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Synthetic Economy Research Environment (SERE)

Robert Bloomfield
Cornell University
May 20, 2011

Overview

This document provides a brief introduction to the Synthetic Economy Research Environment (SERE), an online platform that allows researchers to manipulate regulatory and environmental variables and observe their systemic effects in self-contained synthetic economies. As in traditional experimental economics, researchers can use SERE to create games in which human subjects (players) choose actions that, in conjunction with other players' decisions and environmental variables, determine the monetary payments they receive. SERE goes beyond existing platforms by providing a programming language that can be used to create self-contained macro-economies with production functions, consumption functions and institutions the researcher can customize to address the policy questions that interest them. SERE creates additional flexibility by (1) supporting a clear link between the financial incentives of the human player and the utility function of the virtual character they control, and (2) allowing players to alter key institutions, such as markets, corporate governance and governmental powers, if the researcher so desires.

Part 1 of this document is presented as a series of answers to Frequently Asked Questions about SERE. Part 2 presents annotated instructions for "Starter Bounty," a simple game that can be used to train players in the most basic tasks they will encounter in almost any SERE economy, and serves as a foundation for richer games addressing key policy issues. The annotations explain how the features of the game tie to economic theory, while still remaining playable.

PART 1: ANSWERS TO FREQUENTLY ASKED QUESTIONS

What are Synthetic Economy Experiments?

A synthetic economy is a game derived from an economic model. Each player takes the role of character in the model, makes all of the decisions that character is assumed to make, and is paid real money according to how their character fares.

The SERE platform allows researchers to create economies from a set of fundamental building blocks: characters who make decisions about consumption, labor, savings and production; natural resources that can be extracted and transformed into goods of greater value; a very precisely-specified set of decision rights and property rights; contracts between parties; business entities like corporations and banks (and even governments); and a financial reporting system.

Research can inform policy deliberations by conducting controlled experiments with synthetic economies. For example, a researcher might wish to determine whether fair-value accounting

standards for financial institutions increase the frequency, severity or length of credit contractions. They could do so by conducting twenty synthetic economies. All of the economies would have identical structures, but ten would require financial institutions to report assets at fair value, while the other ten would require them to report at amortized historical cost. Researchers could then test whether credit availability and real investment differ across the two regulatory settings.

This type of research is commonly called experimental economics. Experimental economics has been used to address countless policy issues over the last several decades, in fields ranging from market design to environmental policy. Its influence and prestige is reflected in the 2002 Nobel Prize in Economics, which was award to Vernon Smith to recognize his stature as the "father of experimental economics."

Why Not Just Observe Real World Outcomes?

Experiments on synthetic economies are intended to complement, not replace, careful analysis of real-world responses to financial reporting standards. In the real world, the effect of a single policy is invariably muddied by a variety of other changes. For example, comparing market behavior before and after the passage of Sarbanes-Oxley does not clarify the effect of any *individual* policy included in that comprehensive legislation. Similarly, comparing across jurisdictions leaves open the possibility that observed differences are driven by factors other than the policy in question (such as the legal structure). Experimentation allows a researcher to control all factors but the one policy change under consideration. In principle, it would be possible to conduct true policy experiments by promulgating standards, much as the medical profession tests new treatments. However, as macroeconomist and Nobel Laureate Robert Prescott observed, "Social Experiments on the grand scale may be instructive and admirable, but they are best admired at a distance."

Why Have Players Make Choices, Rather Than Solving For Optimal Behavior Mathematically?

Both experimental and mathematical economists model economic settings as games, carefully specifying the players who make decisions, the information and actions available to them, and the payoffs they receive based on outcomes. The difference lies in how the economists determine what is likely to happen in the setting they are attempting to model. Mathematical economists make a host of assumptions about how people behave, and what types of aggregate outcomes will be stable enough to serve as reliable predictions. In contrast, experimental economists implement the rules of the game in a controlled setting, and then observe how the economy behaves.

Most policy settings are extremely challenging for mathematical economists, for two related reasons that go beyond basic concerns about mathematical tractability: *adaptation* and *emergence*.

- **Adaptation.** Policies and external events impact the behavior of many more people than those on whom they are directly imposed. Consider the example of imposing fair-value accounting standards on banks, as discussed above. Such standards will directly alter the reports provided by banks, forcing investors and regulators to adapt to the new reports. Bank managers in turn must change their operational strategies to adapt to the new investor and regulator behavior. If

fair-value accounting standards are viewed as being overly subject to manipulation, banks and their investors may also adapt by providing and finding alternative sources of information. Competitors may arise that serve the business function of traditional banks, while avoiding regulatory problems through different forms of organization or operation.

- **Emergence.** Adaptation creates a high degree of interconnectivity in large economies that makes it difficult to derive aggregate economic outcomes from a theory of individual decision-making. As a result, most macroeconomists work with theoretical constructs (such as aggregate supply and demand) that operate at the aggregate level, much as epidemiologists construct models based on population behavior rather than quantum mechanics.

Mathematical models allow only very limited forms of adaptation; even so, they are able to derive predictions of emergent behavior in only the simplest of settings. In contrast, synthetic economies can capture both adaptation and emergent behavior because researchers do not need to calculate optimal outcomes—instead, they simply observe outcomes as they occur.

Observing actual behavior has another advantage, relative to deriving predictions from mathematical analysis. Macroeconomic models are so complex that even the most elite mathematicians are unable to derive optimal behavior. Nevertheless, economists still assume that the agents they are modeling behave optimally. Such modeling methods have led economist Paul Krugman to argue that economists "mistook beauty, clad in impressive-looking mathematics, for truth." Decades of research in experimental economics show that behavior in economic games deviates from the predictions of mathematical economics in much the same way as behavior in real economic settings appears to.

How Complex Must Synthetic Economies Be to Provide Useful Insights?

While synthetic economies can be more complex than mathematical models, they are still far simpler than the real world. Synthetic economies are designed to be simple because simple settings provide a best-case scenario for proposing optimal financial reporting policies. Those who claim to know what policies would be optimal in the real world should have little problem applying their reasoning to far simpler synthetic economies.

The complexity of real world settings also makes it difficult to test proposals for optimal financial reporting policies. People can easily attribute their prediction errors to unusual circumstances ("that would have been the right policy if Greece had not imploded") or to complex institutional details that may or may not have accounted for the outcome. Because synthetic economies can be replicated many times, and all institutional details are clearly specified, failures to predict the effects of financial reporting policies can more easily be attributed to shortcomings of the predictions.

How Can We Trust the Results of a "Game"?

Successful economic experiments must achieve three goals: the setting must faithfully capture the most important economic features of the real-world environment; the participants must have a clear

understanding of their task and the opportunity to become expert in the decisions they are being asked to make; and the data must allow researchers to understand why the regulation had the effect it did.

The flexibility of SERE allows researchers to create settings that faithfully capture real-world economic environments. While such settings will never be identical to the real world, results of SERE economies can still provide a useful road map for anticipating and avoiding unintended consequences. Players will be thoroughly trained, though a series of progressively more complex games, to bring considerable expertise to their decisions. SERE provides comprehensive data on all aspects of the economy to allow for detailed information on exactly how regulations affect individual decisions, and how those decisions affect systemic outcomes.

Will People Play SERE Games? Will They Be the "Right" People?

The SERE platform will take advantage of recent advances in game design and social media to engineer games that are engaging to play, and to develop a community of people who are interested in business issues. SERE provides several benefits to participation, including an effective form of education in business and economics, incentive compensation, and entertainment.

A standard tenet of experimental economics is that players need not be experts in the real-world institutions that motivate the research; instead, they must be experts in the economy they are participating in. Consider, for example, a research study examining how restrictions on margin trading affect the behavior of equity markets. The researcher designing such a study would typically create highly simplified margin-trading rules, to allow for clearer inferences about the effects of changing those rules. The study would be most effective if all traders were given enough training and experience to become experts in the margin rules governing the market they are trading in. However, there is no need for the traders to understand the far more complex rules that govern trading in real-world markets. In fact, professional traders may be at a significant disadvantage, because they are likely to rely on their knowledge of rules that do not apply to the markets they are being asked to trade in.

While SERE need not recruit business and financial professionals, players still need to have the intelligence, background and time to become expert in the types of decisions they are being asked to make. Most players will therefore need to have some background in business, economics and accounting, as well as participate in training focused on particular synthetic economies. Such players are likely to be current post-secondary students in business or economics, as well as those who are currently under-employed (retirees, stay-at-home spouses and the unemployed) who have relevant backgrounds.

What are SERE's Applications?

The original motivation for developing SERE was to examine the impact of accounting policy choices on macroeconomic outcomes. Because accounting is 'the language of business', the platform has evolved to support all aspects of business that accounting must describe. As a result, SERE is also well-suited to examining many dimensions of both the private and the public sectors, including: contract design for motivating workers and controlling enterprise risk; the impacts of fiscal and monetary policy;

privatization of public services; regulation of natural monopolies; copyright and patent law; and tax policy.

Why Build an Entire Platform, Rather Than Just a Few Games?

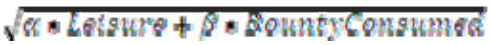
The most successful research programs accommodate replication of previously-demonstrated results and extension of those results to slightly-modified settings. Replication demonstrates that the results of the economies are robust and reliable, and provide a strong foundation for simple extensions that extend researchers' knowledge about the systems they are studying. SERE fosters replication and extension by allowing the elements of prior economies to be added to a library of components that subsequent researchers can draw from.

A well-designed platform will encourage broad participation from the academic community. Researchers have strong incentives to learn how to conduct studies on platforms that can be used repeatedly, allowing them to generate many publishable studies from their efforts. These benefits are enhanced further if the platform can be used for education as well as research. Users (players and students) enjoy similar benefits from a unified platform, which allows them to participate in a variety of economic games once they have expended the effort to learn the basics of SERE's interfaces and economic challenges.

PART 2: ANNOTATED INSTRUCTIONS FOR A SIMPLE GAME

This following pages present annotated instructions for *Starter Bounty*, a very simple game that can be used to introduce players to the most basic decisions and economic tensions in models of large economies. The left side of each page provides instructions to players; the right side includes annotations that explain why the game is structured as it is, with particular focus on links to theoretical models and playability.

INSTRUCTIONS	NOTES
Overview In this game, you will control a character who lives in a virtual world called Bounty. Your character owns a plot of land that can be farmed, resulting in a harvest of a good called Bounty later on. You can hire people to work on your land, or take a job working on other characters' land. You can also organize your farm as a Corporation, and sell shares of the Corporation to others, using the share payments to invest in additional labor. Every time your character enjoys leisure or consumes Bounty you will see an increase in your "KaChing" account. When the game ends, the balance of your KaChing account will be converted into US dollars, which will be paid immediately. If you stop participating before your character dies you may forfeit your payment.	The character takes on the role of the economic decision-maker and optimizer in a microeconomic model. Because the character is not real, its decisions must be made by a human player. The relationship between the player and the character is analogous to the relationship between a corporation and its owner-manager. The corporation owns assets and hires employees, but does so according to the wishes of the owner-manager. Similarly, the character owns assets and hires employees in Bounty, but does so according to the wishes of the player. The owner-manager benefits from corporate ownership when the corporation distributes dividends. Similarly, the player benefits from controlling a character when the character experiences positive utility, which is paid out in the form of dividends, called "KaChing".
Time and Death Time is measured in "Ticks". There is a tick every 15 minutes from 9am to 7pm ET every day (40 ticks every day), including Saturday and Sunday. Every tick, there is a 1/1000 chance that the volcanic Mount Bount erupts, ending participation for every player. These probabilities imply that at every tick you can expect to play for approximately 25 days. This is true regardless of how many ticks the game has already progressed.	The overnight delay allows participants adequate time to consider complex decisions (such as the decision to trade shares of corporations) without concern that available financial statements will become out of date. Macroeconomic models typically use infinite horizons with a risk-free discount rate. Because infinite horizons are impossible to implement in an experiment, Bounty uses a constant probability of game termination. This indefinite end is mathematically equivalent to an infinite horizon with a discount rate reflecting the fact that immediate consumption is more valuable than

	future consumption that the character may not live to enjoy.
The Labor-Leisure Decision Every tick your character has 100 units of activity to allocate between Labor and Leisure. Every activity unit allocated to Labor allows the plot of land worked on to produce N units of Bounty in D ticks. Every unit not allocated to Labor is allocated to Leisure, and increases the balance of your KaChing account according to the formulas set out below. You need not enter a Labor-Leisure allocation every tick. Instead, you indicate an allocation policy that remains in force until you choose to change it.	The Labor-Leisure tradeoff is central to many macroeconomic models. In this setting, Labor is a long-term investment that increases the character's ability to consume in the future. The parameters N and D (which determine the quantity of Bounty created and the delay before the Bounty appears) will need to be balanced with one another, and with other parameters defined below, to ensure that the Labor-Leisure tradeoff is a reasonable one. In Starter Bounty all plots of land and all workers are equally productive, and the timing and amount of Bounty produced is always certain. These assumptions will be relaxed in later games, once players have mastered their tasks in this much simpler setting. The use of policies greatly reduces the number of times players must interact with the game interface.
The Consumption Decision Once you have Bounty in your possession, you must decide what percentage of your holdings you will consume. Again, you need not enter this decision every tick; you indicate a consumption policy that remains in force until you choose to change it.	The consumption-savings decision is also a foundation of most macroeconomic models.
Earning KaChing Every period your KaChing account increases by 	Macroeconomic models typically assume that agents receive declining marginal utility for consumption at any time: every additional unit enjoyed at a moment in time adds less to utility than the unit before it. The square-root payoff for Leisure and Bounty Consumed captures this assumption, and creates a preference for consumption smoothing: holding constant the total labor and leisure the character will enjoy over the course of play, the player earns the most money by holding the level of consumption constant. Consumption smoothing introduces a role of trade between players, so that players can secure

	immediate consumption when their consumption would otherwise be low, in exchange for a promise that allows future for consumption for someone whose current consumption would otherwise be relatively high.
Employment As the owner of a plot of land, you can hire other characters to allocate Labor to your land. To do so, you post an offer to hire on the Labor Market website, stating the units of Bounty you are willing to pay per activity unit and the maximum number of activity units you will hire. You may also enter the Labor Market to work for others. The terms of all labor contracts specify that the employer provides an immediate payment of Bounty at the time the labor is applied to their land. Any Bounty produced by the labor becomes the property of the employer. All employment contracts are also "at will," meaning that the employer and the employee have the right to terminate the contract at any time.	Employment is the simplest form of trade, and allows players to smooth consumption: someone with a great deal of current bounty they do not immediately wish to consume can transfer it to someone who has a strong incentive to consume immediately. In exchange, the wealthy player can consume more at a later time. The price of labor is determined entirely endogenously. However, Starter Bounty does restrict the form of labor contracts. Later variations will allow for more sophisticated contracts, including deferred compensation, incentive compensation and profit sharing. All contracts are denominated in Bounty, meaning that Bounty serves as "commodity money". It is a commodity because all units of Bounty are identical and durable (they never decay); it is a form of money because it is the sole medium of exchange. Commodity money is the simplest form of money because its supply exactly tracks the material wealth being produced (because that wealth is simply the amount of Bounty). This strong link between money and wealth eliminates the possibility of inflation (an increase in the money supply relative to the goods money can purchase), so Starter Bounty can convey only limited insights into important dimensions of monetary policy. Natural extensions are to allow for fiat money, as well as various forms of lending that effectively increase the money supply.

Incorporation Once you are comfortable with your Labor-Leisure, Consumption and employment decisions, you may choose to incorporate your farm. When you incorporate your Character's farm, you create a legal entity that can enter into contracts. The first step of incorporation is to give your plot of land to your Corporation in exchange for 100 shares of a security, each of which grants the holder the right to 1/100th of the Bounty distributed from the corporation during any tick they hold the security. By transferring your land to your Character's Corporation you also transfer the rights to all future Bounty the land produces. However, this does not alter your Character's wealth, because it still owns all 100 shares, and can distribute the Bounty from the Corporation to your Character. You also assign any contracts in which your Character is an employer to the Corporation, meaning that the people your Character had been employing are now employed by the Corporation under identical terms.	Incorporation allows players to issue non-voting equity, increasing the funds they may need to invest in labor.
Corporate Decisions Once you have Incorporated your Character's farm, you can sell shares of the distribution security to other players and Corporations. However, you retain your rights to make decisions on the corporation's behalf. In particular: • You must decide how much of the Corporation's Bounty to distribute to shareholders. • You can hire and fire workers for the Corporation's land • You can buy and sell shares of other Corporations. • You can issue additional shares to sell to other Characters. Bounty received from the sale of these shares becomes the property of the corporation.	Because Starter Bounty is a training game, all players must be given the opportunity to make corporate and production decisions. This is why players are not permitted to transfer decision-making control of their corporations, nor are they allowed to sell their land. The simplest variations on Bounty allow transfers of corporate control and land.

Trading Shares Characters and Corporations may buy and sell shares in the Share Market, which is open from 10pm to 9am ET every night. All trades are denominated in Bounty, so purchasing a share of a corporation means that you are giving up Bounty you could otherwise have consumed immediately, in exchange for the promise of future Bounty when it is distributed by the Corporation.	Shares are traded overnight to ensure that players have enough time to examine financial statements before making their trading decisions.
Financial Reporting At any time you may request current financial statements. The financial statements include: Your Character's Balance Sheet and Income Statement. Any Corporation's Balance Sheet and Income Statement. The accounting methods are described separately.	The simplicity of production and contracting in Starter Bounty allows for simple financial reporting as well. The economy includes no information asymmetry and no uncertainty, other than that players cannot divine the intentions of other players. However, every action that is taken is publicly available. Despite this simplicity, the economic still supports three very different approaches for calculating assets and income. (Note that there is no debt). Specifically, resources devoted to labor could be expensed immediately, with revenue recognized as Bounty is generated, or capitalized as an asset that is amortized as Bounty is generated. As a third alternative, labor could be expensed immediately, but revenue could be recognized at the time labor is applied to the land, in an amount reflecting the revenue expected to be received. These three accounting approaches provide a natural experimental manipulation to determine whether they influence the rate of the world's economic growth. If players are rational and face no limits to the information processing abilities, the accounting method should be irrelevant as players have access to the information they need to convert financial statements prepared under one method to the statements that would be prepared under another. However, prior research demonstrates convincingly that reporting methods do affect individual decision making (though they provide little insight into how individual effects will alter aggregate economic outcomes.