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Reinterpreting Vernon Smith's "*Microeconomic Systems as an Experimental Science*" as Model-View-Controller Software Architecture

Robert L. Mayo[*]

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ABSTRACT

Smith (1982) presented a model of microeconomic systems as information processing mechanisms consisting of an environment and set of institutions. As an information processing discipline, computer science has developed an analogous paradigm by dividing processing elements into functional units in Model-View-Controller software architecture. Comparison of these two models provides new perspectives on Smith's microeconomic systems model and suggests an extension through the addition of an explicit information feedback mechanism.

1. Introduction

How should we define a microeconomic system? Although there are certainly as many ways to define such systems as there are systems to be defined, one perspective useful to practitioners of experimental economics is the view of microeconomic systems as information processing mechanisms. In 1982, AER published Vernon Smith's *Microeconomic Systems as an Experimental Science*. In that paper, Dr. Smith proposed that the study of information systems in resource allocation theory is closely related to the experimental study of resource allocation under different market mechanisms and observed that these two perspectives are tied together by the New Institutional Economics study of the information and incentive structure in markets.

If we model microeconomic systems in terms of their information processing characteristics, we may find it useful to compare our models to those produced by the discipline devoted to the study of information processing. Computer science, and in particular its sub-field of software engineering, offers perspectives that may inform our model design both by inspiring extensions and by helping us to see where revisions may be appropriate. One such framework, the Model-View-Controller software design architecture (MVC) closely parallels many aspects of Smith's taxonomy. The purpose of this paper is to review the similarities of these two models and then to propose an extension of the Smith model by incorporating a difference found in Model-View-Controller.

2. Microeconomic Systems as Information Processing Mechanisms

An information processing mechanism requires several components. For information to be processed it must be acquired. It must be transmitted from its generating source to a secondary location, either physical or logical, where it will be available to be combined with other information gathered from their respective points of origin. The need to aggregate information from dispersed sources as a prerequisite to centralized information processing was presented in an economic context by Friedrich von Hayek's 1945 paper "The Use of Knowledge in Society" which described prices as not merely defining opportunity sets but also functioning as channels of communication for diffuse knowledge of economic conditions. As a rebuttal to (at that time) prominent advocates of central economic planning, Hayek pointed out that if the information required to make an economic decision cannot be assembled by the decision maker, then the optimal decision cannot be made.

After information is acquired, it must be processed. Fifteen years after Hayek, Leonard Hurwics extended this concept by introducing economics as information flow in resource allocation theory (Hurwicz 1960). In this perspective, outcomes are not determined solely by the choices of interacting the economic agents but rather are processed through economic institutions which map choices to outcomes through a set of allocation rules. In the study of mechanism design the institutional rule set for processing agent

[*] North Dakota State University, Richard H. Barry Hall 228, Fargo, ND 58105 USA. E-mail address: robert.mayo@ndsu.edu (R. L. Mayo)

communications is the target of inquiry, while in experimental economics the institutional rule set is the probe employed to generate insight about economic behavior. In both areas of study, the central importance of institutions as mediators between the choices of economic agents and economic outcomes is recognized, while being applied towards different research goals.

Both Hayek and Hurwics make a distinction between intent and result. In Hayek's case, preferences and capabilities of a very large number of economic actors, embodied by their choices, are unavailable to the central planner in his attempt to achieve a particular economic result. From Hurwics, the choices of economic agents are known to the allocating entity, but the rules embodied in that entity may be such that a suboptimal allocation decision results despite information availability. Smith makes this separation between communication and processing explicit, *"The import of all this is that agents do not choose direct commodity allocations. Agents choose messages, and institutions determine allocations via the rules that carry messages into allocations."* It is this separation of functions that is the central feature of MVC software architecture.

3. Model-View-Controller

The Model-View-Controller system of software design was created at Xerox PARC in the late 1970s and was first implemented in the SmallTalk-80 programming language. SmallTalk was one of the first object-oriented programming languages and, having new capabilities, it provided the opportunity for software engineers to create new coding frameworks. As the direct manipulation by the user of large and complex data structures became increasingly impractical, an approach to mitigate this difficulty was developed in the introduction of an intermediate layer between the user input and data editing. The result was the three tier MVC architecture. MVC embodies the principle of separation of concerns with each concern being a separate functional level of data processing. In an MVC paradigm, a user initiates action by sending input to a controller. The controller analyzes the user's request and constructs the necessary series of commands to implement that request which are then passed to the database model. The model responds by passing the requested information back to the controller, not directly to the user. The controller receives data from the model, organizes the information so that it will be a meaningful response to the user's initial request and passes that information to the view layer which presents the data to the user.

There are several related advantages to this style of software construction. First, since functions are compartmentalized both development and testing can be done on a modular basis. The model is only required to store data and respond correctly to controller commands. The view layer only needs to receive structured data from the controller and present it to the user in a way that is convenient for consumption. Since the model has no direct interaction with the view, it does not need to be concerned with issues of form but only of substance. Conversely, the view is not required to do any data retrieval or manipulation. Its only task is to take what it is given by the controller and present it to the user. By separating the concerns of data storage, manipulation, and presentation, multiple teams can develop the different layers of the software product in parallel with minimal concern for interoperability. A second advantage of MVC software architecture is improved maintainability. For example, since the model is compartmentalized from the view, the controller system could migrate from one data storage technology to another without requiring the entirety of the software using that database to be rewritten. The third advantage of MVC, and the one most relevant for this discussion, is that the user does not interact directly with the model. Users only send messages to a controller. It is the controller, not the user, that accesses the data in the model.

4. Microeconomic Systems Model

4.1. Environment

In *Microeconomic Systems as an Experimental Science,* Smith presented a model that paralleled the MVC framework by dividing his description of microeconomic systems into two parts, environment and institutions. An environment can be defined by $N = \{1, \ldots, N\}$ agents and $K + 1$ commodities $K = \{0, \ldots, K\}$. Agents are defined by a set of characteristics including utility function u, technology endowment T, and commodity endowment vector ω. Agent i is therefore described by $e^i = (u^i, T^i, \omega^i)$ A microeconomic environment is then defined as the aggregation of agents $e = (e^1, \ldots, e^N)$.

4.2. Institutions

The second element of the model is institutions. Institutions are, from the New Institutional Economics perspective, the rules of the game. This includes both de jure and de facto constraints on action. By de jure rule if I approach you on the street and display a gun and communicate that I will shoot you if you don't hand over your wallet, I may be punished with imprisonment. By de facto rule, if my statements regarding price are contradictory, I will be unlikely to make a sale. In both cases the institutional rule set defines not only what transactions I may undertake, but also what messages I may send. In this, institutions define not only property rights in objects and ideas but also rights in the communications that are/are not allowed and under what conditions they may be used.

4.3. Institutions can be sub-divided into their components:

Language: Communication is predicated on the existence of a language $M = \{M^1, \ldots, M^N\}$ where M^i is the set of all possible messages from agent i and $m = \{m^1, \ldots, m^N\}$ is the subset of M of messages sent. Note that the set of possible messages for agent i does not have to be the same as the set of possible messages for agent ¬ i. As an example, a buyer may have the right to make multiple bids at auction, but the seller may be restricted to one or none.

Allocation rules: A set of rules $H = (h^1[m], \ldots, h^N[m])$ which determine the allocation of commodities to each agent i as a function of the set m of messages sent by all agents.

Cost imputation rules: Although cost could be folded into allocation by defining the numeraire as a commodity, it can also be represented as the set $C = (c^1[m], \ldots, c^N[m])$ which determine the payments to or from each agent as a function of the messages sent by all agents.

Adjustment process rules: A set of rules G is required to specify the conditions under which message exchange may begin, t_0, end t, and a rule T governing which messages may be sent at each point between t_0 and t. Adjustment process rules are thus defined as $G = (g^1[t_0, t, T], \ldots, g^N[t_0, t, T])$. As with the set of possible messages m, the set of adjustment rules may be different for each agent.

Property Rights: Language, allocation rules, cost imputation rules, and adjustment process rules collectively define the property rights of each agent as $I^i = (M^i, h^i[m], c^i[m], g^i[t_0, t, T])$ and the microeconomic institution is therefore the set of property rights of all agents $I = (I^1, \ldots, I^N)$. Combining the environment $e = (e^1, \ldots, e^N)$ with institutions $I = (I^1, \ldots, I^N)$ completes the definition of the microeconomic system as $S = (e, I)$.

5. Institutions as Controller

Smith's micro economic systems model and the Model-View-Controller software architecture are both based on a separation between messages and outcomes. From the MVC perspective this is implemented by the introduction of a controller layer between user and database. The user does not choose the data to be retrieved or modified in the model but rather only communicates a choice message. That message is received by the controller and is processed according to a set of rules which in turn determine how data stored in the model is to be modified. This process is shown in figure 1.

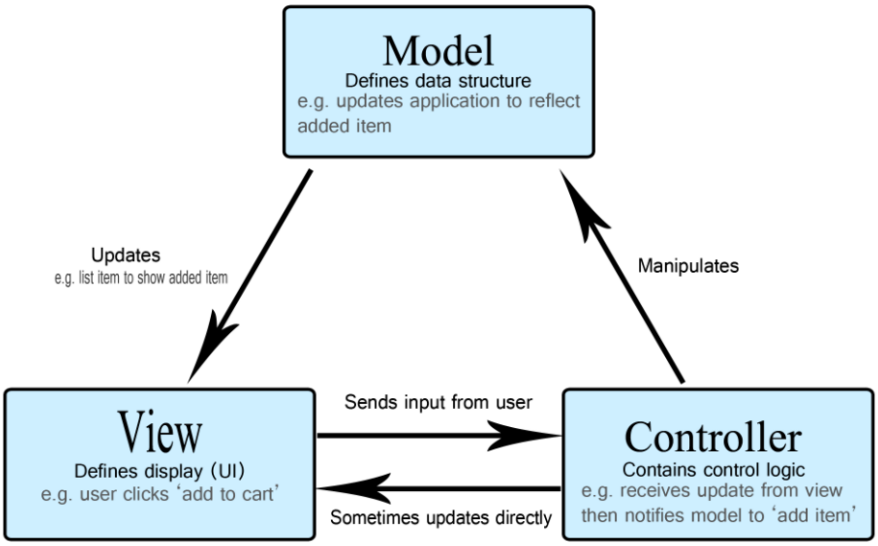
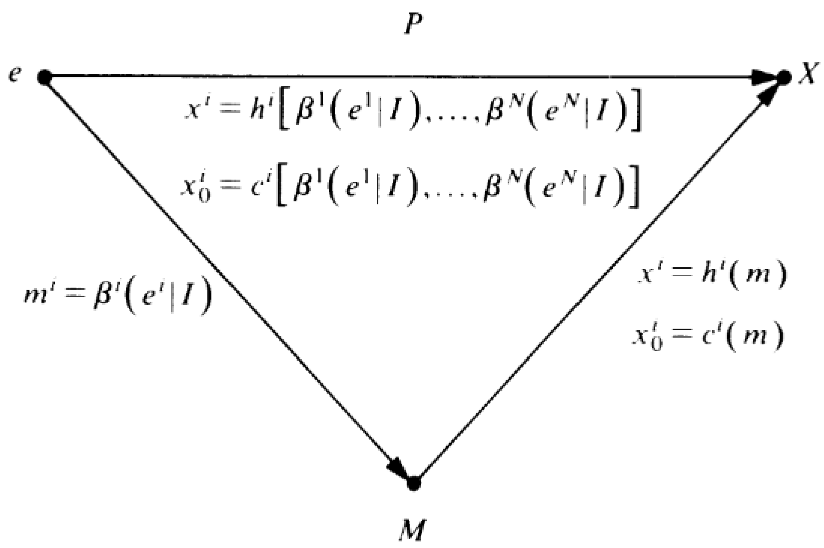


Figure 1. MVC Data Flow Diagram from MDN Web Docs Glossary: Model View Controller licensed under CC BY-ND 2.0. https://developer.mozilla.org/en-US/docs/Glossary/MVC

The same separation of concerns is seen in Smith's model where agent i generates message set m^i, which is taken as input to the system's institutions. The institutions then apply the set of rules for commodity allocation h^i and cost imputation c^i to construct a particular outcome, as shown in figure 2.



$$e^i = (u^i, \omega^i, T^i), \qquad I^i = \left(M^i, h^i(m), c^i(m), g^i(t_0, t, T)\right)$$

$$e = (e^1, e^2, \ldots, e^N), \qquad I = (I^1, I^2, \ldots, I^N)$$

Figure 2. *"A Microeconomic System"* reproduced by permission from Smith, Vernon L. 1982. *"Microeconomic Systems as an Experimental Science."* The American Economic Review 72 (5): 923–55.

6. Discussion and Conclusion

The structural parallels between Vernon Smith's microeconomic systems model and the Model-View-Controller (MVC) software architecture highlight a shared emphasis on separating messages from outcomes, a feature that underscores the role of institutions (or controllers) as mediators in processing agent inputs into economic allocations or data modifications. While this commonality provides a robust foundation for reinterpreting Smith's framework through a computational lens, the divergence in how these models handle feedback reveals an opportunity to extend Smith's model. Specifically, the absence of an explicit feedback mechanism in Smith's framework, contrasted with the MVC's view layer that communicates outcomes back to users, suggests a limitation in capturing the dynamic interplay between allocations and agents' knowledge in modern economic systems. This section explores how integrating such a mechanism could enhance the predictive power of Smith's model and broaden its applicability to real-world contexts.

In Smith's original formulation, the process concludes once institutions process agents' messages into commodity allocations and cost imputations, with outcomes implicitly reflected in agents' updated endowments. This assumes that agents directly perceive and internalize these outcomes, an assumption rooted in traditional economic settings where reallocations often involve tangible exchanges, such as goods changing hands. By contrast, the MVC architecture incorporates a view layer that explicitly communicates processed outcomes back to the user, acknowledging that data modifications in a database do not inherently alter the user's awareness or behavior unless conveyed. This difference becomes particularly salient in today's digital economy, where assets like cryptocurrencies, stock portfolios, or intellectual property exist as electronic records rather than physical objects. Here, ownership transfers may occur without immediate agent awareness, necessitating a mechanism to bridge the gap between objective outcomes and subjective knowledge.

Introducing an explicit feedback mechanism into Smith's model, modeled as a set of messages (V) from institutions to agents, with a subset $v \subseteq V$ reflecting specific outcome communications, would address this gap by decoupling allocations (h) and (c) from agents' beliefs about their endowments (ω) and (T). This extension enhances the model's predictive power in several ways. First, it allows for the representation of information asymmetries or delays, which are pervasive in real-world markets. For instance, an agent who sells a stock may not immediately learn of a market crash, leading to decisions based on outdated beliefs about their wealth. By modeling feedback as a distinct process, the framework can simulate how such discrepancies influence subsequent message sets (m), allocation rules (h), and economic outcomes, offering a more nuanced prediction of agent behavior under uncertainty.

Second, this addition improves the model's ability to capture learning and adaptation, key features of real economic systems. In experimental economics, Smith emphasized the role of institutions as probes for understanding behavior, yet his model does not explicitly account for how agents update their strategies based on prior outcomes. An explicit feedback loop, akin to the MVC's view layer, would enable the model to track how knowledge of allocations (e.g., prices, costs, or commodity distributions) shapes agents' utility functions or bidding strategies over time. For example, in a repeated auction setting, agents who receive delayed or incomplete feedback about winning bids might overbid or underbid in subsequent rounds, a dynamic that the current model overlooks. By integrating this mechanism, the framework could predict not only static equilibrium outcomes but also the evolution of market efficiency as agents adjust to institutional signals, a critical enhancement for testing hypotheses about market convergence or stability.

The broader implications of this extension extend to real-world applicability, particularly in digitally mediated markets where information flows are neither instantaneous nor uniform. Consider electronic trading platforms, where high-frequency trades occur in milliseconds, yet retail investors may only receive updates via delayed notifications. Here, the feedback mechanism could model how differential access to outcome information creates arbitrage opportunities or exacerbates inequality, aligning the model with phenomena observed in modern financial systems. Similarly, in decentralized systems like blockchain-based economies, where agents rely on network consensus to validate transactions, an explicit feedback layer could simulate the impact of latency or misinformation on resource allocation, offering insights into the robustness of such institutions under stress.

This modification also bridges Smith's model to contemporary economic theories, such as behavioral economics and mechanism design, which emphasize the role of perception and information processing in decision-making. By distinguishing between objective wealth (allocations) and subjective wealth (beliefs), the extended model can incorporate cognitive biases, e.g., overconfidence or anchoring, into agents' utility functions, enhancing its explanatory power for deviations from rational choice predictions. Furthermore, in mechanism design, where institutions are engineered to achieve desired outcomes, an explicit feedback mechanism allows designers to optimize not just allocation rules but also the communication channels that inform agents, potentially improving efficiency or equity in applications like spectrum auctions or carbon credit markets.

While this proposed extension adds complexity to Smith's framework, requiring additional parameters for feedback messages (V, v) and their integration into endowments (ω, T) it aligns the model more closely with the realities of modern economic systems. The digital economy blurs the lines between data and property, and economic agents increasingly operate in environments where outcomes are not self-evident. By adopting an MVC-inspired feedback layer, Smith's microeconomic systems model gains the flexibility to predict behavior and outcomes in these contexts, from individual decision-making under uncertainty to systemic responses to institutional design. Future experimental work could test this extension by comparing agent behavior in settings with and without explicit feedback, providing empirical grounding for its theoretical benefits.

In conclusion, reinterpreting Smith's model through the MVC lens not only clarifies its information-processing structure but also reveals a pathway for enhancement. An explicit feedback mechanism, inspired by the view layer, enriches the model's predictive capacity by accounting for the dynamic relationship between allocations and knowledge, making it a more powerful tool for understanding and designing real-world economic systems.

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