*RESPONDING ON CONCURRENT-CHAINS SCHEDULES IN
OPEN AND CLOSED ECONOMIES*

MICHAEL H. LAFIETTE AND EDMUND FANTINO

UNIVERSITY OF CALIFORNIA-SAN DIEGO

Pigeons' key pecks were reinforced according to concurrent-chains schedules of reinforcement. The programmed average time from the onset of the initial links to a terminal link entry was held constant across conditions while the value of variable-interval schedules in the terminal links was varied. Performance was assessed under two economic conditions: (a) an open economy in which session duration was limited to 1 hr and subjects were maintained at 80% of their free-feeding body weights with postsession food when necessary; and (b) a closed economy in which sessions were 23.5 hr long and no deprivation regimen was in effect. In all cases, the relative rate of responding in the initial links matched the reduction in overall delay to primary reinforcement correlated with entry into one terminal link relative to the reduction in delay correlated with entry into the other terminal link. Although the sum of responses made in the initial links and terminal links was found to increase, then decrease, as the rate of food presentation decreased in the closed economy, there was no consistent effect of overall rate of food presentation on total responding in the open economy. The choice data suggest that relative delay reduction predicts choice accurately, regardless of economic context.

Key words: choice, delay reduction, closed economy, concurrent-chains schedules, variable-interval schedules, deprivation regimen, key peck, pigeons

Several studies have shown that response rate is a monotonically increasing function of manipulations that produce more frequent reinforcement (Autor, 1969; Catania, 1963; Catania & Reynolds, 1968; Clark, 1958; Farmer, 1963; Ferster & Skinner, 1957; Herrnstein, 1961, 1964; Nevin, 1964; Schoenfeld & Cumming, 1960). The results of Collier, Hirsch, and Hamlin (1972), on the other hand, show that response rate sometimes decreases, rather than increases, as reinforcement is made more frequent. Collier et al. studied 2 rats responding on fixed-ratio (FR) schedules for food rewards and found that, for both subjects, response rate increased as the ratio value was increased. The crucial difference between the results reported by Collier et al. and those from other studies that have examined responding on FR schedules is that the subjects in Collier et al.'s research were housed in their experimental chambers for 24 hr a day; as such, subjects were not maintained explicitly at a fixed body weight, and the total amount of food subjects received per day was determined

strictly through contact with the programmed contingencies of reinforcement.

Hursh (1980) stated that manipulations in reinforcement parameters, such as frequency, will have different effects on behavior depending on whether an open or closed economy is in effect. Hursh defined open and closed economies in terms of whether a subject acquires some (open economy) or all (closed economy) of its daily food during an experimental session. One reason for the atypical results of Collier et al. (1972) was the use of a closed economy. Hursh's analysis and the results of Collier et al. are supported by the results from other studies that have employed closed economies and have used different types of schedules, reinforcers, and subjects. An inverse relation between response rate and frequency of reinforcement has been obtained under fixed-interval (FI) schedules of reinforcement (Allison, Miller, & Wozny, 1979; Lucas, 1981), variable-interval (VI) schedules (Allison, 1980), and concurrent VI VI schedules (Graft, Lea, & Whitworth, 1977; Hursh & Natelson, 1981). The different reinforcers used included water (Allison et al., 1979; Hursh, 1978) and electrical brain stimulation (Hursh & Natelson, 1981); subjects have ranged from pigeons (Lucas, 1981), to monkeys (Hursh, 1978), chickens (Duncan, Horne,

Research supported by NIMH Grant MH-20752 and NSF Grant BNS 83-02963 to the University of California-San Diego. Reprints may be obtained from E. Fantino, Department of Psychology, C-009, University of California-San Diego, La Jolla, California 92093-0109.

Hughes, & Wood-Gush, 1970), and dynamic and obese hyperphagic rats (Teitelbaum, 1957).

Although there are demonstrable differences in the effects of open and closed economies on the relation between rate of reinforcement and response rate, there is no evidence that suggests that molar determinants of choice are any different in a closed economy than in an open economy. Relative rate of reinforcement has been demonstrated to be a major controlling variable of choice behavior (Catania, 1963; Herrnstein, 1961, 1964; see also Williams, 1983), and the results of Baum (1972) showed that when concurrent VI VI schedules of reinforcement were available for 24 hr a day, a pigeon's obtained relative response rates were, just as in an open economy, equivalent to the obtained relative rates of reinforcement.

Many of the variables controlling an organism's choice behavior within open economies have been studied using the concurrent-chains schedule of reinforcement (Autor, 1969). In this procedure, an organism responds on two concurrently available keys, each illuminated by the same stimulus. Responses on each key occasionally produce another stimulus correlated with entry into the terminal link of the chain on that key, and the other key becomes dark and inoperative. Responses in the presence of the terminal link are reinforced with food.

Performance on concurrent-chains schedules has been explained by various models, with each model making similar and accurate predictions of behavior using the programmed values of the schedules of reinforcement. According to the delay-reduction hypothesis, the strength of a terminal-link stimulus as a conditioned reinforcer is a function of the reduction in time to reinforcement correlated with the onset of that stimulus. In terms of relative delay reduction,

$$\frac{P_1}{P_1 + P_2} = \frac{r_1(T - t_1)}{r_1(T - t_1) + r_2(T - t_2)},$$

when $t_1 < T, t_2 < T$,

$$= 1.0, \text{ when } t_1 < T, t_2 > T,$$

$$= 0, \text{ when } t_1 > T, t_2 < T,$$

where P_1 and P_2 are the responses on the two alternatives in the initial links, t_1 and t_2 are the average durations of the two terminal links,

T is the average arranged delay to primary reinforcement from the onset of the initial links, and r_1 and r_2 represent the overall rate of primary reinforcement scheduled on the keys associated with the mutually exclusive terminal links (Squires & Fantino, 1971). The equation states that choice, represented by the relative rate of responding in the initial links, matches the reduction in the average delay to primary reinforcement correlated with entry into one terminal link relative to the reduction correlated with entry into the other.

The delay-reduction hypothesis specifies when there should be exclusive selection of one alternative, when choice between the two alternatives should be indifferent, and how choice will change as the relative reduction in delay to reinforcement is manipulated. In general, when the difference in the relative reduction in time to reinforcement is great, preference tends to be more exclusive in the direction of the alternative that is correlated with the shorter delay. When the difference in relative reduction in delay is made smaller, choice moves away from the alternative with the shorter delay and choice responses are more equally distributed between the alternatives.

It was the purpose of the present experiment to examine the extent to which an organism's choice on concurrent-chains schedules is consistent with delay reduction in a 24-hr closed economy. The main question asked is whether relative rate of responding as a function of terminal-link schedules of reinforcement will differ for subjects in a closed versus an open economy. To this end, pigeons' key pecking on concurrent-chains VI VI schedules was examined in a closed economy of the type used by Collier et al. (1972) and in an open economy in which the time subjects could obtain food was limited to approximately 1 hr. Comparisons of performance under open and closed economies have usually been done between subjects, and sometimes between experiments. In the present experiment the same subjects were exposed to both types of economies.

METHOD

Subjects

Four male pigeons served as subjects. Birds R87 and B54 were White Carneaux and had been trained previously on concurrent-chains

schedules. Birds G45 and G47 were Indian Mondains and were naive at the outset of the experiment. Water and grit were available freely in home cages and were also available in experimental chambers when a closed economy was in effect. All subjects commenced a condition at 80% of their ad-libitum weights regardless of economic context but were maintained at this weight only during the open economy segments of the experiment through supplemental feeding, when necessary, after an experimental session.

Apparatus

A standard operant conditioning chamber with internal dimensions of 30.5 by 30.5 by 40.5 cm was enclosed in a larger wooden box. The wooden box was ventilated at all times by an exhaust fan rated at 45 cfm. The top and sides of the chamber were constructed of clear Plexiglas. A 1-W miniature bulb located in the ceiling near the rear wall provided general chamber illumination. A mounting bar for removable water and grit cups was located on the rear wall, 7 cm above a grid floor. The tops of cups when present in the chamber were no more than 10 cm above the chamber floor. Two pigeon keys, 2.5 cm in diameter, requiring a force of approximately 0.1 N for operation, were mounted on an aluminum front wall. Each key was mounted 25 cm above the floor and 5 cm from the midline plane of the front panel. White, red, or green stimuli were projected on the keys from behind by 28-V IEE in-line projectors. A hopper opening, which was illuminated with white light when food was available, was centrally located 10 cm above the floor. The reinforcer was 3.5-s access to grain. During reinforcement, both the prevailing keylight and houselight were darkened. All experimental events were controlled, and data collected, by conventional electro-mechanical equipment situated in an adjacent room.

Procedure

Birds G45 and G47 were naive subjects. Thus, key pecks in the presence of white, red, and green stimuli on both keys were shaped by the method of successive approximations. These subjects were then exposed to a concurrent-chains schedule (described below) in which initial links and terminal links were

equal VI 5-s schedules of reinforcement. This pretraining was in effect until each subject was pecking both keys reliably (this took an average of nine sessions). Birds R87 and B54 had prior histories of key pecking and were exposed to the first condition in the first session.

In all conditions, the initial links of the concurrent-chains schedules were illuminated white. Terminal-link entry was arranged according to a single VI programmer (Stubbs & Pliskoff, 1969). Each time one of the schedule's interreinforcement intervals had elapsed the next response on the appropriate key produced a colored light, either red or green, and the terminal-link schedule on that key. The probability of entering either the left, or right, terminal link was set at .5. This procedure ensured that the relative number of terminal-link entries obtained on each key would be similar. The mutually exclusive terminal links consisted of VI schedules of food delivery. During reinforcement, keylight and houselight were extinguished; following this, the initial links were again available. Sessions were terminated after 1 hr (open economy) or 23.5 hr (closed economy) unless a terminal link had been entered, in which case the session was terminated after the next scheduled reinforcer had been obtained.

Throughout all experimental conditions the average time from the onset of the initial links to a terminal-link entry was 90 s. The VI terminal-link schedules were 5 s, 15 s, 30 s, 60 s, or 180 s. All VI intervals were derived from the distribution suggested by Fleshler and Hoffman (1962). Table 1 shows the sequence of experimental conditions, terminal-link stimuli and terminal-link schedules for each subject, and predicted choice proportions, from arranged initial-link and terminal-link values, as required by the delay-reduction model.

For each bird, sessions were continued with a given arrangement of terminal-link schedules until the following stability criterion had been satisfied. After 20 sessions the relative rates of responding in the initial links for the previous nine sessions were divided into blocks of three sessions. Performance was considered stable when the means of the three blocks differed by no more than .05 and no upward or downward trend was apparent. Once the stability criterion had been met, the terminal-link schedules were reversed and sessions were con-

Table 1

Order of experimental events, the value (in seconds) of the terminal-link VI schedules used in each condition, and economic context for each subject. Terminal-link stimuli were either red (R) or green (G). Shown in the last column are the choice proportions predicted by the Squires and Fantino (1971) equation based on the programmed values of the terminal-link schedules.

Condi- tion	Terminal link		Economy		Pre- dicted choice proportion
	Left	Right	R87 & B54	G45 & G47	
1	30 (R)	180 (G)	closed	open	.95
	180 (R)	30 (G)			
	30 (R)	180 (G)	open	closed	
	180 (R)	30 (G)			
2	30 (R)	60 (G)	closed	open	.64
	60 (R)	30 (G)			
	30 (R)	60 (G)	open	closed	
	60 (R)	30 (G)			
3	60 (R)	180 (G)	closed	open	.87
	180 (R)	60 (G)			
	60 (R)	180 (G)	open	closed	
	180 (R)	60 (G)			
4	5 (R)	30 (G)	closed	open	.57
	30 (R)	5 (G)			
	5 (R)	30 (G)	open	closed	
	30 (R)	5 (G)			
5	5 (R)	15 (G)	closed	open	.52
	15 (R)	5 (G)			
	5 (R)	15 (G)	open	closed	
	15 (R)	5 (G)			

ducted until relative response rate once again met the criterion for stable responding. A change of conditions occurred only after a subject had been exposed to both economies within a condition.

The closed economy differed from the open economy in that subjects lived in their experimental chambers, the houselight was switched off at 5:45 p.m. and on at 5:45 a.m. each day, body weight was under the subject's control, grit and water were freely available in the experimental chambers, and all food was obtained through contact with the programmed contingencies of reinforcement. Each day at noon the subjects were removed from their chambers for approximately 20 min for weighing and to allow cleaning and maintenance of the chambers and controlling equipment. A subject that had just completed an open-economy condition was, in the next session, introduced either to the same concurrent-chains

schedule but with a closed economy or to a new condition with a closed economy, depending on the subject and the prior condition. For a subject that had just completed a closed-economy condition, the mean weight taken from the last five sessions was designated as that subject's new ad-libitum weight (the subjects' initial free-feeding body weights and weights after closed economy conditions are shown in Appendix 1). The subject was then deprived systematically of food, in the home cage, until body weight was 80% of this new ad-libitum weight. Subsequent to the deprivation regimen the subject was then exposed to the same condition but with an open economy or to a new condition and an open economy, depending on the subject and the prior condition. Accordingly, Subjects G45 and G47 were placed on deprivation regimens between conditions, and Subjects R87 and B54 were placed on deprivation regimens within conditions (see Table 1).

Responses in both the left and right initial links and in the terminal links, the number of terminal-link entries on both chains, and time spent in the presence of the initial links and terminal-link stimuli were recorded separately for each bird. In addition to these measures, the time the subject engaged in keypecking in the initial links was assessed by having the first response in an initial link, either at the start of a session or after the initial links had been reinstated following reinforcement, start a clock which operated for 3 s. Responses during this period had no effect on the operation of this timer. Once the 3-s clock had elapsed it was reset, and the next initial-link response after the clock was reset restarted the clock, unless that response produced a terminal link. If the 3-s timer was active when a terminal link was entered, timing was immediately terminated and the clock was reset. A running time meter recorded the cumulative time that the 3-s clock was active during the initial links. This measure of cumulative time spent responding during the initial links (working time) provided an additional time base for calculating initial-link response rates.

RESULTS

All data represent the average of the mean from the last five sessions from the initial exposure to a pair of terminal-link schedules and

Fig. 1. Obtained overall relative rate of responding (choice proportion) for each bird in the open economy (open squares) and closed economy (filled squares) as a function of increasing the programmed relative delay reduction correlated with entry to the shorter terminal link (Conditions 5, 4, 2, 3, 1, in that order). The open triangles in each graph represent choice proportions predicted by the Squires and Fantino (1971) model for the terminal-link schedules presented in Table 1.

the mean from the last five sessions from the reversal of those schedules. Initial-link responses, terminal-link responses, and the number of obtained reinforcers on each chain in all conditions can be found in Appendix 1. Also shown in Appendix 1 are the initial body weights of each subject and body weights subsequent to each closed-economy condition. The average time spent in the initial links and each terminal link, working time in the initial links, and the number of sessions in each condition can be found in Appendix 2.

Figure 1 shows for each bird the obtained relative rate of responding (the rate of responding on one key in the initial links divided by the rate of responding on both keys in the initial links) averaged across reversals for the key leading to the shorter terminal link as a function of increasing the programmed relative

reduction in time to primary reinforcement correlated with terminal-link entry on that key (Conditions 5, 4, 2, 3, and 1, in that order). Also shown in each graph are the choice proportions predicted by the delay-reduction hypothesis as presented in Table 1 (open triangles). By comparing, for each subject, the filled and unfilled squares, Figure 1 shows that obtained choice proportions were affected systematically by the relative delay reduction associated with the terminal links and not by economic context. For all subjects, regardless of economy, the relative rate of responding for the key leading to the shorter terminal link increased as the relative delay reduction for that key increased. In all cases, obtained choice proportions and the direction in which they changed as a function of the relative difference in the terminal-link schedules were well de-

Table 2

Responses per minute during the initial links and terminal links for each bird in each condition in the open economy and the closed economy. Working response rate refers to responses per minute pecking the keys in the initial links only. Richer and leaner refer to the terminal-link schedules. Conditions are presented in order of increasing programmed relative delay reduction correlated with the shorter terminal link.

Condi- tion	Absolute response rate				Working response rate	
	Initial links		Terminal links		response rate	
	Richer	Leaner	Richer	Leaner	Richer	Leaner
Open economy						
R87						
5	24.2	19.0	71.9	26.5	24.4	19.2
4	12.6	9.1	64.8	19.2	13.0	9.4
2	13.9	9.3	81.8	22.6	14.8	9.9
3	21.6	4.1	45.1	4.4	22.2	4.2
1	62.0	2.6	91.9	4.0	67.0	2.8
B54						
5	21.7	15.7	89.9	16.3	21.9	15.9
4	20.5	16.8	72.4	21.6	21.2	17.3
2	11.2	8.8	55.8	16.0	12.6	9.9
3	15.9	2.5	53.3	8.7	17.1	2.7
1	37.8	2.8	169.5	9.2	42.2	3.2
G47						
5	19.1	17.1	130.6	41.5	19.3	17.1
4	20.4	16.7	119.2	20.1	19.0	17.0
2	16.9	13.8	94.9	30.3	17.8	14.4
3	19.3	3.5	102.0	13.2	19.7	3.6
1	41.2	5.6	176.2	9.2	42.3	5.8
G45						
5	16.7	13.7	142.5	32.3	16.9	13.8
4	11.1	8.4	122.8	22.3	11.3	8.6
2	18.9	10.8	121.9	29.7	19.0	10.9
3	19.1	2.9	65.1	10.4	20.2	3.0
1	18.6	2.3	121.2	10.3	19.2	2.4
Closed economy						
R87						
5	3.6	3.5	112.5	66.9	12.2	11.7
4	5.6	3.9	88.6	13.7	20.0	13.9
2	5.7	3.8	37.9	9.2	18.1	12.1
3	5.2	0.6	23.1	1.5	23.1	2.5
1	8.1	0.3	64.9	3.7	27.0	0.8
B54						
5	7.2	6.9	137.8	50.0	18.4	17.7
4	12.3	6.3	122.6	19.7	32.0	16.5
2	11.7	4.8	85.8	32.4	20.2	8.2
3	7.8	1.4	42.5	9.2	19.9	3.5
1	9.9	0.8	103.0	12.1	21.7	1.6
G47						
5	3.4	3.3	42.1	11.7	18.4	17.7
4	7.7	5.6	44.9	10.0	43.2	31.3
2	6.3	4.2	24.3	6.1	33.7	22.4
3	5.9	1.3	24.2	2.9	28.3	6.2
1	7.5	0.8	27.5	2.0	36.3	4.0

Table 2 (Continued)

Condi- tion	Absolute response rate				Working response rate	
	Initial links		Terminal links		response rate	
	Richer	Leaner	Richer	Leaner	Richer	Leaner
G45						
5	4.9	4.0	115.3	28.6	19.0	15.5
4	7.5	5.0	92.4	21.7	27.1	18.1
2	11.9	7.3	27.6	6.5	28.2	17.3
3	11.5	1.9	34.4	4.8	34.0	5.5
1	17.0	1.3	72.1	3.6	39.5	3.0

scribed by the delay-reduction model. There were two cases in which the obtained choice proportions were, for all subjects, more extreme than those predicted by the delay-reduction model (Condition 4, closed economy, and Condition 5, open economy); across conditions and subjects, however, there was no systematic deviation of obtained choice proportions from those predicted due to economic context. The mean absolute deviation was .03 for conditions conducted under the open economy and .03 for conditions within the closed economy.

Absolute response rates in the initial links and terminal links for each bird, in each condition, are shown in Table 2. Also shown in Table 2 are the working response rates in the initial links. The working initial-link rates differ from the absolute response rates in that the time frame used for calculating rate was based on accumulated time spent key pecking and not on absolute time in the presence of the initial-link stimuli (see Appendix 2). For all subjects in all conditions, absolute and working response rates in the initial link and absolute rates in the terminal link of the chain schedule providing more frequent reinforcement were higher than in the chain providing less frequent reinforcement, regardless of economic context. Absolute rates in either initial link tended to be higher in the open economy than in the closed economy. Response rates in either terminal link, for 3 subjects, tended to be higher in the open economy than in the closed economy; for Subject B54 the opposite was true (terminal-link rates tended to be higher in the closed economy than in the open economy). For all subjects in all conditions, the average time between reinforcers, once a terminal link had been entered, was very close to the scheduled rate, regardless of economic context (time

spent in a terminal link divided by the number of reinforcers obtained in that terminal link, see Appendices). With the exception of Subject G45, there was no systematic effect of economy on measures of working response rate; the working rates for Subject G45 were, in all conditions, higher in the closed economy than in the open economy.

Finally, presented in Table 3, are the total responses emitted (the sum of responses made in the initial and terminal links) for each subject as a function of decreasing rate of food presentation. Reward density was varied by manipulating the outcome schedules to produce variations in the time between available food reinforcers. In the open economy, all subjects emitted the fewest total responses during the schedule that provided less frequent overall reinforcement (Condition 3); however, there was no systematic effect of changes in reward density on total behavior emitted. For all subjects in the closed economy, the total number of responses emitted first increased as the average delay to food was increased, then decreased as the average delay to food was further increased.

In the closed economy, the number of reinforcers obtained by each subject fell far short of the maximum number attainable, but as can be seen in Appendix 1, body weight was defended across conditions. The average time spent in the initial links (absolute time in the initial links, Appendix 2, divided by total number of obtained reinforcers, Appendix 1) before a terminal-link entry occurred was much greater than the average duration of 90 s arranged by the initial-link schedules, whereas obtained initial-link times in the open economy did not deviate systematically from programmed times. In all conditions, the average time between reinforcers once a terminal-link had been entered was very close to the scheduled rate regardless of subject, condition, or economic context (time spent in a terminal link, Appendix 2, divided by the number of reinforcers obtained in that terminal link, Appendix 1), and the number of obtained reinforcers was approximately equal between the two chain schedules.

DISCUSSION

The results indicate that the same variable, relative reduction in delay, accounts for choice in both open and closed economies. All subjects

Table 3

Total responses emitted as a function of increasing the average delay to food from the onset of the initial links for each subject in the open economy and the closed economy. In all conditions the average time from onset of the initial links to terminal-link entry was 90 s; terminal-link schedule values are reported in seconds, and the number in parentheses indicates their order of presentation. All data have been rounded to the nearest whole number.

Terminal-link schedules	Subjects			
	R87	B54	G47	G45
Open economy				
VI 5 vs. VI 15 (5)	2,422	2,196	2,237	1,908
VI 5 vs. VI 30 (4)	1,311	2,052	2,122	1,273
VI 30 vs. VI 60 (2)	1,616	1,297	2,051	2,141
VI 30 vs. VI 180 (1)	2,264	2,088	2,265	1,420
VI 60 vs. VI 180 (3)	1,204	1,120	1,679	1,410
Closed economy				
VI 5 vs. VI 15 (5)	12,003	23,501	9,992	15,072
VI 5 vs. VI 30 (4)	14,334	27,631	18,631	19,327
VI 30 vs. VI 60 (2)	15,055	31,876	14,857	25,120
VI 30 vs. VI 180 (1)	12,884	21,605	10,592	22,929
VI 60 vs. VI 180 (3)	8,605	17,107	10,377	17,921

responded in the initial links of concurrent-chains VI VI schedules in a manner consistent with predictions of the delay-reduction model, regardless of economic context. This study differs from previous studies in that the same subjects were examined in both an open and a closed economy and that session lengths used in the closed economy were approximately 24 hr in duration. In the closed economy, subjects were able to maintain a stable weight across conditions, and delay-reduction predictions of preference were unaffected by naturally occurring deprivation and satiation. The obtained choice proportions were in no way forced by the procedure. The subjects could have distributed their responses in almost any manner and still received the number of reinforcers needed to maintain their daily requirement of food.

The present results confirm and extend the findings of previous studies showing that the delay-reduction model provides a reasonable account of choice behavior in open and closed economies (Abarca, Fantino, & Ito, 1985; Fantino & Abarca, 1985). However, the closed economies in the earlier studies involved relatively short (2- to 3-hr) sessions. The use of a 24-hr closed economy in the present study is of some import, given that there is disagreement on the appropriate conditions that define

a closed economy. Hursh (1980), for example, defines closed and open economies in terms of whether a subject acquires some (open economy) or all (closed economy) of its daily food during the experimental session; Collier and Rovee-Collier (1981), on the other hand, claim that the critical distinction is whether or not an animal controls the initiation and termination of its meals (closed economy) or not (open economy). Subjects in the closed economy used by Abarca et al. (1985) and Fantino and Abarca (1985), although allowed to obtain all of their daily food in the experimental session, were limited to an arbitrary number of reinforcers per day; as such, these studies meet the criteria established by Hursh for a closed economy but not those proposed by Collier and Rovee-Collier. In the present closed economy, subjects could initiate eating at any time in the course of a 24-hr session by completing the schedule requirements, were relatively unlimited with respect to the amount of food they could consume, and no effort was made to prevent subjects from becoming sated. Although meals were obtained in parts (i.e., hopper durations of 3.5 s), subjects were in strict control of how long it took to obtain enough food to comprise a meal. The present experiment is closer to satisfying both conceptions of a closed economy than previous efforts that have examined performance on concurrent-chains schedules.

Along with differences in the conditions of daily food intake, the present open and closed economies differed with respect to three other variables: session duration, deprivation level, and feeding versus no feeding outside of the experimental situation. These variables covaried with changes in economic context and constitute a potential confound in any study that uses as an independent variable the type of nominal economy differences presented here. Similar problems associated with a within-subjects comparison of the effects of closed versus open economies have been discussed with respect to successive schedule performance (LaFiette & Fantino, 1988). Because the terminal links of concurrent-chains schedules may be viewed as successively presented schedules (see Wardlaw & Davison, 1974), and the effects of these variables (those related to open and closed economies) on responding in successive schedules are well documented (Elliffe & Davison, 1985; Herrnstein & Loveland,

1974), there is the possibility that these factors might have interacted to produce the present results. However, other studies that have examined simultaneously available schedules of reinforcement with closed economies have not found any differences in obtained relative response rate as a function of economic context (Abarca et al., 1985; Baum, 1972, 1974; Fantino & Abarca, 1985; Graft et al., 1977). The result that obtained choice proportions were no different from predicted values, and the fact that this result was obtained with an experimental design that did not control for differences in session duration, deprivation level, or postsession feeding, strengthens the proposition that a fundamental determinant of choice is the relative reduction in delay to reinforcement.

Initial-link response rates were greater in the open economy than in the closed economy, and the difference between measures of absolute response rates and working response rates were greater in the closed economy than in the open economy. These differences most likely reflect the effects of session duration on the time bases used for calculating the measures of rate. Although most of the available time in an open economy is devoted to pecking, in 24-hr sessions there are extended periods of nonresponding (Elliffe & Davison, 1985; Lucas, 1981). When this "dead time" is incorporated in the time base used for calculating response rates, rates will be lower than rates based on a time measure in which such periods are excluded. Terminal-link response rates were always higher in the link that provided more frequent reinforcement, regardless of economy. There was no systematic effect of economy on terminal-link response rates. When one terminal-link schedule was lengthened and the other was not (e.g., Conditions 2-1, 2-3, 4-1, 4-2), response rate in the unchanged terminal link increased for all subjects in both the open and closed economy; this occurred for Subject G47 in the closed economy when the VI 15-s terminal link was lengthened to a VI 30-s schedule. This result is similar to the contrast effect seen on multiple schedules, which occurs when only one of two successively available reinforcement schedules is lengthened (Reynolds, 1961). This result has been demonstrated previously on concurrent-chains schedules, but only with short sessions (Hursh & Fantino, 1973). The interaction between

responding in the terminal links of the present study is consistent with the claim by Wardlaw and Davison (1974) that the terminal links of a concurrent-chains schedule are functionally equivalent to successive reinforcement schedules. However, there were no conditions in which obtained terminal-link response ratios were more disproportionate with respect to terminal-link reinforcer ratios in the closed economy than in the open economy, a result previously demonstrated on multiple schedules in a closed economy (Elliffe & Davison, 1985; LaFiette & Fantino, 1988).

Prior studies have suggested that whereas responding is a direct function of reinforcer rate or magnitude in open economies, it is an inverse function of these variables in closed economies. In the present experiment, there was no systematic change in the open economy as overall food rate was varied, whereas in the closed economy total responses increased, then declined. The finding that behavioral output declined in a closed economy as food became more scarce (Conditions 2, 1, and 3, in that order) is inconsistent with a number of other closed-economy studies in which food availability has been manipulated (e.g., Collier et al., 1972; Hursh & Natelson, 1981).

One possible explanation for the difference between these results and those of earlier closed-economy studies centers on the chaining aspect of the concurrent-chains procedure. With the notable exception of Ferster and Skinner (1957), there have been no studies that have examined pigeons' performance on chained VI VI schedules with session durations greater than 2 to 3 hr, and except for some data from Findley (1959), none of the dozen (or so) prior studies that have explored the relationship between reinforcement parameters, such as rate and magnitude, and responding in 24-hr closed economies have involved chained schedules. In Findley's study, a single male marmoset monkey, housed in its experimental chamber, could obtain food, water, or light by completing a chain $FR_x FR_1 FR_x$ schedule. The value x was varied from 5 to 320 with the value of the first and last FR equal. It was found that total response output increased linearly between ratio values of 5 and 80, but as the ratio values were increased above 80, total responses were substantially lowered and decreased dramatically as the ratio schedule was further increased. Findley's

data are indeed suggestive of the possibility that in chains one sees response decrements in the face of depleting resources under a closed economy.

It may be that the lack of a monotonic function between behavior and reward density found in the present study was due to the chaining of schedules that do not easily allow for intake defense. One explanation for the typical inverse relationship between responding and reward found in closed economies centers on the fact that only in closed economies is the subject's food intake completely dependent upon its performance in the experimental session. Thus, in order to defend its daily intake the subject responds at a higher rate as food becomes more scarce. Because the present study was designed to assess the adequacy of the delay-reduction hypothesis in 24-hr closed economies, VI schedules were employed. Over a wide range of response rates, such schedules do not enable subjects to increase their rate of food intake appreciably by increasing rate of responding. Responding during the VI terminal links was insensitive to changes in terminal-link VI values, whereas responding in the choice phase was sensitive to changes in the outcome schedules but reflected the opposite of intake defense. The relative sensitivities of initial-link and terminal-link behavior to changes in terminal-link schedules has been demonstrated in studies that have used short sessions (e.g., Kelleher & Gollub, 1962; Lendenmann, Myers, & Fantino, 1982). Perhaps, in a closed economy, the "psychological distance to reward" (Duncan & Fantino, 1972) is sufficiently great in chained schedules that an objectively rich rate of reward is responded to as a lean rate. This suggests that the use of schedules that permit an organism to affect more readily its rate of intake would lead to the more common closed-economy finding. For example, had a form of ratio schedule been employed rather than VI schedules perhaps total responding would have increased as the overall delay to food was increased. (Other researchers, including Hursh, 1978, Allison, 1980, and Hursh & Natelson, 1981, however, have obtained an inverse relation between frequency of reinforcement and responding with VI schedules.)

There is another possible explanation for the atypical closed-economy results of the present study. Timberlake and Peden (1987) have

suggested that the observed differences in responding found in open and closed economies are not due to economic context per se but are due to the presence of a bitonic function that relates behavior to reward density. The bitonic function supported by Timberlake and Peden takes the form of an inverted U, where the ordinate and abscissa correspond with increments in responding and reward density, respectively. An implication of this function is that a given change in reward density will serve either to increase or decrease behavioral output depending on which side of the bitonic function the change has occurred. Timberlake and Peden suggested that the typical closed-economy finding of an inverse relation between responding and reward frequency is the result of employing schedules of reinforcement that are representative of the descending limb of the bitonic function (i.e., fewer responses with richer schedules), whereas the typical open-economy finding could be explained by subjects making contact with only the ascending limb (i.e., more responses with richer schedules). According to Timberlake and Peden, inverse functions should also be evident in an open economy because the determinants of the function are the same in both cases: the cost of instrumental responding relative to the payoff, which in this case is access to food; and due to the symmetry of the bitonic function there should also be cases in which the traditional open-economy finding of response decrements in face of declining reward frequency occurs within a closed economy.

Thus, it may be that the anomalous closed-economy finding of response decrements as a function of increasing the time between available rewards with a concurrent-chains procedure was due to making contact with the ascending limb of the bitonic function. In the present experiment, when richer schedules were employed (Conditions 4 and 5), the more traditional closed-economy result was seen; there was an inverse relation between rate of food presentation and responding. The pattern of the closed-economy results shown in Table 3 supports the analysis proposed by Timberlake and Peden (1987); however, the lack of any systematic changes under the open economy undermines the generality of such an interpretation.

Time in the initial links varied as a function of economy. In the open economy, initial-link

times were close to arranged times. In the closed economy, obtained initial-link times were much greater than arranged values. This result suggests that in the closed economy the experienced amount of relative delay reduction signaled by a terminal-link entry may be less than the programmed amount. In experiments using short session durations, as required by the delay-reduction hypothesis, the longer the initial-link times the more indifferent an organism becomes between the terminal links (Fantino, 1969). Accordingly, subjects in the present closed economy should not prefer either initial link (choice proportions around .50) in any condition because the relative reduction in delay to reinforcement signaled by a terminal-link entry would be approximately equal, regardless of the value of the terminal-link schedules; yet, there was no systematic deviation of obtained choice proportions from those predicted by the delay-reduction model, based on scheduled initial-link values in the present closed economy.

The results of Fischer and Fantino (1968) suggest a possible mechanism by which choice behavior can be controlled by arranged values, despite large deviations between experienced and arranged initial-link times that occur in 24-hr sessions. In a within-session satiation procedure, Fischer and Fantino showed that the terminal-link stimuli in chained VI VI schedules became progressively less potent as conditioned reinforcers for responding in the initial links. Subjects in the present closed economy were less deprived, generally, than in the open economy (measures of body weight support this conclusion), but due to the long session durations employed, they presumably experienced varying levels of satiation in the course of a session. Based on Fischer and Fantino's results we would expect that terminal-link production would control behavior more effectively when subjects are relatively less sated. Because this occurs, in general, when subjects are responding, and when obtained initial-link times are close to arranged times, subjects' behavior should be under better control of these initial-link times than the longer ones that occur when subjects undergo long periods without responding. This argument is consistent with the results obtained. Moreover, other studies with concurrent-chains schedules in open economies have shown that obtained temporal values do not necessarily override ar-

ranged values (Fantino & Davison, 1983; Fantino & Dunn, 1983).

There is evidence that in 24-hr sessions there are distinct periods in which responding on schedules of reinforcement is more, or less, likely to occur. The results of Lucas (1981) and Elliffe and Davison (1985) revealed that pigeons responded at sustained rates for only the first few hours after a session had commenced and for a few hours just prior to the end of a session; for most of the session, in the time between the periods of sustained responding, there was little or no key pecking. Data from our laboratory, not reported here, with long-duration (24-hr) sessions suggest that a similar pattern occurs on concurrent chains VI VI schedules (data available from first author on request), and informal observations during the present experiment suggest that in the closed-economy conditions subjects responded in a manner comparable to the bimodal distribution of key pecking noted by Lucas and Elliffe and Davison. Appendix 2 shows that all the available time for responding in the initial links was not spent on that activity (compare Work time with Abs time in the initial links). Despite extended periods of non-responding, it is possible that the amount of time subjects did respond during the initial links was sufficient to contact programmed, or near to programmed, relative delay value. In most cases, the overall work, or on-task, time in the initial links of the present closed economy differed from arranged initial-link time by only minutes. Subjects, therefore, were not as far removed from programmed relative-delay values as one might suspect given the overall time spent in the presence of the initial-link stimuli; hence, the absence of considerable deviation between obtained and predicted choice proportions is not so surprising. If the pigeons' behavior were a function of variables integrated over the total experimental time, subjects should have been indifferent to the outcome of responding in the initial links, and obtained choice proportions should have reflected this indifference. Rather than distributing their choice responses according to experienced delays during a 24-hr session, all subjects were more sensitive to programmed delay reduction than obtained delay reduction, presumably because only time actually spent responding on the schedules affected choice. In any event, the present study shows that choice

behavior is consistent with the delay-reduction hypothesis whether subjects are maintained on open or on closed economies.

REFERENCES

- Abarca, N., Fantino, E., & Ito, M. (1985). Percentage reward in an operant analogue to foraging. *Animal Behaviour*, *33*, 1096-1101.
- Allison, J. (1980). Conservation, matching, and the variable-interval schedule. *Animal Learning & Behavior*, *8*, 185-192.
- Allison, J., Miller, M., & Wozny, M. (1979). Conservation in behavior. *Journal of Experimental Psychology: General*, *108*, 4-34.
- Autor, S. M. (1969). The strength of conditioned reinforcers as a function of frequency and probability of reinforcement. In D. P. Hendry (Ed.), *Conditioned reinforcement* (pp. 127-162). Homewood, IL: Dorsey Press.
- Baum, W. M. (1972). Choice in a continuous procedure. *Psychonomic Science*, *28*, 263-265.
- Baum, W. M. (1974). Choice in free-ranging wild pigeons. *Science*, *185*, 78-79.
- Catania, A. C. (1963). Concurrent performances: Reinforcement interaction and response independence. *Journal of the Experimental Analysis of Behavior*, *6*, 253-263.
- Catania, A. C., & Reynolds, G. S. (1968). A quantitative analysis of the responding maintained by interval schedules of reinforcement. *Journal of the Experimental Analysis of Behavior*, *11*, 327-383.
- Clark, F. C. (1958). The effect of deprivation and frequency of reinforcement on variable-interval responding. *Journal of the Experimental Analysis of Behavior*, *1*, 221-228.
- Collier, G. H., Hirsch, E., & Hamlin, P. H. (1972). The ecological determinants of reinforcement in the rat. *Physiology & Behavior*, *9*, 705-716.
- Collier, G. H., & Rovee-Collier, C. K. (1981). A comparative analysis of optimal foraging behavior: Laboratory simulations. In A. C. Kamil & T. D. Sargent (Eds.), *Foraging behavior: Ecological, ethological, and psychological approaches* (pp. 39-76). New York: Garland STPM Press.
- Duncan, B., & Fantino, E. (1972). The psychological distance to reward. *Journal of the Experimental Analysis of Behavior*, *18*, 23-34.
- Duncan, I. J. H., Horne, A. R., Hughes, B. O., & Wood-Gush, D. G. M. (1970). The pattern of food intake in female Brown Leghorn fowls as recorded in a Skinner box. *Animal Behaviour*, *18*, 245-255.
- Elliffe, D., & Davison, M. (1985). Performance in continuously available multiple schedules. *Journal of the Experimental Analysis of Behavior*, *44*, 343-353.
- Fantino, E. (1969). Choice and rate of reinforcement. *Journal of the Experimental Analysis of Behavior*, *12*, 723-730.
- Fantino, E. (1987). Operant conditioning simulations of foraging and the delay-reduction hypothesis. In A. C. Kamil, J. R. Krebs, & R. H. Pulliam (Eds.), *Foraging behavior* (pp. 193-214). New York: Plenum Press.
- Fantino, E., & Abarca, N. (1985). Choice, optimal foraging, and the delay-reduction hypothesis. *Behavioral and Brain Sciences*, *8*, 315-330.

- Fantino, E., & Davison, M. (1983). Choice: Some quantitative relations. *Journal of the Experimental Analysis of Behavior*, **40**, 1-13.
- Fantino, E., & Dunn, R. (1983). The delay-reduction hypothesis: Extension to three-alternative choice. *Journal of Experimental Psychology: Animal Behavior Processes*, **9**, 132-146.
- Farmer, J. (1963). Properties of behavior under random interval reinforcement schedules. *Journal of the Experimental Analysis of Behavior*, **6**, 607-616.
- Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement*. New York: Appleton-Century-Crofts.
- Findley, J. D. (1959). Behavior output under chained fixed-ratio requirements in a 24-hour experimental space. *Journal of the Experimental Analysis of Behavior*, **2**, 258.
- Fischer, K., & Fantino, E. (1968). The dissociation of discriminative and conditioned reinforcing functions of stimuli with changes in deprivation. *Journal of the Experimental Analysis of Behavior*, **11**, 703-710.
- Fleshler, M., & Hoffman, H. S. (1962). A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior*, **5**, 529-530.
- Graft, D. A., Lea, S. E. G., & Whitworth, T. L. (1977). The matching law in and within groups of rats. *Journal of the Experimental Analysis of Behavior*, **27**, 183-194.
- Herrnstein, R. J. (1961). Relative and absolute strength of response as a function of frequency of reinforcement. *Journal of the Experimental Analysis of Behavior*, **4**, 267-272.
- Herrnstein, R. J. (1964). Secondary reinforcement and rate of primary reinforcement. *Journal of the Experimental Analysis of Behavior*, **7**, 27-36.
- Herrnstein, R. J., & Loveland, D. H. (1974). Hunger and contrast in a multiple schedule. *Journal of the Experimental Analysis of Behavior*, **21**, 511-517.
- Hursh, S. R. (1978). The economics of daily consumption controlling food- and water-reinforced responding. *Journal of the Experimental Analysis of Behavior*, **29**, 475-491.
- Hursh, S. R. (1980). Economic concepts for the analysis of behavior. *Journal of the Experimental Analysis of Behavior*, **34**, 219-238.
- Hursh, S. R., & Fantino, E. (1973). Relative delay of reinforcement and choice. *Journal of the Experimental Analysis of Behavior*, **19**, 437-450.
- Hursh, S. R., & Natelson, B. H. (1981). Electrical brain stimulation and food reinforcement dissociated by demand elasticity. *Physiology & Behavior*, **26**, 509-515.
- Kelleher, R. T., & Gollub, L. R. (1962). A review of positive conditioned reinforcement. *Journal of the Experimental Analysis of Behavior*, **5**, 543-597.
- LaFiette, M. H., & Fantino, E. (1988). The effects of component duration on multiple-schedule performance in closed and open economies. *Journal of the Experimental Analysis of Behavior*, **50**, 457-468.
- Lendenmann, K. W., Myers, D. L., & Fantino, E. (1982). Effects of reinforcer duration on responding in two-link chained interval schedules. *Journal of the Experimental Analysis of Behavior*, **37**, 217-222.
- Lucas, G. A. (1981). Some effects of reinforcer availability on pigeon's responding in 24-hour sessions. *Animal Learning & Behavior*, **9**, 411-424.
- Nevin, J. A. (1964). Two parameters of conditioned reinforcement in a chaining situation. *Journal of Comparative and Physiological Psychology*, **58**, 367-373.
- Reynolds, G. S. (1961). Behavioral contrast. *Journal of the Experimental Analysis of Behavior*, **4**, 57-71.
- Schoenfeld, W. N., & Cumming, W. W. (1960). Studies in a temporal classification of reinforcement schedules: Summary and projection. *Proceedings of the National Academy of Sciences*, **46**, 753-758.
- Squires, N., & Fantino, E. (1971). A model for choice in simple concurrent and concurrent-chains schedules. *Journal of the Experimental Analysis of Behavior*, **15**, 27-38.
- Stubbs, D. A., & Pliskoff, S. S. (1969). Concurrent responding with fixed relative rate of reinforcement. *Journal of the Experimental Analysis of Behavior*, **12**, 887-895.
- Teitelbaum, P. (1957). Random and food-directed activity in hyperphagic and normal rats. *Journal of Comparative and Physiological Psychology*, **50**, 486-490.
- Timberlake, W., & Peden, B. F. (1987). On the distinction between open and closed economies. *Journal of the Experimental Analysis of Behavior*, **48**, 35-60.
- Wardlaw, G. R., & Davison, M. C. (1974). Preference for fixed-interval schedules: Effects of initial-link length. *Journal of the Experimental Analysis of Behavior*, **21**, 331-340.
- Williams, B. A. (1983). Another look at contrast in multiple schedules. *Journal of the Experimental Analysis of Behavior*, **39**, 345-384.

Received March 25, 1988

Final acceptance December 8, 1988

APPENDIX 1

The number of responses, in each initial link, each terminal link, and number of reinforcers obtained in each terminal link, in parentheses, for each subject in each condition. Also shown for each subject is initial free-feeding body weight and weight after each closed-economy condition. All data were pooled across reversals. Richer and leaner refer to the keys associated with more frequent and less frequent reinforcement.

Condition	Initial links		Terminal links (reinforcers)		Weight (g)
	Richer	Leaner	Richer	Leaner	
Open economy					
R87					
1	1,709.9	71.3	386.0 (8.6)	96.5 (7.8)	
2	550.0	366.7	433.7 (10.2)	266.1 (11.2)	
3	703.5	134.0	274.9 (6.2)	91.4 (6.0)	
4	638.8	462.4	77.8 (14.2)	132.6 (13.4)	
5	1,242.6	976.2	102.8 (16.0)	100.6 (14.6)	
B54					
1	1,047.1	78.8	711.9 (8.0)	250.2 (8.2)	
2	457.6	359.6	301.5 (10.4)	177.8 (10.2)	
3	473.0	74.1	389.0 (7.0)	184.0 (6.6)	
4	975.4	797.8	108.6 (16.8)	171.0 (15.2)	
5	1,048.8	893.2	143.8 (17.4)	110.4 (16.0)	
G47					
1	1,014.0	138.3	845.9 (9.2)	267.1 (9.0)	
2	632.1	517.1	550.3 (11.2)	351.9 (11.0)	
3	558.9	100.8	713.7 (7.1)	305.9 (7.2)	
4	973.2	796.0	178.8 (17.2)	174.8 (15.4)	
5	976.2	865.6	196.0 (18.0)	199.2 (17.4)	
G45					
1	645.0	79.2	484.8 (7.6)	211.3 (6.4)	
2	754.9	443.4	621.9 (9.8)	320.5 (10.2)	
3	584.8	87.4	501.4 (6.8)	235.9 (7.0)	
4	542.0	409.2	159.6 (14.0)	162.6 (14.2)	
5	878.6	718.8	185.2 (15.4)	126.0 (15.0)	
Closed economy					
R87				ad-libitum weight: 644	
1	8,114.0	250.0	3,420.6 (103.2)	1,098.6 (98.2)	652
2	6,927.5	4,618.3	2,398.0 (124.4)	1,111.6 (117.4)	660
3	4,907.3	545.3	2,623.8 (111.2)	528.6 (112.2)	658
4	7,351.2	5,108.4	965.8 (123.4)	908.8 (120.6)	663
5	4,892.8	4,700.8	1,401.4 (137.6)	1,008.8 (139.2)	665
B54				ad-libitum weight: 593	
1	13,272.7	5,421.2	7,627.6 (174.8)	5,554.5 (168.2)	604
2	8,978.5	675.8	6,913.5 (131.6)	5,036.9 (137.6)	600
3	6,676.3	1,178.2	5,551.3 (128.1)	3,700.9 (131.4)	610
4	15,770.0	8,124.0	1,959.2 (188.0)	1,777.8 (175.8)	615
5	9,470.2	9,099.0	2,410.0 (201.8)	2,521.8 (197.4)	620
G47				ad-libitum weight: 583	
1	7,679.4	6,463.2	1,462.3 (103.4)	597.3 (95.8)	595
2	7,705.0	6,463.2	1,330.4 (107.6)	685.4 (110.6)	600
3	6,082.2	1,335.1	2,160.2 (87.2)	799.0 (90.0)	588
4	10,142.2	7,344.4	506.7 (130.2)	638.0 (127.6)	602
5	4,647.2	4,465.0	489.6 (136.8)	390.6 (128.4)	605
G45				ad-libitum weight: 433	
1	14,484.0	1,090.2	5,736.8 (156.8)	1,618.3 (149.8)	450
2	13,245.7	8,118.4	2,554.3 (183.6)	1,202.0 (180.0)	457
3	9,984.8	1,625.4	4,417.8 (127.2)	1,893.4 (131.2)	445
4	9,643.2	6,428.6	1,372.6 (171.4)	1,883.4 (173.0)	459
5	6,529.4	5,342.2	1,916.8 (188.2)	1,284.4 (179.6)	460

APPENDIX 2

Time spent in the presence of initial-link stimuli (Abs), time spent responding during the initial links (Work), and time in the presence of terminal-link stimuli associated with richer and leaner chain schedules. All time measures are reported in minutes. All data were pooled across reversals. Shown in the last column are the number of sessions per condition in the initial exposure to the chain schedules, and from the terminal-link reversals (rev).

Condi- tion	Initial links		Terminal links		Session (rev)
	Abs	Work	Richer	Leaner	
Open economy					
R87					
1	27.6	25.2	4.6	24.0	23 (24)
2	39.6	37.1	5.3	11.8	30 (22)
3	32.5	31.7	6.1	20.7	22 (20)
4	50.8	49.2	1.2	6.9	34 (23)
5	51.3	50.9	1.5	3.8	33 (25)
B54					
1	27.7	24.8	4.2	27.1	21 (27)
2	40.8	36.2	5.4	11.1	23 (22)
3	29.8	27.6	7.3	21.2	22 (22)
4	47.6	46.1	1.5	7.9	30 (33)
5	52.0	51.3	1.6	4.2	29 (26)
G47					
1	24.6	24.0	4.8	28.9	29 (23)
2	37.4	35.8	5.8	11.6	31 (22)
3	29.0	28.3	7.0	23.1	25 (27)
4	47.7	46.9	1.5	8.1	34 (28)
5	51.1	50.7	1.5	4.8	27 (24)
G45					
1	34.7	33.6	4.0	20.5	31 (24)
2	40.0	39.7	5.1	10.8	25 (20)

APPENDIX 2 (Continued)

Condi- tion	Initial links		Terminal links		Session (rev)
	Abs	Work	Richer	Leaner	
3	30.6	29.0	7.7	22.6	26 (23)
4	48.8	47.8	1.3	7.3	28 (22)
5	52.6	51.9	1.3	3.9	25 (30)
Closed economy					
R87					
1	989.6	300.1	52.7	298.6	48 (42)
2	1,211.2	382.1	63.2	120.8	43 (30)
3	938.6	212.6	113.4	340.1	45 (26)
4	1,318.5	367.8	10.9	66.3	57 (39)
5	1,359.8	401.9	12.5	15.1	55 (37)
B54					
1	907.6	413.2	67.1	415.4	40 (33)
2	1,129.6	657.6	88.9	171.2	47 (36)
3	857.8	336.1	130.7	400.7	41 (33)
4	1,281.9	492.1	16.0	90.2	49 (46)
5	1,316.6	513.7	17.5	50.4	48 (38)
G47					
1	1,057.8	211.6	53.2	291.6	56 (30)
2	1,227.4	228.9	54.7	112.7	38 (31)
3	1,035.7	214.9	89.1	276.5	36 (22)
4	1,319.2	234.8	11.3	63.8	43 (45)
5	1,350.0	252.8	11.6	33.4	54 (45)
G45					
1	853.4	367.1	79.6	450.1	43 (30)
2	1,111.0	470.1	92.5	185.3	32 (30)
3	870.1	293.8	128.6	397.6	35 (33)
4	1,287.1	355.6	14.9	86.8	48 (36)
5	1,324.9	343.7	16.6	45.0	51 (43)