STANDARDIZATION, LABOR INVESTMENT, SKILL, AND THE ORGANIZATION OF CERAMIC PRODUCTION IN LATE PREHISPANIC HIGHLAND PERU

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Specialization encompasses many ways to organize craft production, ranging from small, household-based work units to large workshops. Distinctive types of specialization develop in response to various social, economic, and environmental factors, including the demand for crafts, the social relations of producers, and the support base for artisans. These factors in turn influence manufacturing technology. Thus, different types of specialization can be characterized by a "technological profile," which reflects relative labor investment, skill, and standardization. An analysis of Prehispanic ceramic technology in the central sierra of Peru demonstrates how these technological profiles can be used to identify the ways ceramic production was organized to provision consumers with utilitarian and luxury pottery. As we demonstrate in our analysis of pottery recovered in the Yanamarca Valley, utilitarian Wanka-style cookwares and storage jars were produced by independent household-based artisans, while imperial Inka-style jars were produced by locally recruited corvée labor working for the state.

La especialización económica incluye múltiples estrategias para organizar la producción de bienes. Estas estrategias abarcan desde pequeñas unidades domésticas, hasta talleres de producción. Diferentes y bien definidas formas de especialización se desarrollan en respuesta a factores sociales, económicos y ambientales como la demanda por los bienes producidos, las relaciones sociales establecidas entre los productores y las bases socioeconómicas de soporte de los artesanos. Estos factores, a su vez, influencian la tecnología de producción. Diferentes tipos de especialización económica pueden estar caraterizados por "perfiles tecnológicos" que reflejan la inversión relativa de trabajo, la habilidad de los productores, y la regularización de los productos. El análisis del aspecto tecnológico de una serie de alfares prehispánicos tardíos de la sierra central del Perú demuestra cómo los "perfiles tecnológicos" pueden ser usados para identificar las formas en que la producción de cerámica estuvo organizada para proveer cerámica utilitaria y suntuaria a los consumidores. El caso que se analiza en detalle es el de los Wanka de la sierra central del Perú. En esta sociedad, ollas y otras formas utilitarias, así como grandes jarras de almacenamiento, fueron producidas en el estilo local Wanka por artesanos independientes cuyo nivel de producción no sobrepasó la unidad doméstica de producción. Por otro lado, la producción de "aribalos" en el estilo Inka imperial estuvo a cargo de trabajadores tributarios reclutados localmente pero que trabajaron directamente para el estado Inka.

Analyses of technological attributes such as standardization, labor investment, and skill are often suggested as appropriate for characterizing the organization of ceramic production (e.g., Barnes 1987; Benco 1986, 1987; Costin 1991; Davis and Lewis 1985; Feinman et al. 1984, 1991; Hagstrum 1985, 1986, 1988, 1989; Rice 1981, 1989, 1991; Riley 1979–80; Sinopoli 1988). These analyses are especially useful when direct evidence of manufacture such as kilns, wasters, tools, and raw materials are lacking in the assemblage under study. Standardization, labor investment, and skill are considered to reflect specific characteristics of distinctive forms of specialization. When analyzed together, these measures provide insight into the organization of production, reflecting how industries servicing different demands were organized to meet best the needs of the consuming population. Analysis of technological data bearing on standardization, labor investment, and skill allows us to identify gen-

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eral trends in the organization of production. Such analysis is most useful in comparing different wares from a single assemblage in terms of their relative organization of production or change in a single ware over time. In this paper, we study three ceramic wares from the Upper Mantaro Valley to demonstrate how the organization of production can be investigated by technological analyses of manufacture.

The Organization of Craft Production

Specialization is not a unitary form of economic organization, but rather must be viewed as a broad concept encompassing several distinctive types of organization. Costin (1986, 1991) has identified four parameters that can be used to describe the organization of production. The first parameter is the *context* of production, which reflects the nature of the demand for a particular good. When referring to context, we distinguish between "attached" and "independent" specialization (Costin 1986; Hagstrum 1985, 1986; see also Brumfiel and Earle 1987; Earle 1981; Gero 1983; Russell 1988). Attached specialists produce politically and socially symbolic goods and wealth that circulate primarily within the political economy and serve to maintain political power and to enforce social distinctions. Distribution of these goods is controlled since artisans produce upon command for elite sponsors and patrons. In contrast, independent specialists manufacture utilitarian and domestic wares that circulate within the subsistence economy and serve in household maintenance. Because there are no implicit or explicit sanctions on the acquisition of these goods, producers and consumers are free to make distribution and procurement arrangements within a framework of established social reciprocity or market exchange (Hagstrum 1996).

The second parameter is the *concentration* of production. It describes the spatial relationship between producers and consumers. At one extreme, producers are uniformly dispersed throughout the consuming population, minimizing transportation time and costs from place of manufacture to place of use. At the opposite extreme, all producers are nucleated in a single production location, and goods and consumers (or distributors) must move some distance to transfer goods from producer to user.

The third parameter is the *constitution* of the production unit. It describes the group size and social relations of those individuals who regularly cooperate to produce a recognized corpus of goods. At one extreme is household production. Crafts are manufactured within a domestic setting by a single family member or a small group of related individuals who reside together. At the opposite extreme is the factory, or workshop in a nonindustrial setting. This is a large facility staffed by unrelated individuals who are recruited voluntarily through wage contract or involuntarily through bondage, slavery, or mandatory labor tax obligations.

The fourth and final parameter is the *intensity* of production. It describes the relative amount of time individual producers devote to craft production relative to other economic tasks. At one extreme are part-time producers, individuals whose economic strategies combine production of a specific craft with service, agricultural or wage labor, or who rotate among several different crafts, working at each part-time. At the opposite extreme are individuals who hypothetically devote all their economic energies to a single craft, or even a single task, procuring all other necessities from others in exchange for the goods they produce or the wages they earn.

These four parameters—context, concentration, constitution, and intensity—reflect the underlying causes of the organization of production. For example, knowing the context of production—attached or independent—allows us to focus on either political or economic explanations for the rise of specialization in a particular case (cf. Brumfiel and Earle 1987). The relative concentration of production—nucleated or dispersed—is in part dependent on resource distribution, and identification of this parameter value allows us to evaluate the appropriateness of applying resource access/allocation models (such as those of Arnold [1975] and Rice [1981]) to a particular case. The choice between part-time and full-time production is an economic one, although the considerations are different among attached and independent specialists (Costin 1991; D'Altroy and Earle 1985; Hagstrum 1989; Hicks 1987; Murra 1980). Although each of these parameters is described heuristically as a dichotomous variable, having two opposite values, they are in reality a continuum, with the values for the production of any one commodity falling somewhere between the two most extreme values.

Combining the four organizational parameters, Costin (1986, 1991) has proposed eight idealized types of specialization, each of which is expected to evolve under particular social, economic, political, and environmental circumstances. Briefly described, they are:

Individual specialization: autonomous individuals or households dispersed uniformly among the population and producing for unrestricted local consumption

Dispersed workshop: larger workshops dispersed among the population producing for unrestricted local consumption

Community specialization: autonomous individual or household-based production units, aggregated within a single community, producing for unrestricted regional consumption

Nucleated workshops: larger workshops aggregated within a single community, producing for unrestricted regional consumption

Dispersed corvée: part-time labor producing for elite or government institutions within a household or local community setting

Nucleated corvée: part-time labor recruited by a government institution, working in a special-purpose, elite, or administered setting or facility

Individual retainers: individual artisans, usually working full-time, producing for elite patrons or government institutions within an elite (e.g., a "palace") or administered setting

Retainer workshop: large-scale operation with full-time artisans working for an elite patron or government institution within a segregated, highly specialized setting or facility

Demand, Technology, and the Organization of Production

The different ways craft producers are organized and the different demands consumers have for crafts influence the technology of craft manufacture. The relationships among technology, the organization of production, and the nature of product demand center on the contexts of manufacture and use: who makes pottery for whom, under what conditions, and for what purposes. Manufacturing technology, analyzed here by labor and skill invested and the standardization attained in finished goods, is a sensitive indicator of the sociology and economy of craft production and consumption.

Labor Investment

Labor investment refers to manufacturing costs, measured by the time required to produce some commodity. The relative investment of labor and the degree of specialization may be interrelated insofar as specialized industries are competitive, emphasizing efficiency in production (Arnold 1987; Feinman et al. 1984; Hagstrum 1985, 1986; Torrence 1986). An example of competitive, efficient production is provided by utility wares. These are the vessels produced for general consumption whose manufacture reflects the constraints of a competitive economic situation. Such pottery is recognized by simple shapes lacking surface decoration.

Competition and efficiency, however, are not always hallmarks of specialized craft production. The social functions of pottery vessels affect the labor invested in their manufacture. Decoration, requiring more labor to execute, is positively correlated with vessel visibility because decorative elements can communicate important social information, for example, group affiliation and socioeconomic status (DeBoer and Moore 1982; Thompson 1958). Craft goods produced for elite patrons encode more social and political information (Clark and Parry 1990:293–294; Earle 1982; Pollock 1983), requiring greater energy in manufacture, than utility items produced for general consumption (Clark and Parry 1990; Costin 1991; Hagstrum 1986, 1989). Moreover, craftspeople working under elite sponsorship are freed from the economic constraints of a competitive market because the disposal of their wares is guaranteed.

The lack of competition, the importance of intelligible communication, and the practice of conspicuous consumption underlie the often high labor intensity of attached craft production, whereas efficiency in production and competition in distribution underlies the minimal labor investment of independent specialization.

Standardization

Standardization refers to homogeneity in ceramic materials, vessel shape, and/or decoration. As with labor investment, standardization reflects economic and social constraints within the production system. In general, specialists produce standardized wares because their tasks are routine and fewer potters introduce less idiosyncratic behavior into the ceramic assemblage (Hagstrum 1985:69; Rice 1981, 1989, 1991; van der Leeuw 1976). We recognize two important exceptions to this generalization. First, even in communities served by large numbers of potters, there may be limits to the amount of variability tolerated. For instance, potters have been observed to use tools and measures to reduce the variability in their output (Arnold 1991; Hagstrum 1989). Second, elite patrons may sponsor specialists to produce unique goods, where uniqueness confers value to the product (Earle 1982).

To study standardization, we must distinguish between attributes reflecting vessel function and those reflecting the organization of production. Here, we recognize two types of attributes: *intentional* and *mechanical* (cf. Sackett 1977 on passive and active style and Benco 1989 on technological and functional diversity). The artisan consciously controls intentional attributes. These include technological, morphological, and stylistic properties that broadly reflect vessel function, whether economic, social, or political. Examples of intentional attributes include materials choices (and their appropriateness for vessel function), morphology reflecting function (e.g., bowl vs. jar, large vs. small, high-neck vs. low neck), and most stylistic elements (e.g., choices about decorative motifs and colors). Intentional attributes are less likely to inform us about the organization of production because they are intended primarily to meet specific functional and/or social needs.

Mechanical attributes are those which the potter unintentionally introduces into his or her works. The variability associated with these attributes relates to the level and type of mass production technology employed, training, skill, experience, the amount of supervision or quality control, efficiency, motor habits, work habits, and idiosyncratic behavior (cf. Rice 1989). These variables include resource selection and preparation unrelated to functional requirements; texture and color variation caused by differences in clay and pigment preparation and by firing fluctuations; variability in metric aspects of designs such as line width; minor size variation within size classes; and morphological and proportional variation within specific shape classes. Because they are in a sense unconscious, these attributes more directly reflect the organization of production (see Hill 1979).

Ultimately, the distinction we make between intentional and mechanical standardization is an etic construct, an analytic distinction invoked to make sense of the archaeological record. The types of variability we record reflect a continuum, rather than a dichotomous differentiation, between fully conscious and fully unconscious practices on the part of the potter. Some attributes are chosen explicitly by the manufacturer; for example, some clays are known to be less susceptible to heat fracture and some design elements are preferred by consumers. These decisions do not reflect the organization of production, although they clearly do reflect other important economic and social dynamics within the society under study. In contrast, the less deliberate aspects of vessel variability, such as minor variation in metric attributes, do reflect the organization of production, because they are hallmarks of different production strategies.

Measures of standardization aim to gauge the relative number of hands or work units responsible for producing a particular assemblage, on the assumption that the amount of variability in these mechanical attributes correlates directly with the number of independent potters or work groups (Costin 1991). The amount of variability or standardization vis-à-vis the organization of production is a relative measure: more or less standardized industries are said to be more or less specialized only in comparison with some other assemblage. Yet simply comparing two assemblages is inadequate unless other considerations are made. The first consideration is the total amount of pottery consumed: obviously, a higher demand will require more hands, all other variables held constant. Second is labor intensity:

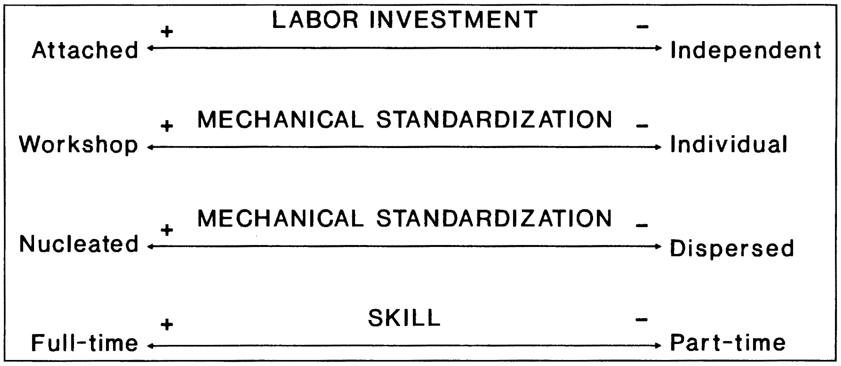

Figure 1. Chart illustrating the relationship between the value of the technological characteristics of craft goods and the four parameters that describe the organization of production.

vessels that take longer to make require more hands, total output levels being equal. Third is the intensity of production: all other variables being equal, fewer full-time potters will be required than part-time potters. Fourth is the length of time the assemblages represent: longer occupations by definition will have been served by greater numbers of artisans, and therefore long periods or phases will exhibit greater variability than will shorter periods with similar forms of production.

Skill

Skill reflects the craftperson's experience, proficiency, and talent and is recognized and appreciated by artisans and consumers alike. Although archaeologists often mention skill as an attribute of specialized manufacture, it is rarely quantified. Indeed, skill is a difficult behavioral trait to measure in ethnographic, much less archaeological, contexts. Analytically, however, we may expect to recognize skill under certain conditions. The repetition and experience characteristic of specialist production should lead to regularity and consistency in technique, with fewer errors as measured by manufacturing rejects (Clark and Bryant 1986). The mastery of technologically or artistically complex production sequences is also evidence of skill. Finally, skill is expected to be positively correlated with the intensity of production, because artisans who spend more time at their craft accomplish their tasks with increasing deftness through repetition and experience.

The recognition of an artisan's technical skill involves a measure of subjectivity, since skill implies facility and assuredness in accomplishing the production tasks. The confidence of skilled artisans, as manifest in their crafts, applies to practiced household potters and to highly trained workshop potters alike. The vagaries of quantifying skill lead us to suggest that ceramic technological attributes related to skill and control, to standardization, and to labor investment be considered together, since they combine in distinctive ways, discriminating different kinds of specialization.

Technological Characteristics and the Organization of Production

Identifying the parameters of production and the types of specialization is more conclusive when the actual production locations have been identified (Costin 1991). Yet it is still possible to use the technological characteristics of the objects themselves to delimit the organization of production (Arnold and Nieves 1992; Benco 1986; Hagstrum 1985, 1986; Rice 1981; Sinopoli 1988). Figure 1 illustrates the relationships among the technological attributes of the products themselves and the parameters that describe the organization of production.

The context of production—identifying the sociopolitical status of consumers and the nature of the producer-consumer relationship—is most clearly reflected in the amount of labor investment. The products of most attached specialists will be more labor intensive than the products of independent specialists because of the greater information load they carry and because of the desire of elite patrons to add value or uniqueness to these goods through greater labor input.

Table 1. Technological Characteristics of Various Types of Specialization.

	Labor Investment	Intentional Standardization	Mechanical Standardization	Skill
Individual specialization	low	low–high[a]	low	low–moderate
Community specialization	low	low–high[a]	low–moderate	moderate
Dispersed workshop	low	low–high[a]	moderate	moderate
Nucleated workshop	low	low–high[a]	moderate–high	moderate
Dispersed corvée	low	low	low	low
Nucleated corvée	moderate–high	high	low–moderate	moderate
Individual retainer	high	low	low-moderate	high
Retainer workshop	high	high	high	high

Note: All of these comparisons are made within a particular class of artifacts (i.e., pottery, stone, metal, textile). Comparisons among artifact classes do not hold because of differing technological requirements.

[a] A combination of social requirements or expectations and functional variability affect the amount of intentional standardization in utilitarian wares.

The relative geographic concentration of production is reflected in the amount of mechanical, and to a lesser extent intentional, standardization. The products of dispersed specialists should exhibit more variability than nucleated specialists because workers aggregated within a single community are more likely to share raw material sources, to participate in ad hoc sharing of facilities, to exchange tools and labor, and to have general access to one anothers' products.

The constitution of production units' personnel is also reflected in the amount of mechanical standardization. The products of large workshops are likely to be more standardized than those of individual forms of production because workshop artisans generally work in close proximity under supervision, share technology, and draw from a common store of tools and raw materials. Among attached specialists, intentional standardization should reflect the constitution of production units: small and/or dispersed labor groups will be used when standardization is unimportant (e.g., the serviceable goods of dispersed corvée laborers) or when uniqueness is intended (e.g., the elaborate, one-of-a-kind goods produced by individual retainers), while larger workshops and factory-like settings will be employed when patrons require large numbers of standardized goods with standard values (cf. Wattenmaker 1991).

Finally, the intensity of production can be measured in part by the skill manifested in the assemblage. Whereas the products of full-time specialists should be more skillfully made, reflecting continuous attention to craft manufacturing operations, the products of part-time workers should reflect less proficiency, resulting from interruptions and hiatuses in their craft production activities. Those industries that require greater skill and training to master technological complexity or design elaboration will employ full-time laborers, as it is more efficient to train relatively fewer workers.

Integrating the parameters of production, as they define the eight types of specialization, with the technological characteristics, it is possible to identify a unique "technological profile" for each type of specialization (Table 1). For example, community specialization is defined by independent context, nucleated concentration, household constitution, and usually part-time intensity. Thus, it should be characterized technologically by relative low labor investment, low to moderate standardization, and moderate skill.

The Study Sample

The ceramic collections analyzed in this study were made as part of the Upper Mantaro Archaeological Research Project (UMARP) (see D'Altroy and Hastorf 1996; Earle et. al 1987). UMARP conducted fieldwork in highland Peru (Figure 2), investigating the social and political changes that occurred after the indigenous Wanka population was conquered by the Inka empire in roughly A.D. 1460.

Domestic contexts from four sites occupied after the Inka conquest of the Wanka yielded the ceramic assemblages discussed here. The basic unit of analysis was the patio group, an architec-

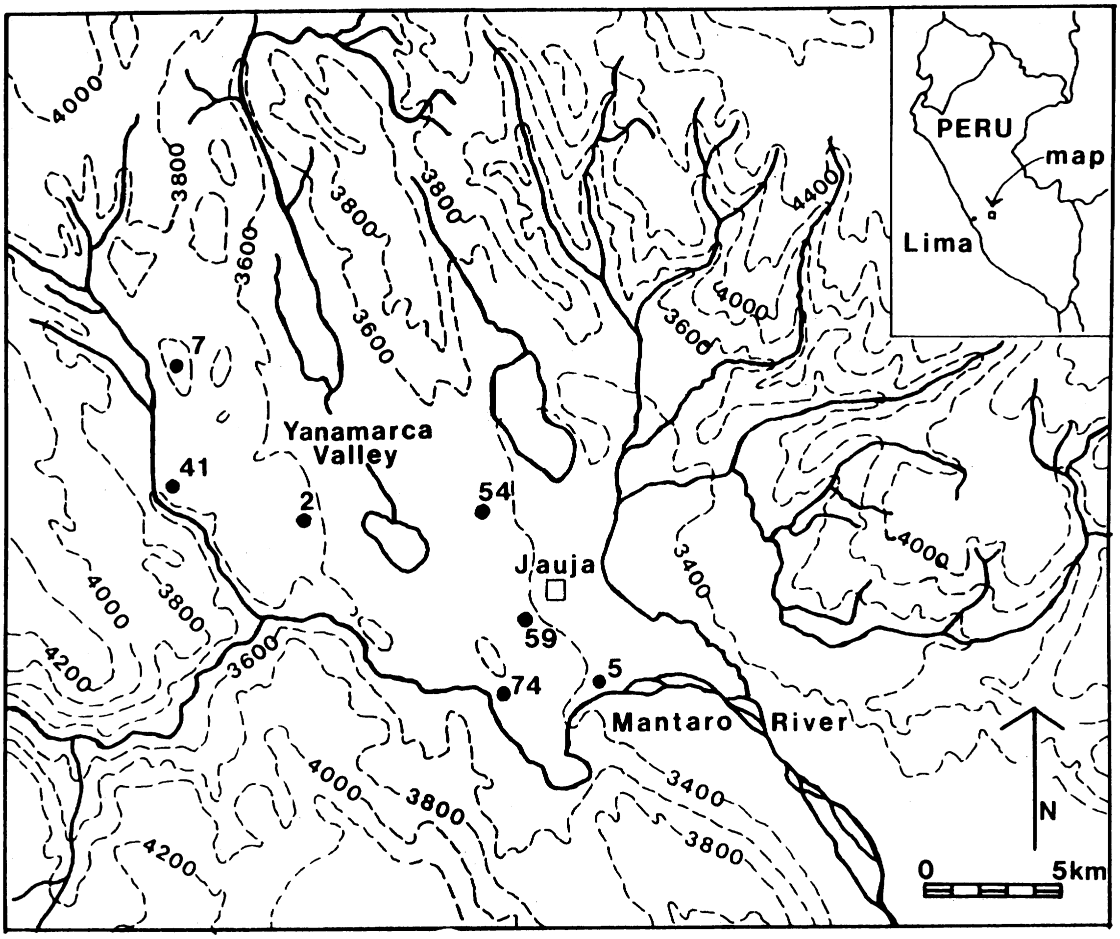

Figure 2. Map of the research area. Sites indicated are (2) Hatunmarca (Wanka II center, Wanka III town); (5) Hatun Xauxa (Inka provincial capital); (7) Tunanmarca (Wanka II center); (41) Umpamalca (Wanka II town); (54) Marca (Wanka III town); (59) Wankas de la Cruz (Wanka III village); (74) Chucchus (Wanka III village). After Earle et al. 1987:Figure 1.

tural complex consisting of one or more circular stone structures opening to a walled patio space. Each patio group probably accommodated a single household. A combination of random and judgmental procedures was used to select 14 patio groups and areas within them for excavation (see Earle et al. 1987:7–16 for a complete discussion). Both elite and commoner households—distinguished by size, masonry quality, and location—were included in the sample.

The three ceramic wares analyzed are the local Wanka transport, storage and serving wares, called Base Clara and Wanka Red; the ubiquitous cooking ware, called Micaceous Self-slip; and the prestigious Inka-style state ware. Micaceous Self-slip and the Wanka decorated wares were manufactured both before and after the Inka conquest. However, only materials from Inka period (Wanka III) contexts were included in this analysis. Each of these wares served distinct functions, and each met a particular demand, as characterized by level of consumption, the social makeup of the consuming population, and the political and symbolic nature of the vessels.

Base Clara and Wanka Red

These two decorated types shared many characteristics (Figure 3). Both were produced in slipped and unslipped varieties, and were painted with rapidly executed black and red designs (Figure 3a,

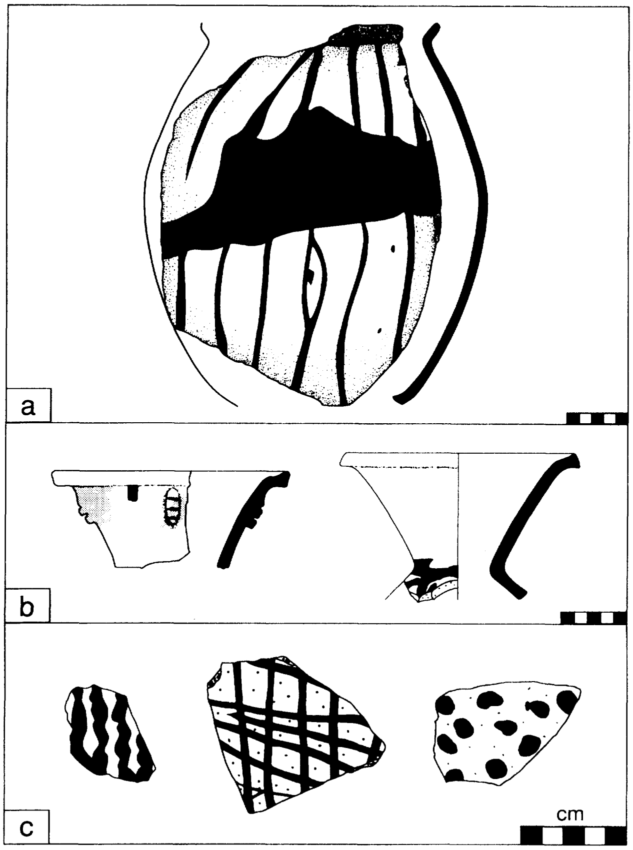

Figure 3. Local style storage/transport jars: Base Clara body fragment (a); Wanka Red and Base Clara body jar rim and neck fragments (b); and decorated Base Clara body fragments (c). After Costin 1986:Figures 2.25, 2.51, 2.54, 2.55, 2.57 and Hagstrum 1989:Figure 6.4a.

c). Morphological similarities suggest they served similar functions. Petrographic analysis indicates they were made of similar clays (Costin 1986). Although each ware was made in several different vessel forms, only high-necked jars were included in our analysis (Figure 3b). These jars were likely multifunctional; the smaller jars used for transporting liquids and the larger ones used for storing wet and dry foods. Jars were recovered in both elite and commoner contexts, suggesting they met a broad demand.

Our understanding of the organization of production of Base Clara and Wanka Red is based on the analysis of direct evidence for their manufacture. The concentration of wasters from their manufacture at a single town in domestic contexts unassociated with special purpose or elite architecture argues strongly for independent community specialization. Petrographic analyses support this identification of a single source for the production of these pottery types (Costin 1986, 1996).

Micaceous Self-slip

The globular low-necked jars characteristic of this undecorated type (Figure 4) were manufactured from a distinctive, highly micaceous clay similar to that still used today to produce cooking *ollas* in the Mantaro Valley (Hagstrum 1989). Many sherds had carbonized deposits on interior or exterior surfaces, suggesting use in cooking. Cooking vessels were recovered in all households, but were more concentrated in elite households. We suggest this reflects greater periodic demand for cooking vessels during intermittent feasting sponsored by local elites (Costin 1986).

In general, however, the demand for cooking vessels was broad-based and unrestricted.

We recovered little direct evidence for the manufacture of Micaceous Self-slip. A large dump yielding enormous quantities of unused vessels of this type may indicate production of this ware during the pre-Inka period at the site of Tunanmarca, but the associated production facilities were not identified. No comparable deposit was identified in a Wanka III context. Petrographic analysis suggests relative homogeneity in the resource materials used in manufacturing this pottery (Costin 1986, 1996), and suggests nucleated production, either community specialization or nucleated workshop production.

Inka

Inka-style aryballoid jars (Figure 5) were used for transport and storage in Wanka households. Inka vessels were complex forms with conical bases, globular bodies, and flaring necks (Figure 5a,b). Surface treatment included polychrome geometric designs painted on a light colored, highly polished background (Figure 5c). Inka pottery was remarkably standardized in form and decoration throughout the empire (Costin 1986; D'Altroy 1981; D'Altroy and Bishop 1990; Fernandez Baca 1971; Meyers 1975; Morris and Thompson 1985), functioning as a symbolic commodity to indicate favor and cooperation with the ruling bureaucracy.

Unlike the local Wanka types, Inka aryballoids were concentrated in elite households (Costin 1986:303–305). Ethnohistoric records tell us that Inka ceramics were distributed initially through state-controlled channels (Morris 1982). Thus, Inka pottery did not serve the broad, unrestricted demand serviced by independent potters, but rather was an elite ware whose distribution was probably carefully controlled by state bureaucrats and institutions. Such a ware is generally made by attached specialists.

Two lines of evidence suggest Inka ceramics were produced outside the local Wanka system in a newly established framework of artisans and/or workshops. First, no direct evidence (e.g., wasters) for Inka ceramic production was recovered from the domestic contexts in which Wanka-style vessels were produced, nor from any Wanka communities. Second, paste and compositional analyses indicate that clays used to manufacture Inka ceramics were distinct from those used for manufacture of Micaceous Self-slip, Wanka Red, and Base Clara vessels in the Wanka III period (Costin 1986, 1996; D'Altroy and Bishop 1990).

Mineral and chemical analyses confirm that Inka wares were produced and distributed on a regional level. This conclusion is based on the observation that Inka wares recovered in the Yanamarca Valley were petrographically and compositionally distinct from morphologically and stylistically similar sherds collected from other Inka administrative sites throughout the empire (Costin 1986:496–499; D'Altroy and Bishop 1990), indicating each province had its own production center or centers.

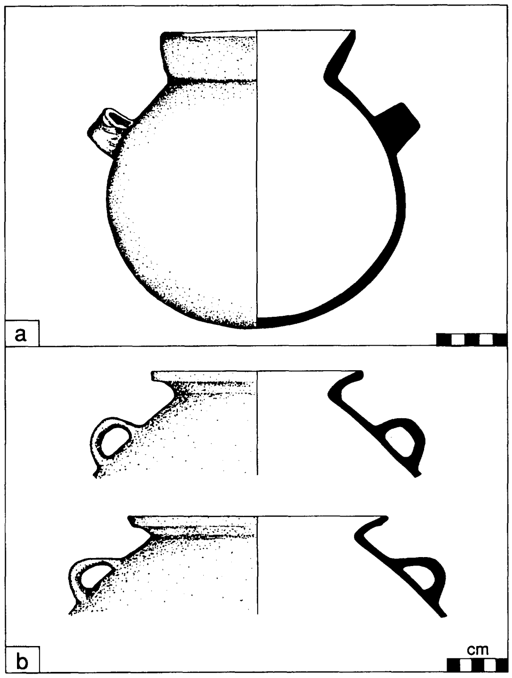

Figure 4. Micaceous Self-slip cooking jars: whole vessel (a) (after Costin 1986:Figure 2.5a; Hagstrum 1989:Figure 1.1) and rim and upper body fragments (b) (after Costin 1986:Figure 2.15).

Data Analysis

Research Expectations

Based on chemical, stylistic, distributional, and ethnographic studies, we can characterize the

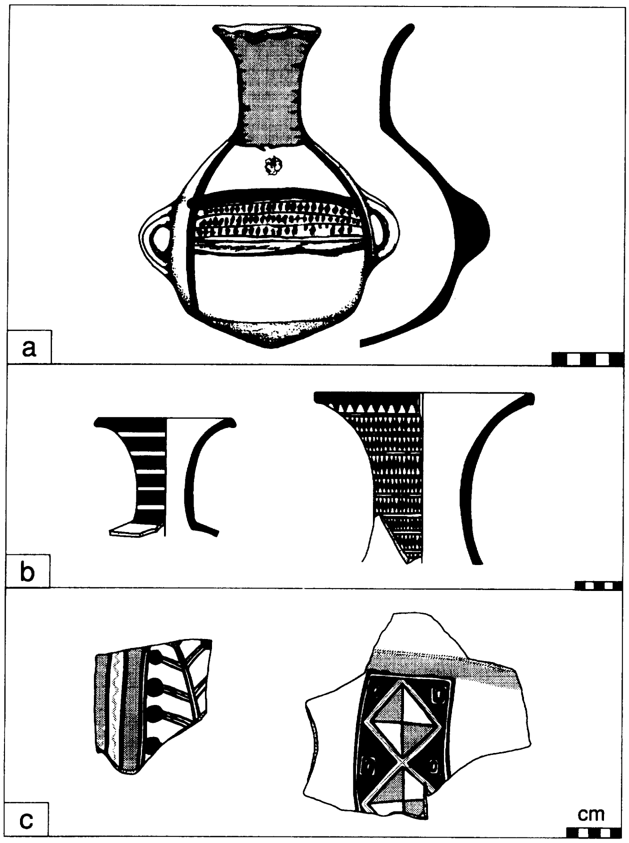

Figure 5. Inka aryballoid jars: miniature jar form showing globular body and conical base (a) (after Costin 1986:Figure 2.28; Hagstrum 1989:Figure 5.32); jar rim and neck fragments (b) (after Costin 1986:Figure 2.29); and decorated body fragments (c) (after Costin 1986:Figure 2.62).

organization of production of the Base Clara and Wanka Red wares as community specialization. Less is known about the organization of production of Micaceous Self-slip and Inka pottery. Given the relationships among the parameters of the organization of production and labor investment, standardization, and skill as set forth in the model above, we suggest that by comparing the technological characteristics (labor investment, standardization, and skill) of Inka, Micaceous Self-slip, and the painted Wanka types, we should be able to identify the organization of production of the former two wares more conclusively. Drawing on earlier studies of ceramic production in the Upper Mantaro (Costin 1986; D'Altroy 1981; D'Altroy and Bishop 1990; Hagstrum 1986, 1989; LeVine 1987), we focus our expectations for Micaceous Self-slip and Inka production to develop a set of hypotheses and test implications for the organization of production of each ware. Specifically, we ask whether the organization of production of Micaceous Self-slip was community specialization or nucleated workshop production; we ask whether the production of Inka-style pottery was nucleated corvée or retainer workshops.

Micaceous Self-slip: Community Specialization or Nucleated Workshop Production?

Given the general, unrestricted nature of the demand for cooking vessels and the petrographic homogeneity of the wares, we initially suggested that this ware would have been produced by independent, nucleated craftspeople, either community specialists or nucleated workshops. The two

Table 2. Technological Profiles of Four Types of Specialization.

	Labor Investment	Intentional Standardization	Mechanical Standardization	Skill
Micaceous Self-slip				
Community specialization	low	low–high	low–moderate	moderate
Nucleated workshop	low	low–high	moderate–high	moderate
Inka				
Nucleated corvée	moderate–high	high	low–moderate	moderate
Retainer workshop	high	high	high	high

types of production can be distinguished by the technological profiles of the manufactured wares. As outlined in Table 2, the assemblage produced by community specialists is expected to manifest low labor investment and moderate skill. The amount of intentional standardization should reflect social expectations and the range of vessel functions. In the case of Micaceous Self-slip, such standardization should be relatively high, since this undecorated ware served a single function, cooking. Although the amount of mechanical standardization should reflect the number of work groups, we expected standardization of this kind to be low because community specialization is characterized by relatively many part-time artisans.

If Micaceous Self-slip were produced by workshops, we would expect the assemblage to exhibit greater standardization than one produced by community specialists because of greater sharing of raw and prepared materials, tools, and other technology by workshop members. Workshop products should exhibit less energy expenditure than those of individual specialists, as the relative "mass production" of independent workshops tends toward greater efficiency.

Inka: Nucleated Corvée or Retainer Workshops?

Given that this ware was distributed through state channels primarily to state institutions and local elites, we expected this ware to have been produced under some form of attached specialization. The documented petrographic homogeneity and the impression of stylistic homogeneity narrowed our choices to some form of nucleated production, either nucleated corvée or retainer workshops. As with the types of specialization to be tested for Micaceous Self-slip, we expected that the possible types of production organization proposed for Inka wares would be distinguishable by their technological profiles (Table 2). An assemblage produced by corvée labor will manifest moderate to high amounts of labor investment. Intentional standardization will also be high, because of the need to systematize the message embodied in the wares. Mechanical standardization will be relatively low, reflecting the relatively large number of part-time laborers. Skill is expected to be moderate: adequate for producing the relatively elaborate or complex products, but not high because of the part-time nature of the work.

Retainer workshop production would be distinguished by high levels of all the technological attributes. Labor investment and intentional standardization would be high for the same reasons they are high for nucleated corvée. In contrast with part-time corvée, mechanical standardization is high in full-time retainer workshops, because these workshops employ relatively fewer specialists. Skill is expected to be high because the full-time nature of the work is assumed to lead to greater perfection of technique.

Procedure

We analyzed jar fragments from all three wares, selecting specific sherds with a nonproportional, multistage cluster, random sampling procedure (Costin 1986:54–57; Hagstrum 1989:144–145). Sherds were included only if they met certain specific size (greater than 4 cm^2 surface area) and surface preservation (uneroded) criteria. A range of stylistic, morphological, and technological attributes was recorded for each selected sherd (see Costin 1986:Appendix A; Hagstrum

Table 3. Production Task Index Points.

Task	Points
Primary formation (points for each side)	1
Evident—coiled	2
Evident—rotated	3
Secondary formation (points for each side)	0
Not evident	1
Evident—wiped or scraped	1
Obliterated	2
Handles—formation	
Coiled	1
Pulled	2
Handles— attachment	
Simple	1
Plug	2
Finishing— application (points for each side)	
Slip or wash (each color adds 1 point)	1
Finishing— modification (points for each side)	
Pebble smoothed	1
Burnished	2
Polished	3
Finishing—plastic decoration[a]	
Simple incision	1
Complex incision	2
Simple applique	1
Complex appique	2
Finishing— paint (each color adds 1 point)[a]	
Simple motif	1
Complex motif	2

Note: Scoring after Hagstrum 1989:Table 6.5.
[a] Noteworthy skill adds 1 point.

1989:Appendixes D and E) to assess manufacturing techniques.

Analysis of the wares in terms of labor investment, standardization, and skill enabled us to compare the technological profile of each ware with a known organization of production. Base Clara and Wanka Red provided the baseline information. We then assessed the technology of production for each relative to one another to identify the probable organization of production.

Labor Investment

In ethnographic situations we can determine time and other costs of production directly. In archaeological contexts, we must devise an alternative way to assess these costs. Here, we measure labor investment using a production step index (Feinman et al. 1981). The production step index is an ordinal measure of manufacturing costs, where the number and complexity of production tasks involved in manufacturing wares correspond directly to the time required to execute these tasks. Based on her experience as a practicing potter and her ethnographic fieldwork among traditional Mantaro Valley potters, Hagstrum (1989) modified the Feinman et al. index to quantify the labor invested in the manufacture of local Wanka and Inka wares (Table 3). Formation and finishing tasks were ranked by the relative amount of time necessary to complete them, and proportional numbers of points were then assigned for each task. We rated Base Clara and Wanka Red separately in this analysis to control for possible differences in labor investment in the two Wanka decorated types.

Figure 6 presents the results of the labor investment analysis. Because the assignment of points to particular tasks represents a ranking of the relative amount of time spent in particular tasks (rather than a recording of actual time spent), the scores are ordinal, not interval, scales. Therefore, scores are presented as medians for the different parts of the vessel. A sum of the total vessel is presented as a rough indicator of the relative amount of time required to produce each of the types.

Micaceous Self-slip cooking vessels ranked lowest, with a summed median score of 22 points. It is noteworthy that median scores for Micaceous Self-slip vessel parts consistently fell at the low end of the range of scores. Low labor investment for pottery used to cook over an open fire meets the expectation of low labor investment for low visibility.

Base Clara and Wanka Red received nearly identical scores for each vessel part and for their summed medians (medians of 37 and 38, respectively). The decorated Wanka wares scored higher than Micaceous Self-slip, but significantly lower than Inka pottery. The additional labor invested in the local decorated types is expected given their decoration and the use of these vessels in a more visible public forum, away from the family hearth.

Inka wares scored significantly higher than any of the local Wanka wares. All body parts were more labor intensive and the summed median—85 points—quadrupled that of Micaceous Self-slip (22 points) and tripled that of Base Clara (37 points) and Wanka Red (38 points). Note that medians for individual Inka body parts generally fell in the middle-to-high end of the range of scores for that ware.

The labor investment scores confirm our suggestions for the context of production for these wares. Inka, with its much higher labor investment, is most likely a ware produced by attached specialists. The local types received similar scores, suggesting that they were made by independent specialists.

Standardization

We analyzed relative standardization among morphological and technological attributes as a measure of the number of production units manufacturing each ceramic type.

Morphological attributes. The radius of curvature was measured for three vessel parts, rim, collar, and body-at-handle, using a carpenter's contour gauge. Body sherds were oriented through recognition of remnant coils and curvature. Measuring sherds with radius of curvature greater than 30 cm presents difficulties, as these sherds were virtually flat (Hagstrum and Hildebrand 1990).

Histograms of the measurements were inspected first to evaluate modality in the distributions of these measurements. We were concerned that there might be discrete size classes represented within a single vessel form. Many distributions were arguably bimodal, with a small number of large vessels forming a clearly distinguishable size class. Because it is invalid to calculate summary statistics on bimodal distributions, these relatively few large jars (≤6 for each ware) were judgmentally eliminated from the sample.

We calculated the coefficient of variation for each of the morphological variables as

$$C.V. = \frac{std \times 100}{X}$$

Table 4 shows that the coefficients of variation for all attributes measured for all wares were high, ranging from 29.46 percent to 49.09 percent. Coefficients of variation on the metric variables of rim radius, collar radius, and body radius are close for the three wares. Inka pottery appears to be somewhat less variable than Micaceous Self-slip and the painted Wanka wares in terms of rim and body-at-handle radius measurements.

Our coefficients of variation are greater than the 10 percent maximum used to characterize a unimodal biological population (Thomas 1976). What can we make of these numbers? Although we did not detect unambiguous size (or shape) classes beyond the relatively small number of outliers removed from the analysis, it is likely that the assemblage contained several classes or sizes of vessels that went unrecognized in our analyses.

In the Mantaro Valley today, potters and consumers recognize three shape categories and four size classes of cooking vessels (small to extra-

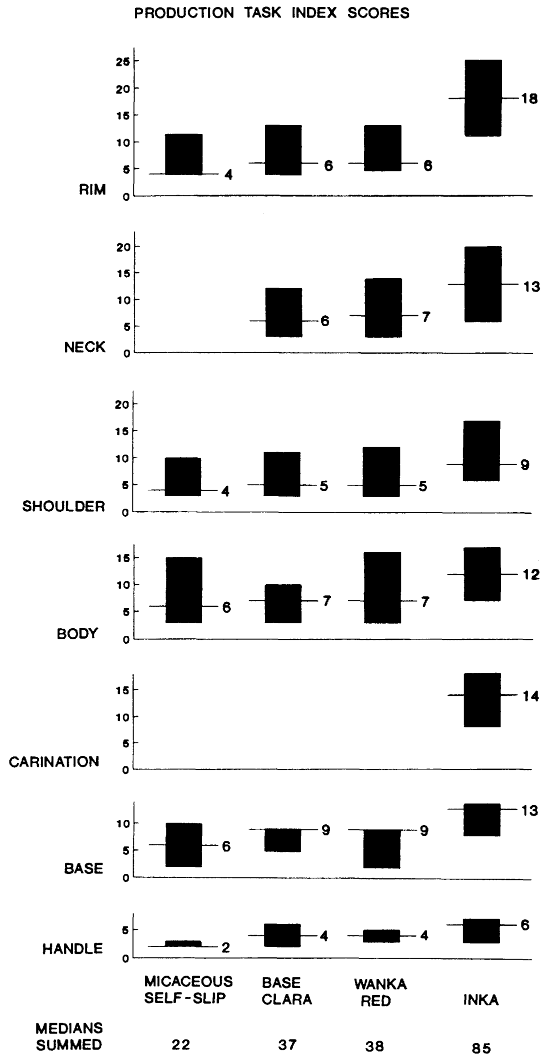

Figure 6. Production task index scores on Micaceous Self-slip, Base Clara, Wanka Red, and Inka body parts. Vertical bars indicate range of scores, while horizontal lines indicate median score for each ware/body part.

Table 4. Coefficients of Variation on Morphological Variables.

	Mean	S.D.	C.V.
Rim radius of curvature			
Inka (N=81, 6 outliers removed)	10.98	3.23	29.46[a]
Wanka (N=137, 4 outliers removed)	8.79	2.82	32.10[b]
Micaceus Self-slip (N=220)	9.08	3.19	35.16
Collar radius of curvature			
Inka (N=22)	9.66	4.74	49.09
Wanka (N=46)	7.00	2.76	39.38
Micaceous Self-slip (N=49)	8.04	2.66	33.11
Body-beneath-handle radius of curvature			
Inka (N=47)	15.89	5.46	34.40
Wanka (N=34)	14.96	5.51	36.83
Micaceous Self-slip (N=78)	12.65	4.57	36.13

Note: Measurements in centimeters. C.V. calculated as $C.V. = \frac{std \times 100}{X}$

[a] Without the outliers removed, the Inka coefficient of variation is 33.5, still the lowest rim variability;

[b] Without the outliers removed, the Wanka coefficient of variation is 39.74, which would make it the most variable of the three wares.

large *ollas*, small to large *chatas*, and small to large *tostaderas*) and three shape categories and five size classes of transport/storage jars (individual to medium *porongos*; individual to extra-large *ulpus*; and small and medium *tinajas*). We did not recognize the range of morphological or size variability in the archaeological assemblage that was encountered in modern households. This may be a result of the difficulty in reconstructing vessel size and shape from an assemblage of sherds.

Longacre et al. (1988) calculated coefficients of variation on the same order of magnitude as ours for an assemblage from Grasshopper Pueblo. The Grasshopper data, like ours, rendered coefficients of variation higher than those calculated on ethnographic samples of known production organization. Longacre et al. (1988) ultimately concluded that their archaeological data contained several ceramic classes unrecognized by the archaeologists (see Stark 1991).

It is intriguing to note, however, that the coefficients of variation on our archaeological assemblage are within the same order of magnitude as those calculated on other hand-built assemblages (Crown 1991; Longacre et al. 1988), although coefficients of variation calculated for wheel-made pottery from Late Roman and Early Islamic sites were much smaller (Benco 1986: Figures 6 and 7). These studies suggest there may in fact be greater variability within hand-built archaeological ceramic assemblages than in biological populations, ancient mass-produced assemblages, or ethnographic assemblages. This is likely for several reasons. First, potters with limited mass-production technology will produce more variable assemblages than those using standardized tools or mass-production technology. More important, archaeological assemblages are created over a much longer period than are those studied by ethnographers. Logically, more potters should have created the archaeological assemblages than the ethnographic ones, and therefore the former should be expected to manifest greater variability than the later. In many ways, comparing the statistics of an archaeological assemblage with those of an ethnographic assemblage to judge the degree of specialization counters some of the most important principles of such comparative analysis, most notably that the assemblages compared must have been produced over a similar amount of time and must represent total populations of similar size (Costin 1991).

Technological Attributes. The second set of attributes analyzed consisted of paste color, slip color, and paint color. Ceramic color is affected by several factors, the most important being the composition of the raw materials and the firing process. Variability in color, to the extent it relates to the technologies of resource preparation and firing, should reflect the organization of production in two ways. First, we assume the variability in composition (or number of "recipes" used to formulate the clay bodies, slips, and paints) to be correlated with the number of work units to the

Table 5. Shannon-Weaver Diversity Scores (H′) on Color Variables.

		Paint		Slip	
	Paste	Red	Black	Red	Cream
Micaceous Self-slip	1.34 (N=552)	—	—	—	—
Wanka wares[a]	1.19 (N=941)	1.08 (N=172)	.90 (N=256)	1.02 (N=57)	.91 (N=581)
Inka	1.05 (N=400)	.93 (N=119)	.97 (N=133)	1.02 (N=116)	1.13 (N=108)

Note: Shannon-Weaver diversity score (H′) calculated: $H' = \Sigma\ p_i \log p_i$

[a] Base Clara and Wanka Red analyzed together for paste and black paint, separately for red paint and slip.

extent that each work unit will have its own sources and methods for procuring and preparing raw materials. Second, we assume that relative uniformity in firing characteristics reflects the number of work groups because we expect each work group to have its own consistent firing regimen, including pot stacking arrangements, fuels used, and cues for determining the end of firing.

Five color attributes—paste color, cream slip, red slip, red paint, and black paint—were recorded using standard Munsell notation of value, hue, and chroma (Munsell 1975). Variability in Munsell values for each attribute was assessed using the Shannon-Weaver diversity index (Pielou 1966a, 1966b; Shannon and Weaver 1963), calculated as

$$H' = \Sigma\ p_i \log p_i$$

This statistic was developed in information theory to measure the amount of noise or randomness in a message. To the extent that we can assume the Wanka and the Inka had particular colors in mind when they decorated their vessels, we can assume that the variability in achieving those colors was in fact unintentional "noise." Although some precision in assessing variability is lost by treating the ordinal (or continuous) Munsell readings as nominal data, this may have been the most effective method for measuring variability in multidimensional data.

The results of the analysis of color diversity are somewhat ambiguous (Table 5), because none of the wares was consistently more or less variable than the others. Given the lack of consistent patterning in the color data, we conclude similar amounts of color diversity in the Wanka and Inka assemblages.

Conclusions drawn from comparative standardization. In sum, the three wares showed surprisingly little difference in their degrees of mechanical standardization as measured by color variability and morphological standardization. These data, then, suggest that the producers of all wares were nucleated to a similar degree, since they exhibit equivalent homogeneity (or heterogeneity). This conclusion is supported by the petrographic data, which indicate a single "source" for each of the wares. Furthermore, the data suggest similar numbers of potters or workshops were at work producing each of the three wares.

Skill

Skill can be measured in a number of ways. Standardization itself is sometimes considered a hallmark of potters' skill. However, this measure is useful only in industries in which the products were intended to be homogeneous. For those products whose uniqueness is desired (a hallmark of many elite wares), such a measure would be inappropriate. Although none of the industries considered in our study represents highly individual and unique pottery produced exclusively for elite patrons, we do recognize Inka potters to have been more skilled (or at least more consistent) than those potters producing the Wanka pottery analyzed here.

Two technical aspects of pottery manufacture—wall thickness and firing core—were analyzed to inform us of the relative skill of the artisans. Pots constructed in the Wanka and Inka ceramic traditions were probably manufactured by coiling on a *muyuchiku* or slow wheel (Hagstrum 1989:161–162). By measuring wall thickness on opposite sides of a potsherd oriented according to its axis of revolution, we expect to see evidence for skill in vessel forming technique (including coiling, scraping, and subsequent surface modification).

For each sherd, wall thickness was measured in two locations. The data presented in Table 6 show

Table 6. Variation Around Mean Wall Thickness.

	<1%	1–5%	>5%	Range
Rim				
Inka (N=76)	.84	.14		0 – .045
Micaceous Self-slip (N=177)	.73	.17	.10	0 – .194
Wanka (N=136)	.84	.11	.05	0 – .088
Collar				
Inka (N=17)	.18	.82		0 – .046
Micaceous Self-slip (N=69)	.16	.61	.25	0 – .187
Wanka (N=39)	.23	.41	.36	0 – .191
Body-beneath-handles				
Inka (N=45)	.12	.44	.44	0 – .252
Micaceous Self-slip (N=77)	.10	.39	.51	0 – .526
Wanka (N=38)	.03	.45	.52	0 – .301

Note: Variation in wall thickness calculated as:

$$\text{Var\_wt} = \frac{\text{Maximum wall thickness} - \text{minimum wall thickness}}{(\text{maximum wall thickness} + \text{minimum wall thickness}) / 2}$$

the variation around the mean wall thickness, calculated

$$\text{Var\_wt} = \frac{\text{Maximum wall thickness} - \text{minimum wall thickness}}{(\text{maximum wall thickness} + \text{minimum wall thickness}) / 2}$$

Summary statistics and coefficients of variation for these measurements are inappropriate, because the distribution more closely approximates a Poisson distribution than a normal distribution. The general pattern, however, indicates that the control of the Inka potters in forming their pots is somewhat greater than the potters producing the Wanka and Micaceous Self-slip wares. All Inka vessels (100 percent) showed less than five percent variation in rim and collar wall thickness. In percentage terms, Micaceous Self-slip potters showed less control in two of three locations than did artisans producing Wanka-style transport/storage jars. However, this is in part a function of the differences in mean wall thickness. Because Micaceous Self-slip cooking vessels are thin walled, even a slight variation will translate into a relatively large percentage difference.

The second variable used to evaluate the skill of the potters was the presence or absence of a firing core, considered a rough indicator of the level of control and consistency in firing. As Table 7 demonstrates, Inka and Micaceous Self-slip potters showed significantly more control/consistency in firing than did the makers of Wanka-style jars. Specifically, only 11 percent of Micaceous Self-slip sherds and 17 percent of Inka sherds retained a grey organic core, while 37 percent of Wanka sherds had a gray core. A chi-square statistic calculated on the distributions indicates the differences to be statistically significant at the .001 level.

Although the quantitative measures indicate only slight skill differences among the Inka and Wanka wares, there appears to be a qualitative difference. Inka vessels appear to have been more carefully constructed and decorated than were the Wanka vessels, indicating greater skill and/or effort on the part of the artisans producing them (compare Figures 3 and 5). The complex morphology of the Inka aryballoid jar form, including conical base, sharp-angled carination at the juncture of the base and body, and the tall smoothly curved necks, required an understanding of the drying properties of clay and careful timing for building the constituent parts of this vessel shape, hallmarks of accomplished and skilled artisans (Figure 5a). The qualitative difference recognized in the care and control, if not skill, to execute the painted decoration of Inka jars by contrast to Wanka jars is graphically illustrated by comparing Figures 3a and 5a. The Inka repertoire of geometric design elements (Figure 5c) exhibits technical mastery not apparent in the Wanka repertoire (Figure 3c), which consists of haphazard squiggles, dots, and randomly intersecting lines. Hagstrum (1989:254) more often gave additional points for "noteworthy skill" to Inka sherds than to local pieces, so this "qualitative" difference was quantified to some extent in the analysis of labor investment.

Conclusions from analysis of skill. In sum, the similarities in skill level suggest that all potters producing the wares recovered in the Yanamarca worked at the same relative intensity, that is, the same degree of part- or full-time work.

Table 7. Presence or Absence of Firing Core.

	% Absent	% Present
Inka (N=404)	83	17
Micaceous Self-slip (N=561)	89	11
Wanka (N=953)	63	37

chi-square = 146.995 df = 2 prob < .001

Summary and Conclusions

Labor investment, standardization, and skill assessed in the manufacture of Micaceous Self-slip cooking vessels, Base Clara and Wanka Red storage/transport jars, and Inka aryballoids are summarized in Figure 7. Inka was the most labor intensive of the wares, followed by the Wanka decorated wares and then Micaceous Self-slip. As expected, labor investment in manufacture varies according to the social and political functions these wares served. Micaceous Self-slip was a purely utilitarian cooking ware limited to use within domestic contexts. Base Clara and Wanka Red vessels served multiple functions, including transportation and storage of wet and dry commodities; these pots were used and seen outside a family context. Their decoration apparently signaled some form of social affiliation, perhaps political allegiance or moiety membership (LeBlanc 1981). Inka aryballoids—the most labor intensive—served the most overt political function, and clearly had the most public role of any of the wares analyzed. These highly standardized vessels were used throughout the empire to transport, store, and prepare symbolically charged commodities such as maize and *chicha* (maize beer), and were often distributed to local populations as part of imperial largess (Morris 1978).

In Figure 7, we see that Inka involved the greatest amount of skill in manufacture, followed by Micaceous Self-slip and Base Clara/Wanka Red. The Inka jars showed a much higher degree of intentional stylistic standardization, a function of their use as mass emblems of political allegiance and favor. The Micaceous Self-slip cookware showed the greatest amount of intentional morphological standardization, related to its primary function, cooking. Inka manifested only slightly more mechanical standardization than either of the Wanka wares.

In sum, the primary difference among the three wares is the amount of labor invested in manufacture, indicating differences in production organization specifically in the parameter of the context of production. Specifically, we corroborate previous analyses suggesting Inka ceramics were produced by attached specialists, while Micaceous Self-slip, Base Clara, and Wanka Red were produced by independent specialists.

We argue that the similarities in standardization and skill among all the types in this study indicate they were produced by similar numbers of potters or workshops, with similar degrees of concentration, all working with the same intensity.

Overall, the local storage jars and Micaceous Self-slip *ollas* have similar technological profiles. Micaceous Self-slip did not have the relatively higher degree of mechanical standardization we would expect if the ware had been produced within large, supervised workshops. We conclude that Micaceous Self-slip, like Base Clara and Wanka Red, was produced by community specialists, independent household-based producers aggregated at a few communities (Table 8).

The Inka data are in line with expectations for a supervised form of attached specialization (Table 9). This is the most labor intensive pottery consumed by the Wanka population. Those variables reflecting skill and control—control over fir-

LABOR INVESTMENT	Inka > Wanka > Micaceous Self-slip
SKILL	Inka ≥ Micaceous Self-slip ≥ Wanka
INTENTIONAL STANDARDIZATION	Inka > Micaceous Self-slip > Wanka
MECHANICAL STANDARDIZATION	
—TECHNOLOGICAL	Inka ≥ Wanka ≥ Micaceous Self-slip
—MORPHOLOGICAL	Inka ≥ Micaceous Self-slip ≥ Wanka

Figure 7. Three primary wares ranked by technological characteristics used to identify the organization of production.

Table 8. Technological Profile of Micaceous Self-slip.

	Labor Investment	Intentional Standardization	Mechanical Standardization	Skill
Expected value for				
Community specialization	low	low–high	low–moderate	moderate
Nucleated workshop	low	low–high	moderate–high	moderate
Micaceous Self-slip	low	moderate	low	moderate

ing atmosphere and variability in wall thickness—indicate more care in manufacture than was recognized for the local types. The Inka ceramics are also intentionally standardized in terms of decoration. However, the Inka wares did not exhibit the degree of mechanical standardization that would indicate production by a small number of carefully regulated work groups working in retainer workshops. Indeed, those variables that we contend measure the number of hands working in an industry, secondary morphological and technological attributes, indicate similar numbers of workers producing Inka wares as those producing other local types. With the exception of labor investment, the technological profile of Inka is surprisingly similar to those of the other wares.

We suggest that the Inka wares recovered in Wanka households were not produced in full-time retainer workshops but rather by relatively larger numbers of corvée laborers working only part-time throughout the year in service to the state. This is precisely the type of labor organization that has been identified from written records for the production of Inka-style pottery at the administrative center of Huánuco Pampa (LeVine 1987) and among the Lupaqa of the southern altiplano (Julien 1982). Levine (1987:24) argues from the ethnohistoric documents that the potters conscripted to produce Inka wares were the same artisans who produced utilitarian wares for local domestic consumption. Moore (1958:56) also reports that local potters were required to produce ceramics as their tax contribution. If the local potters who produced cooking *ollas* and local style storage and transport jars were recruited to produce Inka vessels, then the slight differences in "skill" between the local and state wares might more correctly reflect supervision, and to a lesser extent training.

Our study demonstrates how measures of labor investment, standardization, and skill can be used to identify the organization of ceramic production. We conclude that all the local Wanka wares analyzed were the products of specialists aggregated within a single community and working independent of elite or bureaucratic control, a type of specialization called community specialization. In contrast, Inka-style ceramics were produced by nucleated corvée labor, possibly local potters mobilized part time to produce pottery in the Inka style as their *mit'a* labor obligation.

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Table 9. Technological Profile of Inka Aryballoids.

	Labor Investment	Intentional Standardization	Mechanical Standardization	Skill
Expected value for				
Nucleated corvée	moderate–high	high	low–moderate	moderate
Retainer workshop	high	high	high	high
Inka	high	high	moderate	moderate

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