MacroLab
Model-Facilitated Learning of Essential Macroeconomics

David Wheat
PhD Candidate in System Dynamics, University of Bergen
Adjunct Professor, Virginia Western Community College
President, Wheat Resources Inc.

P.O. Box 19234
Roanoke, Virginia 24019

540-966-5939
540-966-5167 (fax)
dwheat@wheatresources.com

Abstract

MacroLab is a series of interactive learning environments (ILEs) for introductory macroeconomics. It is currently used in a distance learning course taught by the author. The underlying system dynamics structure consists of a national accounting model of aggregate income and spending, linked with behavioral models of consumption, investment, production and pricing, labor and capital utilization, and fiscal and monetary policy. After a brief review of the problem that motivated the development of MacroLab, this paper summarizes the rationale for a solution based on system dynamics and model-facilitated learning principles, highlights key features of the ILE series, and outlines a future research agenda. Workshop participants will gain economic understanding by "test driving" some of the ILEs. In addition, they will gain ILE development skills by experiencing the step-by-step content delivery process, reviewing the corresponding design process, and discussing analogous steps for ILEs in their own fields.

keywords: experiment, interactive learning environment, ILE, macroeconomics, management flight simulator, learning lab, microworld, teaching.

1. The Problem

There is reason for concern over the efficacy of economics instruction. Experiments by Walstad and Allgood (1999) indicate that the value added by economics courses is "minimal." Wood and Doyle (2002) report similar findings in a large economic literacy survey, concluding that college and university economics educators should be only "modestly" encouraged by the results.

With respect to macroeconomics in particular, Cohn et al. (2001) find no significant difference in learning gain by students who received traditional instruction—graphical comparative statics—on a Keynesian concept, compared to those who received only verbal

instruction. In a similar experiment involving a monetary policy topic, students receiving graphical instruction actually scored *lower* than those receiving verbal instruction alone.

My own students find it difficult to see how the proliferating textbook graphs relate to one another, and how the variables on different graphs interact to influence economic system performance. Indeed, interaction—inherently *multiplicative*—is de-emphasized by the graphical approach, with its emphasis on *stacking and adding* the components of aggregate spending. The elusive dynamics of interaction is almost certainly missed by students just struggling to keep track of the *ceteris paribus* assumptions behind each new graph.

Boucher (1995) suggests the "…possibility that by over-concentration on comparative statics, the [economics] profession may be omitting or playing down the key importance of the dynamic aspects of most economic problems and issues."

The routine content delivery technique may also impede learning. Becker and Watts (1998) found that about eighty percent of economics classroom contact time was spent lecturing—"chalk and talk"—whether the courses were introductory or advanced. In contrast, the use of techniques to get the students actively engaged in constructing knowledge was minimal. Even in statistics and econometrics courses, just twenty-two percent of the available time was spent in computer labs. Of course, heavy reliance on the lecture style is not *prima facie* evidence of ineffective instruction. Nevertheless, when coupled with other research that is only "modestly" encouraging to economics educators, such findings force the inevitable questions: What might explain the apparent weakness in methods, and what solution is available?

2. Rationale for a Solution Based on System Dynamics and Model-Facilitated Learning

One hypothesis is that the traditional macroeconomics instructional method—graphical comparative statics presented in a lecture format—provides a weakly structured learning pattern for most economics students. Forty years ago, Bruner (1963) concluded that "…the most basic thing that can be said about human memory…is that unless detail is placed into a structured pattern, it is rapidly forgotten."

Of course, the comparative statics model is very simple, compared to a complex economic system characterized by reinforcing and counteracting feedback effects that are often non-linear. If there is a weakness in the model, however, it is not because of simplicity. All models—graphical, econometric, or simulation—are simplifications of reality and, as such, are "wrong." But (continuing to paraphrase) "…some models are useful."[1]

Comparative statics fails the usefulness test if its purpose is to explain the behavior of an economy during a transition from one equilibrium condition (or stable growth path) to another. Apologists would argue that is not its purpose. However, the *essential macroeconomics* for most adults is virtually synonymous with media treatment of such transitions, and public policy debate is dominated by such topics. It is a purpose that needs to be served, and comparative statics fails to do so.

---

[1] The phrase has become a truism in system dynamics circles, yet its origin is obscure, bordering on professional folklore. Richmond (2000) attributes it to quality expert, W. E. Deming. More to the point, however, is that the validity—and, therefore, the usefulness--of any model depends on its purpose, a principle emphasized by Forrester (1961) four decades ago.

In *Macroeconomic Essentials: Understanding Economics in the News*, Kennedy (2000) leads off with this rhetorical question:

> *What do we want our students to be able to do upon completing their macroeconomics course—manipulate a 45°-line diagram and derive the multiplier, or interpret and evaluate media commentary on the macroeconomy? I am not alone in believing that for many students the latter is preferable, and that in terms of meeting this latter goal there is a high opportunity cost associated with pressing students to learn algebraic and graphical derivations.*

His textbook is a lucid exposition of fundamental macroeconomic principles, with hundreds of media clips that serve to test student understanding and demonstrate the relevance and utility of course content. The book contains only a few graphs, but it is nevertheless rigorous in the critical thinking demands placed on student readers. What is missing, however, is Bruner's "structured pattern," or, in Forrester's words (1994): "…the framework into which facts can be placed [so that] learning becomes more relevant and meaningful."

I stand with those who believe that system dynamics provides such a framework, but that is a testable hypothesis.[2] One research frontier is the development of methods for assessing the instructional value added by interactive learning environments (ILEs) based on system dynamics models. A prerequisite for rigorous evaluation, however, is a consensus on the principles of effective ILE development and implementation.

Model Facilitated Learning. In their development of model-facilitated learning (MFL) guidelines, Spector and Davidsen (1998, 2000) and Milrad, Spector, and Davidsen (2003) delineate three stages of encounter between a learner and an ILE. At each stage, they urge a unique instructional approach and expect a different learner development pattern.

The first stage promotes problem orientation**.** Learners confront a relatively simple problem in the subject domain and must offer a solution. Next, the inquiry and exploration stage makes the underlying model more transparent (Alessi 2000), and learners literally begin to see the system structure, albeit in a very simplified form such as condensed causal loop or stock/flow diagrams. This stage also includes "hypothesis formulation and experimentation" that challenge users to articulate in words and diagrams their understanding of the relationship between system structure and behavior. The final stage in the MFL process is the policy development stage, where "learners are immersed in the full complex system and asked to develop rules and heuristics to guide decision making in order to create stability or avoid undesirable situations." (Milrad, Spector and Davidsen, 2003). A common denominator for all stages is the principle of graduated complexity that suggests a developmental sequence of learner challenges.

With only slight modification, these MFL principles frame the design of the MacroLab user interface and the learning activities described in the third section of this paper. The final product is a set of eighteen interactive learning units that comprise a system for learning introductory macroeconomics.[3]

Underlying System Dynamics Model. Much of the structure of the model (that "facilitates the learning") in MacroLab builds on the work of those who pioneered the system dynamics

---

[2] See discussion in the research agenda section.

[3] MacroLab is currently utilized in the author's macroeconomics distance learning course for students at Virginia Western Community College in Roanoke, Virginia. The series could also be used for self-paced learning.

approach to the study of macroeconomics, some of whom remain at the frontier of that research initiative.[4]

In addition, the model makes use of a traditional macroeconomics concept—circular flow of income and spending—recast in stock and flow terms. Figure 1 is a simplified diagram of the current version of the model, which joins "demand side" and "supply side" sectors of a national economy.[5] Most link-forming arrows have been omitted to improve clarity. *Arrows shown are **only** those that are in the main reinforcing feedback loop for economic growth (or decline).* The diamond-shaped icons contain sub-models of various decision processes, within which most of the counteracting feedback loops operate.

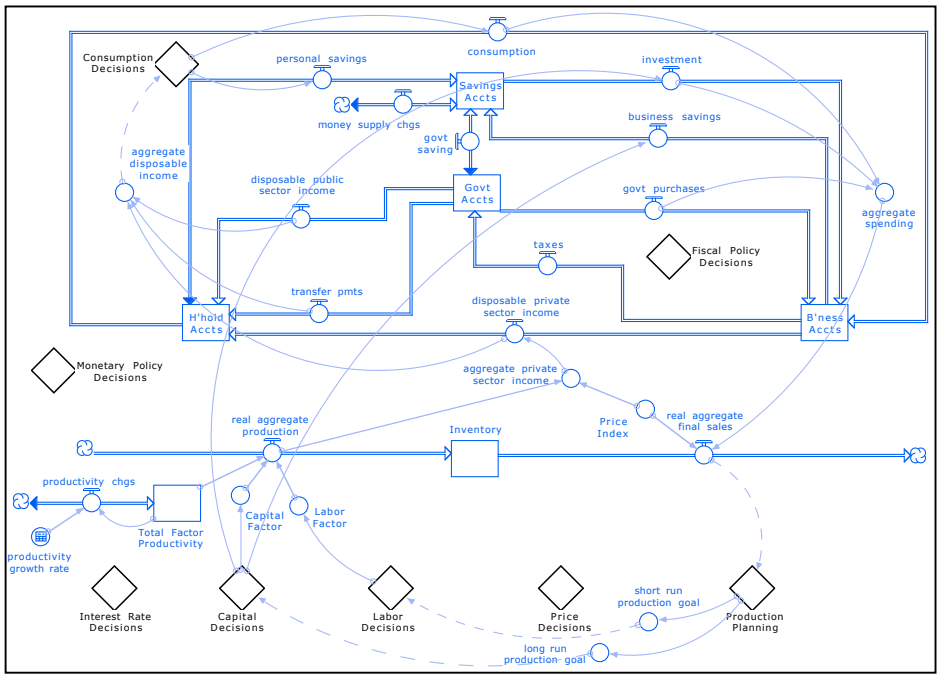

Figure 1. Simplified stock-and-flow diagram of the complete MacroLab model.

The demand sector—top half of Figure 1—is a system dynamics model of the traditional textbook "circular flow" diagram, where the material stocks are trillions of U.S. dollars, and the flow of funds is driven by decisions that affect the timing and distribution of income, private sector spending and saving decisions, and public sector taxation and spending decisions. The bottom half of the figure displays the supply sector, and includes the forces driving production

[4] Any long list runs the risk of inadvertent omissions, but J. Forrester (1961, 1968, 1980, 1994), N. Forrester (1973, 1982), N. Mass (1975, 1980), J. Sterman (2000), and M. Radzicki (1988, 1993) certainly merit short-list acknowledgement. I am deeply indebted to their pioneering efforts, as well as to the guidance provided by E. Moxnes and P. Davidsen at the University of Bergen. Of course, they are in no way responsible for my interpretations or adaptations, and weaknesses in the MacroLab model are solely my responsibility.

[5] This version models a closed economy, but an international sector will be added during the fall semester, 2003.

decisions, including the stocks of labor and capital and their associated productivity.[6] The two sectors are linked by information feedback. Production information and prices/costs update income payments and distributions. Capital decisions determine business saving and investment. Real sales are equivalent to nominal aggregate spending divided by the price index.

Students using the MacroLab series do not encounter the model in Figure 1 until very late in the macroeconomics course. After opening a MacroLab learning unit file, the users are quickly led to an interface page that contains eighteen buttons, one for each learning unit (Figure 2).

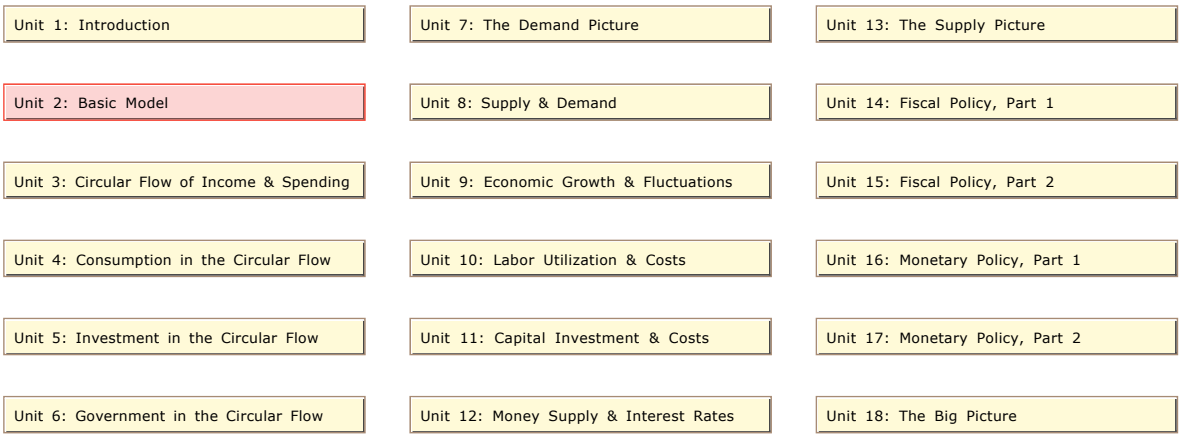

Figure 2. Learning Unit Selection Panel

The entire series consists of eighteen ILEs that are stand-alone, model-facilitated learning units. Together, however, they constitute a learning system. After the initial basic model is introduced in Unit 2, subsequent learning units add dynamic complexity to that model without changing its structural fundamentals. During the semester, the complete model is revealed and becomes operational in stages. The design objective is for students to see the basic model gaining complexity without losing sight of its fundamental structure.

Each of the learning units is a separate Stella file[7]. Clicking on any of the buttons—except the red one—opens a text box that provides a brief summary of the selected learning unit and describes the location of the file on the user's computer. A click of the red button ("Unit 2: Basic Model" in Figure 2) takes users to the interface page that activates the instructional process for the selected unit.[8]

Among other things the user finds in Unit 2, there is the basic model of the entire MacroLab series (Figure 3). It is the foundation structure that supports all subsequent enhancements in later learning units. As in the complete model, the top half of the basic model contains the demand decisions, while the bottom half contains the supply decisions. Decisions

---

[6] The fiscal policy and monetary policy decision points are located somewhat arbitrarily in Figure 1. Also, only the forces contributing to the main reinforcing feedback loop (production>income>spending>sales>production) have visible links. Other links were deleted for diagram clarity. The decision diamonds contain the negative feedback loops that counteract the main reinforcing loop.

[7] High Performance Systems (www.hps-inc.com) offers a free demo version of the STELLA simulation software.

[8] Unit 1 introduces the MacroLab interface and the STELLA software tools, as well as fundamental system dynamics concepts (stocks, flows, and feedback). It, too, is based on MFL principles but will not be discussed here.

about the timing and distribution of income payments link the production flow in the supply sector with the income flow in the demand sector.

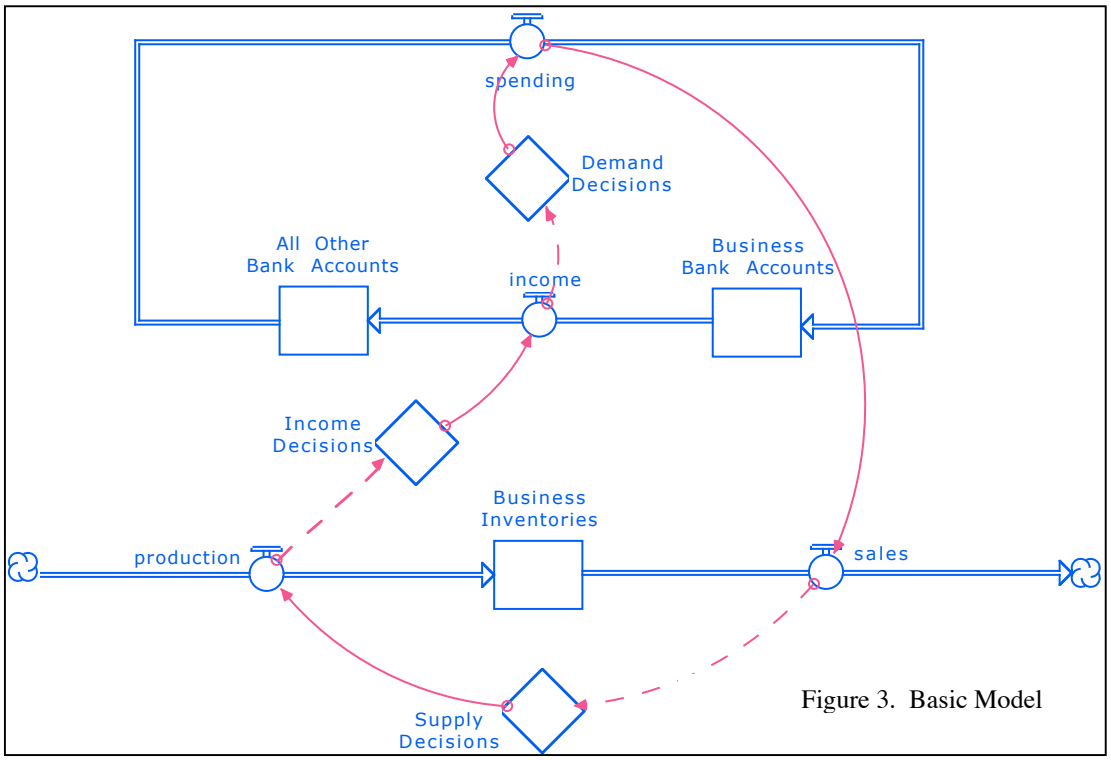

Figure 3. Basic Model

The visible loop in Figure 3 is a reinforcing loop showing that the supply side and the demand side drive each other, and that both Say's Law and Keynes' Critique are incomplete when considered in isolation.[9]

Inside the decision diamonds are sub-models of counteracting loops that limit the ultimate strength of the reinforcing, economic growth loop. The degree to which that growth loop is moderated depends on the adjustment times for the various counteracting feedback processes. The embedded counteracting loops, along with other detailed aspects of Unit 2, are discussed in the next section, which illustrates MacroLab's model-facilitated learning process.

It is important to appreciate the fundamental relationship between the complete model in Figure 1 and the basic model in Figure 3. Small pictures of both diagrams are combined in Figure 4, and the similarity should be evident, despite differences in complexity.

On the left of Figure 4, the basic model is reproduced, while the complete model is on the right. The circular flow of income and spending is visible in the top half ("demand side") of both diagrams, while the lower halves contain the supply decisions that drive production.

[9] Keynes asserted that the macroeconomic views of Say and Ricardo could be summarized as "supply creates its own demand." He said they had it backwards. Using the basic model to distinguish the two theories is discussed in the research agenda section.

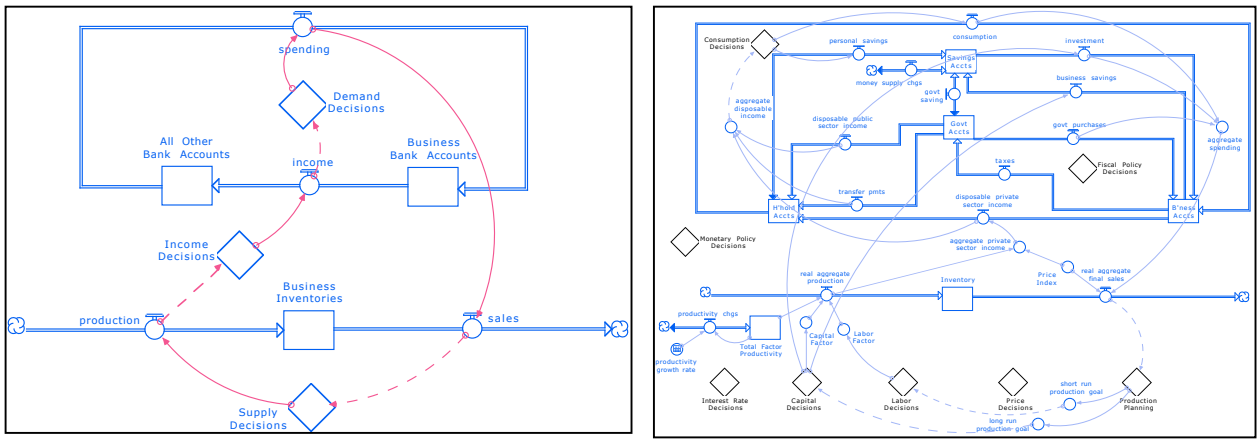

Figure 4. Basic Model (left) vs. Complete Model (right)

3. Model-Faciltated Learning in MacroLab

This section illustrates how MFL principles have been adapted and implemented in MacroLab, using excerpts from Unit 2. Unless indicated otherwise, the Unit 2 excerpts typify the layout in each learning unit, which is organized into three main pages:

- *Home Page* contains information about the purpose of the unit, a diagram of the current model, and buttons that reveal the "story" behind the model.
- *MacroLab* is the page containing the simulation control panel and the learning activities and assignments.
- *Suggested Solutions* is a reference page where users can check their work.

Home Page. Recall that the first MFL principle discussed in section two was "problem orientation," an initial exercise to acquaint users with issues they will confront in the learning activities. And, indeed, the first simulation activity of Unit 2 provides such an exercise. However, that exercise is in the context of the fundamental challenge for the entire course—understanding economic fluctuations in the midst of long-run economic growth—a challenge already introduced in a Unit 1 activity.

Therefore, the home page of Unit 2 (Figure 5) begins with a reminder of what should have been learned in the previous unit, with the implication that the learning objectives are cumulative, and that a review may be appropriate before proceeding.[10]

[10] E.g., behavior of GDP and unemployment, fundamental system dynamics concept (stocks, flows, and feedback), distinctions between mental models and computer models, and guided practice in the use of the software tools necessary to operate the ILE.

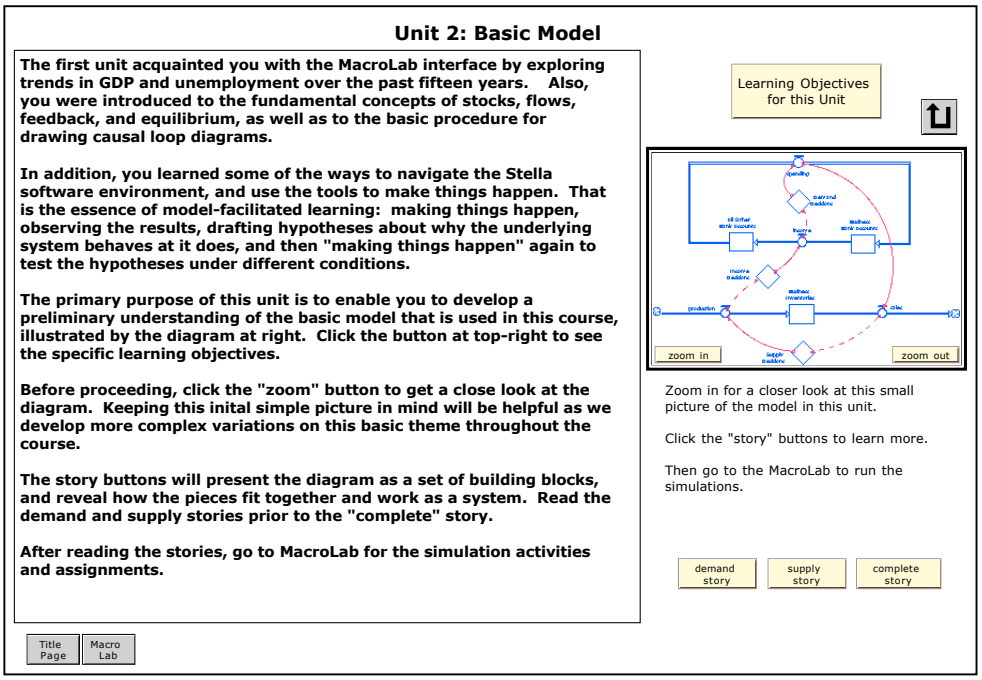

Figure 5. Home Page of a Typical MacroLab Learning Unit

The home page text also clarifies the primary goal of Unit 2: to enable the user to develop a preliminary understanding of the basic model, including its reinforcing and counteracting feedback loops. The goal is operationalized by a set of specific learning objectives that appear when users click the button above the model diagram. Successful completion of the activities in Unit 2 should enable students to:

1. Use a few more Stella tools effectively, and demonstrate a better grasp of concepts introduced in the previous unit.
2. Write a brief summary of the demand and supply sides of the model, and how they fit together.
3. Identify where, in principle, "GDP" fits in the model, and explain how sales and inventory data can be used to estimate production.
4. Sketch a causal loop diagram that expresses an understanding of the basic model in action, and explain that diagram.
5. Understand news media stories about the delayed effects of changes in total (i.e., aggregate) spending in the economy.

Prior to arriving in Unit 2, students would have already encountered the mental model concept in a Unit 1 activity and in supplementary reading materials. As a result, achieving "understanding" in the course would have already been expressed in terms of renovation of the

students' mental models.[11] Thus, the first true learning experience in each unit is to get acquainted with the "current" model in the MacroLab series (i.e., the model that is driving the current learning unit), and that is accomplished in two steps.

First, on the Unit 2 home page, the user is encouraged to "zoom in" and get a close look at the diagram of the model on that page. The home page diagram always contains the essential stock and flow structure of the current model, but it is simplified by omitting links that would add more clutter than clarity. It is, in effect, a type of influence diagram for communicating primary relationships in the model, rather than a detailed stock-and-flow diagram.

After exploring the total picture, users are directed to the three "story" buttons in Unit 2.[12] The "story" function in STELLA permits revealing portions of the model in a logical sequence, accompanied by annotations.[13] In Unit 2, the demand-side and supply-side stories provide different perspectives on how an economic system functions, and the "complete" story ties together the two perspectives in a loop-closing fashion.[14]

Clicking the "Demand Story" button reveals the portion of the model in Figure 6, *a few elements at a time*. Each time the spacebar is pressed, the diagram takes shape, accompanied by explanatory text.

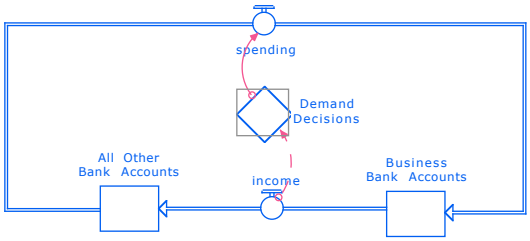

Figure 6. Demand Side of Basic Model

Demand decisions are made by the spending agents in the model: consumers, businesses, governments, and international customers. In the basic version of the model in Unit 2, the only influence on demand decisions is information about the income received by the spending agents

---

[11] An instructor assessing student progress in mental model renovation necessarily has some goal in mind, toward which the students are hopefully moving. Most likely, the instructor's own mental model provides both the implicit target for the students, as well as the conceptual framework for instruction in the course. Instructors are *expected* to teach what they know. In turn, society hopes that what instructors know is accurate and important, and that students' mental models are being effectively renovated.

[12] Most learning units have only one story button.

[13] A powerful feature of the story function is the capability to run a simulation using only the portion of the model revealed at particular stages in the story. In Unit 1, for example, a story is used to reveal the stock adjustment structure responsible for counteracting feedback. Prior to closing the feedback loop, however, a simulation run reveals that the "incomplete" model generates linear growth when the goal of the system is shocked by a step increase. Changing the adjustment time parameter merely affects the slope of the growth pattern. Only when the loop is closed—on the next page of the story—does goal-seeking behavior emerge. That is an important revelation for students who assume it is the delay parameter itself that creates the counteracting behavior. Running two simulations within the story demonstrates that it is the feedback loop that generates the goal-seeking behavior.

[14] See the research agenda section for a discussion of issues raised by a biased instructional perspective (i.e., one that fails to give a balanced treatment to both the demand- and supply-side sectors of the economy).

(including taxes received by government). Income is a (supply-side driven) flow of funds from Business Bank Accounts to All Other Bank Accounts.

In this model, the essence of demand decision making is continuous revision and implementation of spending goals in light of changes in income.[15] Clicking on the demand decisions diamond reveals a sub-model of the information stock adjustment process that has a counteracting feedback effect on the positive link between income and spending. Demand decisions are carried out by spending, which causes a flow of funds from "other bank accounts" to "business bank accounts."

When users finish the story about the demand sector, they return to the home page and click the "Supply Story" button, which reveals the portion of the model in Figure 7, *a few elements at a time*.

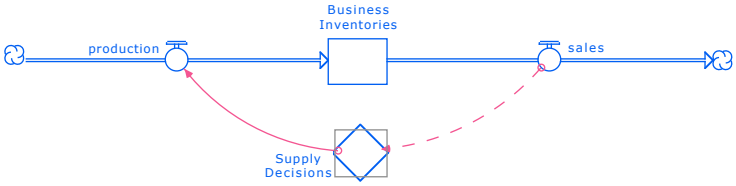

Figure 7. Supply Side of Basic Model

Within the model, supply decisions are made by producing agents (i.e., businesses). In the basic model, information about the sales rate is the only factor that influences decisions about how much to supply. Other influence factors (e.g., inventory levels, availability of labor and capital, price and cost) are added as the model takes shape in later units. The essence of supply decision making is the continuous revision and implementation of production goals. (Clicking on the supply decision diamond reveals the sales information stock-adjustment process.) Ultimately, the supply decisions affect the production rate of final goods and services.

Upon completion of the supply sector story, users return to the home page and click the "Complete Story" button. Initially, the demand side of the model re-appears, along with a brief summary of its previous story. Pressing the spacebar causes the supply side and its summary story to re-appear. Then the connection between the two sides is accomplished by two steps that create a closed loop. See Figure 8.

[15] In later units, other influences on spending are added to the model.

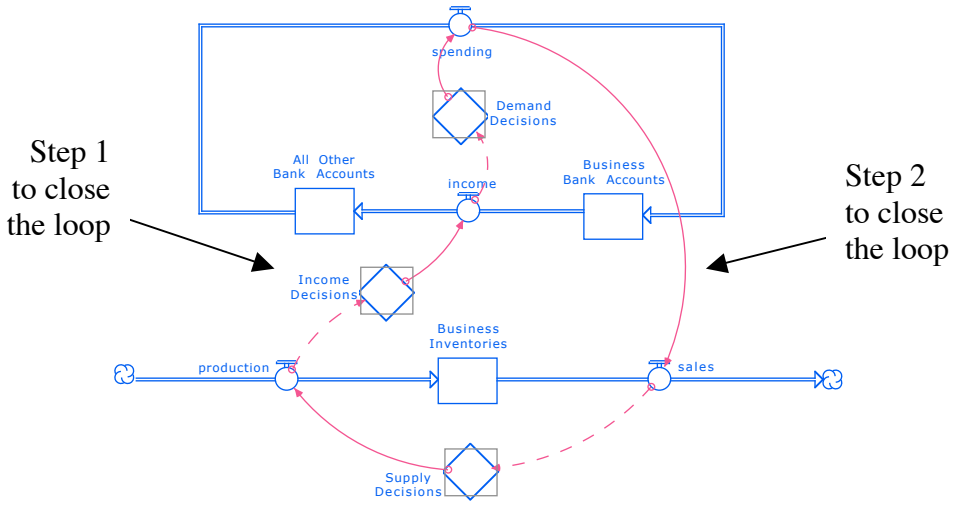

Figure 8. Closing the Loop between Demand Side and Supply Side of Basic Model

The first step involves linking production and income. Income decisions are made by the owners of production (or the producing agents on their behalf). The essence of income decision making is the continuous revision and implementation of income payment goals. In this model, that process is driven by information about current production rates. As before, the information stock adjustment process is revealed by clicking on the decision diamond. Production results from the combined services of the factors of production (labor, capital, raw materials, energy, etc.). Payment for those services is factor income. When factor income is combined with profits of the owners of the production, the total is national income

The second step reflects the fact that the spending flow and the sales flow are two sides of the same coin. Although they represent the same real-world activity, there is a measurement unit difference in the model. Spending is a flow of dollars. Sales, on the other hand, is a flow of real goods and services. In this basic model, the sales rate is identically equal to the spending rate. In later units when the model includes a price sector, sales will be equal to spending divided by a price index.[16]

Closing the loop confirms the mutual dependency of the demand and supply sides of the model, and illustrates the futility of a "chicken or egg" search for primal causes. When the entire MacroLab series is used as a learning tool, the recommended approach is to follow the numbered sequence shown in Figure 2. Of course, that results in learning the "demand side" of the model prior the "supply side." That merely reflects a judgment about graduated complexity, however, and has nothing to do with economic philosophy.[17] The demand-side units (3-7) are easier to learn, and they correlate with the early material in standard textbook arrangements. Nevertheless, if an instructor (or a self-paced learner) preferred to begin with the supply-side units (8-13), there would be no problem since they can stand alone pedagogically.

MacroLab Control Panel Page. A click of the "MacroLab" button takes users to the page containing the simulation controls, graphical outputs, and the associated activities and assignments. The typical control panel contains another small picture of the current model,

[16] Also, the conversion of real production to nominal income (Figure 8) requires *multiplying* by a price index.

[17] See the research agenda section for a related issue.

augmented by "on/off" switches and other parameter controls (e.g., sliders, dials, or input lists) that permit testing the model under different assumptions. In addition to buttons containing instructions and assignments, the control panel also includes a stacked set of graphs for displaying the simulation results. Figure 9 displays the control panel page for Unit 2.

The dials in Figure 9 permit changes in the adjustment times for each information stock. The spending shock switch causes a small (e.g., 2%) but sharp increase in spending in year 2, only to be followed in year 4 by an equally sharp decrease (perhaps analogous to a two-year period when strong demand abroad increased net exports). When the feedback switch is OFF, any variation in spending is entirely due to the spending shock. When feedback is ON, then spending will also be affected by changes in income. The random noise (i.e., disturbance) in the production rate causes fluctuations that might mimic equipment problems, work stoppages, supply bottlenecks, etc., in a real economy.

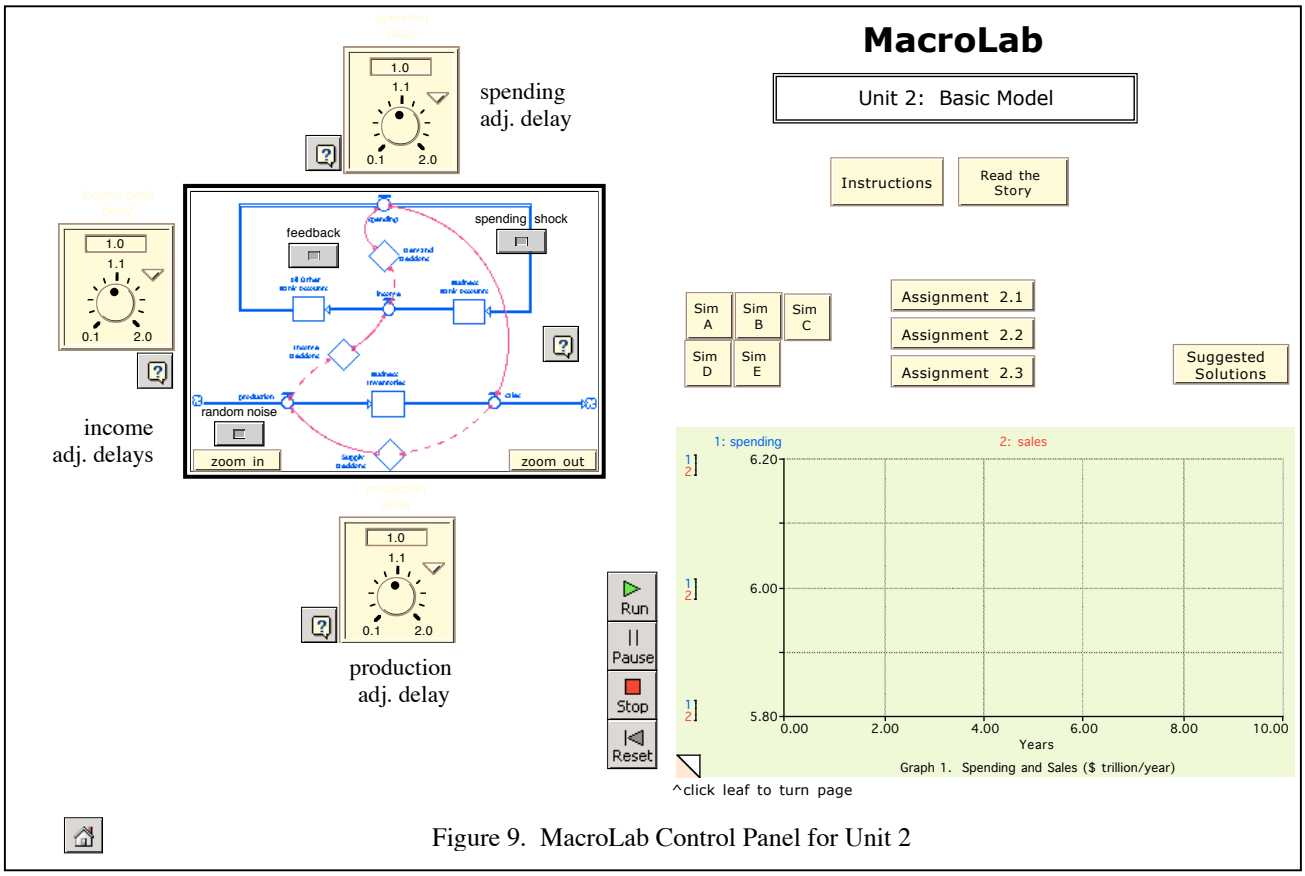

Figure 9. MacroLab Control Panel for Unit 2

Sim A implements the "problem orientation" principle of model-facilitated learning by requiring users to recall and use concepts introduced in Unit 1 (stocks, flows, equilibrium, and GDP) when the model runs without any test inputs. Stocks and flows have to be identified, and equilibrium has to be explained in stock/flow terms. Moreover, users have to associate GDP with the production rate in the model, and recognize the essential equality of production, income and spending/sales in equilibrium. Finally, the user must use a stock/flow understanding of disequilibrium to explain that the sales flow plus changes in the inventory stock will equal the production flow.

The remaining simulation activity and assignment buttons involve use of the spending shock and random noise switches, first with feedback OFF and later with feedback ON. In addition, the effects of changes in delay times (information stock adjustment times) are evaluated. Through a series of questions, simulation runs, graphical results, the user is led to conclusions about direction of causality, the presence of both a major reinforcing loop and three counteracting loop processes, and policy questions about the effects of delays. In some cases (e.g., Assignment 2.1 requiring an interpretation of the three stories of the basic model), the user is required to post an answer to a personal electronic bulletin board. In others, users must compare their own solutions with the suggested solutions, and post their assessment of differences.

Suggested Solutions. Each set of simulation questions and assignments has a corresponding set of suggested solutions. The user is encouraged to consult the suggested solutions for each activity before proceeding to the next one. The culminating assignment requires the user to post online an evaluation of their own solutions in light of the suggested solutions. Figure 10 shows the Suggested Solutions page for Unit 2.

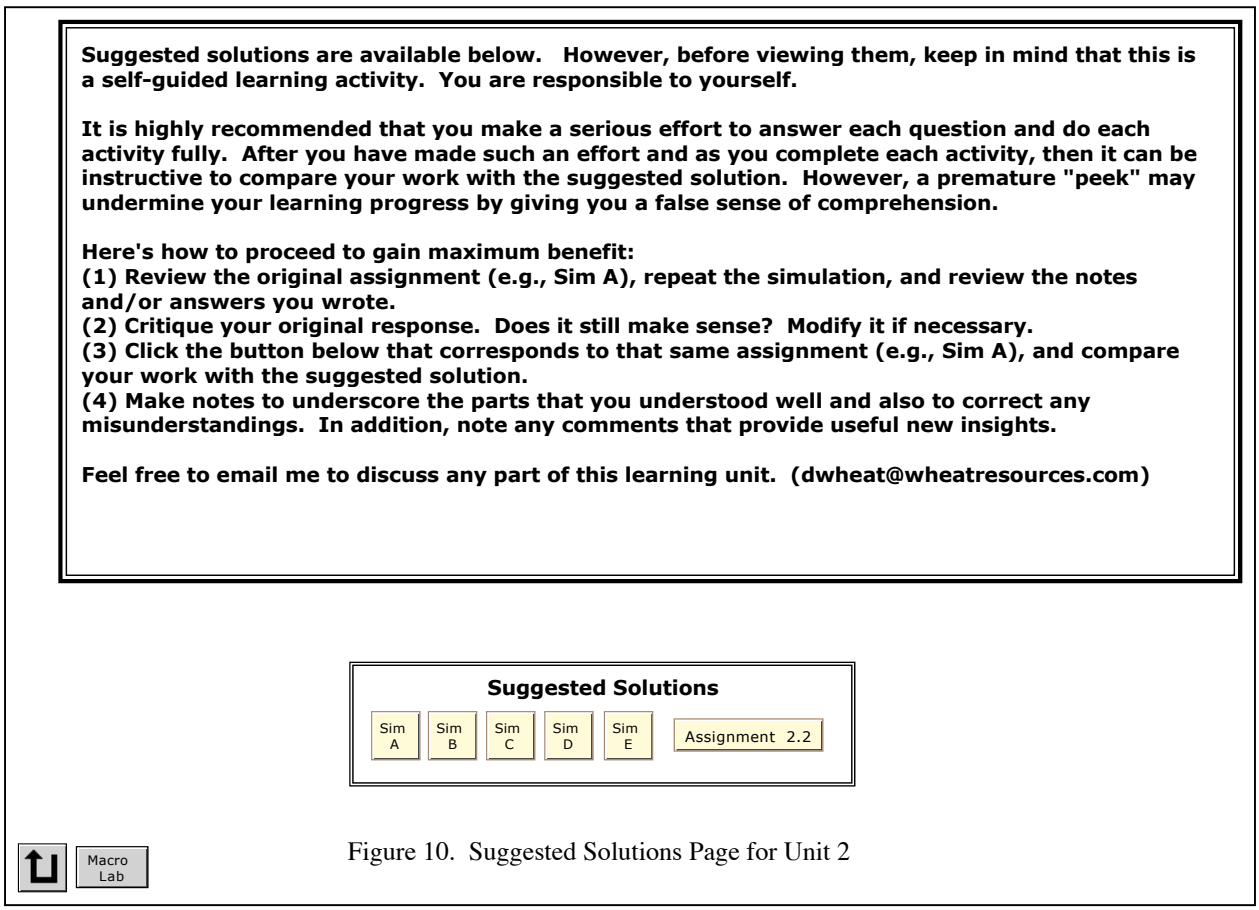

Figure 10. Suggested Solutions Page for Unit 2

The Sim buttons in Figure 10 open text boxes containing suggested solutions for those activities. The Assignment button takes the user to another page, showing causal loop diagrams. Figure 11 provides an example of a solution page for a specific simulation activity, Sim A.

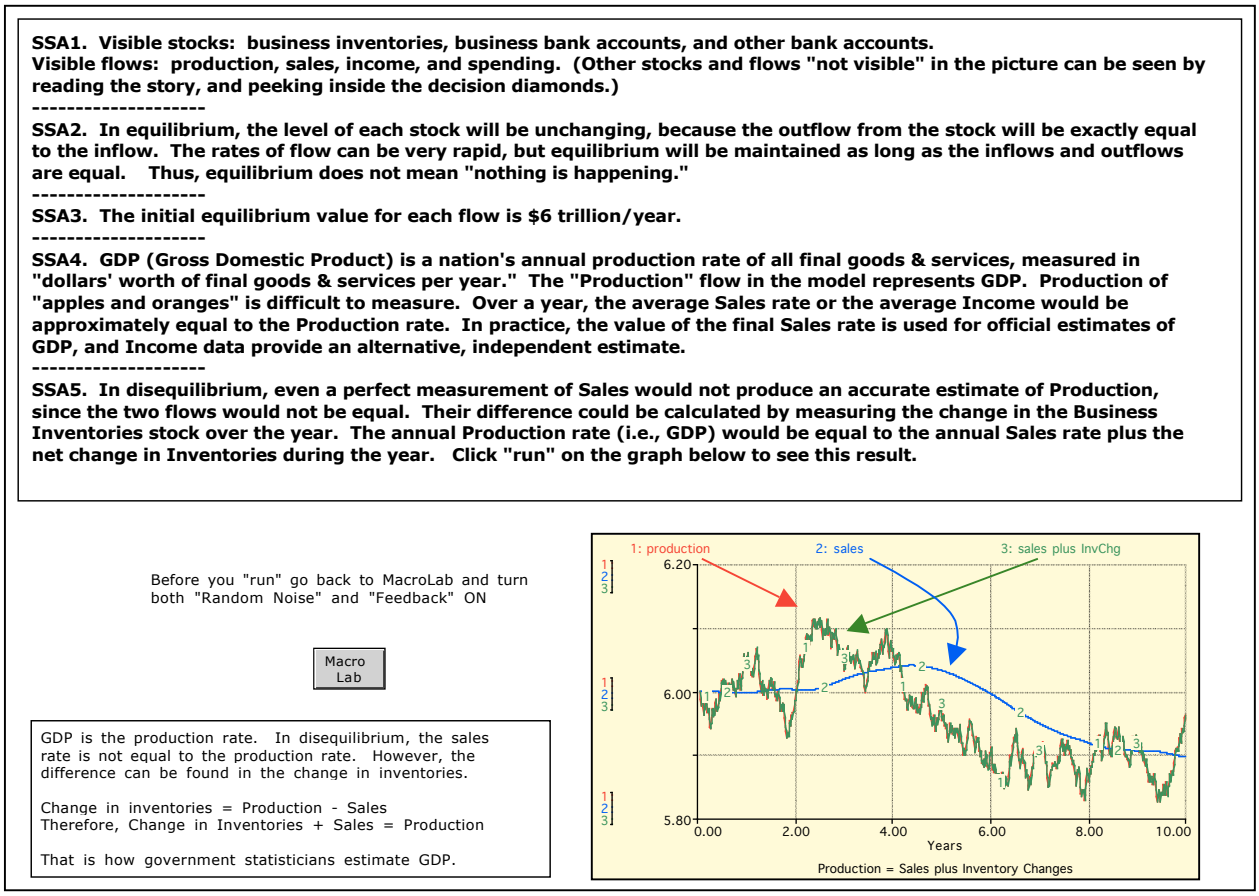

Figure 11. Suggested Solutions for Sim A

Thus, the various simulation activities and the associated questions and assignments involve users in the various stages of model-facilitated learning. Sim A illustrates problem orientation. Sims B and C culminate in the causal loop diagramming exercise involving inquiry, exploration, hypothesis formulation, and experimentation. Policy assessment is emphasized in Sim D, where users consider the time delay circumstances that would be conducive to the success of a particular fiscal policy action.

A central MFL concept is the principle of graduated complexity, and it guides the content delivery process in two ways. As explained previously, MacroLab engages users with simple subsets of the complete model early in the course, and progressively adds complexity. In addition, within each week's learning unit, the principle guides the developmental sequence of assignments for that unit.

5. Research Agenda

System Dynamics vs. Comparative Statics. Section two suggested that the graphical, comparative statics method of teaching macroeconomics fails in two respects. First, it does not provide an effective learning pattern structure that facilitates student learning. Consider, for example, the solution to this typical exercise, adapted from Radzicki (1993):

> *Find the new equilibrium natiional spending and income rates after an exogenous investment shock of $10 billion, given an initial equilibrium at $400 billion and an aggregate spending function defined by AE= .80*Y + I.*

Figure 12 displays the graphical solution, derived by shifting the spending function up by $10 billion. When combined with the algebraic determinatiion of the multiplier of 5 that is implicit in the consumption coefficient of .80, the solution is a $50 billion increase in aggregate spending. The difficulty is not in the analytic geometry or the algebra; both are straightforward. The problem is the method's failure to evoke a vivid mental image of what actually has to happen in the economy—and what assumptions are necessary—before such a result could prevail. That failure makes it difficult for students' mental models to be renovated in any way that is both useful and sustainable.

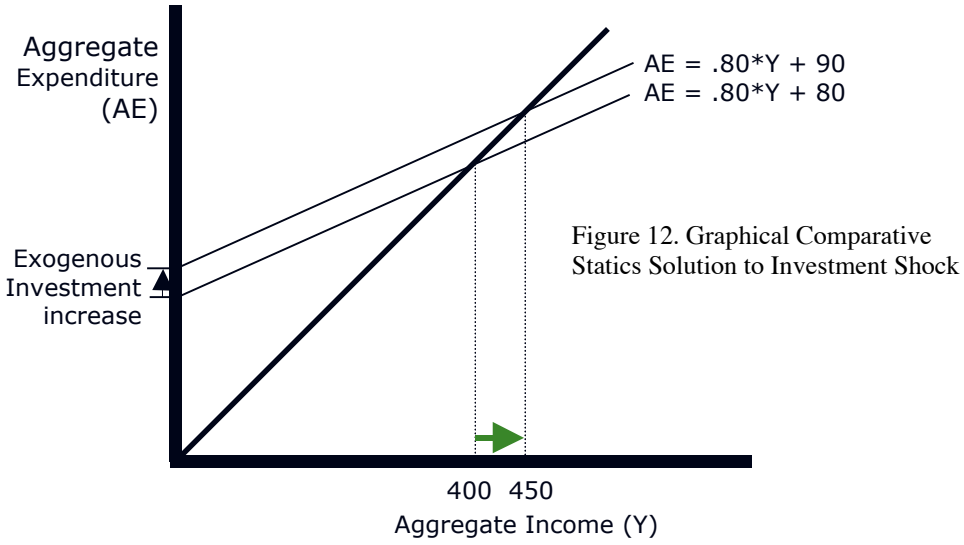

Figure 12. Graphical Comparative Statics Solution to Investment Shock

Section two also suggested that the comparative statics method fails to provide a realistic picture of the transition from one equilibrium to another—a transition of paramount importance to both ordinary citizens and policy makers. Consider, for example, the solution to the previous exercise when graphed over time in Figure 13.

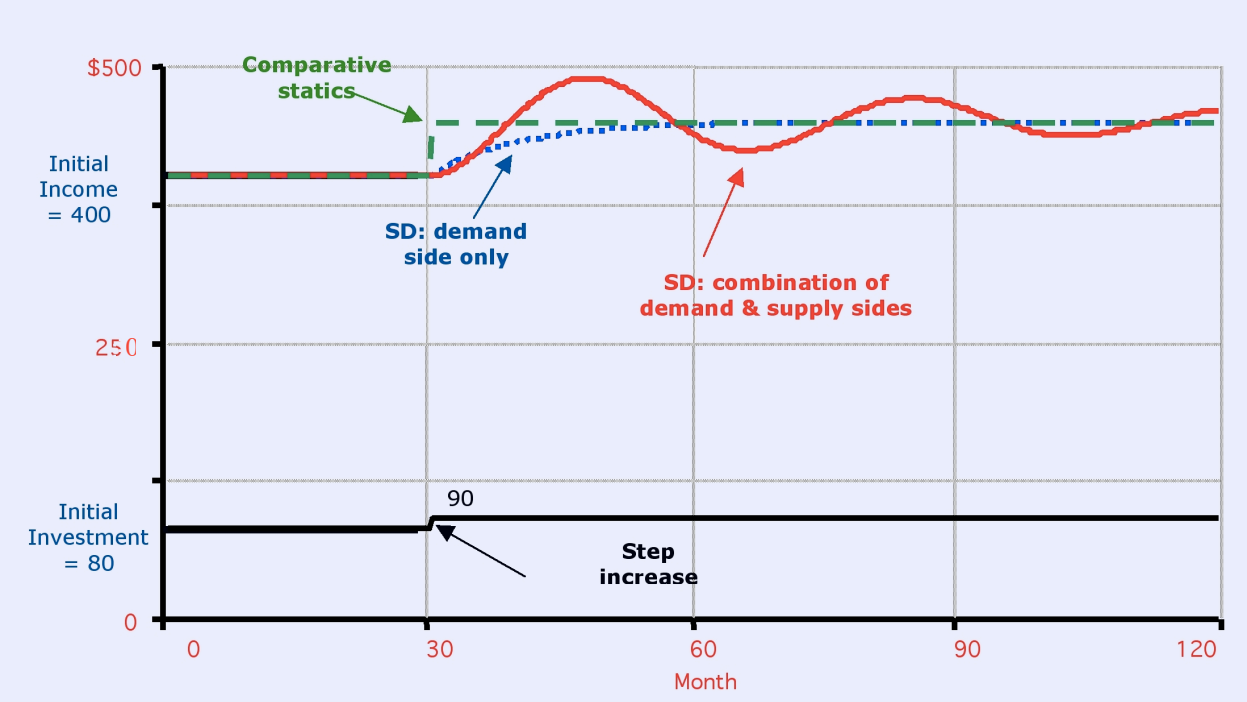

Figure 13. System Dynamics Solutions vs. Comparative Statics Solution

The dashed line represents the implicit comparative statics solution. Granted, most economists and textbook authors acknowledge the issue of time, and they would not deliberately suggest that the new equilibrium would be achieved immediately. Few, however, discuss the practical significance of such delays, particularly those that strengthen counteracting feedback loops.

Two system dynamics solutions to the same problem are also shown in Figure 13. The first reflects only a "demand-side" perspective on the economy (i.e., the top half of the basic model in Figure 3.) The dotted curve displays the effect of gradual adaptation of spending patterns due to changes in income set in motion by the exogenous investment shock. The second SD solution makes use of both the demand and supply sectors of the model. In addition to gradual spending adaptations on the demand side, there are also supply-side adjustments to changes in inventory stocks and desired labor stocks, and the solid curve displays the oscillatory behavior resulting from the interaction of those counteracting feedback effects.

All three solutions are the same in the long run. However, the short-run business cycle character of the second SD explanation is much more in line with actual experience. As a result, it is more likely to renovate students' mental models in an accurate, sustainable way. At least, that is the hypothesis. Future research will test this hypothesis in formal experiments with students receiving alternative methods of macroeconomics instruction, including the system dynamics approach that is embodied in MacroLab.

Complete Framwork vs. "Biased" Framework. A concern over the efficacy of macroeconomics instruction is not limited to strictly cognitive issues. One manifestation of learning about economics is the attitude that one develops regarding appropriate government economic policy and, in general, the role of government in the economy, a persistent conflict with the economics community.[18] Since Keynes legitimized the policy of "demand management," that conflict has sometimes been framed as "supply-siders" vs. "demand-siders." Does "supply create its own demand" (Keynes' coinage of Say's Law), or is it the other way around?

On the issue of government's role, Say's position is clear:

> *The encouragement of mere consumption is no benefit to commerce; for the difficulty lies in supplying the means, not in stimulating the desire of consumption; and we have seen that production alone, furnishes those means. Thus, it is the aim of good government to stimulate production, of bad government to encourage consumption.*[19]

Such a policy perspective is in sharp contrast to Keynes' conclusion:

> *I expect to see the State…taking an ever greater responsibility for…investment, since it seems likely that the fluctuations [in private investment] will be too great to be offset by any practical changes in the interest rate."*[20]

This issue raises a number of questions that might be answered, at least in part, by formal experiments. In a recent pilot experiment, two small groups of graduate students at the University of Bergen received "biased" macroeconomics lectures. The lecture for one group focused on the demand side of the MacroLab model. The subjects studied a model that showed economic behavior to be a function of decisions by spending agents in the economy, including an example of successful demand management by an activist fiscal policy stance by government. The implicit message was that demand creates its own supply, although that phrase was never actually mentioned.[21]

The other group received instruction from a supply-side perspective, and the demand side was taken as "a given." There were no spending agents making demand decisions. The sales rate was equated to the production rate. It was as if supply created its own demand,

---

[18] The spread and adoption of an academic-based conventional wisdom would seem to be heavily influenced by the paradigm of the profession and the means by which the mental models of both instructors and students are shaped by that paradigm. Much of that influential shaping, of course, is done by textbooks. Paul Samuelson is quoted as saying, "I don't care who writes a nation's laws…if I can write its economics textbooks." (Skousen, 1997)

[19] Say, chapter 15.

[20] Keynes, p. 164.

[21] The top half of the basic model was expanded in stages to include consumption, saving, investment, and government taxation and spending. The supply sector was always visible, but there was no reference to that side of the model. It served merely as a conduit for sales to be transformed into income via the production process. One simulation run demonstrated how a sudden decline in consumption spending would be followed by declines in sales, production, and income. Finally, government was added to the model and the effects of changing taxes and spending were observed. In particular, due to a policy equation in the government sector, an increase in government spending was triggered by the stagnating income, with the result that aggregate spending bottomed out more quickly and a higher equilibrium value was attained. Potential implications of deficit spending (e.g., impact on inflation or interest rates, crowding out of private investment, future tax requirements) were not discussed.

although that phrase was never mentioned.[22]

Before and after both lectures, the subjects provided answers to questions designed to tap their attitudes towards fiscal policy as a stabilization tool, and their preference for government spending or business tax cuts as a fiscal stimulus during a recession.

The hypothesis:

> *Subjects receiving "demand-side" instruction would exhibit more of a Keynesian perspective relative to government's role in the economy.*

Operationally, in terms of the pre- and post-test questions, subjects in the "demand-side" group would be more likely to (1) prefer "higher government spending" over "investment tax incentives" as an anti-recessionary policy, and (2) exhibit a more favorable attitude towards the use of fiscal policy as a stabilization tool. The results, while not statistically significant, were consistent with the hypothesis.[23]

The pilot experiment was informal, highly exploratory, and used crude measurement techniques. Efforts are underway to improve the experimental design and repeat similar experiments with a variety of subjects. The primary hypothesis is that instruction presented in a "scientific" manner will cause students to believe it when they see it, even when it is only half the story. The next step is to test how such a transformed belief manifests itself. Do card-carrying members of the supply-side group "see" the same data with a different conceptual lens, and reach different conclusions about the state of the economy, compared to their demand-side siblings? Do the two groups differ in the kinds of information they search for when seeking to assess the state of the economy? Do the two groups evaluate a policy debate with a bias that reflects their renovated mental models?

Most importantly, what benefits—in addition to a more accurate understanding of economic systems—accrue to a *third* group of students who receive a balanced economic education that seamlessly combines the demand side and the supply side?

7. Conclusion

MacroLab applies system dynamics and model-facilitated learning principles to the problem of macroeconomics instruction methods. It is a series of interactive learning units currently used as the organizing instructional tool in a distance learning course, and holds promise as a supplementary tool in traditional undergraduate classroom settings.

Its effectiveness will be evaluated relative to comparative statics methods via formal experiments. In addition, its capacity to provide a seamless presentation of both the supply- and demand-sides of the economy will be tested.

Workshop participants will gain economic understanding by test-driving MacroLab, and will gain ILE understanding by examining the content delivery process and the design process.

---

[22] The supply-side of the model was expanded with detailed assumptions about labor supplies, average workweek, and productivity. The concept of capital was presented as an embodiment of the productivity factor. Labor force, workweek, and productivity were permitted to vary according to historical rates, and the subjects compared the simulated results between 1900 and 2000 with the actual GDP and employment trends over that period.

[23] Details of the experiment are available on request.

References

Alessi, S. (2000). Designing educational support in system-dynamics-based interactive learning environments. *Simulation & Gaming, 31*(2), 178-196.

Boucher, A. (1995). "Systems Modelling in Economics: Use of Object-Oriented Software." *Computers in Higher Education Economics Review*, 9:2 (virtual edition) http://www.economics.ltsn.ac.uk/cheer/ch9_2/ch9_2p03.htm).

Becker, W. and M. Watts (1998). *Teaching Economics to Undergraduates: An Alternative to Chalk and Talk*. Northampton, MA: Edward Elgar.

Bruner, J.S. (1963). *The Process of Education*, New York, NY: Vintage Books.

Cohn, E., S. Cohn, D. Balch, and J. Bradley (2001). "Do Graphs Promote Learning in Principles of Economics?" *Journal of Economic Education* (Fall), 299-310.

Forrester, J. (1961). *Industrial Dynamics.* Waltham, MA: Pegasus Communications.

Forrester, J. (1968). *Principles of Systems.* Waltham, MA: Pegasus Communications.

Forrester, J., N. Maas, and C. Ryan (1980). "The System Dynamics National Model: Understanding Socio-Economic Behavior and Policy Alternatives." *Technology Forecasting and Social Change* 9: 51-68.

Forrester, J. (1994). Policies, decisions, and information sources for modeling. In Morecroft, J. and J.D. Sterman (Ed.) *Modeling for Learning Organizations*, Ed., Portland, OR: Productivity Press.

Forrester, N. (1973). *The Life Cycle of Economic Development*. Cambridge: Wright Allen Press, Inc.

Forrester, N. (1982). *A Dynamic Synthesis of Basic Macroeconomic Theory: Implications for Stabilization Policy Analysis*. Unpublished PhD dissertation, Massachusetts Institute of Technology. Cambridge, MA.

Godley, W. (1983). *Macroeconomics*. New York: Oxford University Press.

Kennedy, P. (2000). Macroeconomic Essentials: Understanding Economics in the News. Cambridge: The MIT Press.

Maas, N. (1975). *Economic Cycles: An Analysis of Underlying Causes.* Cambridge, MA: Wright-Allen Press, Inc.

Maas, N. (1980). "Stock and Flow Variables and the Dynamics of Supply and Demand" in Randers (1980).

Milrad M., J.M. Spector, and P.I. Davidsen (2003). Model facilitated learning. In S. Naidu (Ed.), *Learning & Teaching with Technology. London: Kogan Page Limited.*

Moxnes, E. (2000). "Not only the tragedy of the commons: misperceptions of feedback and policies for sustainable development." *System Dynamics Review 16:4*

Radzicki, M. (1988). "Institutional Dynamics: An Extension of the Institutionalist Approach to Socio-economic Analysis." *Journal of Economic Issues, 22:3, 633-665.*

Radzicki, M. (1993). "A System Dynamics Approach to Macroeconomics." Unpublished paper delivered at the Univeristy of Bergen. March, 1993.

Richmond, B. (2000). *An Introduction to Systems Thinking*. Hanover, NH: High Performance Systems.

Skousen, M. (1997 *The Making of Modern Economics: The Lives and Ideas of the Great Thinkers*. New York: M.E. Sharpe.

Spector, J. M., & Davidsen, P. I. (2000). Designing technology enhanced learning environments. In B. Abbey (Ed.), *Instructional and cognitive impacts of web-based education*. Hershey, PA: Idea Group.

Sterman, J. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World.* Boston, MA: McGraw-Hill Companies.

Stigler, G. (1963). "Elementary economic education." *American Economic Review*. 53:2. 653–59.

Walstad, W. B., and S. Allgood. (1999). "What do college seniors know about economics?" *American Economic Review.* 89:2. 350–354.

Wood, W.C. and J.M. Doyle (2002). "Economic Literacy Among Corporate Employees." *Journal of Economic Education* (Summer), 195-205.

Back to the Top