What Are Economic Models?

How economists try to simulate reality

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THE MODERN ECONOMY is a complex machine. Its job is to allocate limited resources and distribute output among a large number of agents—mainly individuals, firms, and governments—allowing for the possibility that each agent's action can directly (or indirectly) affect other agents' actions.

Adam Smith labeled the machine the "invisible hand." In *The Wealth of Nations*, published in 1776, Smith, widely considered the father of economics, emphasized the economy's self-regulating nature—that agents independently seeking their own gain may produce the best overall result for society as well. Today's economists build models—road maps of reality, if you will—to enhance our understanding of the invisible hand.

As economies allocate goods and services, they emit measurable signals that suggest there is order driving the complexity. For example, the annual output of advanced economies oscillates around an upward trend. There also seems to be a negative relationship between inflation and the rate of unemployment in the short term. At the other extreme, equity prices seem to be stubbornly unpredictable.

Economists call such empirical regularities "stylized facts." Given the complexity of the economy, each stylized fact is a pleasant surprise that invites a formal explanation. Learning more about the process that generates these stylized facts should help economists and policymakers understand the inner workings of the economy. They may then be able to use this knowledge to nudge the economy toward a more desired outcome (for example, avoiding a global financial crisis).

Interpreting reality

An economic model is a simplified description of reality, designed to yield hypotheses about economic behavior that can be tested. An important feature of an economic model is that it is necessarily subjective in design because there are no objective measures of economic outcomes. Different economists will make different judgments about what is needed to explain their interpretations of reality.

There are two broad classes of economic models—theoretical and empirical. Theoretical models seek to derive verifiable implications about economic behavior under the assumption that agents maximize specific objectives subject to constraints that are well defined in the model (for example, an agent's budget). They provide qualitative answers to specific questions—such as the implications of asymmetric information (when one side to a transaction knows more than the other) or how best to handle market failures.

In contrast, empirical models aim to verify the qualitative predictions of theoretical models and convert these predictions to precise, numerical outcomes. For example, a theoretical model of an agent's consumption behavior would generally suggest a positive relationship between expenditure and income. The empirical adaptation of the theoretical model would attempt to assign a numerical value to the average amount expenditure increases when income increases.

Economic models generally consist of a set of mathematical equations that describe a theory of economic behavior. The aim of model builders is to include enough equations to provide useful clues about how rational agents behave or how an economy works (see box). The structure of the equations reflects the model builder's attempt to simplify reality—for example, by assuming an infinite number of competitors and market participants with perfect foresight. Economic models can be quite simple in practice: the demand for apples, for example, is inversely

A useful model

The standard model of supply and demand taught in introductory economics is a good example of a useful economic model. Its basic purpose is to explain and analyze prices and quantities traded in a competitive market. The model's equations determine the level of supply and demand as a function of price and other variables (for example, income). The market-clearing price is determined by the requirement that supply equal demand at that price. Demand is usually set to decline and supply to increase with price, yielding a system that moves toward the market-clearing price—that is, equilibrium—without intervention. The supply-demand model can explain changes, for example, in the global equilibrium price of gold. Did the gold price change because demand changed or because of a one-time increase in supply, such as an exceptional sale of central bank gold stockpiles?

related to price if all other influences remain constant. The less expensive the apples, the more are demanded. Or models can be rather complex: some models that seek to predict the real level of output of an economy use thousands of complex formulations that go by such names as "nonlinear, interconnected differential equations."

Economic models can also be classified in terms of the regularities they are designed to explain or the questions they seek to answer. For example, some models explain the economy's ups and downs around an evolving long-run path, focusing on the demand for goods and services without being too exact about the sources of growth in the long run. Other models are designed to focus on structural issues, such as the impact of trade reforms on long-term production levels, ignoring short-term oscillations. Economists also build models to study "what-if" scenarios, such as the impact on the overall economy of introducing a value-added tax.

How economists build empirical models

Despite their diversity, empirical economic models have features in common. Each will allow for inputs, or exogenous variables, which do not need to be explained by the model. These include policy variables, such as government spending and tax rates, or nonpolicy variables, like the weather. Then there are the outputs, called dependent variables (for example, the inflation rate), which the model will seek to explain when some or all of the exogenous variables come into play.

Every empirical model will also have coefficients that determine how a dependent variable changes when an input changes (for example, the responsiveness of household consumption to a $100 decrease in income tax). Such coefficients are usually estimated (assigned numbers) based on historical data. Last, empirical model builders add a catchall variable to each behavioral equation to account for idiosyncrasies of economic behavior at the individual level. (In the example above, agents will not respond identically to a $100 tax rebate.)

There are, however, fundamental differences among economists regarding how an empirical model's equations should be derived. Some economists insist that the equations must assume maximizing behavior (for example, an agent chooses its future consumption to maximize its level of satisfaction subject to its budget), efficient markets, and forward-looking behavior. Agents' expectations and how they react to policy changes play a vital role in the resulting equations. Consequently, users of the model should be able to track the effect of specific policy changes without having to worry about whether the change itself alters agents' behavior.

Other economists favor a more nuanced approach. Their preferred equations reflect, in part, what their own experience has taught them about observed data. Economists that build models this way are, in essence, questioning the realism of the behavioral constructs in the more formally derived models. Incorporating experience, however, often means it's impossible to untangle the effect of specific shocks or predict the impact of a policy change because the underlying equations do not explicitly account for changes in agent behavior. The gain, these same economists would argue, is that they do a better job of prediction (especially for the near term).

What makes a good economic model?

Irrespective of the approach, the scientific method (lots of sciences, such as physics and meteorology, create models) requires that every model yield precise and verifiable implications about the economic phenomena it is trying to explain. Formal evaluation involves testing the model's key implications and assessing its ability to reproduce stylized facts. Economists use many tools to test their models, including case studies, lab-based experimental studies, and statistics.

Still, the randomness of economic data often gets in the way, so economists must be precise when saying that a model "successfully explains" something. From a forecasting perspective that means errors are unpredictable and irrelevant (zero) on average. When two or more models satisfy this condition, economists generally use the volatility of the forecast errors to break the tie—smaller volatility is generally preferred.

An objective signal that an empirical model needs to be revised is if it produces systematic forecasting errors. Systematic errors imply that one or more equations of the model are incorrect. Understanding why such errors arise is an important part of the regular assessment economists make of models.

Why models fail

All economic models, no matter how complicated, are subjective approximations of reality designed to explain observed phenomena. It follows that the model's predictions must be tempered by the randomness of the underlying data it seeks to explain and by the validity of the theories used to derive its equations.

A good example is the ongoing debate over existing models' failure to predict or untangle the reasons for the recent global financial crisis. Insufficient attention to the links between overall demand, wealth, and—in particular—excessive financial risk taking has been blamed. In the next few years there will be considerable research into uncovering and understanding the lessons from the crisis. This research will add new behavioral equations to current economic models. It will also entail modifying existing equations (for example, those that deal with household saving behavior) to link them to the new equations modeling the financial sector. The true test of the enhanced model will be its ability to consistently flag levels of financial risk that require a preemptive policy response.

No economic model can be a perfect description of reality. But the very process of constructing, testing, and revising models forces economists and policymakers to tighten their views about how an economy works. This in turn promotes scientific debate over what drives economic behavior and what should (or should not) be done to deal with market failures. Adam Smith would probably approve. ■

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