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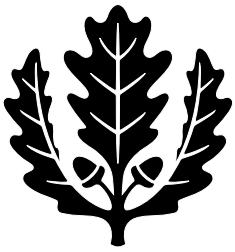

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Abstract

This paper provides standardized estimates of labor productivity in arable farming in selected regions of the early Ottoman Empire, including Jerusalem and neighboring districts in eastern Mediterranean; Bursa and Malatya in Anatolia; and Thessaly, Herzegovina, and Budapest in eastern Europe. I use data from the tax registers of the Ottoman Empire to estimate grain output per worker, standardized (in bushels of wheat equivalent) to allow productivity comparisons within these regions and with other times and places. The results suggest that Ottoman agriculture in the fifteenth and sixteenth centuries had achieved levels of labor productivity that compared favorably even with most European countries circa 1850.

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Agricultural Productivity in the Early Ottoman Empire

Metin M. Coşgel

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 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 there are reliable estimates of agricultural productivity in various European countries in the nineteenth century, little is known about productivity in other parts of the World and for the pre-industrial period (Clark, 1999). This paper aims to close this gap by estimating agricultural productivity in the Ottoman Empire during the fifteenth and sixteenth centuries. 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. They carefully 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, 2004). I use this information to estimate output per worker in various representative regions of the Empire and make temporal and spatial comparisons of productivity. The results suggest that grain output per worker in Ottoman provinces in the fifteenth and

sixteenth centuries was higher than even some countries in northwestern European in mid-nineteenth century.

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.

ESTIMATING COMPARATIVE PRODUCTIVITY

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[1]. 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). Yield and productivity are typically reported in standard units of measurement to facilitate comparisons with other times and places.

[1] 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.

The literature 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.[2] 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.[3]

This study aims to contribute to the literature in all three dimensions. Its primary objective is to provide direct estimates of labor productivity in eastern Europe and western Asia in the pre-industrial period for inclusion in the list of estimates available for comparison. Despite the high demand for comparable estimates of productivity in these regions, the demand has not yet been met satisfactorily by systematic, comprehensive analysis of available sources. Although historians of the Ottoman Empire have published numerous studies to examine agricultural taxes

[2] See, for example, Allen (1999), Clark (1999, 2004), and Overton (1996).

[3] For a more recent comparative study of this type, see Allen (2000).

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.

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.[4] These regions include Gaza, Jerusalem and southern Syria in eastern Mediterranean, Erbil in northern Iraq, Bursa and Malatya in Anatolia, and Thessaly, Herzegovina, and Budapest in Europe.[5] For some of these districts, tax registers are available for multiple dates, making it possible to examine both temporal and spatial variations in productivity. In addition to using tax registers as primary sources of information on tax paying subjects and taxable agricultural activities, I rely on recent

[4] 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 (1943), Göyünç and Hütteroth (1997), Hütteroth and Abdalfattah (1977), Kaldy-Nagy (1971, 1982), McGowan (1983), Ünal (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.

[5] For easier recognition, I use the better known current English names, rather than those used by the Ottomans, for some of these regions.

studies of Ottoman society and economy as secondary sources to supplement information required by some parameters of the estimation procedure.

The estimation procedure is consistent with recent studies of labor productivity in agriculture (Allen, 2000, Clark, 1999, Karakacili, 2004). Focusing on the arable sector, I estimate the grain output (wheat, barley, and other cereal grains and legumes) per arable worker. 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 all parameters, several simplifying assumptions had to be made to generate the first comprehensive set of systematic and comparable estimates of labor productivity in these regions. The sources, methods, and simplifying assumptions of the estimation procedure are provided in detail in an appendix to allow future researchers to improve on these estimates.

LABOR PRODUCTIVITY IN THE OTTOMAN EMPIRE

In the absence of direct information on some parameters of the estimation process, it may be more appropriate to carefully consider all possible scenarios that could have determined the quantities of output and labor and first estimate productivity as a range, rather than a single point. The first two columns in Table 1 show the low and high estimates of productivity (based on two alternative sets of scenarios described in detail in the appendix) in representative Ottoman districts. The next two columns summarize this information into simpler indices for easier comparison of productivity across districts. The first index is defined simply as the average of the low and high estimates of productivity for each region and date. Such an index can be misleading, however, if the relative price of wheat varied significantly between regions and over

time. An index of labor productivity measured in bushels of wheat equivalent at local contemporary prices would face the risk of underestimating productivity in areas where wheat was expensive relative to other grains and overestimating it in areas of relatively cheap wheat. The second index avoids this problem, because it uses not the local contemporary price weights but fixed weights. By controlling for differences in the price ratio, it provides an index better suited for regional and temporal comparisons of productivity when prices vary significantly. The two indices in Table 1 take as their base the average productivity estimate for the villages of Bursa, the first capital of the Ottoman Empire, in 1521. Whereas the first index is measured in local contemporary prices of each district, the second uses the price weights of the base district and date.

Table 1 should be about here

These estimates help us to identify some of the systematic regional differences in productivity in the Ottoman Empire. Ottoman provinces varied significantly in climate, natural resources, and institutional history, raising questions about comparative performance in agricultural production. The information in Table 1 shows some of the general differences in productivity between the different regions of the Empire. During the second half of the sixteenth century labor productivity was generally high in the region known as the Fertile Crescent, corresponding roughly to the lands between the Nile and the Euphrates and Tigris rivers, as can be seen in the estimates for Erbil, Gaza, and Hawran. Labor was generally less productive in the European districts during the same period, as seen in the estimates for Budapest, Srem, and Gyula.

Productivity sometimes varied significantly even within a region. Although the climate and institutional history could be uniform among the districts within a region, soil quality, irrigation possibilities, and population density could vary significantly, causing variations in labor productivity. Whereas Lajjun, a district along eastern Mediterranean, recorded one of the highest productivities, other districts in the same region (e.g., Safad and Jerusalem) were remarkably lower.[6] Similarly, whereas labor productivity was high in Novigrad, it was significantly lower in some of the other European districts.

Estimates of labor productivity also help to identify productivity variations over time. There are noticeable patterns of productivity change during this period. The estimates for the fifteenth century are generally lower than those for the early sixteenth century, indicating a growth in labor productivity throughout the Empire. The estimates are mixed, however, for the sixteenth century, generally considered to be the height of the Empire's long reign of six centuries. Although historians generally agree that the sixteenth century was a period of demographic growth and economic expansion in the Ottoman Empire, it is not clear whether this growth and expansion also meant an increase in the economic performance and living standards of Ottoman subjects on average. 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. Our results show that a parallel decline took place in rural incomes and labor productivity in grain farming in some Ottoman districts. Although productivity rose or remained stagnant in some regions during the second half of the sixteenth century (for example, in Ajlun, Lajjun,

[6] For an analysis of the relationship between the tax system and agricultural incomes in this region, see Coşgel (2005b).

Budapest, Gyula), it generally declined significantly during the same period in Anatolia. The sharp decline in labor productivity in Anatolia is consistent with the well-known demographic growth in this region and the recent research that has found a negative relationship between rising population and labor productivity in other parts of the World. It is also consistent with the general fall in agricultural productivity observed in various parts of Europe between 1500 and 1600 (Allen, 2000).

Having estimates of labor productivity would also contribute to recent debates surrounding the performance of the Ottoman economy after the sixteenth century. Whereas the previous generation of historians spoke of an Ottoman decline during this period, recent research has rejected the notion of a decline, seeking to revise or reinterpret the periods of Ottoman history. Although very few scholars would nowadays take the notion of an absolute decline seriously, the timing of the relative slip of the Middle East (compared to northwestern Europe) remains an issue. Whereas some historians would identify the end of the "Golden Age of Islam" in the twelfth century as the turning point, others (e.g., Marxists) would point to the western imperialism of the eighteenth and nineteenth centuries, and still others would see the problem in other religious, military, technological, or institutional causes rooted in other centuries. Despite being involved in an essentially quantitative debate on economic performance, however, participants have so far been unable to offer any direct quantitative evidence to substantiate their claims about the performance of the economy during this period. At the heart of the debate is the question of how well the Ottoman economy has performed over time, which has been difficult to quantify. Although Özmucur and Pamuk's (2002) recent 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. Our estimates

will help to learn about the rest of the story by establishing a benchmark against which productivity in other periods can be compared.

COMPARATIVE PRODUCTIVITY

Measuring productivity in standard units makes it possible to use this information not just for issues of limited local interest and regional analysis but also for broader questions and global comparisons. There are numerous questions of global importance that require reliable estimates of agricultural productivity in the Ottoman Empire 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 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, 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.

To compare labor productivity in the Ottoman Empire with other times and places, we have to proceed with great caution and choose comparable estimates carefully. International and intertemporal comparisons of productivity may be problematic, because estimates could be based on different sources of data and methods of estimation could be incompatible, in addition to the usual complications caused by differences in prices and units of measurement. To minimize these difficulties, we have to restrict comparisons to regions and time periods with well-

developed scholarship that have resulted in commonly accepted estimates of agricultural productivity.

Economic historians have recently developed several innovative methods for measuring agricultural productivity in studying the nature and causes of gaps in incomes and productivity between nations. They have had limited success, however, in producing commonly accepted estimates for the pre-industrial period. This is true even in the highly developed scholarship of English history.[7] England's leadership in economic development has made her the focus of attention for various important questions of economic history, and the availability of sources has allowed scholars to examine these questions in great detail. But historians have so far failed to reach a consensus on productivity levels in pre-industrial England and the magnitude of productivity growth in agriculture since that time. These estimates have generally emerged in the context of the debate on the nature and timing of the agricultural revolution and vary significantly among scholars based on their sources of data, approaches to the problem, and method of estimation.

[7] Some of the pioneering studies in the field, such as Overton's (1979) method of extracting information from probate inventories, Clark's (1991a, 2004a) 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.

For a more reliable comparison, we turn to estimates of labor productivity in the nineteenth century. There is less debate on what the outputs were in the nineteenth century in England other countries in Europe. Clark (1999) has provided estimates of output per worker in various countries in Europe circa 1850, which we can use as benchmark for comparison. Since his estimates are given in bushels of wheat equivalent, they are directly comparable with ours.

To simplify the comparison, let us summarize the productivity estimates for the Ottoman Empire by aggregating them according to the distinct geographic regions and identifiable time periods they belong. Ottoman districts for which we have information from the tax registers can be categorized into three distinct geographic groups based on differences in climate and religious and institutional history. These groups consist of the districts in the east corresponding roughly to the Fertile Crescent, the European districts in the west (further separable between those in southeastern Europe conquered long before the sixteenth century and those further north in Serbia and Hungary conquered during the sixteenth century), and the districts in the core lands of the Empire in Anatolia. For some of these groups the tax registers provide information for multiple periods of time, making it possible to aggregate the estimates separately for different time periods. Although we do not currently have comprehensive information for all villages in each of these regions and for all times, we can use the available data for preliminary generalizations about comparative productivity.

Table 2 should be about here

Table 2 shows how output per worker in various parts of the Ottoman Empire in the fifteenth and sixteenth centuries compared with various countries in Europe circa 1850.[8] To be consistent with Clark's (1999) figures, productivity estimates for the Ottoman Empire are reported based on the same index (England, 1851=100). Output per worker in England was clearly far ahead of most other countries in Europe during the nineteenth century. Productivity was also generally higher in northwestern Europe than in eastern Europe during this period, falling gradually as we move from the west of Europe to the east, as Clark (1999: 211) also noted. Although our estimate for southeastern Europe in the fifteenth century appears to be consistent with this trend, the estimate for Serbia-Hungary in the sixteenth century is significantly higher than Clark's estimate for the same region in the nineteenth century. In any case, our estimates show that the eastward decline of productivity was purely a pre-industrial and European phenomenon, inapplicable to Ottoman provinces during the fifteenth and sixteenth centuries. They also show only small gains in labor productivity in agriculture between the pre-industrial period and the nineteenth century, rather than the dramatic increase in productivity implied by the notion of the agricultural revolution that supposedly took place in northwestern Europe during this period according to some historians. Indeed, output per worker was higher in some districts of the Ottoman Empire in the fifteenth and sixteenth centuries than in most countries in northwestern Europe circa 1850.

One has to be careful, of course, in interpreting these results. They are clearly preliminary estimates that aim to identify areas for further research into important questions of economic

[8] Given the simple and elementary nature of the intended comparison in Table 2, I did not report separately the index adjusted for differences in the relative price of wheat, because making the adjustment did not change the results significantly.

history rather than provide definitive answers to such questions. It is also important to note the limitations of using labor productivity to assess overall economic performance. Because output per worker is a partial measure of productivity, it does not include information about a variety of factors, such as input ratios, that may have also affected productivity. If workers in one region worked with more land or machinery than workers in another region, then their productivity would of course be higher. Even though the technology or input ratios may have been similar between regions, there is still the effect of climate, irrigation facilities, land quality, and various other economic, social, and cultural factors. Further research into the peculiarities of regions and times may be necessary to explain what caused the differences in the productivity of arable labor.

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 parts of eastern Europe and western Asia. By standardizing and comparing productivity estimates across regions and over time, we are able to identify some general tendencies in comparative performance and even reach preliminary conclusions on the question of how output per worker in these regions compared with various countries in Europe. 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 improved with better information on these parameters. The procedure can also be used to generate estimates of labor productivity in other regions of the Ottoman 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 the Ottoman Empire 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? How commonly was the productivity decline seen in some regions of the Ottoman Empire during the sixteenth century observed elsewhere in the world, and was there a common cause? Numerous other questions emerge about the nature, causes and consequences of comparative performance.

APPENDIX: MEASURING LABOR PRODUCTIVITY FROM TAX DATA

A. 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 Anatolia 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 the Ottoman Empire (Coşgel, 2004).

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 A1 should be about here

Table A1 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. In the second half of the sixteenth century, villages in eastern Mediterranean and those in the Singar, Çemişgezek and Nehr ül-Cevaz regions in eastern Anatolia stand out as the most heavily populated. Villages in the Trikala district in Thessaly were also heavily populated in the fifteenth century.[9]

b. Measuring Output

[9] In comparing the entries in Table A1 with current populations of these regions or with other time periods, one has to keep in mind that district boundaries may have changed since the sixteenth century.

The Ottoman system of taxing agricultural production makes it easy to calculate the gross output of grains.[10] 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. 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.[11]

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 for us to use the appropriate conversion factor to calculate the standard equivalent of output.

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

[10] For Ottoman system of taxation, see Coşgel (2005a) and Coşgel and Miceli (2005).

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

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 too 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 A2 should be about here

Table A2 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 first used the local prices 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 the 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 the contemporary market 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, I was able to convert the information about the nominal values of output into wheat equivalents.

c. Measuring Labor

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.[12]

[12] 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.

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 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. Given the size of the Ottoman Empire stretching over three continents, the household size could have varied between districts. The size could have also changed over time in each district, for example during the population expansion of the sixteenth century. Unfortunately, there are no comprehensive estimates of the household size specific to each district and time period that can be incorporated into our estimates. Quantitative studies of the Ottoman Empire that require information on the household size typically proceed by assuming the size to be consistent among districts and over time, and we have no choice but to follow this convention.

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). Leaving the possibility of regional and temporal variations in household size to future researchers, I use Barkan's estimate of five as the high estimate of household size in all districts and assume 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, then 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.

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.[13] 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.

[13] This would be consistent with Allen's (1991) assumption that each family supplied three workers. See also Clark's (1991b) criticisms of Allen's method.

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 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, recorded consistently by the tax registers across regions. The value of *a* can be estimated from

the proportion of production taxes from grains, assuming the ratio of taxes to labor supply to be the same between taxable activities.[14]

The results of the outlined estimation procedure can be seen in the two tables presented in the main text. 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 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.

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

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TABLE 1
ESTIMATES OF GRAIN OUTPUT PER WORKER
IN THE OTTOMAN EMPIRE

District	Year	High Estimate (bu. of wheat equivalent)	Low Estimate (bu. of wheat equivalent)	Index of Labor Productivity (Bursa, 1521=100)	
				At Contemporary Local Prices	At Bursa, 1521 Prices
Bursa	1521	300	132	100	100
Bursa	1573	121	53	40	52
Inegöl	1521	276	122	92	92
Inegöl	1573	133	59	44	57
Yarhisar	1487	313	138	104	101
Yarhisar	1521	250	110	83	83
Yarhisar	1573	113	50	38	48
Ermeni Pazarı	1573	57	25	19	24
Domaniç	1487	218	96	73	70
Domaniç	1573	86	38	29	37
Yenişehir	1521	446	196	149	149
Yenişehir	1573	199	88	66	85
Sögüd	1487	255	112	85	82
Sögüd	1521	185	81	62	62
Sögüd	1573	116	51	39	50
Göl	1487	362	159	121	116
Göl	1521	176	78	59	59
Göl	1573	122	54	41	52
Yenice-i Taraklu	1487	162	71	54	52
Yenice-i Taraklu	1573	75	33	25	32
Geyve	1487	325	143	108	104
Geyve	1521	151	66	50	50
Geyve	1573	112	49	37	48
Akyazı	1487	145	64	48	47
Akyazı	1521	77	34	26	26
Akyazı	1573	84	37	28	36
Akhisar	1521	363	160	121	121
Akhisar	1573	185	81	62	79

Göynük	1487	206	90	69	66
Göynük	1521	197	87	66	66
Göynük	1573	119	52	40	51
Beğ Bazarı	1487	203	89	68	65
Beğ Bazarı	1521	181	80	61	61
Beğ Bazarı	1573	130	57	43	56
Estergom	1570	197	87	66	85
Novigrad	1570	379	167	127	163
Budapest	1546	132	58	44	56
Budapest	1562	225	99	75	97
Srem	1566	213	94	71	107
Gyula	1567	176	77	59	63
Gyula	1579	242	106	81	95
Trikala	1454	104	46	35	36
Herzegovina	1477	256	113	86	88
Evia Island	1474	160	70	53	49
Çemişgezek	1518	183	81	61	52
Çemişgezek	1541	100	44	33	32
Çemişgezek	1566	76	34	26	25
Mardin	1564	162	71	54	52
Berriyecik	1564	169	74	56	72
Hasankeyf	1564	152	67	51	49
Nisibin	1564	340	150	114	122
Akçakala	1564	149	66	50	53
Singar	1564	105	46	35	37
Habur	1564	43	19	14	11
Ana	1564	209	92	70	66
Maraş	1563	164	72	55	49
Malatya	1560	103	45	34	37
Gerger	1560	74	32	25	26
Kahta	1560	85	37	28	30
Behesni	1560	114	50	38	41
Antep	1536	415	183	139	148
Antep	1543	486	214	162	156
Antep	1574	294	129	98	94
Tel-Bāşer	1543	613	270	205	197
Tel-Bāşer	1574	417	183	139	134
Nehr ül-Cevāz	1543	426	187	142	137
Nehr ül-Cevāz	1574	201	88	67	65
Erbil	1542	326	143	109	126

Ajlun	1538	206	91	69	82
Ajlun	1596	305	134	102	114
Gaza	1596	268	118	90	103
Lajjun	1538	430	189	143	167
Lajjun	1596	642	282	214	241
Nablus	1596	202	89	67	123
Hawran	1596	330	145	110	118
Jerusalem	1596	182	80	61	70
Safad	1596	181	80	61	72

Sources: See footnote #4.

TABLE 2
COMPARATIVE PRODUCIVITY IN
OTTOMAN EMPIRE AND EUROPE

Region	Date circa	Output per Worker (England, 1851=100)
Anatolia	1490	58
Anatolia	1520-40	64
Anatolia	1560-75	40
Fertile Crescent	1540	76
Fertile Crescent	1590	68
Southeastern Europe	1450-75	39
Hungary-Serbia	1545-80	53
Britain	1851	100
Netherlands	1850	54
Belgium	1850	37
Ireland	1851	47
France	1850	44
Germany	1850	42
Romania	1870	40
Austria	1854	32
Sweden	1850	37
Hungary	1854	30
Russia	1870	29

Sources: Table 1, Clark (1999).
Notes: Clark (1999) estimates output per worker in England in 1851 at the equivalent of 272 bushels of wheat.

TABLE A1
RURAL HOUSEHOLDS IN OTTOMAN DISTRICTS

District	Year	Number of Villages in Sample	Average Number of Households per Village	Standard Deviation
Bursa	1521	47	16.9	15.0
Bursa	1573	60	32.3	22.8
Inegöl	1521	27	20.0	14.7
Inegöl	1573	44	26.6	17.2
Yarhisar	1487	9	6.7	3.8
Yarhisar	1521	10	14.6	9.6
Yarhisar	1573	20	23.1	22.6
Ermeni Pazarı	1573	4	40.5	34.3
Domaniç	1487	38	8.2	5.6
Domaniç	1573	37	23.8	23.8
Yenişehir	1521	17	18.9	12.6
Yenişehir	1573	46	30.1	20.2
Sögüd	1487	29	7.8	6.8
Sögüd	1521	4	16.8	10.5
Sögüd	1573	27	19.9	10.3
Göl	1487	38	10.5	6.8
Göl	1521	17	18.8	12.1
Göl	1573	75	17.1	17.9
Yenice-i Taraklu	1487	23	25.6	20.5
Yenice-i Taraklu	1573	84	14.9	13.6
Geyve	1487	26	14.6	11.3
Geyve	1521	13	30.8	20.0
Geyve	1573	69	19.7	17.0
Akyazı	1487	24	22.0	17.8
Akyazı	1521	4	40.0	46.1
Akyazı	1573	101	16.7	28.3
Akhisar	1521	34	19.7	14.3
Akhisar	1573	39	21.8	15.0
Göynük	1487	50	18.4	13.0
Göynük	1521	49	18.7	14.8

Göynük	1573	146	12.8	9.4
Beğ Bazarı	1487	95	16.7	13.6
Beğ Bazarı	1521	108	21.6	17.7
Beğ Bazarı	1573	178	21.6	22.3
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
Herzegovina	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	532	24.6	50.5
Berriyecik	1564	227	18.8	37.0
Hasankeyf	1564	181	30.8	41.6
Nisibin	1564	165	10.3	14.5
Akçakala	1564	64	13.4	13.5
Singar	1564	52	47.8	73.0
Habur	1564	6	69.7	82.4
Ana	1564	342	10.0	24.9
Maraş	1563	300	25.2	20.5
Malatya	1560	266	28.4	28.2
Gerger	1560	145	28.8	24.9
Kahta	1560	121	30.1	34.1
Behesni	1560	83	21.0	23.3
Antep	1536	101	15.7	15.8
Antep	1543	103	21.6	24.2
Antep	1574	92	27.3	27.4
Tel-Bāşer	1543	98	22.8	25.6
Tel-Bāşer	1574	95	25.0	27.5
Nehr ül-Cevāz	1543	19	40.3	63.1
Nehr ül-Cevāz	1574	25	45.8	76.1
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	64	16.1	18.0
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

Sources: See footnote #4

TABLE A2
UNITS AND PRICES OF WHEAT
IN OTTOMAN TAX REGISTERS

Region	Year	Price in Tax Register	Unit	Standard Price per (Winchester) 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)
Herzegovina	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, 1954: 491)
Ajlun	1596	140	*ghirara*	5.8	Lewis (1952:17, 1954: 491)
Gaza	1596	250	*ghirara*	5.2	Lewis (1952:17, 1954: 491)
Lajjun	1538	120	*ghirara*	5.0	Lewis (1952:17, 1954: 491)
Lajjun	1596	140	*ghirara*	5.8	Lewis (1952:17, 1954: 491)
Nablus	1596	710	*ghirara*	6.8	Lewis (1952:17, 1954: 491)
Hawran	1596	150	*ghirara*	6.2	Lewis (1952:17, 1954: 491)
Jerusalem	1596	500	*ghirara*	6.9	Lewis (1952:17, 1954: 491)
Safad	1596	130	*ghirara*	5.4	Lewis (1952:17, 1954: 491)

Note: See the Appendix for the details of the conversion procedure.
Sources: See footnote #4