

A Case of “Failed” Technology Transfer : Land Survey Technology in Early Modern Japan

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A Case of "Failed" Technology Transfer —Land Survey Technology in Early Modern Japan—

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| 1. Introduction | 4. Explaining the Decision to Retain Traditional Methods |
| 2. The Tradition of Mensuration and its Shortcomings | 5. The Demise of Traditional Mensuration |
| 3. The "Objective" Needs for Increased Precision | 6. Final Observations |

1. INTRODUCTION

Common images and many studies of technological transfer in nineteenth and early twentieth century Japan focus on industrial and agricultural development, especially sectors of the economy perceived as fundamental to national defense and its economic foundations. Adoption of new technologies (often treated as "successful" technology transfer) is emphasized and is implicit in adoption of the factory system even when technological transfer is not itself the focus of study. The choice not to adopt a new, modern technology is widely viewed as a "failure" of technology transfer.¹⁾ In the Asian context—including nineteenth century Japan—the cases explored have largely been in agriculture; and the reasons for success have generally sought in the context of adaptation to local climatic and geographic conditions.²⁾ In this context, institutional developments are treated as supportive of transfer, and largely as they apply to developing research, irrigation facilities, and the like. Broader socio-cultural factors are often taken as given or fixed. Since Japan is viewed widely as having industrialized "successfully", it is seen as a nation which did so by "successful" adoption of foreign industrial technology.

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- 1) Francesca Bray [1986] notes how widespread the sense of failure or underdevelopment is in Asia because large scale, highly mechanized agriculture did not develop as it had in the West. Bray is also sharply critical of this perspective.
- 2) See, for example, Hayami Yujiro and Vernon W. Ruttan [1985]. Although their more detailed analysis of the failure of proven technologies lies in Southeast Asia, they also discuss some early Japanese "mis-direction" in the development of nineteenth century agriculture. In another, less well-known study, Kikuchi Masao and Hayami address a broader range of determinants [1981].

This approach has an overly narrow, presentist focus which avoids analysis of factors shaping demand as opposed to supply of a product or technology.³⁾ Exclusive focus on the stories of effective adoption of new technologies ignores the question of why only some of the many inventions made available each year are ever utilized. Furthermore, even in societies (like Japan) which frequently adopt new technologies, this willingness to experiment and innovate may vary by field. In societies which exhibit much interest in technological development there are cases in which new technologies are rejected.⁴⁾ The different reactions in two technologically oriented societies, Japan and the U.S., to "fuzzy logic" represent an interesting contrast in this regard. "Fuzzy logic" has been of great interest in Japan for some time and is a buzzword in the electronics industry, while it has received very little attention in the U.S. What accounts for this selectivity? From what perspective are we to evaluate these choices? From whose standpoint and by what yardstick are a given set of outcomes a "success", "neutral" or a "failure"? In answering such questions, examination of rejected technological development and diffusion can be as suggestive of factors influencing technological change as analysis of adopted technologies.⁵⁾

Examination of land survey technology in Japan between 1600 and 1900 represents one case of rejection of a new technology. My previous research has revealed 1) that Japan was not always effective in adopting new survey technologies, even in the nineteenth century; 2) this was true in spite of the presence of what many would suggest were "objective" needs to record accurately all taxable land and to demarcate boundaries clearly; and 3) rejection occurred despite the fact that more precise measuring tools and techniques were known, widely available, inexpensive, and even employed in other endeavors.⁶⁾

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- 3) By this I mean looking only at those developments which led to an outcome that by today's standards appears to be successful. For more on the role of presentism in historical explanation, see David Hackett Fischer [1970: 135-140].
 - 4) One clue to the ability of a society to deal with innovation may lie in its response to failure or potential failure—is it interpreted as confirmation of a generally fatalistic or pessimistic outlook toward change or as a natural part of change? The need to examine "failures" of technological transfer has been recognized in other national contexts. See, for example, Nathan Rosenberg [1972, 1976, 1982]. I am indebted to David Feeny for these references.
 - 5) Closely tied to these issues is the question of the role of the individual in gaining acceptance of new technologies,—the role of the entrepreneur, the salesman, and the opportunist who sees potential gain where others do not. This is an issue even in societies which discourage such behavior, for no individual's socialization is ever completely successful. However, this aspect of technological diffusion lies outside the scope of this essay.
 - 6) The analysis of the weaknesses of Tokugawa land surveys which follows summarizes data contained in two previously published articles, Philip C. Brown [1987, 1989]. Readers may consult them for more detailed references.

2. THE TRADITION OF MENSURATION AND ITS SHORTCOMINGS

Widespread land surveying in the early modern era began in the late sixteenth century. The story of these land surveys is usually told strictly within the context of Toyotomi Hideyoshi's *Taikō kenchi*.⁷⁾ These surveys presumably marked a new standard in thoroughness and precision in land measurement and registration. Scholars widely argue that these surveys established nationally uniform methods of land survey and registry.

One method, the crossed rope technique (*jūji nawa*) was widely employed, but, contrary to standard conceptions, it was not the only method of land measurement employed. In the crossed rope technique, surveyors stretched two ropes across the field at right angles so that each end of the line bisected a side of the field. The length of the lines was measured and field area computed.

Two other styles of survey, the circumferential survey (*mawari kenchi*) and the estimation of area by sighting (*ikenchi*) were also widely employed at this time. Triangulation was used in some circumferential surveys. Nonetheless, its use was not widely encouraged. In the case of the sight estimates, surveyors made no formal measurement.⁸⁾ Other variants were employed as well, but these three were, to the best of my knowledge, the most widely used.

Significant imprecision was associated with several survey practices. In the case of the crossed rope technique, no effort was made to measure along the boundaries of the fields being surveyed. In other instances, rounding practices introduced substantial error. In all cases in which actual measurements were made, hemp ropes were employed. One well-recognized problem with them was that they stretched 1) with use and 2) stretched or contracted as they became wet with dew, rain and paddy water, and then dried. Constant checking was necessary to ascertain the degree to which the ropes had stretched and to make adjustments.⁹⁾

In addition, surveyors knew that more accurate techniques of measurement were available; but their use was actively discouraged. A major manual of local administration, *Sanpō jikata taisei*, encouraged administrators to avoid fastidious measurement. It cautions, "Regarding all land area measures (*jitsubo*) there is to be no argument over small differences of increase or decrease [MURAKAMI AND ARAKAWA 1976: 23]." In the measuring of the smaller, irregularly shaped areas, another master of surveying, Ishiguro Nobuyoshi, in *Kenchikata hissho*, urged that measurements not be too precise. He argued that a balance must be maintained

7) The most comprehensive effort to examine Early Modern Japanese land surveying is Kanzaki [1983].

8) This kind of estimate need not be highly inaccurate. A well practiced specialist could be relatively precise. This form of "measurement" was widely employed in the early years of the Early Modern era even in Europe [A.W. RICHESON 1966: 34-35].

9) One other practice was to wrap the measuring line in copper tubing (*kudanawa*). As the rope stretched, space opened between the tubes indicating that adjustments were required.

between accuracy and speed. This admonition takes on added significance in the context of his admission that techniques for measuring curved areas were known, but that they were not employed.¹⁰⁾

More precise measurements had been employed for many years in China. The Chinese (and Japanese) were long aware of the value of right triangles as a tool in measurement [NEEDHAM 1959 3: 95-]. A reasonable approximation of *pi* had been calculated by the eighth century [NEEDHAM 1959 3: 100-101]. Furthermore, the Chinese also offered Japan models of quantitative cartography [NEEDHAM 1959 3: 106ff]. Modern trigonometry was available in China and Japan by the early seventeenth century and devices long available were employed in the early nineteenth century in coastal defense, especially after Perry's arrival.¹¹⁾ Calculus, in the form of "packing" problems and the *enri* calculus, was present in the seventeenth century and widespread by the eighteenth [NEEDHAM 1959 3: 142, 145]. Yet none of these techniques found widespread acceptance by Japanese surveyors.

Much of the instrumentation for angle measurement was available from the field of navigation. In addition to the Chinese tradition, Western measurement and navigational techniques arrived in Japan by the late sixteenth and early seventeenth centuries. One prominent, widely (but secretly) circulated manuscript on navigation, the *Genna kōkai ki*, was devoted largely to an explication of these techniques. Triangulation, the basis for more precise area measurement, was employed in other fields—large-scale map-making, castle, mine, and irrigation construction, for example—throughout the early modern period, but not in land surveys.

A variety of instruments for measuring angles accompanied these techniques to Japan. Just as with firearms manufacture, Japanese engineers not only produced telescopes, astrolabes, and related instruments, they were adroit at perfecting them, combining one or more instruments and building upon received technical concepts in a variety of ways.¹²⁾

Nonetheless, it would be a mistake to assume that more precise measurement was only possible with the adoption of modern calculus and sophisticated instrumentation. European surveyors greatly improved the precision of their measures by adopting a metal measuring chain in place of hemp ropes. With this simple tool and triangulation they measured land area precisely enough to consider as unacceptable errors of 3 percent - 5 percent. European surveyors improved precision by employing a variety of mathematical checks on calculations. They furthermore used methods of measurement which were easily replicated and

10) MS., Toyama University Library, Kawai monjo, Ume no yon. See folios 31 and 3 respectively.

11) [NEEDHAM 1959 3: 110]. In China, one of the most important early works was Matteo Ricci and Hsu Kuang-Chhi, *Tshe Liang Fa* I, 1607.

12) In these endeavors their work paralleled that of their European counterparts [RICHESON 1966].

checked by other surveyors.

In contrast, Japanese survey practices did not build in regular checks. In addition, they left surveyors great latitude of judgment and could result in substantial error. For example, surveyors were frequently permitted to adjust area measures downward when they felt that the preliminary results were overly strict.¹³⁾ Such practices rendered independent replication by others impossible.

3. THE "OBJECTIVE" NEEDS FOR INCREASED PRECISION

Japan's rulers (both Shogun and daimyo) experienced a revenue crisis from the mid-eighteenth century, which provided a significant incentive to adopt more precise survey methods. Despite increasing crop yields and signs of a growing rural economy, domain lords were unable to tax these potential revenues effectively. Expenditures consistently outpaced revenues, and administrators made up the difference through standard loans, forced loans, and reductions in retainers' stipends.

Land taxation was the principal source of revenue for domain administrations, and the major purpose of land surveys was to register land for taxation, to assess its value and to determine which village was responsible for paying the taxes on it. (From the rulers' perspective land tax payment was a corporate responsibility, not an individual one.) Actual taxes due were widely computed based on tax rates established through either annual crop inspections (*kemi hō*) or a fixed tax rate (*jomen hō*). The tax rate was multiplied by the value of a village's land to compute the taxes due. The more complete and accurate the measurement of land area, the more realistic were the land tax rolls. Large-scale re-survey of Japan using more precise measuring techniques would have contributed to more complete and accurate tax registers and improved land taxation.¹⁴⁾ However, this trend never developed.¹⁵⁾

In addition to these administrative functions, two other activities usually associated with an increased need for surveys should be mentioned: widespread sales of land or superior land use rights, and the growing practice of mortgaging land.¹⁶⁾ Although the sale of land and land use rights was prohibited in many parts of Japan in the early to mid-seventeenth century, this prohibition proved highly

13) The practice was called *yōbu*.

14) Nineteenth century tax registers for villages in the domain of Kaga list land lost from cultivation for clearly temporary reasons which, instead of being restored quickly to taxable status, remained untaxed for many years. This became a major source of irritation to the domain's rural administrators, the *Kaisaku bugyō*. See also below, the discussion of the Meiji land tax reforms.

15) Some scholars would object that the rural classes were already sorely pressed by excessive taxes; however, the substantial increases in land on the tax roles and, in many provinces, significant increases in land tax revenues which accompanied the Meiji land tax reforms suggests that this often was not the case.

unsuccessful and many domain lords reversed their policy about a century later. From the early eighteenth century, such sales became common. Along with the relaxation of the prohibitions on the transfer of land and superior land use rights came an increased use of land as security on loans. In the West and elsewhere, such developments often encouraged the practice of land surveying and improvements in measuring techniques as part of the process of clearly defining what piece of land had been bought, sold, or pledged as security. We might well expect the same trend to have developed in early modern Japan.

4. EXPLAINING THE DECISION TO RETAIN TRADITIONAL METHODS

Several socio-cultural factors discouraged use of more precise survey methods. The first centers on samurai conceits that they were above the sharp calculations of commoners. They were not supposed to concern themselves with details of petty gain and loss. This did not mean that they were completely uninterested in mathematics and measurement, but that they felt themselves to be above haggling over small amounts of money or numerical differences. Certainly they learned mathematics and measurement for the purposes of warfare and the construction of public works such as castles, mines, and irrigation works.

Second, (and reflecting the influence of samurai conceits) the nature of education impeded acceptance of more precise techniques. Throughout the early modern period, formal education was dominated by and served the purposes of samurai more than commoners. It failed to transmit new and more effective measuring and mathematical skills to surveyors.

The impact of poor mathematical education for samurai was magnified by the fact that commoners were largely limited to learning surveyors' skills on the job, as assistants to samurai in the official domain surveys. They largely learned only what was employed in that context. By the middle and late early modern period that situation had begun to change (witness the prominence of such commoners as Ishiguro Nobuyoshi, in the field), but on the whole, samurai influence in land surveying remained dominant.

Third, problems in surveyor education were aggravated by government censorship. Bakufu officials did not want administrative uses of survey techniques

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- 16) Some land rights in early modern Japan approximated those of modern private land ownership. However, in many other regions, perhaps a third of the country, access to arable land was reassigned periodically through a lottery. Under this system (commonly called *warichi* or some variant of that term), control of the land lay with the senior members of the village—those who held shares which entitled them to use the land and/or lease it out. These shares, subject to the same policy restrictions as outright sale of land, were traded like shares of stock. These rights to manage land I refer to as "superior land use rights." I am not referring to the rights of those who rented land from another. For an overview of *warichi*, see Aono [1982].

discussed in public.¹⁷⁾ Under the guise of "respect authority; despise the people (*kanson minpi*)," the mysteries of official practice were not to be released to the public domain.¹⁸⁾

Fourth, the market for surveys was very narrow. It was highly segmented by domain, and even by district or village. Within each domain there were, practically speaking, only two employers of surveyors: the domain authorities and villages, acting as corporate entities.¹⁹⁾ While individual sales and mortgages were common, surveys never became a part of either process prior to the Meiji Restoration of 1868. The absence of surveys from these processes is, I believe, a function of the legal context within which these transactions occurred and which I shall discuss shortly. For the moment, I simply wish to emphasize that these omissions limited the market for surveyors to domain and village administrative functions.

Among the domain lords there were no sales of land nor did they pledge their domains as collateral on loans.²⁰⁾ Villages, as corporate entities, also did not generally engage in land sales or mortgaging of land. Some conducted surveys as part of land repartition practices (e.g., *warichi*) or for other administrative purposes. If these various administrative bodies were satisfied with survey methods, there was no incentive to increase survey accuracy.²¹⁾ In the case of village-run surveys, all whose land was the object of a measurement resolved differences during the process. In this context, the survey event was a venue in which fairness was negotiated; the methods of actual, precise measurement were not seen as objective, rigid arbiters of fairness in themselves (as was true in England, for example, at this same time).

Comparison of Japanese and British uses of land surveys helps to explain the impact of limited demand for the surveyors' skills. British surveyors were employed to present evidence to royal courts in order to resolve competing claims over private landholding rights. Surveyors operated in a competitive market as individual businessmen, not as appointees in a domain or village monopoly. Over time, competition pressed surveyors to develop more precise techniques. Accurate

17) See the introduction to *Sanpō jikata taisei*, which describes Bakufu efforts to suppress its publication in 1837 [MURAKAMI AND ARAKAWA 1976].

18) This was true even after the eighth Shogun, Yoshimune, lifted the ban on foreign books and the Dutch-influenced school of land measurement grew after the early eighteenth century. Even under these circumstances these traditions were largely transmitted in secret. Kawamura Hirotda [1992: 57, 62].

19) In some domains villagers conducted frequent surveys for their own purposes. These surveys were conducted either by a domain bureaucrat or cooperatively by the villagers. In neither case was there competition for the work or any other incentive to increase accuracy.

20) They did pledge future tax yields as loan guarantees, however.

21) In my experience, there is no indication that they were dissatisfied with survey methods, although they were sensitive to the possibility that villagers had hidden land or mislead officials about crop yields.

boundary demarcation and precision measurement had immediate consequences for the client. The more reliable and incontestable a surveyor's measurements in court, the greater his chances of employment.

By contrast, in Japan conflicts between lords (*daimyo*, *Hatamoto*) over land were usually settled by fiat of the Tokugawa house, without surveys. Large-scale surveys of domains were largely completed by the late seventeenth century and were never undertaken again until the 1870s.²²⁾ Surveys were required to register newly cultivated land, to settle disputes between villages, or to adjust land registers when land was lost from productivity. Yet each of these jobs was for a single client, the domain lord, and they were completed by his servants rather than contracted to competitive private surveyors.²³⁾ Among them there was little sense of urgency about improving precision or even recognition that it was possible. In effect, there was little room for an aggressive innovator to make a mark.

The persistence of traditional practices suggests (among other things) an inability to identify the potential contribution of improved measurement techniques.²⁴⁾ In the area of revenue raising one even detects a degree of frustration about the prospects for extracting more revenues from cultivators. There was a shift away from trying to increase tax yields on agriculture toward developing (largely unsuccessfully) new sources of revenues (e.g., forced loans, *goyōkin*). These developments also suggest the availability of comparatively cheaper (in terms of both financial and social costs) alternatives, and these may have provided domain lords some elasticity in their use of land surveys and the land tax.

Fear of farmer revolts may have played a role in the attempt to exploit other potential sources of revenue. Samurai control over the villages, vigorous in the early seventeenth century, relaxed with the passage of time. Throughout most of Japan samurai moved out of the countryside and into castle towns. There they lost regular contact with, and knowledge of agriculture. Their attention focused more on the delights of urban life than on effective, detailed oversight of village conditions.

I would like to suggest, however, that the failure to develop better survey methods itself might have contributed to villagers' discontent with surveys as well as the ability of the samurai class to tap agricultural resources. In contrast to the British recognition that precise measurement and boundary demarcation could

22) I believe that even these early surveys were very rough estimates of land area and that they suffered from the arbitrariness I discuss below [BROWN 1993: especially chapter 3].

23) The scale of such surveys was quite limited, often to part of a village.

24) Kawamura [1992: 57] suggests that a simple method was necessary for the work of conducting surveys for land taxation purposes. To argue in this fashion seems to me to beg the key question. It takes the initial methods of surveying as severely restricting future developments rather than exploring the social and perhaps political contexts which might explain why more sophisticated methods were not adopted and why known advances did not spread.

promote an objective standard that would provide a foundation for settling tax and boundary issues, Japanese villagers and administrators never developed similar confidence in such a standard. Yet continued use of old methods fueled rural hostility toward authorities because it maintained all of the arbitrariness, manipulability and unverifiability of the late sixteenth and early seventeenth century land surveys. These surveys were not replicable and their outcome was unpredictable. They lacked basic checks on internal consistency and accuracy. Survey outcomes were subject to a potentially high degree of variability, both from village to village and from one survey of a village to the next. Under such circumstances it is small wonder that villagers voiced protests over survey outcomes. Since a re-survey was likely to be unreliable, they had no effective appeal except through vociferous or violent protest.²⁵⁾

To this point we have considered questions of cultural values, the structure of the market for surveys, education/information flows and the like. An additional set of considerations lies in divergent class and bureaucratic relationships. Economist David Feeny stresses the role of class interests in hindering technological innovation in Thai agriculture. While his main concern is the development of irrigation systems, he also notes that well into the twentieth century land surveying and the recording of deeds in a modern system of land registration proceeded only in those areas in which the political and/or economic interests of local and national elites coincided.²⁶⁾ Feeny's analysis suggests that any attempt to understand the development and diffusion of technology (as well as institutions) must consider the question of who will benefit from the innovation. At a very general level of analysis we often presume that there is either a congruence of interests favorable to adoption of the technology or that the people desirous of implementing the change face no serious opposition (e.g., the opposition of labor to the introduction of labor-saving equipment). Yet this frequently is not the case.

Land survey practices Early modern Japan present examples of the impact of conflicts in social and economic interests on adoption of new technology at three different levels. First, at a national level, Hideyoshi's attempts to implement uniform, precise measuring techniques and to demand actual measurements were of questionable effectiveness. Domain lords manipulated measuring systems,

25) One explanation for the origin of *warichi* is that tax-paying villagers needed to compensate for the inaccuracies and unfairness of domain surveys [RICHESON 1966: 29-30]. See also Brown [1988: 369-401] on other evidence of the loss of samurai control of the countryside.

26) [FEENY 1988: 159-209, 1982]. In the latter, see especially pages 95-97. Feeny [1982: 97-98] argues, "Movements in the private rate of return for the elite for making the change and the rate for the society as a whole did not diverge, and as a result the changes were made." Property rights in land became more attractive than those in people (slavery) as a result of changing economic conditions, but also because of changes in the rivalries between the king and princes. Feeny contrasts this situation, in which the interests of society and the elites coincided, with that of irrigation, where they did not.

techniques, and land values to suit their own political and economic purposes. These included jockeying for social status and minimizing financial obligations to Hideyoshi and the Shoguns who followed him by manipulating assessment and measuring systems.²⁷⁾

Second, during an on-sight survey, there were incentives for surveyors to maintain those practices which allowed them to exercise their own judgment and protected them from checks on their accuracy. For example, as previously noted, surveyors were widely allowed to make adjustments of up to 20 percent in the area measured in order to compensate for purportedly over-stringent measurements. This provision presented the survey magistrate an opportunity to manipulate figures to engage in a bit of extortion or to respond to bribes from villagers (who, we might note, could also initiate and benefit from this practice).²⁸⁾

Third, intra-village surveys raise the question of "who benefits?" from a somewhat different perspective. As noted previously, there was a widespread market among villagers in both land and credit, yet this market never relied heavily on surveyors to demarcate precisely the boundaries of land traded or pledged as collateral. Land sale documents simply include the value of land, not detailed descriptions of its location and precise dimensions. This appears to reflect two considerations. On the one hand (and with the exception of very large absentee land holders, for example), most of the transactions were between local residents who knew the layout of fields well. From this perspective, surveys were not needed. Further, most transactions were small and did not involve plots sufficiently large so as to be hard to estimate, and with the exception of cases of secretly altering field size by incremental moving paddy ridges (a process called *kirisoe*), surveys had no significant role to play.

Fourth, at the village level, any disputes over land were settled within a legal context that emphasized compromise rather than determination of absolute "right" or "wrong". In contrast to the British reliance on royal courts to resolve land disputes, in Japan intra-village disputes generally were resolved through local compromises, not by formal legal action. Suspicion of the lord's courts and officials was very high. If domain officials entered a village there were no institutional restraints on the range of their investigation. They could enquire about any subject that piqued their curiosity. The risks of their deciding that the

27) In Brown [1993], I present evidence on this point. See especially Chapter 3.

28) I can not document an instance of this practice, however, domain authorities widely recognized the potential for officials to extort special benefits from villagers. At least as a preventative measure survey regulations frequently enjoined officials from accepting special gifts. In the context of *yōbu*, there might be a difference of opinion among two different surveyors in the unusual instance of a second survey, but it was not likely to result in a clear-cut finding of malfeasance. Since villagers benefited from this kind of "flexibility" they were not likely to report it and the domain had little basis for questioning the work of its survey crew. If I am correct in these judgments, this kind of manipulation of survey results was virtually undetectable.

village owed more taxes or labor dues was too great to invite them into the village unless it was absolutely necessary. Courts represented a last resort, used only when repeated negotiations had failed.²⁹⁾ In this negotiating context, strict adherence to legal principle and the promotion of rigorously objective criteria, such as accurate land measurement, took second place to a procedural flexibility conducive to maximizing chances for intra-village settlement.³⁰⁾ Indeed, reliance on cold, precise figures was an obstacle to successful dispute resolution in this context, for it discouraged compromise.

This same argument applied when two people from different villages engaged in a dispute. If they and the officials of the two villages involved could not settle the dispute, the domain courts sought solutions with which all could live rather than to impose an absolute standard as a resolution to the conflict. This reasoning was extended to dispute settlement among domain lords and other cases which might appear in Shogunal courts.

Finally, we must bear in mind that the years after the beginning of the seventeenth century were peaceful for Japan. The kinds of interests which created inertia in Japan—the self-interest of surveyors and villagers, the problems with education, etc.—all existed in some degree in early modern Europe, too. Yet one of the primary currents which forced statesmen to overcome these forces was the financial demands created by frequent wars.³¹⁾ Such demands were absent in Japan. Financial problems there were, but they were not associated with a threat to national viability. At least until the nineteenth century, the inconvenience of budgetary problems did not seem such a large threat as to call for measures which challenged the established positions of low-level officials and village landholders.

5. THE DEMISE OF TRADITIONAL MENSURATION

The domestic and international pressures that undermined the Tokugawa Bakufu in the mid-nineteenth century encouraged Meiji leaders to reconsider the financial and social foundations upon which samurai dominance had rested. Heretofore Japan had not had a fully centralized national administration. There were no regular nation-wide taxes and although there were hints of a nascent

29) There is substantial evidence to indicate that by the nineteenth century the villagers' reluctance to use domain courts had broken down considerably; yet inviting officials into the village was different from taking a matter before a "judge" in his office and must have remained a last resort even in the late Edo period.

30) The emphasis on compromise maintained a degree of harmony within communities which needed to cooperate in many economic and ritual activities. Conflict involved irrigation and management of common lands from which firewood, green manure, and special products were collected. Compromise may have failed to make any one party fully happy, but by minimizing the chance that a party would feel totally humiliated, the community laid a claim on his loyalty and cooperation.

31) For an excellent overview of the pressures of military conflict, see Tilly [1985: 169–191].

national bureaucracy (e.g., the Inspectorate or *ōmetsuke*, the gradually expanding role of the Shogunal courts and financial support to domains to build dikes and other riparian works), by the time of the Restoration none had been established. The new government, faced with what leaders saw as an imminent European threat to national survival, set about to form a true central government. A prerequisite to creation of a viable national government was the establishment of a predictable and secure flow of revenues. The threat to national security reduced administrators' sense of flexibility. With something of a "damn the torpedoes" attitude, they promulgated the Meiji Land Tax Reforms in the 1870s. These measures met the revenue needs of the government and created an environment that ultimately stimulated the adoption of modern survey methods.

The Restoration leaders adopted a system of land taxation and tenures similar to the English system, in which land taxes were based on the market value of property rather than its putative yield (*kokudaka*). Under the new statutes, responsibility for paying taxes was removed from corporate villages and placed directly on individual landholders. All the arable land in Japan was re-measured and revalued. Official land area figures increased by almost 49 percent in the course of the tax reform.³²⁾

Yet actual implementation of modern, precise survey methods took Meiji officials some time. At first, old Tokugawa documents were employed and surveyors used traditional techniques when they made actual measures. Only during the second decade after the commencement of land tax reform did modern techniques and instrumentation come into widespread use. Regulations requiring their use were not issued until 1884.³³⁾ Current evidence suggests that this change in government policy was the major stimulus to adopting modern measurement techniques. Nonetheless, with tax law now emphasizing individual (rather than joint village) responsibility for tax payment, the rural landowners shared with the central government a clear, general need to employ more precise survey procedures. The adoption of modern financial systems, with banks removed from the local community and lenders requiring more rational-bureaucratic mortgage practices, also supported improvement in measurement precision. At the same time, the abolition of legal class distinctions, increased freedom of geographic movement, and modern education now provided a new source of surveyors outside the samurai class and opened the field to broad competition.

32) [FUKUSHIMA 1968: 246]. There were regional variations, but the aim of reforms was only to stabilize revenues. Nationwide, land tax revenues did not rise despite increases in land area on the tax registers. Japan's leaders softened the blow of more efficient registration of land by lowering the average tax on each *tan* of land.

33) See Fukushima [1968: 266–267] and Arimoto [1968: 216].

6. FINAL OBSERVATIONS

The persistence of imprecise early modern survey practices suggests the role of cultural influences on the selection of technology. It hints at an explanation for why a relatively small proportion of available technologies, many equally implementable and cost-effective, are never adopted at all. We can not adequately understand technological development and diffusion by studying only the "success" stories and (by implication) deprecating the abilities, foresight, or sensitivity of those who reject a technology which in other contexts proves acceptable. To assume that unadopted technology did not meet an objective need or that it was somehow faulty is not always reasonable. In some cases such an analysis may be appropriate, but in others, other social needs with which the technology was not designed to cope, social values, and vested interests simply took precedence. From these perspectives we may suggest that some important actors benefited from the rejection of the technology.

Benefits from the existing system of early modern land measurement most clearly accrued to disreputable surveyors, villagers who successfully bribed them or in other ways benefited from their mismeasurements, and the leadership and taxpayers of the communities which retained control of their own affairs at the expense of daimyo overlords. Even rulers who might have gained a more accurate basis for assessment of land taxes had some flexibility in avoiding additional investments in measurements and the substantial institutional changes required to support new techniques—as long as they were protected from the larger threat of conquest. They also escaped the popular discontent that re-surveying might pose, but that risk in itself might have been minimized if lords had introduced more reliable survey techniques in smaller tasks—a relatively low-risk way to demonstrate that there were measuring methods that could produce consistent results.³⁴⁾

Socio-cultural factors appear to have been able to play a large role in this case because 1) there was substantial elasticity of demand for surveys; no sudden, severe financial crisis or pressure of war forced a challenge to vested interests which were well served by the existing state of affairs; rejection of the new technology defined a successful outcome in the short run; 2) benefits of more precise measures were not well demonstrated over the course of the era in the existing context of use; and 3) a large number of intervening educational, legal-administrative, and financial institutions would have had to be created to train practitioners in the use of the new technology.³⁵⁾

34) For still another perspective on the question of defining "successful" technological diffusion in the context of social violence, see Roumasset and La Croix [1988: 315–336]. The authors examine the successful adoption of strong property rights in Hawaii and their role in promoting despotic control by native Hawaiian leaders and an increase in warfare using modern arms.

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- 35) The issue of cultural influence arises in all societies—non-industrial and industrial alike. It is evident in the modern world in a whole array of technologies from simple items like toothbrushes to much more complex tools such as personal computers and the adoption of new, fertilizer-intensive strains of seeds. The role of advertising, entrepreneurial abilities, and related activities in product development and sales, and in organizational success in these activities attest to the manipulability of “need” and “demand.” Based on the example of early modern land survey techniques, we can hypothesize that these manipulative influences would most likely be effective in those situations in which 1) there was relatively great elasticity of demand; 2) advantages of new technology could not be well verified in the short run; and 3) the new technology would require little reconstitution or creation of intervening institutions such as schools or legal codes.

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