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Towards an Econometrically Informed Archaeology: The Cologne Tableau (KöTa)

Abstract: Economic archaeology is currently oriented toward either ecological approaches or aspects of handicraft and exchange. The Cologne Tableau is designed to represent total economies as well as different economic sectors for comparative purposes in order to stress the macroeconomic interdependency of production, exchange, and consumption. The tableau displays every imaginable good or service, and it is based on an open monohierarchichal system that assigns positions in the table. As for the actual production, the surpluses, and the demand for goods may be given in the cells of the Tableau. For econometric analyses all the goods must be valued using the same measure of value necessary for covering the demand, regardless of whether it is an amount of money, an expenditure in kilojoules or the hours of work. The latter are used here. A case study of Early Neolithic Linear Pottery economy shows that the female labour force was most likely the key resource of the analysed economic system.

The Cologne Tableau: A Tool for Measurement and Communication

Economic archaeology is an accepted and substantial branch of today's archaeological research (Clark 1989). In recent decades the field split into several distinct subdisciplines. One approach is strongly influenced by ecology and focuses on food production (e.g. Schibler et al. 1997); it is closely connected to archaeobotany, physical anthropology and archaeozoology. A different perspective is restricted to the abiotic production: The archaeology of mining and archaeometallurgy are some of the related fields of particular interest here (e.g. Dobiat / Sievers / Stöllner 2002). Besides production, exchange receives ever-increasing attention – as the accessibility of analytical tools included in GIS applications has become widespread (e.g. Zimmermann 1995). Consumption is seldom seen as part of economies. Our project, "Econometrics of the Central-European Neolithic" (financed by the German Research Council DFG), stresses the macroeconomic interdependency of production, exchange, and consumption.

The Cologne Tableau is a simple table depicting every imaginable good or service except rights. It has the potential to name everything a human being ever used. It is designed to address archaeological issues of past economies enabling the use of simple econometrical approaches borrowed from economics. Every good can be allocated to a sector. We differentiate initial production, crafts, and services as well as an exchange and a reproduction sector. The first three sectors are mainly in accordance with the familiar model of three sectors in macroeconomics, while the latter two are added to solve archaeological and anthropological problems. Gathering, hunting, agricultural production, and mining are allocated to the sector of initial production. Crafts, such as food preservation and some construction work, the production of tar, of ropes, the furrier's and the carpenter's work add up to the second sector. The third sector of "services" contains arts, medical care and midwifery, and educational and religious expenditures. Here one finds, for example, offerings and the building of ritual monuments. The exchange sector includes the infrastructural services of road-building, as well as bribery and warfare. Most likely underestimated is the reproductive sector. Cooking, maintenance of the household, child care and care for the elderly, personal hygiene, sports, and the sweetness of doing nothing are only a few examples connected to the wide range of household activities. The Cologne Tableau orders goods systematically in a table, and it allows us to merge less complex goods to goods of higher complexity by simple addition. The sectors are differentiated down the columns. In the rows the complexity increases from the right to the left. Every cell contains the information of the cells to its right – thus the cells form a monohierarchical classification. An example: Let clearing and threshing be necessary steps in crop production of a given agricultural system. Crop and livestock are part of the agricultural sector, while agriculture is part of the more complex production sector. Each

good, each sector, actually every cell of the table bears an ID number. The ID gives the relation of the cell to the neighbouring cells to the right and left: 1.4.1.5 ("harrowing") is part of 1.4.1 ("tillage"); 1.4.1 is part of 1.4 ("farming"); and 1.4 is part of 1 ("initial production").

There are different ways of using the Tableau: One can display actual numbers, for example the demand for or the output of a certain good. For intercultural comparisons the demand for goods can be given in the cells of the Tableau. Comparisons may be made between archaeological stages or between economic systems. It is possible to show a stage of a development or to give the difference between two economic systems in terms of a ratio. This means every good becomes assessable and every arbitrary mix of goods – a "market basket" – becomes interculturally assessable. For quantitative analyses all goods must be valued using a common unit of measure, whether it be money, expenditure in kilojoules, or hours of work. The latter is used in the project.

Labour Time

The collection of actual labour time data is an important part of the project. The ever-growing catalogue presently contains more than thirteen hundred citations from ethnology, ethno-archaeology, experimental archaeology, from historical sources and from pre-modern legal benchmarking. Obviously, it takes more time to harvest a field using a flint sickle than using a steel scythe, especially if we consider the need for re-sharpening and the total life span of the artefact. Invariably a certain standardization of the actual working times of analogies is necessary. We standardize the entries of our data base on work per unit of time; we rank these values and we choose the nearest analogy to our archaeological case. It is of course a matter of complex archaeological modelling to ascribe technological abilities to historical stages. What we are doing resembles Marx' (1969, 21) determination of the "socially necessary labour time". In neo-classical economics one may interpret this as a certain kind of cost: the total time within an economy, calculated to be expended. Actually we do not deal with goods, we compute expenditures. We do not count apples but instead ask for the average annualised per capita expenditure of working time in pomiculture.

Those values are sometimes astonishing: The reconstruction of a typical longhouse from the Middle Neolithic of Western Germany (length 22 m) could be built – in its ecological setting and with the tools of the Neolithic – in 2900 hours (Luley 1990). A coat from the North European Iron Age required more than 6000 hours of work (Schlabow 1965, 54; cf. Pfarr 2001). One immediately understands why the assiduous maiden of our fairy tales or the decorous Athenian housewife are characteristically engaged in doing textile handiwork – textile production was simply one of the most time consuming necessities in pre-industrial times.

Budgeting Time

Sometimes time itself is a scarce resource – as every farmer has always known. Daylight hours vary according to the month. Working time may be bound or may be free, and there may be preferred times for special tasks. There are narrow time slots for harvesting and best practices for butchering or for cutting leaf. The preferable time for collecting leaf fodder lies somewhere in the harvesting period, thus decisions about how to mobilise the available labour force becomes indispensable. In order to estimate the best harvesting date one has to take into account ripeness of the fruit and weather conditions. From the eighteenth century onwards labour time data were published for legal and benchmarking purposes (e.g. von Benekendorf 1775; Kuratorium 2005). Those numbers can be evaluated with further experimental and ethnographical data to obtain averages of necessary labour time.

Archaeological modelling of economic systems demands adequate information about the ecological setting as well as the technologies used. Some of the reconstructed activities are seasonally performed, while others are not. An adequate level of displaying an activity seems to be its proportional share of the total annual hours of daylight. Though some work requires a computable amount of labour every day (e.g. watering cattle), it is not reasonable to be meticulous. A monthly, weekly or even daily allocation of all the work done is certainly below any justifiable resolution but such a higher resolution may serve as a test of whether it is possible to do the reconstructed work in a given time span.

Archaeobotanist Ursula Maier's work at Younger Neolithic Hornstaad-Hörnle IA, a wet-preserved "pile-dwelling" village fom the shore of Lake Constance may be considered as an example (Maier / Vogt 2001). The economy was based both on glume

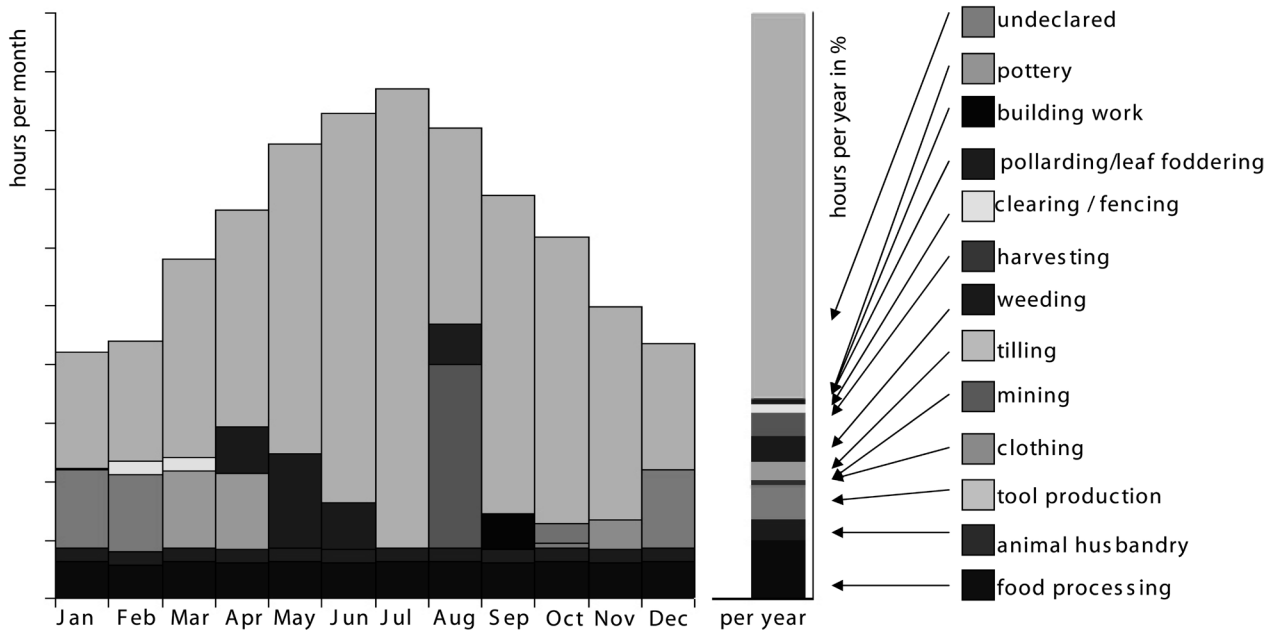

Fig. 1. Model of time need per year of Early Neolithic Linear Pottery economy. The plausible allocation to the months verifies that the necessary amount of labour could be provided during the annual round.

and free-threshing cereals. There is no indication of animal draught for ploughing. Maier determines a key variable, the cereals' proportion in caloric intake, but there is no botanical argument for estimating that proportion. She needs additional external assumptions. According to the archaeobotanical evidence one can try to do plausible time allocation; a model based on an amount of 1816 kcal. from cereals per person and day would not work. If for example a population of 100 human beings tilled 25.5 ha of arable land during March and April more than 5500 hours of work would be missing. Thus there simply would not be enough time for tilling in spring or autumn. Consequently we think it is more plausible to lower the caloric intake from cereals to 890 or 1000 kcal. This lowering is also in accordance to historical and ethnographical time requirements (e.g. Blanchard 1994), but those tables are still very rare.

Based on a case study (see below) I calculated the annual amount of work for the Early Neolithic Linear Pottery Culture *(Fig. 1)*. There is no evidence of the use of animal traction for ploughing, at least not to any significant extent (Bogaard 2004, 30; cf. Lüning 2000). The cultivated cereals are almost exclusively the glume weeds *einkorn* and *emmer*, supplemented by bromegrass and legumes. The allocation of work per month shows the model to be principally consistent, regardless of whether winter or summer cereals were concerned, and regardless of whether pottery, flintwork or tar was produced in spring or autumn. The high proportion of hours spent on domestic work deserves closer scrutiny. Daily food processing includes collecting firewood from the average distance of estimated forest edges and carrying water from the average distance to the next well or source; it includes several hours per household and day de-husking as well as grinding, and includes preparation of porridge or bread. It is daily food processing – not tilling, harvesting, or wood clearing – that is the most time consuming activity that can be identified. It possesses by far the highest proportion of all activities per household and year.

Case Study: Labour Force during the Early Neolithic in Western Germany

Early Neolithic settlement of the developed Linear Pottery culture (5300–4900 BC) is widespread on loess soils all over temperate Europe. In the Rhineland loess plains near Cologne are very well examined due to extensive lignite mining in the area. For more than 30 years working groups in Cologne and Frankfurt have excavated and analysed Neolithic landscapes in the Rhineland. The work was inspired, organised and directed by Jens Lüning (Univ.

of Frankfurt) and now continues under the direction of Andreas Zimmermann (Univ. of Cologne). The system of complex dependencies between the settlements is the focus of interest and centrality is measured with different indices. It is possible to define several clusters of central villages, hamlets and farmsteads, even with small activity areas outside the settlements (for references: Zimmermann 2003; Zimmermann et al. 2005; Kunow / Wegner 2006).

We have already identified cereal processing as one relevant factor – and perhaps the most relevant one – in daily work organisation. Glume processing was most likely done in wooden mortars, now lost. What is left are grinding stones, indicating food processing activities in the households. In the following discussion, I propose to examine the significance of these stone tools in relation to flint tools and to blades of adzes. While those adze blades are to a certain proportion highly valued exotic items, the raw material of grinding stones is of regional origin (Kegler-Graiewski 2004, 426–431). The counts or weights of grinding stones therefore do not represent the supply of stones rather they mirror the different grinding, food-processing, and domestic activities. The quantity of grinding stones per phase – counts as well as weights – corresponds well to the number of households from the Rhineland. The three curves are correlated, with Pearson's r well over 0.8. The case study focuses on one cluster of settlements in the valley of the Merzbach[1]. The inhabitants of central village Langweiler 8 founded the smaller hamlets and farmsteads in its vicinity. The valley's settlement rises from the first generation (4 households) to a peak during phase 12 (13 households) after that an decrease in the number of houses sets in, with nearly a total abandonment in the last generation, phase 15. We computed the weight of grinding stones per household and phase for Langweiler 8 as well as for the dependent hamlets and farmsteads. There is a highly significant negative correlation (Pearson's r = –0,91) between the two curves up to phase 12. This overwhelming negative correlation ends when the decrease in settlement sets in: From phase 12 to 14 there is no correlation of any significance at all (Pearson's r = –0,36). Why do the inhabitants of the central village grind more than the others? Also, why does this picture invert every generation? This pattern can be observed over a time span of 8 phases of (nearly 200 years). Since the development is cyclical, and since we have reason to believe that new hamlets and farms are founded as offshoots of the central village, we may venture a simple – maybe simplistic – demographic hypothesis. If there is only a slight overpopulation in the central village a new hamlet or farm is founded. However if overpopulation occurs in these small settlements the additional labour force would be given back – at least to some extent – to the central village. Many scenarios would fit such a situation, e.g. if there is a preferred direction of marriage and relocation from the farmsteads to central villages. In any case there is no independent grinding activity. A strong connection between the village and the hamlets and farms is undeniable.

For further analysis of the settlements' relationships – in terms of stone artefacts – a principal component analysis (PCA) of settlements and artefacts was carried out. The settlements of the Merzbach valley and the neighbouring Schlangengraben valley were chosen because of the reliable information about their rank in the flint exchange network according to Zimmermann's (1995) research. In 8 settlements a total of 2775 flint tools, 133 adzes and 588 grinding stones were analysed. Although only the counts are is given here, the picture is quite similar if using the artefacts weights instead of counts. We chose a method (Jongman / ter Braak / van Tongeren 1995, 116–132; 158–160) which focuses on distances between the settlement's inventories, where the artefacts' scores are divided by the standard deviation. The inventories' space of the displayed graphical interpretation is standardized by norm and the artefact-space is centred. The first axis of such a centred PCA accounts for nearly the total variance. As only three classes of artefacts were used, the result displays the grinding stones on the horizontal and the adzes on the vertical axis.

The PCA's solution allows us to reproduce and display several well known features of the settlement system while at the same time leading to new insights *(Fig. 2)*. The settlements are marked as central villages, hamlets or farmsteads. One can identify two clusters – one with the two central villages and the other contains the remainder. Prima facie there is no visible difference, between a hamlet or

[1] The sites are: Langweiler 2, Langweiler 8, Langweiler 16, Laurenzberg 7, Niedermerz 4, in PCA also Weisweiler 6, Weisweiler 17, Weisweiler 110 (for references Kunow / Wegner 2006).

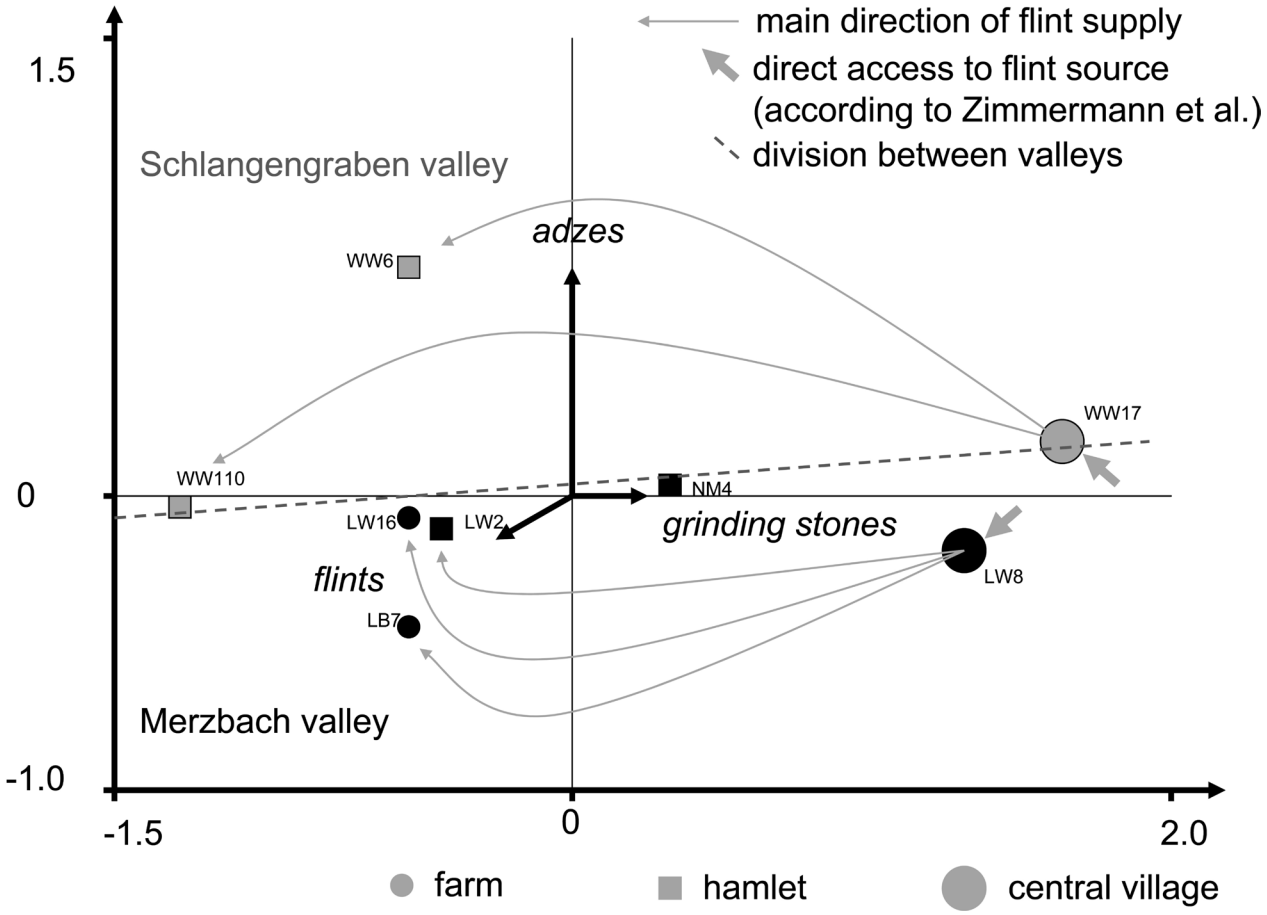

Fig. 2. Principal component analysis of settlements (Langweiler 2, Langweiler 8, Langweiler 16, Laurenzberg 7, Niedermerz 4, Weisweiler 6, Weisweiler 17, Weisweiler 110) and lithics from the valleys of the Merzbach and the Schlangengraben, Aldenhovener Platte, Germany.

a farm. The spatial locations of the settlements play an important role. The graphical solution displays the Schlangengraben valley and the Merzbach valley sites clearly separated from each other. The settlements are situated according to their rank in their particular settlement system. The large central villages are situated on the right, the hamlets in the middle and the single farmsteads to the left. The Merzbach valley sites show this ranking quite clearly, while in the Schlangengraben material there is no farmstead present in the data. The two central villages and one of the hamlets plot closely to the grinding stones. The grinding stones best characterise the inventory of the central villages. All the other sites are better explained through flints and adzes. It is remarkable that the adzes especially differentiate the valleys. The two valleys appear to be supplied with adze blades in a different way or mode.

Considering the Zimmermann (1995) model of flint exchange one may expect the central villages to be close to the flint vector as the inhabitants of the central villages had direct access to the flint sources and they were in the position to control the supply of raw material. Nevertheless the analysis shows that it is grinding, that predominantly determines the position of the central villages.

Female Labour Force as the Key to Early Neolithic Economies?

The grinding stones indicate household activities. They are more important in the households of the central villages. In all likelihood the greater significance of grinding stones has to do with a denser population per household, regardless of whether we take the number of querns as representing the intensity of grinding or indicating the head count of persons involved in food preparation or for the size of the consuming group. In every case the number of persons per household is higher in the settlements

of higher centrality. This suggests, from an economical perspective, that the work force is bound more strongly to the villages, then to hamlets or farmsteads. Since in ethnographic observations domestic grinding is nearly exclusively done by women, one can assume that this is also the case in the Linear Pottery Culture.

Once it is observed that the settlements have to be understood in terms of their valleys' internal ranks, one notices that as a rule the different valleys show higher proportions of grinding stones in the central villages, while adzes are relatively frequent in the households of minor settlements. We may take the relative frequency of adzes as a proxy for male activities and male display – since by far the majority of those adze blades occur in male graves (cf. Nowak 2008 in this volume). The adzes to a certain extent show characteristics that are inversely related to the grinding stones.

There has been until now no convincing evidence for the use of animal draught in Linear Pottery Culture. The only available force for tilling and for the transport of heavier items was provided by the human body and by human labour. One strategy for strengthening the household's economic force would have been to bring additional labour force into the household. Genetic and isotope analytical work as well as demographic studies point to patrilocal residence of Linear Pottery Culture households (cf. Schiesberg 2008 in this volume). If obeying patrilocal residential rules, one must either bring in females or maintain the female labor force in the household. The latter may be done, e.g. simply by setting the bride's age one or two years up or by assigning a wife the duty of helping her mother or her mother-in-law during harvest. Polygyny would be another strategy to accumulate female labour force, but there is so far no indication of such a practice.

The minor settlements, hamlets and farmsteads, are highly connected to their parental central villages. The grinding activities show this dependency quite clearly, even though we do not know exactly what the dependency means. The central villages control the labour force of the valleys or at least the domestic labour force of the households, since they control the supply with adze blades and flints. Approximately one fifth of the annual daylight working time was consumed by food processing. Agriculture, crafts, and the building of the houses and ritual places were far less important, at least in terms of their relevance as measured in labour time. Grinding is so important that it allows us to reproduce the observed settlements' centrality. The key resource in Linear Pottery Culture was, in all probability, the female labour force.

Towards an Econometrically Informed Archaeology

The Cologne Tableau (Kölner Tableau) is a tool designed to examine archaeological issues of past economies by using simple econometrical approaches borrowed from economics. Determining the relative importance of the particular economic sectors remains a central problem. Such an integrative approach allows us to bring together the different branches of economic archaeology as explored before. Future research should focus on comparing the long term development of different sectors by the effort devoted to them, measured in labour time. It is in this way that prehistoric archaeology can contribute its share to economic history.

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