Model of spatial microeconomic samples for assessing of distributed industrial networks performance

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Abstract. The article is dedicated to the consideration of the basic principles of cybernetics and to definition of a discrete model of microeconomic equivalents of samples of longitudinal (panel) data. The efficiency of the work of elements of industrial production (which have the properties of emergence in relation to each other) is substantiated. The author's panel model of metric data for the economic subsystems of the enterprise is presented.

1. Rationale
The problem of data representation in cybernetics is well known for a long time. With all the variety of types of presentation of data that are the object of storage, transmission, processing, there are certain restrictions on use. Constant adaptation, or rather, conversion of data for specific analysis and processing tools is nothing more than an inhibitor of cybernetic processes.
Often, economics is predetermined by the planarity and scalarity of the computed values. Standard econometric values, that is, variables, predetermine only the quantitative side, without giving a deep qualitative characteristic. Assessment of the work of automated production cannot be determined only by simple economic benefits, by determining the value of the costs of certain units [1].

The transactional nature of production is not inherent everywhere; often, many elements of production lines do not work in direct relationship with each other. Some components even perform a service role. Such are the distribution of automated control systems using industrial network standards. For example, CAN (Controller Area Network) is a widespread specification of an industrial network, created primarily for combining various actuators and sensors into a single network [2].

2. Determining the role and significance of spatial samples in production econometrics

The concept of CAN is simple: computers, their sensors and all energy-intensive components are turned on.

The twisted-pair wire or fiber-optic single-mode or multi-mode interface used by this interface-oriented system to communicate within a computer system is called a bus. Bus is essentially nothing more than a telemetry communication network. The bus interface allows all electronic information to be received at any time within the network of components, since it is sent by each computer or controller and received by all computers connected to the network.

Figure 1 demonstrates the integration of the bus approach to interaction using the example of a production control system for an automobile unit that participates in the economic activity of a certain enterprise [3].

![Figure 1. Visual demonstration of the bus interface.](image)

The cybernetic feature of such standards eliminates the relational redundancy inherent in stochastic events that arise within the framework of ordinary (traditional) interactions that are of a microeconomic nature. It studies the behaviour of individual agents in the course of their production and distribution and exchange activities. The distribution activity of the actuators is simplified with the CAN distribution approach:

![Figure 2. A cybernetic distribution model that minimizes the number of connections.](image)
In more modern approaches to the design of datalogical and infological principles of interaction, the connections indicated in the "WithoutCAN" scheme shown in figure 2 can be dynamically determined. It determines the greater durability of enterprise management subsystems. Such systems are called distributed or dynamic. They include Zigbee, IIoT [4].

And already here, it becomes almost impossible to consider the economic subsystems of an enterprise as a sample of values that are reduced to economic analysis [5].

First of all, each of the elements of CAN, or a distributed network, can have its potential equivalent, differentiated primarily by its location in the overall structure of the network. Often, during enterprises designing, assemblies and units of assembly lines are unified. But it does not mean that unified equipment has a dominant role. It is clear that the actuator responsible for opening of the doors for the loader has a similar mechanics as the mechanism for opening/ closing of the conveyor line. However, untimely opening of the warehouse door (delayed for a few seconds) at the stage of product shipment does not have such destructive economic damage and impact on the processes of the enterprise econometrics as the actual stop of the conveyor. Moreover, in case of a stop for longer than the maximum permissible time, the conveyor line will not be able to put itself "in order" due to the fact that it is overfilled products. And this situation requires the human intervention. It is also important to understand the spatial component of the connected sensors because it also plays a role.

For example, detection sensors, which are widely used in any industry, have technical limitations, expressed in a certain angle of coverage. And most often they are represented by groups of devices that have a general systemic nature.

In the theory of systems there is a concept that expresses the appearance of a dynamic system of properties that are not inherent in its elements separately (i.e. system properties are not reduced to the sum of the properties of its components).

This principle is also inherent in mechatronic systems that are introduced into economic realities in developed countries.

But how can the econometric analysis of such heterogeneous sources of information and generators of conscious activity be bound together? How to trace the connection between the movements of a robotic device (manipulator) with microeconomics?

It is quite difficult, because only a part of the parameters that have a rather distant calculation value is known (the price of finished products, the cost of operation, at best a marker of the depreciation of a mechanical or electronic device per unit of time) [6].

Indeed, in this case, it makes sense to use a method of organizing of all calculated, measured values in the form of longitudinal multivariate data obtained by a series of the same direct measurements or reports, observations over several periods of time for the same components. Panel data are great for networked organizations of distribution systems. Spatial analysis is implemented in the form of any formal methods of studying objects using their topological, geometric and parametric properties.

And the possibility of use of topological data determines the importance of use of econometric tools for complex economic systems. For example, it is very well expressed in the information industry. These objects include data centers, laboratory networks, server units. It would seem difficult to track the dynamic trajectory of contractual relations between different data centers within the same cluster. Although it is obvious that global telecommunication systems are organized on the same principle as CAN systems or the modern industrial Internet of things. And, therefore, they are emergent to each other [7].

Then spatial statistics have great econometric importance, determined by the benefits of multivariate analysis presented by multivariate samples. The classical tools of economics simply will not allow to identify the optimization components and to adjust the interaction. But longitudinal data demonstrate the possibilities of analysis, similar to the basic dogmas of the mathematical apparatus of graph theory.

The fact is that the principle of uncertainty is often used to refer to networks as objects of econometric analysis. Earlier, when the globalization processes in society, industry, and the service sector have not been so defined, this was permissible. But now, when there is a clear connection of a logistic nature,
which determines the functional parameters of the work of any object of entrepreneurial activity, it becomes obvious that the logistic study must be continued. And instead of explicit geographical routes for the supply of raw materials, materials, energy carriers, there is also internal logistics (the logic of the functioning of devices and mechanisms that have weight in econometrics) [8].

It is necessary to unequivocally iterate the spatial rather than quantitative model of relationships.

At the first stage, it is necessary to determine the cobweb-like standards (models) for each final product and input raw materials, which will be needed to apply spatial competitions between the establishment of values for the implementation rate of a certain stage of production based on demand fluctuations (for example, identified by filling the conveyor or production line) and supply. Production and processing speed values for goods with a short shelf life (for example, raw materials with a high oxidation state) after going out of balance are not necessarily returning to it. It is dictated by the real paradigm of the production culture, with the inherent percentage of defects and other components.

3. Methodology for determination of cybernetic emergence in the industrial Internet of things

The nature of competition in technical systems is predetermined by the principles of functioning of distributed networks or networks with a bus interface. It is equivalent to the pure competition model in business cycle theory. [9].

Let's rephrase the model for technological microeconomics. With this interaction, individual recipients (processors) and executive mechanisms responsible for delivering of raw materials for processing cannot influence priority, cost and time value alone and take it for granted, without trying to occupy all the bandwidth. At the same time, the collective behavior of all economic agents leads to the fact that the changing price balances market demand and market supply. The inability to influence the price alone is due to the fact that the volume of supply or demand of each agent is small in comparison with the general market.

![Figure 3. The graph of the perfect model in general.](image)

Obviously, now it is necessary to give an idea of the approximate structure of the spatial sample, which, we note, makes sense only in that production mode, if all observations are obtained in approximately unchanged conditions, that is, they are a set of independent sample data from a certain general population. This is dictated by the principles of measurement invariance reflected in metrology.

Since most modern production facilities and impact devices (as well as devices susceptible to impact, i.e. sensors) are built on digital (discrete) logic, the appearance of the finished samples has the form of balanced panels [10,11].

The balanced panel (figure 4) is a dataset where each member of the group (i.e. a person) is observed every reporting period (line cycle). Therefore, if the balanced panel contains N observation units and T periods, the number of observations (n) in the dataset will necessarily be as per formula: n = N × T.
Parameters \( p_1, p_2 \), etc., are optional and can show logistic regression, delivery metrics, package lifetime, cargo value, raw material group or class, or other microeconomic indicators of the production process. Tact implies iteration of the step of the device, which perceives this information in the form of spatial choices. The I/O field determines the state of the port of information receiving. If output option is set, then the role is reduced to mediator role (i.e. delegating).

| Role | Tact | \( p_1 \) | \( p_2 \) | I/O |
|------|------|---------|---------|-----|
| 1    | 20   | ...     | ...     | Input |
| 1    | 21   | ...     | ...     | Output|
| 1    | 22   | ...     | ...     | Input |
| 2    | 20   | ...     | ...     | Output|
| 2    | 21   | ...     | ...     | Input |
| 2    | 22   | ...     | ...     | Output|

**Figure 4.** Panel model of balanced econometric indicators of the actuator.

An assessment of the significance of the entire economic system of interaction as a whole (showing the presence and level of severity of emergence) can be determined through the classical analysis of spatial samples [12,13]. For the mentioned data centres and highly distributed economic objects it can be determined through the method of geographically weighted regression that shows whether a remote, but interconnected production or commercial business is needed at all. Regression on the metrics \( p_1, p_2 \) will give an answer on the impact of time delays determined by the physical characteristics of telecommunications and industrial networks on the cost of the final product.

4. Findings

The cybernetic role of distributed systems, expressed through telecommunication environments of interaction in industry, is determined. The principles of reducing of technical management to a model of pure or perfect competition are proposed. The proposal for the integration of the balanced panel model into the econometric aspect of the theory of technical systems control has been implemented and justified. Metrological and emergent value of the proposed analysis tools have been emphasized.

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