Go West Young Man:
Self-selection and Endogenous Property Rights[*]

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Abstract: If, as Hume argues, property is a self-referring custom of a group of people, then property rights depend on how that group forms and orders itself. In this paper we investigate how people construct a convention for property in an experiment in which groups of self-selected individuals can migrate between three geographically separate regions. To test a hypothesis of Demsetz, we vary across two treatments the external benefits of migrating. We find that self-selection has a powerful effect on establishing conventions of property and begetting increases in wealth through exchange and specialization. We also find support for the Demsetz hypothesis.

Key Words: experimental economics, property rights, migration and exit

JEL Classifications: C92, D23, D51, F10

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The conception of property certainly did not fall ready made from heaven.
-- F.A. Hayek, *Law, Legislation and Liberty, Volume 1: Rules and Order*

I. Introduction

A property right is an agreement between two or more parties on the rules to establish and modify possession. According to Hume (1740), the development of conventions of justice produced the institution of property, which denominates three fundamental laws of human nature: the stability of possession, it's transference by consent, and the performance of promises. Furthermore, these laws portend that "[w]here possession has no stability, there must be perpetual war. Where property is not transferr'd by consent, there can be no commerce. Where promises are not observ'd, there can be no leagues or alliances" (p. 363). Hence the wealth of nations is built upon such agreements, yet we know surprisingly little about the origin of property—why rights to property exist and the process by which they are formed.

Instead, the literature on property rights has focused on the content of emergent norms within close-knit groups. For example, Ellickson (1991) identifies the pervasive use of informal norms among cattle ranchers in Shasta County: these homegrown customary property rights fostered cooperation, often taking the place of formal law in dispute resolution. Dixit (2003) presents a model of trade that specifies a feasible "range" of contract (including property rights) enforcement under self-governance. Without assuming a fixed cost, the increasing size of the world limits the extent of enforceable contracts; world size predicts the presence or absence of third-party enforcement. Demsetz (1967) was perhaps first among modern economists to describe how property rights institutions could emerge absent third-party enforcement. In his example, the intensification of the fur trade on the Labrador Peninsula led private property to replace communal property rights, since the prospect of overuse tilted the cost-benefit scale in favor of greater internalization of externalities.

In addition, previous research on the economics of conflict has focused on the allocation of resources in predator-prey environments without third-party enforcement of property rights. For example, Grossman and Kim (1995) develop a model that supports a non-aggressive outcome when the allocation of resources to defense is relatively effective against allocations to predation or when predation is too destructive. In a laboratory experiment, Durham, Hirshleifer, and Smith (1998; hereafter DHS) observe coordination close to the non-cooperative equilibrium, although deviations from this outcome tend toward cooperation. DHS emphasize the choice of the

predator-prey environment, in particular, the normal-form game presentation of decisions, in generating this behavior.[1]

These studies are important contributions to understanding the function of property rights institutions and the consequences for economic activity of their absence. However, there is no account of the discovery process that creates or sustains them, nor an explanation of the counterfactual cases when property rights do not arise in environments that are seemingly comparable. Also, the test-bed for theories of predation has been limited to the predator-prey environment. In contrast, our experimental approach places subjects in a world with repeated interaction, gains from trade, and a relatively open action space. This environment allows subjects to engage in a trial-and-error discovery process and gives them the opportunity to endogenously form groups to overcome the poverty of an initial "no property rights" condition.[2] Thus, subjects can improve on this condition by realizing gains from exchange through specialization under-girded by property rights rediscovered within a group.

In this vein, Kimbrough, Smith, and Wilson (2009; henceforth KSWb) design a laboratory experiment to explore the formation of property rights among subjects in production and exchange economies with near costless theft. In half of their baseline sessions, subjects establish stable possession and the transference of goods by consent to exploit the gains of specialization and exchange. The efficiency of these sessions rivals the wealthiest baseline economies in which theft is exogenously impossible. In marked contrast, the other half of the sessions are in a perpetual state of war; possession is not stable and the economies are woefully inefficient (one is over 20% less efficient than *autarky*). KSWb then introduce three exogenous enforcement mechanisms as treatments to ascertain whether the bad apples can be brought into line. For example, in one treatment the subjects can, at a cost, block others from taking their goods. In only one out of six sessions is this effective. The remaining sessions, in contrast, tend to be *less*

[1] See also Hirshleifer (1989, 1991) and Skaperdas (1992) for other relevant theoretical discussions and Carter and Anderton (2001), Duffy and Kim (2005), and Powell and Wilson (2008) for studies using laboratory experiments.

[2] The phrase "no property rights" is not equivalent to "no notion of property rights" among our subjects. Instead, we transplant our subjects from a world *with* property rights into an experimental world where they must rediscover the "rules of the game" and reapply them within their own subject groups. As Crockett, Smith, and Wilson (2009) put it, "we are relying on them to draw upon their individual experiences, as they see fit, to activate their own implicit rules for the novel tasks that we give them. [Throughout] history, people had to learn ways of interfacing with each other in the context in which they lived and to create a social system from the inside based on natural language adapted to economic change." The importance of group determination is emphasized by DHS: "Fixed [predictable] partners over multiple rounds of interaction favor the development of mutual understanding relative to [randomly] varying partners" (p. 981). Our variation from "fixed" groups is groups of "self-selected" subjects (see below).

efficient than when this blocking mechanism is not present.

All three KSWb mechanisms were constructed on the view, in contrast to Hume, that property rights are a procedure by which individuals adjust to exogenous shocks that affect the costs and benefits of internalization versus externalization. KSWb confess that in the design process they did not appreciate how much the success of their treatments would depend on how each mechanism would operate in conjunction with the particular dispositions and impulses of a group of eight subjects, a group exogenously fixed from the outset. Unless the dispositions rendered the mechanisms unnecessary to begin with, or exactly matched the problematic temperaments that needed to be overcome in a particular economy, KSWb find that the mechanism treatments tend to *worsen* outcomes.

If, as Hume argues, property rights are a self-referring custom of a particular group, then property rights depend on how the group forms and then orders itself. To address this question, we design an experiment in which group formation is endogenous through the decision to migrate between three geographically separate regions. To test the Demsetz (1967) hypothesis, we construct two treatments in which the potential returns to migration vary. In one treatment, the benefits of establishing property rights are two times greater if at least four of the eight subjects undertake the cost of migrating to a new region. In the second treatment, there is no super-additive productivity when individuals migrate to that same region. Hence, by comparing the behavior in these two treatments we can distinguish the emergence of property rights due to increased production possibilities *and* predation from the case where property rights emerge as a response to predation only.

Our results suggest that self-selection, through the decision to migrate as opposed to imposed enforcement mechanisms, is essential for realizing the gains from exchange in our environment. This is highlighted by (1) the negative impact of theft on profit—suggesting the importance of property rights for wealth creation in our environment—(2) the absence of theft among migrants—suggesting a successful mechanism for finding latent cooperation among a subset of subjects—and (3) declining theft among non-migrants—suggesting the potential to reform among initially uncooperative subjects. Building on the literature cited above, our results identify a mechanism that helps solve the problems faced in the absence of secure personal property rights.

The rest of this paper proceeds as follows. In section II, we describe our experimental design,

and in section III, we outline our hypotheses. Section IV presents the results and section V concludes.

II. Experiment Design

II.A. Motivation

By inducing two "histories", one with experimenter enforced property rights and another with no exogenous property rights enforcement, Kimbrough, Smith, and Wilson (2008; hereafter KSWa), find that economies with a history of property rights are substantially more specialized, wealthier, and more equitable, than economies without this history. Hence, as North (2006) argues, path-dependence is important in the evolution of exchange and specialization. KSWa, however, treat property rights as historically, i.e., exogenously, given or not, and then explore differences between these two conditions. This approach powerfully demonstrates that groups with fixed size and a history of property rights can uniformly outperform economies without this history. But this raises the question of how a group might order itself to take advantage of specialization and exchange.

It is possible that property rights could fail to emerge, not because there is no latent desire for them among *some* members of the group, but rather due to the tenuousness of a convention that is based solely upon the reciprocal behavior of *all* members of the group and that is not enforced by a third party.[3] Migration in our experimental design allows latent cooperators to flee the plunderers and perpetual war to establish stable possession. As experimenters, we then have the luxury of varying the potential returns to migration to distinguish between the effect of super-additive productivity and the operation of social convention on the emergence of property rights.

II.B. Institution

Each experimental session consists of 48 periods of 130 seconds. We refer to each seven-period increment as a "week" (e.g. week 1 is periods 1-7, week 2 is periods 8-14, and so on), where every 7th period is a rest period in which there is no production. Figure 1 displays the computer interface. The chat room in the center of the screen allows subjects to send messages to each

[3] Collins and Margo (2007) present evidence of this fragility in the modern American context. They find that property values declined further in US cities that experienced severe as opposed to minor riots in the 1960s. Moreover, the losses were localized in and around the most riot-effected areas within cities. Thus, setting aside the effect of legal regime, the value and security of property rights appear to derive from expectations about a particular group in a particular environment.

other throughout the experiment. In addition, subjects can post a one-line message below their house that is visible to all subjects. We adopt the *Build8* treatment of Crockett, Smith, and Wilson (2009; hereafter CSW) as our baseline: two subject types, *odd* and *even*, begin the experiment in four paired groups, in period 21 group size doubles to two quartets, and then one group of eight in period 28.[4]

[Figure 1 here]

In Figure 1, the subject's own house and field (a split rectangle) are highlighted in green while those of other subjects are grey. Subjects allocate time to the production of two commodities, red and blue, using the scroll wheel in the top-center portion of the screen. *Odd* subjects have an absolute advantage in the production of red and *even* subjects in blue. Production is displayed in the field, and when the field is selected and highlighted in yellow, its contents, blue and red chit icons appear in the top left portion of the screen. A subject moves units by left-clicking to select them (turns them yellow) and then right-clicking and dragging them to the desired destination with the right mouse button depressed. Notice, the institution allows "stealing" since subjects can move units from another subject's house or field into their own house or field. Thus, the end-of-period allocation of red and blue units is a function of production, chat room messages, and units moved. Subject earnings are calculated based on Leontief preferences over red and blue units in a subject's house. *Odd* subjects earn 3 cents for each combination of 3 red and 1 blue and *even* subjects earn 2 cents for each combination of 1 red and 2 blue.

As in CSW, we instruct our subjects on how to produce and move goods but they must *discover* specialization, exchange, and plunder, i.e., subjects are not informed that they can move items to or from others, only that items can be moved (in the intentional passive voice). Finally, when travel becomes possible in period 28, we instruct subjects how to travel but they must discover its benefit. This approach to the experimental institution is aimed at studying whether there is consistency in the exchange and property rules subjects discover. This approach is less intended to answer the set of questions related to *how* agents behave within a given set of

[4] The results of CSW and an experiment reported by Weber (2006) suggest that the gradual increase of group size promotes cooperation. Like CSW and unlike Weber, we do not inform subjects beforehand that these increases in the group size will occur. We note that although this feature and others may encourage cooperation, alone they do not appear sufficient to encourage the formation of property rights. The limit of *at most* eight on group size controls for factors of "size" identified in the literature as important to the resolution of collective action problems (Ostrom 1990, Dixit 2003).

institutional rules. Rather, we are interested in whether specific rules emerge and *why*. KSWb summarize the experimental approach this way: "Think of our subjects' task of creating a social order as a stylized and simplified model of early 19th century settlers on the American frontier. They too came from a world with a history of property rights, but they also had to construct their own social system of property based upon the new ecological conditions they faced and the experiences that they brought with them" (p. 5). The substantial difference with our paper is that we actually allow our subject-settlers to self-select and form their own groups with a reciprocal respect for property.[5]

II.C. Property Rights and Theft

The absence of experimenter enforced property rights allows subjects, in addition to moving red and blue units to the house or field of another subject, to remove units from another subject's house or field. Since we are interested in studying the causes of the emergence of property rights among our subjects we define a measure of theft that indicates the insecurity of property rights.[6] Following KSWb, we distinguish theft from other types of movement: barter, gift, and steal trade (mutual taking with consent which is equivalent to bartering).

We define theft as the unidirectional movement by Person *i* from Person *k* to *i*'s house or field without *k*'s consent. The task of identifying theft (as opposed to steal trading) was performed by (1) identifying each action in which *i* removed units from *k*'s house or field, (2) determining *i*'s relationship with *k* through chat room communication, (3) recording as steal trade only actions by *i* for which *k* gave consent, and (4) recording as theft remaining actions by *k*. Once *i* and *k* have established a cooperative relationship, the relationship is terminated if *i* or *k*

[5] One critical comment on this type of economic experiment is that the findings are likely to be specific to the particular experimental interface and thus provide little insight "in general" on the question of interest. KSWa (p. 1029) and CSW directly address this and similar concerns. KSWb handle this critique by noting: "This skepticism of what seems to be a less general case emanates from an inkling that it is somehow incomplete and conveniently overlooks the fact that no method of inquiry is complete. No empirical study is context-free. Did the Maori of New Zealand, the Cherokee of North America, and the 9th century settlers of Iceland live a context-free world and develop property rights *in general*? No, they and everyone else interface with each other in the contextual circumstances in which they live and construct their own social system of property rights. The virtue of laboratory experiments is that the potentially confounding effects of the 'real world' are traded off for replicable conditions of a precisely specified environment and institutional structure" (p. 4).

[6] Smith (1982) defines property rights through the institution: rules by which "agents may communicate and exchange or transform commodities for the purpose of modifying initial endowments in accordance with private tastes and knowledge" (pp. 924-25). In our experiment, the institution does not enforce property rights in exchange: a subject can remove units from the house or field of another subject. Thus, the presence of theft signals that subjects do not have the exclusive right to exchange commodities in line with their own (private) tastes and knowledge. It is how subjects arrive at exclusive rights in exchange that we aim to study.

take an action to which the other verbally objects. As a check of the validity of this method, Finding 1a below tests whether theft has the anticipated negative relationship with profit.

II.D. Treatments

The experimental world consists of three regions: East, Middle, and West, which are displayed in Figure 2. Notice, the region layout is such that subjects must first move to the Middle to travel between the East and the West. In the East and West there is no enforcement of personal property rights. Production possibilities in the West are varied by treatment (see below) and, in the Middle, subjects are limited to autarky production but the software exogenously enforces property rights. The characteristics of each region are displayed in the top left of the screen. When travel is introduced in period 28 an instruction box appears describing the "view" and "travel" buttons. The "view" button allows subjects to view the characteristics of other regions without traveling. The "travel" button allows subjects to transport their house and field to a new region. The nontrivial cost of moving is that a migrant produces zero units in the first period in a new region; production resumes the following period. Thus, to make it to the West, a migrant foregoes two full days of production and consumption unless one of those periods is a rest period.

[Figure 2 here]

In the first four weeks both treatments are identical. All subjects reside in the East as group size increases from four pairs to two quartets in period 21 and then from two quartets to a single group of eight in period 28. In period 28, when we offer travel options to the subjects, we also introduce the treatment conditions. In the first treatment, subjects produce twice as much in the West as in the East, provided that there are four or more subjects in the West. This does not necessarily increase earnings, but an *odd-even* subject pair completely specialized in their absolute advantages and trading at the competitive price earns 180 and 160 cents, respectively, as opposed to 90 and 80 cents in the East. The second treatment provides the same opportunity for travel to the West, but subjects produce according to the same production function as in the East. Each treatment contains six sessions with eight subjects each. We refer to the first treatment as *Double* and the second as *Single*. When we refer to a particular session, sessions 1 through 6 are in *Double* and sessions 7 through 12 are in *Single*.

II.E. Competitive Equilibrium

The *ex ante* autarkic and trade equilibria of these production and exchange economies follows directly from the preferences and production functions, which are reported in Appendix I. The interested reader is directed to CSW for the derivation of the competitive equilibrium and a discussion of its uniqueness. In autarky, *odd* subjects earn a maximum of 30 cents and even subjects earn 26 cents, in each period. In the competitive equilibrium, an *odd* and *even* subject-pair specialize completely in their absolute advantaged good, exchange at the competitive price (40 red for 30 blue, in total), and earn 90 and 80 cents per period, respectively. Thus, the total profit for eight subjects in autarky is 224 cents and at the competitive equilibrium is 680 cents.

However, the trade equilibrium described above does not hold where *odd* and *even* subjects are not evenly matched due to the introduction of travel after period 28. For this reason, we define an *ex post* trade equilibrium based on a bilateral trading rule that minimizes waste. Starr (1976) describes a bilateral procedure in which agents exchange repeatedly until the smaller of excess supply *or* excess demand is exhausted. Kimbrough (2009) employs a modified version of Starr's trading rule that we adopt. First, from their production, agents consume to their autarkic best according to their Leontief preferences. The remaining red and blue units are then available for trade. Second, agents identify a trading partner, the units available for trade are summed across the two agents, and an optimization applied. The optimization yields an integer solution that allocates units according to agent preferences and minimizes waste.

We apply the trading rule as follows: (1) in each group of subjects in the same region, each subject is given an initial consumption allocation according to his preferences, (2) the remaining (marginal) units within each group are summed, (3) an optimization is applied that minimizes waste from the marginal units, (4) the optimization yields an allocation for each subject type, which is added to initial consumption, and (5) final potential earnings are calculated for that period. Notice that this optimization can yield a number that is greater than actual profit, since it is not all but only marginal units that are available to trade. We apply this trading rule since it fits with observed behavior in CSW and it provides an analogy to a procedure that replicates CSW's *Build8* treatment with property rights using simulated agents (discussed below).

Furthermore, the application of this trading rule provides an analytical benchmark not available with the *ex ante* trade equilibrium: how well do subjects trade marginal units to minimize waste and maximize social welfare given production *ex post*? What prevents agents

from performing better? Kimbrough demonstrates that simulated agents using this trading rule are indistinguishable from behavior in human-subject experiments in a similar *Build8* environment with perfectly enforced property rights. For our purposes, the trading rule provides a benchmark of human-subject performance *with* property rights to compare with the performance of our subjects *without* property rights.

II.F. Procedures

We recruited 96 subjects from the undergraduate population at a large state university. Subjects, with one exception, had no prior experience in a related production and exchange experiment and conducted 6 sessions of 8 people with each treatment condition.[7] Upon arriving in the laboratory subjects were seated at visually isolated computer terminals and read self-paced instructions on their computer screen. Each subject was paid $7 for showing up on time, plus what they earned based on their decisions made during the experiment. Each session lasted approximately 110 minutes after which subjects were paid their full earnings in private. Not including the show-up payment, mean earnings for the twelve sessions were $13.65, ranging from a low of $2.47 to a high of $31.96.

III. Hypotheses

Before period 28 we expect no differences between the *Double* and *Single* treatments. Our main predictions concern the differences in our sessions after travel is introduced in period 28. However, we use the data before period 28 to identify the interesting empirical regularities. In particular, we examine the impact of theft on profit and *hypothesize that theft will reduce profit*. Our experimental design and previous experimental studies suggest further hypotheses regarding cooperation and the emergence of property rights after the introduction of travel.

The potential for doubled production (and profit) in the West in *Double* increases the incentive for these subjects to incur the cost of travel relative to subjects in *Single*. This feature of our experimental design allows us to test a hypothesis articulated by Demsetz (1967) in which "property rights develop to internalize externalities when the gains of internalization become larger then the cost of internalization" (p. 350). In our experiment, the gains from property rights

[7] Due to a recruiting error, Person 2 in session 4 had previously participated in a similar experiment. Chat room transcripts reveal this person did not noticeably improve the performance of another participant by disseminating prior knowledge of design similarities.

come from the ability to explore the production function and identify a relationship with a suitable trading partner undisturbed by thieves. After the introduction of travel these gains are (potentially) doubled for subjects in *Double* that move to the West, while subjects in *Single* faced identical production opportunities whether they stay in the East or move to the West. In both treatments the costs of travel are identical: foregone production following each travel period. Thus, *we hypothesize that we will observe more migration among subjects in the* Double *treatment*. Identical production possibilities in the East and the West in *Single* would naively suggest no western settlement. However, the potential for gains from specialization through exchange means that among subjects in *Single* who have discovered specialization there should be greater incentive to migrate if property rights are unrecognized. Thus, we also expect to observe migration in *Single* where a lack of property rights has prevented the realization of gains from exchange.

The introduction of travel in period 28 is meant to address the lack of property rights observed by KSWb, despite their exogenous enforcement mechanisms. We introduce migration to allow latent cooperation among a group of apparent thieves to be revealed through travel to the West. The significance of the decision to travel to the West, i.e., to self-select into a group of cooperators, is suggested by previous experimental studies examining the evolution of cooperation. For example, DHS observe a greater tendency toward the cooperative solution (of a normal form game) when partner groups are fixed relative to random re-matching.[8] Fixed partners can learn to cooperate over time, while randomly re-matched partners have no history from which to infer the likelihood of cooperation. In our experimental design, the adoption of *Build8* allows subjects to learn to cooperate or failing this, to migrate away from non-cooperators. Thus, *we hypothesize less theft and more profit for subjects who travel to the West*. We will find evidence for or against this hypothesis in the comparison of subject performance relative to potential earnings *ex post*, the level of theft in the West versus the East, as well as individual characteristics of migrants and non-migrants.

In the next section, we proceed by observing whether (1) property rights (agreements over the exchange of goods) are positively related to profit, (2) migration is determined, in part, by the potential for reaping gains from exchange, and (3) property rights are more prevalent in the

[8] See, *inter alia*, McCabe, Rassenti, and Smith (1996) and McCabe, Rigdon, and Smith (2003, 2007) for supporting experimental results in extensive form games with punishment, no repeat play, and re-matching based on previous decisions to cooperate or defect, respectively.

West. Our hypotheses can be summarized as follows:

Hypothesis 1. Before the introduction travel, among pairs and groups of four, the presence of theft will reduce profit (*Theft Hypothesis*).

Hypothesis 2. The number of migrants to the West will be greater in the *Double* treatment than in the *Single* treatment (*Demsetz Hypothesis*).

Hypothesis 3. Theft will be lower for migrants than for non-migrants and profit will be higher (*Self-selection Hypothesis*).

IV. Results

We first note that all sessions follow similar baseline dynamics before the treatment differences are introduced in week 5. Panel (a) of Table 1 shows the mean specialization, efficiency, and theft in each session for weeks 1 through 4.[9] Two-sided Wilcoxon rank sum tests on the means of each variable for pairs and groups of four fail to reject the null hypothesis of equal means across the *Double* and *Single* treatments.[10] In addition, panel (b) compares the *ex post* trade equilibrium described above calculated for weeks 1 through 4 with data on actual profit from CSW. Two-sided Wilcoxon rank sum tests for each week fail to reject the null hypothesis of equal means for weeks 2 and 3 in pairs and for week 4 in groups of four.[11] This suggests that the comparison of the performance of our subjects to the *ex post* trade equilibrium is analogous (for weeks 2 through 4) to the comparison between subject-performance *with* and *without* property rights.

[Table 1 here]

IV.A. Profit and Theft Before the Possibility of Migration

[9] Efficiency and specialization are defined in Appendix I.B. Theft is defined in Section IV.A.

[10] The results of the Wilcoxon rank sum tests for specialization for week 1 ($W_{24,24}$ = 240.5, p-value = 0.3324, two-sided), week 2 ($W_{24,24}$ = 227.5, p-value = 0.2159, two-sided), week 3 ($W_{24,24}$ = 282.5, p-value = 0.9179, two-sided), and week 4 ($W_{12,12}$ = 63, p-value = 0.6233, two-sided), cannot reject the null hypothesis for equal means across the *Double* and *Single* treatments. Similarly, the results for efficiency for week 1 ($W_{24,24}$ = 334.5, p-value = 0.3428, two-sided), week 2 ($W_{24,24}$ = 297.5, p-value = 0.8609, two-sided), week 3 ($W_{24,24}$ = 239.5, p-value = 0.3173, two-sided), and week 4 ($W_{12,12}$ = 239, p-value = 0.2986, two-sided), cannot reject the null hypothesis for equal means across *Double* and *Single*. Finally, the results for theft for week 1 ($W_{24,24}$ = 275, p-value = 0.7966, two-sided), week 2 ($W_{24,24}$ = 280, p-value = 0.8768, two-sided), week 3 ($W_{24,24}$ = 311, p-value = 0.6351, two-sided), and week 4 ($W_{12,12}$ = 81, p-value = 0.6209, two-sided), cannot reject the null hypothesis for equal means across *Double* and *Single*.

[11] The results of the Wilcoxon rank sum tests comparing the *ex post* trade equilibrium and profit from CSW for week 1 ($W_{48,40}$ = 625.5, p-value = 0.0050, two-sided), week 2 ($W_{48,40}$ = 880, p-value = 0.5040, two-sided), week 3 ($W_{48,40}$ = 860.5, p-value = 0.4060, two-sided), and week 4 ($W_{24,20}$ = 274, p-value = 0.4296, two-sided), can only reject the null hypothesis of equal means in week 1, otherwise the profit in the *ex post* trade equilibrium and CSW are indistinguishable.

In our environment, in the absence of experimenter enforced property rights subjects can discover theft. Thus, we measure the extent of property rights in our economies by the quantity of theft, i.e., more theft signals less secure property rights. Figure 3 displays theft per person throughout the experiment: in pairs from period 1 to 20, in quartets from period 21 to 27, and in groups of eight in the East and in the West from period 28 to 48. In the first four weeks, theft increases gradually from a low of 24 units per person to a maximum of 109 units. Figure 3 illustrates that the quantity of theft, in the theft first four weeks and beyond, is substantial. North (1982), Acemoglu and Johnson (2005), Hornbeck (2008), and many others, argue that well-defined property rights institutions provide an essential foundation for wealth creation. Thus, a mechanism that helps to mitigate the potential losses from theft could advance our understanding not just of the importance of property rights but also how they develop within groups.

[Figure 3 here]

To proceed we first need to examine whether the hypothesized positive relationship between property rights and wealth is present in our data. In this sub-section, we examine the relationship between theft and profit before the introduction of travel and then in later sub-sections we address the effectiveness of migration for reducing theft.

We estimate the following reduced-form profit equation for each group *j* of two or four subjects in period *t*:

$$(1a) \quad Profit_{jt} = \beta_0 + \beta_1 Period_{jt} + \beta_2 Specialization_{jt} + \beta_3 Words_{jt} + \beta_4 Theft_{jt} + \beta_5 Theft_{jt}^2 + \eta_j + \varepsilon_{jt}$$

where $Profit_{jt}$ is the natural log of profit per person (plus one). *Period* is an integer counter for the period *t* of production and consumption (omitting the rest period on every 7th day). *Specialization* is the average rate of specialization for each group *j* in period *t*, and *Words* is the average number of space-delimited strings of characters typed by the subjects. *Theft* is the total number of goods moved from another person's house or field without his or her consent and $Theft^2$ is the square of *Theft*.[12] We include the variable *Words* as a measure of sociality; the more that people converse with each other, the more cooperation they achieve by increasing exchange and specialization and by decreasing plunder. Importantly, since all of the independent variables in equation (1a) are set before the determination of profit, these variables are exogenous to the

[12] The prevalence of large quantities of theft led us to control for this effect by including $Theft^2$.

dependent variable. Equation (1a) is estimated for 48 pairs in weeks 1 through 3 and 24 quartets in week 4, with a random effect η_j for each group j.[13] The results are reported in columns 1 and 2 of Table 2.[14]

[Table 2 here]

Finding 1a: *For both pairs and quartets, an increase in* Theft *significantly reduces profit.*

In pairs and quartets, an additional unit of theft reduces profit by 0.13 percent (see columns 1 and 2 of Table 2). The mean (standard deviation) quantity of theft per period is 66 (167) units in pairs and 77 (131) units in quartets. Thus, a one standard deviation increase from the mean of quantity of theft reduces profit 22 percent in pairs and 18 percent in quartets. This effect is diminished by the positive coefficient on $Theft^2$, however, this effect is economically small in pairs and statistically insignificant in quartets. This finding is evidence for Hypothesis 1, but only measures the effect of theft on deviations from mean profit. How much money is left on the table as a result of theft?

[Figure 4 here]

Figure 4 shows the difference between the *ex post* trade equilibrium and actual profit in the first four weeks. Remember that the *ex post* equilibrium minimizes the waste from the marginal units produced in each period. Thus, the difference between *ex post* and actual profit measures how well subjects were able to solve the problem they faced within each period. The difference between *ex post* and actual profit remains roughly constant throughout the first four weeks, although some growth does occur. To assess the contribution of theft to deviations from *ex post* profit, we estimate equation (1b):

$$(1b) \quad Profit_{jt}^{ex\ post} - Profit_{jt} = \beta_0 + \beta_1 Period_{jt} + \beta_2 Specialization_{jt} + \beta_3 Words_{jt} + \beta_4 Theft_{jt} + \beta_5 Theft_{jt}^2 + \eta_j + \varepsilon_{jt}$$

where $Profit_{jt}^{ex\ post} - Profit_{jt}$ is the natural log of the *ex post* profit minus natural log of actual profit, both plus one. The independent variables in equation (1b) are identical to those of (1a). The results are reported in columns 3 and 4 of Table 2.

[13] Recall that each pair and quartet is independent in weeks 1 through 4.

[14] We also estimated equations 1a and 1b with a dummy variable for treatment. The coefficient is not statistically significant in either case.

Finding 1b: *For pairs, an increase in* Theft *significantly increases the gap between the observed profit and the waste minimizing allocation conditional on production. For quartets,* Theft *is statistically insignificant.*

In pairs, an additional unit of theft increases the divergence of actual profit from *ex post* profit by 0.17 percent (see column 3 of Table 2). A one standard deviation increase from the mean quantity of theft increases the gap roughly 30 percent in pairs. This effect is statistically significant at the 1% level and economically large. The positive coefficient on $Theft^2$ only slightly diminishes this effect. Although the coefficient on *Theft* for quartets in column 4 is statistically insignificant, the positive sign does cut in favor of Hypothesis 1.

Together findings 1a and 1b are strong evidence for Hypothesis 1. Theft decreases actual profit and amplifies deviations from *ex post* profit. However, theft is only part of property rights. In our experiment, explicit agreements are only possible through chat room communication, i.e. no third party enforcement mechanisms exist. Thus, typed words are the source of such agreements and the presence of chat room communication suggests cooperation and should increase profit. In columns 1 and 2, the coefficient on *Words* indicates that an additional word increases profit by 0.69 and 1.1 percent in pairs and quartets, respectively. In columns 3 and 4, the coefficient on *Words* indicates than an additional word decreases deviations from *ex post* profit by 0.47 and 0.95 percent.

These findings also demonstrate the consequence of our weak institutional rules and, more interestingly, the actions taken by subjects to fill this void. Importantly, the ability to communicate through a chat room has the opposite effect of theft, which suggests that communication allows subjects to generate agreements over property rights that work to increase profit. This is particularly true for quartets, where the effect is economically quite large.

Finally, in columns 1 and 2, each percent increase in specialization increases profit by 2.1 and 1.8 percent in pairs and quartets, respectively. The effect of specialization on profit in both group sizes is unsurprising: additional units of production are required to increase profit. In column 3, the effect of specialization is statistically insignificant in pairs. In column 4, the effect is significant in quartets, which suggests that more specialized subjects are more proficient at trade. Also, in columns 1 and 2, each period increases profit by 2.3 and 3.5 percent in pairs and quartets, respectively. There is an analogous effect for pairs in column 3: each period decreases the divergence of actual profit from *ex post* profit. This suggests that growth in our economies is

part of an experiment-long process of growth, even after controlling for specialization, communication, and theft.

IV.B. Migration

The final exogenous increase in group size occurs in period 28, when all eight subjects in a session form a single group. After period 28, the introduction of travel relaxes experimenter control over group size and allows subjects to form their own groups. This progression is identical for all twelve sessions. The only variation across treatments is the potential returns to migration, which allows for a test of Hypothesis 2 (Demsetz). Figure 5 shows the number of subjects in the West by treatment and illustrates the result summarized in Finding 2.

[Figure 5 here]

Finding 2: *The mean number of periods subjects spend in the West in the* Double *treatment is significantly greater than in* Single.

After the introduction of travel, a subject could have spent 19 total periods in the West. The mean number of periods spent in the West is 4.4 in the *Double* treatment and 0.6 in the *Single* treatment. A Wilcoxon rank sum test rejects the null hypothesis of equal mean periods in the West in favor of the alternative hypothesis that the number of periods in the West is greater among subjects in *Double* ($W_{6,6} = 30.5$, p-value = 0.0228, one-sided). [15] This finding is evidence for Hypothesis 2. In addition, the mean number of periods spent in the East is 12.7 in *Double* and 16.7 in *Single*. A Wilcoxon rank sum test rejects the null hypothesis of equal mean periods in favor of the alternative hypothesis that subjects in *Single* spend, on average, more periods in the East than subjects in *Double* ($W_{6,6} = 28$, p-value = 0.0621, one-sided). Mean periods spent in the Middle are 1.8 and 1.7 in *Double* and *Single*, respectively; a Wilcoxon rank sum test fails to reject the null hypothesis that this difference is significant ($W_{6,6} = 19.5$, p-value = 0.8714, two-sided). These findings suggest that subjects in *Single* are trading off time in the West for time in the East, rather than the Middle, while subjects in *Double* are doing the opposite.

What explains this propensity to move West among subjects in *Double*? Does this lead to stronger property rights? From Demsetz, the hypothesis is that the greater external benefits in

[15] The mean reported is the total number of periods subjects spent in the West in each treatment divided by the total number of people in the West in each treatment. The Wilcoxon rank sum test was performed on the session means for each treatment.

Double versus *Single* should lead to improved property rights in exchange. Initial evidence for this hypothesis is provided by analysis of the migration decision. Equation (2) specifies a random effects probit in which the characteristics of subject *i* in week 4 explain the decision to move to the West, a binary variable that is 1 if the subject was in the West in period 48 and 0 otherwise.[16] For the independent variables, *Double* identifies the treatment, *Specialization4* is the mean rate of specialization, *Theft4* is the mean amount of theft, and *Words4* is the mean number of words, all in week 4 before migration is possible. In addition, we include a random effect for each session *s*. Specific predictions of the effects of these variables follow and Table 3 reports the results.

$$(2) \quad West_{is} = \beta_0 + \beta_1 Double_s + \beta_2 Specialization4_{is} + \beta_3 Words4_{is} + \beta_4 Theft4_{is} + \eta_s + \varepsilon_{is}$$

[Table 3 here]

First, we expect *Double* will have a positive effect on location in the West. Second, we predict a negative sign for *Theft4* because uncooperative subjects, a.k.a., "thieves", will be revealed through a sustained willingness to take from others and these non-cooperators will be less likely to move. Finally, we expect *Words4* will positively predict location in the West. Words increase the likelihood of moving west since more social subjects (and groups) will be better able to coordinate profit-seeking activities in the West, whereas subjects who remain in the East and cooperate will have had the previous three weeks to accomplish this goal. In part, the coefficient on *Words* in Table 2 support this interpretation.[17]

In general, the results of estimating equation (2) provide support of Demsetz's hypothesis. Column 3 of Table 3 reports the results of the estimation and columns 4 and 5 report the marginal effects stratified by the dummy variable for treatment. The strongest predictor of moving west is belonging to the *Double* treatment: a discrete change of *Double* from 0 to 1 increases the probability of moving west by 48.7 percent. In addition, the marginal effect of *Theft4* among subjects in *Double* suggests that an additional unit of theft decreases the probability a subject will move west by 0.13 percent; an additional 146 units of theft (one standard deviation of *Theft4* in *Double*) decreases the probability a subject will move west by

[16] The qualitative results are unchanged when the dependent variable is defined as subjects in the West in the last week or subjects in the West in any period.

[17] We provide no prediction for *Specialization4*, since its could work in both directions: specialization coupled with little theft discourages migration while specialization and theft encourages migration.

19.0 percent. These results provide stark support of the Demsetz hypothesis: the greater external benefits (doubled production) in the West attract subjects with a history of stealing less. Also note that *Words4* predicts moving west among subjects in *Double*: an additional word increases the probability a subject will move west by 2.6 percent. For such a crude measure of sociality, just a few words of interaction explain a subject's propensity to move. More casually, we frequently observe that "thieves" are rather silent relative to those preyed upon, who are often quite vocal in expressing their disapproval.

Similar results for *Steal4* and *Words4* for subjects in the *Single* treatment do not hold, i.e., the marginal effects on these variables in column 5 are statistically insignificant. We cautiously interpret the difference in significance between the treatments by emphasizing the differential effect of the subjects' experience prior to the introduction of travel. However, remember that across treatments the experimental environment is identical prior to the introduction of travel. For subjects in *Double*, the interaction with others prior to the introduction of travel was crucial. The promise of doubled production in the West could easily induce a subject with a previous bad experience, i.e., unpredictable earnings from period-to-period due to high volumes of theft (see Finding 1), to move. While, for subjects in *Single*, history does not seem to account for the decision to move. One possibility is that the experience of these subjects after the introduction of travel was much more important. In other words, subjects in *Single* were not *immediately* prone to travel, but their initial unwillingness to incur these costs could be removed through repeated bad interactions with others: Figure 5 shows that the population of the West in *Single* increases only in the last week. In contrast, subjects in *Double* required only a bad history to be coaxed to move: Figure 5 shows earlier and much more substantial migration among these subjects.

The results reported in this sub-section provide strong evidence for Hypothesis 2 and suggest a possible explanation. Clearly, the effect of the *Double* treatment on the decision to move is substantial. In addition, in *Double*, theft and typed words are indicative of the characteristics possessed by migrants. In particular, migrants steal less and talk more. However, similar results from this analysis do not hold for *Single*. In the final sub-sections, we focus on the role that location in the East, Middle, or West plays in determining the amount of theft and profit of individual subjects.

IV.C. Theft in the West

Previous findings suggest the initial characteristics of subjects who choose to move to the West. Some of these findings are confirmed by looking at periods 29 through 48 in Figure 3. In period 29, theft increases sharply in the East after subjects form groups of eight and the introduction of travel. However, whereas theft was either constant or increasing in weeks 1 through 4, theft in the East is rapidly decreasing in weeks 5 through 7. In the West, theft is low and increases only slightly by the end of the experiment. At least initially, Figure 3 suggests that migration effectively encourages establishing property rights. To examine this more closely, we estimate the following reduced-form linear mixed effects regression:

$$(3)\quad TheftperPerson_{it} = \beta_0 + \beta_1 Period_{it} + \beta_2 Specialization_{it} + \beta_3 Words_{it} + \beta_4 Double_i + \beta_5 Travel_{it} + \beta_6 Region_{it} + \eta_i + \varepsilon_{it}$$

where $TheftperPerson_{it}$ is the natural log of the quantity of theft of a subject (plus one), divided by the number of other subjects in the same region as person *i* in period *t* to control for population. Thus, independent variables measure the effect on the average quantity of theft by a subject. The interpretation of *Words* in equation (3) is ambiguous since it is determined contemporaneously with theft. However, our main independent variables of interest are fixed before any theft occurs and are thus exogenous to the dependent variable. *Double* is a dummy variable that is 1 for subjects in the *Double* treatment and 0 for subjects in *Single*; *Travel* is a dummy variable that is 1 if the subject produces nothing due to travel in the previous period and 0 otherwise; *Region* is a set of dummies to indicate the location of subject *i* in period *t*. We expect a negative relationship between theft and location in the West. Equation (3) is estimated for individuals from period 30, the first period that subjects could reside in the West, until the end of the session, with random effects for each person *i* by session *s*. The results are reported in column 1 of Table 4.

[Table 4 here]

Finding 3*: Migrants in the* West *significantly steal less from each other than the Easterners do amongst themselves.*

As column 1 in Table 4 reports, when other characteristics are held constant, subjects in the West steal 64.0 [$= -100 \times (e^{-1.023} - 1)$] percent less than subjects in the East. This suggests that one reason subjects may prefer the West at all is the relative absence of theft in that region compared to the East. Moreover, Finding 3 reports the importance of endogenous group

formation: by allowing subjects to *choose*, through migration, a sub-group from among others randomly assigned to their session, subjects can avoid interacting with those who do not share the cooperative characteristics of westbound migrants.

However, Finding 3 only illuminates the effect of relocating to the West on the level of theft, and since we are also interested in the treatment- and region-specific effects over time we estimate the following reduced form regression to examine these relationships:

$$(4)\quad TheftperPerson_{it} = \beta_0 + \beta_1 Period_{it} + \beta_2 Specialization_{it} + \beta_3 Words_{it} + \beta_4 Double_i + \beta_5 Travel_{it} + \beta_6 Region_{it} + \beta_7 Period_{it} * Double_i + \beta_8 Period_{it} * Region_{it} + \beta_9 Double_i * Region_{it} + \eta_i + \varepsilon_{it}$$

where the dependent variable is identical to the dependent variable in equation (3). The results are reported in column 2 of Table 4. The interaction variable *Period*Double* captures changes in theft over time due to the treatments, while *Period*Region* captures changes due to the location differences. Finally, *Double*Region* will provide another test of the hypothesis (from Demsetz) that when the external benefits to establishing property rights exceed costs, property rights evolve to internalize these gains. That is, will subjects in the West steal less in *Double* than in *Single*. Thus, in addition to the negative relationship between the quantity of theft and location in the West, we also expect the reduction in theft to be greater in *Double* than in *Single*.

Finding 4: *The quantity of theft by a subject is significantly less in the West than in the East.*

In column 2 of Table 4, with the addition of the interaction terms the coefficient on *West* captures the effect of the West region for subjects in the *Single* treatment, while the sum of the coefficients on *West* and *Double*West* captures the effect of the West for subjects in *Double*. Subjects in the West steal 94.4 [$= -100 \times (e^{-2.875} - 1)$] and 86.0 [$= -100 \times (e^{-2.875 + 0.912} - 1)$] percent less than subjects in the East, in *Single* and *Double*, respectively. These findings show a strong negative effect of relocating to the West on the quantity of theft by a subject for both treatments. However, the ordering of the effects on reducing theft is not that implied by Demsetz: subjects in *Single* steal less (not more) than subjects in *Double*. We return to this hypothesis in the next sub-section after we have considered the impact of *Double*West* on profit (see Finding 6).

Finding 5: *Theft is declining in the East and slightly increasing in the West in both treatments.*

The coefficient on *Double* in column 2 of Table 4 is not statistically different from zero. Thus, subjects from the two treatments have roughly the same *level* of quantity of theft in the East in period 30. However, the significantly positive coefficient on *Period*Double* and the significantly negative coefficient on *Period* together imply different rates of decline across treatments: each period reduces theft in the East by 7.1 and 2.5 percent in *Single* and *Double*, respectively.[18] A Wald test rejects the null hypothesis that the sum of the coefficients on *Period* and *Period*Double* is zero ($F_{2,1632}$ = 31.55, *p*-value < 0.0001). Thus, subjects in *Double* have a smaller rate of decline in theft, but the trend in both treatments is distinctly downward.

The slower rate of decline in *Double* suggests that subjects who realize the benefit from migration in this treatment, in general, leave behind uncooperative subjects who take longer to reform. This is contrasted with the much faster rate of decline in theft in *Single*, which suggests that among subjects who remain in the East are those who might have traveled in the *Double* treatment but perhaps did not see the benefit absent doubled production. Instead, with a high success rate, these subjects tolerate initial high levels of theft in the East in order to eventually find the cooperators and reform non-cooperators in their midst. This finding is consistent with our probit analysis of the migration decision.

In addition, a comparison of the sum of coefficients on *Period* and *Period*West* and the sum of the coefficients on *Period*, *Period*West*, and *Period*Double* suggest further evidence that the gap between East and West is narrowing over time. These effects are 1.6 and 6.2 percent in *Single* and *Double*, respectively. Wald tests reject the null hypotheses that (a) the sum of the coefficients on *Period* and *Period*West* is zero ($F_{2,1632}$ = 32.99, *p*-value < 0.0001) and (b) the sum of the coefficients on *Period*, *Period*West*, and *Period*Double* is zero ($F_{3,1632}$ = 23.16, *p*-value < 0.0001). However, these figures should be viewed in light of the much lower level of theft in the West starting in period 30. Theft in the West in the last three weeks shown in Figure 3 illustrates this point nicely: theft in period 48 is higher than in period 30, but remains low relative to theft in the East. Thus the erosion in the gap between theft in the East and theft in the West is due predominately to decreases in the East, but increases in the West contribute to the erosion as well.

[18] 2.5 percent is equal to the sum of the coefficients on *Period* and *Period*Double*; 7.1 percent is equal to the coefficient on *Period*.

IV.D. Profit in the West

The previous findings for theft provide strong evidence for our Hypothesis 3: theft is lower in the West in both treatments. In addition, we also noted the decline of theft in the East, specifically, the different rates of decline across *Double* and *Single*. This finding suggests how our subjects' behavior evolves in response to the prospect of migration: cooperative subjects are less willing to tolerate predatory behavior by others in the face of potentially peaceful existence in the West, while many of the subjects who remain in the East appear to reform due to the decline in the profitability of predation. This is illustrated in figures 6a and 6b, where the shaded portions represent the difference between the *ex post* profit and actual profit per person within the West and the East.[19]

[Figure 6 here]

The difference in the two regions couldn't be starker. First, residents in the West realize profits at levels extremely close to the waste minimizing optimum; there is little waste because there is little theft. The gap, however, between *ex post* and actual profit in the East is initially considerably larger. Interestingly, this gap is shrinking by the last week as theft in the East also begins to decline. Apparently after the plundered have left, the situation becomes dire enough that the plunderers themselves begin to reform. Second and more noticeable, wealth in the West grows briskly. Having migrated to establish property rights, Westerners are taking more and more advantage of exchange and specialization, and in the *Double* treatment, are also experiencing a two-fold increase in production when there are four settlers. Importantly, growth occurs in both *Double* and *Single*, in fact, migrants in session 9 are the only migrants to find and maintain the *ex ante* trade equilibrium. In the East *ex post* profit falls slightly because the more specialized (and hence productive) subjects have left. The Easterners may be stealing less by the end, but they aren't exchanging and specializing more. This hysteresis is reminiscent of what KSWa find in their history of no property rights treatment. With a history of no property rights, KSWa observe that there is one village in each session which wallows in self-sufficiency even though the software perfectly enforces property rights.

To quantify this effect of location on actual profit we estimate equation (5) with the same independent variables as in equation (4) and over the same time period.

[19] Series stratified by the *Double* and *Single* treatments are qualitatively similar.

$$(5)\quad Profit_{it} = \beta_0 + \beta_1 Period_{it} + \beta_2 Specialization_{it} + \beta_3 Words_{it} + \beta_4 Double + \beta_5 Travel_{it} + \beta_6 Region_{it} + \beta_7 Period_{it} * Double + \beta_8 Period_{it} * Region_{it} + \beta_9 Double * Region_{it} + \eta_i + \varepsilon_{it}$$

The dependent variable is the natural log of profit (plus one) for person *i* in period *t*. The results are reported in column 4 of Table 4.[20]

Finding 6*: Westerners earn significantly more than Easterners, and there is no difference in profits between Westerners in the* Double *and* Single *treatments.*

Finding 6 indicates that, holding other characteristics constant, subjects residing in the West earn roughly 240 [= 100 × ($e^{1.243}$ – 1)] percent more than subjects in the East in period 30 (see column 4 of Table 4). The insignificant coefficient on *Period*West* indicates that the level difference between the East and the West in profit is not eroded over time. In addition, the second part of Finding 6 indicates there is no additional benefit to residing in the West in the *Double* treatment. This finding accords with Finding 4, which showed that theft was much lower in the West than the East in both *Double* and *Single*, but that the reduction was greater in *Single*. It seems that the potential for doubled production provides incentives to migrate and steal less, but these do not translate into greater earnings. This brings up the question of why subjects in the West in *Double* do not specialize more. It appears that the potential for doubled production does not accelerate the learning process in our subjects. While subjects in the East stagnate slightly above autarky, subjects in the West are consistently above autarky and improving.[21]

Similarly, these findings are particularly surprising given the regression results for the same coefficients (i.e. *Period*West* and *Double*West*) when the dependent variable was theft. Recall that theft was decreasing at significantly different rates in the East across the treatments: 7.1 percent in *Single* and 2.5 percent in *Double* (see Finding 5).[22] Thus, other characteristics constant, different rates of decline in theft do not translate into different rates of profit increase (or decrease) in the East.

[20] In addition, in column 3 we estimate and report the results from estimating an equation that excludes the interaction variables. In this sub-section we only discuss findings based on equation (5), as these provide the most interesting picture of subject behavior.

[21] This is true even when we consider that doubled production raises autarky profit to (at most) 56 cents, on average.

[22] Theft was also increasing at significantly different rates in the West across treatments. However, the level of theft in the West was low overall so we focus the discussion on changes in the East.

Finding 7*: In the East and West, profit is increasing faster in* Single *than in* Double.

The coefficient on *Double* in column 4 of Table 4 is not statistically different from zero. However, the coefficients on *Period* and *Period*Double* are both statistically significant and indicate that while there is no initial difference between the treatments, profit is increasing at significantly different rates across the treatments: 2.5 and 5.8 percent in *Double* and in *Single*, respectively. This supports previous evidence suggesting a difference in the evolution of subject behavior across the two treatments. We emphasize that migration for subjects in *Single* seems to allow those who choose it to improve their circumstances significantly.

V. Conclusion

In 1766 the English jurist and professor Sir William Blackstone famously wrote in his *Commentaries on the Law of England*:

> There is nothing which so generally strikes the imagination, and engages the affections of mankind as the right of property; or that sole and despotic dominion which one man claims and exercises to the external things of the world, in the total exclusion of the right of any other individual in the universe. And yet there are very few, that will give themselves the trouble to consider the origin and foundation of this right. Pleased as we may be with the possession, we seem to be afraid to look back to the means by which it was acquired, as if fearful of some defects in our title; or at best we rest satisfied with the decision of the laws in our favor, without examining the reason or authority upon which those laws have been built. (Book II, Ch. 1, p. 2)

This paper is an attempt to uncover the foundations upon which the law of property has been built. We report a laboratory experiment designed to explore how property rights emerge as a convention when people can self-select to form their own communities through geographic migration. When given the opportunity, we find that socially-minded individuals leave areas in which the stability of possession, Hume's first fundamental law of human nature, is neither recognized nor respected. Upon resettlement, there is little theft and these migrants become much wealthier than their counterparts as they quickly adhere to Hume's second fundamental law of nature, the transference of property by consent. Surprisingly, we also observe that the plunderers, when left with each other, also begin to establish more stable possession amongst themselves. They, however, engage in little specialization and exchange, and hence are rather poor. Finally, we find strong support for the Demsetz hypothesis that property rights develop the greater the ecological benefits of internalizing the stable possession of property relative to the

cost of achieving it (which in our economies is costly travel). Subjects in *Double* move to the West earlier and in much greater numbers than subjects in *Single*.

In conclusion, we have observed a means by which subjects in the laboratory rebuild a system of the property rights that they routinely apply in their daily lives: Latent cooperators form communities of like-minded individuals by putting physical and social distance between them and the uncooperative plunderers. This experiment powerfully supports what Samuel Pufendorf discussed in 1672, namely we "too discover the Falsity of that vulgar Saying, *Mine* and *Thine* are the cause of all Wars and Quarrels in the World. For on the contrary the Distinction of *Mine* and *Thine* was rather introduc'd to prevent all Contention" (Book IV, Ch. 4, Section 7). And it is this necessary distinction that undergirds Adam Smith's most fundamental insight, viz. exchange and specialization create the wealth of nations.

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Figure 1: Screenshot of Experiment Interface

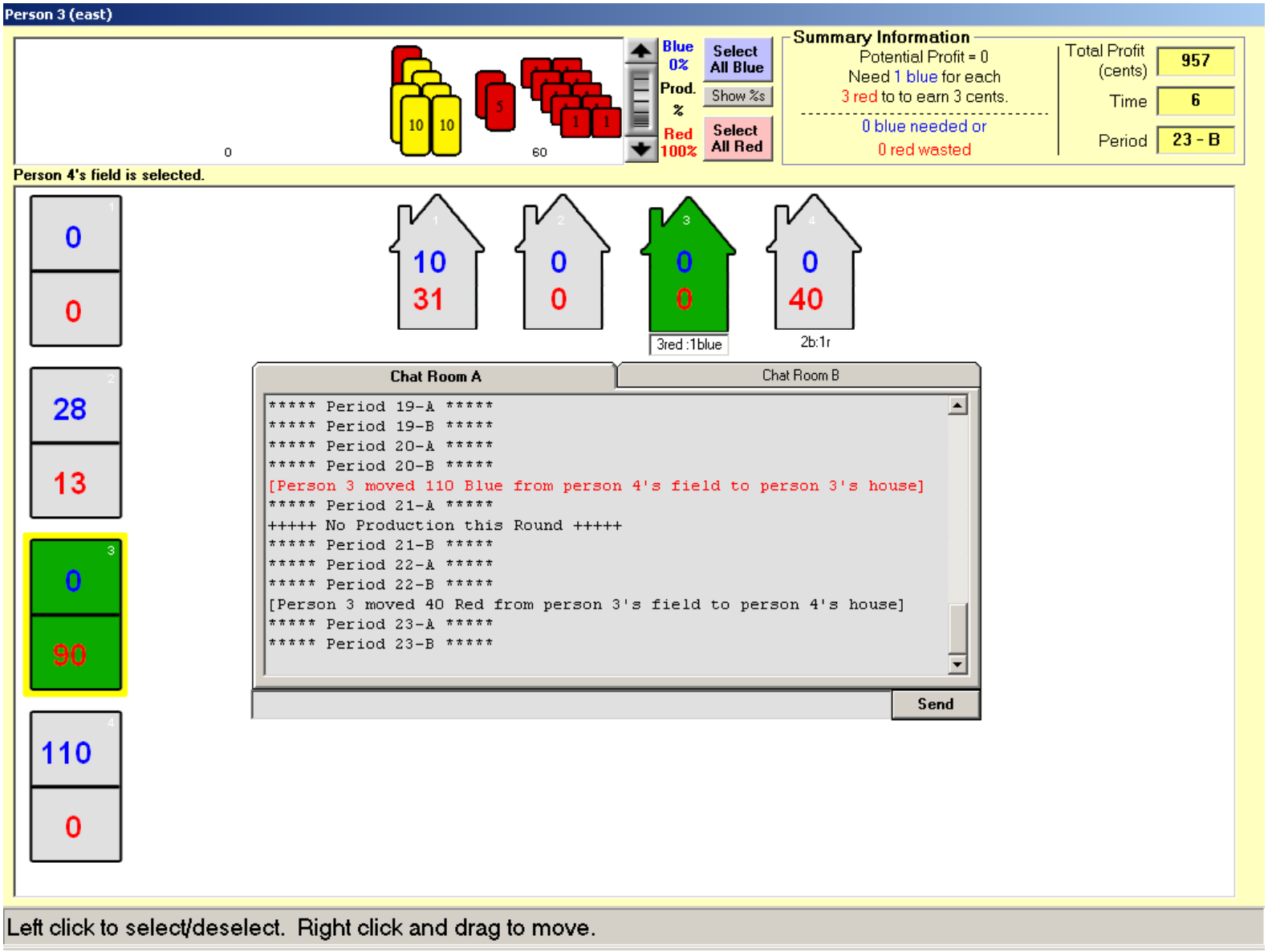
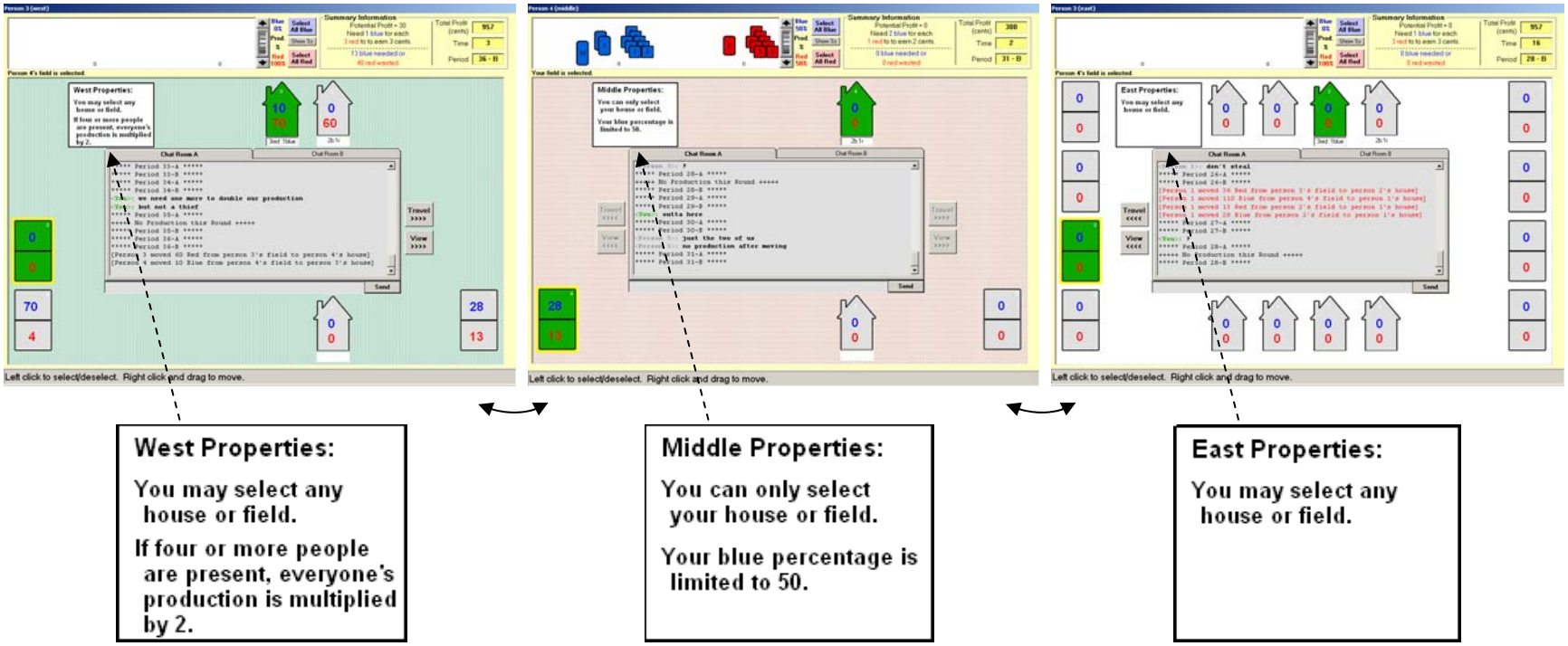
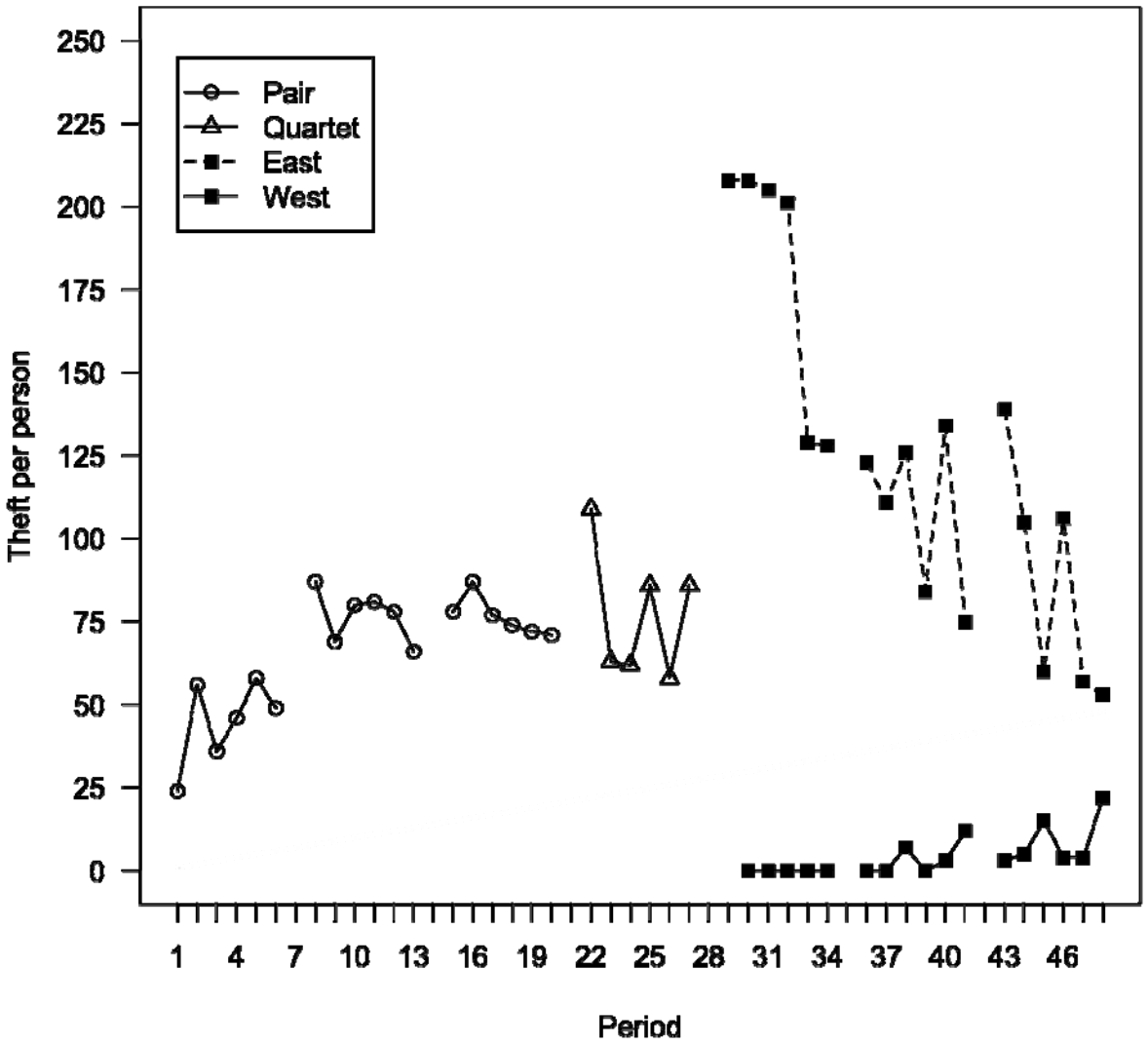


Figure 2: Region Layout



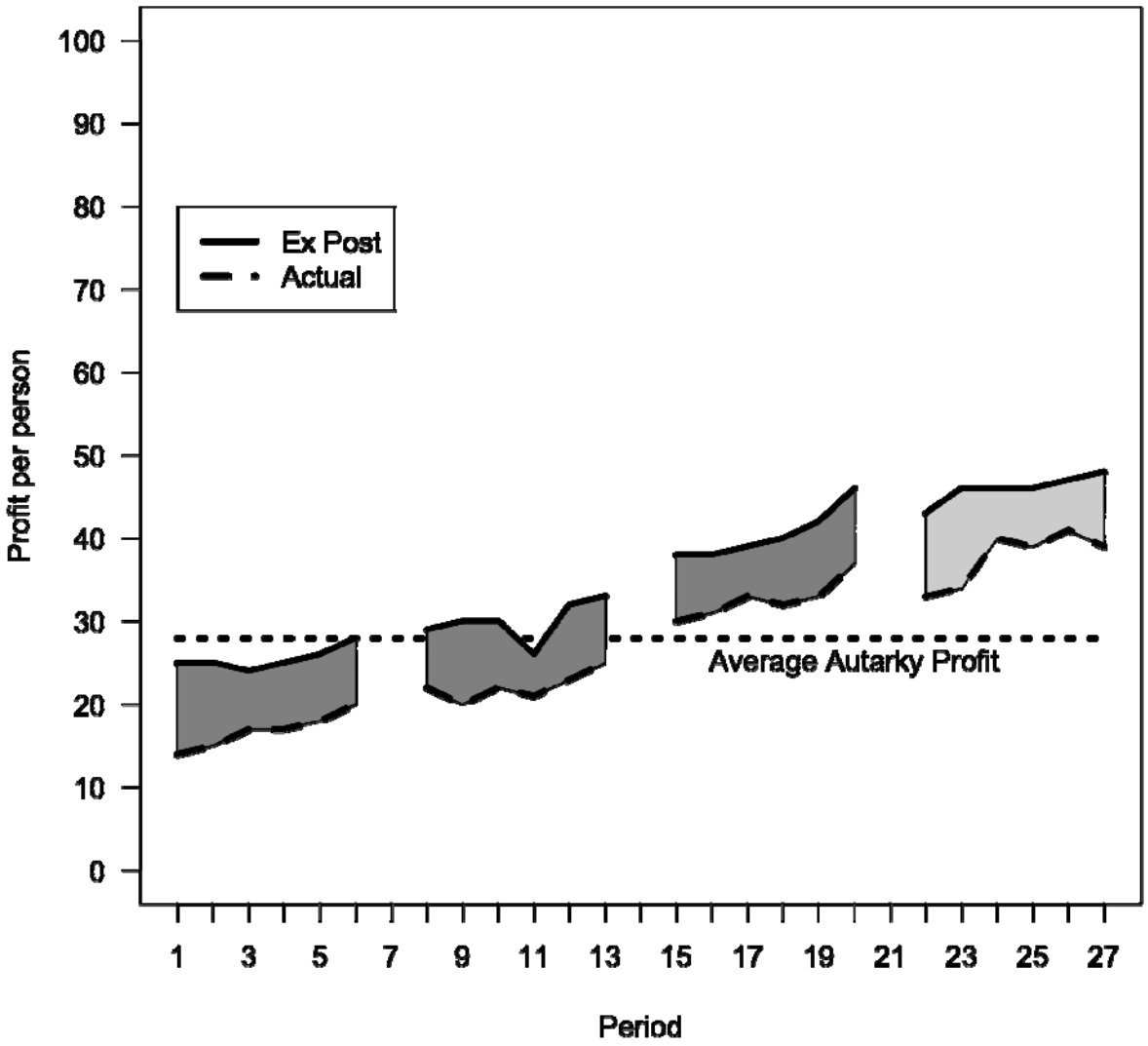
Notes: The properties of the West shown above are for the *Double* treatment. For the *Single* treatment, the properties in the West are identical to those the properties in the East: "You may select any hour or field." The "travel" and "view" buttons to the right and/or left of the chat room allows subjects to perform these functions as described in Section II.C.

Figure 3: Theft Per Person, Weeks 1-7



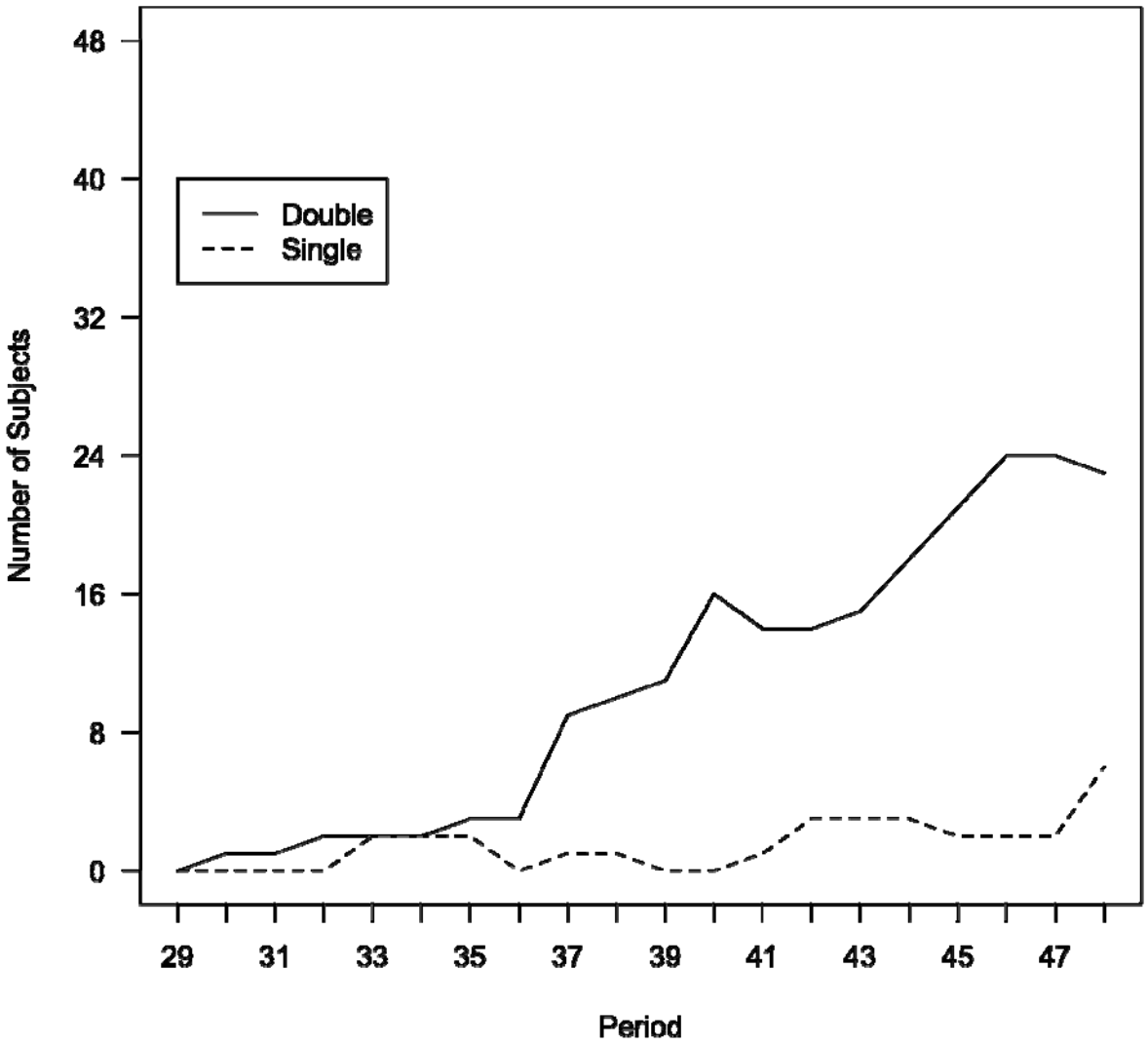
Notes: In the first four weeks, we calculate theft by summing total quantity of theft in each period and dividing by 96, the total number of people. In the final three weeks, we calculate theft by summing the total quantity of theft in the East and the West in each period and dividing by the population of the region in each period. From period 29 to 48, the two series marked with squares are for groups of eight in the East and the West. The West is missing an observation for period 29 since subjects could not be in the West until period 30.

Figure 4: Difference Between Ex Post and Actual Profit, Weeks 1-4



Notes: From period 1 to 20, the dark-shaded area in Figure 3 represents the difference between *ex post* and actual profit per person in pairs. From period 21 to 27, the light-shaded area represents the difference between *ex post* and actual profit per person in quartets. The data used to construct these figures was the *ex post* profit as determined by the optimization described in Section II.D. and actual profit averaged over all pairs and quartets.

Figure 5: Number of Subjects in the West by Treatment, Weeks 5-7



Notes: In *Single*, subjects in Session 9 make up most of the migrants. In the last period, Session 9 contains 5 migrants in the West. Of the remaining sessions only one contains one migrant in period 48.

Figure 6a: Difference Between Ex Post and Actual Profit in the West

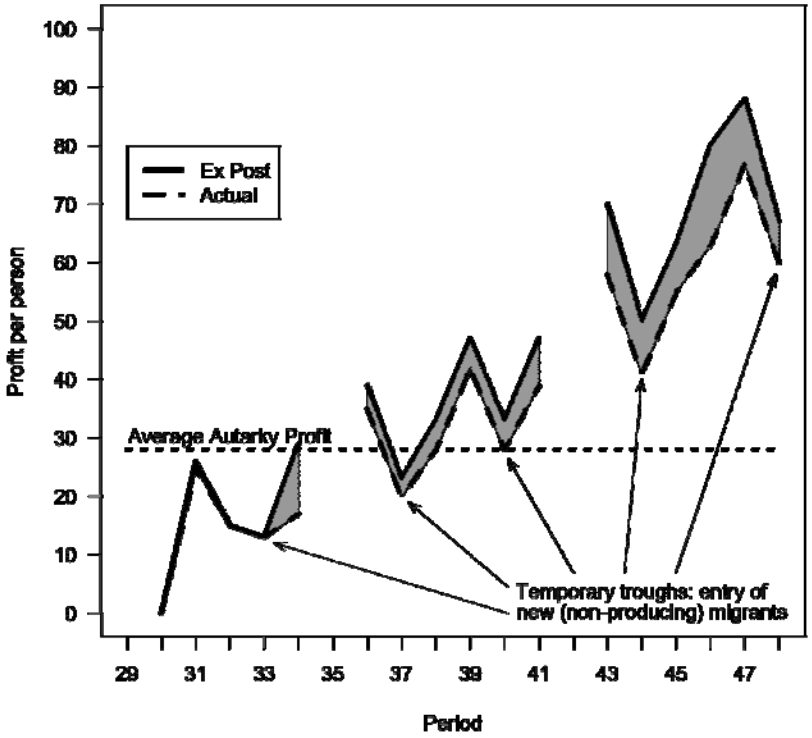
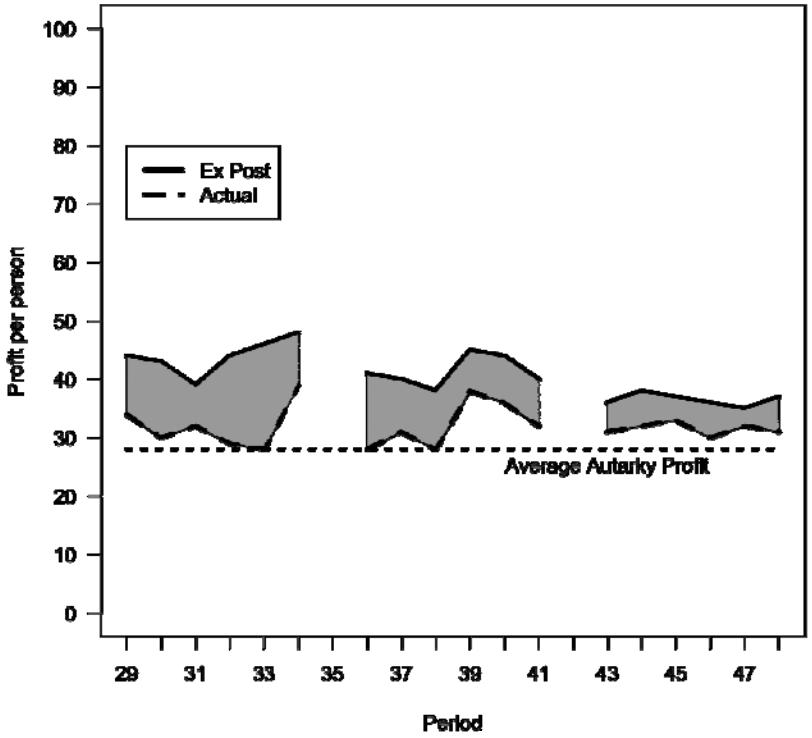


Figure 6b: Difference Between Ex Post and Actual Profit in the East



Notes: Figures 6a and 6b show the difference in *ex post* and actual profit per person in the West and the East, respectively. The data used to construct these figures is the *ex post* profit as determined by the optimization described in Section II.D. and actual profit averaged over all twelve sessions. Series stratified by treatment are qualitatively similar.

Table 1. Summary Statistics

a. Specialization, Efficiency, and Theft

Variable:	(1) Specialization		(2) Efficiency		(3) Theft	
Treatment:	Double	Single	Double	Single	Double	Single
Week 1	36	39	-20	-19	345	373
	(4.8)	(4.9)	(4.8)	(7.2)	(374.9)	(327.9)
Week 2	41	44	-11	-10	593	634
	(11.2)	(7.5)	(12.0)	(8.9)	(601.2)	(266.6)
Week 3	49	54	0	15	723	500
	(11.6)	(15.6)	(14.8)	(23.2)	(1011.1)	(468.8)
Week 4	55	62	9	25	719	520
	(14.7)	(24.5)	(16.8)	(37.4)	(617.2)	(537.0)

b. Comparisons With Other Experimental Data

Variable:	(4) Profit	
Experiment:	Build8	Ex Post
Week 1	22.0	26.0
	(6.5)	(8.6)
Week 2	31.0	30.0
	(15.0)	(12.6)
Week 3	37.0	40.0
	(19.8)	(24.2)
Week 4	42.0	38.0
	(16.4)	(21.7)

Notes: In panel (a), two-sided Wilcoxon rank sum tests on the mean of each variable fail to reject the null hypothesis of equal means in each of the first four weeks. In panel (b), two-sided Wilcoxon rank sum tests on the mean of actual profit from *Build8* sessions and *ex post* profit from the present experiment fails to reject the null hypothesis of equal means in three of the first four weeks. In week 1, *ex post* profit is greater than CSW actual profit. Standard deviations are reported in parentheses.

Table 2. Profit: Weeks 1-4

Dependent Variable:	*Profit*		*Profit*$^{ex\ post}$ - *Profit*^{actual}	
	(1) pairs	(2) quartets	(3) pairs	(4) quartets
Constant	1.7306 ***	1.6635 ***	0.7044 ***	1.6765 ***
	(0.1079)	(0.3791)	(0.0963)	(0.4355)
Period	0.0233 ***	0.0345 **	-0.0085 ***	-0.0104
	(0.0056)	(0.0170)	(0.0054)	(0.0180)
Specialization	0.0210 ***†	0.0179 ***†	-0.0014	-0.0199 ***
	(0.0019)	(0.0020)	(0.0018)	(0.0038)
Words†	0.0069 **	0.0108 **	-0.0047 *	-0.0095 *
	(0.0037)	(0.0050)	(0.0035)	(0.0059)
Theft†	-0.0013 ***	-0.0013 **	0.0017 ***	0.0011
	(0.0004)	(0.0007)	(0.0004)	(0.0010)
Theft^2	0.0000 **	0.0000	0.0000 *	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Observations	864	144	864	144

Notes: Linear mixed-effects regressions estimating equation (1a) in columns 1 and 2 and equation (1b) in columns 3 and 4. The standard errors are reported in parentheses. † indicates the p-value is one-sided, otherwise two-sided. *** indicates statistically different from zero at the 1% level; ** indicates 5% level; and * indicates 10% level.

Table 3: Decision to Move West

Dependent Variable:			*West*		
			Estimates	Marginal Effects	
	(1) *Single*	(2) *Double*	(3)	(4)	(5)
Constant			-2.706 **		
			(1.11)		
Double†			2.464 **		0.487 **
			(1.14)		(0.25)
Specialization4	62	55	0.001	0.000	0.001
	(14.7)	(24.5)	(0.01)	(0.00)	(0.00)
Words4†	8	4	0.066 **	0.001	0.026 **
	(8.0)	(5.5)	(0.04)	(0.00)	(0.02)
Theft4†	65	90	-0.003 **	0.000	-0.001 **
	(105.1)	(146.8)	(0.00)	(0.00)	(0.00)
Observations	6	23	96		
Predicted probability				0.007	0.493

Notes: Columns 1 and 2 report the means of the continuous dependent variables by treatment with standard deviations in parentheses. Observations in columns 1 and 2 represent the number of subjects in the west in period 48 in each treatment (out of 48 subjects in each treatment). A random effects probit is estimated for equation (2) and reported in column 3. The marginal effects, at the means of continuous variables and stratified by *Single* and *Double*, are reported in columns 4 and 5, respectively. Standard errors are reported in parentheses. † indicates the p-value is one-sided, otherwise two-sided. *** indicates statistically different from zero at the 1% level; ** indicates 5% level; and * indicates 10% level.

Table 4: Theft and Profit: Week 5-7

Dependent Variable:	*TheftperPerson*		*Profit*	
	(1)	(2)	(3)	(4)
Constant	1.940 ***	2.535 ***	2.318 ***	2.420 ***
	(0.67)	(0.72)	(0.63)	(0.65)
Period	-0.031 ***	-0.071 ***	0.038 ***	0.058 ***
	(0.01)	(0.01)	(0.01)	(0.01)
Specialization	0.001	-0.002	0.006 ***†	0.006 ***†
	(0.00)	(0.00)	(0.00)	(0.00)
Words	-0.018 ***	-0.017 ***	-0.004	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)
Double	-0.679	-1.219	-0.269	-0.524
	(0.88)	(0.94)	(0.69)	(0.72)
Travel†	-0.256 **	-0.256 **	-2.143 ***	-2.133 ***
	(0.14)	(0.14)	(0.18)	(0.18)
Middle†	-1.402 ***	-2.142 ***	0.853 ***	1.386 ***
	(0.11)	(0.29)	(0.13)	(0.36)
West†	-1.023 ***	-2.875 ***	1.231 ***	1.243 ***
	(0.11)	(0.37)	(0.13)	(0.46)
*Period*Double*		0.046 ***		-0.033 **
		(0.01)		(0.02)
*Period*Middle*		0.069 ***		-0.004
		(0.02)		(0.03)
*Period*West*		0.087 ***		0.027
		(0.02)		(0.03)
*Double*Middle*		0.022		-0.635 **
		(0.22)		(0.27)
*Double*West*		0.912 ***		-0.358
		(0.28)		(0.34)
Observations	1632	1632	1632	1632

Notes: Linear mixed-effects regressions estimating equation (3) in column 1, equation (4) in column 2, equation (5) in column 3, and equation (6) in column 4. Standard errors are reported in parentheses. † indicates the p-value is one-sided, otherwise two-sided. *** indicates statistically different from zero at the 1% level; ** indicates 5% level; and * indicates 10% level.

Appendix I. Details of Experiment Design

A. Environment

Each production and exchange economy consists of eight subjects of two types, *odd* and *even*, producing and consuming a combination of red and blue units. Each subject is endowed with a field and house: production and consumption take place in the field and house, respectively. In each period, subjects are given $T = 10$ seconds of time and allocate t to the production of red and $(T - t)$ seconds to the production of blue. For *odd* subjects the production functions are:

$$R_{odd} = \frac{13}{10\sqrt{10}} t^{\frac{5}{2}} \approx 0.41 t^{\frac{5}{2}}$$

$$B_{odd} = \frac{10}{10 - \left(\left(300\sqrt{10}\right)/13\right)^{2/5}} \left(10 - t\right) \approx 2.25\left(10 - t\right)$$

While *even* subjects produce according to the following production functions:

$$R_{even} = \frac{13}{10 - \sqrt{260/11}} t \approx 2.53t$$

$$B_{even} = \frac{11}{10}\left(10 - t\right)^2$$

If the entire production time is allocated to a single commodity *odd* (*even*) subjects produce a maximum of 130 (25) red or 23 (110) blue. Thus, *odd* subjects have a comparative (and absolute) advantage in the production of red and *even* subjects in blue.

The production phase is followed by a 120-second exchange and consumption phase. Units of red R and blue B produced in the production phase appear in the subject's own field. Subjects move units from their field to their house in order to consume (and earn money). *Odd* and *even* subjects derive utility from consuming r red and b blue units according to the following functional forms, subject to integer constraints of strict complements: $U_{odd} = \min\{r, 3b\}$ and $U_{even} = \min\{2r, b\}$. Earnings are calculated only from units in a subject's own house for a given period and units not consumed are wasted.

B. Benchmarks: Efficiency and Specialization

We define efficiency in our economies as $\frac{\sum_{i\in N}\pi_{it}-\sum_{i\in N}\pi_i^a}{\sum_{i\in N}\pi_i^c-\sum_{i\in N}\pi_i^a}\times 100\ \%$, where π_{it} is realized earnings of subject i in period t of session N, and π_i^a and π_i^c are autarky and competitive earnings, respectively. Autarky earnings are subtracted from realized and competitive earnings to standardize autarky at 0 percent. In addition, we define the rate of specialization of our economies as $\frac{\sum_{i\in N}q_{it}}{\sum_{i\in N}\overline{q}_i}\times 100\ \%$, where q_{it} denotes total units of red and blue produced by subject i in session N and $\overline{q}_{it}$ denotes maximum production by i in t under complete specialization.

Appendix II. Experiment Instructions

Page 1

This is an experiment in the economics of decision making. The instructions are simple, and if you follow them carefully and make good decisions you may earn a considerable amount of money which will be paid to you in CASH at the end of the experiment.

In this experiment you are **Person 3**. You and the other **7** people in this experiment each have the ability to produce two fictitious items: red and blue. For the first **10** seconds of each period, you will produce items in your green field. Using the scroll bar in the upper middle portion of your screen, you can change the proportion of each second allocated to producing red and blue. Each person's production is displayed on their field. When a field or house is selected it contents is represented by the domino-shapes in the top left portion of your screen. To select a field or house left click on it, the house or field that is currently selected will be highlighted in yellow.

Page 2

After the production phase ends, the period continues for another **90** seconds. When the clock expires, you earn cash based upon the number of red and blue items that have been moved to your house. To select items to be moved, *left* click on the dominos or click on the red or blue select all buttons at the top of the screen. The yellow highlighted items can be moved by dragging with the *right* mouse button. The maximum number of red or blue items a house or field can hold is 170. (You cannot move items until the experiment has started or during the production phase.)

The specific information on how the red and blue items in your house generate earnings is given in the upper right corner of your screen. You personally earn (in cents) the minimum of the following two numbers:

3 time number of red items,
number of blue items.

Or, think of it this way. You earn by consuming what's in your house in the proportion of 3 red to 1 blue items. For every 1 unit of blue you need 3 red to earn 3 cents. Your potential profit updates as items, unit by unit, are moved into your house.

Page 3

Everyone in this experiment can send text messages. Everyone can read all posted messages. In the center of the screen, you can type a message in the text box next to the send button. To send a text message press the Send button. There are two chat rooms. Messages sent to Chat Room A will only appear in chat room A. Message sent to Chat Room B will only appear in chat room B

Under your house you can also post a one-line message that will be visible at all times to the other players.

You are free to discuss all aspects of the experiment, with the following exceptions: you may not reveal your name, discuss side payments, make threats, or engage in inappropriate language (including such shorthand as 'WTF'). If you do, you will be excused and you will forfeit your earnings.

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During the experiment, every 7 periods will be a "break period" in which nobody produces anything but that the chat rooms are still open. You can open a table of your production possibilities by clicking on the Show % s button. This table will fill in every time you change the proportion of time allocated using the scroll bar.

This is the end of the instructions. If you wish to explore how you produce red and blue items, click the Practice button. You may change the proportion of time allocated to producing red and blue items using the scroll bar, and you may Practice as many times as you wish. (You will not be able to move items until the experiment has begun.)

If you wish to review the instructions, you may go back at this time. If you feel you are prepared to proceed with the actual experiment, click on the Start button. The experiment will begin once everyone has clicked on the Start button. If you have a question that you feel was not adequately answered by the instructions, please raise your hand and ask the monitor before proceeding.