EconPort: Creating and Maintaining a Knowledge Commons

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1. Introduction

Public and academic libraries are traditionally designed and run by librarians and information specialists. The advent of the World Wide Web, however, gave the capacity to build useful libraries to anyone with subject knowledge and information-technological expertise. This chapter focuses on an open access digital library of microeconomics for students, teachers, researchers, and the general public. This digital library, EconPort (http://www.econport.org) is a new knowledge commons.

EconPort was created, beginning in 2002, by a team from the Economic Science Laboratory (http://www.econlab.arizona.edu) and the Artificial Intelligence Lab (http://www.ailab.arizona.edu) at the University of Arizona, under a grant from the National Science Digital Library (http://www.nsdl.org) initiative of the National Science Foundation. The goal of the project was to provide microeconomics educational resources to the public, with a particular focus on the use of microeconomics experiments in learning, teaching, and research. Although the use of microeconomics experiments in teaching had increased significantly during the previous several years, most instructors still faced formidable difficulties when trying to use an array of experiments in their classes. It is this problem, widely shared at other educational institutions, and the experience of creating and using experiments for both teaching and research at the Economic Science Laboratory (ESL), that led the ESL team and other colleagues at the University of Arizona to undertake the creation of EconPort.

Two developments in public policy provided supporting conditions for the creation of EconPort. One was passage by direct democracy of Proposition 301, an initiative by Arizona voters in which they implemented a 20-year increase in the state sales tax with revenues ear-marked to support technology education (at all levels, including K through 12 and the state universities). The other policy development was the National Science Foundation's digital library initiative. In response to the need to develop a plan for spending its part of Proposition 301 funds, the Dean of the Eller College of Management of the University of Arizona appointed a faculty committee with responsibility to make recommendations to the dean "on the use of Proposition 301 funds" and on ways to promote collaborative work involving information technology researchers and researchers from more traditional disciplines including economics. The committee included among its members James Cox (co-author of this paper) from the Department of Economics and Hsinchun Chen from the Department of Management Information Systems. Cox is an experimental economist and Chen is an information technologist specializing in data bases and digital libraries. Following their interaction on the dean's committee, Cox and Chen lead a group of colleagues in the Eller College that included Todd Swarthout (co-author of this paper) that submitted a successful proposal to NSF's digital library initiative to create a microeconomics digital library named EconPort. The incentives of the team members for creation and maintenance of EconPort differed depending on their academic disciplines; they are discussed below.

This paper describes the content of EconPort and the educational philosophy that underlay its creation. However the main focus of the paper is use of EconPort as a case

study of the effectiveness of incentives for creation, maintenance, and use of a specific type of knowledge commons.

2. Microeconomics and Experiments

Microeconomics is the study of individual economic agents such as consumers and firms; how those individual agents interact with each other in markets; the properties of different kinds of markets such as perfectly competitive markets, monopolies, and imperfectly competitive markets; and how distinct markets are aggregated to form an economy. The study of microeconomics dates at least as far back as Adam Smith's (1776) classic work. Throughout much of its history, microeconomics has followed Smith's (1776) lead in seeking to explain how, and under what conditions, markets can harness the motivating drive of economic self-interest to promote the common good. In more recent decades, some areas of microeconomics have adopted the approach of game theory (von Neumann and Morgenstern, 1947; Nash, 1950), which models the interaction of economic agents in terms of each agent adopting a strategy that is the best reply to the strategies of competing agents. Recently there has been a return to an even earlier theme of Adam Smith's (1759) in the development by experimental economists of a body of data to guide development of models of agents characterized by a richer set of motivations that includes trust, reciprocity, and altruism (see, for examples, Cox, 2004 and Cox, Friedman, and Gjerstad, 2004) in addition to the economic self-interest focused on in Smith's (1776) more widely-quoted, later book.

Experimental economics involves the design and implementation of experiments involving human agents in order to study economic behavior and the properties of

economic institutions, such as markets of various types, under controlled conditions. Economics experiments are run both in laboratories, such as the Economic Science Laboratory, and recently in field environments including naturally-occurring markets such as eBay. The use of controlled experiments makes it possible to test theoretical models and, thereby, undertake a process of development of microeconomics as an empirical science.

Experimental methods in microeconomics were developed for research but it was recognized fairly early that experiments could be valuable as a teaching and learning method. For many years, economists using experiments in teaching could cite only their own experience to support the conclusion that class experiments are an effective teaching method. There is now better support for that conclusion.

3. Microeconomics Experiments as a Teaching Method

The benefits of using experiments in teaching economics have been reported in several articles in professional journals (see Emerson and Taylor, 2004) as well as widely discussed informally at professional gatherings. There are several reasons to expect even better learning outcomes with computerized market experiments than with typical hand-run experiments (see Bergstrom and Miller, 2000 for a textbook presentation of several hand-run experiments). One advantage is that trades are faster with computerized experiments. Faster trades mean that more trades per session are possible, which promotes better convergence to theoretically-predicted outcomes and thereby better learning from market participation by the students. Another advantage is that computerized experiments can graphically represent trades relative to the underlying

market conditions (supply and demand) and automate analysis of market performance measures, such as price convergence and market efficiency. With sharper convergence to predicted outcomes and built-in graphics and analysis, the ability of instructors to describe experiment outcomes and relate outcomes to economic models is greatly enhanced. Computerized laboratory market experiments have a twenty-year history of use in experimental economics laboratories. By bringing such experiments to the Internet, and by integrating experiment software into a large array of other types of educational material, EconPort is a culmination of a decades-long development of experimental economics laboratories.

4. Experimental Economics Laboratories as Information Facilities

EconPort is a unique addition to the economics knowledge commons. As a digital library and archive, it is distinctive in that among the artifacts that it incorporates are multi-person interactive experimental economics software packages. These software packages support experiments involving human subjects. Such software is used both for research experiments and for teaching experiments designed to support student learning of economics. EconPort is also a unique experimental-economics laboratory and an epistemic repository, which is described in more detail below. The historical development of experimental economics laboratories has distinct stages associated with the evolution of information technology.

5. Historical Development of Experimental Economics Laboratories

Edward Chamberlain is credited with running the first economics experiments while teaching economics at Harvard in the late 1940s. He subsequently published an article (Chamberlain, 1948) reporting these experiments using the form of market now known as a double auction, which is a market institution (that uses New York Stock Exchange trading rules) that provides robust convergence of price and quantity outcomes consistent with economists' model of perfectly competitive market. These experiments, preceding the invention of modern information technology, were conducted with students in classrooms using paper, pencil, and chalkboard. Subsequent early double auction experiments were also conducted with paper, pencil, and chalkboard by Vernon Smith (1962) but general use of experimental markets in either research or teaching came much later.

In 1977, researchers at the University of Arizona developed the first computerized market experiments. Creating experimental economics software was an important step, since it allowed for the experiments to be run much more efficiently, and also provided the foundation to create more complex types of experiments than could not realistically be conducted by paper, pencil, and chalkboard. The computer technology of the day relied on mainframe computers and "dumb" terminals connected by telephone line because this preceded the development of personal computers and local area networks. The use of this technology was both costly and fragile, and because of this, no other laboratories of this type were in existence.

In response to the above limitations and taking advantage of the increased availability of personal computers in the 1980's, the University of Arizona's Economic Science Laboratory (ESL) was created in 1985 as both an administrative unit of the

university and a dedicated physical laboratory containing a local area network of personal computers. ESL first used DOS-based software for running experiments. Development of specialized software packages for experiments and increasing use of these artifacts required a dedicated laboratory facility and staff for efficient running of research and teaching experiments.

Beginning in 1995 there was a gradual shift from DOS-based to Windows software for running experiments. Because the DOS-based and Windows software was designed to run a local area network, it constituted a common educational resource only for the community of scholars physically in residence at the University of Arizona. The very local nature of the public good elements of the resource made it relatively easy to solve the free rider problem. However, this also limited use of the resource, which was a problem that was only marginally ameliorated by a few transfers of software to other dedicated laboratories.

The growth of the Internet has provided the foundation for building a 21st century virtual laboratory that could be used in research and education in economics anywhere in the world on the favored side of the digital divide. EconPort is a response to this opportunity to develop a new type of facility. There are a variety of other Internet economics facilities, none of which provide experiment software that is integrated with a wide array of other educational material.

6. Challenges in Creating an Economics Common Resource

Two types of challenges were encountered in the effort to construct EconPort: pedagogical challenges and technological challenges. The pedagogical challenges

included the need to locate, evaluate, and select from the huge amount of microeconomics material available on the World Wide Web the artifacts that would be archived and organized by topic in EconPort. Another critical challenge was to find ways to take it easier for people to use microeconomics experiments, especially people with no prior experience with experiments.

The technological challenges that had to be overcome were related to creating new software systems needed for the site to function, including:

- an *archive* of microeconomics artifacts that was Open Archives Compliant so that it could be a component of the National Science Digital Library;
- a framework that makes experimental economics software easy to use over the Internet. This was a challenge because these software resources are not self-contained information but rather networked software that requires many simultaneous users to connect with one another. This was a significant challenge with regard to the typical types of information stored in a digital library. The EconPort framework does not just host program files that people download, instead this system handles most all of the software connection issues present when one is attempting to connect multiple computers to one another when they may be dispersed over the Internet;
- a software interface that allows additional external software to be easily added into the EconPort framework. Software technology inevitably changes over time, so we created an Applications Program Interface that allows externally-created software artifacts to be incorporated into the EconPort facility, independent of programming language or paradigm.

7. EconPort: A Digital Library for Microeconomics Education

EconPort provides a wide variety of content and services for instructors and students:

- *An Online Experimental Economics Laboratory*

  EconPort's software packages can be used in both dedicated experimental economics laboratories and in distance/decentralized online experiments in which participants are located in their dormitory rooms, apartments, coffeehouses, student computer laboratories, or a variety of other locations with Internet connectivity.

  The insider-created software is programmed such that when an experiment is actually running, it does so independently of EconPort and – thus creating no additional processing load on the EconPort server. This substantially ameliorates the congestion problems from use of the common educational resource. Use of the Java language for the experiment software provides cross-platform support and eliminates the need for any client or server software installation other than a one-time installation of the free Java software. EconPort currently provides software for running standard experiments used in teaching economics, including double auctions, extensive form games, normal form games, and one-sided auctions such as English, Dutch, first-price sealed-bid, and second-price sealed-bid auctions. New software is added whenever possible.

  In addition to the actual experiment software, EconPort offers an infrastructure that simplifies configuring and running experiments. This infrastructure provides many "pre-made" configurations that can greatly reduce the

time required to set up an experiment; these configurations are designed to illustrate and bring to life economic and game theoretic principles. Also, experiment management tools and post-experiment analysis tools are provided to better support experiments originating on EconPort. Data from teaching and research experiments are archived on both EconPort and local machines used by experimenters. Users can archive their experiment data on the site.

- *An Underlying Educational Method*

  Advocacy of the use of the experiment software in EconPort for teaching economics is premised on published research that supports the effectiveness of this approach in teaching economics to undergraduates. EconPort supports this interactive approach by providing instructional material and an experimental economics software infrastructure. In addition to experiment software, EconPort incorporates an extensive array of created and collected artifacts, including the following.

  - *A Searchable Portal*

    EconPort provides a searchable portal to existing online economics material which gives users a central access point to instructional material for economics experiments, including economics content and motivation for the use of experiments in teaching in addition to parameter sets designed to demonstrate specific economic principles. EconPort makes it easier to locate and use experimental software contained in EconPort and other facilities and to evaluate the relative merits of different software packages.

- *A Substantive Handbook*

EconPort organizes much of its content by way of a handbook. The goal of the handbook is not simply to discuss economic concepts, but also to: (a) provide a better understanding of the rationale for using economics experiments; (b) make it easier for users to select, understand and use existing experimental tools; and (c) provide knowledge of how to interpret the results. The handbook is divided into major economics topic areas. Each handbook topic section provides: (a) introductory concepts; (b) more advanced discussions; (c) experimental research in the area; (d) citations and suggested additional reading; and (e) related online resources.

- *A Glossary of Economics Terms*

  EconPort contains a glossary of economics terms. The glossary provides definitions of terms written by both the EconPort insider team and outside contributors. Outsider-provided artifacts include "Econterms" – a glossary of over 1300 economics terms – and the "Experimental Economics Glossary" created by the University of Mannheim Experimental Economics Laboratory. The glossary is easy to search and linked to the handbook.

- *Other Collections*

  As a digital library, EconPort collects many types of artifacts created by outsiders. EconPort collects information on hundreds of economics resources found on the Internet, including off-site experiment software, interactive online tutorials, and essays on a variety of economics topics. EconPort provides: (a) a single web portal to access these resources; (b) comprehensive search capabilities; (c) exposure to the National Science Digital Library; and (d) concept integration from these collected artifacts to the EconPort handbook.

8. EconPort As a (Globally-Consumable) Local Public Good

EconPort is freely available on the Internet to every person in the world. In practical terms, this means that the economics educational content of EconPort can be consumed at a price of zero by anyone who reads and understands English and has access to a modern computer, with a browser, that is connected to the Internet. Furthermore, consumption of the central educational content of the experiment software requires the existence of a group of individuals, in communication with each other, each of whom satisfies the preceding qualifications and also has an interest in and ability to coordinate on using the interactive experiment software to implement an economics experiment. Thus EconPort, even more than typical digital libraries without interactive content, is a public good available to be consumed only by some communities of users. In that sense, it is a local public good, albeit one that can be consumed by local communities that might possibly exist worldwide or at least in all parts of the world with institutions of higher education.

9. EconPort as an Associational Knowledge Commons

As explained above, looked at from the demand or consumption side, EconPort is a local public good. We will now examine the supply side of EconPort. As is typical of digital libraries, the supply side of EconPort is best understood as a knowledge commons. Explanation of the particular type of commons that is characteristic of a digital library is helped by the distinction between a *libertarian* commons and an *associational* commons that is drawn by Levin in his contribution to this volume. Open source software is a

supply side example of a libertarian commons in that anyone is free to contribute content. In contrast, the supply side of a digital library such as EconPort is an example of an associational commons, albeit one that is subsidized by taxpayers through the National Science Foundation.

The effort to develop EconPort began with the writing of a grant proposal to the National Science Foundation by faculty and staff of the Economic Science Laboratory and the Artificial Intelligence Lab at the University of Arizona with an author of this paper (Cox) as principal investigator. The motivations for creating EconPort of the economists associated with the Economic Science Laboratory differed from the motivations of the information technology specialists associated with the Artificial Intelligence Lab. These distinct motivations created difficulties that had to be overcome during the initial development phase of EconPort and, more importantly, have implications for the sustainability of EconPort that provide a specific example of a problem that is generic to digital libraries.

The information technologists' primary motivation was to create an OAI-compliant infrastructure for a digital library that was capable of supporting the "active objects" that constitute software for running experiments and that would provide a constituent part of the most recent stage in the development of the National Science Digital Library. This motivation implies a primary interest in the information technology content of the digital library and a possibly-continuing interest in its further development that is *conditional* on the availability of funding for further work in information technology applications. The economists' principal motivation was to create a state-of-the-art experimental economics facility that would provide the early 21st century stage in

the historical development of experimental economics laboratories examined above. This motivation implies a primary interest in the economics content of the digital library and an *unconditional* continuing interest in its further development and use.

The artifacts contained in the EconPort facility have been explained above. Some of these artifacts were created by economists from the Economic Science Laboratory while other artifacts were collected and archived by those insider economists. The collected artifacts were, of course, created by "outsiders" -- other economists not formally associated with the Economic Science Laboratory. These outsiders contribute content to EconPort by allowing its collection but they exercise little control over the facility itself and were not originally motivated to create content for a specific digital library.

Incentives for ESL Insiders to Create EconPort

Funding of the initial grant allowed the ESL a way to showcase and offer its expertise over the Internet to outsiders. Traditionally, the costs associated with packaging and providing the expertise possessed by a research facility may be too high to do solely for the free benefit of outsiders. Previous NSF projects have focused on funding the development of specific types of software. In contrast, we saw an advantage not to develop software, but instead a framework that can host and offer a menu of software made by the ESL, as well as others. This framework can then function as a virtual facility offering many different types of experimental economics software resources on the Internet.

Incentives for ESL Insiders to Continue Supporting EconPort

Since the ESL sees EconPort as a showcase product and a way to increase awareness of what ESL has always done, there is an incentive to support the project even after the period of initial funding. This arrangement of a research facility backing such a project may not be typical, as not all research facilities may possess the technical computer skills needed to maintain such a site. However, there is a definite advantage in terms of sustainability of having a research facility invest its resources in such a project – in this case there is likely to be continued interest in the project even if direct funding for digital libraries is no longer available.

Further, we see the site as a resource we will indeed actively use within our facility, and not just an archive created for the general public. This provides us the incentive to not only work on the site while we are supported by the NSF, but also after the funding period. Obviously, the level of external support we receive will indeed influence the amount of support we are able to provide in the future.

Incentives for ESL Insiders to Provide Software to Outsiders

ESL has made available many of its software applications over the years. In the past, this practice was only marginally successful, as the needed technical knowledge that was required to make full use of the software was relatively costly. This led to relatively little incentive for the ESL to actively share our software, as the support during and after the transfer was costly.

The people in the past most able to make use of our software tools were those at one of the few other experimental economics labs, as there was sufficient in-house

technical and experimental economics knowledge. However, there were likely reasons why some labs had an incentive not to use software developed by others – the recipient lab perhaps would not want to give the impression that it was unable to create its own software.

With the development of EconPort as a platform from which experiment software can be run, the marginal cost of offering experiment software is now much lower – both for the ESL and for other developers. EconPort was designed to allow new pieces of experiment software to be easily added. Experiment software need not even reside on the EconPort server; instead, EconPort can simply serve as an organizer and portal for the integrated software.

Incentive for the Artificial Intelligence Lab to Work on the Project

The incentive for this group, which is likely a very similar incentive for most groups taking on such a project, is the existence of grant funding. Additionally, the AI team was motivated by the challenge provided by the technological problems of providing a framework for experiments, or providing a digital library for non-standard digital resources such as experiment software. However, the AI team does not use the EconPort facility in its teaching or research, in contrast to the economists on the ESL team who do use this facility in their continuing professional work. Thus the AI team does not have an incentive for maintenance and further development of EconPort, as an end in itself, in contrast to the ESL team which has a professional self-interest in sustaining the facility.

Incentives for Outsiders to Contribute Software

Some owners of artifacts have contributed them to be hosted by EconPort, for example the economics glossaries now fully integrated into the facility. In contrast, to date outsiders have not been contributing software to EconPort even though there have been invitations to contribute - and given that the Application Program Interface makes the facility accommodating to a variety of software programming languages. This problem in expanding the association of contributors could be caused by several factors, such as potential contributors fearing that their work would become disassociated from their identities when the material is integrated into EconPort. Also, potential contributors could fear that EconPort will not be sustained, and that associating with such a site would not be wise – this is likely a problem for any collection activity, especially when the project is in its earlier stages.

In order to encourage contributions, we promise to give accreditation to contributors and preserve identification of artifacts with their creators. Examples of this are provided by the glossaries the EconPort hosts. Given the, to date, limited success of this approach, we employ a secondary method to collect material that does not require the content to be hosted on EconPort – we collect pointers to the location of the information elsewhere on the Internet, and provide extra classification information with the pointer. This allows us to virtually collect information across the Internet without the requirement to host the material on the EconPort server. Subsequently, EconPort serves as a central gateway for a variety of annotated links covering microeconomics and relays this information. Additionally, this classification information is OAI-compliant, meaning that OAI harvesting engines (such as NSDL and Yahoo) can collect it and repackage it within search engine databases.

10. Sustainability: Fostering a User Community and Workshop Dissemination

Fostering and supporting a user community is a strategy that will help to ensure success of the facility. This process can encourage development of a group of scholars who care about the site and thus become potential contributors of artifacts. We can identify users that have a particularly strong interest in the site, and thus target invitations to contribute. EconPort tracks users in two general ways. Professors must register to make use of the experiment software, as this allows us to keep their information private and available only to them via a login procedure. As of November 2005, 400 people have registered to use the EconPort software. Since we began tracking site usage in February 2005, EconPort has averaged 254 sessions per day (a session consists of all the pages viewed by a user on a single visit to a web site).

One way that we will strive to foster more informed users is by holding a series of workshops funded by a new NSF national dissemination grant. The planned national dissemination consists of a series of workshops during 2006 - 2009, a few at our home university and more in association with professional conferences. The workshops will teach invited faculty how to use the online educational resources of EconPort in teaching economics at their home universities. Workshop participants who are interested will be invited to contribute data measuring effectiveness of the use of experiments in teaching, as measured in matched sections taught with and without experiments, similar to the Emerson and Taylor (2004) study.

We are currently developing additional resources on EconPort to allow our users to interact as an online community. We are considering several options to aid us in this, including:

- Forum software to allow our users to interact with us and one another on discussion boards on our site;
- Tools to allow users to build and annotate custom sets of resources on our site, and then share these sets with one another. These information sets could cover a specific topic used in a classroom, a specific type of experiment, etc.
- Creation of a better way for users to contribute materials to the site. Currently, we have a feedback mechanism that allows anyone to suggest new information for the site, but we would like to expand and automate this procedure, to make it easier and less costly to add new information that site users identify. The difficulty with doing this is obviously quality control.

11. Conclusion

The development of the Internet has made available many types of resources to large numbers of people – often for free. In academics, many projects have been undertaken to digitize, archive, and present information artifacts in ways that ease access to these resources. Such projects often face sustainability problems, however, when initial funding has ended. By engaging in a large-scale project to create and maintain a digital library for microeconomics education, the EconPort team at the Economic Science Laboratory applied its expertise in microeconomics, experimental economics, and information technology in a way that was consistent with its professional self-interest.

Having professionals associated with a research institution such as the Economic Science Laboratory create and maintain such an information commons may be an important factor in sustainability, especially if the professionals affiliated with the facility actively use the resource in their normal activities.

As discussed in many of the earlier chapters, sustainability of digital libraries is a serious problem once initial funding by external granting agencies has been fully utilized. As evidenced by recent developments with the EconPort team, universities are not always willing to allocate sufficient funds to ensure the long-term sustainability of knowledge commons, even when they have been evaluated highly. In response to severe budget cuts at the Eller College of the University of Arizona, the authors of this paper have relocated to the Andrew Young School of Policy Studies (AYSPS) at Georgia State University. Responsibility for maintenance and development of EconPort will remain with the authors and next be housed at a new Experimental Economics Center at AYSPS, ensuring the continuing provision of EconPort for the near future. We will be working with colleagues at other universities on the central issues of long-term sustainability beyond the professional lives of the creators of this knowledge commons. We hope that we can report in the future that we have developed an effective strategy to make this digital library sustainable for the long run.

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