

Tacit Theories of Economics  
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This paper presents results from work in progress on tacit theories of macroeconomics. The research can be viewed in the context of work on mental models. Virtually all of that research deals with domains where the laws of physics can be applied, where there is a single correct answer with which subjects' data can be compared, and where the underlying representation can be thought of in terms of knowledge. In the domain of macroeconomics -- as in most domains with which people have to deal in their lives, like voting, child-rearing, personal health, predicting and understanding the behavior of other people -- there is no unitary body of truth, people have beliefs and opinions as well as degrees of knowledge, and well-informed people may differ. These are heterodox rule-relevant domains: there is agreement that they are rule-governed, but disagreement about what the rules are.

The overall, long-term goals for this research project are to develop systematic, objective ways to look at mental models or tacit theories; to increase understanding of both the structure and the explanatory utility of such systems of knowledge and belief; and to contribute to addressing the crisis in which the discipline of economics finds itself, in large part as a result of unrealistic implicit psychological assumptions.

The research is still underway. In this paper, I focus on the tacit theory of one subject, as a way to illustrate both the methodology and the nature of the claims I hope to make. Data from other subjects will be considered primarily as a way of putting the single subject in context.

Several major claims are made in this paper: a small set of economic concepts -- called the "economic core" of a subject's conceptual network -- can be seen as driving an individual's understanding of how the economy works; these cores have coherent internal structures and, in effect, constitute tacit theories of macroeconomics; across people, these cores correspond well with both folk theories and crude versions of "real" theories of economics; these cores can be viewed as the machinery for computing expectations, and thus may drive not only economic inferences but perhaps some important economic behaviors as well.

The present research has four primary areas of concern:

1. Does the tacit theory of an individual remain relatively stable over the short- to medium-term? If so, one can argue that the tacit theories may reflect stable patterns of individual differences.
2. What is the internal consistency of an individual's tacit theory? I have not yet fully developed the mathematics for looking at internal consistency. Preliminary results are encouraging, and indicate high degrees of internal consistency. This topic will not be addressed further in the present paper.
3. What is the content of tacit theories? Do they make any sense from the vantage point of economics, or do people have idiosyncratic theories?
4. Are there stable patterns of individual differences in tacit theories? If the answer is no, tacit theories become of limited use as explanatory and predictive constructs, although they may still be quite interesting as objects of psychological investigation.

There are also a number of second-order questions that could be of interest. For example, consistency across time and internal consistency could be viewed as dependent variables, and one could try to explain them based on demographic factors, political beliefs, initial theory, and the like. Similarly, if there are stable patterns of individual differences in tacit theories, one could look for variables that predict the theory an individual holds.

#### METHOD

Subjects for this study were 24 residents of New Haven, Connecticut, randomly selected from the telephone book. Although no claim can be made that this sample provides for valid statistical generalizations to the population at large, the sample was quite demographically diverse. Each subject was interviewed twice: first in person for about an hour and a half; after four to eight weeks, by telephone, for 20 to 30 minutes. The heart of both interviews, and all that will be discussed here, was a series of questions of the following form: "If interest rates go up, what do you think would happen to inflation? Why?"

The typical answer was a "causoid" path containing two to four intervening links. For example, a response might be: "Well, if interest rates go up, it costs the business more to borrow, so they have to pass that cost on, so prices would rise and inflation would go up." Note that there are equally plausible alternatives: "If interest rates go up, people will have to pay more on their loans, so they wouldn't want to borrow as much to buy things. And to get that money, then, businesses would have to charge less, so inflation would go down." Most of the reasoning was causal in nature, but also included diagnostic inferences (e.g., "Well, if interest rates went up, that would have to be because the deficit was high, and a high deficit means a lot of government spending, driving prices up and making inflation worse."), statements of correlation, appeals to authority (e.g., "The Federal Reserve makes those interest rates go higher to stop inflation, so I guess it would make it go down."), and occasional confusions about where the reasoning was going or had come from. Each interview was tape-recorded, transcribed, and coded.

For each subject, for each interview, a signed, directed graph was constructed, consisting of, essentially, all of the subject's answers connected together. A typical graph contains 35 nodes, of which 15 were provided by the experimenter in questions, and about sixty links. Many concepts and links were mentioned more than once.

These graphs were transformed into matrices by setting a parameter of link strength (in the data reported below this was .7) and by assuming that link strengths were multiplicative along chains. The links between concepts were extremely simple: if a change in A made B change in the same way, it was coded as a direct link from A to B, and if a change in A made B change in the opposite direction, it was coded as an inverse link from A to B. Each entry in these matrices thus represented the directed causal coefficient from the row concept to the column concept. For example, there would be three entries in the matrix for the following fragment of protocol: "If interest rates go up, people would have to pay more on their loans, so they wouldn't borrow as much." The matrix entries would be: INTEREST-RATES to COST-OF-BORROWING, +7; COST-OF-BORROWING to CONSUMER-BORROWING, -7; and INTEREST-RATES to CONSUMER-BORROWING, -49. When there was more than one entry for a cell, a formula was used to combine cell entries such that they were asymptotic to +1 or -1.

The statistical methodology was rather complex, and no attempt will be made to explain it in detail here. Other papers will treat that in some depth. The two primary analytical approaches to the data both involved the use of principal components factor analysis on each matrix. The first approach looked at only first principal component

for each matrix. Each first principal component is a vector of length equal to the number of concepts used by the subject of interest. And each entry in that vector is a good measure of the aggregate causal importance of that concept in the subject's matrix. Thus, concepts that appear early and often in causal chains will tend to have higher loadings, as the values are called, on the first principal component. The second technique looked at the four-dimensional structure embodied in the loadings on the first four principal components. Loadings on second and subsequent principal components reflect clusters of causal importance; for example, two concepts that are both causally important, but cause different effects, would not be distinguished on the first principal component -- both would have high loadings -- but would be distinguished on subsequent components. To oversimplify slightly, then, the values on the first principal component reflect causal importance, while the values on the first four principal components reflect causal structure.

To look at the extent to which causal importances between subjects (or for the same subject, between initial interview and follow-up) were similar, the loadings of the concepts on the first principal components were correlated. The higher the correlation, the more similar the relative values of the loadings. And to look at similarity of causal structures, the first four principal components from one interview were canonically correlated with those from another interview. Canonical correlation allows the two four-dimensional structures to rotate freely in order to maximize fit with each other. Thus, the canonical correlation is a summary measure of the extent to which the two causal structures are congruent.

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## RESULTS

Both modes of analysis are relevant to addressing the first question of interest, the consistency of a subject's tacit theory over time. The most direct and constrained way of looking at consistency over time is to correlate the concept loadings from a subject's initial interview with those from the follow-up, four to eight weeks later. For the first twelve subjects, these correlations ranged from .13 to .72. The lowest correlation indicates virtually no consistency. This subject repeatedly protested during the interview that she "knew nothing about economics," an on-line introspection that is supported by the data. The next lowest correlation is .44. Seven of the remaining ten are .60 or above.

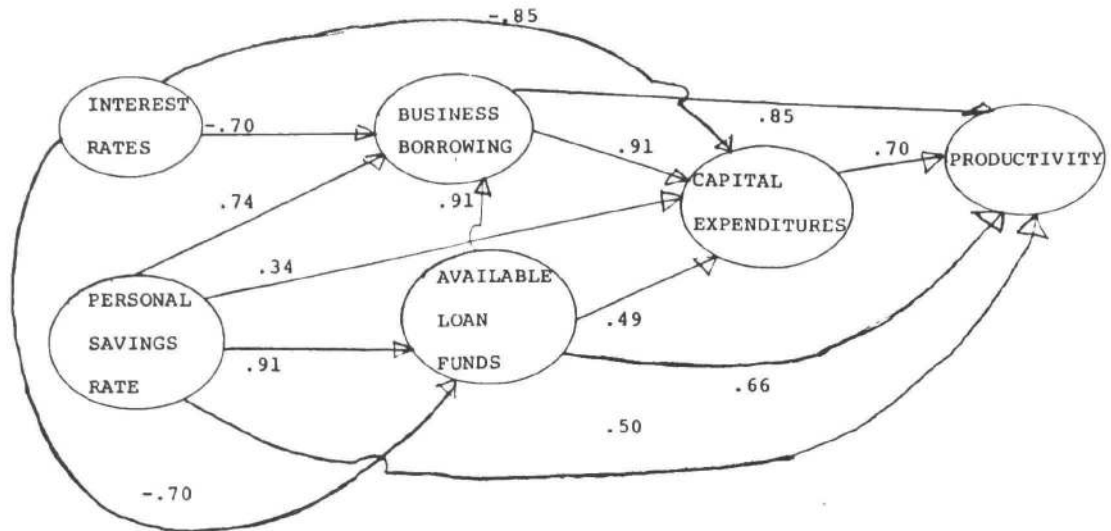
In order to put these correlations in some context -- after all, it is not immediately clear that a correlation of, say, .55 is high -- the first principal components of all 24 interviews for the first twelve subjects were correlated. Of interest here is the extent to which the correlations within-subject are higher than those between-subjects. (Note that, if there are a relatively small number of importantly different tacit theories across subjects, some between-subject correlations should be quite high.) Of the 276 correlations, only 30 were .60 or above; of these 30 correlations, seven were within-subject. Nine of the 12 within-subject correlations were in the top 15 percent of the total number of correlations. I take this to be strong evidence that tacit theories are relatively stable psychological entities.

Note that concepts which a subject mentioned in one of his interviews but not in another hurt the correlation, in that they have zero loadings when not mentioned and non-zero loadings when mentioned.

The subject who will be discussed in detail was the first subject interviewed and had a correlation between his interview and follow-up of .64. A very strict criterion of semantic agreement was used to code responses. If this criterion is relaxed slightly -- collapsing the terms "investment" and "capital expenditures," which seems amply justified from the full protocols -- the correlation for this subject goes up to .76.

go down, more money becomes available for industry to borrow, borrowing increases, capital expenditures go up, and productivity climbs. Note the absence of tax rates, disposable income, the budget deficit, and consumer spending -- the key ideas in Keynesian and neo-Keynesian economics. These do enter into the cores of other subjects.

FIGURE 1:  
SUBJECT 1 CORE, DIRECTED CAUSAL COEFFICIENTS FROM INITIAL INTERVIEW



The analyses of individual differences across subjects have not been completed. Based on preliminary analyses, however, it appears that there will be a small set of three to six of basic cores, with variations. These cores may well reflect stable patterns of individual differences in causal structures in the economic domain.

### DISCUSSION

Tacit theories, as operationalized in this research, appear to be legitimate and interesting objects of investigation. Subjects seem to possess a high degree of internal conceptual organization and coherence in the domain of macroeconomics, a domain in which they are non-expert and in which, in fact, they may well disagree with each other.

It may well be possible to view tacit theories, as characterized by the conceptual cores, as miniature "expectation machines," which could then serve as proxies for the endogenous measures of expectations in economic models based on rational expectations theory. This might introduce stronger psychological foundations into the models, and would also allow for a systematic treatment of individual differences, generally considered noise in economics. Such applications await further research, but offer a tantalizing promise of interdisciplinary collaboration.

Another way to look at the consistency from the initial interview to the follow-up is to look at the canonical correlation of the four-dimensional structure of the first four principal components from the interview with that from the follow-up. Canonical correlation is a way to look at the similarity of the underlying causal structures, while simple correlation of first principal components looks at similarity in the causal importance of the set of concepts. For this subject, the first canonical correlation, reduced for capitalization on chance, was .84. Thus, the two structures could be rotated into a very high degree of congruence.

Note that canonical correlation does impose a considerable degree of constraint. For example, the subject with the correlation of .13 on the first principal components had an adjusted first canonical correlation, using the first four principal components, of .24. This is statistically non-significant, and is converging evidence that, indeed, she did not have a consistent model over time.

To look at the content of tacit theories, I define the notion of a conceptual core of the tacit theory. The core contains those concepts with the highest loadings; thus, they are causally most important. In terms of the analytic procedures employed, the methods of core extraction imply that the cores are what the subject views as driving the economy. If the subject were making economic policy, and used his or her tacit theory to do it, the concepts in the core are those that the subject would attempt to influence to affect the critical endogenous variables of inflation and unemployment. The conceptual core can be computed on both the first principal components and on the results of the canonical correlations. Table 1 summarizes the concepts with loadings over .25 on the first principal components or the first canonical variate for the first subject. (The loading on the first canonical variate is a summary measure of the causal salience of each concept in the fit-maximizing rotation of the underlying four-dimensional causal structure.) In this table, investment and capital expenditures are collapsed. Note the extent to which the interview and follow-up show the same cores; note also the degree to which the results of the first principal component analysis and the canonical correlations agree.

TABLE 1:  
LOADINGS OF CONCEPTS IN SUBJECT 1's CORE

CONCEPT	FIRST PRINCIPAL COMPONENT		FIRST CANONICAL VARIATE	
	INTERVIEW	FOLLOW-UP	INTERVIEW	FOLLOW-UP
Available loan funds	.33	.32	.43	.30
Business borrowing	.38	.27	.39	.23
Capital expenditures	.33	.56	.27	.33
Interest rates	-.47	-.32	-.58	-.61
Personal savings rate	.26	.26	.34	.20
Productivity	.28	.36	.15	.08

In figure 1, the subject's core is presented as a directed graph; the numbers associated with each arrow are the directed causal coefficients between concepts in the subject's initial interview. (They are very similar for the follow-up, as the high correlations require.) The data in this figure are a subset of the data input to the extraction of principal components; thus, they are several statistical transformations prior to the correlations of the first principal components and to the canonical correlations. They provide another vantage point for looking at internal consistency and conceptual coherence, of a more qualitative sort. One can ask, of this core, does it make economic sense? It does; this core is very close to what orthodox supply-side theory (if this is not an oxymoron) specifies. As the personal savings rate goes up, and as interest rates

