Discussion Paper Series

RIEB

Kobe University

DP2011-10

Impact of Ethnicities on Market Outcome: Results of Market Experiments in Kenya

Ken-Ichi SHIMOMURA

Takehiko YAMATO

March 15, 2011

Research Institute for Economics and Business Administration

Kobe University

2-1 Rokkodai, Nada, Kobe 657-8501 JAPAN

Impact of Ethnicities on Market Outcome:

Results of Market Experiments in Kenya

by
Ken-Ichi Shimomura*
and
Takehiko Yamato**

Abstract

We study market exchange in the laboratory by a multiethnic experiment in Kenya. The subjects of our experiment are of three ethnicities, Kikuyu, Luo, and Kalenjin. Our model contains two types of consumers and two kinds of commodities, and three competitive equilibria exist. The two equilibria with the lowest, and highest relative prices are beneficial for one type of the consumers, and the intermediate price gives an equitable allocation. The tatonnement dynamics however predict that relative prices diverge from the intermediate equilibrium towards the lowest equilibrium or the highest equilibrium depending on initial prices. In order to examine how much effect the ethnicities of subjects have on the equilibrium selection, we conducted manual experiments of pit market trading with different combinations of ethnicities of subjects. Our result shows strong support for the convergence to the intermediate equilibrium when Kalenjin subjects participated, whereas no such data are obtained without them. In addition, the frequencies of transactions with Kalenjin subjects were significantly less than that with the other subjects only, and the less frequent transactions resulted in the more efficient outcomes of the experimental market.

Keywords: Economic Experiment, Kenya, Pit Market, Perfect Competition, Multiple Equilibria
JEL codes: C92, D51

* Research Institute for Economics and Business Administration, Kobe University, 2-1 Rokkodai, Nada, Kobe 657-8501, Japan. E-mail: ken-ichi@rieb.kobe-u.ac.jp

** Department of Social Engineering, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, 2-12-1 Ookayama, Meguro-ku, Tokyo 152-8552, Japan. E-mail: yamato@soc.titech.ac.jp

We thank Hiroyuki Hino, Anjan Mukhurji, Syham Sunder, and Motoki Takahashi for their detailed comments and useful suggestions. We also appreciate special supports to conduct experiments in Kenya and to compute statistics by Michiharu Masui, Joseph Onjala, Tokinao Ohtaka, Kiyotaka Takahashi, and Kohei Yoshida. This research was partially supported by Japan International Cooperation Agency (JICA) and Grand-in-Aid for Scientific Research (B) 20330036.

1. Introduction

Ethnic diversity has played a central role in explaining differences in business management and local market performance within a country. However, results from economic experiments are not always characterized in terms of ethnicities of subjects because there is no hypothesis of economic behaviors or phenomena peculiar in ethnicities and it is generally difficult to have ethnically different subjects.

The purpose of our research is to conduct a laboratory experiment of an exchange economy with different ethnicities of subjects and investigate which equilibrium is selected from the multiple equilibria for the economy. The model to experiment is an exchange economy with two types of consumers and two kinds of commodities in which three competitive equilibria exist. One type of consumers initially own the more of the first good, and the less of the second good, than the other type of consumers have. The same type of consumers are all rationed identical commodity bundles of endowment.

We choose the second good as the numeraire, the price of which is always fixed to be oneand focus on the behavior of the relative price of the first good. There are three equilibrium prices in our exchange model. The lowest relative price is beneficial for the type of consumers having more of the second good, and the highest relative price is advantageous to the type of consumers having more of the first good. The intermediate price gives a “equitable” allocation.

The tatonnement dynamics predict that relative prices go up when the first good is excessively demanded, and go down when it is excessively supplied, in the market. According to this dynamics, relative prices diverge from the intermediate equilibrium towards the lowest equilibrium or the highest equilibrium depending on initial prices. It means that the market mechanism causes an income inequality and the “invisible hand” leads the economy to an efficient but inequitable state.

We thus have strong interest in conducting experiments of our exchange model with multiple equilibria using two ethnic groups of subjects. We can simply conjecture that trading outcomes will converge to the intermediate equilibrium when the two groups are of the same ethnicity. On the other hand, when the two groups are from different ethnicities, trading outcomes will converge to an extreme equilibrium which is beneficial for one group when their members are tougher negotiators than the other group members are. One could think that ethnically different subjects would never trade if the two ethnic groups are not getting along well.[1]

As the Washington consensus states, both developed countries and developing countries

[1] In the literature of economic experiment, there are findings from international comparisons about bargaining and market exchange (Roth et al, 1991), and public good provision (Cason et al, 2002), for which they conducted experiments in different places separately but the subjects did not interact across countries. We thus wondered where to conduct an experiment with subject of different ethnicities.

are expected to have market mechanisms to warrant the minimum quality of life. We know that in the world there are quite a few countries in which different ethnicities of people coexist. Kenya is a well-known country having remarkable ethnic diversity. Each of the Kenyan ethnic communities has its own culture and some of the communities have not been getting along well. We wonder if the ethnic diversity prevents the Kenyan economy from developing smoothly.

To consider this problem, however, we are unable to take either theoretical approach or empirical approach. We have no theoretical model of market exchange in which characteristics or behavioral principles of different ethnicities are formulated. Whether the competitiveness of a market under investigation is perfect or imperfect, we always assume the "anonymity" of traders in a market. It means that every participant in the market only care for qualities and quantities of commodities traded, so it does not matter who buys or sells commodities. Hence, ethnicities of the traders are regarded as nothing to do with market trades. Thus, the standard theory of market does not work out for our interest. In addition, we would like to compare market outcomes traded within one ethnic group with those when two different ethnic groups trade, but the existing economies with ethnic diversity have been working for a long time and it is almost impossible to take data to compare the two ideal market outcomes.

We have therefore decided to take the experimental approach and selected Kenya as a place to conduct an experiment to consider the problem we are interested in. For testing our conjecture on trading outcomes within one ethnic group and between two different ethnic group, Kenya would be one of the best places in the world because more than 40 different ethnic groups are present. Each group has its own background, and some groups have been historically in conflict. We conducted experiments in Nairobi with the three ethnic groups for subjects of Luo, Kikuyu, and Kalenjin. The subjects are all college students originally from the three ethnic communities, and the numbers of subjects of the same ethnicity are equal. We divided each ethnic cohort of the subjects into two groups, and assigned to them the roles of the two types of consumers in our economic model. We made each group to trade with the same ethnic group in their first-round session, and with different ethnic groups in the other sessions.

Our results show that it made the variance of individual patterns of trades remarkably smaller to conduct sessions with Kalenjin subjects than without them. In addition, the frequency of transactions with Kalenjin subjects were significantly less than that with the other subjects only, and the less frequent transactions resulted in the more efficient outcomes of the experimental market. The main reason is that Kalenjin subjects quickly began to make offers of the intermediate equilibrium only and ceased to accept other proposals although the other ethnic groups of subjects kept making small adjustments to improve themselves upon. Thus, our observations tell that the bilateral trading does not cause large inequalities of income or welfare, and the participation of a non-negligible number of Kalenjin people in the experimental market significantly facilitates the prompt decisions of negotiations at the exact point of the intermediate equilibrium.

The problem of multiplicity of competitive equilibria in exchange economies has recently been investigated by using laboratory markets. The example given by Gale (1963) is a well-known simple model of a two-good two-consumer exchange economy in which consumers' preferences are of the Leontief type. In his model, there are three equilibria: two of them are "extreme" (the allocations are respectively supported by the price vectors (1,0), and (0, 1)), and the other is an interior equilibrium. The Walrasian stability depends on the initial holdings of the consumers: the interior equilibrium is the only stable point in some cases, and it is unstable and the two extreme equilibria are stable in other cases. Crockett et al. (2010) designed and conducted an experiment of the Gale example in the double auction institution using the MarketScape software. Their observations surprisingly coincide with the predictions by the Walrarian theory. The methodology of our experiment is different from theirs: our institution is a manual experiment of trading a pit market while theirs is an on-line experiment of double auction.

The example by Shapley and Shubik (1977) is also a simple two-good two-consumer exchange model of which the two consumers have strictly convex preferences linear in different goods. Huber et al. (2009) implemented an experiment of the Shapley-Shubik example by asking the subjects to write and submit their proposal of trades only once in a period. In their model, there are three equilibria which are all interior, the intermediate equilibrium is unstable, and the two other equilibria are unstable. Their data shows that there is a tendency that allocations converge to the intermediate equilibrium in the Edgeworth box. The methodology of our experiment is also different from Huber et al. (2009): we told subjects to trade face–to-face and reset holdings to the initial state at the beginning of every trading period while they used computers for the subjects to write their offers and accept others' offers and have the subjects to carry over their holdings from the end of one period to the beginning of the next period until the end of one session of trade periods .

The paper is organized as follows. In Section 2, we present the model of an exchange economy with three competitive equilibria which we used to conduct our experiment. We also discuss the Walrasian local stability of each equilibrium. In Section 3, we explain the design and procedures of our experiment. Namely, we describe how we transformed the theoretical model into the experiments. In Section 4, we analyze the results of the experiment to find tendencies of the data and effects of our scientific controls. Section 5 is for concluding remarks.

2. An Exchange Economy with Multiple Equilibria

We consider the following exchange economy with two commodities called X and Y, and two types of consumers named 1 and 2. The utility functions of consumers 1 and 2 are, respectively,

$$U_1(x_1, y_1) = a_1 \min[g_1(x_1), y_1] + b_1 \text{ and}$$
$$U_2(x_2, y_2) = a_2 \min[g_2(x_2), y_2] + b_2 \quad (2.1)$$

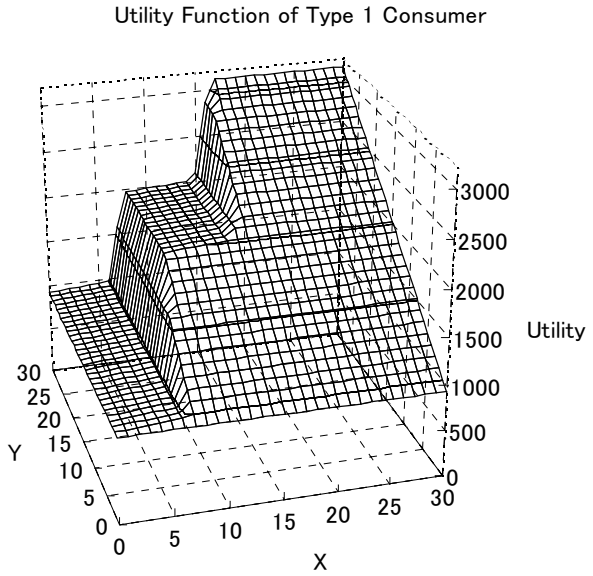
In the experiment, we set $a_1 = 72.77$, $b_1 = 927.23$, $a_2 = 69.2$, $b_2 = 961.98$,

$$\begin{aligned}
g_1(x_1) &= x_1/9.8 && \text{if } x_1 \in [0, 6.2] \\
&= 10.5x_1 - 6.2(10.5 - 1/9.8) && \text{if } x_1 \in [6.2, 7.5] \\
&= x_1/9.8 + 1.3(10.5 - 1/9.8) && \text{if } x_1 \in [7.5, 14.9] \\
&= 10.5x_1 - 13.6(10.5 - 1/9.8) && \text{otherwise;}
\end{aligned}$$

and

$$\begin{aligned}
g_2(x_2) &= x_2/9.1 && \text{if } x_2 \in [0, 7.35] \\
&= 11.3x_2 - 7.35(11.3 - 1/9.1) && \text{if } x_2 \in [7.35, 8] \\
&= x_2/9.1 + 0.65(11.3 - 1/9.1) && \text{if } x_2 \in [8, 17.45] \\
&= 11.3x_2 - 16.8(11.3 - 1/9.1) && \text{if } x_2 \in [17.45, 18.45] \\
&= x_2/9.1 + 16.5(11.3 - 1/9.1) && \text{otherwise.}
\end{aligned}$$

Figure 1. Utility Functions of Consumers



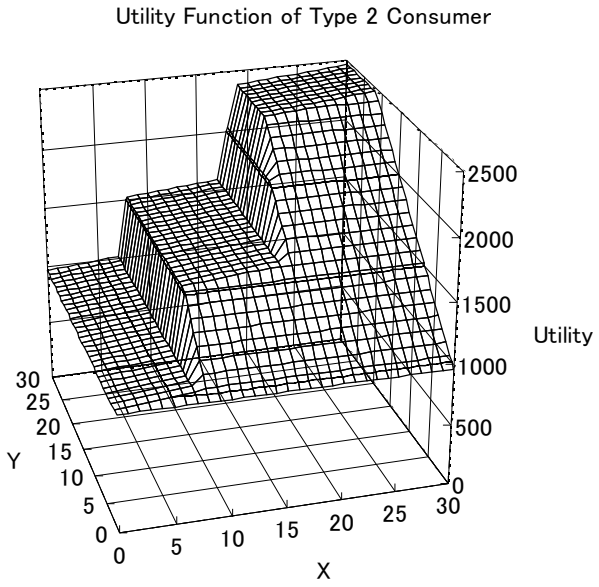
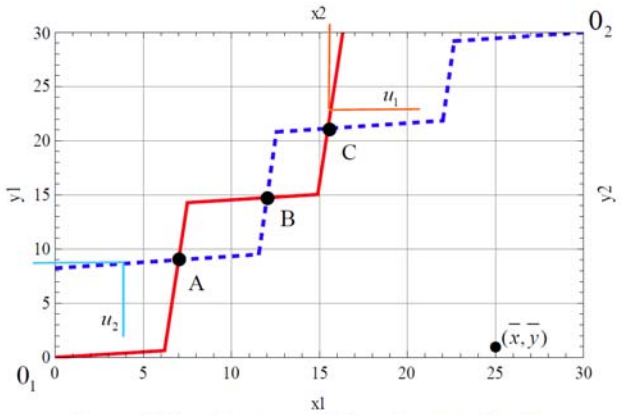


Figure 1 illustrates these utility functions. The individual endowment of consumer 1 is given by $(\bar{x}_1, \bar{y}_1) = (25,1)$ and the individual endowment of consumer 2 is $(\bar{x}_2, \bar{y}_2) = (5,29)$.

Figure 2 displays this economy in an Edgeworth box. The solid (resp. dashed) piecewise linear line denotes consumer 1's (resp. consumer 2's) offer curve, derived by varying prices and asking the consumer how much she would like to trade to maximize her utility at each price. Notice that the offer curves are given by $y_1 = g_1(x_1)$ and $y_2 = g_2(x_2)$, because the utility maximization points are the loci of the verteces of the L-shaped indifference curves. There are three competitive equilibria indicated by the points of intersection of the two offer curves at which supply equals to demand.

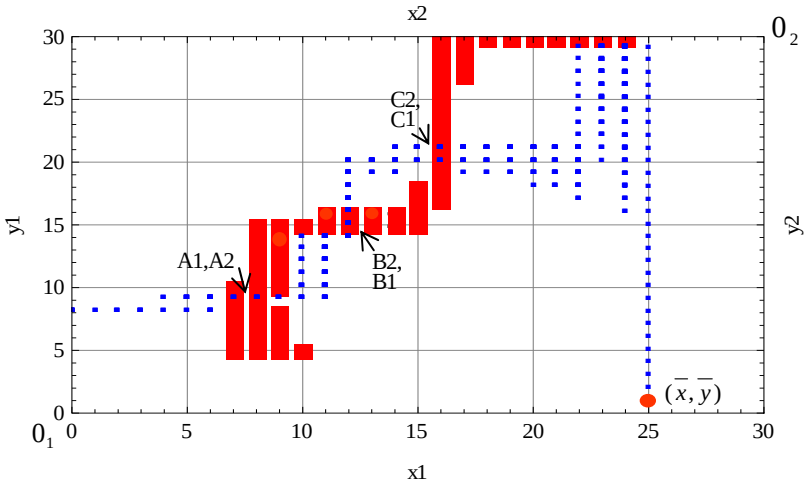
Figure 2. Exchange Economy with Three Competitive Equilibria



Consider a market excess demand function of an exchange economy. We say that a competitive equilibrium, or simply an equilibrium, is locally stable (resp. unstable) if the market demand function is strictly decreasing (increasing) at the equilibrium price. The intermediate equilibrium B = (12.0132, 14.7432) is locally unstable, whereas the other two equilibrium A = (6.99771, 9.00859) and C = (15.4803, 21.1309) are locally stable. Figure 2 can be also regarded as demonstrating symmetric equilibrium outcomes in a market with *n* traders on each side when all traders of the same type take the same action.

In our experiment, subjects chose integers as trading units, not real numbers in usual theory. Therefore, it is important to consider a discrete version of the exchange economy corresponding to the experimental setting to make a rigorous theoretical prediction. Figure 3 shows this discrete exchange economy in an Edgeworth box. The locus of circles (●) (resp. multiplication signs (×)) denotes consumer 1's (resp. consumer 2's) offer curve, which is thick, in the discrete economy. The two offer curves intersect at six points indicating competitive equilibria: A1 = (7, 9), A2 = (8, 9), C1 = (16, 20), and C2 = (16, 21) are locally stable equilibrium points with the corresponding equilibrium price ratios p_X / p_Y = 0.44, 047, 2.11, 2.22, respectively, while B1 = (12, 15) and B2 = (12, 16) are locally unstable points with p_X / p_Y = 1.08, 1.15, respectively.[2]

Figure 3. Discrete Version of Offer Curves in the Exchange Economy



[2] The number of competitive equilibria when only integer units are allowed in trading in experimental settings could be quite larger than that when trading units are real numbers in theory. For Shapley-Shubik (1977) exchange economy with two goods, there are only three competitive equilibria in theory. However, there are 198 equilibria with only integer trading units and no trading price constraint (see Masui, Ohtaka, Shimomura, Takahashi, and Yamato (2010)).

Moreover, we prohibited subjects from trading commodities at which the price ratio p_X / p_Y, the trading ratio of Y to X (= (Amount of Y)/(Amount of X)), was less than 1/4 = 0.25. For $p_X / p_Y < 1/4$, there are several competitive equilibria other than the above six equilibria. In Figure 2, we omit these equilibria and focus on the six equilibria close to the three equilibria in Figure 2 of the usual Edgeworth box.

Table 1 summarizes the equilibrium predictions. There are trade-off between stability and "equity" of the competitive equilibria. The equilibria A1 and A2 with low relative prices of commodity *X*, p_X / p_Y, are beneficial for type 1 consumer having more of commodity *Y*, while the equilibria C1 and C2 with high relative prices of commodity *X* is advantageous to type 2 consumer having more of commodity *X*. These four equilibria are locally stable, but not equitable. On the other hand, the equilibria B1 and B2 with intermediate prices give allocations that generate a negligible difference between the payoffs to the two types of consumers. We say that the equilibrium and allocation are equitable. In particular, each type receives the same equilibrium payoff at B1. However, they are locally unstable.

Table 1: Theoretical Predictions about Discrete Equilibria

		Allocation				Payoff	
Discrete Equilibria		Type 1 (x1, y1)	Type 2 (x2, y2)	Price	Walrasian Stability	Type 1 U1	Type 2 U2
	A1	(7, 9)	(23, 21)	4/9=0.44	stable	1582	2415
	A2	(8, 9)	(22, 21)	8/17=0.47	stable	1582	2407
	B1	(12, 15)	(18, 15)	14/13=1.08	unstable	2000	2000
	B2	(12, 16)	(18, 14)	15/13=1.15	unstable	2000	1931
	C1	(16, 20)	(14, 10)	19/9=2.11	stable	2383	1572
	C2	(16, 21)	(14, 9)	20/9=2.22	stable	2455	1572

In a society consisting of different and conflicting ethnic groups, we conjecture that trading outcomes when the traders are of different ethnicities will be an extreme and inequitable equilibrium, A1, A2, C1, or C2, which is beneficial for one type of trader who is a tougher negotiator than the other type is. One might also think that ethnically different people would never trade if the two ethnic groups are not getting along well. On the other hand, trading outcomes may converge to equilibrium B1 or B2, when the two types of traders are of the same ethnicity.

3. The Experimental Design and Procedures

3-1. Design

For testing our conjecture on trading outcomes between two ethnic groups in the previous section, we select Kenya as a place to conduct an experiment because Kenya would be one of the best places in the world because more than 40 different ethnic groups are present. Each group has its own background, and some groups have been historically in conflict.

We conducted nine sessions at the University of Nairobi during March 2-4 of 2010. In 2008, different ethnicities of students there were in conflict due to a problem of student politics although they were settled down when we visited. We wondered if the students sharply separate market trades in experiment from the somewhat complex feelings with different ethnic groups. We thus believed that the university is the Kenyan society in microcosm. Needless to say, we are unable to conduct an experiment for every possible combination of the existing ethnicities. We therefore choose three ethnic groups: Luo, Kikuyu, and Kalenjin. The reason why we choose them is that these three groups of people together with Luhya actually conduct the central economic activities in Kenya.

The number of subjects from each of the three ethnic communities, Luo, Kikuyu, or Kalenjin, was 24 for a total of 72 distinct subjects. For each ethnic group, 12 subjects played the role of type 1 consumer and 12 subjects did the role of type 2 consumer. Their roles were fixed throughout the experiment. Twenty-four subjects participated in each session. Table 2-(a) summarizes the session names. For example, 12 Luo subjects whose roles were of type 1, and 12 Kikuyu subjects whose roles were of type 2 participated in L1-Ki2 session.

Table 2. Nine Laboratory Sessions

		Type 2		
		Luo	Kikuyu	Kalenjin
Type 1	Luo	L1-L2	L1-Ki2	L1-Ka2
	Kikuyu	Ki1-L2	Ki1-Ki2	Ki1-Ka2
	Kalenjin	Ka1-L2	Ka1-Ki2	Ka1-Ka2

Table 2-(a). Session Names

	3/2/2010	3/3/2010	3/4/2010
AM	L1-L2	Ka1-Ka2	L1-Ka2
	Ki1-Ki2		Ka1-L2
PM	L1-Ki2	Ka1-Ki2	
	Ki1-L2	Ki1-Ka2	

Table 2-(b). Time Schedule

Each subject participated in three sessions. Table 2-(b) shows the time schedule. Each subject first faced participants of the same ethnic group and then those of different ethnic groups. For example, first of all, Luo subjects of type 1 faced Luo subjects of type 2 in L1-L2 session in the morning of the first day. Second, they participated in L1-Ki2 session with Kikuyu subjects of type 2 in the afternoon of the first day. Finally, they met Kalenjin subjects of type 2 in L1-Ka2 session in the morning of the third day.

The subjects were students at the University of Nairobi and Kenyatta University situated

in major urban centers as well as at universities located in (relatively) small towns such as Moi University, Egerton University, Mount Kenya University, Kimathi University College of Technology, and Jomo Kenyatta University of Agriculture and Technology. Also, the number of male subjects was the same as that of female subjects.

No subject had prior experiences in market experiments. The three sessions in which each subject participated required approximately 5 hours to complete in total. The average payoff per subject was 5791 Ksh (One US dollar approximately exchanged for 77 Ksh in March of 2010). The maximum payoff among the 72 subjects was 6277 Ksh, and the minimum payoff was 4502 Ksh.

3-2. Procedures

In each session we made 12 pairs out of the 24 subjects so that there were 12 trading teams in total, and each had two participants. Each team received two experimental procedure sheets, a record sheet, a payoff table, and two name tags. The name tag of each subject indicated his team name (A, B, C, …, or L), his identification number (1 or 2), and an abbreviation for his ethnicity ("L" for Luo, "Ki" for Kikuyu, or "Ka" for Kalenjin), such as "C-2-Ki". Six teams A, B, …, and F played the role of type 1 consumer, and six teams G, H, …, and L played the role of type 2 consumer.

Each team was given pink cards and/or white cards in an envelope. One pink card was one unit of commodity X, and one white card was one unit of commodity Y. We explicitly noticed to every subject that he is not allowed to reveal any information regarding the payoff table or the endowment of his team to any other team.

The subjects walked around a relatively large laboratory room and found a team to trade. We prohibited any subject from giving any amount of commodity X or Y more than he held to the team. In addition, as explained in the previous section, the trading ratio of Y to X should be greater than or equal to 1/4 = 0.25 to exclude undesirable equilibrium allocations.

We told the subjects to trade commodity X for Y or Y for X when two teams reached an agreement. After writing the trading results in their record sheets, the teams reported them to the experimenter. The following information on the results was written on the blackboard and displayed publicly: the team name giving commodity X, the amount of the traded X, the team name giving Y, the amount of the traded Y, and the trading ratio of the commodities (=Y/X). This was the end of one trade.

We mean by a "period" the time in which subjects trade by starting from their initial holdings. The subjects had 10 minutes for each period and they were allowed to trade as many times as they wanted within the time limit. For the next partner, the subjects could choose any

team as they wanted: it might be the same as or different from one of the teams they had already traded. After each period, the subjects went back to their seats and the experimenter collected all commodity cards. This was the end of the one period.

At the beginning of the next period, the subjects received the same materials as those of the previous period. In particular, *holdings of commodities were reset at the end of each period and each team held the same endowment at the beginning of each period*. After a 2-minute break, the next period started. We mean by a "session" a sequence of periods of experiment with the same subjects. One session had 5 periods. The above steps were repeated 5 times. The sessions were conducted in English.

Each subject's earnings depended on the final payoff that his team earned in one randomly selected period from the experiment. This period was chosen by a random device after the experiment. Each member of the same team received the same earnings.

We distributed to each team a payoff table showing how its payoff depends on the amounts of commodities X and Y. See Table 3 (resp. Table 4) in the Appendix for the payoff table of type 1 (type 2) in which the column denotes the amount of commodity X and the row denotes the amount of commodity Y. We round off the decimal places of payoff values.

4. Experimental Results

Figure 4 shows differences between the distributions of the end-of-period holdings of commodities *X* and *Y* over three consecutive sessions for type 1 of Luo and Kalenjin (Figure 8 in the appendix shows those for type 1 of Kikuyu). Each session has 5 periods in which 6 teams of subjects of each type trade, so our data consist of 5×6 = 30 consumption bundles of *X* and *Y* for each type and each session. In Figure 4, the XY planes of the bases of three-dimensional diagrams represent the possible holdings of goods X and Y for the subjects, and the heights denote the frequencies of the holdings observed in experiment.

Figure 4(a) shows the distributions of holdings of type 1 of Luo subjects when they traded with type 2 of Luo subjects: many patterns of holdings were observed and there was no pattern in which the data concentrated. Figure 4(b) shows the distributions of holdings of type 1 of Kalenjin subjects when they traded with the other type of Kalenjin subjects: several patterns of holdings were attained and the data concentrated in $(x_1, y_1) = (12,15)$, which is the consumption bundle for type 1 at the intermediate equilibrium.

Figure 4(c) shows the distributions of holdings of type 1 of Luo subjects when they traded with type 2 of Kikuyu subjects: the patterns of holdings were less than in Figure 4(a) and the

data concentrated around (12, 15). Figure 4(d) shows the distributions of holdings of type 1 of Kalenjin subjects when they traded with type 2 of Kikuyu subjects: the patterns of holdings were less than in Figure 4(c) and the data extremely concentrated in (12, 15).

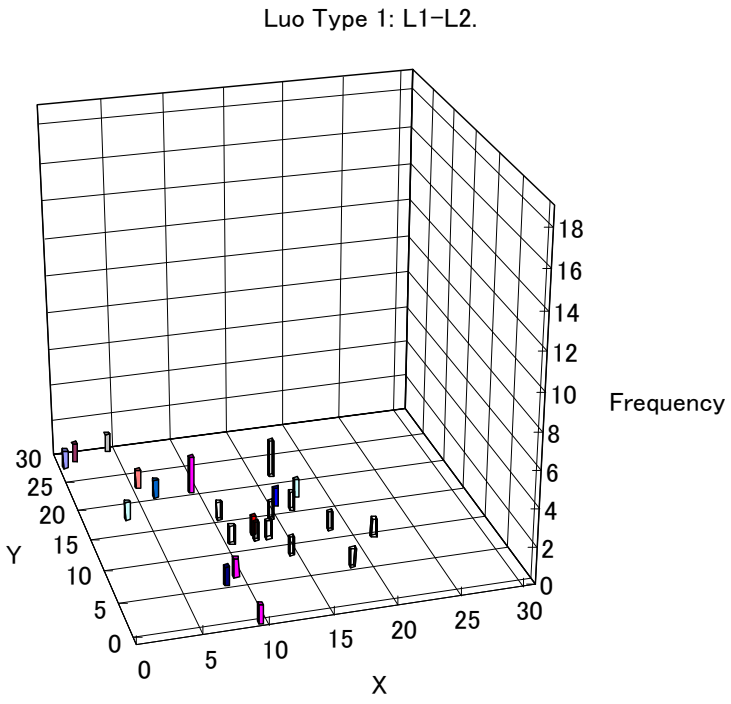
Figure 4(e) shows the distributions of holdings of type 1 of Luo subjects when they traded with type 2 of Kalenjin subjects: the patterns of holdings were much less than in Figure 4(c) and the data remarkably concentrated in (12, 15). Figure 4(f) shows the distributions of holdings of type 1 of Kalenjin subjects when they traded with type 2 of Luo subjects: the patterns of holdings were the least of the six diagrams of Figure 4 l and almost all of the data are (12, 15).

These observations tell that, in the sessions Kalenjin subjects participated in, most of type1 of consumers finally had the bundle (12, 15) regardless of their ethnicities.

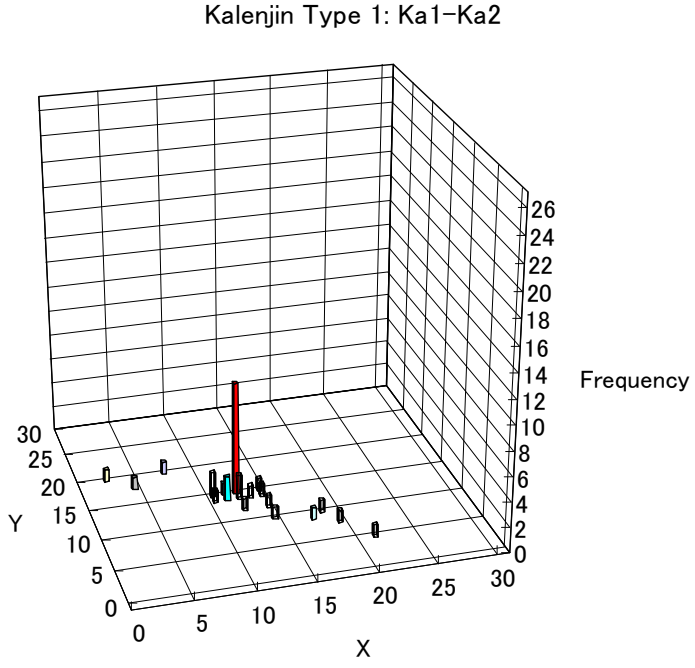
Figure 4. Distribution of End-of-Period Holdings of X and Y:

Luo Type 1 and Kalenjin Type 1

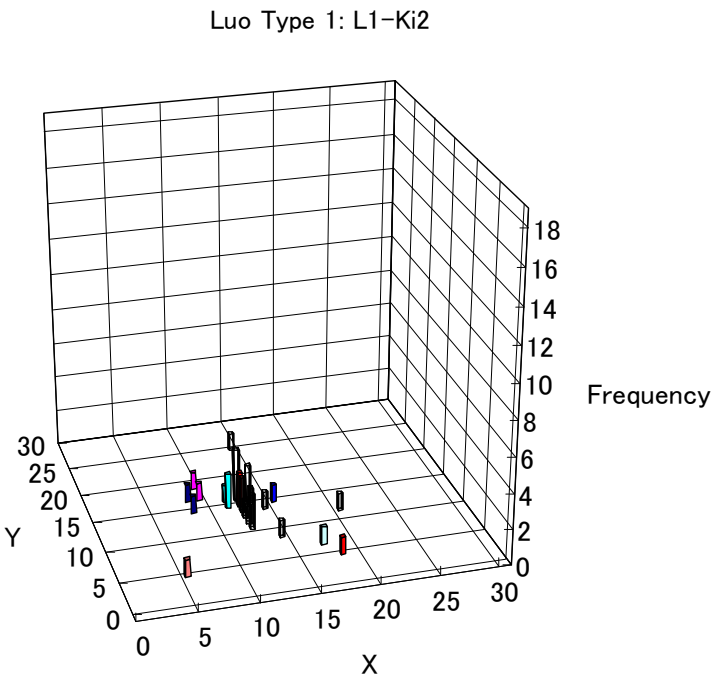
(a) Session with Luo Type 1 and Luo Type 2



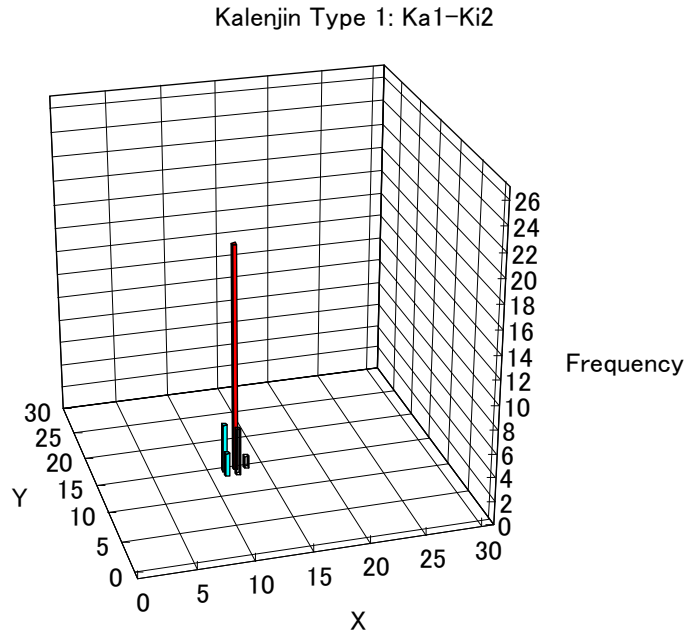
(b) Session with Kalenjin Type 1 and Kalenjin Type 2



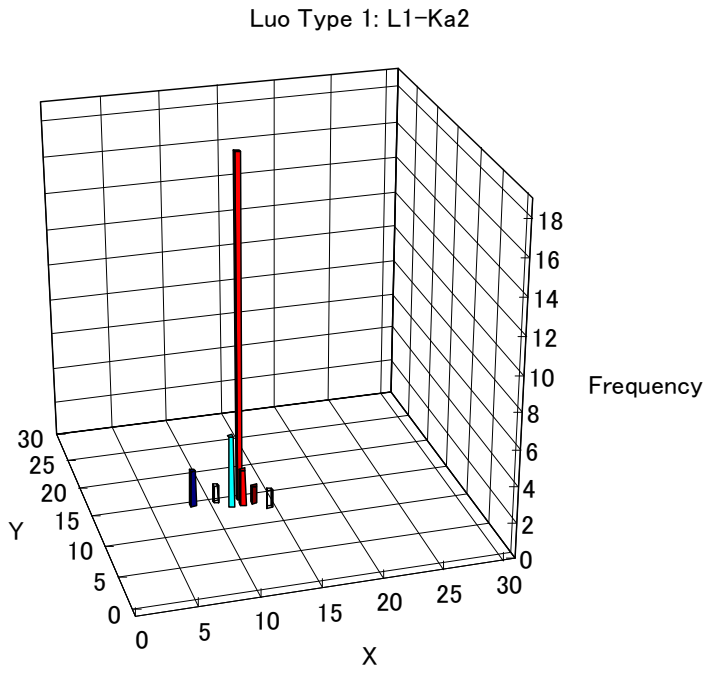
(c) Session with Luo Type 1 and Kikuyu Type 2



(d) Session with Kalenjin Type 1 and Kikuyu Type 2



(e) Session with Luo Type 1 and Kalenjin Type 2



(f) Session with Kalenjin Type 1 and Luo Type 2

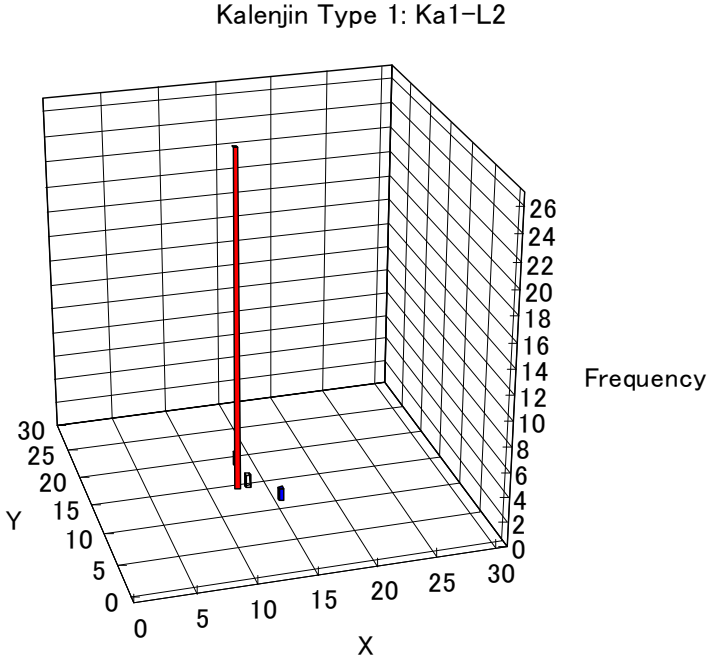
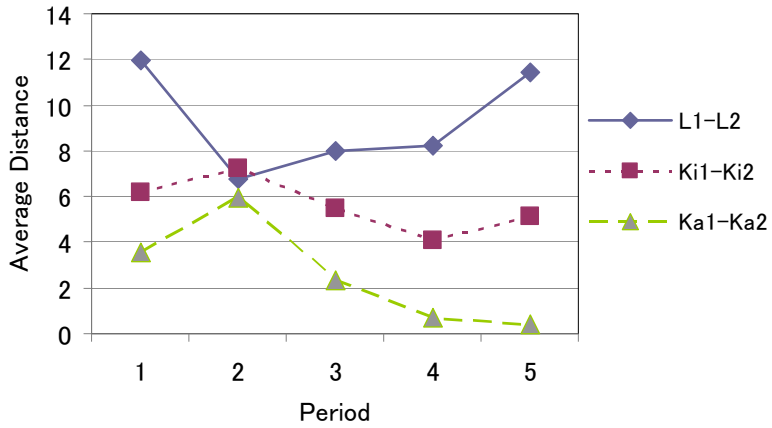


Figure 5 shows the average distance from the intermediate equilibrium B1 consumption bundle per subject for each ethnic group of subjects. Here the distance of each subject at each period is defined as the Euclidean distance[3] between her end-of-period holdings and the consumption bundle her type of consumer receives at B1. Figure 5-(a) indicates that average distances are high in the Luo group, middle in the Kikuyu group, and low in the Kalenjin group in the sessions with the same ethnicity. Figure 5-(b) demonstrates that in the sessions with different ethnicities, average distances are lower in the sessions including the Kalenjin group (i.e., Sessions Ka1-Ki2, Ki1-Ka2, L1-Ka2, and Ka1-L2) than in those in the sessions consisting of the Luo and Kikuyu groups (i.e., Sessions L1-Ki and L2-Ki2). In particular, the average distance approaches to zero as periods advance, that is, allocations converge to the intermediate equilibrium allocation B1 in every session including the Kalenjin group.

We test the hypothesis that the mean distance per subject is equal between two ethnic groups by pooling the data across periods with a random effects model. The pooled distance data rejects (i) the hypothesis between each pair of Luo, Kikuyu, and Kalenjin groups at the one-percent significant level in the first-round session with the same ethnicity and (ii) the hypothesis between Luo and Kalenjin groups as well as that between Kikuyu and Kalenjin at the one-percent significant level in the second-round session with different ethnicities. On the other hand, the data fails to reject the hypothesis between Luo and Kikuyu groups in the second-round session with different ethnicities or that between any pair of the three groups in the third-round session with different ethnicities at the five-percent significant level.[4]

Figure 5. Average Distances from the Intermediate equilibrium Allocation B1

(a) Session with the same ethnicity



(b) Session with different ethnicities

[3] The Euclidean distance between points (a_1, a_2) and (b_1, b_2) is $\sqrt{(a_1 - b_1)^2 + (a_2 - b_2)^2}$.

[4] A Wilcoxon signed rank test and a t-test give the same result as that by the panel data analysis.

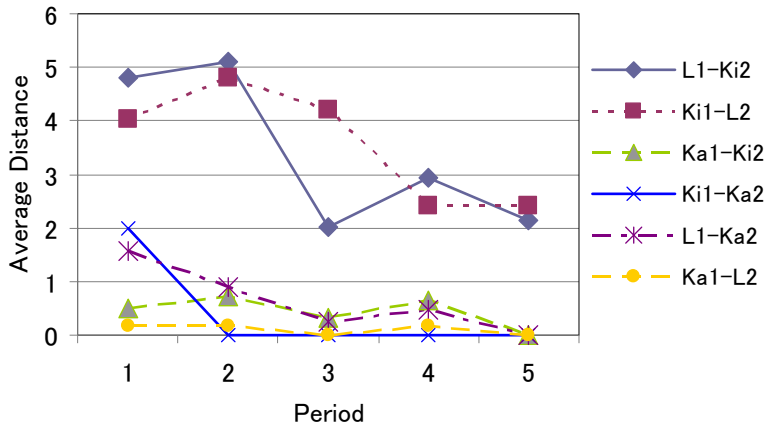
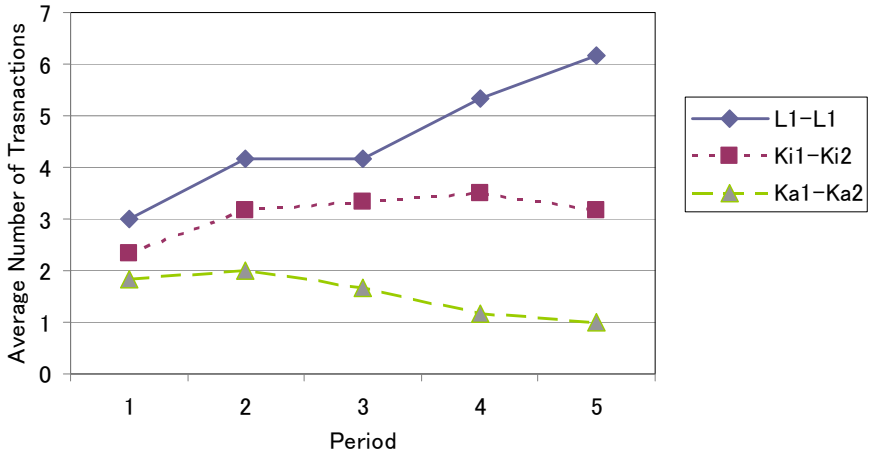


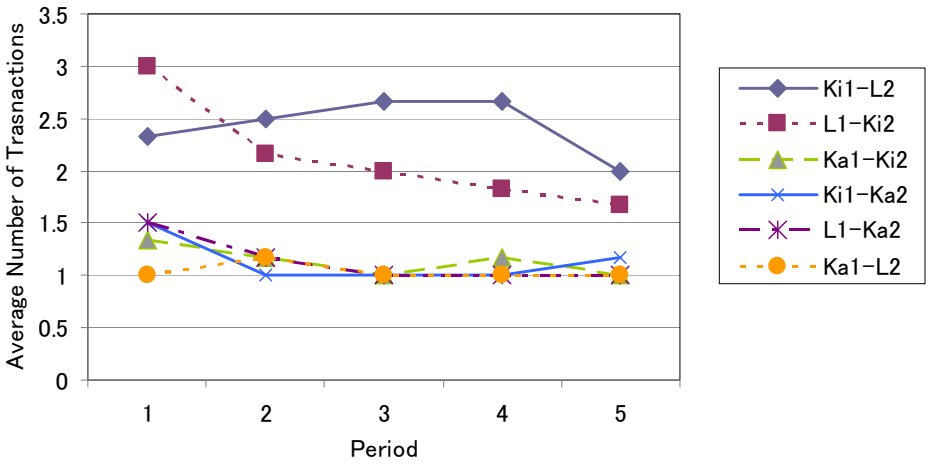
Figure 6 shows the average number of transactions per subject for each session. The number of transactions is high in the Luo group, middle in the Kikuyu group, and low in the Kalenjin group in the sessions of the same ethnicity groups. In the sessions with different ethnicities, transactions occur more often in the sessions consisting of Luo and Kikuyu subjects than in the sessions including Kalenjin subjects in which one subject carried out only almost one transaction on average.

Figure 6. Average Numbers of Transactions per Subject

(a) Session with the same ethnicity



(b) Session with different ethnicities



We test the hypothesis that the mean number of transactions per subject is equal between two ethnic groups by pooling the data across ethnic groups with a random effects model. The pooled transaction data rejects (i) the hypothesis between each pair of Luo, Kikuyu, and Kalenjin groups at the one-percent significant level in the first-round session with the same ethnicity and (ii) the hypothesis between Luo and Kalenjin groups as well as that between Kikuyu and Kalenjin at the one-percent significant level in the second-round session with different ethnicities. However, the data fails to reject the hypothesis between Luo and Kikuyu groups in the second-round session with different ethnicities or that between any pair of the three different ethnic groups in the third-round session at the five-percent significant level.[5]

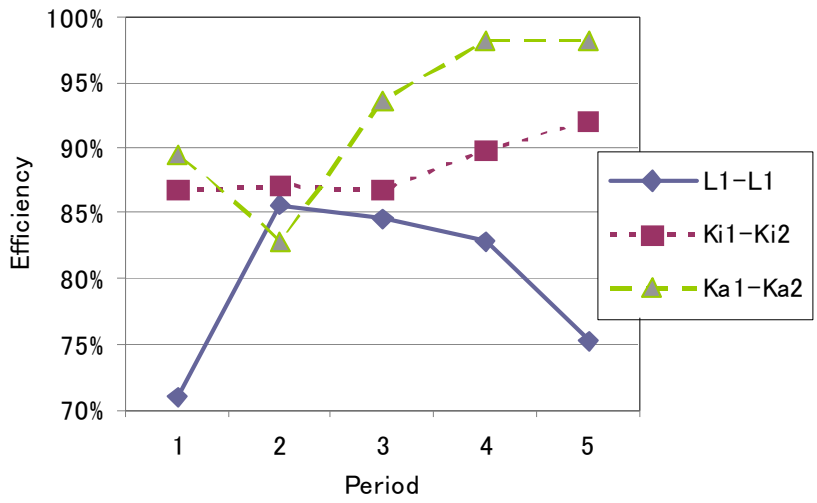
Next we examine a key question of whether the outcome is efficient. Here we define efficiency as the sum of realized payoffs over all subjects as a percentage of the maximum payoffs achievable.[6] Figure 7 demonstrates efficiency across periods in each session. Efficiency is low in the Luo group, middle in the Kikuyu group, and high in the Kalenjin group in the sessions of the same ethnicity groups. In the sessions with different ethnicities, efficiency is lower in the sessions consisting of Luo and Kikuyu subjects than in the sessions including Kalenjin subjects. Figures 6 and 7 together suggest that there is an inverse relationship between the number of transactions and efficiency in our experimental market.

[5] A Wilcoxon signed rank test and a t-test provide the same result as that by the panel data analysis..

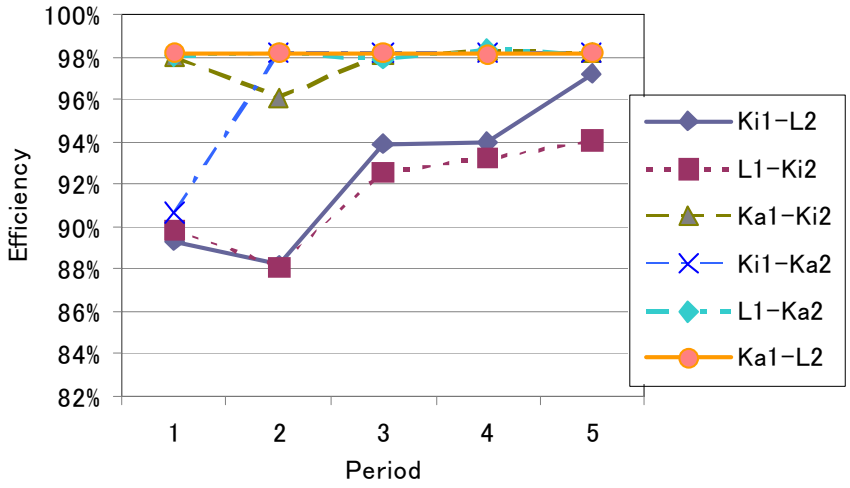
[6] The maximum value of the sum of the payoffs of two consumer types is 4072.

Figure 7. Efficiency

(a) Session with the same ethnicity



(b) Session with different ethnicities



Why is the “Kalenjin effect” on achieving the intermediate equilibrium so strong? Kalenjin subjects quickly began to make offers of the intermediate equilibrium only and ceased to accept other proposals although the other ethnic groups of subjects kept making small adjustments to improve themselves upon. Our observations tell that the bilateral trading do not cause large inequalities of income or welfare, and the participation of a non-negligible number of Kalenjin people in the experimental market significantly facilitate the prompt decisions of negotiations at the exact point of the intermediate equilibrium.

To sum up, we observe the following:

(a) CIn the sessions with Luo and/or Kikuyu subjects only, we do not observe convergence of allocations. In the sessions with Kalenjin, however, allocations converge to the intermediate equilibrium allocation, which is equitable but locally unstable, as periods go on.

(b) The speed of convergence to the intermediate equilibrium B1 is remarkably faster with Kalenjin subjects than without them. Kalenjin subjects quickly began to make offers of the intermediate equilibrium only and ceased to accept other proposals.

(c) The frequency of transactions with Kalenjin subjects are significantly less than that with Luo and/or Kikuyu subjects only, and the less frequent transactions result in the more efficient outcomes of the experimental market.

5. Concluding Remarks

We have reported the organizations, implementations, observations, and statistics of our multiethnic experiment in Kenya. Before starting this project, we conjectured that the backgrounds of the ethnic communities would influence the results of this series of experiments. The conjecture is disproved in our experiment. Our data show that the outcomes from sessions Kalenjin subjects participate in converge to the intermediate equilibrium at least in the sense that the average of the distance between the intermediate equilibrium and the observation goes to zero.

In our experiment, the key players are the Kalenjin subjects. We observe that it surprisingly facilitates the fast and exact convergence to the intermediate equilibrium to get Kalenjin into the market. We find a few remarkable differences between the two data sets: one set contains data with Kalenjin subjects, and the other set includes no data with Kalenjin subjects.

References

Anderson, Christopher M., Charles R. Plott, Ken-Ichi Shimomura, and Sander Granat (2004): "Global Instability in Experimental General Equilibrium: the Scarf Example," *Journal of Economic Theory* 115, 209-249.

Bergstrom, Theodore C., Ken-Ichi Shimomura, and Takehiko Yamato (2009): "Simple Economies with Multiple Equilibria," *The B.E. Journal of Theoretical Economics* 9: Article 43.

Cason, Timothy, Tatsuyoshi Saijo, and Takehiko Yamato (2002): "Voluntary Participation and Spite in Public Good Provision Experiments: An International Comparison," *Experimental Economics* 5, 133-153

Chipman, John S. (2010): "Multiple Equilibrium under CES Preferences," *Economic Theory* 45, 129-145.

Crockett, Sean, Ryan Oprea, and Charles R. Plott (2010): "Extreme Walrasian Dynamics: The Gale Example," Mimeo, University of California at Santa Cruz.

Gale, David (1963): "A Note on Global Instability of Competitive Equilibrium," *Naval Research Logistics Quarterly* 10, 81-87.

Huber, Juergen, Martin Shubik, and Syham Sunder (2009): "Default Penalty as Disciplinary and Selection Mechanism in Presence of Multiple Equiliria," Cowles Foundation Discussion Paper No. 1730, Yale University.

Roth, Alvin E., Vesna Prasnikar, Masahiro Okuno-Fujiwara, and Shmuel Zamir (1991): "Bargaining and Market Behavior in Jerusalem, Ljubljana, Pittsburgh, and Tokyo: An Experimental Study," *American Economic Review* 81, 1068-1095.

Masui, Michiharu, Tokitaka Ohtaka, Ken-Ichi Shimomura, Kiyotaka Takahashi, and Takehiko Yamato (2010): "Discrete Exchange Economies: a Simulation Analysis," Discussion Paper, Tokyo Institute of Technology.

Scarf, Herbert (1960): "Some Examples of Global Instability of the Competitive Equilibrium," *International Economic Review* 1, 157-171.

Shapley, Lloyd. S. and Martin Shubik (1977): "An Example of a Trading Economy with Three Competitive Equilibria," *Journal of Political Economy* 85, 873-75.

Smith, Vernon L. (1962): "An Experimental Study of Competitive Market Behavior," *Journal of Political Economy* 70, 111-137.

Appendix

Table 3. Payoff Table Provided to Subjects of Type 1

Payoff Table

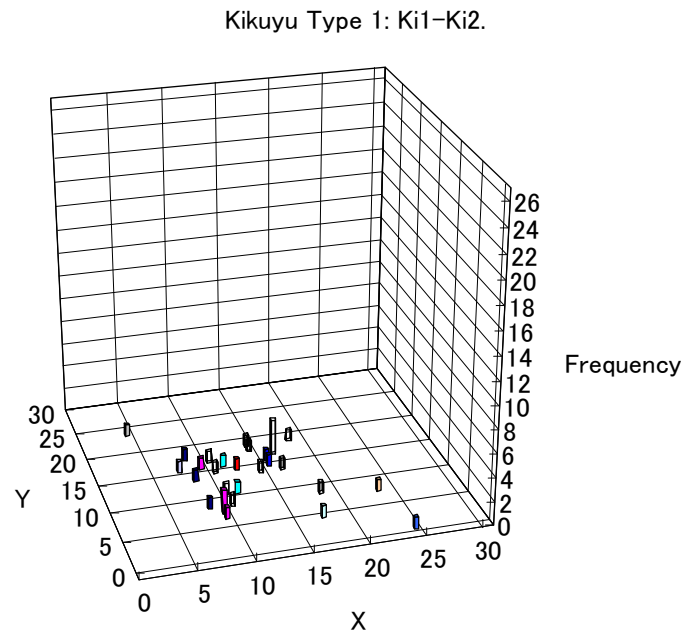
Amount of Y \ Amount of X	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
30	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2862	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110	3110
29	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2862	3038	3038	3038	3038	3038	3038	3038	3038	3038	3038	3038	3038	3038	3038
28	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2862	2965	2965	2965	2965	2965	2965	2965	2965	2965	2965	2965	2965	2965	2965
27	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2862	2892	2892	2892	2892	2892	2892	2892	2892	2892	2892	2892	2892	2892	2892
26	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819	2819
25	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746	2746
24	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674	2674
23	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601	2601
22	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528	2528
21	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455	2455
20	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383	2383
19	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310	2310
18	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237	2237
17	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2098	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164	2164
16	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092	2092
15	927	935	942	950	957	964	972	1585	1970	1978	1985	1993	2000	2007	2015	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019
14	927	935	942	950	957	964	972	1585	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946	1946
13	927	935	942	950	957	964	972	1585	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873	1873
12	927	935	942	950	957	964	972	1585	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
11	927	935	942	950	957	964	972	1585	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728	1728
10	927	935	942	950	957	964	972	1585	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655	1655
9	927	935	942	950	957	964	972	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582	1582
8	927	935	942	950	957	964	972	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509	1509
7	927	935	942	950	957	964	972	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437	1437
6	927	935	942	950	957	964	972	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364	1364
5	927	935	942	950	957	964	972	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291	1291
4	927	935	942	950	957	964	972	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218	1218
3	927	935	942	950	957	964	972	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146	1146
2	927	935	942	950	957	964	972	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073	1073
1	927	935	942	950	957	964	972	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
0	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927	927

Table 4. Payoff Table Provided to Subjects of Type 2

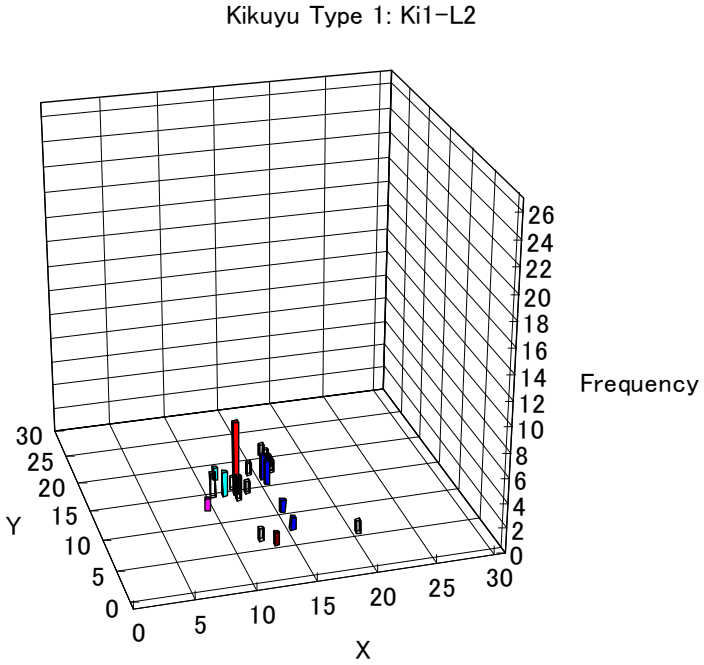
Amount of Y \ Amount of X	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
30	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
29	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
28	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
27	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
26	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
25	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
24	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
23	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
22	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2422	2430	2437	2445	2453	2460	2468
21	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2384	2392	2399	2407	2415	2415	2415	2415	2415	2415	2415	2415
20	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346	2346
19	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2277	2277	2277	2277	2277	2277	2277	2277	2277	2277	2277	2277
18	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2208	2208	2208	2208	2208	2208	2208	2208	2208	2208	2208	2208
17	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2138	2138	2138	2138	2138	2138	2138	2138	2138	2138	2138	2138
16	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2028	2069	2069	2069	2069	2069	2069	2069	2069	2069	2069	2069	2069
15	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
14	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	1931	1931	1931	1931	1931	1931	1931	1931	1931	1931	1931	1931	1931
13	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862	1862
12	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	1792	1792	1792	1792	1792	1792	1792	1792	1792	1792	1792	1792	1792
11	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	1723	1723	1723	1723	1723	1723	1723	1723	1723	1723	1723	1723	1723
10	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1587	1595	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654	1654
9	962	970	977	985	992	1000	1008	1015	1526	1534	1541	1549	1557	1564	1572	1579	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585	1585
8	962	970	977	985	992	1000	1008	1015	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516	1516
7	962	970	977	985	992	1000	1008	1015	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446	1446
6	962	970	977	985	992	1000	1008	1015	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377	1377
5	962	970	977	985	992	1000	1008	1015	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308	1308
4	962	970	977	985	992	1000	1008	1015	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239	1239
3	962	970	977	985	992	1000	1008	1015	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170	1170
2	962	970	977	985	992	1000	1008	1015	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100	1100
1	962	970	977	985	992	1000	1008	1015	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031	1031
0	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962	962

Figure 8. Distribution of End-of-Period Holdings of X and Y: Kikuyu Type 1.

(a) Session with the same ethnicity



(b) Session with Kikuyu Type 1 and Luo Type 2



(c) Session with Kikuyu Type 1 and Kalenjin Type 2