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On the econometrics of world business cycles*

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1. Introduction

Over the past 10 or 15 years, interest in business cycles has recovered to a level not matched perhaps since the 1930s. In his editorial statement in the first issue of *Econometrica* in 1933, Ragnar Frisch not only introduced a new word, *econometrics*, which he defined as quantitative economic theory, but also listed business cycle theory among four fields of particular interest to econometricians. This inclusion reflected the views not only of Frisch, but also of Hayek (1931), Tinbergen (1935), and others. This interest waned, however, in the 1950s and 1960s. A major factor leading to its reawakening was the paper by Robert Lucas (1977) on 'Understanding business cycles'. Perhaps this course of events was not surprising. A prerequisite for making much progress in this field was dynamic general equilibrium theory. By the 1970s, the basic theory had been developed, and neoclassical growth theory evolved as the dominant framework for business cycle analysis.

Most of the business cycle research has been conducted within closed-economy frameworks. Only recently has the focus started to shift toward international model environments. In the next section, I describe briefly the econometrics of the general equilibrium approach to business cycles.[1] The following section includes two applications to international questions.

2. The econometric approach

Central to the econometric approach are the computational experiments.

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[1]A more extensive discussion of the econometric approach is in Kydland and Prescott (1991b).

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Leading up to these experiments are three steps. The first is a clear statement of the question to be addressed. For example, some of the recent business cycle literature asks how much of the variation in postwar U.S. aggregate economic activity would have remained if technology shocks, also called Solow (1957) residuals, were the only source of fluctuation. In business cycle theory, questions about the source of impulse are of course standard. This phrasing of the question leaves open the possibility that the contributions from different sources may interact.

The next step is to choose a model economy with a bearing on the question at hand. Other considerations in the model selection are tractability and computability. If existing tools overly constrain the freedom to analyze a suitable model economy, then, of course, the development of new methodology is needed. The main point is that model-economy selection depends on the question being asked and not on the answer.

The model economy must be calibrated. Unlike the system-of-equations approach to macroeconomics, under which the parameters are the coefficients of behavioral equations and are estimated using the data series whose behavior the researcher is studying, the approach here is to determine parameter values on the basis of non-business-cycle measurements. The parameters are those of preferences, technology, information structure, and institutional arrangements. For example, with constant-elasticity-of-substitution (CES) functional forms for preferences and technology, there are share parameters and elasticity parameters. The former generally follow from average relations between aggregates that change little from one cycle to another. These relations may follow from national income and product accounts data or from panel data. Values of elasticity parameters sometimes are implied by dramatic experiments provided by history, such as a change in relative quantities (or the absence thereof) associated with a large change in relative prices. In some cases, however, the necessary experiment or information is not yet available to the researcher. Before a new parameter is introduced, however, it ought to be evident that, in principle at least, it can be measured.

The parameters should not be chosen so as to produce the best fit of the model to the business cycle data. The goal is to provide the clearest possible answer to the question. In some cases, deviations of the theory from the data even provide independent verification of the answer. [See, for example, Kydland and Prescott (1991a, p. 79).] Moreover, given the simplicity of abstractions, some discrepancies or anomalies will remain. Attempting to fit the model to the data is not helpful in making the anomalies stand out as clearly as possible, providing motivation for further research.

If all parameters could be accurately calibrated, then in principle only one computational experiment would be needed. In practice, however, the researcher will not have access to that much information. Consequently, some additional experiments, with different parameter values in a reasonable range, may be useful. These experiments may tell us either of two things. One possibility is that the answer is not sensitive to different values of a given parameter, in which case its measurement is not urgent. Alternatively, if the answer is indeed sensitive to values of an imprecisely measured parameter, then efforts directed towards its measurement could have considerable payoff.

The description of the findings could include a summary of the outcomes of the experiments along with a quantitative assessment of the precision with which the question has been answered. For example, in answer to the question about the role of technology shocks for the cycle, Kydland and Prescott (1991a) estimate that Solow residuals have accounted for about 70 percent of U.S. business cycle fluctuations since the Korean War. The numerical answer to the research question, of course, is dependent on the model. The degree of confidence in the answer depends on the degree of confidence placed in the economic theory being used and in the underlying measurements.

3. Applications to international business cycles

In using the neoclassical growth paradigm for addressing international business cycle questions, several problems arise. Here, I shall concentrate on two. First, with technology shocks as a major impulse, one must allow for the possibility that Solow residuals in different countries interact somehow. There are at least two basic ways in which that can happen. One is that technology innovations are correlated across countries. Another is that an innovation in either country over time spills over to other countries. This suggests the estimation of interrelated technology-shock processes.

A related issue is that the data needed for computing Solow residuals in different countries may not be consistent. Most countries have collected quarterly data for substantially shorter periods than has the United States. Moreover, the quality of either the output or the input data may be questionable. Most countries do not report quarterly capital-stock data. The experience from the United States, however, suggests that omitting the capital input makes little difference for the measurement of Solow residuals. There may be two reasons: first, the capital stock fluctuates relatively little; and second, its cyclical behavior is essentially uncorrelated with that of output. The case of the labor input could be more serious, however. Many countries have not collected comprehensive hours-per-worker data. In the United States, roughly one-third of the total hours variation takes this form. For now, however, we make do with employment data.

The second problem relates to the need for relaxing the assumption of homogeneous goods. Examples of relevant classifications of goods are traded versus nontraded goods and consumption versus investment goods. A difficulty is that, with most potentially useful classifications, large quantities of the same class of goods simultaneously are being shipped in both directions between any pair of countries or groups of countries.

3.1. The role of international borrowing

A natural question to ask is whether a significant bias exists when the role of technology shocks is estimated from closed-economy models. A missing feature, then, is the possibility of shifting resources to the country with relatively high technology. At the same time, risk-sharing in the form of borrowing or lending through international trade theoretically may make the consumption paths quite similar. Indeed, one can construct simple multi-country economies in which the consumption paths are perfectly correlated while the output paths are not. This result would not hold with leisure entering preferences in a nonseparable way, and other model features as well could modify the result. A question is, then, whether allowing for world trade affects the quantitative estimate of the role of technology shocks. Presumably, this question could be asked while maintaining a framework of only one traded good, so that one would not need to take a stand on the second problem mentioned at the beginning of this section. This is what Backus, Kehoe and Kydland (1991a) set out to do.

Experiments with a calibrated two-country economy based on estimated technology-shock processes with spillover effects demonstrated anomalies of such magnitude relative to the data that the original question could not reasonably be asked in this simple extension of the closed-economy framework. The theoretical flow of resources across borders simply responded too much to productivity differences, while too much risk-sharing was taking place. In the data for the United States and almost any other major country, the cross-country correlation between consumptions in the two countries is usually about the same or lower than the correlation between the two countries' outputs. In the model, the consumption correlation was much too large. Consequently, we shifted our focus to asking what salient features of international data would be consistent with a simple real business cycle theory and how robust the anomalies are to parameter variation within reasonable ranges. It turns out, for example, that the consumption anomaly remains if a transport cost or tariff is introduced that slows down international trade. In fact, with the estimated spillover effects, it remains even with absolutely no trade.

3.2. Why is there a J-curve?

Some devaluation studies have shown that the trade balance initially moves against the devaluing country, but then, after a few quarters, improves

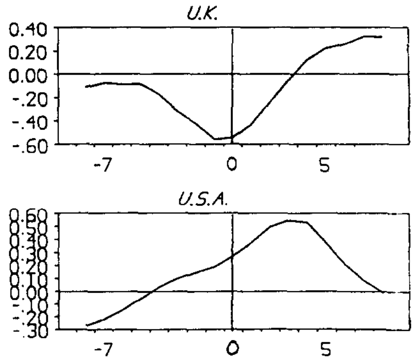

Fig. 1. Correlations of terms of trade with net exports at lag j, $j=-8.8$.

steadily. This pattern over time resembles a tilted J, and hence its name. Attempts at an explanation tend to focus on various sources of inertia, such as import quantities being slow to respond to price changes, perhaps because of delivery lags or costs of changing suppliers. More generally, if we plot the correlation coefficient between contemporaneous terms of trade and leads and lags of the trade balance, the picture for most major countries also looks like a tilted J. The example of the U.K. in fig. 1 is typical. The question asked in Backus, Kehoe and Kydland (1991b) is whether this pattern can be reconciled with a general equilibrium framework in which technology shocks are a major source of fluctuations.

To have a theoretical concept of terms of trade, one obviously needs at least two traded goods. This means that one is faced with the second problem mentioned at the beginning of this section. In embarking on this project, we did not feel we had the information required to use trade classifications such as consumption versus investment goods. [See, however, Stockman and Tesar (1991)]. Instead, we adopted a modeling approach with a long tradition in computable models in international trade. We made use of the Armington (1969) assumption. Following him, home-produced goods simply are assumed to be different from foreign-produced goods. Domestic goods need at least some imported goods to be useful. Thus, omitting time subscripts, one can write:

$$c_1+x_1=G(a_1,b_1),$$

and

$$c_2+x_2=G(b_2,a_2),$$

where c_i and x_i are consumption and investment in country i, $i=1,2$; and a_i

and b_i are the quantities of the home- and foreign-produced goods, respectively, used in country i. These quantities are constrained by

$$a_1+a_2=F(k_1,n_1),$$

and

$$b_1+b_2=F(k_2,n_2),$$

where k_i and n_i are the capital and labor inputs in country i. Using a CES function for the aggregator function, G, the share parameters follow from average import or export shares, leaving the elasticity of substitution to be determined. Whalley (1985) cites dozens of studies at various levels of aggregation that have produced estimates of this elasticity. Generally, they are larger than one, with a central tendency toward 1.5.

Using this value as a benchmark, a calibrated two-country economy indeed produces the J-curve pattern. The intuition is that when the home country experiences a favorable technology shock, output of home-produced goods rises relative to foreign-produced goods, resulting in an increase in the terms of trade. At the same time, with positive serial correlation in technology changes, this shock signals high future productivity of capital, which is exploited initially by a net increase in imports. In other words, the increase in the sum of what the home country wishes to consume and invest exceeds the output increase – the trade balance becomes negative. Over time, investment slows down, and the productivity differential narrows, resulting in the trade balance eventually becoming positive. As in the data for most countries, the United States being an exception (see fig. 1), the benchmark economy's contemporaneous correlation between terms of trade and net exports is negative.

Some have suggested that the elasticity of substitution between home- and foreign-produced goods varies across countries. For example, supposedly it is larger for the United States than for most European countries. With a larger elasticity, say three or four instead of 1.5, the model still produces a J-curve pattern, but the contemporaneous correlation then is positive.

Again, the description of the findings would be incomplete without a presentation of the discrepancies or anomalies relative to the data. In this case, while the J-curve arises naturally through interaction between the technology-shock processes and the natural dynamics of capital formation, the volatility of the terms of trade is substantially greater in the data than in the model. Zimmermann (1991) finds that this general pattern persists in three-country models with differences across countries in size and/or proximity. Part of this deviation from theory may be a measurement problem associated with the export and import price indices used. A recent study by Alterman (1989) shows that for the 1980s, a decade for which data are available to construct better indices, these alternative indices display substantially less volatility. Yet, even with such an improvement in measurements, the model volatility of the terms of trade probably still would be substantially larger than that in the data.

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