Agricultural Productivity in Eastern Europe and Western Asia in the Fifteenth and Sixteenth Centuries

Metin M. Coşgel

Economics Dept., U-1063
The University of Connecticut
Storrs, CT 06269-1063

Tel: (860) 486-4662
Fax: (860)486-4463
Email: Cosgel@UConn.Edu

For presentation at the conference:

"Towards a Global Study of Prices and Incomes"

Utrecht, August 19-21, 2004

Agricultural Productivity in Eastern Europe and Western Asia in the Fifteenth and Sixteenth Centuries

Metin M. Coşgel

ABSTRACT: This paper provides standardized estimates of labor productivity in arable farming in selected regions of eastern Europe and western Asia during the fifteenth and sixteenth centuries. The regions include Jerusalem and neighboring districts in eastern Mediterranean; Erbil in northern Iraq; Bursa, Antep and Mardin in Asia Minor; and Thessaly, Hercegovina, and Budapest in Europe. Data from the tax registers of the Ottoman Empire are used to construct estimates of grain output per worker, standardized (in bushels of wheat equivalent) to allow productivity comparisons between regions and over time. The results suggest new areas of research to understand the nature, causes, and consequences of variations in productivity.

Economic historians have long tried to determine how agricultural productivity has varied over time and between societies. The magnitude of variations in productivity is often at the core of such important historical debates as to whether there was an agricultural revolution, when and where it happened, and how the standard of living has varied among societies. Identifying the variations in productivity is also required to be able to determine the divergence of incomes and reversals of fortune in history and to examine the effects of climate, resources, technology, and institutions on productivity.

Although economic historians have recently developed several innovative methods for measuring agricultural productivity, they have had limited success in producing reliable estimates for the pre-1800 period outside of northwestern Europe. Some of the pioneering studies in the field, such as Overton's (1979) method of extracting information from probate inventories, Clark's (1991a) method of estimating productivity from payments to workers for different types of tasks, and Karakacili's (2004) direct measurement of arable workers' labor productivity before the pre-industrial period, have focused exclusively on English agriculture. Although there have been various attempts at comparing agricultural productivity between nations or regions, the lack of reliable sources has restricted these comparisons either to the period after 1800 or to places in western Europe. For example, Bairoch (1975, 1976) used the production of vegetable-based calories as an index to compare the level of agricultural development in various parts of the World, but only since 1800; and Wrigley (1985) pioneered the method of using the proportion of population engaged in agriculture to estimate comparative productivities going back to 1500s, but only within western Europe. The progress in measuring agricultural productivity has had limited success in producing reliable estimates for places beyond western Europe for the pre-1800 period.

This paper aims to fill this gap by estimating agricultural productivity in eastern Europe and western Asia during the fifteenth and sixteenth centuries. By mid-sixteenth century much of this region was under the control of the Ottoman Empire. The Ottomans carefully to recorded and preserved detailed information about all taxpaying subjects and taxable activities under their control, providing the historian a wealth of information for studying the economic history of these lands (Coşgel, 2004a). I use this information to measure the outputs and labor inputs of arable farming in various representative regions of the Empire and estimate the range of grain output per worker in each region. To facilitate regional and temporal comparisons of productivity, I convert local measurements and currencies into standard units and report final estimates in bushels of wheat equivalent. Because primary or secondary sources did not always provide direct information on some parameters of the estimation procedure for some regions, several simplifying assumptions had to be made to generate the first set of systematic, comprehensive, and comparable estimates of labor productivity in these regions. The sources, methods, and simplifying assumptions of the estimation procedures are provided in detail to allow future researchers to improve on these estimates.

Standardized estimates of labor productivity presented in a comparable format should benefit various areas of research in Ottoman and general history alike. Economic historians of the Ottoman Empire who specialize in other regions or time periods can follow, and if necessary revise, the procedure proposed here to estimate productivity in those regions or times. The results also suggest new areas of research, ranging from using these estimates in providing better answers to some of the old questions of Ottoman historiography to asking entirely new questions. By contributing estimates from eastern Europe and western Asia to the archive of known agricultural productivities in the world, the results will make it possible for the general historian to use these estimates for comparative studies of economic performance and living standards.

ESTIMATES OF LABOR PRODUCTIVITY IN THE OTTOMAN EMPIRE

The literature on agricultural productivity can be categorized according to whether the primary objective is to compare productivity among places, over time, or both. Studies in the first group typically focus on productivity differences between nations or regions at some fixed point in time, seeking to explain what caused these differences (Clark, 1987). Those in the second group chart the growth of productivity in a fixed place, identifying periods of significant growth and explaining their causes and consequences. For example, the problem of identifying the nature, timing, and causes of the agricultural revolution in England has been at the center of one of the well-known controversies in economic history, generating a debate between those who argue that an agricultural revolution accompanied and even contributed to the industrial revolution of the late eighteenth century and those who either view the event as happening much earlier or not happening at all.[1] Studies of the third type essentially combine the first two approaches by comparing how the growth of productivity varied over time between nations. Influential studies of productivity by Bairoch (1965) and Wrigley (1985), for example, compare the growth of labor productivity among nations to understand differences in patterns of urbanization and industrialization.[2]

This study will aim to contribute to this literature in all three dimensions. There are numerous historical questions of global importance that require reliable estimates of agricultural productivity in eastern Europe and western Asia for answers. If one of the fundamental tasks of economic history is to understand the nature and causes of the rise of northwestern Europe, the other is to understand why close neighbors and trading partners in eastern Europe and western Asia lagged behind. Having reliable estimates of agricultural productivity for these regions would make it possible to observe how incomes and productivity differed from northwestern Europe before the Industrial Revolution and whether and how fast productivity grew over time. By comparing these trends with northwestern

[1] See, for example, Allen (1999), Clark (1999), and Overton (1996).
[2] For a more recent comparative study of this type, see Allen (2000).

Europe, we can examine whether there was a significant gap in productivity, when and why it started, and whether there was a direct causal relationship between the growth of agricultural productivity and the rise of industry in these regions.

Information about agricultural productivities in this region can also help to answer some of the important questions of Ottoman history. By mid-sixteenth century the Ottomans had built a vast Empire that controlled the lands between the Crimea in the north to Egypt and the Arabian Peninsula in the south, and between the Persian Gulf in the east to central Europe and North Africa in the west. There are numerous differences between these regions in climate, natural resources, institutional history, and ethnic and religious composition, which naturally invite questions about comparative performance. For example, how different were the incomes and productivity between Asia Minor, Arab lands, and eastern Europe?

There are also questions about how the performance of the Ottoman economy changed during the sixteenth century, generally considered to be the height of the Empire's long reign of six centuries. Historians generally agree that the sixteenth century was a period of demographic growth and economic expansion in the Ottoman Empire. It is not clear, however, whether this growth and expansion also meant an increase in the economic performance and living standards of Ottoman subjects on average. Did incomes and labor productivity, for example, also rise during this period? In a pioneering analysis of the wages of construction workers in Istanbul and other Ottoman cities, Özmucur and Pamuk (2002) have shown that real wages actually declined during the sixteenth century, a trend similarly observed in other European cities as well. This raises the question of whether rural incomes and labor productivity also displayed a similar trend, a question that requires estimates of labor productivity for an answer.

Estimates of productivity would also help to contribute to the recent debates surrounding the performance of the Ottoman economy after the sixteenth century. Whereas previous generation of historians spoke of an Ottoman decline during this period, recent scholars have rejected the notion of a decline, seeking to revise or reinterpret the periods of Ottoman history. Despite being involved in an essentially quantitative debate on performance, however, participants on have been unable to offer direct quantitative evidence to substantiate claims about the long term performance of the Ottoman economy. Although Özmucur and Pamuk's (2002) study of long term trends in real wages may help settle some of the issues in the debate, other issues will remain because urban wages tell only part of the story for a primarily agrarian state like the Ottoman Empire. To start learning about the rest of the story, we need to estimate labor productivity in agriculture during this period and establish the benchmark against which later developments can be compared.

Despite the high demand for comparable estimates of productivity in the Ottoman Empire, the demand has not yet been met satisfactorily by systematic, comprehensive analysis of available sources. Although historians of the Empire have published numerous studies to examine agricultural taxes and production in various districts, they have generally refrained from making temporal or spatial comparisons of productivity. Despite McGowan's (1969) early exception to this trend, regional historians have typically chosen to limit their analysis to the geographic boundaries and local measurement units of the sources, rather than produce estimates of output and productivity in real, standard, thus comparable units.

SOURCES OF DATA

Studies of Ottoman economy during the fifteenth and sixteenth centuries typically use the tax registers known as *tahrir defterleri* for source. Conducted upon conquering new lands and updated periodically, these registers are the outcome of the government's attempt to have current information on sources of revenue. They contain detailed information about tax-paying subjects and taxable resources, including the names and legal status of adult males and estimates of tax revenues from productive resources and activities in all villages, towns, tribes, and other taxable units in a district. Although the Ottomans discontinued conducting new registers in most districts after the sixteenth century, they nevertheless preserved existing registers and relied on them for various decisions of government finance. Hundreds of registers have survived from as early as the 1430s, available to researchers in various archives in Turkey and in other countries that were once under Ottoman domination. There now exist registers of regions ranging from Asia Minor and the Balkans to Syria and Palestine in the south, Georgia in the northeast, and Hungary and Poland in the northwest, altogether forming an indispensable series of documents for studying the economic and social history of eastern Europe and western Asia (Coşgel, 2004a).

For a comprehensive analysis of agricultural productivity in the Ottoman Empire during the fifteenth and sixteenth centuries, I use data from the tax registers of various regions of the Empire that represent its geographical diversity during this period.[3] These regions include Gaza, Jerusalem and southern Syria in eastern Mediterranean, Erbil in northern Iraq, Bursa,

[3] Sources of data are the Ottoman tax registers numbered 5, 23, 44, 64, 111, 113, 161, 186, 345, 365, 373, 388, 410, 449, 453, 507, 549, 580, 970, 1050 in the Prime Ministry Archives in Istanbul; and 67, 68, 69, 72, 75, 80, 97, 99, 100, 101, 106, 112, 142, 164, 181, 185, 192, 570, 580, 585 in the Cadastral Office in Ankara. Contents have been published by İlhan (1994-95), Özdeğer (1988), Alicic (1985), Bakhit and Hmuod (1989a, 1989b), Balta (1989), Barkan and Meriçli (1988), Bayerle (1973), Delilbaşı and Arıkan (2001), Fekete (Lajos), Göyünç and Hütteroth (1997), Hütteroth and Abdalfattah (1977), Kaldy-Nagy (1971, 1982), McGowan (1983), Ünal

Antep and Mardin in Asia Minor, and Thessaly, Hercegovina, and Budapest in Europe.[4] For some of these districts, tax registers are available for multiple dates, making it possible to examine both temporal and spatial variations in productivity.

Since estimating the expected tax revenue was the primary purpose of the tax registers, information was not always recorded in ways that allowed direct estimates of agricultural production. For example, enumerators entered the tax amount as a lump sum payment for some villages, making it impossible to individually estimate the outputs of productive activities. They similarly recorded incomplete information about some resources or activities, or recorded potential sources of revenue (such as from ruined mills or uninhabited lands called *mezra'as*) that could have been idle at the time of the registry. To keep only the relevant and accurate information about agricultural production, I thus omitted those fiscal units that made a single lump-sum payment for taxes, did not provide sufficient information on inhabitants or agricultural taxes, or consisted of ruined or unemployed resources. I also omitted towns, nomadic tribes, and other fiscal units that were not rural settlements engaged in agricultural production. Remaining data thus consists of only inhabited villages for which complete information was available to estimate agricultural production.

Table 1 presents summary information about the villages included in the data for the selected districts, some at multiple dates. For each district and date, the table shows the number of villages included in the data set and the mean and standard deviation of the number of households in these villages. There is a clear upward trend in the average number of households over time, as can be seen in districts for which we have data for multiple dates.

(1999), Yinanç and Elibüyük (1983, 1988). The data for Maraş, Srem, and Trikala are systematic samples of the population. The data for other districts are full samples.

[4] For easier recognition, I use the current English names, rather than those used by the Ottomans, for these regions.

In the second half of the sixteenth century, villages in the Çemisşezek region and eastern Mediterranean stand out as the most densely populated. Villages in the Trikala district in Thessaly also stand out as heavily populated in the fifteenth century.[5]

THE PROCEDURE FOR ESTIMATING LABOR PRODUCTIVITY IN GRAIN FARMING

To estimate labor productivity in agriculture, economic historians have either used indirect measures based on aggregate data or measured productivity directly from disaggregated data at the farm or village level. Well-known in the first category are Bairoch's (1965) index based on the production of vegetable-based calories and Wrigley's (1985) index based on the proportion of population engaged in agriculture. Both indices have been variously used to compare productivities across time and nations. Direct measurements of productivity have used information about agricultural inputs and outputs recorded in a variety of documents, such as probate inventories and manorial rolls, to estimate yields and labor productivity (Overton, 1979; Allen, 1988a; Karakacili, 2004). Yields and productivities are usually reported in standard units of measurement to facilitate comparisons with other times and places.

With the ultimate objective of including places in eastern Europe and western Asia during the fifteenth and sixteenth centuries in the list of productivities available for comparison, this paper will generate direct estimates of labor productivity in standard units. Consistent with other studies of agricultural productivity, the focus will be on the arable

---

[5] In comparing the entries in Table 1 with current populations of these regions or with other time periods, one

sector (Karakacili, 2004: 27). Using tax registers as sources of information on tax paying subjects and taxable agricultural activities, I will estimate the grain output (wheat, barley, and other cereal grains and legumes) per arable worker. Although the values and physical quantities of output in the initial direct estimates will be in local units of measurement, I will report them in standard (Winchester) bushels of wheat for easy comparison with other parts of the world.

The Ottoman system of taxing agricultural production makes it easy to calculate the gross output of grains.[6] Taxes on grains were typically levied as a proportion of output, making the calculation of output a simple matter of multiplying the taxes listed in the registers by the inverse of the tax rate. But the difficulty lies in determining the equivalent of output in a standard unit. As seen in Table 2, the tax registers used a variety of local units for measuring grain, most common being *kile*, an Ottoman measure of volume. The standard *kile* was equivalent to 35.27 liters or 0.97 Winchester bushels.[7]

Although for their own accounting purposes the Ottomans tried to standardize units of measurement across regions or at least record taxes in units of standard *kile*, this was not always possible. When the local unit was different from *kile* or the local *kile* varied significantly from the standard *kile* and enumerators somehow had no choice but to record taxes in local units, they sometimes noted these differences in the tax code of the district to alert the treasury personnel or other users of the register. As long as this practice was followed, it becomes equally easy to use the appropriate conversion factor to calculate the standard equivalent of output.

---

has to keep in mind that district boundaries may have changed since the sixteenth century.

[6] For Ottoman system of taxation, see Coşgel (2004b) and Coşgel and Miceli (2004).

[7] As a measure of weight, the standard *kile* was equivalent to 25.65 kg.

The remaining problem is when the enumerators recorded taxes in different (non-*kile*) units or in non-standard *kile* without entering any information about how this unit differed from the standard *kile*. In Jerusalem and surrounding districts, for example, grain taxes were entered in units of *ghirara*, a commonly used unit in that region but one that could also vary locally (Lewis, 1952). Whenever available I used information from secondary sources to convert these units to the standard *kile*. But in some cases, no information is available from the registers or other secondary sources on how the local units varied. In the Mardin region, for example, *kile* clearly varied from one subdistrict to another (as can be inferred from the varying prices of products like wheat and barley), but in unknown ways (Göyünç and Hütteroth, 1997).

When no direct information was available about the local units used in a district, I determined the rates of conversion based on the price of wheat recorded in the registers and known conversion rates in neighboring districts at that time. For proportionally taxed products like grains, enumerators had to specify a price to convert physical quantities to nominal values in order to calculate the total tax revenue in each village. In cases of unknown conversion rates for a district, I compared the price of wheat specified in the registers of this district with the (standard) prices used in the registers of other districts for the same time period to determine whether the enumerators were likely to have used a standard *kile* for measurement. If the price appeared too low or high compared to known standard prices, I relied on comparable prices and conversion rates observed in the region to specify a rate of conversion for this district.

Table 2 demonstrates the procedure for standardizing the local units and measurements recorded in tax registers to standard equivalents. Entries in the Table show how the local prices and units have varied across Ottoman districts and how these prices have been converted to prices per standard *kile* and bushel for each district and date. The last column shows the sources used for conversions, whenever such information was available. The absence of a source thus indicates that a rate of conversion had to be constructed based on other information and assumptions. Of course, researchers familiar with sources not stated here are encouraged to supply the information and suggest revisions in the conversion table as necessary.

To determine the total output of grains, I used the price of wheat to convert the nominal values of all grains to their bushels of wheat equivalent. Because the products on the arable were typically subject to proportional taxation, enumerators entered both the quantity and value of expected taxes from these products for accounting purposes. Although the prices used for this purpose were simply the average prices of these products in the region, rather than local prices faced by each village, they provided sufficient information for enumerators to convert physical quantities to values. By reversing the procedure and using the same relative prices for calculation, we are able to convert the information about the nominal values of output into wheat equivalents.

The other variable we need to estimate in measuring productivity is labor. Although no direct information is available on the quantity of labor on the arable devoted to grain production, this can be estimated from the number of households. The tax registers did not include direct information on labor, simply because the Ottomans did not tax labor directly. Rather than tax unobservable labor of households, they based personal taxes on the household as a whole or on the observable characteristics of heads of households like land ownership and marital status. Although the rates and types of personal taxes varied between regions, the records related to them consistently included the names and numbers of heads of households.[8]

To transform the information about households into an estimate of the labor used in grain production, we need to specify the quantity of labor per household and the proportion of their labor devoted to work on grains, the multiplication of which would provide the desired estimate. Because the tax registers do not provide direct information on either of these quantities, however, it may be too optimistic to aim a reliable single estimate of the labor used in grain production. It may be a more reasonable to proceed cautiously and generate low and high estimates based on alternative sets of scenarios and simplifying assumptions.

Let us start by generating a high estimate of the range of labor. The quantity of labor in a household would depend on the size of the household and the effective labor input of each member of the family. The problem of determining the size of a household has been highly debated in Ottoman historiography. In his pioneering study of Ottoman population, Barkan (1953) assumed a household size of five, which later studies have generally found as being too high (Göyünç, 1979). Using this number as a high estimate of household size and assuming on average one member of the family to be ineligible to work (because of age or some other restriction), the total number of workers potentially available to perform all tasks in the household, including farm and domestic work, becomes four. Suppose on average workers in a family consisted of a man, a woman, a boy, and a girl, and denote the quantities of their labor by M, W, B, and G.

[8] Even though the registers also included the names and numbers of male bachelors, the age criteria for inclusion in this category was not always explicitly specified, making regional comparisons based on this inconsistent information questionable.

Effective labor could have differed significantly between age and gender groups. To consider these possibilities, use H to denote the units of standard "adult male equivalent" labor, such that H=M. Studies generally agree that the effective labor, including skill and physical strength, of adults was significantly higher than children, though differences between men and women have been a matter of dispute (Clark, 2003). To estimate such differences in England, Allen (1988b, 1991) uses information about the average annual earnings of these groups as recorded in Young's data for English rural society, and he finds the average earnings of boys to be about half of men's. Although Allen also finds a similar difference between the earnings of males and females, one might object to using this difference in estimating the total labor supply of the household available for all activities, because the difference could simply have been caused by such things as unpaid domestic labor and earnings differentials between specialized tasks. That is, it may not be legitimate for us to consider the earnings differences between men and women as an index of their overall marginal contribution to household labor supply, because it included not just farm work but domestic tasks as well. To construct a high estimate of the labor input per household, therefore, let us suppose that there were significant differences between adults and children but no differences between males and females. These assumptions imply M=W=2B=2G, with a corresponding estimate for the average labor supply per household equal to 3H.

To construct a low estimate of the household labor, let us consider different arguments about household size and male-female differences in labor input. Criticizing Barkan's household multiplier as being too high, other studies of Ottoman population have proposed lower estimates for the average size of a household. Although there is no direct evidence to substantiate these arguments for the fifteenth or sixteenth centuries, Göyünç (1979) was able to construct an estimate based on documents relating to migrants in the nineteenth century. His calculations show that household size was about 4, a figure we can use to determine a low estimate of family labor supply. Suppose an average family with four members could supply three workers: a man, a woman, and a child.[9] Suppose also that we accept differences between the earnings of men and women as an index of their effective labor inputs and that the differences Allen (1991: 487) found in England in the eighteenth century applied equally to the Ottoman population during the fifteenth and sixteenth centuries, such that M=2W. Supposing age based differences to continue to hold, these assumptions altogether give us the low estimate of household labor supply, equal to 2H.

The remaining issue is to determine the proportion of household labor devoted to grain production. Suppose for simplicity that labor is used for domestic or farming activities and that farming consisted of producing grains or other products. The proportion of labor allocated to grain production must have varied between regions, depending on differences in climate, topography, and other factors affecting regional specialization. Let *a* denote the proportion of farm labor devoted to grain production.

The proportion of household labor allocated to domestic tasks could also have varied by regions, depending on such factors as the size of farms, availability of alternative opportunities, cultural standards on the nature and amount of domestic tasks, the types and sizes of homes, and the division of labor between age and gender groups. Because sources do not provide direct information on domestic labor or on factors that could have affected its proportion in labor allocation, it may similarly be reasonable to proceed by generating low

[9] This would be consistent with Allen's (1991) assumption that each family supplied three workers. See also

and high estimates for this proportion. A high estimate of the proportion of labor devoted to domestic tasks could be one-half of the total labor supply, suggested by approximately equal populations of men and women and the hypothesis of complete specialization by men and women between farming and domestic tasks jobs. This gives us an estimate for the proportion of total labor for grain production as 0.5 *a*. A low estimate is suggested by a hypothesis of incomplete specialization, with asymmetric participation between men and women in each other's activities. More specifically, suppose that women participated more in farming than men participate in domestic activities to such an extent that the proportion of household labor allocated to domestic tasks was only one-third. The corresponding proportion of household labor for grain production would thus be 0.33 *a*.

These assumptions altogether give us the low and high points needed to estimate the total effective supply of household labor devoted to grain production. The low estimate is equal to (2 x 0.33) *a* H, and the high estimate is (3 x 0.5) *a* H. By determining the values of H and *a* in a village, therefore, we can calculate the low and high estimates of the labor used in grain production in the village. The value of H is simply the number households in the village (Table 1), recorded consistently by the tax registers across regions. The value of *a* can be estimated from the proportion of taxes from grains, assuming the ratio of taxes to labor supply to be the same between taxable activities.[10]

Table 3 shows the average α for each district. It also shows the corresponding low and high estimates of labor productivity, equal to the ratio of grain output to labor used in grain production. Of course, as with all first estimates of historical phenomena based on simplifying assumptions, these figures should be taken with some caution. Given the current

---

Clark's (1991b) criticisms of Allen's method.

[10] Personal taxes and occasional fees are excluded from the calculation of total tax revenue.

state of our knowledge of the Ottoman economy and society during this period, the primary objective of these estimates has been to lay the groundwork for a procedure to calculate labor productivity as accurately as possible. Further research is required to improve the procedure by replacing questionable assumptions with more reliable estimates based on direct evidence.

LABOR PRODUCTIVITY IN COMPARATIVE PERSPECTIVE

To see how these estimates help us to answer some of the questions posed earlier and to raise new ones, let us define an index of labor productivity. One way to summarize the calculations for comparative purposes is to define the index as the simple average of the low and high estimates of productivity for each region and date. Suppose also that we take the average productivity estimate for the villages of Bursa (1521), the capital city of the Empire before the conquest of Istanbul, as the base. Table 4 shows how the index varied within the regions and dates in the sample. It also shows how productivity in these regions compares with some of the estimates provided by others for labor productivity in England.

Given the numerous differences between these regions and time periods, it is not surprising that labor productivity also varied widely between them. Focusing first on the regional differences within the Ottoman Empire, we see no clear patterns that support generalizations of systematic differences in regional productivity. Although some districts along eastern Mediterranean (e.g., Lajjun, Hawran, and Ajlun in 1596) recorded some of the highest productivities, other districts in the same region (Nablus and Jerusalem) were remarkably lower during the same time.[11] Similarly, although labor productivity was high in Novigrad in mid-sixteenth century, it was low in some of the other European districts (e.g.,

[11] For an analysis of the relationship between thetax system and agricultural incomes in this region, see Coşgel (2004c).

Gyula and Estergom) during the same period. We leave it to future research to analyze these variations in more detail and explain them more satisfactorily.

There are noticeable patterns of productivity change over time. The estimates for the fifteenth century are generally lower than those for the early sixteenth century, suggesting that an overall shift may have happened in productivity. The estimates are mixed, however, for the sixteenth century. Although in all regions of Asia Minor for which we have estimates for multiple periods (namely, Bursa, Çemişgezek, and Antep) productivity declined significantly during the second half of the sixteenth century, it rose or remained stagnant in other districts during the same period (for example, Ajlun, Lajjun, Budapest, Gyula). The sharp decline in Asia Minor raises questions for future research about how widespread was the trend within the region and what caused it. It is also worth noting that the decline in labor productivity in grain farming is consistent with other indicators of economic performance estimated for the Ottoman Empire during this period and for other places as well. For example, as noted earlier, Özmucur and Pamuk (2002) found a downward trend in real wages in Ottoman cities during the same period, and Allen (2000) similarly observed a general fall in estimates of agricultural productivity in various parts of Europe between 1500 and 1600.

To see how labor productivity in grain farming in eastern Europe and western Asia during this period compared with other places and times, let us focus on comparable estimates available for England. These estimates have generally been made in the context of the debate on the nature and timing of the agricultural revolution, so they understandably vary significantly among scholars based on their method of estimation. Karakacili (2004: 39) has recently converted some of the previous estimates of labor productivity into bushels of wheat equivalent per worker, the same units of measurement used in this study. She has also produced her own estimates of labor productivity in Ramsey estates prior to the Black Death (1300-1348) in the same units, making it possible for us to rely on her calculations for direct comparison.

Karakacili's surprisingly high estimates for the pre-Black Death period generally compare favorably with most Ottoman districts in the fifteenth and sixteenth centuries, as they do for England until about 1800. Putting aside the question of how well Ramsey estates represented England, we see that productivity there, if not in all of England, before 1350 far exceeded some of the regions in eastern Europe and western Asia a century or two later. Although there were also regions where workers were more productive than those in Ramsey estates, the significant differentials are surprising and need explanation. Of course, what may be even more surprising to some is that rural workers in parts of eastern Europe and western Asia were more productive in the sixteenth century than their counterparts were in England at the beginning of the nineteenth century, an observation that also needs an explanation.

To explain away these puzzles we may have to begin by sorting out methodological differences between estimation procedures and better understanding the peculiarities of regions and times. Using grain output per worker as a standard measure and estimating output and labor consistently has gone a long way to ensure reasonable comparisons. Because output per worker is a partial measure of productivity, however, it does not include information about a variety of factors, such as input ratios, that also affected productivity. If, for example, workers in one region worked with more land or machinery than workers in another region, their productivity would be expected to be higher. It was highly possible for technology and input ratios to be vastly different between regions at any point in time, or in one region over time. Even though technology and input ratios may have been similar, there is still the effect of climate, irrigation facilities, land quality, and various other economic, social, and cultural factors. Further research into these factors is needed to explain why labor productivity in some places or times was higher than in others.

CONCLUDING REMARKS

Using information from the tax registers of the Ottoman Empire recorded during the fifteenth and sixteenth centuries, this paper has developed estimates of labor productivity in grain farming in various regions of eastern Europe and western Asia. By standardizing and comparing productivity estimates across regions and over time, we were able to identify some general tendencies in comparative performance and even find some tentative answers to the question of how workers in these regions performed relative to rural workers in English history. The estimation procedure and simplifying assumptions are made abundantly clear in order to allow other researchers to examine these first estimates critically and to modify them as necessary in answering various longstanding questions in the economic history of these regions, or to ask new ones.

The analysis suggests future work in at least three areas. The first is to improve the estimates themselves and expand their geographic and temporal coverage. When no direct information was available on some parameters of the estimation procedure, such as local units of measurement and the size of the household or the proportion of their labor devoted to grain farming, I had to make simplifying assumptions based on other information and secondary sources to generate estimates. The accuracy of these estimates can thus be greatly be improved with better information on these parameters. The procedure can also be used to generate estimates of labor productivity in other regions of the empire or for the same regions at other times.

The second area of future work is to understand the causes and consequences of differences in labor productivity. Although generating estimates and identifying patterns are essential tasks of quantitative inquiry into productivity, they are only the first steps. For a more satisfactory understanding of productivity, we also need to examine whether and how geographic, institutional, demographic and other differences affected productivity and what productivity differences implied for living standards and long term growth.

A related field of analysis made possible by these estimates is comparative history. Understanding labor productivity in grain farming in eastern Europe and western Asia has clear implications for various important questions of historical scholarship. For example, how differently, if at all, did agricultural productivity affect industrial growth in these regions? Similarly, how widespread was the productivity decline observed in some regions of the Ottoman Empire during the sixteenth century elsewhere in the world, and was there a common cause? Numerous other questions emerge about the nature, causes and consequences of comparative performance.

WORKS CITED

- Alicic, Ahmed S. 1985. *Poimenicni popis Sandzaka vilajeta Hercegovina*. Monumenta Turcica historiam Slavorum Meridionalium illustrantia; t. 6. Serija II, Defteri; knj. 3. Sarajevo: Orijentalni institut u Sarajevu.
- Allen, Robert C. 1988a. "Inferring Yields from Probate Inventories," *Journal of Economic History*, 48(1): 117-25.
- Allen, Robert C. 1988b. "The Growth of Labor Productivity in Early Modern English Agriculture," *Explorations in Economic History*, 25(2), 117-146.
- Allen, Robert C. 1991. "Labour Productivity and Farm Size in English Agriculture before Mechanization: Reply to Clark," *Explorations in Economic History*, 28(4): 478-92.
- Allen, Robert C. 1999. "Tracking the Agricultural Revolution in England," *Economic History Review*, 52 (2), May, 209-235.
- Allen, Robert C. 2000. "Economic Structure and Agricultural Productivity in Europe, 1300-1800," *European Review of Economic History*, 4 (1), 1-26.
- Bairoch, Paul. 1976. "Agriculture and the Industrial Revolution," in Carlo Cipolla, ed. *The Fontana Economic History of Europe,* vol. 3, The Industrial Revolution, Glasgow: Collins.
- Bairoch, Paul. 1965. "Niveaux de développement économique de 1810 à 1910," *Annales: Économies, sociétés, civilisations*, 20.
- Bairoch, Paul. 1975. *The Economic Development of the Third World since 1900*. Berkeley : University of California Press.
- Bakhit, Muhammad Adnan and Nufan Raja Hmuod. 1989. *The Detailed Defter of Liwa' 'Ajlun*. Amman: The University of Jordan.
- Bakhit, Muhammad Adnan and Nufan Raja Hmuod. 1989. *The Mufassal Defter of Marj Bani 'Amir and Its Dependents Entrusted to Amir Tarabey 945 A.H./1538 A.D.* Amman: The University of Jordan.
- Balta, Evangelia, 1989. *L'Eube à la fin du Xv^{e} siècle. Economie et Population. Les Registres de l'année 1474*. Athens.
- Barkan, Ömer Lütfi and Enver Meriçli, 1988. *Hüdavendigâr Livası Tahrir Defterleri. I.* Ankara:Türk Tarih Kurumu.
- Barkan, Ömer Lütfi. 1953. "'Tarihi Demografi' Araştırmaları ve Osmanlı Tarihi," *Türkiyat Mecmuası* 10: 1-26.
- Bayerle, Gustav. 1973. Ottoman Tributes in Hungary. According to Sixteenth Century Tapu Registers of Novigrad The Hague and Paris.
- Clark, Gregory. 1987. "Productivity Growth Without Technical Change in European Agriculture before 1850," *Journal of Economic History* 47: 419-32.
- Clark, Gregory. 1991a. "Yields per acre in English Agriculture, 1250-1860: Evidence from Labour Inputs," *Economic History Review*, 44 (3): 445-460.
- Clark, Gregory. 1991b. "Labour Productivity and Farm Size in English Agriculture Before Mechanization: A Note," *Explorations in Economic History*, 28(2): 248-57.
- Clark, Gregory. 1999. "Too Much Revolution: Agriculture and the Industrial Revolution, 1700-1860" in Joel Mokyr (ed.), *The British Industrial Revolution: An Economic Assessment*. Second Edition. Boulder, Colorado: Westview Press.
- Coşgel, Metin M. 2004a. "Ottoman Tax Registers (*Tahrir Defterleri*)," *Historical Methods*, forthcoming.
- Coşgel, Metin M. 2004b. "The Economics of Ottoman Taxation," Working papers 2004-02, University of Connecticut, Department of Economics.
- Cosgel, Metin M. 2004c. "Taxes, Efficiency, and Redistribution: Discriminatory Taxation of Villages in Ottoman Palestine, Southern Syria, and Transjordan in the Sixteenth Century," *Explorations in Economic History*, forthcoming.
- Cosgel, Metin M. and Thomas J. Miceli. 2004. "Risk, Transaction Costs, and Government Finance: The Distribution of Tax Revenue in the Ottoman Empire," *Journal of Economic History*, forthcoming.
- Delilbaşı, Melek and Muzaffer Arıkan. 2001. *Hicrî 859 Tarihli Sûret-i Defter-i Sancak-ı Tırhala.* Ankara: Türk Tarih Kurumu.
- Fekete, Lajos. 1943. Az Esztergomi Szandzsák 1570 Évi Adóösszeirása Budapest.

- Göyünç, Nejat and Wolf Dieter Hütteroth. 1997. *Land an der Grenze: Osmanische Verwaltung im Heutigen Turkisch-Syrisch-Irakischen Grenzgebiet im 16. Jahrhundert*. Istanbul: EREN.
- Göyünç Nejat. 1979. "Hane Deyimi Hakkında," *İ.Ü.E.F. Tarih Dergisi*, 32: 331-348.
- Hütteroth, Wolf Dieter and K. Abdalfattah. 1977. *Historical Geography of Palestine, Transjordan and Southern Syria in the Late 16th Century* Erlanger Geographische Arbeiten, Vol. 5, Erlangen.
- İlhan, Mehdi. 1994-95. "Erbil Vilayeti Mufassal ve Mücmel Tahrir Defteri (H. 949/M. 1542)." *Belgeler* Cilt XVI, Sayı 20.
- İnalcık, Halil. 1994 [with Donald Quataert]. *An Economic and Social History of the Ottoman Empire, 1300-1914*. New York: Cambridge University Press
- Kaldy-nagy, Gyula. 1971. *Kanuni Devri Budin Tahrir Defteri (1546-1562)* Ankara: Ankara Üniversitesi Dil Tarih-Coğrafya Fakültesi Yayınları No. 77.
- Kaldy-Nagy, Gyula. 1982. A Gyulai Szanzsak 1567 es 1579. evi osszeirasa Bekescsaba.
- Karakacili, Eona. 2004. "English Agrarian Labor Productivity Rates Before the Black Death: A Case Study," *Journal of Economic History*, 64(1): 24-60.
- Lewis, Bernard. 1952. *Notes and Documents from the Turkish Archives*. Jerusalem: The Israel Oriental Society.
- McGowan, Bruce W. 1983. *Sirem Sancğı Mufassal Tahrir Defteri* Ankara: Türk Tarih Kurumu.
- McGowan, Bruce. 1969. "Food Supply and taxation on the Middle Danube (1568-1579)," *Archivum Ottomanicum* 1: 139-96.
- Overton, Mark. 1979. "Estimating Crop Yields from Probate Inventories: An Example from East Anglia, 1585-1735," *Journal of Economic History* 39: 363-78.
- Overton, Mark. 1996. Agricultural Revolution in England: The Transformation of the Agrarian Economy 1500-1850. Cambridge: Cambridge University Press.
- Özdeğer, Hüseyin. 1988. *Onaltıncı Asırda Ayıntab Livası* İstanbul.
- Özmucur, Süleyman and Şevket Pamuk. 2002. "Real Wages and Standards of Living in the Ottoman Empire, 1489-1914*", Journal of Economic History*, 62(2): 293-321.
- Ünal, Mehmet Ali. 1999. XVI. Yüzyılda Çemişgezek Sancağı. Ankara: TTK.
- Wrigley, E. A. 1985. "Urban Growth and Agricultural Change: England and the Continent in the Early Modern Period," *Journal of Interdisciplinary History*, 15, 683-728.
- Yinanç, Rafet and Mesut Elibüyük, 1983. *Kanuni Devri Malatya Tahrir Defteri (1560)* Ankara
- Yinanç, Rafet and Mesut Elibüyük, 1988. *Maraş Tahrir Defteri (1563)* 2 cilt Ankara.

TABLE 1
RURAL HOUSEHOLDS IN REPRESENTATIVE REGIONS OF EASTERN EUROPE AND WESTERN ASIA

Region	Year	Number of Villages	Average Number of Households	Standard Deviation
Bursa	1521	47	16.9	15.0
Bursa	1573	60	32.3	22.8
Hüdavendigār[a]	1487	332	15.1	13.3
Hüdavendigār	1521	330	20.2	16.4
Hüdavendigār	1573	930	20.1	20.1
Estergom	1570	121	25.4	21.2
Novigrad	1570	78	17.6	11.9
Budapest	1546	295	24.9	22.4
Budapest	1562	286	26.2	19.1
Srem	1566	100	21.0	14.0
Gyula	1567	199	26.3	21.0
Gyula	1579	202	30.7	25.4
Trikala	1454	276	38.2	38.2
Hercegovina	1477	231	18.5	27.4
Evia Island	1474	115	28.8	28.1
Çemişgezek	1518	267	20.2	17.2
Çemişgezek	1541	330	27.7	31.8
Çemişgezek	1566	96	43.3	31.2
Mardin	1564	1570	20.3	41.3
Maraş	1563	300	25.2	20.5
Malatya	1560	615	27.8	28.2
Antep	1536	101	15.7	15.8
Antep	1543	220	23.8	30.3
Antep	1574	212	28.5	36.9
Erbil	1542	52	29.8	36.3
Ajlun	1538	136	30.6	32.8
Ajlun	1596	121	27.9	23.5
Gaza	1596	199	46.0	64.4
Lajjun	1538	55	15.6	19.0
Lajjun	1596	53	18.5	19.4
Nablus	1596	215	29.7	28.4
Hawran	1596	366	22.4	23.0
Jerusalem	1596	176	35.6	35.9
Safad	1596	283	45.7	55.6

Notes: *a*. The Hüdavendigār province includes the Bursa district.
Sources: See footnote #3

TABLE 2
UNITS AND PRICES OF WHEAT

Region	Year	Price in Tax Register	Unit	Price per Bushel	Source for Unit Conversion
Bursa (Hüdavendigār)	1487	60	*mud*	5.2	İnalcık (1994: xl)
Bursa (Hüdavendigār)	1521	70	*mud*	6.0	İnalcık (1994: xl)
Bursa (Hüdavendigār)	1573	100	*mud*	8.6	İnalcık (1994: xl)
Estergom	1570	12	*kile*	12.4	
Novigrad	1570	12	*kile*	9.3	Bayerle (1973: 22n)
Budapest	1546	10	*kile*	10.3	
Budapest	1562	12	*kile*	12.4	
Srem	1566	14	*kile*	14.4	McGowan (1969: 166)
Gyula	1567	10	*kile*	10.3	Kaldy-Nagy (1982: 400)
Gyula	1579	11	*kile*	11.3	Kaldy-Nagy (1982: 400)
Trikala	1454	8	*kile*	3.3	Barkan (1943: 289)
Hercegovina	1477	24		3.1	
Evia Island	1474	20	*himl*	2.6	Akgündüz (1990, Vol. V: 387)
Çemişgezek	1518	8	*kile*	8.2	Barkan (1943: 189)
Çemişgezek	1541	9	*kile*	9.3	Barkan (1943: 189)
Çemişgezek	1566	12	*kile*	12.4	Barkan (1943: 189)
Mardin	1564	3	*kile*	12.4	
Maraş	1563	10	*kile*	10.3	
Malatya	1560	5	*kile*	10.3	Barkan (1943: 111)
Antep	1536	5	*kile*	5.2	
Antep	1543	6	*kile*	6.2	
Antep	1574	9	*kile*	9.3	
Erbil	1542	90	*tagar*	9.3	Akgündüz (1990, Vol. V: 173)
Ajlun	1538	130	*ghirara*	5.4	Lewis (1952:17)
Ajlun	1596	140	*ghirara*	5.8	Lewis (1952:17)
Gaza	1596	500	*ghirara*	6.9	Lewis (1952:17)
Lajjun	1538	120	*ghirara*	5.0	Lewis (1952:17)
Lajjun	1596	140	*ghirara*	5.8	Lewis (1952:17)
Nablus	1596	710	*ghirara*	8.8	Lewis (1952:17)
Hawran	1596	150	*ghirara*	6.2	Lewis (1952:17)
Jerusalem	1596	500	*ghirara*	6.9	Lewis (1952:17)
Safad	1596	130	*ghirara*	5.4	Lewis (1952:17)

Notes: See text for the details of the conversion procedure. The standard price is per Winchester bushel.
Sources: See footnote #3

TABLE 3
COMPARISON OF GRAIN OUTPUT PER WORKER WITHIN THE OTTOMAN EMPIRE AND WITH ENGLAND

Region	Date	Proportion of Land Used for Grains	Labor Productivity (High Estimate)	Labor Productivity (Low Estimate)	Index of Average Labor Productivity	Source for Other Estimates
Bursa	1521	0.66	300	132	100	
Bursa	1573	0.71	121	53	40	
Hüdavendigār	1487	0.86	220	97	74	
Hüdavendigār	1521	0.78	236	104	79	
Hüdavendigār	1573	0.77	123	54	41	
Estergom	1570	0.65	197	87	66	
Novigrad	1570	0.56	379	167	127	
Budapest	1546	0.67	132	58	44	
Budapest	1562	0.58	225	99	75	
Srem	1566	0.56	213	94	71	
Gyula	1567	0.70	176	77	59	
Gyula	1579	0.77	242	106	81	
Trikala	1454	0.56	104	46	35	
Hercegovina	1477	0.61	256	113	86	
Evia Island	1474	0.64	160	70	53	
Çemişgezek	1518	0.89	183	81	61	
Çemişgezek	1541	0.83	100	44	33	
Çemişgezek	1566	0.72	76	34	26	
Mardin	1564	0.82	173	76	58	
Maraş	1563	0.77	164	72	55	
Malatya	1560	0.68	95	42	32	
Antep	1536	0.62	415	183	139	
Antep	1543	0.69	542	238	181	
Antep	1574	0.67	338	149	113	
Erbil	1542	0.85	326	143	109	
Ajlun	1538	0.52	206	91	69	
Ajlun	1596	0.42	305	134	102	
Gaza	1596	0.46	201	89	67	
Lajjun	1538	0.70	447	197	149	
Lajjun	1596	0.59	642	282	214	
Nablus	1596	0.38	157	69	52	
Hawran	1596	0.61	330	145	110	
Jerusalem	1596	0.41	182	80	61	
Safad	1596	0.57	181	80	61	
England	1300-1348				105	Karakacili
England	pre 1350				36	Allen
England	1600				49	Allen
England	1700				73	Allen
England	1800				90	Allen

England	c. 1800	114	Timmer

Sources: See footnote #3. Estimates for England are from Karakacili (2004: 39).