EXPERIMENTAL ECONOMICS, POVERTY, AND ECONOMIC GROWTH

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Abstract: *As in other sciences, an economic experiment is an artificial situation created by a researcher for the purpose of answering one or more scientific questions. Experiments of various types are used in economics to understand the causes of poverty and how it might be alleviated. The methods can identify causal relationships between variables and thereby isolate factors that can lead to poverty as well as to document the behavioral consequences of poverty. Experiments can also be used to provide test beds for proposed policies to alleviate poverty. This essay describes a variety of ways in which experiments have been employed to understand and combat poverty. A line of laboratory experiments that considers which economic institutions are conducive to economic growth is discussed in detail. The results show that decentralized markets are conducive to allowing an economy to operate as efficiently as it can. However, in an economy with a theoretical "poverty trap," the market works more efficiently if accompanied by a democratic voting process and freedom of communication.*

KEY WORDS: economic growth, experiment, institution, poverty, laboratory

I. Introduction

Economists typically think of poverty as a situation in which an individual, town, region, or nation does not create sufficient wealth to support what is viewed as an acceptable standard of living. At each of these levels of aggregation—individual, local, regional, or macroeconomic—poverty may be defined relative to a reference level. For example, at the macroeconomic level, regions or countries can be defined as poor based on the gap between themselves and other locations or relative to a potential optimal wealth level. There is a consensus that poverty is one of the pressing issues of our time and requires the attention of economists, sociologists, psychologists, and political scientists.

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A scientific approach to achieving the goal of reducing poverty requires understanding the issues involved in a manner that can inform economic and social policy. Such a systematic understanding would require answers to each of the three following questions:

(1) What causes poverty? This is important because the prevention of poverty in the future may be easier if its causes are understood. Attempts can be made to mitigate these causes.
(2) What are the consequences of poverty? To understand how best to allocate available resources toward remediation of poverty, we must understand its consequences and their costs. Resources can then be concentrated into activities that yield the greatest social benefit at the lowest social cost.
(3) What can be done about poverty? Proposed policies need to be evaluated for their effectiveness.

Answering these questions using empirical data is difficult because of the challenge of identifying causal relationships. Poverty is associated with many economic, political, and social variables on a correlational basis. For example, at the level of the individual, health, educational level, and the number of children a family must feed are all positively related to the likelihood of being in poverty. Other factors include the political and economic systems that the individual lives under, current government and central bank policies, where the economy is in the business cycle, political stability, and global trends. Other variables not typically considered economic are also important. For example, poverty is correlated with mental illness and risky behaviors such as smoking and drinking. It is also negatively associated with the presence of high social capital, certain religious traditions, and geographic latitude. Poverty may also be associated with some unknown variables for which hard data do not exist or that are difficult to measure, making such variables speculative. There may be other key variables that have not even come to mind to researchers as potential correlates.

However, identifying correlations are one thing and establishing causality is another. Many variables are correlated with poverty, but do they *cause* poverty? Or does poverty cause them? Or are both poverty and the other variable caused by a third factor? For example, does having freedom of the press or democratic elections reduce poverty and contribute to prosperity, are countries with less poverty more likely to introduce freedom of the press and democratic voting processes, or does geography or the historical dominance of a particular religious faith cause both prosperity and the appearance of these institutions? Sophisticated and elegant econometric techniques along with clever choice of instrumental variables are employed to try to extract causal relationships from data. For example, at the individual level, it has been found in a number of studies that people with lower income are

more risk averse and are more impatient than those with higher incomes.[1] This is true in both developed and developing countries. Weather, which can affect income, can be used as the exogenous variable to establish causality in agrarian economies or regions.[2] Because income cannot affect the weather and the way that weather affects poverty is through its effect on income, causality can be established. However, this type of analysis typically requires high-quality data and strong assumptions about the variables, which are often not possible. Experimental methods allow a researcher to clearly isolate the causal relationships behind these correlations.

Unlike traditional empirical data available to economists, experimental methods allow a researcher to obtain data expressly designed to address a specific research question. One such question is whether a causal relationship between two variables exists. Experimental economics involves constructing synthetic economic settings for research purposes. While these settings are synthetic, they are just as real as naturally occurring situations, in a sense similar to the way that plastic is as real as wood, even though it is a synthetic material created with human intervention rather than found in nature.

The capacity to control the environment accorded by experimental methods offers a number of advantages. Different experimental treatments can be implemented that only differ in one aspect, allowing ceteris paribus comparisons that isolate the effect of a change in exactly one variable. Thus, experiments can be used to deal with the problem that many of the factors that may contribute to or ameliorate poverty tend to occur together. For example, democratic voting and a free press generally are present in the same countries, so it is difficult to isolate their individual contributions to economic growth. At the individual level, for example, alcoholism and poor health are highly correlated with each other, so that it is not easy to know which one of the two variables might be contributing to poverty.

In this essay, I focus on a particular line of experimental research. This line of inquiry uses laboratory experiments to study the effect of economic institutions on the overall wealth and consumption levels of an economy. Although the experiments are small in scale, the questions posed and the interpretations made are at the macroeconomic level. The overriding question is: What institutions promote economic growth and permit the economy to operate at close to its potential? This focus on a specific line of research is not to meant to slight other lines of experimental inquiry, some of which are briefly mentioned below in Section III and discussed elsewhere in detail.

[1] See Luigi Guiso and Monica Paiella, "Risk Aversion, Wealth, and Background Risk," *Journal of the European Economic Association* 6, no. 6 (2008): 1109–50; Tomomi Tanaka, Colin F. Camerer, and Quang Nguyen, "Risk and Time Preferences: Linking Experimental and Household Survey Data from Vietnam," *American Economic Review* 100, no. 1 (2010): 557–71.

[2] Edward Miguel, Shanker Satyanath, and Ernest Sergenti, "Economic Shocks and Civil Conflict: An Instrumental Variables Approach," *Journal of Political Economy* 112, no. 4 (2004): 725–53.

This essay is organized in the following manner. In Section II, I provide a rationale for conducting experiments. In Section III, I describe some of the methods covered within the rubric of experimental economics. In Section IV, I describe a few studies that use the laboratory to study the relationship between institutions and the economic performance of an economy. In Section V, I summarize what we can learn from this kind of research. Section VI provides some concluding thoughts and observations.

II. The Rationale for Experimentation

Experimentation involves creating an artificial setting with the purpose of answering one (or more) research question. Rather than waiting to observe data, the experimenter actively creates a situation in which the relevant data can be observed. In economics, this traditionally involves creating a decision environment that allows a hypothesis of interest to be tested. This can be done within the confines of a dedicated laboratory facility or in a field setting.

Experimentation has two important features. The first is randomization of individuals or groups, who are drawn from a similar participant pool or who have a similar profile, into different treatment conditions. The randomization ensures that there are no systematic differences between those participating in each condition. The second feature is the ability to vary only one factor at a time in order to isolate the effect of a single variable.

Some of the most important advantages of an experimental approach are:

Advantage (1) Establishing Causal Relationships. Experiments can be used to establish the causal relationships needed to understand the effect of one variable on another. Such relationships are essential to understanding how an economy operates. We want to know whether A causes B, not just whether A co-occurs with B. This can be studied by randomizing individuals in two groups, inducing A in one of the groups, and measuring and comparing the incidence of B in the two groups.

Advantage (2) Observability of Key Parameters. Economic theories are constructed based on unobservable variables. Using experiments allows us to observe more of these than would otherwise be possible. For example, in an experiment the maximum potential production of an economy is observable to the researcher, so that she can precisely measure how far the economy is operating below its potential.

Advantage (3) Ability to Control for Confounding Variables. The key here is that individuals are randomly assigned into treatment conditions. This means that, at least in principle, all factors other than the treatment variable would be on average the same in the two conditions. Any difference between treatments can only be due to the treatment variable.

Advantage (4) Replicability. Two important types of replication are made possible by experimental methods. The first is the ability to

construct multiple identical economies. It is difficult to gather, in the real world, multiple independent observations at the macroeconomic level; for example there is only one United States, Peru, or Panama. In the laboratory, however, many "countries" with an identical underlying parametric structure can be constructed. This allows one to establish results at high levels of significance. The second type of replication is that conducted by competing researchers, who are free and able to conduct the same experiment. The convention in experimental economics of providing sufficient detail about procedures to allow others to replicate the study, provides discipline in encouraging researchers to conduct their studies carefully.

There was at one time a consensus among economists that economics was a science in which controlled experiments could not be conducted. The renowned economist Milton Friedman captures this traditional view: "Economists and social scientists complain that we are at a disadvantage compared with physical and biological scientists because we cannot conduct controlled experiments."[3] The thought was that researchers had to observe the world and wait until auspicious circumstances occurred naturally that allowed the researcher to exploit exogenous variation in an independent variable. However, decades of progress and innovation in experimental economics has shown it to be a rigorous and informative methodology.

To illustrate the scientific value of running laboratory experiments, consider the most basic model of economics: the theory of supply and demand, which is a theory that makes predictions about the prices that would prevail in a market and how much trade would occur. Suppose that there are some potential buyers and sellers of a product trading in a market for the product. Each buyer has a valuation for the product. This valuation can be thought of as the amount of money that has the same value to the buyer as the item has or, equivalently, as the most money one would be willing to pay for one unit of the product. One would be willing to buy it at any price that was lower—and not willing to purchase it at any price that was higher—than this valuation. Analogously, each seller has a cost of producing or procuring the item. This cost represents the lowest price that the seller would accept for the item. The seller would be willing to sell at any higher price because she can cover her cost, but not at any lower price where she cannot cover it.

The theory of supply and demand proposes that a good will trade at a market price equal to that arising from the following thought experiment. Suppose that all of the valuations held by all potential buyers are ordered from highest to lowest and call the resulting relationship between the valuations and the rank ordering of units a demand curve. The costs can also be ordered from lowest to highest to create a relationship between cost

[3] Milton Friedman, "The Real Lesson of Hong Kong," *National Review*, December 31, 1997, 36–37.

of a unit and unit number, termed a supply curve. Both the supply and demand curves thus plot prices against quantities. It must be stressed that there is no entity constructing these curves; they are theoretical notions. If the two curves have an intersection where supply equals demand, the price and quantity at that point is termed a market equilibrium. The principal prediction of the theory of supply and demand is that, in the market, the quantity corresponding to the market equilibrium would be exchanged with each unit trading at the market equilibrium price.

Does this theory describe the behavior of actual markets? Out in the world, we typically do not know the unit-by-unit cost structure for sellers nor do we know the valuations of buyers. Demand and supply curves are unobservable variables. We can only observe prices and quantities exchanged, not whether they correspond to an intersection of unobservable demand and supply curves. With access only to data from the field, we would have to take it on faith that the theory is operating. There seems no way to disprove the claim of a skeptic that the theory does not describe market behavior.

However, this theory could finally be evaluated with the advent of experimental methods. Vernon Smith's seminal experimental study found that prices converge to the price and quantity at which supply meets demand, if trade in the market follows a procedure called continuous double-auction rules.[4] Under these rules, the market is open continuously in the sense that, at any time, any potential buyer or seller can submit an offer to the market to buy or sell and these offers are immediately made visible and available to all participants. Any buyer or seller can accept any available offer at any time; if such an acceptance occurs, a trade is concluded at the offered price. The strong tendency of such markets to reach their market equilibrium has been consistently replicated in subsequent experiments and found to extend to much more complicated environments with up to twenty-one markets operating simultaneously.[5] This result shows that markets can be designed in such a manner that they reliably attain the market equilibrium. Because this outcome is optimal in a wide class of environments, this result also indicates that, in this class of environments, attaining an optimal outcome is possible.

III. Types of Experimentation in Economics

A spectrum of different methodologies falls under the umbrella of experimental economics. Which of these methodologies is best to employ depends on the goals of the research and the resources available. A traditional approach to conducting economic experiments is to recruit participants to come to a dedicated economics laboratory and engage in a structured task.

[4] Vernon Smith, "An Experimental Study of Competitive Market Behavior," *Journal of Political Economy* 70, no. 2 (1962): 111–37.

[5] Charles N. Noussair, Charles R. Plott, and Raymond G. Riezman, "Production, Trade, Prices, and Equilibration in Large Experimental Economies," *European Economic Review* 51, no. 1 (2007): 49–76.

The participants are typically university students. The advantages of using student populations are that they are typically available to researchers in relatively large numbers and have a relatively low cost of time for their participation. This facilitates the replication of studies by other research groups because it is easier to gain access to participants with a similar demographic profile as the original study. These experiments are typically not intended to simulate situations outside the laboratory with their richness and complexity. On the contrary, laboratory experiments attempt to simplify the environment and distill it to a small number of essential elements to facilitate interpretation of the data.

Conventional norms in experimental economics require that individuals are incentivized, typically with cash payments proportional to their payoff in the economic model under consideration. In other words, the participant earns more, the better her performance in her task. For example, a participant in the role of a firm would get paid proportionally to the earnings of the firm. The other important norm is one of no deception of participants. This means, for example, that any random variable in the experiment must actually be drawn from the distribution indicated to participants and no confederates of experimenters may be employed in the experiment without informing participants. These norms of incentivization and no deception, which set economics apart from psychology where such constraints are not always observed, add to the cost of doing experiments. However, some observers have expressed the view that such norms have allowed experimental economics to avoid the replication crisis that is currently affecting experimental psychology. Others would argue that the hypothetical payments possible in psychology studies allow one, for example, to study decisions that would be made with a large or negative amount of money. In addition, they would hold that allowing deception allows the researcher to study a greater range of situations than they could otherwise, such as instances where unlikely events occur.

Laboratory experiments are typically constructed to evaluate hypotheses. These hypotheses can arise as (1) implications of theoretical models (such as in the supply and demand example in Section II), (2) previous experimental results, or (3) empirical patterns observed in the world. Basing an experiment on a theory facilitates the interpretation of the results. If an experiment can support a theory, the experimental result moves beyond the level of a factoid, relevant beyond the particular context studied in the experiment. With a general theory able to organize the results, the experiment can be viewed as supporting general principles of behavior. As another example of an experiment with hypotheses originating from a theoretical model, consider the hypothesis: "If two countries have access to the same technology, the rate of economic growth in the poorer country will be greater than the rate of growth in the richer country." This hypothesis is an implication of the theory of economic growth, which is tested by one of the experiments discussed below in Section IV. An example of approach (2) would be to

hypothesize, based on results observed in the Western world, that "in non-Western country x, women are more generous than men to their peers." An example of (3) would be to hypothesize, based on the fact that women are less than proportionally represented in high-paying jobs—such as CEOs of large companies—that are competitive to obtain, that "women shy away from competition more than men."[6]

Taking tasks developed in laboratory research and administering them to nonstudent subjects is referred to as conducting an artefactual laboratory experiment or a lab-in-the-field study.[7] Many studies conducted in this manner have involved the measurement of an economic parameter at the individual level. Examples include procedures to measure risk aversion[8] and prudence.[9] The trust game is used to measure the level of trust and reciprocal behavior among members of a population.[10] The dictator game registers altruism,[11] the linear public good game is used as a measure of cooperativeness,[12] and the die-rolling task is commonly employed as an indicator of honesty.[13] These protocols are often administered to nonstudent populations, including the poor, to learn whether and how those living in poverty differ from other individuals in their economic attitudes and behavior. There are a number of excellent surveys of lab-in-the-field experiments.[14]

This experimental work has shown that poverty causes one to behave differently in some ways but not others, establishing that certain types of

[6] Muriel Niederle and Lise Vesterlund, "Do Women Shy Away from Competition? Do Men Compete Too Much?" *Quarterly Journal of Economics* 122, no. 3 (2007): 1067–1101.

[7] Glenn Harrison and John A. List, "Field Experiments," *Journal of Economic Literature* 42, no. 4 (2004): 1009–55.

[8] See Hans Binswanger, "Attitudes toward Risk: Experimental Measurement in Rural India," *American Journal of Agricultural Economics* 62, no. 3 (1980): 395–407; Uri Gneezy and Jan Potters, "An Experiment on Risk Taking and Evaluation Periods," *Quarterly Journal of Economics* 112, no. 2 (1997): 631–45; Charles Holt and Susan Laury, "Risk Aversion and Incentive Effects," *American Economic Review* 95, no. 5 (2002): 1644–55; Catherine Eckel and Philip Grossman, "Sex Differences and Statistical Stereotyping in Attitudes toward Financial Risk," *Evolution and Human Behavior* 23, no. 4 (2002): 281–95.

[9] Charles N. Noussair, Stefan Trautmann, and Gijs van de Kuilen, "Higher-Order Risk Attitudes, Demographics, and Financial Decisions," *Review of Economic Studies* 81, no. 1 (2014): 325–55.

[10] Joyce Berg, John Dickhaut, and Kevin McCabe, "Trust, Reciprocity, and Social History," *Games and Economic Behavior* 10, no. 1 (1995): 122–42.

[11] Robert Forsythe, Joel Horowitz, N. E. Savin, and Martin Sefton, "Fairness in Simple Bargaining Experiments," *Games and Economic Behavior* 6, no. 3 (1994): 347–69.

[12] R. Mark Isaac and James Walker, "Group Size Effects in Public Good Provision: The Voluntary Contributions Mechanism," *Quarterly Journal of Economics* 103, no. 1 (1988): 179–99.

[13] Urs Fischbacher and Franziska Follmi-Heusi, "Lies in Disguise: An Experimental Study on Cheating," *Journal of the European Economic Association* 11, no. 3 (2013): 525–47.

[14] See Catherine C. Eckel and Natalia Candelo, "How to Tame Lab-in-the-Field Experiments," in *Advances in Experimental Political Science*, ed. James N. Druckman and Donald P. Green (Cambridge, MA: Cambridge University Press, 2021), 79–102; Lata Gangadharan, Tarun Jain, Pushkar Maitra, and Joe Vecci, "Lab-in-the-Field Experiments: Perspectives from Research on Gender," *Japanese Economic Review* 73 (2022): 31–59; Angelino Viceisza, "Creating a Lab in the Field: Economics Experiments for Policymaking," *Journal of Economic Surveys* 30, no. 5 (2016): 835–54.

decisions make one more likely to end up poor. There is causal evidence that poverty increases risk aversion and impatience through its effect on emotional states and stress level.[15] Poverty also inhibits cognitive function[16] and there is evidence that one channel whereby it does so is through liquidity constraints.[17] Mere exposure to images of poverty can lower productivity.[18] Low income and debt accumulation is also correlated with imprudence, defined as concavity of the marginal utility function, which leads one to be more accepting of risk when one's wealth is relatively low.[19] On the other hand, welfare participants in the United States do not differ from university students with regard to their risk aversion, prudence, altruism, trust, the tendency to reciprocate kind and unkind actions, and beliefs about the rationality of their peers.[20] At the national level, it has been documented that there is a strong positive relationship between per-capita GDP in a country and how patient its citizens are.[21] This makes sense from an economic point of view. Those who are more patient sacrifice current consumption and save and invest for the future. They accumulate wealth, which increases their future productivity and their future standard of living. Another established relationship between behavior and national income is that, in general, there is less honesty in relatively poor countries.[22]

Addressing question (3) (posed above in Section I), which involves field-testing new policies for alleviation of poverty, typically involves considerable challenges. Trying new policies at scale, especially new ideas that have never before been evaluated, involves substantial cost and a risk that they will not work or may even be counterproductive. An experimental approach involving randomization of a relatively small sample into separate conditions and appropriate control groups is now well-established as a

[15] See Johannes Haushofer and Ernst Fehr, "On the Psychology of Poverty," *Science* 344 no. 6186 (2014): 862–67; Johannes Haushofer and Jeremy Shapiro, "The Short-Term Impact of Unconditional Cash Transfers to the Poor: Experimental Evidence from Kenya," *Quarterly Journal of Economics* 131, no. 4 (2016): 1973–2042; Narayanan Kandasamy et al., "Cortisol Shifts Financial Risk Preferences," *Proceedings of the National Academy of Sciences of the United States of America* 111, no. 9 (2014): 3608–13; Michala Iben Riis-Vestergaard et al., "The Effect of Hydrocortisone Administration on Intertemporal Choice," *Psychoneuroendochrinology* 88 (2018): 173–82.

[16] Anandi Mani, Sendhil Mullainathan, Eldar Shafir, and Jiaying Zhao, "Poverty Impedes Cognitive Function," *Science* 341, no. 6149 (2013): 976–80.

[17] Leandro S. Carvalho, Stefan Meier, and Stephanie W. Wang, "Poverty and Economic Decision-Making: Evidence from Changes in Financial Resources at Payday," *American Economic Review* 106, no. 2 (2016): 260–84.

[18] Patricio Dalton, Victor Gonzalez Jimenez, and Charles N. Noussair, "Exposure to Poverty and Productivity," *Public Library of Science One (PLoS-One)* 12, no. 1 (2017): 1–19.

[19] Noussair, Trautmann, and van de Kuilen, "Higher-Order Risk Attitudes, Demographics, and Financial Decisions."

[20] Jorge Zumaeta, "Decisions of Welfare Recipients and College Students" (unpublished manuscript, 2019).

[21] Armin Falk et al., "Global Evidence on Economic Preferences," *The Quarterly Journal of Economics* 133, no. 4 (2018): 1645–92.

[22] Alain Cohn, Michel A. Marechal, David Tannenbuam, and Christian L. Zund, "Civic Honesty Around the Globe," *Science* 365, no. 6448 (2019): 70–73.

means of evaluating a policy. An economic field experiment testing a proposed policy is known as a randomized controlled trial (RCT). The design of such experiments is similar in spirit to the evaluation of a new medical treatment. To study the effectiveness of a new treatment, what is typically done is to randomize patients into two groups, one that receives the treatment and another that receives a placebo. The outcomes of the two groups are then compared to each other. In an economic RCT, there is one (or more) treatment group on whom the new policy is implemented and a control group that is not subject to the new policy. The random assignment into treatments acts as the mechanism to ensure that other confounding variables are not influencing the conclusions. The unit of observation may be the individual, the household, the village, or a larger administrative unit such as a state or province. In these field studies, the emphasis is on implementation of the policy in the actual setting for which it is proposed for application; the greater control offered by the laboratory setting carries relatively low weight in the experimental design.

The use of experimentation to test policies to combat poverty has made remarkable progress in the past few years and revolutionized how economists approach poverty alleviation. Michael Kremer, in a lecture penned after winning the Nobel Prize in Economics, situates the RCT methodology in relation to other types of economic experiments.[23] He holds that RCTs provide a richer context than more traditional laboratory experiments, they address very specific practical problems, and they require collaboration with practitioners who are not academics. He notes that one pathway to progress in research is first to conduct a laboratory experiment that leads to a behavioral economic theory, which can then lead to an RCT informed by the behavioral theory. Behavioral economic theories are expressly intended to be descriptive; they often dispense with the assumptions of optimal and purely self-interested behavior, when doing so is needed to explain empirical patterns of behavior.

Other economic methodologies might be considered experimental under a broad definition. These include the analysis of naturally occurring exogenous events that enable the empirical researcher to be able to pair two sets of data. These are often called "Natural Experiments." For example, suppose that a tornado strikes one town but misses another town ten miles away with a similar demographic and economic profile and the towns have a low degree of interdependence. In such a situation, one can reasonably use the two towns to study the effects of a disaster on outcomes by using the unaffected town as a control or baseline condition. This type of situation differs from the experiments discussed in this essay in that the setting is not created by the researcher, but rather has occurred naturally. One can also argue that agent-based modeling of poverty, in which computer

[23] Michael Kremer, "Experimentation, Innovation, and Economics," *American Economic Review* 110, no. 7 (2020): 1974–94.

simulations are run under different scenarios, is an experimental methodology. Such a method is valuable, but since it studies artificial rather than human decision-makers, I will not discuss this method here. However, as artificial intelligence advances, one can expect artificial agents to make increasingly many of the important decisions in an economy. Consequently, we can expect studying the outcomes of artificial agents interacting with each other and with human decision-makers to become more important in the future.

IV. Laboratory Experiments: Macroeconomics and Poverty

Why is Norway richer than Belarus? There are many differences between the two countries. Norway is endowed with rich oil reserves, while Belarus is not. Belarus is land-locked, while Norway has a long coastline. The two countries have different political systems, levels of press freedom, histories, religious traditions, and neighboring countries. Any one of a combination of these or other factors might contribute to the difference between the economic wealth of two countries.

How can we isolate and identify those factors that influence a country's wealth? The standard approach in economics is to conduct a regression analysis in which the effect of different independent variables thought to influence economic growth can be isolated.[24] In principle, this allows the effects of the variables of interest to be measured while holding the others constant. However, this approach requires a number of strong conditions to be satisfied. In principle, the data for all variables that could influence the dependent variable must be available. The variables must not be too correlated with each other. The estimation must take into account, and correct for, reverse causality because economic growth can itself affect the levels of some other variables.

A rich body of macroeconomic theories describes processes whereby countries might develop and increase their level of prosperity. The original such theories were termed "growth models," with economic growth originating from saving and investment and the deferment of current consumption.[25] These models, in which there was no technological progress in the economy, were extended to allow growth to arise though such progress.[26]

[24] See Robert Barro, "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics* 106, no. 2 (1991): 407–43; Nazrul Islam, "Growth Empirics: A Panel Data Approach," *Quarterly Journal of Economics* 110, no. 4 (1995): 1127–70.

[25] See Frank P. Ramsey, "A Mathematical Theory of Saving," *Economic Journal* 38, no. 152 (1928): 543–59; Robert Solow, "A Contribution to the Theory of Economic Growth," *Quarterly Journal of Economics* 70, no. 1 (1956): 65–94; David Cass, "Optimum Growth in an Aggregative Model of Capital Accumulation," *Review of Economic Studies* 32, no. 3 (1965): 233–40.

[26] See Robert Lucas, "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22, no. 1 (1988): 3–42; Paul M. Romer, "Endogenous Technological Change," *Journal of Political Economy* 98, no. 5 (1990): S71–S102.

The use of laboratory experiments to consider economic growth was initiated by me and Vivian Lei.[27] We studied a setup with the structure of an optimal growth model in which the theoretical results of Frank Ramsey, David Cass, and Tjalling Koopmans[28] can be applied. In these theoretical models, the economy is assumed to be directed by a benevolent social planner, who possesses all of the information about the underlying structure of the economy and seeks to maximize the total economic payoff over time for the economy. Under these assumptions, the economy converges over time to an optimal steady state, in which the maximum possible potential sustainable wealth level of the economy is achieved. This optimal steady state involves a constant level of consumption as well as a constant level of capital to serve as input to produce this consumption. In an experiment, achieving this optimal wealth level would result in the most money possible being taken home by the participants. The experiment studies the conditions under which such optimal outcomes can be achieved.

The general structure of the economy in two of the treatments we studied is as follows. There is a sequence of periods, which can each be thought of as representing an operating period—such as a month, quarter, or year—though in the experiment each period lasts only a few minutes. In each period, the economy has a resource, called capital, which can be converted to consumption. Consumption is in effect cashed in by participants in each period and translates into money payments to the participants in the experiment. The capital that is not converted to consumption is used in a production process to create more capital and consumption for the next period. For the economy to achieve the highest long-run level of consumption, it must find the correct balance between consuming and preserving the stock of capital. Too much consumption in one period runs down the amount of capital available for future consumption, while too little consumption means that some value from consumption is lost in the current period. The optimal level of consumption and capital holdings is called the optimal steady state.

The first experimental treatment is called the Social Planner Treatment. In this treatment, the economy is directed by an individual, who has an incentive to maximize the total welfare (understood as the economic value) of the economy. That is, the participant in the role of the social planner makes more money in the experiment the higher the economic value her decisions create. Thus, in the experiment, the social planner is benevolent, without any incentives to drain resources from the economy for personal gain or other purposes. This provides the opportunity, possible only in a laboratory

[27] Vivian Lei and Charles N. Noussair, "An Experimental Test of an Optimal Growth Model," *American Economic Review* 92, no. 3 (2002): 549–70.

[28] See Ramsey, "A Mathematical Theory of Saving"; Cass, "Optimum Growth in an Aggregative Model of Capital Accumulation"; and Tjalling Koopmans, "On the Concept of Optimal Economic Growth," in *The Econometric Approach to Development Planning*, ed. J. Johansen (Amsterdam: North-Holland Publishing Co., 1965), 225–87.

experiment, to observe an economy free of the hazards of corruption and the misuse of public funds. The individual in the role of social planner decides how much of the economy's resources go into current consumption and how much are saved for the future. In essence, the social planner makes a sequence of decisions about how much to consume now and how much to save for future consumption and later saving. The experimental data show that the social planner has great difficulty with this problem and the economy operates well below its potential. It is difficult for an individual to solve this dynamic economic-planning problem even if her only incentive is to do so.

In a second treatment, called the Market Treatment, the economy is populated with five interacting agents. These five individuals each own a portion of the productive capacity of the economy. They also each have their own private incentives to consume output. Therefore, their incentives are not to maximize the consumption of the economy, but rather to maximize their own consumption. They have no information about others' production capacity or incentives to consume. There is a market in which they can buy and sell the capital required for production from each other.

In this second treatment, the results show consistent convergence toward the optimal steady state of the economy, which leads to the highest overall payoffs possible. Thus, even though no individual has an incentive to maximize any payoff other than their own and all have minimal information about the economy, this treatment leads to greater overall payoff than under the Social Planner Treatment. The key to its efficient operation appears to be the fact that buying and selling in the market allows prices for capital to form. The prices make information available to all about the scarcity of capital in the economy. When prices are high, people consume less and invest more in capital. When prices are low, they consume more and deplete their capital. The presence of flexible market prices is crucial to the efficient allocation of resources, and thus to the effective functioning of the economy.

These results provide a demonstration that a decentralized economy with market prices can allocate resources in a more beneficial way for society than can an individual entrusted with the task. This difference exists despite the fact that the experimental economy is a more favorable environment than the market setup for the social planner. This is because the social planner has direct incentives to maximize the social good. With other incentives, such as to extract wealth from the economy for her own use, her performance with regard to economic efficiency would likely have been worse. Furthermore, if the environment were scaled up or made more complicated, the cognitive burden on the social planner would become even more exigent, while the price system would arguably function better with more participants as the market becomes thicker and more competitive. Nobody has to manage the price system, so the cognitive burden in the decentralized economy would presumably not increase with more participants.

In follow-up work, Lei and I study a similar environment, but one in which it is more challenging for the market to achieve an optimal outcome because there is a theoretical poverty trap.[29] In macroeconomics, a poverty trap is a situation in which an economy can be stuck in poverty. That is, there is a theoretical equilibrium state that has lower levels of consumption and capital than the optimal level possible and the economy permanently remains at the same level. An equilibrium is a situation in which every individual is optimizing, given the actions of all other individuals in the economy. In other words, in a poverty trap, individuals working independently, even if they made the best decisions possible for themselves, would not be able to extract themselves from economic poverty. They need somehow jointly to coordinate their actions or get an external push to get out of the poverty trap and into a better equilibrium. It is often argued that some countries are much poorer than others because they are stuck in a worse equilibrium; the extent to which this might be the case in the developing world is an active area of debate.[30]

For example, a city needs good tourism facilities, good transportation, and an effective police force to create a viable destination for tourists. Two of these three things are not sufficient; the city needs all three. If the city has none of them, they all must be created together. Creating one alone does not have a high enough value to justify the cost incurred to create it. Therefore, there are two equilibrium states: one in which all three things are provided and one in which none of the three is. Such situations with multiple equilibria represent a challenge for economists. It means that economic theory is indeterminate in its predictions. Even if the assumptions of an economic theory all hold, we cannot deduce what would happen. Such situations are a natural focus for experimental study since experiments can be used to determine which among multiple equilibria a group of players is likely to end up reaching.[31]

We constructed an economy with two such equilibria. There are two levels of consumption and capital where the economy can get stuck. To go from the worse equilibrium, with lower consumption and capital, to the better one, the members of the economy must sacrifice much of their consumption for a few periods and instead invest in building up the economy's stock of capital. In this study, we find that an economy with a market for capital, unlike the Market Treatment in our 2002 study, tends to fall into the poverty trap. The market is very effective in finding an equilibrium state,

[29] Vivian Lei and Charles N. Noussair, "Equilibrium Selection in an Experimental Macroeconomy," *Southern Economic Journal* 74, no. 2 (2007): 448–82.

[30] See Christopher B. Barrett and Michael R. Carter, "The Economics of Poverty Traps and Persistent Poverty: Empirical and Policy Implications," *The Journal of Development Studies* 49, no. 7 (2013): 976–90; Aart Kraay and David McKenzie, "Do Poverty Traps Exist? Assessing the Evidence," *Journal of Economic Perspectives* 28, no. 3 (2014): 127–48.

[31] John Duffy, "Macroeconomics: A Survey of Laboratory Research," in *The Handbook of Experimental Economics*, *Volume 2*, ed. John Kagel and Alvin Roth (Princeton, NJ: Princeton University Press, 2015), chap. 1.

but it might fail to find the best equilibrium. Later research would show that supporting institutions are needed in conjunction with the market to make sure the economy does not fall into a poverty trap.

C. Monica Capra and her coauthors used my and Lei's paradigm to conduct an experiment to study whether allowing free communication between citizens of the economy and including a democratic voting process to allocate capital and consumption would help the economy exit a poverty trap.[32] Their experiment has four treatment conditions: (1) voting and a free press are both present in the economy, (2) there is voting but no free press, (3) there is a free press and no voting, and (4) neither of the two institutions is present. The authors find that with neither a free press nor voting, the economy did not exit the poverty trap in any of the experimental sessions. When only one of the two institutions is present, the results are mixed, with some economies staying mired in a poverty trap and others reaching the optimal steady state. When both free press and the voting process are operative, all of the economies avoid the poverty trap and most attain the optimal steady state. The conclusion of this work is that having a free press and a voting process together exert positive effects on the likelihood of avoiding a poverty trap and reaching an equilibrium with a higher standard of living.

V. What Have We Learned from This Research?

A number of important lessons emerge from laboratory experimental work on growth and development.

(1) The experiments demonstrate a well-known idea, but with a new methodology. The way in which the economy is organized, its institutional structure, is crucially important to its performance. It makes a difference whether all resources, production capabilities, and demand for consumption are held centrally or distributed among different citizens. A distributed endowment of resources, capabilities, and demand means that the exchange of inputs and outputs is required. The fact that this exchange must occur helps to optimize resource allocation because those with more efficient production capabilities will outbid others to acquire the resources to use in production. Similarly, those who have the highest value in consumption for the outputs will outbid others to acquire what is produced. This rationing based on price does not happen unless the production and consumption of the economy is decentralized. This benefit of decentralization is obtained relative to even a centralized authority that has no incentive to appropriate wealth for itself.

(2) Market prices are important factors in allowing agents to make good decisions and in signaling scarcities in the economy. When market prices for capital are high, they indicate to members of the economy that it needs more

[32] C. Monica Capra et al., "The Impact of Simple Institutions in Experimental Economies with Poverty Traps," *Economic Journal* 119, no. 539 (2009): 977–1009.

investment as well as incentivize the production of capital. In the world, the price of capital is the interest rate and capital may take the form of plant and equipment or human capital built though education. Producing more capital means lowering consumption and increasing the savings available for investment. Without prices, the correct information about scarcities cannot be extracted and communicated to market participants. In the absence of prices, an intertemporal allocation problem is too difficult for even a well-intentioned and well-informed social planner to achieve.

(3) A free market with a flexible price system is highly effective at finding an economic equilibrium. Most prices in the world, even if they are flexible, are quite stable, a property of equilibrium. However, if there are multiple equilibria, such a system could end up finding an equilibrium that is at a lower level of wealth and consumption than another potential equilibrium. If a country's failure to develop is due to it being trapped in a low-wealth, low-consumption equilibrium, the free market may need to be supplemented with other institutions that facilitate coordination on a better equilibrium. The possibility of an economy falling into such poverty traps could be a reason that there is skepticism in some developing countries about market solutions; it may be obvious to citizens that the price system alone in such circumstances is leading the country to produce below its potential.

(4) A democratic voting process can be an effective means to exit a poverty trap. Such a process combines the power to compel behavior on the part of all citizens with the ability for policy to reflect the will of the citizenry. Thus, if most people would like to reach a better equilibrium, but it takes collective action to do so, democratic voting can provide a way to coordinate on a policy that forces the coordination and makes the country better off. However, using a voting process as a means of allocating resources between consumption and investment is not without its drawbacks. If the price system is not the sole means of resource allocation in an economy, this can perturb or prevent convergence to a good market equilibrium.

(5) The price system functions better in the presence of institutions that facilitate citizen participation in resource allocation and that encourage citizens to share their information and opinions. A free press, freedom of association, and an open voting process all appear to be conducive to economic growth.

(6) Poverty traps, if and when they exist, are a hazard. There is a real danger that an economy can get stuck in a situation in which the economy could achieve a permanently higher standard of living, if many actors could jointly coordinate their actions, but these actors fail to do so. The possibility of multiple equilibria necessitates special institutions to avoid poverty traps.

A common criticism of the type of laboratory research I discuss in this essay is that the world's economies are much larger in scale and vastly more complex than the economies created in laboratory experiments. My response to this line of argument is, first, to try to provide a compelling account, preferably backed with economic theory, about why a particular

experimental result has been observed. The second step is to place the burden on the critic to provide an argument for why this theory or account would fail as the economy is scaled up or features are added. It is not enough to assert that just because a theory is supported for an economy with ten people, that it would not be supported in a country of ten million people, without explaining why this would be so. In some cases, the critic may be able to provide good arguments; in such cases, the argument might be able to be evaluated with subsequent experimental work.

Solid economic arguments suggest that markets would operate more efficiently as more individuals participate on either side of the market. The effect of adding more markets is less clear theoretically, but this has been explored in experimental work, with at least one experimental study considering a laboratory economy with twenty-one separate markets divided up among three countries with different production technologies available in each country.[33] Three goods can be produced in each country, with two inputs—labor and capital—resident in each country. Each country has its own currency and outputs can trade internationally, but inputs cannot migrate to other countries. In this complicated laboratory economy, there is one equilibrium and the economy converges toward it, much like one market operating in isolation, albeit at a slower pace. This study shows that market systems, when they deviate from equilibrium relationships during the process of convergence to equilibrium, tend to do so in specific patterns. For example, when a laboratory economy begins to operate, wages typically tend to be lower than would be justified by the productivity of labor. Exchange rates between currencies tend to some extent to equalize the gains from trade between the two countries rather than attaining the level that equalizes prices between countries.[34] In addition, Dynamic Stochastic General Equilibrium economies, which is currently the structure favored by macroeconomists for modeling national economies, have recently been successfully designed, implemented, and analyzed in the laboratory.[35]

VI. Conclusion and an Agenda for Future Work

Experimentation has been applied in a number of ways to understand and potentially reduce poverty. One benefit of the experimental methodology is its ability to directly measure key behavioral parameters rather than having to infer them indirectly from other decisions, such as investment behavior or consumption expenditure. This capacity for direct

[33] Noussair, Plott, and Riezman, "Production, Trade, Prices, and Equilibrium in Large Experimental Economies."

[34] Charles N. Noussair, Charles R. Plott, and Raymond G. Riezman, "The Principles of Exchange Rate Determination in an International Finance Experiment," *Journal of Political Economy* 105, no. 4 (1997): 822–62.

[35] Charles N. Noussair, Damjan Pfajfar, and Janos Zsiros, "Frictions in an Experimental Dynamic Stochastic General Equilibrium Economy," *Journal of Money, Credit, and Banking* 53, nos. 2–3 (2021): 555–87.

measurement has allowed researchers to understand some of the consequences of poverty, such as greater risk aversion, more impatience, and difficulty with cognitive tasks.

A second way that such experiments are beneficial is in testing policies designed to reduce poverty through RCTs, which serve as a means to measure the performance of a policy against business-as-usual conditions or alternative interventions. This application of experimental methods has revolutionized development economics and can be expected to continue being employed in policy formulation.

A third way that such experimentation can help understand and alleviate poverty is by using the laboratory to study and develop economic institutions. This experimental testing has shown that the ability of economies to attain favorable outcomes depends on the way the economy is structured, and thus optimistic theories of optimal economic growth are operative only under certain institutions. Key features of an economy—such as the freedom of prices to adjust to reflect scarcities in the economy, open communication between members of society, and participatory voting processes to formulate policy—help the economy operate closer to its maximum potential. In the future, this research can be taken much further. Laboratory experimental methods can provide an arena to test novel economic systems. As technology to implement computerized interactions advances, this becomes increasingly feasible.

In the work described above, the research agenda was to establish the conditions under which theoretical models can predict well. We have found that for models of optimal growth, the models predict better when certain institutions are present, but not so well under other conditions. The fields of development economics and macroeconomics have proposed successive new generations of models. A similar investigation of the institutional structures required for accurate predictions can also be undertaken for these models.

In particular, endogenous growth theory, which allows technological advancement to increase the productivity of the economy, has not been studied in the laboratory. In such models, technological advancement can arise from various sources. Education, referred to as an investment in human capital, can increase the productivity of the labor force and make people more likely to innovate and discover better technologies. If a country becomes large enough, efficiencies resulting from the large scale of the economy and from networks of people working together can lead to a greater likelihood of technological breakthrough. Such breakthroughs, in turn, translate into higher productivity and wealth. Experiments can be used to establish what institutional features of the economy might both make technological progress more likely and allow such progress to translate into a higher level of wealth for society.

A second line of research is to study the interaction of multiple countries. The notion of comparative advantage—that is, the idea that a country

exports the good which it is relatively efficient in producing—has been strongly supported in prior experimental work when input, output, and foreign exchange markets are permitted to operate freely.[36] This work has also found that tariffs are more damaging to the international economy than economic theory predicts. However, the economies in which this has been studied are static, without the possibility for investment, saving, economic growth, or technological progress. It could be valuable to study multiple dynamic economies to investigate a number of fundamental questions: What conditions need to be present in a poor country to allow it to catch up to a richer one? What policies in the rich country are conducive to allowing the poor one to catch up? What conditions allow investment by the rich country into the poor one to flourish? What is the role of migration policy in promoting development? Is the risk of losing human capital to the rich country too great when migration is allowed or is free migration beneficial to developing countries? What are the consequences of free trade or international economic integration for development?

A third interesting potential line of research involves income distributions. Some previous experimental research has found that, all else being equal, many individuals prefer relatively equal distributions of income.[37] Some institutions, such as democratic voting, provide an opportunity to enact policies that make the distribution of income more equal through mechanisms such as income taxes and wealth transfers. It would be interesting to consider the extent to which the institutions in place affect the distribution of income. Studying this topic, as well as others mentioned in this section, is made possible with experiments in which the institution in question can be added, removed, or amended exogenously, with all else kept equal across treatments.

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[36] Charles N. Noussair, Charles R. Plott, and Raymond G. Riezman, "An Experimental Investigation of the Patterns of International Trade," *American Economic Review* 85, no. 3 (1995): 462–91.

[37] Ernst Fehr and Klaus M. Schmidt, "A Theory of Fairness, Competition, and Cooperation," *The Quarterly Journal of Economics* 114, no. 3 (1999): 817–68.