Preliminary Draft
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The Voluntary Provision of Public Goods Under Varying Endowment Distributions: Experimental Evidence

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Abstract

Bergstrom, Blume and Varian (1986) claimed that - theoretically - skewing the income distribution can increase the aggregate amount voluntarily contributed to a public good market. This result depends on an interior Nash equilibrium of non-zero contribution for the contributors. We test this claim experimentally, and find that the result holds at the aggregate level, but it is driven by individual behaviour. Specifically, the larger endowed individuals contribute less than predicted, while lesser endowed individuals over-contribute.

The Voluntary Provision of Public Goods Under Varying Endowment Distributions: Experimental Evidence

1. Introduction/Motivation

1.1 Theory

Theoretical analysis of the public good externality has suggested that the use of a voluntary contribution mechanism (VCM) will systematically under-provide such goods. It is assumed that agents will use Nash behaviour and individually maximize profits. This behaviour fails to internalize the externality inherent in a public goods environment, and contributions to the public good are less than the social (or Pareto) optimum.

There are two basic strands to this argument. Samuelson (1964) proposed that a public good VCM would provide no provision of the public good. This was identified as the 'free-rider' problem, and depends on a dominant Nash equilibrium of zero contribution. This would suggest that the public good characteristic is necessary and sufficient for free-riding. Bergstrom, Blume & Varian (1986) [BBV] show that if an interior Nash equilibrium exists, a VCM will lead to the provision of the public good. This modification implies that the public good characteristic is sufficient but not necessary for free-riding.

1.2 Experimental Work

1.2.1 Free-rider type (Samuelson)

A variety of experiments have analyzed the free-rider phenomenon (Issac, McCue & Plott, 1985; Issac, Walker & Thomas, 1985), and the results are quite supportive. As the game is repeated, donations to the public good tend to decay from a level near the Pareto optimal towards the Nash solution of no contribution. The decay process itself has been studied in markets of complete information (Issac & Walker, 1989). These experiments use parameters which have a dominant Nash strategy of zero contribution and it is generally concluded that the VCM fails to provide the public good.

1.2.2 Interior Solution type (BBV)

Some VCM experiments involve non-zero Nash equilibria. Li (1991) found that in such cases the public good is indeed provided. The data suggests provision levels that vary from the Pareto to Nash outcomes, depending on whether subjects were permitted to communicate or not, and shows similar decay processes as the free-rider experiments. Li also analyzed provision points, and again obtained similar results, but the decay process was reduced or disappeared altogether.

Andreoni (1990) experimentally tested the crowding-out effects of government taxation. Theory suggests that in public goods environments with interior Nash solutions, taxation which is deposited into the communal good should completely crowd-out voluntary contributions (Warr, 1983; BBV, 1986). However, the Andreoni data supports incomplete crowding-out, which he labelled the 'warm-glow' effect.

1.2.3 Other work

Bagnoli & Lipman (19??) created a VCM experiment which involved both multiple equilibria and provision points. They found that altering income distribution has no effect, but this result is attributed to the combination of provision points and multiple equilibria.

1.3 Proposal

Li (1991) provides some evidence that suggests a VCM can lead to the provision of a public good. This theory was proposed by Warr (1983) and BBV (1986). Andreoni (1990), provides evidence which suggests that the neutrality theorem of BBV (discussed below) may be too strict.

The BBV paper develops Warr (1983), and shows that theoretically, endowment distribution (redistribution) may alter private contributions. By creating an experimental study which alters the endowment distribution of subjects in a public goods environment, we are able to test Theorems 1 and 5 of the BBV paper.

2. Design

2.1 Theory to be tested

This experiment focuses on the following claim:

> **[W]e can show that when consumers are identical, the more equal the wealth distribution, the less of the public good will be supplied.**
>
> (BBV, 1986, p.37)

Looking at this from the view of efficiency (albeit ruthless), it argues that the more unequal the endowment distribution, the greater the provision of the public good.

More specifically, we analyze the claims of Theorem 1 - the neutrality theorem - and Theorem 5 (BBV, 1986).

Theorem 1 (p.29)

Assume that consumers have convex preference and that contributions are originally in a Nash equilibrium. Consider the

redistribution of income among contributing consumers such that no consumer loses more income than his/[her] original contribution.

(i) After the redistribution there is a new Nash equilibrium in which every consumer changes the amount of his/[her] gift by precisely the change in his/[her] income.

(ii) In this new equilibrium, each consumer consumes the same amount of the public good and the private good as he/[she] did before the redistribution.

[The bold characters and division of claims done by author].

Theorem 5 (p.38)

If preferences are identical, then in Nash equilibrium:

(i) All contributors will have greater wealth than all non-contributors.

(ii) All contributors will consume the same amount of the private good as the public good.

(iii) An equalizing wealth redistribution will never increase the voluntary equilibrium supply of the public good.

(iv) Equalizing wealth redistributions among current non-contributors or among current contributors will leave the equilibrium supply unchanged.

(v) Equalizing income redistributions that involve any transfers from contributors to non-contributors will decrease the equilibrium supply of the public good.

2.2 Parameterization

In this experiment, there are n players, and each player i is endowed with e_i tokens at the beginning of each period (for each of T=15 periods). Each agent then decides how much they will invest in the public good (y_i), and any remaining endowment is invested in the private good ($x_i=e_i-y_i$). The payoff to player i (π_i) is calculated using the following function:

$$\pi_i=(e_i-y_i)\sum_{j=1}^{n} y_j+(e_i-y_i)+\sum_{j=1}^{n} y_j \qquad \textbf{(1)}$$

This can be simplified to the following if we let Y represent the total provision of the public good (ie. the sum of the y_i's):

$$\pi_i=x_iY+x_i+Y \qquad \textbf{(2)}$$

The interactive term (x_iY) creates an interior Nash solution, while the additive terms ensures that $\pi_i>0$ for all i. This guarantees each subject a positive payoff if the subject invests her entire endowment in either market.

In the laboratory environment, n=3, so the reaction function is quite easy to construct from equation (1):

$$y_i^* = \frac{(e_i - E(y_j + y_k))}{2} \tag{3}$$

where E is the expectations operator. If $y_i^*<0$, then the optimal strategy is to set $y_i^*=0$. As this experiment deals with varying the endowment distribution, one further assumption is needed to formulate Nash predictions. We assume that if $e_i=e_j$, then $y_i^*=y_j^*$. This is called the symmetric Nash equilibrium. Furthermore, associated with each symmetric Nash equilibrium is <u>one</u> Pareto optimum that results in a Pareto improvement for <u>all</u> agents. These Nash and related Pareto optimal levels of contribution to the public good are summarized in **Tables 1** and **2** below.

Table 1 <u>Symmetric Nash Equilibria and Pareto Optima for Varying Endowment Distributions</u>

Distribution	Nash	Pareto
A (20,20,20) = [60]	(5,5,5) = [15]	(10,10,10) = [30[1]]
B (18,18,24) = [60]	(3,3,9) = [15]	(8, 8,15) = [31]
C (15,15,30) = [60]	(0,0,15) = [15]	(5, 5,21) = [31]
D (12,12,36) = [60]	(0,0,18) = [18]	(3, 3,25) = [31]
E (9, 9,42) = [60]	(0,0,21) = [21]	(2, 2,27) = [31]

Note: Numbers in () represent individual endowments/investment while numbers in [] represent their summation.

Table 2 <u>Symmetric Nash and Pareto Optimal Payoffs for Varying Endowment Distributions</u>

	Payoff			
Distribution	Nash	[Total]	Pareto	[Total]
A (20,20,20)	255,255,255	[765]	340,340,340	[1020]
B (18,18,24)	255,255,255	[765]	351,351,319	[1021]
C (15,15,30)	255,255,255	[765]	351,351,319	[1021]
D (12,12,36)	246,246,246	[852]	319,319,383	[1021]
E (9, 9,42)	219,219,483	[921]	255,255,511	[1021]

[1] Note that 10,10,10 is the symmetric optimum, but the Pareto optimum can be achieved if a cycle is established in which one player contributes 11 for a period, while the other two provide 10 each.

It is evident that distribution C forms a corner in terms of Nash contributions. Up to, and including this point, the non-negativity constraint on public goods contributions (y_i^*) is not binding. Past this point it is.

These values, and their associated payoffs, correspond directly to the analysis put forth in **Theorem 5** of BBV (1986) (see Section 2.1). The use of identical payoff functions implies that there is some overlap between theorems 1 and 5. This will be pointed out in the Results section.

It is important to note that these values are based upon two key assumptions. First, it is assumed that the subjects' preferences and payoffs are identical, or at least directly related. Second, this analysis assumes that players behave in an individually payoff-maximizing manner (Nash).

2.2 Design

2.2.1 Subjects

All subjects were recruited from the McMaster University student population. At each session, there were 9 subjects. Three designs were run during a session. At the beginning of a session, the students were presented with a folder that contained instructions, the necessary payoff matrices, a record sheet and scrap paper for calculations (examples in the **Appendix**). The instructions were read aloud, and a short test was given with sample payoff matrices to ensure that the subjects understood how to read the tables. Students were also informed that they would be paid, in cash and at the end of the experiment, $5 for showing up plus a sum of money based upon their decisions during the game.

2.2.2 Complete Information

The subjects had complete knowledge of the market. They knew their endowment and the individual endowments of the other two subjects within their group. In addition to their own payoff table, they were supplied with the payoff table of the other two members in the group. They were informed that the experiment would last 15 periods. After each period, their record sheets were collected, filled in by the monitors and returned to the subject. These returned sheets listed each member's contribution to the public good. All of this information was provided in order to increase the probability of observing the Nash equilibrium (see Issac & Walker, 1989).

The subjects were <u>not</u> informed of the identity of the other members within their group. Though each person knew their own token for dollar exchange rate, they did not know the exchange rate of the other subjects - although this was a common value of 200 tokens = $1.00 Canadian. During the session, the subjects were not permitted to communicate with anyone other than the monitors.

3. Experimental Results

3.1 General Results

The data from this experiment provides some very general results that do not necessarily deal with the claims set out in BBV (1986) theorems 1 and 5, but are nonetheless interesting.

Result 1: The Nash equilibrium prediction of individual voluntary contribution to the public good is the most accurate the more equal or unequal the endowment.
Support: Referring to Figures A.2, D.2 and E.2, it is evident that on average, individuals over time are converging to the Nash predicted levels of contribution to the public good. Figures B.2 and C.2 do not follow this pattern.■

Result 2: Aggregate contribution and individual contribution analysis lead to quite different conclusions about the market behaviour.
Support: Comparison of Figures A.1 to A.2 through E.1 to E.2, shows that although the average aggregate contribution may be Nash individual behaviour does not necessarily follow this pattern. This is elaborated upon in Result 3.■

Result 3: On average, players with larger endowments under-contribute to the public good whereas players with smaller endowments tend to over-contribute, as compared to Nash predictions.
Support: See Figures B.2 through E.2. Such offsetting behaviour implies that simple analysis of aggregate contributions is myopic, as it does not capture all of the important dynamics of this market.■

Result 4: The decay process (see Section 1.2) holds for the equal distribution case, but fails in individual analysis when the endowment is skewed.
Support: In Figure A.2, contribution to the public good starts at above Nash and decays to the Nash predicted level, a result noted in previous experiments (see Section 1.2). Once the endowment is skewed however, this is not the case. The players with lower endowments show the familiar decay pattern (see Figures B.2 through E.2). However, the 'richer' players tend to start below their Nash levels. Up to, and including the corner distribution, the rich players start below Nash, and their contributions decay over time to even lower levels. After the corner, the rich players start below Nash, but their contributions rise over time, towards Nash levels.■

Result 5: <u>The 15 period, total market contribution falls as income is skewed towards the corner, and rises as it is skewed away from the corner</u>.

Support: See Figure 4. As income is skewed from equality towards the corner, the average 15 period, total market contribution falls. This value rises as the endowment scheme becomes even more unequal. See Result 11 for a more detailed discussion. ■

Result 6: <u>The 15 period, total market contribution exceeds the Nash prediction in all but the most skewed endowment case</u>.

Support: See Figure 4. This result is important, as it warns against the careless conclusion that skewing endowments is necessarily a worthwhile policy. ■

Nash behaviour (ie. zero conjectural variation) and Nash equilibrium levels of contribution are two very different concepts. Although players may be "playing Nash", if somebody in their group is not doing so, a Nash equilibrium will not be reached. The following result points this out.

Result 7: <u>The more skewed the endowment, the more often subjects use strategies that lead to contributions 'close' to Nash zero conjectural variation (ZCV) reaction function predictions based on lagged once market information</u>[2].

Support: Refer to Figure 1. For each player, their actual contribution to the public good was compared to the value predicted by a ZCV reaction function based upon the lagged once values of the other contributors. The root mean squared deviation was calculated for each endowment scheme, and the results were grouped. It is evident that the frequency of plays that are within 2 root mean squared deviations rises as the endowment scheme is skewed.

In Table 3 below, we see that in all but the A-type experiments, the absolute deviations from the lagged ZCV reaction function shows a lower variance than the absolute deviation from the static Nash prediction. This lends some support to the idea that people **react** in a Nash manner, rather than play the Nash equilibrium.

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[2] A lagged once reaction function fit better, in terms of a lower variance, than either an average lagged twice or lagged three times.

TABLE 3

	Absolute Deviations from Nash Predictions			
	Deviations from ZCV		Deviations from Static	
Group	Avg	Vars	Avg	Vars
A	4.083	12.621	3.157	5.856
A*(no A1)	2.997	7.753	2.798	6.222
B	2.843	7.037	2.905	8.862
C	2.324	6.718	2.776	11.055
D	2.231	12.742	2.814	13.434
E	1.340	12.923	2.119	18.019
Total	2.564	11.180	2.754	11.520

Notice that the average absolute deviation falls as the endowment distribution is skewed. Again, this supports the result that subjects 'play Nash' more often as endowments are skewed.■

3.2 Specific Results

These observations deal much more directly with the claims set out in BBV (1986) theorems 1 and 5. For the remainder of this paper, the following reference scheme will be used: claim 1.ii, refers to theorem 1 claim (ii) of BBV (1986).

Result 8: When distribution is changed within contributors, the people with lower endowments tend to contribute more than the Nash predicted amount, while the larger endowed people contribute less than Nash levels. Specifically, a person's contribution does not change by the amount their endowment changed.

Support: This result rejects claim 1.i of the neutrality theorem. Looking at Figures B.2 and C.2, we see this is evident. In B.2, the low-endowed subjects decrease their endowment, tending, on average, towards the correct amount. The high-endowed subjects also decrease their contribution. Similar results are found in C.2, though the low-endowed subjects keep their contributions relatively constant, at about 3 units on average.■

Result 9: When distribution is changed within contributors, consumers do not consume equal amounts of private and public goods.

Support: This result rejects claims 1.ii, and 5.ii. Again, the under-contribution by the larger endowed people is the driving force. A comparison of Figures A.2, B.2, and C.2 shows this to be the case.■

Result 10: The contributors are more wealthy, in terms of payoffs, than the non-contributors.

Support: This results is trivial given the previous results. More important is the fact that the larger endowed people are richer than theory suggests, as they tend to under-contribute and let the less endowed people over-contribute. This provides some support for claim 5.i.■

Result 11: Equalizing wealth redistributions (within contributors) can increase the contributions to the public goods.

Support: This refutes claim 5.iii and 5.iv. This result gains some weak, but important support because of the Pareto optimal contributions achieved in experiment A1. Figure 4 should show total contributions (for the 15 periods) of 225 for distribution types A, B and C, if they all played Nash (see hatched bars). This is not the case (see solid bars); as endowments are skewed towards the corner, the contribution falls. Under the equal endowment scheme (A), 118.5% of the Nash predicted contribution is realized, whereas only 102.0% and 104.3% of the Nash predicted contributions are realized in the B and C type endowment schemes respectively. If experiment A1 is dropped from the analysis, then the result still holds, but statistical significance is negligible.■

Result 12: Skewing the endowment distribution, past the corner solution, tends to increase the market contribution to the public good. That is, as endowments are redistributed from non-contributors to contributors, more of the public good is provided.

Support: This lends support to claim 5.v. This is evident in Figures A.1 through E.1 and Figure 3. As the distribution is skewed past the corner, provision of the public good increases. Figure 8 also supports this result.■

4. Conjecture/Conclusions

Through this experiment, we were able to confirm the theoretical claims in BBV (1986) with some important modifications. One can suggest many reasons for this imperfect matching of theory and practise, but here we propose two.

First, players may find it easier to make individual payoff maximizing decisions, the more (or less) endowment they receive. Essentially, as the endowment distribution is skewed the triopoly situation more closely mimics a monopoly. It may be easier for players to make individual profit maximizing decisions. In the equal distribution case, and in every case of the larger endowed player, payoffs are subject to uncertainty about other players' actions. Furthermore, the gradient at the optimal contribution level is very shallow. Thus, large deviations from optimal contribution levels imply only small payoff changes. On the other hand, the profit functions of the lower endowed player are constrained to the positive quadrant, so uncertainty is reduced and the gradient is very steep. This implies less deviation on their part as the endowment is skewed. This conjecture is supported by Result 8, and Figures 1, 2, and 3.

Second, people may use some sort of fairness rule, in which contribution to the public good is proportional to their endowments. If people use a fairness rule that states each person should contribute 25% of their endowment, then the contributions in Table 4 will be realized.

TABLE 4

Nash versus Fairness

Endowment	Nash		Fairness (25%)	
A (20,20,20)	5,5,5	[15]	5,5,5	[15]
B (18,18,24)	3,3,9	[15]	4.5,4.5,6	[15]
C (15,15,30)	0,0,15	[15]	3.75,3.75,7.5	[15]
D (12,12,36)	0,0,18	[18]	3,3,9	[15]
E (9,9,42)	0,0,21	[21]	2.25,2.25,10.5	[15]

With any of the distributions up to the corner such a decision rule would lead to a Nash outcome in aggregate. With the equal distribution, the fairness rule also produces individual Nash behaviour. As the income is skewed to the corner, the larger endowed players would under-contribute, while the less endowed would over contribute. Figures A.2, B.2, and C.2 all support this fairness rule, and it is consistent with Results 1, 2, 3, 8, 9, and 10. Past this corner, people may abandon this decision rule and return to individual payoff maximizing behaviour.

These results support the argument that skewed endowment schemes do provide more of a public good. This is not the whole story though. This sort of scheme tends to lead to over-contribution by the poor, and under-contribution by the rich. Thus, while the theory gains some support in an experimental environment, it does not necessarily increase the social welfare - this is a case of the "rich-getting-richer" while the "poor-get-poorer".

MEAN VOLUNTARY CONTRIBUTIONS

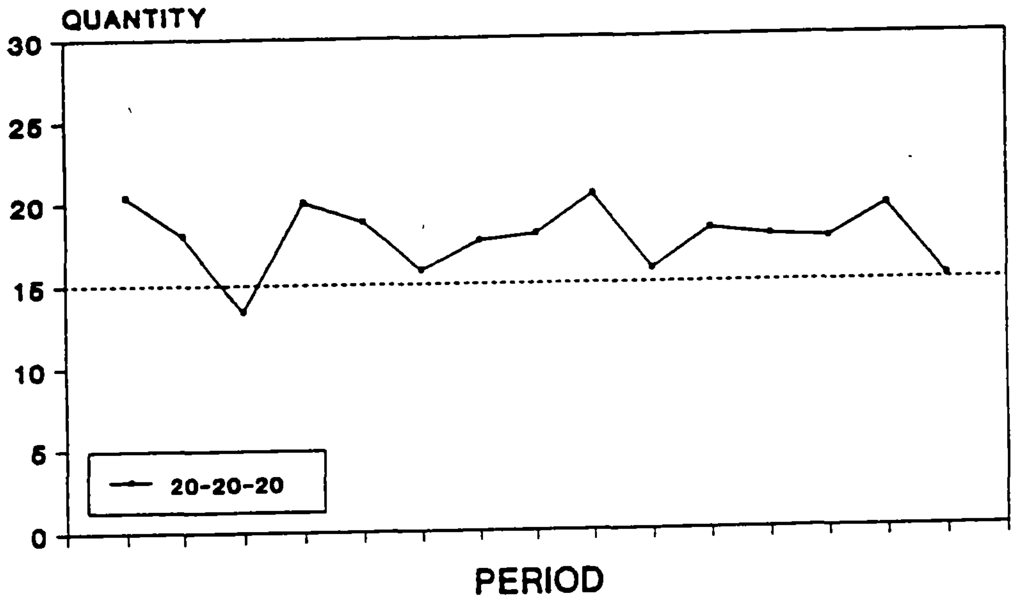


FIGURE A.1

MEAN INDIVIDUAL CONTRIBUTIONS

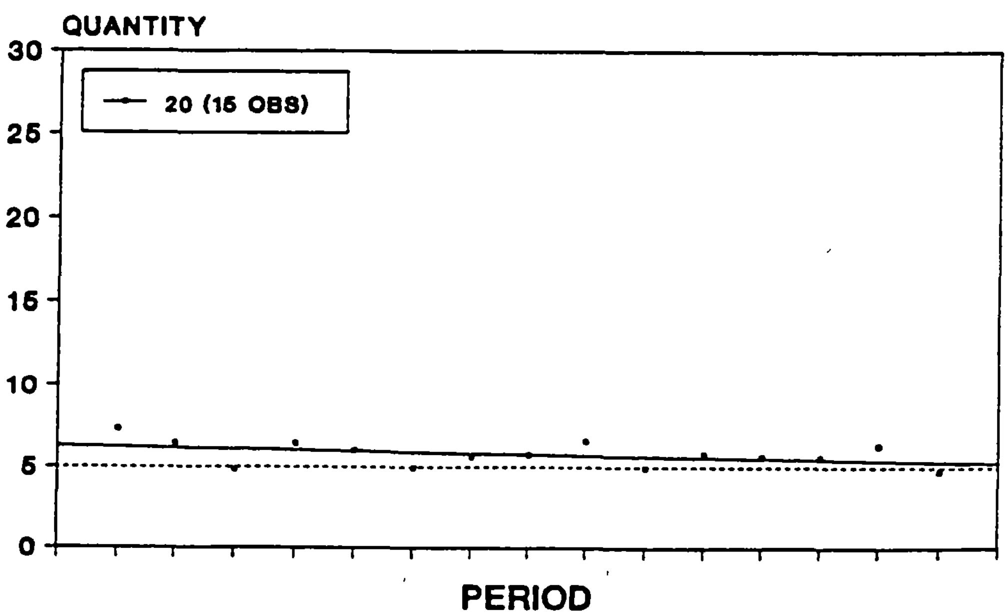
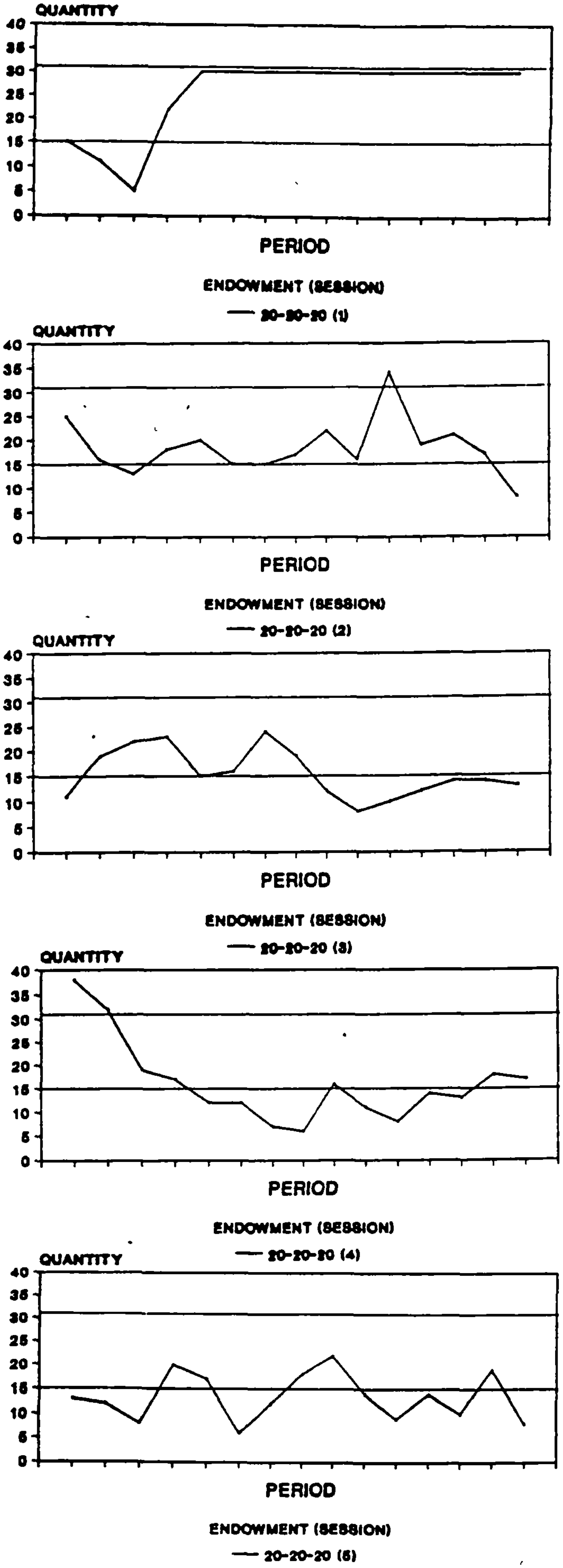


FIGURE A.2

VOLUNTARY CONTRIBUTIONS
TOTAL BY PERIOD

FIGURE A.3

a) b) c) d) e)



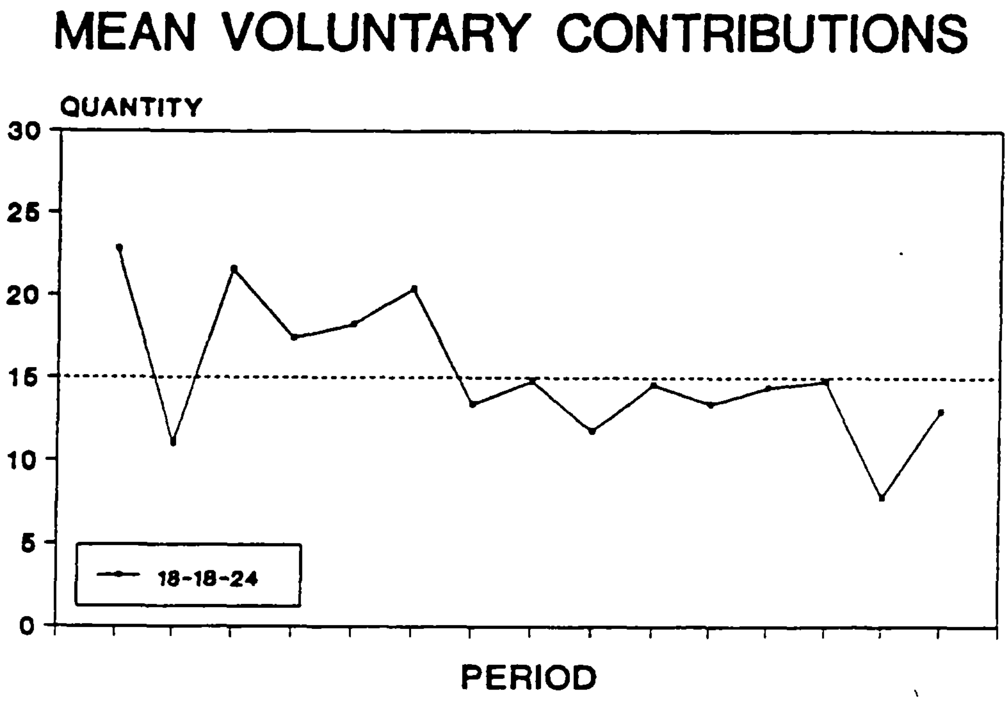


FIGURE B.1

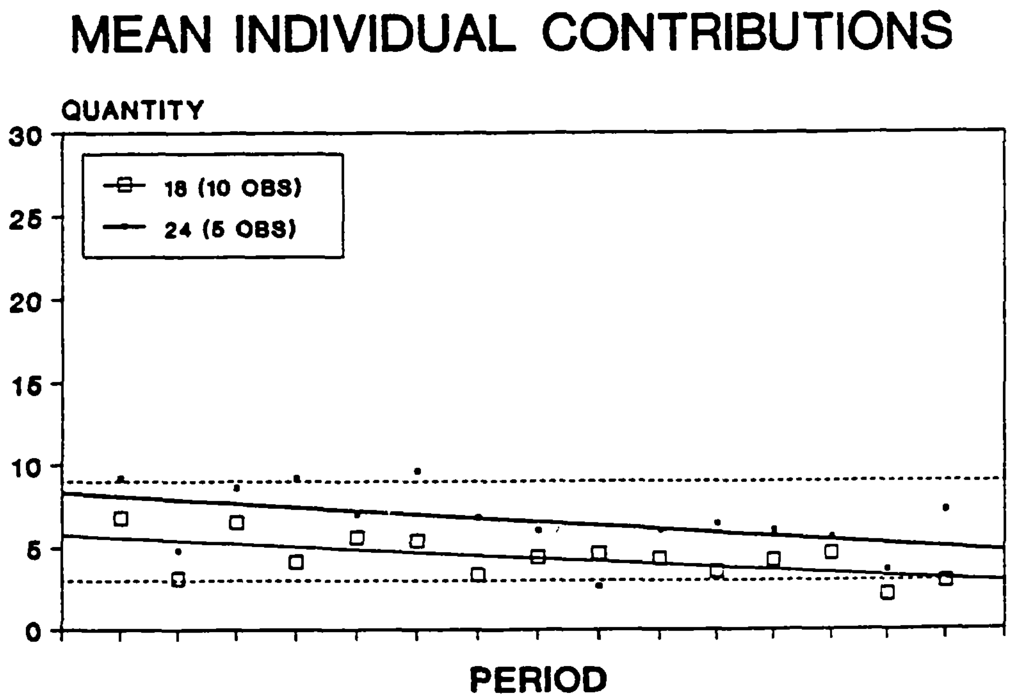
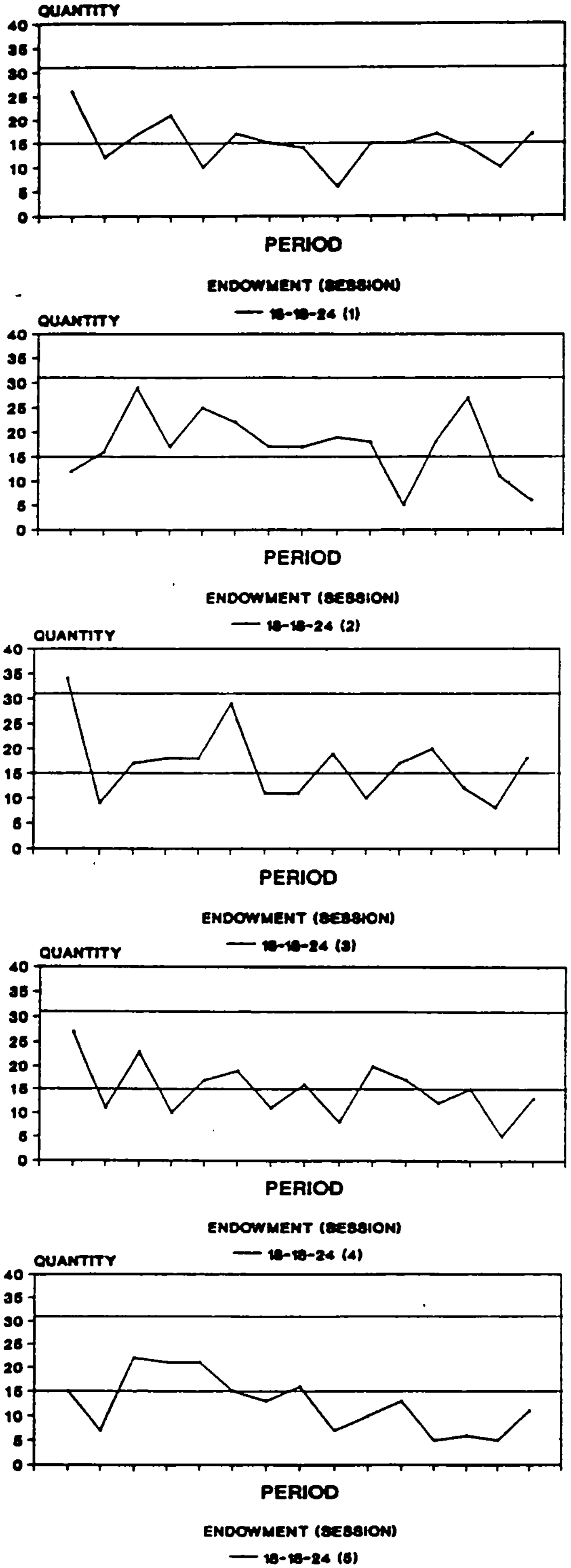


FIGURE B.2

FIGURE B.3

VOLUNTARY CONTRIBUTIONS
TOTAL BY PERIOD

a) b) c) d) e)



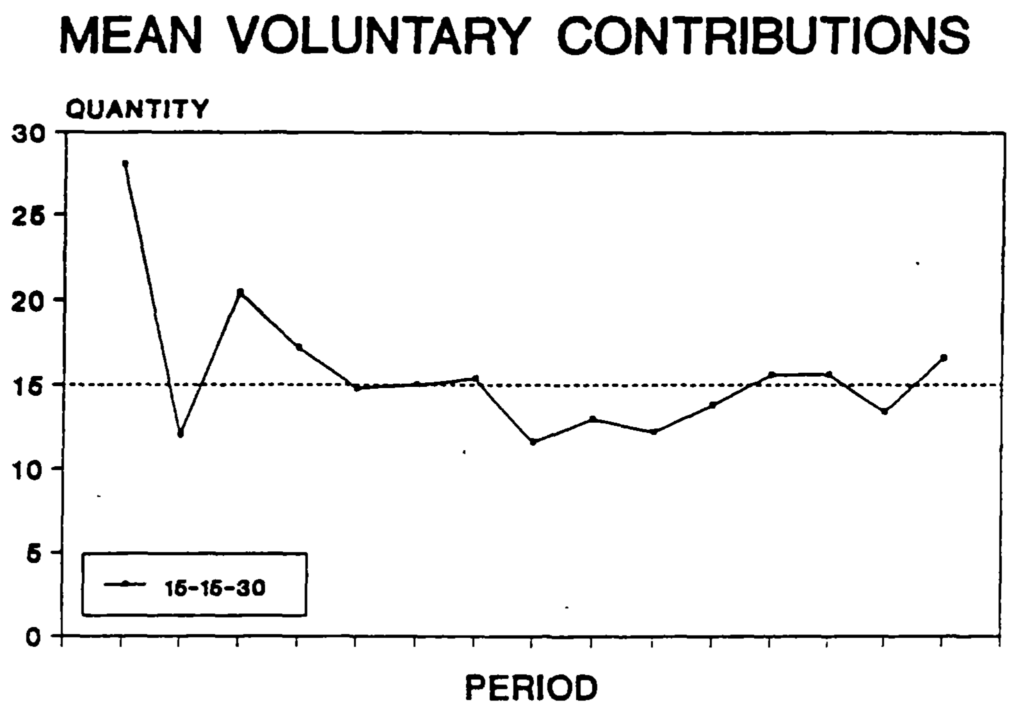


FIGURE C.1

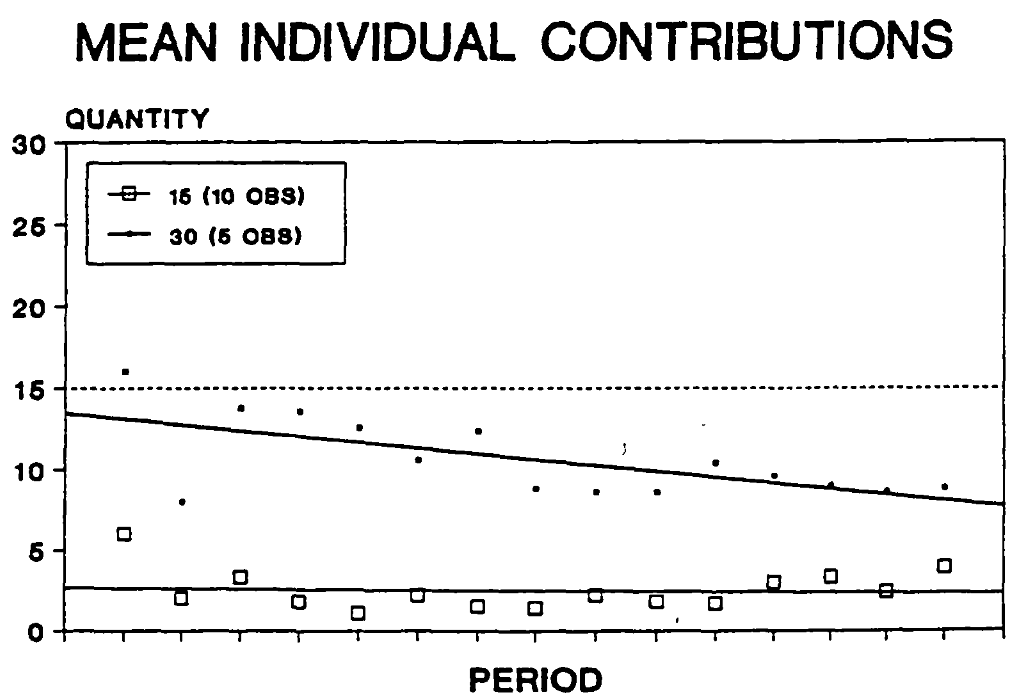
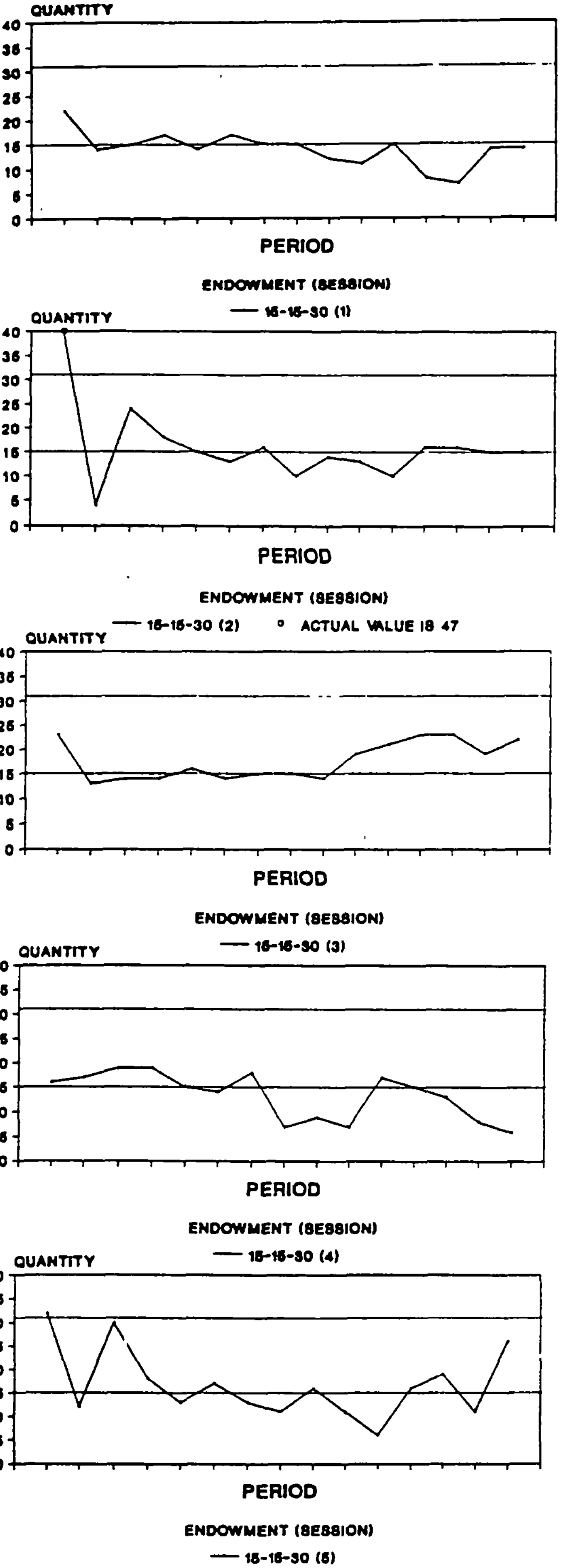


FIGURE C.2

VOLUNTARY CONTRIBUTIONS
TOTAL BY PERIOD

FIGURE C.3

a) b) c) d) e)



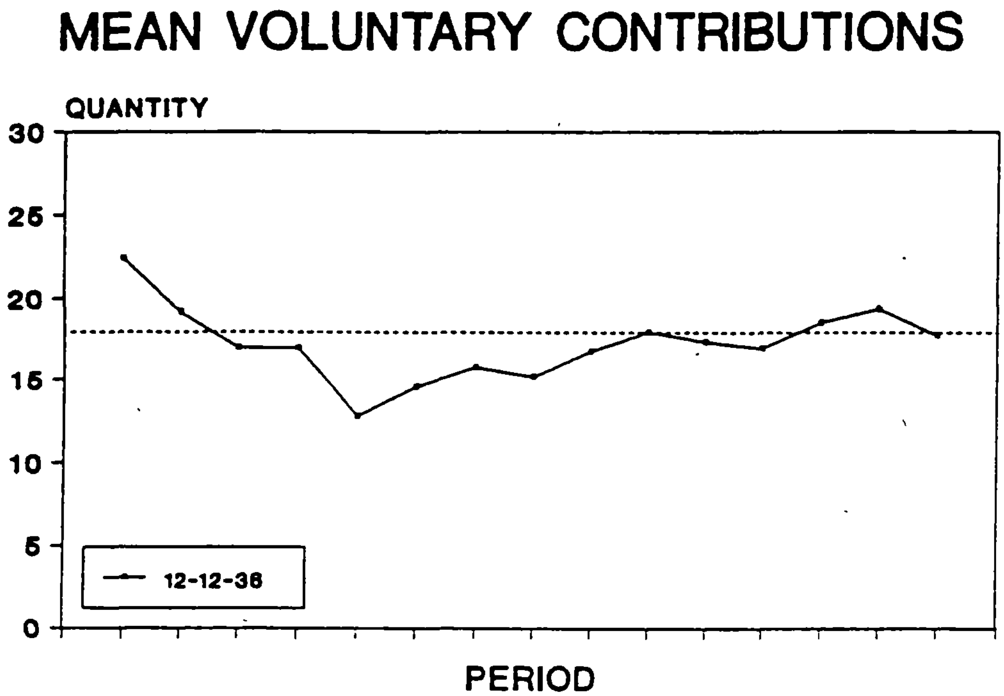


FIGURE D.1

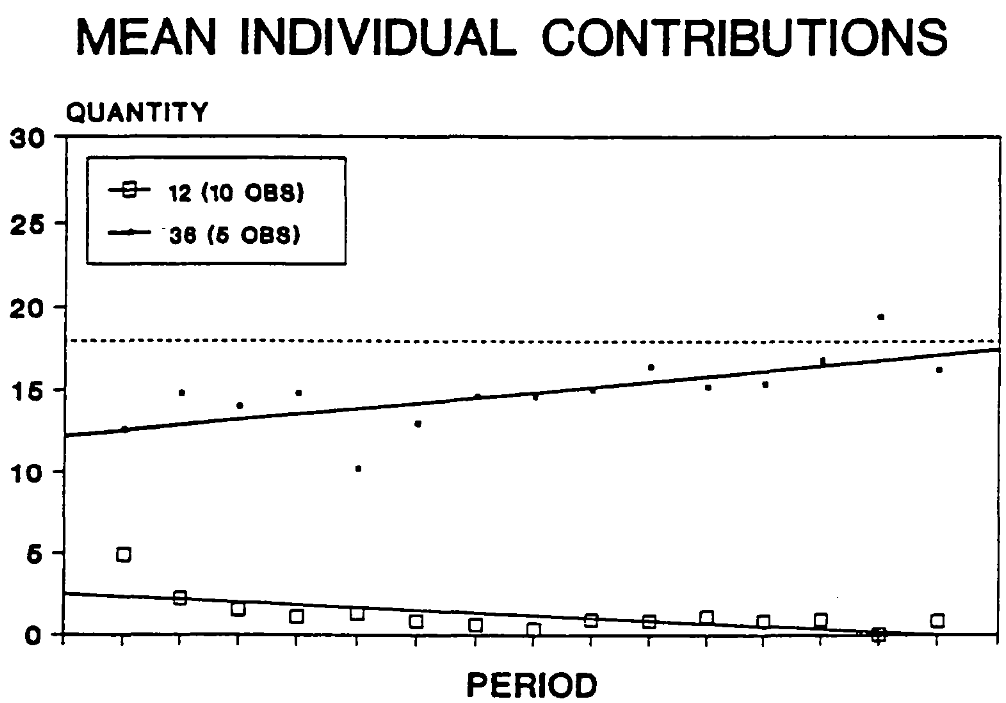
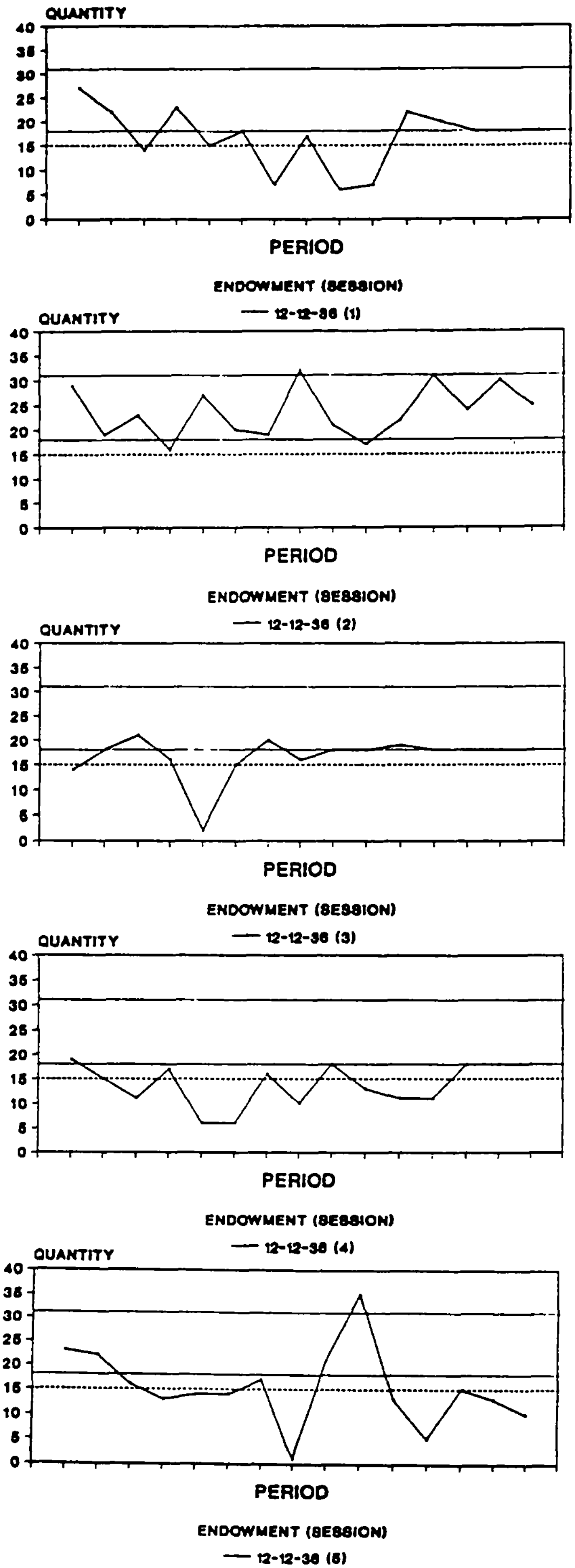


FIGURE D.2

VOLUNTARY CONTRIBUTIONS
TOTAL BY PERIOD

FIGURE D.3

a) b) c) d) e)



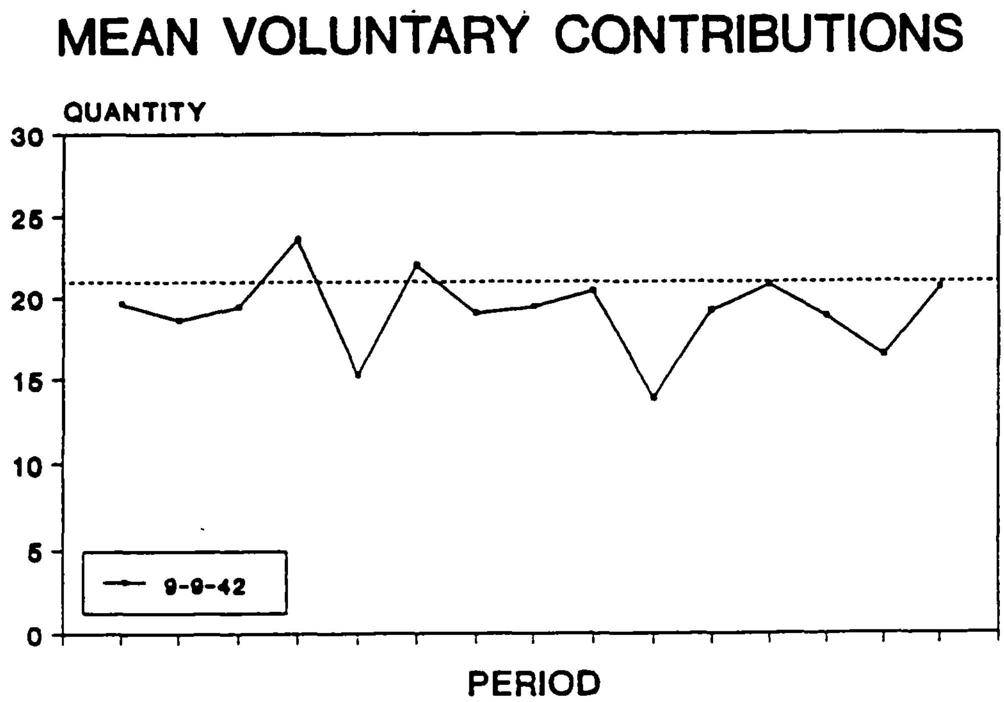


FIGURE E.1

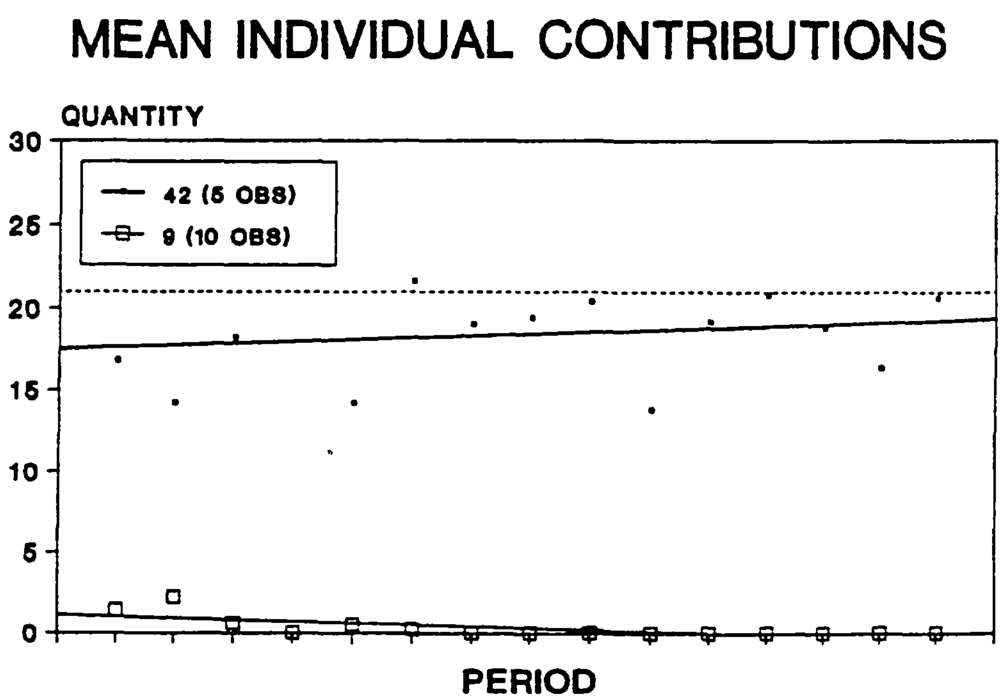


FIGURE E.2

VOLUNTARY CONTRIBUTIONS
TOTAL BY PERIOD

FIGURE E.3

a)

b)

c)

d)

e)

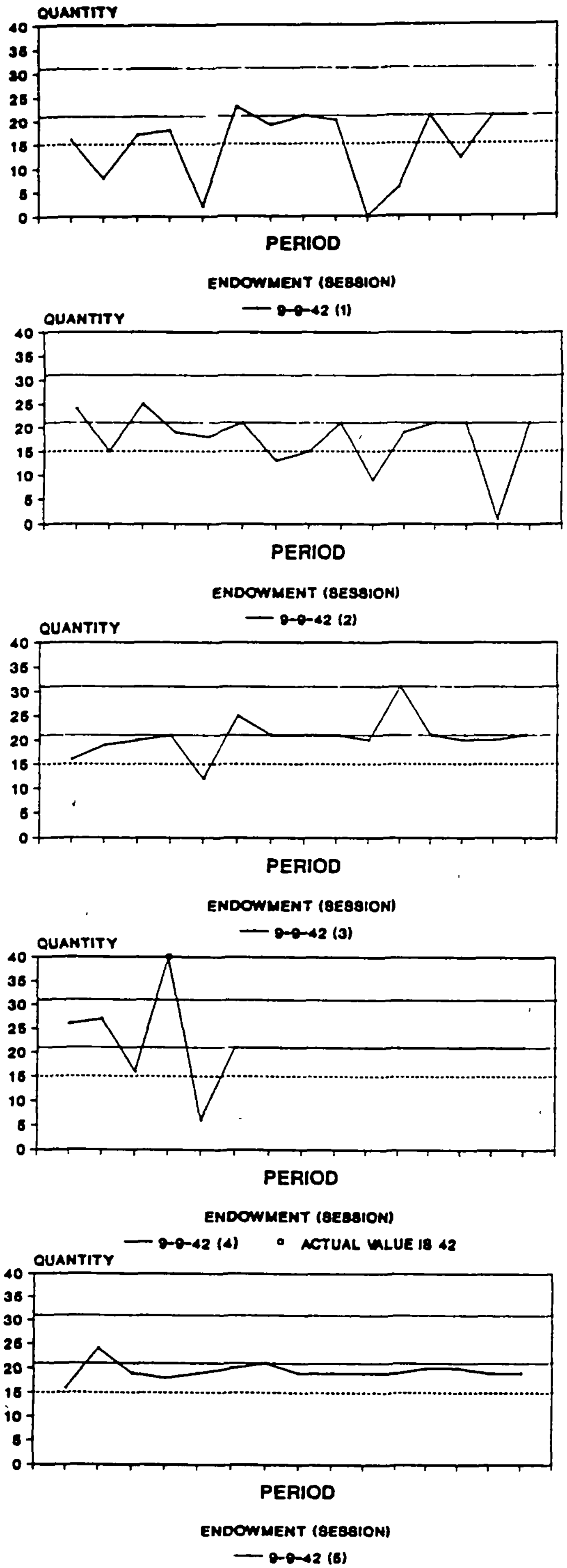


FIGURE 1

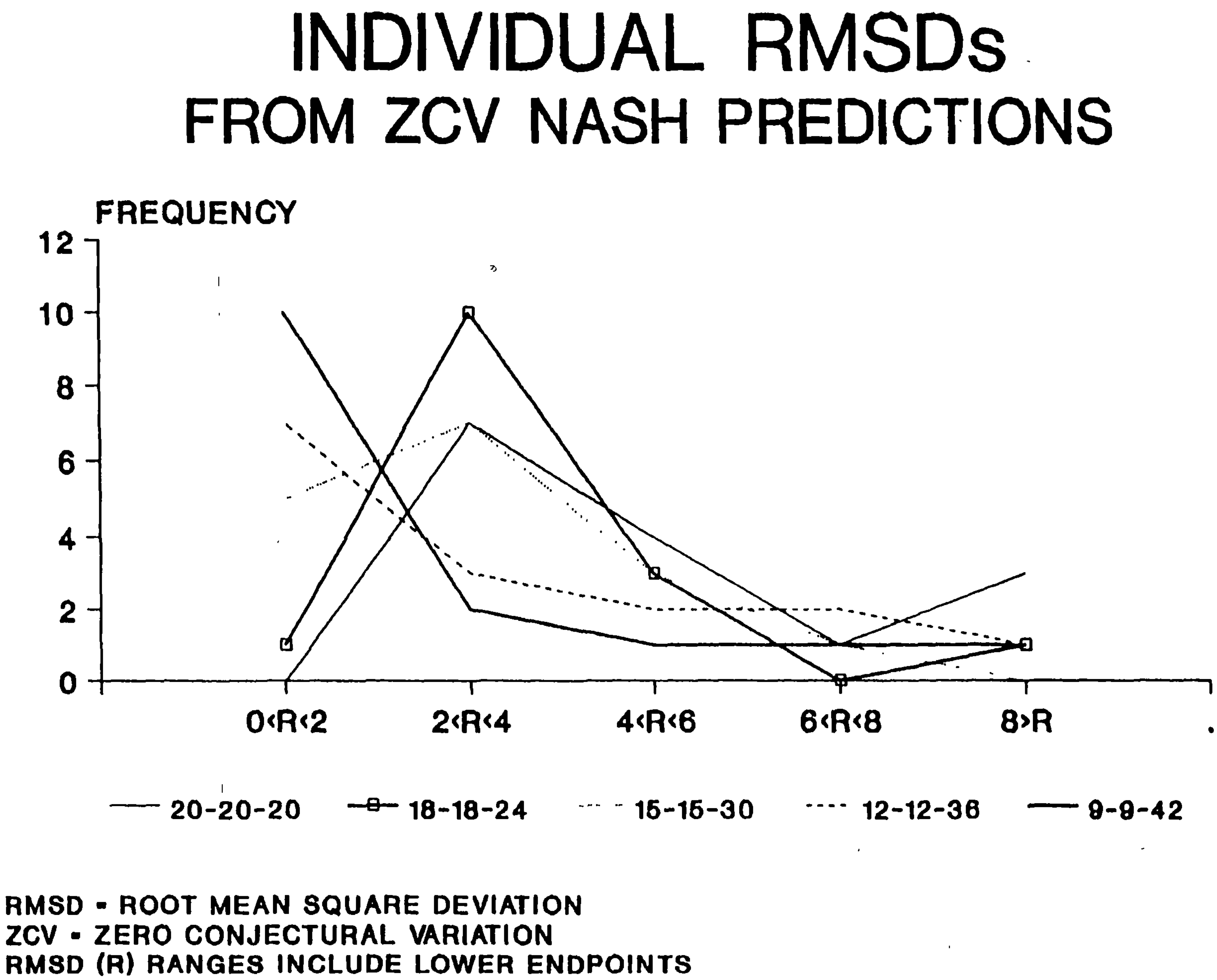

INDIVIDUAL RMSDs
FROM ZCV NASH PREDICTIONS
FREQUENCY
12
10
8
6
4
2
0
0‹R‹2
2‹R‹4
4‹R‹6
6‹R‹8
8›R
20-20-20
18-18-24
15-15-30
12-12-36
9-9-42
RMSD - ROOT MEAN SQUARE DEVIATION
ZCV - ZERO CONJECTURAL VARIATION
RMSD (R) RANGES INCLUDE LOWER ENDPOINTS

FIGURE 2

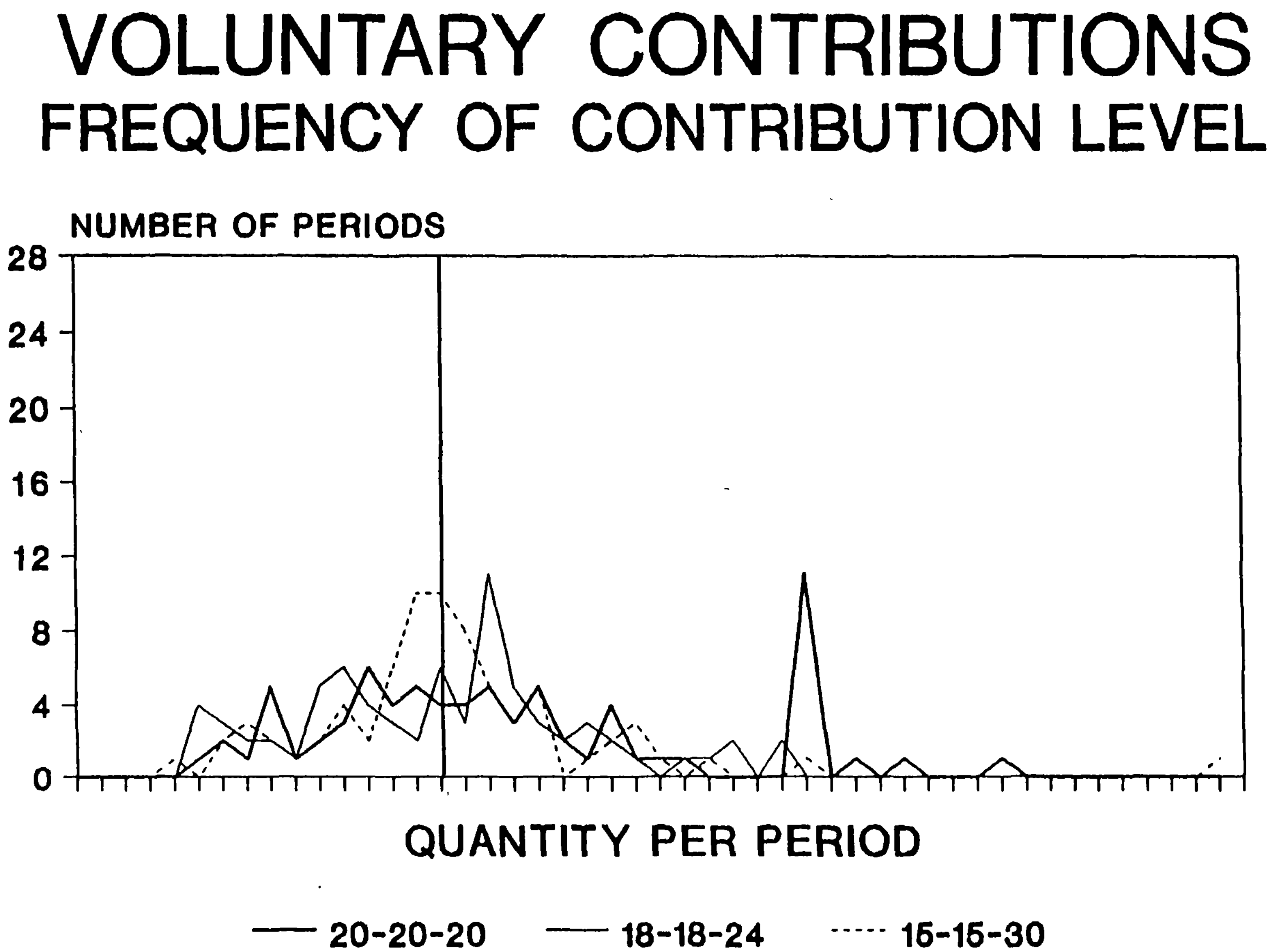

VOLUNTARY CONTRIBUTIONS
FREQUENCY OF CONTRIBUTION LEVEL
NUMBER OF PERIODS
28
24
20
16
12
8
4
0
QUANTITY PER PERIOD
20-20-20
18-18-24
15-15-30

FIGURE 3

VOLUNTARY CONTRIBUTIONS
FREQUENCY OF CONTRIBUTION LEVEL

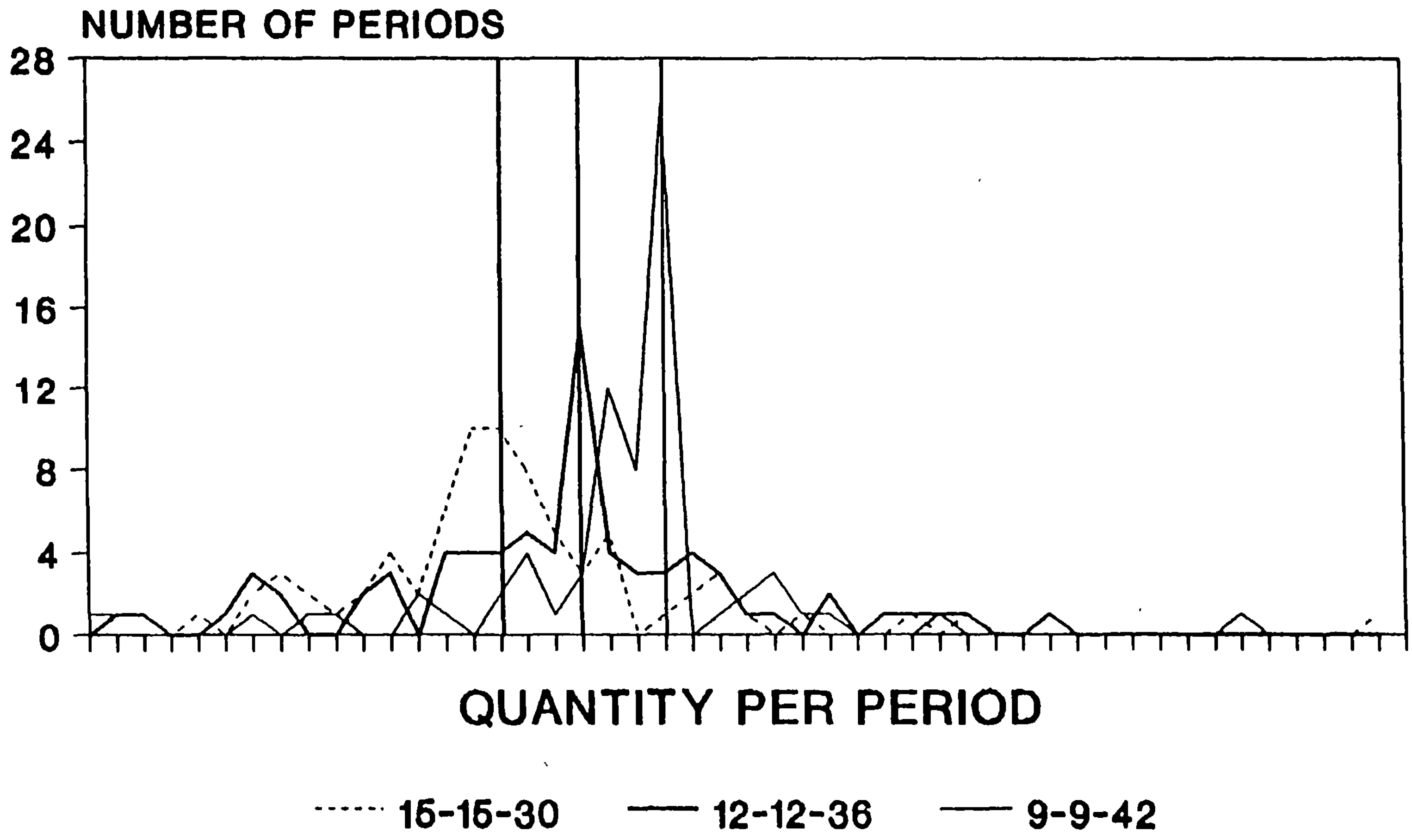
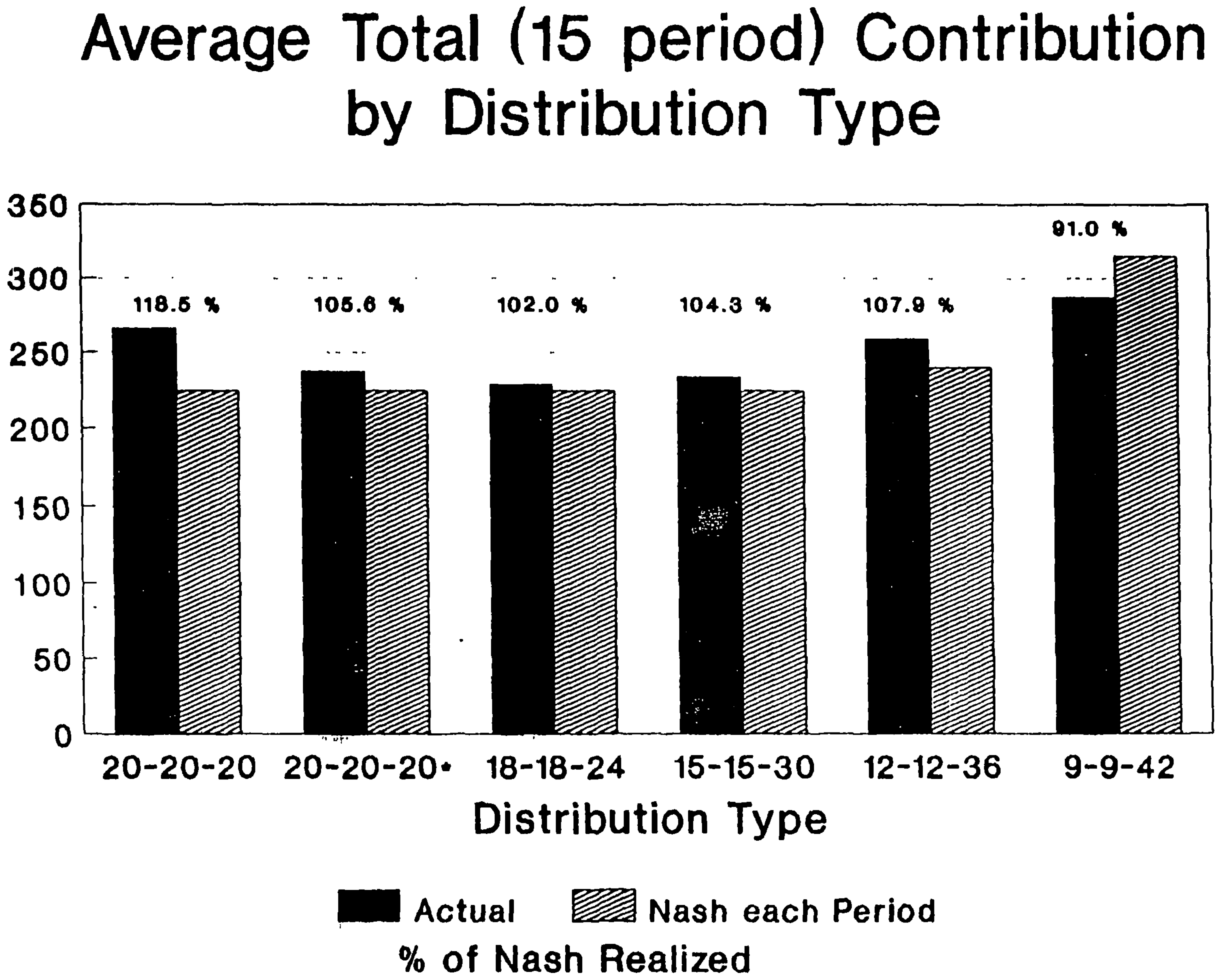


FIGURE 4



Average Total (15 period) Contribution
by Distribution Type
350
300
250
200
150
100
50
0
118.5 %
105.6 %
102.0 %
104.3 %
107.9 %
91.0 %
20-20-20
20-20-20*
18-18-24
15-15-30
12-12-36
9-9-42
Distribution Type
Actual
Nash each Period
% of Nash Realized

APPENDIX

INSTRUCTIONS

General

This is an experiment in economic decision-making. Various research foundations have provided funds for this research. The instructions are simple, and if you follow them carefully, you may earn a considerable amount of money which will be paid to you in cash.

Introductory Instructions

At the start of each round of decision-making, you are endowed with a specific number of tokens. You will have to decide how many tokens will be invested in each of two markets. Your payoff will depend upon the number of tokens you invest in market 1 and the number of tokens you and others in your group invest in market 2. Actually, you only have to make one decision in each round. By deciding the amount to invest in market 2, you will simultaneously determine your investment in market 1. Tokens not invested in market 2 will automatically be invested in market 1.

To assist you in making decisions, you have been provided with a "payoff table" which shows how your payoff will be affected by what you invest in market 2 and what the other members of your group invest in market 2. You also have a "payoff table" which will tell you what each of the other members of the group will earn, based on their investments in market 2 and the investments of the rest of the members of the group.

Included in you folder is a set of sample payoff tables. The numbers on these tables are illustrative only. They do not provide any information about the actual decisions you will have to make after we complete reviewing the instuructions. Please look at Table A on the sheet titled Sample Payoff Tables.

Across the top of Table A are the numbers 0 through 3. These represent the different number of tokens which player 1 may invest in market 2. The numbers 0 through 6 running down the left side of the table are the different number of tokens which players 2 and 3, together, may invest in market 2. Read question 1 on the sheet containing Tables A and B.

To find player 1's earnings you must determine the investment of player 1 in market 2 and the investment made by players 2 and 3, together, in market 2. Player 1 invested two tokens. Players 2 and 3, together, invested four tokens. You can find player 1's payoff by reading across the row associated with an "Investment in Market 2 by Others" of 4 (the fifth row from the top) to the column associated with "1's Investment in Market 2" of 2 (the third column from the left). The intersection of the fifth row and the third column shows a payoff of 70 tokens.

To test your understanding of how payoffs are determined, please answer questions 2 and 3 on the sheet with the sample tables. Write the answers in the places indicated on the sheet.

Market Organization

Included with these instructions, along with the sample payoff tables, are the payoff tables which will be used during this session and a record sheet. on which you will record your investment in market 2 for each round. Also included on the record sheet is your endowment of tokens for investment in markets 1 and 2 in each round.

You are participating in a decision-making session with two other people. You will not know the identity of the members of your group, but you will know their endowments and their payoff tables. The endowments for the other two members of your group are on your record sheet below your endowment. The payoff tables are identified with player numbers.

You will have 3 minutes to decide how many tokens you will invest in market 2 in a round. You may not invest more than your endowment of tokens in this market. You will record your investment in market 2 on your record sheet in the row corresponding to the appropriate round and in the column headed "1's Investment in Market 2" if you are number 1, "2's Investment in Market 2" if you are number 2, or "3's Investment in Market 2" if you are number 3. After three minutes, your record sheet will be collected. When it is returned to you, entries will be made in all of the columns. You should confirm that your payoff is recorded correctly by checking your payoff table for the payoff you should receive given your investment in market 2 and the total investment by the other participants in market 2. You will then have three minutes to make an investment decision for the next round.

When the session ends you will calculate your total payoffs for the sessions. Tokens are converted to dollars at the rate reported on the third line from the top of your record sheet. The session will last for fifteen (15) rounds.

You should not communicate to anyone other than the monitors during the session. If you have any questions, please raise your hand and one of us will help you.

Technical Note

Formally, your payoff will be calculated using the equation

$$\text{Token Payoff} = xY + x + Y \quad (1)$$

where x indicates the number of tokens you invest in market 1 and Y indicates the number of tokens you and the others invest in market 2. xY is equal to the product of x and Y (x times Y). If there are three players in your group, Y can be represented as

$$Y = y_1 + y_2 + y_3 \quad (2)$$

where y_1, y_2, and y_3 are the investments in market 2 made by players 1, 2, and 3, respectively. Each player has the same token payoff function. Each payoff table is constructed from the payoff function. Differences in the payoff tables across players reflect differences in token endowments.

YOUR NUMBER ________ YOUR ENDOWMENT ________

YOUR GROUP NUMBER ________

Endowment for ___ ______
Endowment for ___ ______

Your Token/Dollar Rate ________

Period	1's Investment in Market 2	2's Investment in Market 2	3's Investment in Market 2	Your Payoff
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				

TOTAL PAYOFF ________

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