transferred)					
Buyer[#1]	---	---	---	---	---		88.5	44.1	24.8	16.3	12.9
							-11.5	**-2.4**	**-3.2**	**-3.7**	**-2.1**
Seller[#2]	---	---	---	---	---		91.5	52.6	37.5	30.0	28.1
							-8.5	**2.6**	**5.5**	**7.0**	**9.1**
Session B											
Part 1						Part 2					
Buyer[#1]	93.0	45.7	28.8	17.9	13.2		83.7	38.9	16.8	11.3	8.1
	-36.0	**-14.3**	**-7.2**	**-7.1**	**-6.8**		**-16.3**	**-7.6**	**-11.2**	**-8.7**	**-6.9**
Seller[#2]	86.4	50.4	46.6	36.2	29.6		79.4	51.0	29.9	22.3	17.8
	-29.6	**-9.6**	**7.6**	**8.2**	**6.6**		**-20.6**	**1.0**	**-2.1**	**-0.7**	**-1.2**
Part 3 (not transferred)						Part 3 (transferred)					
Buyer[#1]	99.2	51.8	24.4	16.2	11.4		---	---	---	---	---
	-29.8	**-8.2**	**-11.6**	**-8.8**	**-8.6**						
Seller[#2]	96.8	63.5	45.0	33.9	30.1		---	---	---	---	---
	-19.2	**3.5**	**6.0**	**5.9**	**7.1**						
Session C											
Part 1						Part 2					
Buyer[#1]	89.7	47.1	19.3	14.1	7.0		94.7	44.6	20.9	16.3	10.0
	-39.3	**-12.9**	**-16.7**	**-10.9**	**-13**		**-5.3**	**-1.9**	**-7.1**	**-3.7**	**-5**
Seller[#2]	90.7	53.7	39.0	30.8	27.4		79.3	44.2	30.2	21.3	18.1
	-25.3	**-6.3**	**0.0**	**2.8**	**4.4**		**-20.7**	**-5.8**	**-1.8**	**-1.7**	**-0.9**
Part 3 (not transferred)						Part 3 (transferred)					
Buyer[#1]	83.6	40.0	31.0	15.4	10.0		66.0	43.0	16.8	14.6	7.8
	-45.4	**-20.0**	**-5.0**	**-9.6**	**-10.0**		**-34.0**	**-3.5**	**-11.2**	**-5.4**	**-7.2**
Seller[#2]	93.2	58.6	37.4	25.2	21.6		81.0	46.0	44.0	23.2	19.0
	-22.8	**-1.4**	**-1.6**	**-2.8**	**-1.4**		**-19.0**	**-4.0**	**12.0**	**0.2**	**0.0**
Session D											
Part 1						Part 2					
Buyer[#1]	135.6	60.7	31.5	20.3	15.1		101.9	44.5	19.0	14.1	9.7
	6.6	**0.7**	**-4.5**	**-4.7**	**-4.9**		**1.9**	**-2.0**	**-9.0**	**-5.9**	**-5.3**
Seller[#2]	71.3	49.0	36.3	25.2	19.5		69.3	49.8	38.8	22.8	18.3
	-44.7	**-11**	**-2.7**	**-2.8**	**-3.5**		**-30.7**	**-0.2**	**6.8**	**-0.2**	**-0.7**
Part 3 (not transferred)						Part 3 (transferred)					
Buyer[#1]	89.8	46.4	25.0	15.0	12.8		134.0	57.8	27.2	19.2	14.2
	-39.2	**-13.6**	**-11.0**	**-10.0**	**-7.2**		**34.0**	**11.3**	**-0.8**	**-0.8**	**-0.8**
Seller[#2]	90.2	55.4	37.2	26.6	23.8		73.2	53.2	32.0	25.2	21.6
	-25.8	**-4.6**	**-1.8**	**-1.4**	**0.8**		**-26.8**	**3.2**	**0.0**	**2.2**	**2.6**

Note: [#1] Average Agent 1's schedule. Average aggregate demand schedule is five times the numbers indicated in the rows. [#2] Average Agent 2's schedule plus average Agent 3's schedule. Average aggregate supply schedule is five times the numbers indicated in the rows.

Table S.2. *The Median Subject's Demand/Supply Schedule*

The median subject's demand or supply schedules were close to the schedules predicted by the theory summarized in Fig.1 of the paper.

	Quantity demanded/supplied [kg] in no transfer condition					Quantity demanded/supplied [kg] in transfer condition				
Price/kg:	0.2	1.0	2.0	3.0	4.0	0.2	1.0	2.0	3.0	4.0
Theory prediction										
Buyer	129.0	60.0	36.0	25.0	20.0	100	46.5	28.0	20.0	15.0
Seller	116.0	60.0	39.0	28.0	23.0	100	50.0	32.0	23.0	19.0
Session A										
Part 1						Part 2				
Buyer	85.0	30.0	22.5	13.5	10.0	100.0	46.0	28.0	20.0	15.0
Seller	104.0	55.0	39.0	28.0	23.0	82.0	50.0	32.0	23.0	22.0
Part 3 (not transferred)						Part 3 (transferred)				
Buyer	---	---	---	---	---	100.0	46.5	28.0	20.0	15.0
Seller	---	---	---	---	---	100.0	50.0	33.5	23.0	19.0
Session B										
Part 1						Part 2				
Buyer	115.0	55.0	33.5	24.5	17.5	100.0	46.0	20.5	14.0	10.5
Seller	104.5	56.0	39.0	28.0	23.0	100.0	50.0	32.0	23.0	19.0
Part 3 (not transferred)						Part 3 (transferred)				
Buyer	116.5	60.0	33.0	22.0	14.0	---	---	---	---	---
Seller	113.5	60.0	39.0	28.0	23.0	---	---	---	---	---
Session C										
Part 1						Part 2				
Buyer	70.0	54.5	22.5	17.5	0.0	100.0	46.0	26.5	20.0	15.0
Seller	116.0	60.0	39.0	28.0	23.0	100.0	50.0	32.0	23.0	19.0
Part 3 (not transferred)						Part 3 (transferred)				
Buyer	129.0	60.0	35.0	20.0	10.0	75.0	46.0	20.0	20.0	9.0
Seller	116.0	60.0	39.0	28.0	23.0	100.0	50.0	32.0	23.0	19.0
Session D										
Part 1						Part 2				
Buyer	129.0	60.0	36.0	25.0	20.0	100.0	47.0	22.5	17.5	11.0
Seller	82.0	60.0	39.0	28.0	23.0	84.0	50.0	32.0	23.0	19.0
Part 3 (not transferred)						Part 3 (transferred)				
Buyer	100.0	60.0	30.0	20.0	15.0	100.0	47.0	28.0	20.0	15.0
Seller	116.0	60.0	39.0	28.0	23.0	95.0	50.0	32.0	23.0	19.0

Note: The seller's supply schedule reported here is the sum of (a) the schedule exhibited by median Agent 2 and (b) the schedule exhibited by median Agent 3.

Table S.3. *Distribution of Realized Trading Prices in Simulated Periods*

	Realized trading price				
	0.2 [ECUs/kg]	1.0 [ECU/kg]	2.0 [ECUs/kg]	3.0 [ECUs/kg]	4.0 [ECUs/kg]
Part 1	6 (18.8%)[#1]	17 (53.1%)	4 (12.5%)	2 (6.3%)	3 (9.4%)
Part 2	12 (37.5%)[#2]	14 (43.8%)	1 (3.1%)	2 (6.3%)	3 (9.4%)
Part 3 (not transferred)	1 (25.0%)	2 (50.0%)	1 (25.0%)	0 (0.0%)	0 (0.0%)
Part 3 (transferred)	0 (0.0%)	3 (75.0%)	0 (0.0%)	0 (0.0%)	1 (25.0%)

Notes: The numbers in the table are realized cases (frequencies) in the simulate periods for payment. Each number in parenthesis is the percentage in which a given price was realized. The numbers in Part 3 are much less compared with Parts 1 and 2 since subjects' interactions were one-shot in Part 3.

As explained in the paper, any price was realized dependent on a group composition due to strongly heterogeneous individuals' schedules (Fig. S.1 of the online Appendix) and also their seemingly strategic behaviors in experiment sessions. However, the probability distribution in Part 1 first-order stochastically dominates that in Part 2, and one aspect is clear from the above table: the minimum price, 0.2 ECUs/kg, was more frequently realized in the simulated four periods of Part 2 than of Part 1, as the competitive equilibrium analysis suggests (Table 1 of the paper). The test result is shown as below:

H_0: #1 in the table above ≥ #2 in the table

One-sided *p*-value = .0477 (z = -1.668; N = 64; two-sample test of proportions)

Here, one-sided tests were used since the theory predicts a specific direction. The null hypothesis is that the market price is not smaller with the transfer than without it.

Consistent with the analysis result shown in Table 2 of the paper, the price change benefited not only Agent 1s, but also Agent 2s and 3s, driven by the subjects' strategic behaviors (Fig S.1). 79.2% of Agent 1s, 75.0% of Agent 2s and 66.7% of Agent 3s received higher payoffs with than without transfer. While the positive effect on the donor subjects is consistent with the theory, the positive effects on the recipient and the third-party subjects are at odds with the theory.

Table S.4. *Determinants of Agent 1's Transfer Decision in Part 3* (supplementing Table 3 of the paper)

In the regression below, since subjects experienced strong negative correlations between relative prices and payoffs in the two exogenous parts, only one of the price and payoff variables (variables *a* or *b*) was included as an independent variable in a given regression specification.

Independent variable:	(1)	(2)
a. Price diff. {= (Avg. realized price in Part 2) – (Avg. realized price in Part 1)}	-.798** (.333)	---
b. Payoff diff. {=(Avg. realized payoff in Part 2) – (Avg. realized payoff in Part 1)}	---	.031** (.016)
c. Female dummy {= 1(0) for female (male) subjects}	.973*** (.323)	.768*** (.296)
d. Econ major dummy {= 1(0) for Economics major}	.635* (.359)	.604 (.381)
e. CRT score {= 0, 1, 2, 3}	.067 (.205)	.171 (.182)
f. Beauty contest game responses	-.002 (.009)	-.002 (.009)
Constant term	-.807 (.569)	-.748 (.701)
# of observations	40	40
Pseudo R-squared	.1669	.2088

Notes: Probit regressions. The numbers in parentheses are robust standard errors clustered by session. The dependent variable is a dummy which equals 1 when an Agent-1 subject *i* voted for a transfer in Part 3.
*, **, and *** indicate significance at the .10 level, at the .05 level and at the .01 level, respectively.

Remark for the demographic information: As shown in the coefficient estimates for variable *c*, female subjects were more likely than male subjects to vote for the transfer to Agent 2s. Prior experimental research has documented that female subjects may be more pro-social than male ones (e.g., Croson and Gneezy, 2009). Considering that Agent 1s predominantly hold money compared with the other two agent types in the experiment, female Agent 1s may be motivated to donate some amounts to Agent 2s due to other-regarding purposes, ceteris paribus.

Appendix III. Procedure and Instructions Used in the Experiment

The experiment was conducted at the EXEC (Centre for Experimental Economics) laboratory in the University of York from November 2019 to January 2020. Solicitation messages were sent through *hroot* (Bock, Baetge and Nicklisch, 2014) to all eligible subjects in the database, and a total of 120 undergraduate students there voluntarily participated in the experiment. The experiment, except the instructions and payoff tables, was programmed using the zTree software (Fischbacher, 2007).

This part of the Supplementary materials includes experiment instructions. In the instructions, Agent 1, Agent 2 and Agent 3 are called Agent A, Agent B and Agent C, respectively.

[The following instructions were read aloud by the experimenter at the onset of the experiment:]

Instructions

You are now taking part in a decision-making experiment. Depending on your decisions and the decisions of other participants, you will be able to earn money in addition to the £3 guaranteed for your participation. Please read the following instructions carefully.

During the experiment you are not allowed to communicate with other participants.

During the experiment your earnings will be calculated in points. At the end of the experiment your points will be converted to U.K. pounds at the following rate:

100 points = £1.5

(or each point will be exchanged for 1.5 pence of real money). At the end of the experiment your total earnings (including the **£3** participation fee) will be paid out to you in cash. Your payment will be rounded to the nearest 10 pence (e.g., £15.30 if it is £15.33; and £15.40 if it is £15.37).

At the beginning of the experiment, you are randomly assigned a role, Agent A, Agent B or Agent C. Your assigned role does not change **throughout the entire experiment**.

This experiment consists of three parts. The followings explain the details of Part 1. Part 1 consists of four periods.

I. The Initial Endowment and Payoff Formulas in Each Period

At the onset of each period, you will be randomly assigned **to a group of 15** so that your group consists of five Agents A, five Agents B and five Agents C, and will interact with each other.

In each period, agents will be initially given money, called experimental currency units (ECU), and/or iron. The initial distribution of these goods differs by the type of agent as follows:

- Each agent A holds **100 ECUs and 20 kg of iron**.
- Each agent B holds **20 ECUs and 100 kg of iron**.
- Each agent C holds **80 kg of iron**.

The 15 agents can trade money and iron to increase payoffs. Each player can earn points based on the final amounts of money (m) and of iron (y). The payment formula differs by agent.

- Payoff of an Agent A (in points) = **2*m* or *y*, whichever is smaller**.

  In other words, if you're assigned the role of Agent A, you can earn 1 point by holding 0.5 ECUs of money and 1 kg of iron. Note that both money and iron are required to earn points with a ratio of 1:2 (e.g., the amount of money = 10 and the amount of iron = 20).

  For instance, if $m = 30$ and $y = 30$, then your payoff is 30, since $2m = 60$ and $y = 30$ (thus, y is smaller). Notice that in order to obtain a payoff of 30 points, you only need 15 ECUs of money (because $2 \times 15 = 30$). In this sense, the rest, 15 ECUs of money (= 30 ECUs – 15 ECUs), will not be used towards your payoff. Your payoff is also 30 if $m = 15$ (i.e., $2m = 30$) and $y = 30$. Thus, you can maximize your payoff by aiming to hold iron (y) **twice** as large as the amount of money.

  An Agent A's payoff is 20 with the initial endowment ($m = 100$ and $y = 20$). The Agent A can increase payoff by buying iron. How much you can buy depends on the traded price.

- Payoff of an Agent B (in points) = ***m* or *y*, whichever is smaller.**

  In other words, if you're assigned the role of Agent B, in order to earn 1 point, you need to have both 1 ECU and 1 kg of iron.

  For example, if $m = 30$ and $y = 50$, then your payoff is 30, as your payoff is determined by the minimum of m and y (i.e., m is smaller in this example). Thus, 20 kg of iron (= 50 kg – 30 kg) will not be used towards your payoff. You can maximize your payoff by holding the same amount of iron and money.

  An Agent B's payoff is 20 with the initial endowment ($m = 20$ and $y = 100$). The Agent B can increase payoff by selling iron. How much you can sell depends on the traded price.

- Payoff of an Agent C (in points) = **3*m* or *y*, whichever is smaller.**

  In other words, if you're assigned the role of Agent C, you can earn 1 point by holding 1/3 ECUs and 1 kg of iron. Note that both money and iron are required to earn points with a ratio of 1:3 (e.g., the amount of money = 10 and the amount of iron = 30).

  For example, if $m = 15$ and $y = 80$, then your payoff is 45, since $3m = 45$ and $y = 80$ (thus, $3m$ is smaller). Notice that in order to obtain a payoff of 45, you only need 45 kg of iron (and 15 ECUs). In this sense, 35 kg of iron (= 80 kg – 45 kg) will not be used towards your payoff. Notice that your payoff is also 45 if $m = 15$ and $y = 45$. Thus, you can maximize your payoff by aiming to hold iron (y) **three times** as large as the amount of money.

  An Agent C's payoff is 0 with the initial endowment ($m = 0$ and $y = 80$). The Agent C can increase payoff by selling iron. How much you can sell depends on the traded price.

Note that you will be paid based on points calculated above, not the ECUs (this is virtual money).

Section II describes the rule of trading.

II. The Rule of Trading

There are 5 possible traded prices:

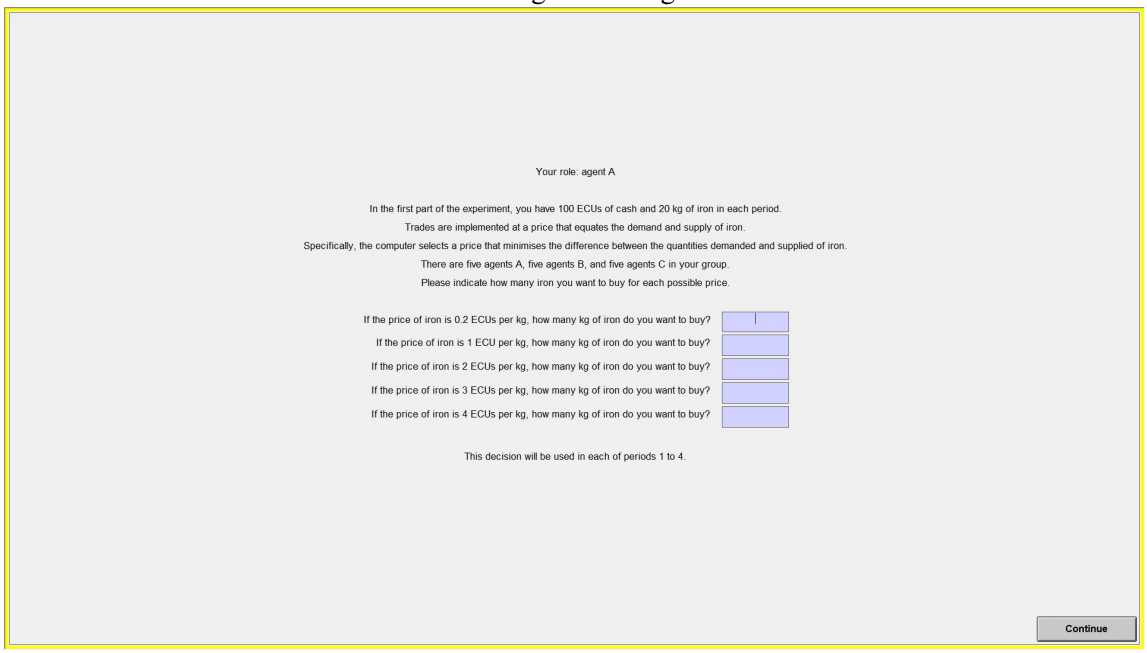
0.2 ECUs per kg
1 ECU per kg
2 ECUs per kg
3 ECUs per kg

4 ECUs per kg

At the onset of Part 1, each Agent A decides how many kg of iron s/he wants to buy for each possible traded price.

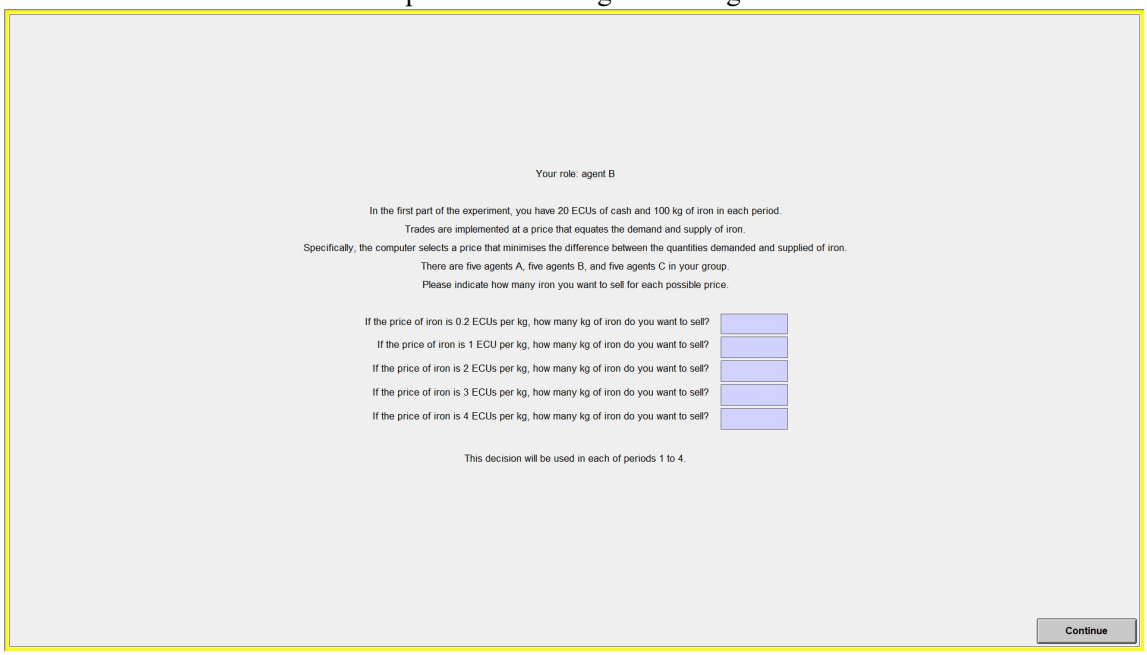
Note that this schedule is important because it will be used for your transactions in all four periods.

Screen image for an Agent A:



Agents B and C each decide how many kg of iron s/he wants to sell for each possible traded price.

Example – Screen image for an Agent B:



Each period after completion of the schedules proceeds as follows:

1. As explained, you will be randomly assigned to a group of 15 so that your group consists of five Agents A, five Agents B and five Agents C.

2. For each possible price (i.e., 0.2, 1, 2, 3 or 4 ECUs per kg), the computer calculates the difference between (a) the total quantity of iron five Agents A want to buy and (b) the total quantity of iron five Agents B and five Agents C want to sell in your group.
→ The price that minimizes the difference (i.e., equates the demand and the supply the most) will be used for trading. In case of a tie, the computer randomly breaks the tie.

3. The quantity of iron you buy or sell will be determined by the schedule you have already completed at the onset of this part. The procedure in case that the quantity demanded is not equal to the quantity supplied is as follows: if the total quantity of iron Agents A wants to buy (Q_d) is *larger than or equal to* the sum of the quantity five Agents B and five Agents C want to sell (Q_s), then the seller sells the exact amounts they want to sell. Each buyer i purchases $Q_s \cdot q_i / Q_d$ kg of iron. If the total quantity demanded Q_d is *smaller than* the sum of the amounts Agents B and C want to sell Q_s, then each Agent A will purchase the exact amount s/he wants to buy. Agents B and C cannot sell all the amounts they want to sell – each seller j sells $Q_d \cdot q_j / Q_s$ kg of iron.

We will distribute instructions for Part 2 once Part 1 is over.

The payoff formulas were explained on page 2. We will also distribute the payoff tables that summarize the relationship between your traded prices and payoffs before we begin.

[Once all questions from participants were answered, the payoff tables were distributed to subjects, in order to mitigate the difference in mathematical literacy among subjects.]

[Subjects were explained how to read the payoff tables, one by one, and after that, they were given several minutes to review the tables along with the instructions. After reviewing, subjects were also free to ask questions for the instructions and the tables. Once all questions were answered, Part 1 began. The payoff tables can be found from the next page (instructions for Part 2 can be found from page 34):]

PART 1: Each Agent A has <u>100 ECUs and 20 kg of iron</u>, each Agent B has <u>20 ECUs and 100 kg of iron</u>, and each Agent C has <u>0 ECUs and 80 kg of iron</u>.

<u>Payoff for Agent A</u>: When the trading price = 0.2 ECUs per kg

buying amount (kg)	ECUs	Iron (kg)	payoff (points)
0	100	20	**20.0**
1	99.8	21	**21.0**
2	99.6	22	**22.0**
3	99.4	23	**23.0**
4	99.2	24	**24.0**
5	99	25	**25.0**
6	98.8	26	**26.0**
7	98.6	27	**27.0**
8	98.4	28	**28.0**
9	98.2	29	**29.0**
10	98	30	**30.0**
11	97.8	31	**31.0**
12	97.6	32	**32.0**
13	97.4	33	**33.0**
14	97.2	34	**34.0**
15	97	35	**35.0**
16	96.8	36	**36.0**
17	96.6	37	**37.0**
18	96.4	38	**38.0**
19	96.2	39	**39.0**
20	96	40	**40.0**
21	95.8	41	**41.0**
22	95.6	42	**42.0**
23	95.4	43	**43.0**
24	95.2	44	**44.0**
25	95	45	**45.0**
26	94.8	46	**46.0**
27	94.6	47	**47.0**
28	94.4	48	**48.0**
29	94.2	49	**49.0**
30	94	50	**50.0**
31	93.8	51	**51.0**
32	93.6	52	**52.0**
33	93.4	53	**53.0**
34	93.2	54	**54.0**
35	93	55	**55.0**
36	92.8	56	**56.0**
37	92.6	57	**57.0**
38	92.4	58	**58.0**
39	92.2	59	**59.0**
40	92	60	**60.0**
41	91.8	61	**61.0**
42	91.6	62	**62.0**
43	91.4	63	**63.0**
44	91.2	64	**64.0**
45	91	65	**65.0**
46	90.8	66	**66.0**
47	90.6	67	**67.0**
48	90.4	68	**68.0**
49	90.2	69	**69.0**
50	90	70	**70.0**
51	89.8	71	**71.0**
52	89.6	72	**72.0**
53	89.4	73	**73.0**
54	89.2	74	**74.0**
55	89	75	**75.0**
56	88.8	76	**76.0**
57	88.6	77	**77.0**
58	88.4	78	**78.0**
59	88.2	79	**79.0**
60	88	80	**80.0**
61	87.8	81	**81.0**
62	87.6	82	**82.0**
63	87.4	83	**83.0**
64	87.2	84	**84.0**
65	87	85	**85.0**
66	86.8	86	**86.0**
67	86.6	87	**87.0**
68	86.4	88	**88.0**
69	86.2	89	**89.0**
70	86	90	**90.0**
71	85.8	91	**91.0**
72	85.6	92	**92.0**
73	85.4	93	**93.0**
74	85.2	94	**94.0**
75	85	95	**95.0**
76	84.8	96	**96.0**
77	84.6	97	**97.0**
78	84.4	98	**98.0**
79	84.2	99	**99.0**
80	84	100	**100.0**
81	83.8	101	**101.0**
82	83.6	102	**102.0**
83	83.4	103	**103.0**
84	83.2	104	**104.0**
85	83	105	**105.0**
86	82.8	106	**106.0**
87	82.6	107	**107.0**
88	82.4	108	**108.0**
89	82.2	109	**109.0**
90	82	110	**110.0**
91	81.8	111	**111.0**
92	81.6	112	**112.0**
93	81.4	113	**113.0**
94	81.2	114	**114.0**
95	81	115	**115.0**
96	80.8	116	**116.0**
97	80.6	117	**117.0**
98	80.4	118	**118.0**
99	80.2	119	**119.0**
100	80	120	**120.0**
101	79.8	121	**121.0**
102	79.6	122	**122.0**
103	79.4	123	**123.0**
104	79.2	124	**124.0**
105	79	125	**125.0**
106	78.8	126	**126.0**
107	78.6	127	**127.0**
108	78.4	128	**128.0**
109	78.2	129	**129.0**
110	78	130	**130.0**
111	77.8	131	**131.0**
112	77.6	132	**132.0**
113	77.4	133	**133.0**
114	77.2	134	**134.0**
115	77	135	**135.0**
116	76.8	136	**136.0**
117	76.6	137	**137.0**
118	76.4	138	**138.0**
119	76.2	139	**139.0**
120	76	140	**140.0**
121	75.8	141	**141.0**
122	75.6	142	**142.0**
123	75.4	143	**143.0**
124	75.2	144	**144.0**
125	75	145	**145.0**
126	74.8	146	**146.0**
127	74.6	147	**147.0**
128	74.4	148	**148.0**
129	74.2	149	**148.4**
130	74	150	**148.0**
131	73.8	151	**147.6**
132	73.6	152	**147.2**
133	73.4	153	**146.8**
134	73.2	154	**146.4**
135	73	155	**146.0**
136	72.8	156	**145.6**
137	72.6	157	**145.2**
138	72.4	158	**144.8**
139	72.2	159	**144.4**
140	72	160	**144.0**
141	71.8	161	**143.6**
142	71.6	162	**143.2**
143	71.4	163	**142.8**
144	71.2	164	**142.4**
145	71	165	**142.0**
146	70.8	166	**141.6**
147	70.6	167	**141.2**
148	70.4	168	**140.8**
149	70.2	169	**140.4**
150	70	170	**140.0**
151	69.8	171	**139.6**
152	69.6	172	**139.2**
153	69.4	173	**138.8**
154	69.2	174	**138.4**
155	69	175	**138.0**
156	68.8	176	**137.6**
157	68.6	177	**137.2**
158	68.4	178	**136.8**
159	68.2	179	**136.4**
160	68	180	**136.0**
161	67.8	181	**135.6**
162	67.6	182	**135.2**
163	67.4	183	**134.8**
164	67.2	184	**134.4**
165	67	185	**134.0**
166	66.8	186	**133.6**
167	66.6	187	**133.2**
168	66.4	188	**132.8**
169	66.2	189	**132.4**
170	66	190	**132.0**
171	65.8	191	**131.6**
172	65.6	192	**131.2**
173	65.4	193	**130.8**
174	65.2	194	**130.4**
175	65	195	**130.0**
176	64.8	196	**129.6**
177	64.6	197	**129.2**
178	64.4	198	**128.8**
179	64.2	199	**128.4**
180	64	200	**128.0**
181	63.8	201	**127.6**
182	63.6	202	**127.2**
183	63.4	203	**126.8**
184	63.2	204	**126.4**
185	63	205	**126.0**
186	62.8	206	**125.6**
187	62.6	207	**125.2**
188	62.4	208	**124.8**
189	62.2	209	**124.4**
190	62	210	**124.0**
191	61.8	211	**123.6**
192	61.6	212	**123.2**
193	61.4	213	**122.8**
194	61.2	214	**122.4**
195	61	215	**122.0**
196	60.8	216	**121.6**
197	60.6	217	**121.2**
198	60.4	218	**120.8**
199	60.2	219	**120.4**
200	60	220	**120.0**
201	59.8	221	**119.6**
202	59.6	222	**119.2**
203	59.4	223	**118.8**
204	59.2	224	**118.4**
205	59	225	**118.0**
206	58.8	226	**117.6**
207	58.6	227	**117.2**
208	58.4	228	**116.8**
209	58.2	229	**116.4**
210	58	230	**116.0**

When the trading price = 1 ECU per kg

buying amount (kg)	ECUs	Iron (kg)	payoff (points)
0	100	20	**20**
1	99	21	**21**
2	98	22	**22**
3	97	23	**23**
4	96	24	**24**
5	95	25	**25**
6	94	26	**26**
7	93	27	**27**
8	92	28	**28**
9	91	29	**29**
10	90	30	**30**
11	89	31	**31**
12	88	32	**32**
13	87	33	**33**
14	86	34	**34**
15	85	35	**35**
16	84	36	**36**
17	83	37	**37**
18	82	38	**38**
19	81	39	**39**
20	80	40	**40**
21	79	41	**41**
22	78	42	**42**
23	77	43	**43**
24	76	44	**44**
25	75	45	**45**
26	74	46	**46**
27	73	47	**47**
28	72	48	**48**
29	71	49	**49**
30	70	50	**50**
31	69	51	**51**
32	68	52	**52**
33	67	53	**53**
34	66	54	**54**
35	65	55	**55**
36	64	56	**56**
37	63	57	**57**
38	62	58	**58**
39	61	59	**59**
40	60	60	**60**
41	59	61	**61**
42	58	62	**62**
43	57	63	**63**
44	56	64	**64**
45	55	65	**65**
46	54	66	**66**
47	53	67	**67**
48	52	68	**68**
49	51	69	**69**
50	50	70	**70**
51	49	71	**71**
52	48	72	**72**
53	47	73	**73**
54	46	74	**74**
55	45	75	**75**
56	44	76	**76**
57	43	77	**77**
58	42	78	**78**
59	41	79	**79**
60	40	80	**80**
61	39	81	**78**
62	38	82	**76**
63	37	83	**74**
64	36	84	**72**
65	35	85	**70**
66	34	86	**68**
67	33	87	**66**
68	32	88	**64**
69	31	89	**62**
70	30	90	**60**

buying amount (kg)	ECUs	Iron (kg)	payoff (points)
71	29	91	**58**
72	28	92	**56**
73	27	93	**54**
74	26	94	**52**
75	25	95	**50**
76	24	96	**48**
77	23	97	**46**
78	22	98	**44**
79	21	99	**42**
80	20	100	**40**
81	19	101	**38**
82	18	102	**36**
83	17	103	**34**
84	16	104	**32**
85	15	105	**30**
86	14	106	**28**
87	13	107	**26**
88	12	108	**24**
89	11	109	**22**
90	10	110	**20**
91	9	111	**18**
92	8	112	**16**
93	7	113	**14**
94	6	114	**12**
95	5	115	**10**
96	4	116	**8**
97	3	117	**6**
98	2	118	**4**
99	1	119	**2**
100	0	120	**0**

When the trading price = 2 ECUs per kg

buying amount (kg)	ECUs	Iron (kg)	payoff (points)
0	100	20	**20**
1	98	21	**21**
2	96	22	**22**
3	94	23	**23**
4	92	24	**24**
5	90	25	**25**
6	88	26	**26**
7	86	27	**27**
8	84	28	**28**
9	82	29	**29**
10	80	30	**30**
11	78	31	**31**
12	76	32	**32**
13	74	33	**33**
14	72	34	**34**
15	70	35	**35**
16	68	36	**36**
17	66	37	**37**
18	64	38	**38**
19	62	39	**39**
20	60	40	**40**
21	58	41	**41**
22	56	42	**42**
23	54	43	**43**
24	52	44	**44**
25	50	45	**45**
26	48	46	**46**
27	46	47	**47**
28	44	48	**48**
29	42	49	**49**
30	40	50	**50**
31	38	51	**51**
32	36	52	**52**
33	34	53	**53**
34	32	54	**54**
35	30	55	**55**
36	28	56	**56**
37	26	57	**52**
38	24	58	**48**
39	22	59	**44**
40	20	60	**40**
41	18	61	**36**
42	16	62	**32**
43	14	63	**28**
44	12	64	**24**
45	10	65	**20**
46	8	66	**16**
47	6	67	**12**
48	4	68	**8**
49	2	69	**4**
50	0	70	**0**

When the trading price = 3 ECUs per kg

buying amount (kg)	ECUs	Iron (kg)	payoff (points)
0	100	20	**20**
1	97	21	**21**
2	94	22	**22**
3	91	23	**23**
4	88	24	**24**
5	85	25	**25**
6	82	26	**26**
7	79	27	**27**
8	76	28	**28**
9	73	29	**29**
10	70	30	**30**
11	67	31	**31**
12	64	32	**32**
13	61	33	**33**
14	58	34	**34**
15	55	35	**35**
16	52	36	**36**
17	49	37	**37**
18	46	38	**38**
19	43	39	**39**
20	40	40	**40**
21	37	41	**41**
22	34	42	**42**
23	31	43	**43**
24	28	44	**44**
25	25	45	**45**
26	22	46	**44**
27	19	47	**38**
28	16	48	**32**
29	13	49	**26**
30	10	50	**20**
31	7	51	**14**
32	4	52	**8**
33	1	53	**2**

When the trading price = 4 ECUs per kg

buying amount (kg)	ECUs	Iron (kg)	**payoff (points)**
0	100	20	**20**
1	96	21	**21**
2	92	22	**22**
3	88	23	**23**
4	84	24	**24**
5	80	25	**25**
6	76	26	**26**
7	72	27	**27**
8	68	28	**28**
9	64	29	**29**
10	60	30	**30**
11	56	31	**31**
12	52	32	**32**
13	48	33	**33**
14	44	34	**34**
15	40	35	**35**
16	36	36	**36**
17	32	37	**37**
18	28	38	**38**
19	24	39	**39**
20	20	40	**40**
21	16	41	**32**
22	12	42	**24**
23	8	43	**16**
24	4	44	**8**
25	0	45	**0**

Payoff for Agent B: When the trading price = 0.2 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	20	100	**20.0**
1	20.2	99	**20.2**
2	20.4	98	**20.4**
3	20.6	97	**20.6**
4	20.8	96	**20.8**
5	21	95	**21.0**
6	21.2	94	**21.2**
7	21.4	93	**21.4**
8	21.6	92	**21.6**
9	21.8	91	**21.8**
10	22	90	**22.0**
11	22.2	89	**22.2**
12	22.4	88	**22.4**
13	22.6	87	**22.6**
14	22.8	86	**22.8**
15	23	85	**23.0**
16	23.2	84	**23.2**
17	23.4	83	**23.4**
18	23.6	82	**23.6**
19	23.8	81	**23.8**
20	24	80	**24.0**
21	24.2	79	**24.2**
22	24.4	78	**24.4**
23	24.6	77	**24.6**
24	24.8	76	**24.8**
25	25	75	**25.0**
26	25.2	74	**25.2**
27	25.4	73	**25.4**
28	25.6	72	**25.6**
29	25.8	71	**25.8**
30	26	70	**26.0**
31	26.2	69	**26.2**
32	26.4	68	**26.4**
33	26.6	67	**26.6**
34	26.8	66	**26.8**
35	27	65	**27.0**
36	27.2	64	**27.2**
37	27.4	63	**27.4**
38	27.6	62	**27.6**
39	27.8	61	**27.8**
40	28	60	**28.0**
41	28.2	59	**28.2**
42	28.4	58	**28.4**
43	28.6	57	**28.6**
44	28.8	56	**28.8**
45	29	55	**29.0**
46	29.2	54	**29.2**
47	29.4	53	**29.4**
48	29.6	52	**29.6**
49	29.8	51	**29.8**
50	30	50	**30.0**
51	30.2	49	**30.2**
52	30.4	48	**30.4**
53	30.6	47	**30.6**
54	30.8	46	**30.8**
55	31	45	**31.0**
56	31.2	44	**31.2**
57	31.4	43	**31.4**
58	31.6	42	**31.6**
59	31.8	41	**31.8**
60	32	40	**32.0**
61	32.2	39	**32.2**
62	32.4	38	**32.4**
63	32.6	37	**32.6**
64	32.8	36	**32.8**
65	33	35	**33.0**
66	33.2	34	**33.2**
67	33.4	33	**33.0**
68	33.6	32	**32.0**
69	33.8	31	**31.0**
70	34	30	**30.0**

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
71	34.2	29	**29.0**
72	34.4	28	**28.0**
73	34.6	27	**27.0**
74	34.8	26	**26.0**
75	35	25	**25.0**
76	35.2	24	**24.0**
77	35.4	23	**23.0**
78	35.6	22	**22.0**
79	35.8	21	**21.0**
80	36	20	**20.0**
81	36.2	19	**19.0**
82	36.4	18	**18.0**
83	36.6	17	**17.0**
84	36.8	16	**16.0**
85	37	15	**15.0**
86	37.2	14	**14.0**
87	37.4	13	**13.0**
88	37.6	12	**12.0**
89	37.8	11	**11.0**
90	38	10	**10.0**
91	38.2	9	**9.0**
92	38.4	8	**8.0**
93	38.6	7	**7.0**
94	38.8	6	**6.0**
95	39	5	**5.0**
96	39.2	4	**4.0**
97	39.4	3	**3.0**
98	39.6	2	**2.0**
99	39.8	1	**1.0**
100	40	0	**0.0**

When the trading price = 1 ECU per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	20	100	**20.0**
1	21	99	**21.0**
2	22	98	**22.0**
3	23	97	**23.0**
4	24	96	**24.0**
5	25	95	**25.0**
6	26	94	**26.0**
7	27	93	**27.0**
8	28	92	**28.0**
9	29	91	**29.0**
10	30	90	**30.0**
11	31	89	**31.0**
12	32	88	**32.0**
13	33	87	**33.0**
14	34	86	**34.0**
15	35	85	**35.0**
16	36	84	**36.0**
17	37	83	**37.0**
18	38	82	**38.0**
19	39	81	**39.0**
20	40	80	**40.0**
21	41	79	**41.0**
22	42	78	**42.0**
23	43	77	**43.0**
24	44	76	**44.0**
25	45	75	**45.0**
26	46	74	**46.0**
27	47	73	**47.0**
28	48	72	**48.0**
29	49	71	**49.0**
30	50	70	**50.0**
31	51	69	**51.0**
32	52	68	**52.0**
33	53	67	**53.0**
34	54	66	**54.0**
35	55	65	**55.0**
36	56	64	**56.0**
37	57	63	**57.0**
38	58	62	**58.0**
39	59	61	**59.0**
40	60	60	**60.0**
41	61	59	**59.0**
42	62	58	**58.0**
43	63	57	**57.0**
44	64	56	**56.0**
45	65	55	**55.0**
46	66	54	**54.0**
47	67	53	**53.0**
48	68	52	**52.0**
49	69	51	**51.0**
50	70	50	**50.0**
51	71	49	**49.0**
52	72	48	**48.0**
53	73	47	**47.0**
54	74	46	**46.0**
55	75	45	**45.0**
56	76	44	**44.0**
57	77	43	**43.0**
58	78	42	**42.0**
59	79	41	**41.0**
60	80	40	**40.0**
61	81	39	**39.0**
62	82	38	**38.0**
63	83	37	**37.0**
64	84	36	**36.0**
65	85	35	**35.0**
66	86	34	**34.0**
67	87	33	**33.0**
68	88	32	**32.0**
69	89	31	**31.0**
70	90	30	**30.0**

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
71	91	29	**29.0**
72	92	28	**28.0**
73	93	27	**27.0**
74	94	26	**26.0**
75	95	25	**25.0**
76	96	24	**24.0**
77	97	23	**23.0**
78	98	22	**22.0**
79	99	21	**21.0**
80	100	20	**20.0**
81	101	19	**19.0**
82	102	18	**18.0**
83	103	17	**17.0**
84	104	16	**16.0**
85	105	15	**15.0**
86	106	14	**14.0**
87	107	13	**13.0**
88	108	12	**12.0**
89	109	11	**11.0**
90	110	10	**10.0**
91	111	9	**9.0**
92	112	8	**8.0**
93	113	7	**7.0**
94	114	6	**6.0**
95	115	5	**5.0**
96	116	4	**4.0**
97	117	3	**3.0**
98	118	2	**2.0**
99	119	1	**1.0**
100	120	0	**0.0**

When the trading price = 2 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	20	100	**20.0**
1	22	99	**22.0**
2	24	98	**24.0**
3	26	97	**26.0**
4	28	96	**28.0**
5	30	95	**30.0**
6	**32**	94	**32.0**
7	34	93	**34.0**
8	36	92	**36.0**
9	38	91	**38.0**
10	40	90	**40.0**
11	42	89	**42.0**
12	44	88	**44.0**
13	46	87	**46.0**
14	48	86	**48.0**
15	50	85	**50.0**
16	52	84	**52.0**
17	54	83	**54.0**
18	56	82	**56.0**
19	58	81	**58.0**
20	60	80	**60.0**
21	62	79	**62.0**
22	64	78	**64.0**
23	66	77	**66.0**
24	68	76	**68.0**
25	70	75	**70.0**
26	72	74	**72.0**
27	74	73	**73.0**
28	76	72	**72.0**
29	78	71	**71.0**
30	80	70	**70.0**
31	82	69	**69.0**
32	84	68	**68.0**
33	86	67	**67.0**
34	88	66	**66.0**
35	90	65	**65.0**
36	92	64	**64.0**
37	94	63	**63.0**
38	96	62	**62.0**
39	98	61	**61.0**
40	100	60	**60.0**
41	102	59	**59.0**
42	104	58	**58.0**
43	106	57	**57.0**
44	108	56	**56.0**
45	110	55	**55.0**
46	112	54	**54.0**
47	114	53	**53.0**
48	116	52	**52.0**
49	118	51	**51.0**
50	120	50	**50.0**
51	122	49	**49.0**
52	124	48	**48.0**
53	126	47	**47.0**
54	128	46	**46.0**
55	130	45	**45.0**
56	132	44	**44.0**
57	134	43	**43.0**
58	136	42	**42.0**
59	138	41	**41.0**
60	140	40	**40.0**
61	142	39	**39.0**
62	144	38	**38.0**
63	146	37	**37.0**
64	148	36	**36.0**
65	150	35	**35.0**
66	152	34	**34.0**
67	154	33	**33.0**
68	156	32	**32.0**
69	158	31	**31.0**
70	160	30	**30.0**

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
71	162	29	**29.0**
72	164	28	**28.0**
73	166	27	**27.0**
74	168	26	**26.0**
75	170	25	**25.0**
76	172	24	**24.0**
77	174	23	**23.0**
78	176	22	**22.0**
79	178	21	**21.0**
80	180	20	**20.0**
81	182	19	**19.0**
82	184	18	**18.0**
83	186	17	**17.0**
84	188	16	**16.0**
85	190	15	**15.0**
86	192	14	**14.0**
87	194	13	**13.0**
88	196	12	**12.0**
89	198	11	**11.0**
90	200	10	**10.0**
91	202	9	**9.0**
92	204	8	**8.0**
93	206	7	**7.0**
94	208	6	**6.0**
95	210	5	**5.0**
96	212	4	**4.0**
97	214	3	**3.0**
98	216	2	**2.0**
99	218	1	**1.0**
100	220	0	**0.0**

When the trading price = 3 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	20	100.0	**20.00**
1	23	99.0	**23.00**
2	26	98.0	**26.00**
3	29	97.0	**29.00**
4	32	96.0	**32.00**
5	35	95.0	**35.00**
6	38	94.0	**38.00**
7	41	93.0	**41.00**
8	44	92.0	**44.00**
9	47	91.0	**47.00**
10	50	90.0	**50.00**
11	53	89.0	**53.00**
12	56	88.0	**56.00**
13	59	87.0	**59.00**
14	62	86.0	**62.00**
15	65	85.0	**65.00**
16	68	84.0	**68.00**
17	71	83.0	**71.00**
18	74	82.0	**74.00**
19	77	81.0	**77.00**
20	80	80.0	**80.00**
21	83	79.0	**79.00**
22	86	78.0	**78.00**
23	89	77.0	**77.00**
24	92	76.0	**76.00**
25	95	75.0	**75.00**
26	98	74.0	**74.00**
27	101	73.0	**73.00**
28	104	72.0	**72.00**
29	107	71.0	**71.00**
30	110	70.0	**70.00**
31	113	69.0	**69.00**
32	116	68.0	**68.00**
33	119	67.0	**67.00**
34	122	66.0	**66.00**
35	125	65.0	**65.00**
36	128	64.0	**64.00**
37	131	63.0	**63.00**
38	134	62.0	**62.00**
39	137	61.0	**61.00**
40	140	60.0	**60.00**
41	143	59.0	**59.00**
42	146	58.0	**58.00**
43	149	57.0	**57.00**
44	152	56.0	**56.00**
45	155	55.0	**55.00**
46	158	54.0	**54.00**
47	161	53.0	**53.00**
48	164	52.0	**52.00**
49	167	51.0	**51.00**
50	170	50.0	**50.00**
51	173	49.0	**49.00**
52	176	48.0	**48.00**
53	179	47.0	**47.00**
54	182	46.0	**46.00**
55	185	45.0	**45.00**
56	188	44.0	**44.00**
57	191	43.0	**43.00**
58	194	42.0	**42.00**
59	197	41.0	**41.00**
60	200	40.0	**40.00**
61	203	39.0	**39.00**
62	206	38.0	**38.00**
63	209	37.0	**37.00**
64	212	36.0	**36.00**
65	215	35.0	**35.00**
66	218	34.0	**34.00**
67	221	33.0	**33.00**
68	224	32.0	**32.00**
69	227	31.0	**31.00**
70	230	30.0	**30.00**

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
71	233	29.0	**29.00**
72	236	28.0	**28.00**
73	239	27.0	**27.00**
74	242	26.0	**26.00**
75	245	25.0	**25.00**
76	248	24.0	**24.00**
77	251	23.0	**23.00**
78	254	22.0	**22.00**
79	257	21.0	**21.00**
80	260	20.0	**20.00**
81	263	19.0	**19.00**
82	266	18.0	**18.00**
83	269	17.0	**17.00**
84	272	16.0	**16.00**
85	275	15.0	**15.00**
86	278	14.0	**14.00**
87	281	13.0	**13.00**
88	284	12.0	**12.00**
89	287	11.0	**11.00**
90	290	10.0	**10.00**
91	293	9.0	**9.00**
92	296	8.0	**8.00**
93	299	7.0	**7.00**
94	302	6.0	**6.00**
95	305	5.0	**5.00**
96	308	4.0	**4.00**
97	311	3.0	**3.00**
98	314	2.0	**2.00**
99	317	1.0	**1.00**
100	320	0.0	**0.0**

When the trading price = 4 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	20	100	**20**
1	24	99	**24**
2	28	98	**28**
3	32	97	**32**
4	36	96	**36**
5	40	95	**40**
6	44	94	**44**
7	48	93	**48**
8	52	92	**52**
9	56	91	**56**
10	60	90	**60**
11	64	89	**64**
12	68	88	**68**
13	72	87	**72**
14	76	86	**76**
15	80	85	**80**
16	84	84	**84**
17	88	83	**83**
18	92	82	**82**
19	96	81	**81**
20	100	80	**80**
21	104	79	**79**
22	108	78	**78**
23	112	77	**77**
24	116	76	**76**
25	120	75	**75**
26	124	74	**74**
27	128	73	**73**
28	132	72	**72**
29	136	71	**71**
30	140	70	**70**
31	144	69	**69**
32	148	68	**68**
33	152	67	**67**
34	156	66	**66**
35	160	65	**65**
36	164	64	**64**
37	168	63	**63**
38	172	62	**62**
39	176	61	**61**
40	180	60	**60**
41	184	59	**59**
42	188	58	**58**
43	192	57	**57**
44	196	56	**56**
45	200	55	**55**
46	204	54	**54**
47	208	53	**53**
48	212	52	**52**
49	216	51	**51**
50	220	50	**50**
51	224	49	**49**
52	228	48	**48**
53	232	47	**47**
54	236	46	**46**
55	240	45	**45**
56	244	44	**44**
57	248	43	**43**
58	252	42	**42**
59	256	41	**41**
60	260	40	**40**
61	264	39	**39**
62	268	38	**38**
63	272	37	**37**
64	276	36	**36**
65	280	35	**35**
66	284	34	**34**
67	288	33	**33**
68	292	32	**32**
69	296	31	**31**
70	300	30	**30**

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
71	304	29	**29.00**
72	308	28	**28.00**
73	312	27	**27.00**
74	316	26	**26.00**
75	320	25	**25.00**
76	324	24	**24.00**
77	328	23	**23.00**
78	332	22	**22.00**
79	336	21	**21.00**
80	340	20	**20.00**
81	344	19	**19.00**
82	348	18	**18.00**
83	352	17	**17.00**
84	356	16	**16.00**
85	360	15	**15.00**
86	364	14	**14.00**
87	368	13	**13.00**
88	372	12	**12.00**
89	376	11	**11.00**
90	380	10	**10.00**
91	384	9	**9.00**
92	388	8	**8.00**
93	392	7	**7.00**
94	396	6	**6.00**
95	400	5	**5.00**
96	404	4	**4.00**
97	408	3	**3.00**
98	412	2	**2.00**
99	416	1	**1.00**
100	420	0	**0.0**

Payoff for Agent C:

When the trading price = 0.2 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	0	80	**0**
1	0.2	79	**0.6**
2	0.4	78	**1.2**
3	0.6	77	**1.8**
4	0.8	76	**2.4**
5	1	75	**3**
6	1.2	74	**3.6**
7	1.4	73	**4.2**
8	1.6	72	**4.8**
9	1.8	71	**5.4**
10	2	70	**6**
11	2.2	69	**6.6**
12	2.4	68	**7.2**
13	2.6	67	**7.8**
14	2.8	66	**8.4**
15	3	65	**9**
16	3.2	64	**9.6**
17	3.4	63	**10.2**
18	3.6	62	**10.8**
19	3.8	61	**11.4**
20	4	60	**12**
21	4.2	59	**12.6**
22	4.4	58	**13.2**
23	4.6	57	**13.8**
24	4.8	56	**14.4**
25	5	55	**15**
26	5.2	54	**15.6**
27	5.4	53	**16.2**
28	5.6	52	**16.8**
29	5.8	51	**17.4**
30	6	50	**18**
31	6.2	49	**18.6**
32	6.4	48	**19.2**
33	6.6	47	**19.8**
34	6.8	46	**20.4**
35	7	45	**21**
36	7.2	44	**21.6**
37	7.4	43	**22.2**
38	7.6	42	**22.8**
39	7.8	41	**23.4**
40	8	40	**24**
41	8.2	39	**24.6**
42	8.4	38	**25.2**
43	8.6	37	**25.8**
44	8.8	36	**26.4**
45	9	35	**27**
46	9.2	34	**27.6**
47	9.4	33	**28.2**
48	9.6	32	**28.8**
49	9.8	31	**29.4**
50	10	30	**30**
51	10.2	29	**29**
52	10.4	28	**28**
53	10.6	27	**27**
54	10.8	26	**26**
55	11	25	**25**
56	11.2	24	**24**
57	11.4	23	**23**
58	11.6	22	**22**
59	11.8	21	**21**
60	12	20	**20**
61	12.2	19	**19**
62	12.4	18	**18**
63	12.6	17	**17**
64	12.8	16	**16**
65	13	15	**15**
66	13.2	14	**14**
67	13.4	13	**13**
68	13.6	12	**12**
69	13.8	11	**11**
70	14	10	**10**
71	14.2	9	**9**
72	14.4	8	**8**
73	14.6	7	**7**
74	14.8	6	**6**
75	15	5	**5**
76	15.2	4	**4**
77	15.4	3	**3**
78	15.6	2	**2**
79	15.8	1	**1**
80	16	0	**0**

When the trading price = 1 ECU per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	0	80	**0**
1	1	79	**3**
2	2	78	**6**
3	3	77	**9**
4	4	76	**12**
5	5	75	**15**
6	6	74	**18**
7	7	73	**21**
8	8	72	**24**
9	9	71	**27**
10	10	70	**30**
11	11	69	**33**
12	12	68	**36**
13	13	67	**39**
14	14	66	**42**
15	15	65	**45**
16	16	64	**48**
17	17	63	**51**
18	18	62	**54**
19	19	61	**57**
20	20	60	**60**
21	21	59	**59**
22	22	58	**58**
23	23	57	**57**
24	24	56	**56**
25	25	55	**55**
26	26	54	**54**
27	27	53	**53**
28	28	52	**52**
29	29	51	**51**
30	30	50	**50**
31	31	49	**49**
32	32	48	**48**
33	33	47	**47**
34	34	46	**46**
35	35	45	**45**
36	36	44	**44**
37	37	43	**43**
38	38	42	**42**
39	39	41	**41**
40	40	40	**40**
41	41	39	**39**
42	42	38	**38**
43	43	37	**37**
44	44	36	**36**
45	45	35	**35**
46	46	34	**34**
47	47	33	**33**
48	48	32	**32**
49	49	31	**31**
50	50	30	**30**
51	51	29	**29**
52	52	28	**28**
53	53	27	**27**
54	54	26	**26**
55	55	25	**25**
56	56	24	**24**
57	57	23	**23**
58	58	22	**22**
59	59	21	**21**
60	60	20	**20**
61	61	19	**19**
62	62	18	**18**
63	63	17	**17**
64	64	16	**16**
65	65	15	**15**
66	66	14	**14**
67	67	13	**13**
68	68	12	**12**
69	69	11	**11**
70	70	10	**10**
71	71	9	**9**
72	72	8	**8**
73	73	7	**7**
74	74	6	**6**
75	75	5	**5**
76	76	4	**4**
77	77	3	**3**
78	78	2	**2**
79	79	1	**1**
80	80	0	**0**

When the trading price = 2 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	0	80	**0**
1	2	79	**6**
2	4	78	**12**
3	6	77	**18**
4	8	76	**24**
5	10	75	**30**
6	**12**	74	**36**
7	14	73	**42**
8	16	72	**48**
9	18	71	**54**
10	20	70	**60**
11	22	69	**66**
12	24	68	**68**
13	26	67	**67**
14	28	66	**66**
15	30	65	**65**
16	32	64	**64**
17	34	63	**63**
18	36	62	**62**
19	38	61	**61**
20	40	60	**60**
21	42	59	**59**
22	44	58	**58**
23	46	57	**57**
24	48	56	**56**
25	50	55	**55**
26	52	54	**54**
27	54	53	**53**
28	56	52	**52**
29	58	51	**51**
30	60	50	**50**
31	62	49	**49**
32	64	48	**48**
33	66	47	**47**
34	68	46	**46**
35	70	45	**45**
36	72	44	**44**
37	74	43	**43**
38	76	42	**42**
39	78	41	**41**
40	80	40	**40**
41	82	39	**39**
42	84	38	**38**
43	86	37	**37**
44	88	36	**36**
45	90	35	**35**
46	92	34	**34**
47	94	33	**33**
48	96	32	**32**
49	98	31	**31**
50	100	30	**30**
51	102	29	**29**
52	104	28	**28**
53	106	27	**27**
54	108	26	**26**
55	110	25	**25**
56	112	24	**24**
57	114	23	**23**
58	116	22	**22**
59	118	21	**21**
60	120	20	**20**
61	122	19	**19**
62	124	18	**18**
63	126	17	**17**
64	128	16	**16**
65	130	15	**15**
66	132	14	**14**
67	134	13	**13**
68	136	12	**12**
69	138	11	**11**
70	140	10	**10**
71	142	9	**9**
72	144	8	**8**
73	146	7	**7**
74	148	6	**6**
75	150	5	**5**
76	152	4	**4**
77	154	3	**3**
78	156	2	**2**
79	158	1	**1**
80	160	0	**0**

When the trading price = 3 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	0	80	**0**
1	3	79	**9**
2	6	78	**18**
3	9	77	**27**
4	12	76	**36**
5	15	75	**45**
6	18	74	**54**
7	21	73	**63**
8	24	72	**72**
9	27	71	**71**
10	30	70	**70**
11	33	69	**69**
12	36	68	**68**
13	39	67	**67**
14	42	66	**66**
15	45	65	**65**
16	48	64	**64**
17	51	63	**63**
18	54	62	**62**
19	57	61	**61**
20	60	60	**60**
21	63	59	**59**
22	66	58	**58**
23	69	57	**57**
24	72	56	**56**
25	75	55	**55**
26	78	54	**54**
27	81	53	**53**
28	84	52	**52**
29	87	51	**51**
30	90	50	**50**
31	93	49	**49**
32	96	48	**48**
33	99	47	**47**
34	102	46	**46**
35	105	45	**45**
36	108	44	**44**
37	111	43	**43**
38	114	42	**42**
39	117	41	**41**
40	120	40	**40**
41	123	39	**39**
42	126	38	**38**
43	129	37	**37**
44	132	36	**36**
45	135	35	**35**
46	138	34	**34**
47	141	33	**33**
48	144	32	**32**
49	147	31	**31**
50	150	30	**30**
51	153	29	**29**
52	156	28	**28**
53	159	27	**27**
54	162	26	**26**
55	165	25	**25**
56	168	24	**24**
57	171	23	**23**
58	174	22	**22**
59	177	21	**21**
60	180	20	**20**
61	183	19	**19**
62	186	18	**18**
63	189	17	**17**
64	192	16	**16**
65	195	15	**15**
66	198	14	**14**
67	201	13	**13**
68	204	12	**12**
69	207	11	**11**
70	210	10	**10**
71	213	9	**9**
72	216	8	**8**
73	219	7	**7**
74	222	6	**6**
75	225	5	**5**
76	228	4	**4**
77	231	3	**3**
78	234	2	**2**
79	237	1	**1**
80	240	0	**0**

When the trading price = 4 ECUs per kg

selling amount (kg)	ECUs	Iron (kg)	payoff (points)
0	0	80	**0**
1	4	79	**12**
2	8	78	**24**
3	12	77	**36**
4	16	76	**48**
5	20	75	**60**
6	24	74	**72**
7	28	73	**73**
8	32	72	**72**
9	36	71	**71**
10	40	70	**70**
11	44	69	**69**
12	48	68	**68**
13	52	67	**67**
14	56	66	**66**
15	60	65	**65**
16	64	64	**64**
17	68	63	**63**
18	72	62	**62**
19	76	61	**61**
20	80	60	**60**
21	84	59	**59**
22	88	58	**58**
23	92	57	**57**
24	96	56	**56**
25	100	55	**55**
26	104	54	**54**
27	108	53	**53**
28	112	52	**52**
29	116	51	**51**
30	120	50	**50**
31	124	49	**49**
32	128	48	**48**
33	132	47	**47**
34	136	46	**46**
35	140	45	**45**
36	144	44	**44**
37	148	43	**43**
38	152	42	**42**
39	156	41	**41**
40	160	40	**40**
41	164	39	**39**
42	168	38	**38**
43	172	37	**37**
44	176	36	**36**
45	180	35	**35**
46	184	34	**34**
47	188	33	**33**
48	192	32	**32**
49	196	31	**31**
50	200	30	**30**
51	204	29	**29**
52	208	28	**28**
53	212	27	**27**
54	216	26	**26**
55	220	25	**25**
56	224	24	**24**
57	228	23	**23**
58	232	22	**22**
59	236	21	**21**
60	240	20	**20**
61	244	19	**19**
62	248	18	**18**
63	252	17	**17**
64	256	16	**16**
65	260	15	**15**
66	264	14	**14**
67	268	13	**13**
68	272	12	**12**
69	276	11	**11**
70	280	10	**10**
71	284	9	**9**
72	288	8	**8**
73	292	7	**7**
74	296	6	**6**
75	300	5	**5**
76	304	4	**4**
77	308	3	**3**
78	312	2	**2**
79	316	1	**1**
80	320	0	**0**

[Once Part 1 was over, the following instructions were handed out to the subjects and read aloud:]

Part 2

Part 1 is now over. Part 2 also consists of four periods. Your assigned role (Agent A, Agent B or Agent C) remains the same in this part.

In this part, you have initial endowments of money and iron, and your payoffs will be calculated with the same formulas explained on page 2 in the first instructions. However, there is one different aspect from Part 1; 20 ECUs of money will be transferred from five Agents A to five Agents B in each period. This means that the initial distribution of money and iron before transactions are as follows:

- Each Agent A holds **80 ECUs and 20 kg of iron**.
- Each Agent B holds **40 ECUs and 100 kg of iron**.
- Each Agent C holds **80 kg of iron**.

As above, each Agent A has 20 ECUs less compared with Part 1. By contrast, each Agent B has 20 ECUs more compared with Part 1. Each Agent C has the same endowment as in Part 1.

The 15 agents can trade money and iron to increase payoffs in their group. The rule of trading is the same as in Part 1. There are 5 possible traded prices:

0.2 ECUs per kg
1 ECU per kg
2 ECUs per kg
3 ECUs per kg
4 ECUs per kg

At the onset of Part 2, Agents A each decide how many kg of iron s/he wants to **buy** for each possible traded price. Agents B and C each decide how many kg of iron s/he wants to **sell** for each possible traded price. This schedule is important because it will be used for your transactions in all four periods.

Each period after completion of the schedules proceeds as follows:

1. As explained, you will be randomly assigned to a group of 15 so that your group consists of five Agents A, five Agents B and five Agents C.

2. For each possible price (i.e., 0.2, 1, 2, 3 or 4 ECUs per kg), the computer calculates the difference between (a) the total quantity of iron five Agents A want to buy and (b) the total quantity of iron five Agents B and five Agents C want to sell in your group.
→ The price that minimizes the difference (i.e., equates the demand and the supply the most) will be used for trading. In case of a tie, the computer randomly breaks the tie.

3. The quantity of iron you buy or sell will be determined by the schedule you have already completed at the onset of this part.

We will distribute instructions for Part 3 once Part 2 is over.

The payoff formulas were explained on page 2 of the first instructions. We will also distribute the payoff tables that summarize the relationship between your traded prices and payoffs before we begin.

[Once all questions from participants were answered, the payoff tables were distributed to subjects, again in order to mitigate the difference in mathematical literacy among subjects.]

[Subjects were explained how to read the tables, and after that, they were given several minutes to review the tables along with the instructions. Subjects were also free to ask questions for the instructions and the tables. Once all questions were answered, Part 2 began. The payoff tables have the same format as included above except that the initial endowment amounts are different. The tables are omitted to conserve space.]

[Once Part 2 was over, the following instructions were handed out to the subjects and read aloud:]

Part 3

Part 2 is now over. Part 3 consists of **one period**. However, the conversion rate between points and UK pounds is four times larger than in Part 1 and Part 2: 1 point is exchanged for 6 pence of real money.

Your assigned role (Agent A, Agent B or Agent C) continues to be the same in this part. In this part, you will be randomly assigned to a group of 15 so that your group consists of five Agents A, five Agents B and five Agents C.

You have the same initial endowments of money and iron as in Part 1.

- Each Agent A holds **100 ECUs and 20 kg of iron**.
- Each Agent B holds **20 ECUs and 100 kg of iron**.
- Each Agent C holds **80 kg of iron**.

However, at the onset of Part 3, Agents A can collectively decide to transfer 20 ECUs to Agent B. If Agent A chooses to do so, the distribution of endowments will be changed to the one in Part 2:

- Each Agent A holds **80 ECUs and 20 kg of iron**.
- Each Agent B holds **40 ECUs and 100 kg of iron**.
- Each Agent C holds **80 kg of iron**.

Part 3 begins with Agent A's voting on whether to transfer 20 ECUs to Agents B. A **majority rule** determines the transfer decision: 20 ECUs will be transferred from five Agents A to five Agents B, if **at least three Agents A** vote in favor of the transfer.

Once Agents A collectively makes the transfer decision, Agents B and C will be informed of the regime they have – either the one in Part 1 or in Part 2.

The 15 agents can trade money and iron to increase payoffs as before. The rule of trading is the same. There are 5 possible traded prices:

0.2 ECUs per kg
1 ECU per kg
2 ECUs per kg
3 ECUs per kg
4 ECUs per kg

At the onset of Part 3, Agents A each decides how many kg of iron s/he wants to **buy** for each possible traded price. Agents B and C each decide how many kg of iron s/he wants to **sell** for each possible traded price.

Once all 15 agents make decisions, for each possible price (i.e., 0.2, 1, 2, 3 or 4 ECU per kg) the computer calculates the difference between (a) the total quantity of iron five Agents A want to buy and (b) the total quantity of iron five Agents B and five Agents C want to sell in your group.

→ The price that minimizes the difference (i.e., equates the demand and the supply the most) will be used for trading. In case of a tie, the computer randomly breaks the tie.

The quantity of iron you buy or sell will be determined by the schedule you have already completed at the onset of this part.

Please note that for Agents A and Agents B, the relationship between traded amounts and payoffs differ according to which regime is in use. Please review the payoff tables already distributed.

For Agents C, the relationship between his/her selling amounts and payoffs do not change by the regime since his/her endowment is always the same: 80 kg of iron.

Are there any question?

[Once all questions were answered, Part 3 began.]