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Modelling of complex systems of production by the analysis of activities

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6. The techno-system of carnelian beads

Modelling of complex systems of production by the analysis of activities

Pierre Matarasso and Valentine Roux

- 1 **Abstract.** To interpret the general organization of Harappan stone production, a quantitative model has been designed based on Cambay data. Its purpose is to ascertain an indication of the Harappan annual bead production and the number of workers involved, based on the number of beads found at different sites. The ultimate goal is to investigate the techno-economic organization of stone-bead makers in the Indus Valley (see Chapter 7).
- 2 The quantitative model used corresponds to what is called an activity analysis. Activity analysis is an effective and simple technique used to describe production systems in many fields of economic science (from energy and agricultural economics to operational research). The basic idea of activity analysis is to deconstruct a complex production system into its constituent elements, called activities. An activity is an elementary production process described by its input and output (consumption and production) for a conventional unit of process. This production process might itself be an aggregate of technical operations (the level of aggregation is dictated by the detail of the analysis). Activities are connected to each other through their respective inputs and outputs. The rule governing the combination of activities into a coherent system is that the goods (in fact any kind of input) consumed in each activity have to be logically produced by other activities. A typical activity analysis consists in determining the relative proportion of the different processes, measured for example in men at work, that compose a coherent complex production system.
- 3 As a result, the activity analysis model enables us to infer, from the final products and for a given system, the different goods circulating in the technical production system: raw materials, waste, tools, workforce, the relative level of the different processes, and so on. Different activities may compete for a given input (for example labour) or for the production of a given good (in the case of the production of the same good by different technical processes). Therefore, activity analysis enables us to highlight constraints and

alternatives within a formal framework designed to provide quantifiable results. In other words, activity analysis has the potential to measure or quantify systems of production and to envision alternative forms of organization.

- 4 Building a model of stone-bead production involves two steps:
 1. quantifying elementary technical activities,
 2. defining networks or integrated technical sequences.
- 5 Quantifying elementary technical activities is done in terms of consumption (raw material, energy, duration of work, etc.) and production (number of objects made per day, etc.). Such measures presuppose the existence of a living traditional techno-economic system in which technical practices are analogous to those employed in the past. Obviously only some, and not all, of the modern activities can serve as a referent for the ancient ones. In the case of Harappan stone-bead production, the chain of fabrication techniques has been identified on the basis of “diagnostic” criteria (see Chapters 2, 3 and 4). This diagnostic fabrication chain contains the following technical operations: heating, knapping, grinding, drilling, polishing, and shining. The complete sequence of these elementary operations is directly observable at contemporary workshops in Cambay. In the case of Cambay, which acts as a test case for the description of the bead-production system through activity analysis, some modern activities are very remote from the ancient ones (for example polishing with the help of an electric motor), but others like knapping seem to have changed little since ancient times and can be therefore used as a referent.
- 6 The description of the bead-production system can be accomplished by creating a record of activities and goods (or items). Once again, activities are the technical operations or processes themselves. Goods are those things that are produced and consumed by operations and processes. They bring into relationship the related activities. Among the main goods, it is essential first to distinguish the beads in their different stages of fabrication, then the labour in its different forms, each corresponding to a different level of qualification, and finally the energetic goods (electricity and vegetable combustible) and equipment (tools, instruments) conceived, in that case, as consumable goods.
- 7 Each elementary operation or activity must become an object of quantification in terms of production and consumption, and thus a conventional unit of measure must be defined for each. These units are simple to define when there is a “natural” restricting element (e.g., a man acting as an isolated craftsman, a furnace, a polishing drum). In such cases, the most natural unit of measure is yearly output by a single individual, or by a furnace or polishing drum. For less homogeneous operations, as in heat/colour treatment (to turn a carnelian bead red), which takes place in furnaces unevenly filled with beads of various dimensions, the consumption and production of beads is measurable against a standard of 10,000 beads.
- 8 Most goods are measured by a “natural” unit: raw nodules and fuel are measured by the ton; electricity in kW/h; beads by their different stages of manufacture in units of 1,000; and labour in terms of workers/day.
- 9 Many of the quantitative data related to technical operations may have cross-cultural value since they are related to determining factors such as the properties of the material resources, environment and human skills. (For example, with the possibilities presented by the raw material itself, given stone cores of certain dimensions and utilizing a particular method and manufacturing technique, how many beads can one produce?)

- 10 Definition of networks or technical sequences as a subsystem of a techno system. Networks correspond to the articulation of technical operations aimed at the production of a single type of object. Technical sequences or associated activities in one network may be relatively independent of other activities associated in another technical sequence or network, although there may be competition for the consumption of primary resources. Technical sequences or networks may be viewed as relatively independent conceptual lines of production. It should be noted that this isolation of technical sequences may be valid in the context of craft production but not in agro-systems, where all the production processes are deeply interrelated (think of the interaction of cattle breeding and cereal production through cross-consumption of animal power and manure). In Cambay, technical sequences (linking extraction, knapping, abrading, drilling, polishing for the production of a bead type) are specific to each bead type, which, nevertheless, compete for the labour of specialists, the use of furnaces, the consumption of energy or the use of polishing instruments. These networks are nonetheless relatively autonomous. They are not linked to each other by circulation of goods, and therefore may be regarded as well-defined subsystems of the global system.
- 11 As for elementary technical activities, technical sequences act as references for interpreting the past in the sense that nothing, at this stage, is particular to Cambay.
- 12 Once technical elementary operations and technical sequences have been quantified and defined, the techno-system may be reconstructed. A techno-system corresponds to a complex combination of technical activities or to an association of networks. It can be described on the basis of the technical sequences and contextual data that give structure to the production. Extant techno-systems cannot act as a referential model for interpreting the past since techno-systems, by definition, correspond to particular cases. Only elementary activities and technical sequences can do this. It is in this manner that we can assess the technical part that does not vary between the past and the present. Past techno-systems are reconstructed with reference to quantified extant elementary operations. Archaeological variables structure the possible alternatives for the organization of the techno-system.