THE RUSSIAN ECONOMY ON ITS WAY FROM PLAN TO MARKET: EXPERIENCES OF MODELLING WITH THE HELP OF APL TECHNOLOGY.

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I don't intend to review the modern Russian economy, or the activity of the Russian government. I shall speak of a more peaceful subject which is nearer to the problems of APL applications.

Why did the plans for Russian economic reform put forward by economists in Russia and the West fail? We can't say that the specialists were bad. Of course, some of them were too hasty, some had political rather then scientific purposes, but many of them honestly did their job. They used economic theory to find a way for the Soviet Union to interact with the world market, but failed. You may hear a lot of explanations why the well known, well examined theories doesn't work in Russia, but many explanations are the same as no explanation at all.

I want to stress that this is may be most annoying for us now, but it is only one example of failures of science when the analysis of complex self-evolving systems is attempted. As an example, consider the "green house" effect. We even can't decide if it really exists. As another example, think of AIDS. There are a lot of less dramatic examples in biology, geology, cosmology. Evolving systems are the greatest challenge to science in all of its history.

The basis of science is the reproducible experiment. But reproducible experiments with the economy or the biosphere are impossible. Observations of such systems are inevitably incomplete. We can see the unique history of an evolving system which does not show all that the system is potentially able to do. When investigating evolving systems we have to rely mainly upon human analytical abilities and the power of our computers.

What are we able to do? We can grasp the structure of the system, and reveal important interconnections within it, but we often make mistakes. What is a computer able to do? It is able to put forward without any mistakes a long chain of logical inference. But it requires unambiguous premises to start inferring.

To couple human images and computer logic we build models. Any model is a strict analogy between the objects of a different nature where a simpler object explains a more complex one. The simplest objects we know are mathematical structures, because we can completely take them apart down to axioms. Therefore, the most abundant models are the mathematical models.

Our knowledge is the interaction of various models, and each model is applicable in its own limits. We often forget this, and apply the most popular models automatically. From my point of view it is a widespread and dangerous fault of large computer systems, where the users and the programmers do not know what model is being used, or why it was built into the system.

The question of explicit model representation in computers is ever more important for evolving systems. Dealing with such systems we cannot confine ourselves to routine models. We ought to try and compare different approaches.

I have been working in the field of mathematical modelling of the economy, and for more than 15 years I have been using APL for this purpose. I prefer APL because APL code contains nothing except the model itself and expresses it sometimes better than common mathematical notation.

It is also very important for economic modelling that APL code is compact and observable. When I modify my models I change the structure, not the data. Economic systems are strongly interconnected systems. By changing one element of the description you should then change many others. I believe that a good economic model can not be built by collecting independent "black boxes". You must see the whole model at a time.

Now I want to illustrate the application of APL to economic modelling with one of my models of the development of Russian economic reform. This article is not the place for a detailed description of the model, but some comments are necessary. First I should say some words about its history.

I am working in the Computer Center of the Academy of Sciences (Moscow), which is a research institute of applied mathematics and computer science of a very wide profile. Our research group, which works under the leadership of academician A.A.Petrov, has substantial experience in economic modelling. We have developed and investigated some dynamic models of the market economy, which includes descriptions of financial mechanisms and the possibility of structural changes in the economy. We also built a model of the centrally planned economy. The model could explain the main economic phenomena of Soviet life of the 1970's, including the phenomenon of the "fictional economy". Here, you see the fulfilled plans and growth of effectiveness in reports, while in reality you had the lowering of the quality of goods, deficits and imbalances. The model also taught us that the economic mechanisms formed in the centrally planned economy had their own strict logic and could not be partially changed. In particular, it appeared that a primitive mixture of central planning and market economics may lead to internal economic instabilities. When radical economic reform in Russia began, it was natural for us to try to model the transition of the economy from plan to market.

The Russian economy is now in a strange position. The level of productivity corresponds to that of underdeveloped countries. It makes the production of raw materials the only competitive sector of the economy. However, unlike the underdeveloped countries, Russian agriculture can't feed the population without fuel, machinery, electricity and imported components, because the structure of employment, production and consumption in Russia corresponds that of developed countries of the 1960's. I believe this contradiction to be the most

important cause of unusual and dangerous processes we currently observe in the Russian economy. The main problem is the leakage of capital when the profit of foreign trading activity financing tends to stay in western banks.

In the 1970's, the USSR had about 8 billion dollars a year income from raw material export, and this income was very ineffectively but somehow divided among the whole population. The last year we had about 20 billion dollars in export net profit which was removed from the country and deposited in the West.

A rather simple model I speak of has been built to check this hypothesis. The model is designed to describe tendencies and not to give a quantitative prediction. First of all no one in modern Russia produces reliable statistical data. Moreover, I strongly believe that dealing with a complex system you could evaluate data only having elaborated a consistent concept of phenomena. Otherwise, you could not be able to decide what is worth observing and would be forced to follow a more routine procedure.

The model presented here is not a final result of my work. It is only the working version that does not satisfy me in many points. I choose it to illustrate the APL technology of modelling, because its structure is rather typical. The model is a system of nonlinear differential equations, which is transferred into the discrete dynamic system by the Euler scheme. The step of this system corresponds to the Main Loop in the code from label cC to the end. It includes except for shifts of dynamic variables (N1,N2,N3,D,W, etc.) the solution of a market equilibrium problem as well as some optimization problem. They are isolated in the SMAX procedure. The procedure BEGIN0 initializes dynamic variables as well as constant parameters.

The two lines in the Main Loop separated by lamp symbols give the example of usage of our package GRAND (GRaphical ANalyzer of Dynamics). It is written in APL and was developed to support numerical experiments with dynamic models. The first line contains the list of model variables of interest. The second calls the main function of the package. This function collects the values of enlisted variables into a time series. It also outputs them in spread-sheet fashion and provides breaks at given steps.

The code is written so that you may assign a vector value to each one of the most important parameters of the model. The program then gives you a number of trajectories corresponding to different values of the parameter. For example, you can see in the pictures the results of runs for two values of taxation. The package GRAND automatically collects vector variables into the appropriate matrix time series. The dimensional independence of APL programs is of course a well known feature of the language. I stress this feature as valuable for modelling. The results of the experiment are presented in the picture. The plots were drown, marked and inscribed during the interruption of experiment with the help of our package GRAND. It uses APL expression for task

definition and provides various facilities of plot manipulating and decorating. The pictures were saved as usual PCX-files that made it possible to transmit the picture from Moscow to your magazine by E-mail.

The upper pictures shows the change in price indices for different groups of products (raw materials (1), machinery (2), consumer goods(3)) as well as the change of GNP (4), the level of consumption (5) and the flow of capital running out of the country (6). The lower pictures shows the dynamic of the same values under less taxation. This dynamic results from three interconnected processes described in the model: reallocation of financial assets among government, enterprises and population, reduction of centralized foreign trade and reduction of military production. Internal prices are assumed to be free and at equilibrium.

You can see the results, which are unusual for traditional economic theory:

Reduction of GNP under intensive inflation, and the dramatic reduction of consumption under growing net export and the absence of investments (which is more surprising). I must say that to bring the reform to a successful conclusion is difficult with the model. For example, the lower pair of plots shows that the slight reduction of taxes may lead to hyperinflation.

Russian reform sustains serious troubles and we often can not properly understand their causes. But the above example shows the ability of mathematical models to explain unusual economic processes, and APL may serve as a convenient tool in these investigations.