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Land Rents and Agricultural Productivity: The Paris Basin, 1450–1789

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Using evidence from leases and price series, this article examines the total factor productivity of farming in the Paris Basin between 1450 and 1789. Existing evidence about productivity is unreliable, the article argues, and the leases provide historians with a new and valuable source for the study of productivity and economic growth. The article defends the methods used with the leases, which point to spurts of noteworthy growth on local farms but also to setbacks during times of war and increased taxation. It concludes with an analysis of the causes of economic growth in preindustrial agriculture.

Like many other religious institutions in early modern France, the Cathedral of Notre Dame in Paris owned a staggering amount of agricultural property—in particular, scores of farms and parcels of land scattered throughout the Paris Basin. The cathedral's papers, housed today in the National Archives, describe these holdings, record the sometimes poignant details of their management, and preserve the leases that tenants agreed to, typically every nine years. As one might expect, the documents are voluminous. The index alone, compiled by an obsessive eighteenth-century archivist, comprises 30 manuscript volumes, and for property after property one encounters strings of leases running from the late Middle Ages to the end of the eighteenth century.

Such agricultural leases have been profitably employed by a number

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of enterprising historians.[1] Yet most have been content to use them to study landlords' revenues or to assess the burden placed on the peasantry. A few researchers, it is true, have attempted to derive an index of agricultural output from series of leases, but they have done so apologetically, as the documents seemed a poor substitute for the records of the tithe.

What historians have not realized, though, is that leases can shed considerable light on agricultural productivity. Under the proper conditions, evidence from leases can be combined with product prices and factors-of-production costs to give a measure of productivity. This measure of productivity is not merely the partial productivity of land or of labor, but total factor productivity (TFP), the ratio of outputs to inputs that takes into account all the factors of production used in farming: land, labor, and capital. Agriculture leases have previously been employed in this way to study the productivity of early modern English agriculture, and though using them may at first seem a picaresque adventure in pseudostatistics, they ultimately furnish us with firmer evidence than the shaky figures we have for crop yields and output per worker. And it is evidence of considerable importance, for it reveals whether agriculture was in fact shackled by organizational and technological rigidities, as so many historians believe, or whether, even under the Old Regime, certain farms could extract more output from the same amount of land, labor, and capital and thereby achieve economic growth.

What follows is an analysis of 809 leases gathered from the archives of the Cathedral of Notre Dame for the period between 1450 and 1789. The leases form 39 series, each one concerning a separate property in one of 25 different villages scattered throughout the Paris Basin (Figure 1). The properties lay on the average a little less than 40 kilometers from Paris, the closest only 5 kilometers and the farthest 96 kilometers from the city center. Most were rented along with only minor rights to collect the local tithe or local seigniorial dues, and none changed significantly in size. (If the size did change appreciably, I began another series of leases for what I considered to be a different holding.) As a whole, the properties ranged from a minuscule plot measuring only 0.26 hectare (roughly two-thirds of an acre) to an enormous farm of 278 hectares, or roughly 700 acres; they averaged 67 hectares. As one might expect, they were devoted overwhelmingly to grain production: only 1.4 percent of the land was vineyard and 4.8 percent natural meadow.[2]

Nearly all the leases were intended to last nine years. Among the most

[1] For the Paris region alone, there are a number of excellent studies using leases: Veyrassat-Herren and Le Roy Ladurie, "La rente foncière"; Desaive, "A la recherche d'un indicateur"; Postel-Vinay, *La rente foncière*; Jacquart, "La rente foncière"; and the contributions by Béaur and Constant in *Prestations paysannes*.

[2] The sources include the index to the *actes capitulaires de la cathédrale de Paris* in Archives Nationales (henceforth AN) LL 319–50/51 and the original leases, property descriptions, and land management records in AN S 123–462. J. P. Desaive was the first to use AN LL 319–50/51 as a source for leases; I have gone over this index myself and I have also consulted all of the corresponding original documents in AN S 123–462. All averages here are calculated counting each lease separately; weighting each property by its area would not change the results appreciably.

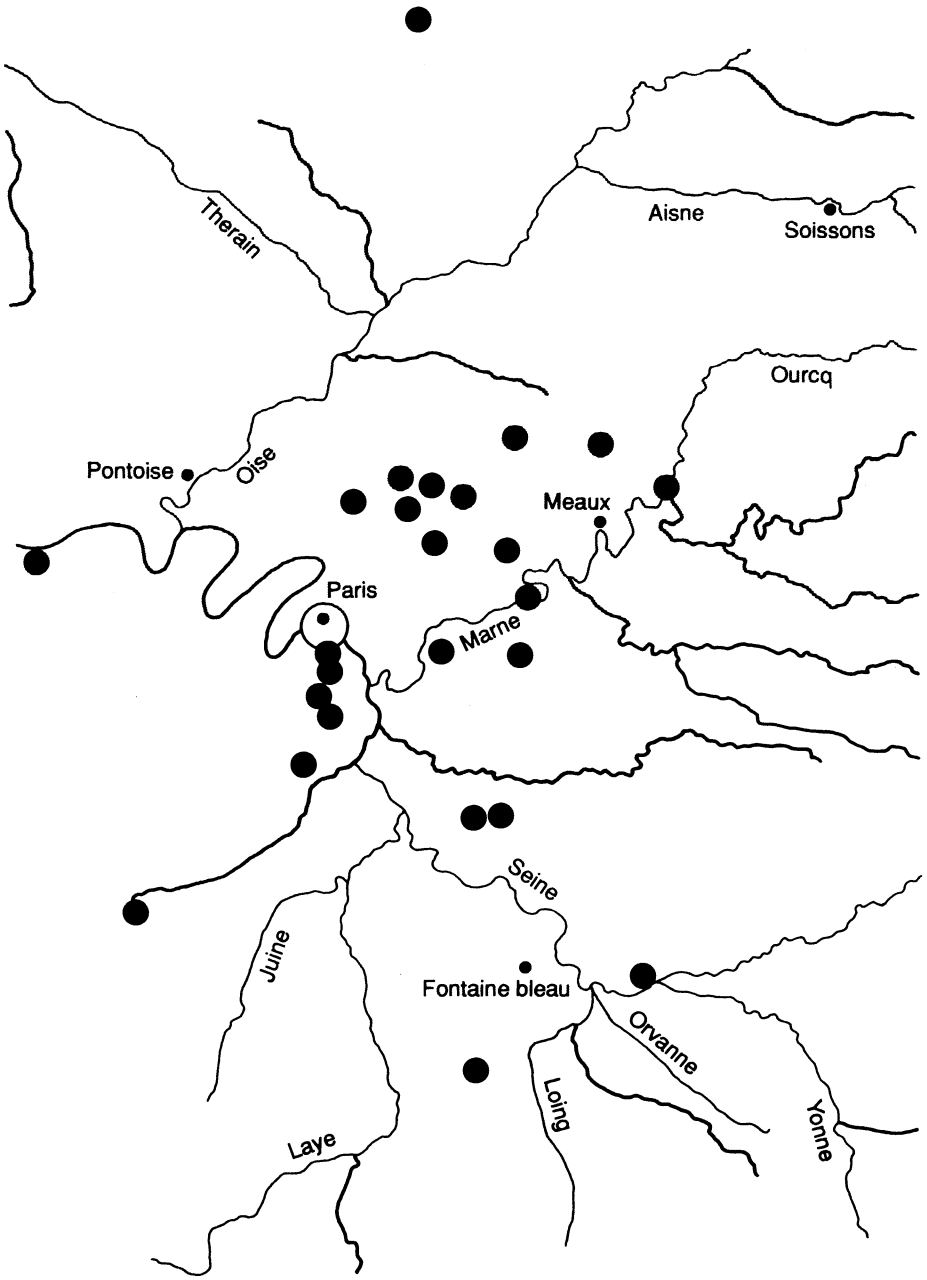

FIGURE 1

LOCATION OF PROPERTIES IN THE NOTRE DAME SAMPLE

ancient—those dating to the early sixteenth century or before—a few were drawn up for longer periods or even for the life of the tenant. Far more common, though, were leases brought to a premature end because of a tenant's death or bankruptcy. Given such interruptions, it is not surprising that the lease series do not run unbroken from 1450 to 1789,

monotonously casting up a new contract every nine years. Some of the series did not begin until well after 1450; others terminated when properties changed. And in several instances leases proved unusable. Still, the series I ended up with seem nearly continuous: between the first and the last usable contract for each property in the sample, the gaps between leases average 9.4 years.

The sample, is of course, not random—few of the properties lie west of Paris—but it does seem representative of open-field agriculture near the city. It also lets us track a large number of identical properties over long periods of time, something previous researchers have never accomplished. The sample has another advantage as well: we know each property's characteristics—the area, the location, the nature of the crops, the identity of the tenant, and so on. We can therefore relate variations in agricultural productivity to those characteristics and do so more precisely than ever before. In the end, the sample paints a somewhat startling picture of an agriculture capable of spurts of considerable growth, at least in the charmed environs of Paris, and it helps us discern, more precisely than in the past, the causes of growth and stagnation under the Old Regime.

LAND RENTS

The first step toward assessing productivity, a step interesting in its own right, is to survey the trend of nominal land rents. Table 1 presents rent averages from the sample for each decade from 1450 to 1789.[3] Most authors limit themselves to simple averages, but because rent depended on land quality and location, I have also adjusted the averages for variations in quality as properties jump in and out of the sample. Columns 2 and 4 display the results of the adjustment, which uses a regression of *ln*(rent) on property characteristics and other variables affecting rent.[4]

The net adjustment is relatively minor and does not affect the overall trend in land rent. Other methods of correcting for quality differences

[3] For a detailed account of how I treated in-kind payments, *pots-de-vin*, *contre-lettres*, rent understatement, *charges*, and a host of related problems, see Hoffman, "Land Rents," appendix 1. Compare with Jacquart, "La rente foncière"; and Béaur, *Le marché foncier*, pp. 231–46.

[4] The relevant property characteristics included soil quality; presence of natural meadow and vineyard, as meadow was scarce and vineyards entailed capital investment; surface area, as large properties typically rented for less; and distance from Paris, which measured the costs of transportation to the major market in the region. Ideally, one would want to have in the regressions a measure of the cost of shipping crops to Paris by the cheapest means available—overland for properties close to Paris, and by river for more distant properties, where the economies of river transport overtook the added costs of shipping crops to a river port and then loading them onto boats. For our properties, however, the shipping costs, as is shown in Hoffman, "Land Rents," appendix 2, were nearly perfectly correlated with simple distance. The quality-adjustment regression also included dummy variables for the devastating war years of the League and its immediate aftermath; for the late eighteenth century, when rents seemed to rise; for repeat tenants, because historians believe they depressed the rent; and a time trend, to capture the effects of inflation and changing prices. Only the property-attribute terms, not the time-attribute terms, were used in adjusting the rents for quality. See Table 1 and Hoffman, "Land Rents," appendix 3, for details.

TABLE 1
NOMINAL RENT (LIVRES/HECTARE) AND AGRICULTURAL PRICE-COST INDEX

Decade	Leases in Sample	Nominal Rent (1)	Nominal Rent (2)	Nominal Rent (3)	*ln*(Rent) (4)	Price-Cost Index (5)
1450–1459	2	0.70	0.76	0.57	−0.29	—
1460–1469	3	0.72	0.80	0.67	−0.23	—
1470–1479	3	0.73	0.94	0.62	−0.07	—
1480–1489	4	0.68	0.69	0.79	−0.69	—
1490–1499	5	0.94	0.97	0.81	−0.07	—
1500–1509	4	1.23	1.33	0.98	0.28	—
1510–1519	6	1.74	1.76	1.40	0.50	—
1520–1529	11	2.14	2.24	1.82	0.57	0.62
1530–1539	14	3.01	2.96	2.23	0.79	0.69
1540–1549	13	3.66	4.12	3.11	1.36	0.72
1550–1559	20	5.07	5.15	4.72	1.58	0.74
1560–1569	13	6.55	7.34	5.86	1.92	0.77
1570–1579	23	9.09	8.74	7.28	1.99	0.86
1580–1589	24	12.43	10.98	10.40	2.27	0.81
1590–1599	26	12.02	12.86	11.92	2.13	1.14
1600–1609	31	12.81	11.64	10.53	2.21	0.95
1610–1619	35	10.85	11.05	8.96	2.25	0.87
1620–1629	38	13.54	13.16	11.61	2.35	0.96
1630–1639	38	20.78	20.26	15.79	2.84	1.19
1640–1649	32	20.91	20.54	17.40	2.83	1.05
1650–1659	27	23.07	22.28	19.14	2.84	1.22
1660–1669	33	26.42	26.53	19.55	3.11	1.13
1670–1679	25	18.78	17.92	17.12	2.79	0.95
1680–1689	24	19.92	19.75	15.88	2.86	1.04
1690–1699	26	21.27	21.58	17.49	2.96	1.10
1700–1709	35	25.44	23.97	20.83	3.06	1.06
1710–1719	31	23.79	23.54	19.12	3.06	1.12
1720–1729	30	30.34	27.81	20.55	3.24	1.07
1730–1739	32	25.01	23.35	22.17	3.10	1.09
1740–1749	32	25.73	25.29	19.03	3.17	1.16
1750–1759	29	27.41	27.14	21.20	3.25	1.12
1760–1769	27	31.90	28.95	23.75	3.32	1.12
1770–1779	19	43.74	43.07	32.44	3.73	1.32
1780–1789	30	49.46	47.91	38.40	3.83	1.16

Notes: Column 1 is the average rent for the leases in the sample; column 2 is the average of quality-adjusted rent for the leases in the sample; column 3 is the area-weighted average of quality-adjusted rent for all leases in force; column 4 is the average of quality-adjusted *ln*(rent) for the leases in the sample; and column 5 is the agricultural price-cost index (mean equals 1). The quality adjustments rely on regression 1 in Table 2 and begin by correcting *ln*(rent) lease by lease. Column 4 is the decennial average of the following: $z = ln(\text{rent}) - a_1x_1 - a_2x_2 - a_3x_3 - a_4x_4 - a_5x_5$, where a_1 through a_5 are the coefficients of percentage meadow, percentage vineyard, good soil, *ln*(distance to Paris), and *ln*(area) in Table 2, regression 1; and x_1 through x_5 are the corresponding variables measured as deviations from their means. The variable z is quality-adjusted *ln*(rent); because the quality adjustment is linear, we would get the same answer if we first averaged *ln*(rent) over each decade and then applied the quality adjustment. Column 2 is the decennial average of e^z for each lease; because exponentiation is not linear, column 2 will not be precisely the same as what we would get by exponentiating the values in column 4. Column 3 averages the area-weighted rent for all the leases in force; it involves the same quality adjustment, except that x_1 through x_5 are now measured as area-weighted averages. Column 5 is $\frac{P}{C}$, the ratio of agricultural prices to the costs of the factors of production other than land, where each price and each cost is weighted by its share in total revenue. Shares are from the Bernonville farm. See Hoffman, "Land Rents," appendices 1, 3, 6, and 9 for details.

Sources: Sample of leases; other sources are listed in Hoffman, "Land Rents," appendix 14.

have an equally small effect. So too does averaging the rent in a different way: weighting all the leases in force in each year by area, under the assumption that each lease remained valid for nine years or until renewed (Table 1, column 3). The difference with the second method is that it weights leases by area and counts not only leases signed in a given year but all those from previous years that remain binding.

The only discrepancy between the two methods appears when crises strike or when rents are growing. During crises, averaging over all the leases in force exaggerates somewhat the rent that was actually paid; during rent inflation, it lags behind the true value of the land. The difference may of course seem small, but it can disturb the calculation of productivity, which requires an up-to-date figure for rent—ideally, what land would fetch if leased to the highest bidder. Given the slight problems with averaging over all the leases in force, I therefore eschew it in favor of the average over the leases in the sample—that is, only the leases signed in any period. In other words, columns 2 and 4 in Table 1 are preferred to column 3.[5]

This rental series, it turns out, matches the evidence unearthed by other historians. Plotting the numbers in Table 1, column 2 against the figures for the outskirts of Paris published by Béatrice Veyrassat-Herren and Emmanuel Le Roy Ladurie yields startling agreement (Figure 2). The same chorus of agreement rings out in a comparison of this evidence with other series from the seventeenth and eighteenth centuries.[6] Although the similarity perhaps detracts from the novelty of my numbers, it lends credence to what they say and in particular to what they reveal about productivity.

USING LEASES AND PRICES TO MEASURE PRODUCTIVITY

Today we can easily measure the productivity of agricultural labor by dividing the quantities of goods produced by the number of workers. Performing a similar computation for the Old Regime, however, is a hopeless undertaking; even though it has been attempted, the results seem dubious. The problem is determining the size of the agricultural labor force, a calculation that, even when based on nineteenth-century census records, is fraught with difficulty. How does one know what

[5] For a discussion, see Hoffman, "Land Rents," appendix 3.

[6] Veyrassat-Herren and Le Roy Ladurie, "La rente foncière." Because these scholars deflated their rent series, I multiplied their figures by the moving average wheat price that they used for deflation. Other ways of comparing the two series led to similar results. See Hoffman, "Land Rents," appendix 4, for details. For other local rent figures that parallel ours, see Béaur, *Le marché foncier*, pp. 262–68; Jacquart, *La crise rurale*, pp. 616, 638, 699; and Bertrandy-Lacabane, *Brétigny-sur-Orge*, pp. 314–15.

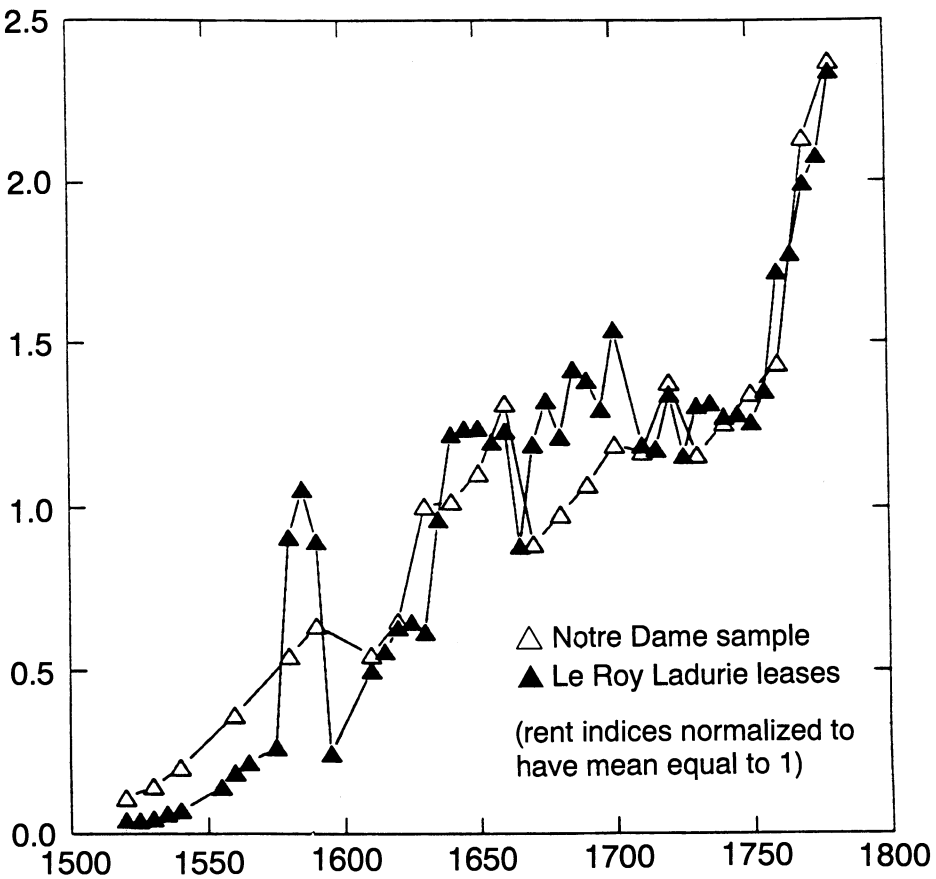

FIGURE 2

NOMINAL RENT INDICES FOR NOTRE DAME SAMPLE AND FOR LE ROY LADURIE LEASES

fraction of the rural population worked in farming when many denizens of the countryside toiled in cottage industry?[7]

It is equally difficult to trace the evolution of the productivity of land. To be sure, we can derive grain yields from a variety of documents, and the yields measure the productivity of land used in grain farming. The problem is that the French evidence is always scanty, making comparisons of yields over time a treacherous venture. Grain output per hectare varied drastically from year to year and from one end of a farm to another, casting doubt on any comparison between, say, a sixteenth-century yield taken from a lone probate description of a particular field and a nineteenth-century yield calculated from a census average for the surrounding *arrondissement*. Worse, even seemingly reliable averages can be deceiving. If wheat supplants crops of lesser value (such as rye)

[7] Postel-Vinay, "A la recherche de la révolution économique"; and Bompard, Magnac, and Postel-Vinay, "Emploi, mobilité et chômage en France."

on poorer soil, then average yields for wheat can stagnate or decline, even though the value of output per hectare and physical yields themselves (on soil of a given quality) are rising.[8]

If following grain yields over the centuries seems intractable, one might hope (as many historians have) that the tithe could be used to track land productivity, provided that it was levied on fields of a fixed size. One serious but largely unacknowledged problem, though, is that the tithe series are likely to omit output from innovations such as artificial meadows and from new crops such as turnips. The large ecclesiastical institutions whose tithe series historians favor often lost their tithe rights when land was planted with new crops. A flat graph of the tithe derived from such records could easily mask growing productivity and thus gravely mislead us.[9]

We therefore cannot easily compute labor productivity or extend yields and other measures of land productivity back into the past. And none of those figures gives us total factor productivity: even when reliable, they furnish only partial productivities of land or of labor and usually only for a single crop, such as wheat. What of agricultural capital and the other factors of production? And what of the farm products that the tithe series skip, such as wool or meat, which were far from negligible even in grain-growing regions? What we need, of course, is a new source of information, preferably one that lets us measure not just the productivity of one output or of one factor but total factor productivity.

That is what the leases allow us to do. When combined with prices and wages, the rental values in the leases yield a measure of total factor productivity that, while itself open to objections, seems much more reliable than the dubious physical measures of output per worker or even output per hectare. Using prices and rental figures in this way was first suggested by Donald McCloskey, in an analysis of English enclosures. More recently, Robert Allen has successfully employed the same

[8] For difficulties with comparisons of yields, see Meuvret, *Subsistances*, vol. 1, pt. 1 (*Texte*), pp. 207–11. The best-known attempt to compare French yields is Morineau's *Les faux-semblants d'un démarrage économique*. One might object that productivity figures calculated from leases would also vary drastically from year to year and place to place, but there are so many leases over which we can average that the problem is less severe than it seems. Furthermore, with the leases we can at least follow the same properties over time and thus control for differences in land quality, something never done with French yields.

[9] In 1603, for example, the canons of Notre Dame went to court because they were unable to collect the tithe on land recently put into cultivation and sown with turnips in the village of Louvres. In 1713 to 1716 they lost the tithe on new artificial meadows in the village of Dampmart to the local curé. In these examples, the sort of tithe records historians use—records of large ecclesiastical institutions such as Notre Dame—might even show a decline in the tithe at a time of agricultural improvements because (as was often the case) the tithe rights to new crops belonged to the curé. See AN LL 327–28, fols. 12–17; LL 331, fols. 210–50.

method to examine the productivity of enclosures and of English agriculture in general in the early modern period.[10]

What McCloskey and Allen relied on was the fact that total factor productivity can be calculated with prices and rents in place of the actual physical measurements of the products and factors of production. The definition of TFP here is a standard one. It gauges the effectiveness of farm production and is defined—roughly speaking—as the average product of all the inputs to farming. Its rate of change equals the speed at which farm production is growing less the rate at which use of the factors of production is increasing, with each product weighted by its share in total revenue and each factor by its share in total cost. In mathematical terms, the rate of growth of TFP is

$$\sum_{i=1}^{m} u_i \dot{y}_i - \sum_{j=1}^{n} v_j \dot{x}_j = \sum_{j=1}^{n} v_j \dot{w}_j - \sum_{i=1}^{m} u_i \dot{p}_i \qquad (1)$$

Here the y_i's are the outputs produced; the p_i's and u_i's are the corresponding output prices and output shares in total revenue; the x_j's, the factors of production used; the w_j's and v_j's, the corresponding factor prices and factor shares in total cost; and dots refer to growth rates. The expression on the left is simply the definition of TFP measured in terms of physical units of inputs and outputs; under conditions specified below, it will equal the expression on the right, which is measured in terms of prices.

If we also assume, as Allen does, that the product and factor shares remain constant over time (an assumption that turns out to be very reasonable for early modern agriculture), then we can integrate equation 1 to get a formula for TFP:

$$\text{TFP} = \frac{{w_1}^{v_1} \cdots {w_n}^{v_n}}{{p_1}^{u_1} \cdots {p_m}^{u_m}} = (r + t)^s \frac{C}{P} \qquad (2)$$

Here r is per hectare nominal rent; t is per hectare taxes; s is the factor share of land; C is a geometric index of the costs of the other factors of production weighted by their factor shares; and P is a geometric index of the price of agricultural products weighted by their shares in total revenue. We have made the reasonable assumption that the burden of taxation falls on land, so that the cost of land equals rent plus taxes, or $(r + t)$. In nonmathematical terms, TFP is high if a property manages to support high rent and taxes despite high costs for the other factors of production and low product prices.[11]

To calculate TFP, it thus suffices to know product and factor shares,

[10] McCloskey, "The Economics of Enclosure"; and Allen, "Efficiency."

[11] The definition of TFP is from Chambers, *Applied Production Analysis*, pp. 235–39. For a derivation of equations 1 and 2, see Hoffman, "Land Rents," appendix 5.

the prices of agricultural products, and the cost of the various factors of production, including land. We can measure TFP either as a weighted ratio of output quantities produced divided by factor quantities utilized, or, equivalently, as a weighted ratio of factor costs divided by product prices. The point is that more efficient techniques and organization not only increase physical outputs for a given level of inputs but also depress product prices relative to factor costs and ultimately show up in the form of higher profits and rents, once we correct for the variation in prices and wages via the indexes P and C. If a clever farmer discovers how to increase his productivity—perhaps he manages to squeeze more wheat from the same plot of land, the same amount of capital, and the same amount of toil—then he will reap higher profits as well, profits that will eventually fund higher rent payments to his landlord. If others imitate him, the price of wheat may fall, but TFP, which is a weighted ratio of factor costs divided by product prices, still increases. On the other hand, a mere shift in rents, wages, and prices in response to population change or price inflation will not affect TFP. If the population increases, for example, rents may rise relative to agricultural prices while wages fall. Yet the index of TFP, if properly calculated, will remain the same.[12]

WHAT THE METHOD OF CALCULATING TFP ASSUMES

The whole method of calculating TFP is open to certain objections, of course. Some are technical and are discussed elsewhere.[13] More important and far more interesting are the assumptions underlying the whole exercise, which may evoke a few howls of execration from economists and historians alike: that the agricultural cost and product shares can be described with some precision for a period of three centuries, that agricultural markets existed, and that the land rental market was competitive. These assumptions obviously deserve detailed scrutiny.

The first is that we know the agricultural technology well enough to calculate the factor and product shares that enter into the formula for TFP. One might suppose that the shares could be recovered from clever regressions with rents, prices, and wages, but such a tactic is doomed to

[12] Imagine, for example, that a growing population drove wages down relative to agricultural prices and pushed rents up, while TFP remained constant. The cost index C would decline relative to the price index P, while rent and hence $(r + t)$ rose, but the change in rent would be just enough to compensate for the change in prices and wages, leaving TFP $= (r + t)^s C/P$ constant. Note that measuring the prices here either in money of account, as I have done, or in precious metal would yield the same answer for TFP and for its rate of change. Converting prices to silver, for instance, would simply multiply the numerator and the denominator in equation 2 by the same number, because the product and factor shares sum to 1. TFP would thus be unchanged.

[13] See Hoffman, "Land Rents," appendix 5.

failure even with the most drastic simplifications.[14] The alternative is to derive the shares from the records of a typical farm in the region. I have done so for the farm of Bernonville, located some 150 kilometers north of Paris near the town of Saint-Quentin. When its accounts for the year 1765 were published in 1767, Bernonville was described as an average large farm, by no means exceptional. And although it lay farther from Paris than any of the properties in the Notre Dame sample, its technology differed little from what one finds elsewhere in the grain-growing regions of the Paris Basin. In the Brie, to the southeast of Paris, in the Beauce, to the southwest, on the plains north of the city, and to its immediate south, farmers grew the same crops, hired similar numbers of workers, and used nearly the same number of animals—and their farm accounts yielded similar product and factor shares. In Bernonville, for instance, 80 percent of the revenue came from grain crops; on a farm in the Brie in the 1730s, 77 percent did. The factor share of land in Bernonville was 27 percent; in the Brie, 31 percent. And on another farm, located some 20 kilometers north of Paris and investigated by Gilles Postel-Vinay and J. M. Moriceau, the numbers are much the same.[15]

Factor and product shares thus seem to have varied little from farm to farm near Paris, and the Bernonville shares would appear to fit the agricultural technology of our sample properties very well, at least in the eighteenth century. One might worry, though, that factor and product shares changed over time. Modern economic growth has accustomed us to increases in the factor share of labor, and in early modern Europe whole regions—Western England, for example—were transformed by the coming of a pastoral economy, which diminished the product share of grain.

Such was not the case, however, near Paris during the period under study. The occasional tenancy contracts we have from other landlords, in which tenants paid a portion of the output as rent, point to similar factor and product shares in the seventeenth century. Death inventories imply that the use of labor and livestock had not changed significantly as far back as the sixteenth century. The number of plowmen hired may have declined somewhat during the eighteenth century, but the overall

[14] In particular, we might try to deduce the shares from a regression of profits on prices and wages. Although we do not know profits directly, we could approximate them by taxes and rents, treating land as a fixed factor and assuming that the rental market would equate profits with the rent and taxes that are the returns to land. The problem, however, is that if we include a realistic number of prices in the regression we run into intractable problems of multicollinearity, which are aggravated by the choice of anything but the simplest form for the profit function. On the other hand, if we reduce the number of prices, the regression coefficients have the wrong sign because of the variables that have been omitted. Differencing the equation and correcting prices for inflation do not resolve the problem.

[15] The Bernonville shares included 14 inputs and 13 outputs; see Hoffman, "Land Rents," appendix 6, for details.

effect on the labor factor share was small. Furthermore, if the factor shares of land and labor had shifted drastically, we should be able to detect it from demographic data, but no such shift is apparent—at least not before the late eighteenth century.[16]

Nor do product shares in total revenue seem to have changed. Farmers did plant new crops such as artificial meadows, but the effect on the overall proportion of outputs was small. Farmers near Paris had specialized in grain production as early as the late Middle Ages; they continued to do so into the nineteenth century. What animal products they produced—such as wool from the sheep that fertilized the arable—derived from grain production, and relative prices never shifted in favor of acquiring additional livestock. Indeed, because much specialization in early modern Europe was driven by the effect of transportation costs on relative prices—farmers hundreds of miles from cities might raise easy-to-transport livestock, while those nearby tilled fields of wheat—it is no wonder that our farms, all near Paris, never abandoned arable farming.[17]

While the assumption of constant product and factor shares appears reasonable, it would be prudent to check the sensitivity of the results to variations in the share values. To do so, I relied on an alternative set of product and factor shares from a farm north of Paris, whose accounts have been analyzed by Gilles Postel-Vinay and J. M. Moriceau. Although the Bernonville and the alternative shares resemble one another, there are a few differences, for the Postel-Vinay and Moriceau farm had specialized to a certain extent in the production of oats. Indeed, one might argue that the differences were as great as might be expected between any two farms on the outskirts of Paris. Nonetheless, as we shall see below, the alternative shares yield similar estimates for TFP.[18]

The formula for TFP also assumes the existence of rudimentary markets in which the factors of production can be purchased and farm products sold. We must be able to measure prices in those markets to calculate the indexes C and P in equation 2 for TFP. Not all of a farmer's dealings need have passed through the product and factor markets—merely a portion. It would not matter, for example, that a farmer employed some family members, provided he also hired servants. Nor would it matter that he consumed some of his crops, provided he also sold a portion. As long as he had some involvement in the markets,

[16] The reason demographic data are useful here is that under constant factor shares the ratio of rent to wages will be proportional to the ratio of labor to land, which we can approximate by the rural population. For details concerning this and the following paragraph, see Hoffman, "Land Rents," appendix 6.

[17] One should not forget the importance of vineyards in certain parts of the Paris Basin; they remained important up to the nineteenth century.

[18] For the factor shares from the Postel-Vinay and Moriceau farm, see Hoffman, "Land Rents," appendix 6.

though, it would be fair to say that the costs and the prices he faced equaled those dictated by the market, once we allowed for the costs of transportation and of market preparation.

Here, obviously, we may raise some historians' hackles, for Old Regime farmers are often considered self-sufficient peasants who were thoroughly isolated from markets. The evidence, though, suggests that self-sufficiency itself was largely a myth. This was certainly the case in the Paris Basin. Nearly all the peasants in the region either cultivated wine for sale, worked on the side as farm laborers, or rented land in a tight land market. By no stretch of the imagination were they self-sufficient.[19]

There remains the practical problem of measuring wages. Ideally we would like to have the wage of farm labor, preferably unskilled. Farm wages, though, are difficult to appraise: domestics were often paid a considerable portion of their earnings in kind, and salaries varied from season to season and task to task. Even for a given task, the salary range could be considerable because of differences in strength and skill. The only alternative, it seems, is to use urban wages for unskilled building workers. Calculating the mode of the observed wages would capture what the average unskilled building worker earned and allow us to overcome differences in strength and skill. One might object that urban and rural wages were different, but fifteenth- and sixteenth-century evidence from the region around Paris suggests that wages for unskilled day laborers in the city differed little from those prevalent in the countryside, at least during the harvest, when farmers hired day laborers from the city. "In the sixteenth century, the wages of two laborers, one working in the fields and the other in the city, were identical," stated Micheline Baulant, who studied wages around Paris—and her data support that assertion. An unskilled urban helper earned 2.5 *sous* a day in 1500 to 1505 and 10.4 *sous* a day in 1594 to 1598; a *hotteur* in the grape harvest earned 2.5 *sous* in 1500 to 1505 and 10 *sous* in 1594 to 1598.[20] Even if there were sometimes differences between city and country wages, the trend of pay for the unskilled was nearly everywhere the same, and it is that trend, not absolute prices, that we need in order to establish changes in our cost index C and thereby in our formula for TFP. For nearly all unskilled occupations, both within the city and without, wages in cash and in kind moved in parallel—or at least this is what the evidence from the Paris region suggests.[21]

[19] Skeptical readers may consult the lengthy discussion in Hoffman, "Social History and Agricultural Productivity."

[20] Baulant, "Prix et salaires"; Fourquin, *Les campagnes*, p. 496; Goubert, *Beauvais*, vol. 1, pp. 139–40, 547–60; and Gutton, *Domestiques et serviteurs*, pp. 111–17.

[21] Baulant, "Prix et salaires," pp. 980–86; and Baulant, "Le salaire des ouvriers." This is sixteenth-century evidence; for evidence for later periods, see Hoffman, "Land Rents," appendix 7. One might worry that cash and in-kind wages could diverge, but evidence from the eighteenth and early nineteenth centuries argues against such divergence. See Labrousse, *Esquisse du*

Of course, we should not jump to the conclusion that a national labor market existed. Labor markets were regional, though the one around Paris was undoubtedly large enough to embrace the localities from which our leases were drawn. Nor should we overlook evidence that the labor market was segmented, with farmers in certain places and at certain times able to hire cheap labor at a cost that bore only a slight relationship to the wages paid in Paris. There is some evidence for such segmentation, but it is as yet neither overwhelming nor convincing. Differences in remuneration were not large, and they may simply have reflected the heterogeneity of labor, the complexities of in-kind pay, and variations in the cost of living. And it is difficult to argue for complete segmentation in the face of the enormous mobility of labor in the Paris Basin during the Old Regime. Parisian workers, we know, helped take in the harvest. Domestics quit the farm for the city, as did paupers fleeing rural poverty. And whole families moved in and out of the small towns surrounding Paris, presumably in search of work. Given such mobility, it seems unlikely that the regional labor market was partitioned into isolated and mutually exclusive compartments.[22]

As it does for agricultural labor, my method also requires the existence of markets for agricultural capital—in particular, livestock. Fortunately, long-distance markets for horses, cattle, and sheep reach far back into the past, and though prices series for livestock are skimpy and we must be careful of differences between breeds, it is possible to assemble the necessary series of cost trends—or at least gross averages for 25-year periods, which are all that is necessary for our cost index C in the formula for TFP.[23]

For the price index P in the formula for TFP, we need prices of agriculture outputs, and here it is grain that poses the most daunting problems. The price of grain was volatile and therefore difficult to measure. Taking long-run averages can adjust for the price volatility, but it is not clear over what period we should average. Furthermore, the cost of transporting grain was high enough to drive a wedge between the farm gate price and the market price that enters into our agricultural price index P. If the wedge were large enough, or if it varied considerably, it could distort our index of TFP.[24]

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mouvement des prix et des revenus, vol. 2, pp. 455–56, n. 33; and also the examples in my appendix 7. For the sources of the wages and the prices that enter into the calculation of the indexes C and P, see my appendix 14.

[22] See Baulant, "Le salaire des ouvriers," p. 472; Baulant, "Prix et salaires," pp. 980–87; Lachiver, *La population de Meulan*, pp. 91–122; Béaud and Bouchart, "Le dépôt des pauvres," pp. 127–43; Hoffman, "Social History and Agricultural Productivity"; and Hoffman, "Land Rents," appendix 7.

[23] Throughout this paper, the price of all capital goods was a rental price, which equaled the sales prices multiplied by interest plus depreciation; see Hoffman, "Land Rents," appendix 6, for details.

[24] Meuvret, *Subsistances*, vol. 3. As much grain reached the consumers in the form of in-kind

But the difficulties here are far from insurmountable. Although we cannot be absolutely certain about what years to average prices over, employing the current year and the previous eight (in other words, averaging over the outgoing lease) seems concordant with contemporary practice. We shall therefore calculate P and C using the Bernonville shares and Paris prices averaged over the outgoing lease. Table 1 displays the resulting decennial averages of the price-cost ratio P/C, which are all we need to calculate TFP. Of course, we can check the sensitivity of our results to this process of averaging by using prices from a radically different set of years in the indexes P and C. We shall do so, using prices averaged over the life of the new lease—or in other words, over the current year and eight years into the future. This alternative set of prices makes strong demands of our tenant farmers (namely, that they be able to see eight years into the future), but as we shall see, it does not change the index of TFP greatly.[25]

As for transportation costs, though they drove a wedge between grain prices in distant markets, the long-run average price trends—all that is necessary for our price index P—tended to move together, as long as the markets were not too far apart. Away from Paris, for instance, grain prices in local markets were lower and more volatile than within Paris in the sixteenth, seventeenth, and eighteenth centuries—yet price trends in markets as far as 100 kilometers away tended to follow the trend of the Paris price, particularly if we examine averages, which smooth out local crises. Such parallel movement should hardly be surprising in view of the considerable evidence that merchants and large-scale farmers carried out what amounted to intermarket arbitrage in the sixteenth, seventeenth, and eighteenth centuries. With individuals buying and selling once price gaps widened, it is no wonder that grain prices, though different in absolute terms, exhibited similar trends.[26]

The last assumption we need is that untaxed profits from farming eventually went to landlords—in other words, that the land rental market was competitive, with no barriers to tenant entry. In the short run, it is clear, such was not always the case, for it might take a landlord time to renew a lease or even to realize that more could be squeezed out of a property. What concerns us, though, is the long run. Unlike the markets for labor, livestock, and agricultural products, which swarmed

payments or self-production, one might suppose that the farm gate price of grain bore no relationship to the market price, but such was not the case near Paris. On this point, see Hoffman, "Land Rents," appendix 8.

[25] See Hoffman, "Land Rents," appendix 9. Prices were too fragmentary to calculate P/C before 1520. Decennial averages of the component prices of P and C and alternative versions of the ratio P/C are available on request from the author.

[26] Kaplan, *Provisioning Paris*, pp. 206, 215–16; Jacquart, *La crise rurale*, pp. 764–66; Dupâquier et al., *Mercuriales*, p. 233; and Baulant and Meuvret, *Prix des céréales*, vol. 1, pp. 12, 25. As we shall discuss, hinterland prices did rise relative to the Paris price between the seventeenth and eighteenth centuries: see Baulant, "Le prix des grains à Paris," pp. 520–40.

with hundreds of minuscule actors, the land rental market in any given village might involve only a small number of tenants, who could conceivably drive rents down and thereby retain some of the profits of farming even in the long run. In a few parts of France—areas of so-called *mauvais gré* or *droit de marché*—tenants actually wielded such power, but *mauvais gré* was unknown throughout most of the area where our sample's farms were located.[27]

One bit of evidence that might nevertheless be construed as a sign of tenant market power is the lower per hectare rent sometimes found on big farms and large plots of land, reflecting the possibility that tenants able to take on a large farm were powerful enough to force down the rent.[28] To judge from regressions of *ln*(rent) on variables affecting rent levels (see Table 2, regression 1), even Notre Dame's larger properties rented for somewhat less per hectare.

But it would be wrong to conclude that Notre Dame's tenants pushed down the rent, for there is a very different explanation for the lower per hectare rent that large plots sometimes fetched, an explanation not dependent in the slightest on the market power of tenants. We should recall that renting out land, even for a fixed rent, involved risks for the early modern landlord. His property might be ruined by neglect, or, worse yet, the tenant might fall behind in paying the rent or not pay it at all. Such risks were far from insignificant, even for small plots of land.[29] Because of them, a landlord might have to seek a judgment against a tenant or seize his assets. But only the large-scale tenants had assets such as livestock or equipment that a landlord could attach. The landlord could therefore allow big *fermiers* to fall into arrears, knowing full well that their livestock and equipment served as collateral for their debts. With small-scale tenants, however, the landlord had no such assurances; his only recourse was to demand a risk premium in the form of higher rent.

Evidence of a different sort also casts doubt on the market power of tenants in the Paris Basin. Large-scale tenants in the region commonly switched farms during their careers. Their mobility would fit a world in which landlords easily introduced new tenants from other villages. Tenants also had large families, and though one could perhaps imagine collusion between two or three tenant patriarchs in order to depress

[27] Hoffman, "Social History and Agricultural Productivity." A *droit de marché* did exist in certain areas north of Paris: see Postel-Vinay, *La rente foncière*, pp. 44–49; and Vinchon, *Le livre de raison*, pp. 36–37, 98–103. But it was largely unknown throughout the rest of the basin, and even to the north of Paris it was hardly universal. See Jacquart, "La rente foncière," p. 375.

[28] Postel-Vinay, *La rente foncière*, pp. 35–54; Grantham, "Agricultural Supply," pp. 43–72; Béaur, *Le marché foncier*, pp. 263–64.

[29] Estienne, *L'agriculture et la maison rustique*, fols. 8–9; *L'art d'augmenter son bien*, pp. 10–17, 171–75; Rozier, *Cours complet d'agriculture*, vol. 2, s.v. "bail"; AN LL 337–38, fols. 96–101 (1748), fols. 236–37 (1747); LL 350–51, fols. 122–24 (1761–1762); S 242 (1754–1762); S 247 (1693); S 176 (1666–1669).

TABLE 2
REGRESSIONS WITH *LN*(RENT) AND *LN*(TFP)

Regression number	1	2	3
Dependent variable	*ln*(rent)	*ln*(TFP)	*ln*(TFP)
Independent variables			
Constant	−11.23	0.079	0.11
	(−16.69)	(0.42)	(0.60)
Dummy: years 1775 and after	0.075	0.064	0.056
	(0.60)	(1.97)	(1.80)
Dummy: war years 1589 to 1597	−0.097	−0.29	−0.28
	(−0.71)	(−8.08)	(−8.30)
Percentage meadow	0.39	0.16	0.11
	(2.09)	(3.25)	(2.51)
Percentage vineyard	0.0018	0.014	0.15
	(0.005)	(0.13)	(1.50)
Dummy: good soil	0.0050	0.00093	0.0041
	(0.09)	(0.06)	(0.28)
ln(distance to Paris in kilometers)	−0.27	−0.067	−0.070
	(−6.24)	(−5.94)	(−5.76)
Dummy: tenant holdover from previous lease	0.021	0.019	0.026
	(0.42)	(1.42)	(2.01)
Time (units of 100 years)	0.91	0.061	0.063
	(23.11)	(5.49)	(5.82)
ln(property area in hectares)	−0.085	−0.024	−0.050
	(−3.42)	(−3.68)	(−7.46)
ln(area per property parcel)	—	—	0.043
	—	—	(6.91)
Observations	652	638	581
R^2	0.57	0.31	0.37
Standard error	0.63	0.17	0.15
Mean of dependent variable	2.70	0.79	0.80
Condition number of single-value decomposition	87.41	93.46	92.83

Note: Years before 1520 are omitted; *t*-statistics are in parentheses. The TFP figures are adjusted for taxes.
Sources: Sample of leases and property descriptions; additional sources are described in Hoffman, "Land Rents," appendix 14.

local rents temporarily, the collusion would in all likelihood break down once the patriarchs tried to establish their numerous children on farms.[30] They would compete with one another to settle their children, and their heirs would do the same. Collusion, even if it existed, would have been hard to maintain.

Finally, if tenant dynasties did in fact hold down rents and capture a share of the untaxed profits, then rent increases would have been significantly lower when the same tenant (or a relative) renewed a lease and significantly higher when an outsider was finally installed. But our

[30] Moriceau, "Un système de protection sociale." Those tenants who did linger were probably the best, retained by the landlord for their mutual benefit.

TABLE 3
REGRESSIONS WITH GROWTH RATE OF RENT AND TFP

Regression number	1	2	3
Dependent variable	Rent growth rate (percentage per year)	TFP growth rate (percentage per year)	TFP growth rate (percentage per year)
Independent variables			
Constant	1.23	0.46	0.45
	(5.78)	(1.32)	(1.09)
Growth rate price-cost ratio	0.61	—	—
	(7.26)	—	—
Growth rate of taxes relative to rents	−0.44	−4.11	−4.44
	(−0.11)	(−2.00)	(−2.10)
Growth rate of Paris population	—	0.24	0.23
	—	(6.16)	(5.88)
Dummy: years 1775 and after	—	1.04	1.03
	—	(3.48)	(3.35)
Dummy: war years 1589 to 1597	−4.14	−2.44	−2.25
	(−4.85)	(−5.85)	(−5.19)
Dummy: repairs	—	−0.31	−0.56
	—	(−0.85)	(−1.39)
Dummy: tenant holdover from previous lease	−0.17	−0.085	−0.041
	(−0.58)	(−0.64)	(−0.29)
ln(distance to Paris in kilometers)	—	−0.074	−0.083
	—	(−0.71)	(−0.70)
ln(property area in hectares)	—	−0.024	−0.012
	—	(−0.43)	(−0.18)
ln(area per parcel)	—	—	−0.022
	—	—	(−0.34)
Observations	648	648	593
R^2	0.086	0.20	0.19
Standard error	3.69	1.68	1.68
Mean of dependent variable	1.10	0.13	0.13
Condition number	2.57	14.34	16.63

Note: Growth rates equal the rate of change of logarithms calculated from lease to lease. The price-cost ratio is as in Table 1, and the TFP growth rates are not adjusted for taxes. As is shown in Hoffman, "Land Rents," appendix 13, the lack of a tax adjustment will not affect the regression coefficients because the growth rate of taxes relative to rents figures among the explanatory variables. Years before 1520 are omitted; *t*-statistics are in parentheses.
Sources: See Table 2 source notes.

sample of leases shows that the rent never behaved in such a fashion. If we regress the rate at which *ln*(rent) increased from lease to lease on the rate of change in the agricultural price-cost ratio *P*/*C* and other variables affecting the rent, we find that retaining the same tenant depressed the rent by a microscopic and statistically insignificant amount (Table 3, regression 1). If a relative of the old tenant renewed the lease, the effect was just as small.

Such a result should not be surprising. Landlords renewed the leases every nine years and did so with an eye toward profits. Except in the regions of *mauvais gré*, nothing kept a landlord from eventually finding

a new tenant, and with no barriers to entry, tenants could not long siphon off profits. One could of course debate the normal entrepreneurial profits due to tenants. Our assumption is that in the long run the competitive rental market would have driven these down to zero, leaving tenants no more than what they would earn in the labor market and making the cost of the entrepreneurial input equal to the wage rate. This assumption is open to criticism, but the evidence for competition in the rental market obviously runs in its favor; so too does an eighteenth-century analysis of farm earnings, which suggests that entrepreneurial profits were minuscule and far too small on the average to affect our TFP calculations.[31]

Although the use of prices and leases to calculate TFP may now seem reasonable, a reader might still like some reassurance that an index of TFP based on something so intangible as prices would really yield reliable results. In one instance where, thanks to an unusual set of family records, we can compare physical quantities produced and factors employed for a real eighteenth-century farm in the Paris Basin, the method of calculating TFP described here gives extraordinarily accurate results. Neither the assumption of constant product and factor shares nor the use of prices in place of physical quantities seems to be misleading.[32]

[31] For how rent was set, see Hoffman, "Land Rents," appendix 9; for entrepreneurial profits, see my appendices 5 and 10. One might still worry that entrepreneurial profits could vary enough in the short run to disturb the trend of TFP. The most likely case would be one in which inflation in agricultural prices drove up profits before rents could be pushed upward. In such cases, TFP as calculated from equation 2 would be negatively correlated with the inflation rate, because with inflation we would underestimate the cost of the entrepreneurial input by setting it equal to the wage rate, and the higher agricultural prices would then push down our estimate of TFP. Fortunately, we can test for such a phenomenon by adding the agricultural inflation rate to regressions with *ln*(TFP). We would expect to find a negative and significant coefficient for the inflation rate, but in fact that never occurs, even if we vary the way we measure inflation. Moreover, the regression coefficient of the inflation rate implies only a small correction to TFP. It is worth noting here that equation 2 does not assume that the land supply is fixed or that the tenant farmers were profit maximizers—though without profit maximization, our definition of TFP has no necessary connection with technical change. We do have to assume the existence of a large number of risk-neutral tenants, but risk neutrality is not an absurd assumption for the sort of wealthy *fermiers* who rented Notre Dame's farms. For them, even profit maximization is not unrealistic. For a discussion and other assumptions, see Hoffman, "Land Rents," appendix 5.

[32] The example, from data kindly furnished by Gilles Postel-Vinay, concerns the highly productive farm that provided our alternative shares. We can compare its productivity in the 1740s and 1780s using physical inputs and outputs via a Törnqvist productivity index. The index is equivalent to using a translog production function, but it allows us to compare productivity without doing regressions. With this technique we find that productivity on the farm rose 9.79 percent between the 1740s and the 1780s. If instead we use the method adopted throughout the rest of this article—with shares that came from the Bernonville farm—we get very nearly the same thing, 9.03 percent. Clearly, our price-dual results are close to the primal, or quantity-based, results. Moreover, practically none of the difference between the two numbers was caused by the constant shares assumption. For details, see Hoffman, "Land Rents," appendix 11.

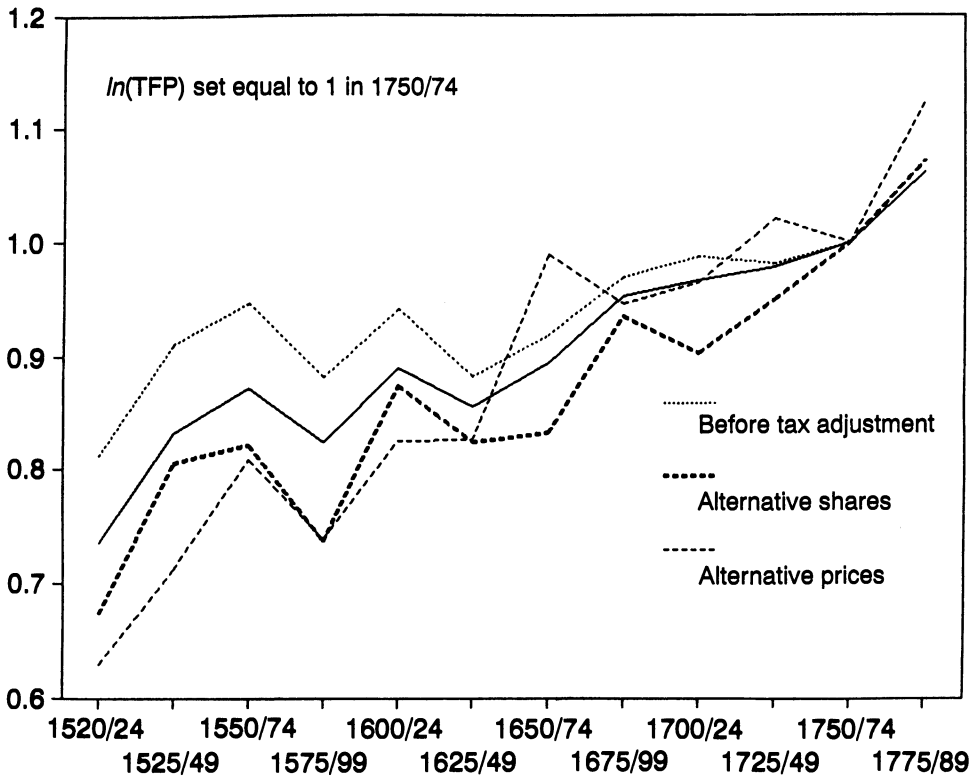

FIGURE 3

LN(TFP) FOR ALTERNATIVE PRICES AND SHARES
(ADJUSTED FOR TAXES AND LAND QUALITY)

THE NOTRE DAME PROPERTIES

Productivity trends

What then do the leases reveal? The place to begin is with the evolution of TFP. From equation 2, TFP equals $(r + t)^s C/P$, where r is per hectare rent; t is per hectare taxes; s is the factor share of land; and C and P are the indexes of agricultural costs and prices. We do not know t precisely, but if we ignore taxes for the moment—an oversight soon to be corrected—then the logarithm of TFP will be very nearly equal to $sln(r) - ln(P/C)$, which we can average across properties for different periods. We can then chart, at least roughly, the changes in TFP, and we can hone the accuracy of the graph by adjusting $ln(r)$ for variations in land quality via the procedure used in Table 1.

Figure 3 plots such an average for 25-year periods. It also charts average values of TFP computed with the alternative factor and product shares and with the alternative prices in the indexes P and C—prices that are averaged over the newly signed lease instead of over the outgoing one. All three curves are corrected for variations in land

quality and location.[33] The alternative shares and prices shift the graph of TFP somewhat but do not disturb the overall trend. The alternative shares tip the curve upward a bit—largely because the land share s is higher—but TFP still traces out the same peaks and valleys. The pattern with the alternative prices is also similar, except in 1650/74 and 1775/89, when its behavior may well be a fluke.[34] Overall, TFP follows essentially the same path, whatever the shares and prices.

Built into Figure 3 is an adjustment for having omitted taxes in the calculation of TFP. Without such a correction, TFP growth would be understated, because of the increasingly heavy fiscal burden that the monarchy imposed on the land. The size of the resulting error, though, turns out to be relatively small. Figure 3 plots TFP both before and after the tax adjustment for the Bernonville shares and for prices averaged over the outgoing lease. The graphs of TFP with alternative shares and prices include tax adjustments of a similar magnitude.[35]

The years from 1450 to 1519 have been excluded from Figure 3, because the prices needed for the indexes C and P become less reliable and the number of usable leases dwindles. As is well known, this earlier period witnessed a recovery from the devastation wrought by the Hundred Years' War. Tenants reoccupied abandoned farms, rebuilt walls and barns, and cleared fields overgrown with weeds. The process

[33] One alternative would be to average $sln(r)$ and $ln(P/C)$ separately, taking the mean of $sln(r)$ over all the leases in each 25-year period and then subtracting $ln(P/C)$ averaged over all the years in the period, rather than over all the leases. This procedure, though, yields results nearly indistinguishable from simply averaging ln(TFP) lease by lease; see Hoffman, "Land Rents," appendix 12, for a discussion. We could also average ln(TFP) by decade, but the decennial averages obscure the trend. Finally, though it might seem promising to chart TFP for clusters of properties (the landlocked ones north of Paris, for example) or to single out farms with high rates of TFP growth, in the end neither technique proved illuminating.

[34] In 1650/74 the TFP index with alternative prices is inflated—perhaps artificially—because it employs prices eight years into the future; it thus incorporates the depressed prices of the 1670s, when P/C is very low (Table 1, column 5). Its jump in 1775/89 may also be a fluke. As our prices series stops in 1789, we cannot really incorporate prices eight years forward; rather, we have to calculate P/C in the late 1780s with prices from only a few years in the late 1780s, making the alternative price estimates suspect.

[35] As TFP equals $(r + t)^s C/P$, omitting taxes t, as we have, would tend to understate both the level and the growth rate of TFP, if taxes were rising relative to rents. The precise taxes t for each piece of property will never be known precisely, but one reasonable assumption is that for the ith property the fraction of gross rent (that is, rent plus taxes) going to the landlord rather than to the fisc is g, where $ln(g)$ equals $b\ ln(t_a/r_a) + c_i$. Here b is a negative constant, t_a is the average per capita tax assessment, r_a is the average per hectare rent, and c_i is a constant that varies from property to property. Under this assumption, which amounts to saying that taxes were apportioned with an eye toward average rent and population levels, we can estimate the magnitude of the error involved in omitting taxes from the formula for TFP. The way to do so, shown in Hoffman, "Land Rents," appendix 13, is to regress the growth rate of TFP measured without taxes on the growth rate of t_a/r_a, which we can derive from tax receipts, population statistics, and average rent levels. We then subtract the product of the growth rate of t_a/r_a and its regression coefficient from the measured growth rate of TFP in order to correct the measured growth rate of TFP for the omission of taxes. To adjust the measured level of TFP, we subtract the same regression coefficient times $ln(t_a/r_a)$. Table 3, column 2, contains the necessary regression; the error involved in ignoring taxes turns out to be very small, particularly in the case of the growth rate of TFP. See my appendix 13 for details.

of reconstruction swept on well into the sixteenth century, particularly in villages that were cursed with poor soil or situated far from Paris. As late as 1545, for example, Notre Dame was still clearing land in the village of La-Grande-Paroisse 77 kilometers to the southeast of Paris, where one of its tenants, Jean Godet, had to reclaim nine hectares of briar-choked meadow. Godet also had to enclose the meadow with ditches to keep wandering animals out, evidence that the process had extended beyond mere rebuilding to become one of general improvement to the soil.[36]

If the wave of improvements persisted well into the sixteenth century, it might explain the relatively high levels of TFP we observe in 1550/74 (Figure 3). Investment hidden in improvements would boost rents and thereby appear—somewhat erroneously—as higher TFP. It would also explain the rapid pace of TFP growth. Between 1520/24 and 1550/74, TFP grew between 0.3 and 0.4 percent a year, a brilliant achievement by early modern standards and, as we shall see, one that compares favorably with the English performance even two centuries later.[37]

In all likelihood, however, the cause of the higher productivity in 1550/74 lies elsewhere than in recuperation and improvements after the Hundred Years' War. In the first place, information contained in the leases often allows us to deduct the portion of the rent that reflects improvements, at least when buildings are concerned. When it is deducted, the rent and consequently the TFP estimates hardly change. One could argue that clearing and other investments in land would not leave a trace in the leases, but clearing was unlikely to have continued after 1550, particularly on properties close to Paris, where the TFP increases in the middle of the century were largest. The farms near Paris had suffered much less during the Hundred Years' War, and they would in any case have been rebuilt during the fifteenth century, not as late as 1550 nor even after 1525.[38] Evidently, some other force was pushing TFP upward in the mid-sixteenth century, a force that waxed stronger near Paris. Perhaps it was the opportunities offered by proximity to a large city—a point to which we shall return.

After the heights of 1550/74, TFP plummeted during the Wars of Religion of the late sixteenth century. If we compute the growth rate of TFP from lease to lease and average it across properties, we see that it too dropped, confirming the dismal picture at the close of the 1500s.[39] Between 1550/74 and 1575/99, TFP fell 5 percent or more, depending on which shares and prices we employ.

[36] See AN S 407 (1464); S 272 (1522, 1545); and S 409 (1479, 1482, 1483, 1498, 1511). Compare with Fourquin, *Les campagnes*, pp. 389–97, 430–531, map 5.

[37] The 0.3 to 0.4 percent range covers the growth rates one gets with all the various shares and prices.

[38] Fourquin, *Les campagnes*, pp. 389–97, 430–531; and Jacquart, *La crise rurale*, pp. 42–47.

[39] See Hoffman, "Land Rents," fig. A-3.

The cause of the collapse was undoubtedly war. The decline was steepest during and immediately after the years 1589 to 1594, the period of most intense fighting in the Paris Basin, when undisciplined armies traversed the region sowing devastation in their wake. During these accursed years soldiers wreaked the greatest havoc: not content to trample crops, seize livestock and grain, and burn farm buildings to the ground, they resorted to extortion and kidnapping and completely disrupted trade. Understandably, many a farmer fled, abandoning his farm to weeds or to pillage. Notre Dame's tenant Bernaye quit his lease in La Grande Paroisse in 1594 because of attacks by soldiers, and warfare left Notre Dame's farm in Dampmart abandoned and ruined in 1597. During the worst period of anarchy and plunder, TFP dropped by perhaps 25 percent.[40]

Such were the heavy consequences of war. To be sure, the index of TFP might seem ill suited for gauging the effects of such transitory events, as it was designed to measure only long-term trends. Yet the evidence suggests that the plunge of TFP during the Wars of Religion was in fact real. What pushed TFP down in the 1590s was not a decline in rent but a sharp upswing in agricultural prices (Table 1). Those leaping prices were a direct result of markets disrupted and products destroyed.[41]

Productivity growth increased sharply in the peaceful opening years of the seventeenth century. Then, in the second quarter of the century, TFP again declined (Figure 3). The drop probably resulted from the heavy taxes imposed to fund the kingdom's involvement in the Thirty Years' War. Our TFP figures were of course adjusted for taxes, but the adjustment concerned only that portion of the farm profits or surplus that went to the fisc instead of to the landlord. Skyrocketing taxes also could have wreaked havoc by disrupting the agrarian economy. Tax increases, after all, pushed peasants into debt and led to the frequent seizure of livestock and other agricultural capital for the payment of back taxes. Along with troop movements during the Fronde rebellion and a series of disastrous harvests in the early 1630s, the tax-provoked

[40] See AN LL 329–30, La-Grande-Paroisse (1594); S 242 (June 25, 1597); and Jacquart, *La crise rurale*, pp. 171–207. The 25 percent decline in TFP comes from Table 2, regression 2, which is discussed later.

[41] The regression with *ln*(rent) also suggests that rising prices, rather than declining rents, lay behind the drop in TFP, as the dummy variable for the war years 1589 to 1597 does not have a large or significant coefficient (Table 2, regression 1). The chief argument against the reality of the TFP drop would run something like this: The 1589/90 siege of Paris might have temporarily driven up the Paris grain prices that figure in our index P (thereby depressing TFP), even though farm gate prices and true TFP in fact remained the same. But the index P averages prices for the current year and for the eight years of the previous lease; it is therefore unlikely to be swayed unduly by any single year of crisis. Furthermore, some local markets show the same spike in prices in 1589/90 as does Paris, suggesting that the price increase was not confined to the city (see Jacquart, *La crise rurale*, p. 765). As it turns out, we observe the same decline of TFP with the alternative shares and prices.

disruptions fit the chronology of declining TFP in 1625/49 and no doubt lay behind it.[42]

The following century witnessed a recovery and then slow growth. At least a part of the apparent gains in the century after 1650 was in fact a mirage, reflecting a decline in transportation costs rather than increased agricultural productivity. The cost of transport, we recall, drove a wedge between farm gate prices and Paris prices for bulky commodities such as grain and thus progressively reduced rents on land farther from the city. Because our calculation of TFP is based on Paris prices, and because the measure of TFP combines low local rents with high Paris grain prices, we undoubtedly underestimate the absolute level of TFP for farms distant from the city. The reason again is the simple fact that local rents adjust to transportation costs and local prices, not to the higher prices prevailing in Paris.

As long as local grain prices moved in parallel with Paris prices—the usual pattern—there would be no cause for worry. Although absolute levels of TFP might err slightly, trends in productivity and rates of productivity growth would be the same. But over the course of the late seventeenth and early eighteenth centuries, local prices in markets such as Pontoise and Soissons rose slightly to approach those prevailing in Paris, and the gap between the Paris price and the local prices closed.[43]

What was happening was that transportation costs were dropping. The increase in local prices relative to the Paris price was more pronounced the farther markets were from Paris, just as we would expect if the cost of transportation were falling. Such declining costs were themselves a mark of increased productivity, but in transportation rather than in farming.[44] Unfortunately, our measure of TFP would mistakenly confound the two. Rents would increase as local grain prices converged to meet the Paris price, but as we would be judging rents relative to a Paris price index P, it would seem as if TFP were rising, particularly on distant farms where the effect of declining transportation costs was most conspicuous. It was precisely on such farms that the productivity gains in the late seventeenth century seemed largest.

Prices in markets outside of Paris can therefore reveal how much of the TFP growth between 1650/74 and 1750/74 actually resulted from

[42] Jacquart, *La crise rurale*, pp. 623–99.

[43] Meuvret, *Subsistances*, vol. 3, pt. 2, pp. 116–34; Baulant, "Le prix des grains"; AN F 11 207 (Soissons price, corrected following the indications in Goubert, *Beauvais*, vol. 1, p. 408); and Dupâquier, *Mercuriales*. Graphs of the Soissons and Pontoise prices show that they rose roughly 5 to 10 percent relative to the Paris price between 1650 and 1750, with more of an increase in distant Soissons than in Pontoise.

[44] For direct evidence of declining costs of transportation, see Letaconnoux, "Les transports en France au 18e siècle," pp. 97–114, 269–92. Part of the transportation improvements undoubtedly involved the arduous task of establishing networks of specialized middlemen, a subject I shall pursue in a forthcoming book. Separating agriculture and transportation here is, of course, somewhat artificial because much of the grain was carted to market by the farmers themselves.

declining costs of transportation and from the concomitant rise in local prices. Let us consider, for instance, a market far from Paris, where the shift in grain prices relative to those in Paris was large. Soissons provides a perfect example: at nearly 100 kilometers from Paris, it was farther away than any of the properties in our sample. Not surprisingly, the increase of grain prices in Soissons relative to Paris accounts for an 8.3 percent rise in our measure of TFP between 1650/74 and 1750/74, roughly three-quarters of the 11.3 percent gain we observe if we compute TFP with the Bernonville shares and with prices averaged over the outgoing lease.[45]

Closer to Paris, the convergence of local prices and the Paris price has much less effect on our measurement of TFP. At a market such as Pontoise, approximately 30 kilometers from Paris, the convergence of prices explains only a 3.6 percent increase in the same TFP measure over the same period. Clearly, Pontoise provides the example relevant to our sample of properties, for they lie on the average a little less than 40 kilometers from the city, not 100 kilometers away. Between 1650/74 and 1750/74, then, true agricultural TFP grew by perhaps only 7.7 percent—the other 3.6 percent we measure resulted from better transportation. Improved transportation should not, of course, be slighted: it helped feed the growing city of Paris as much as did more efficient farms.

After the century of slow growth, TFP finally accelerated in the late eighteenth century (Figure 3). Between 1750/74 and 1775/89 TFP vaulted 6.5 percent, measured with the Bernonville shares and outgoing prices. The spike at the end of the Old Regime is even more pronounced if we look at rates of growth. They averaged more than 0.3 percent a year between 1750/74 and 1775/89 and reached a peak of more than 1 percent—rates comparable or superior to those achieved across the English Channel. Indeed, in the early eighteenth century, when TFP growth in English agriculture seemed to crest, it was gaining 0.6 percent annually, according to N. F. R. Crafts; later in the century, he estimated, the growth rate was only 0.2 percent. Robert Allen's work on the English Midlands points to a similar range: between 0.2 and 0.3 percent over the seventeenth and eighteenth centuries.[46] Agriculture in the Paris Basin was thus hardly lagging behind England; in fact, its performance seems positively buoyant.

But was the late eighteenth-century increase in TFP in the Paris Basin illusory? Did it, at least in part, mirror declining transportation costs, as did the slow growth in the years before 1750? The answer this time is no. In the first place, after 1775 our index of TFP rose no faster on distant

[45] Prices at Rozay-en-Brie suggest a similarly large role for transportation in the period between 1650/74 and 1725/45, when the Rozay price series unfortunately stops.

[46] See Crafts, *British Economic Growth*, pp. 83–85; and Allen, "The Growth of Labor Productivity."

properties than on those near Paris—the opposite of what one would expect given declining transport costs. Local prices, moreover, had by 1750 ceased rising relative to the Paris price, and their movement no longer accounted for any of the increase in TFP. Prices in Soissons explain perhaps a 1.8 percent increase in our measure of TFP between 1750/74 and 1775/89; those in Pontoise—the ones relevant to our sample—explain none at all.

It is true that the measure of TFP used here may lag a bit behind reality. It took time to renew a lease, time to determine that a tenant was thriving and that the rent could be ratcheted upward. A wise landlord might wait before demanding more from his tenant, lest the tenant go bankrupt and the landlord receive nothing. Notre Dame, for example, investigated several tenants in the late 1750s, discovered that they were profiting, and ruled out the prospect of bankruptcy. Only then did it raise the rent. If such a pattern were general, the increase in productivity could have begun earlier than the graphs suggest.[47]

Whether the upturn began slightly earlier or not, nothing suggests that the eighteenth-century jump in TFP was peculiar to the properties owned by Notre Dame. Nominal rent increases of 79 to 120 percent between the 1730s and 1780s were common in Ile-de-France, Picardy, and the Beauce. On the Notre Dame farms the increase was 105 percent (Table 1, column 2). Because the trend of prices and taxes was similar throughout the environs of Paris, TFP must have grown by a like amount on farms throughout the region.[48]

Regression Results

Regression analysis based on individual leases corroborates this three-century story of productivity change and helps us refine our results. In the regressions the dependent variables are the logarithm of TFP and its growth rate, both calculated lease by lease. Here *ln*(TFP) is computed from equation 2 using Bernonville shares, prices averaged over the outgoing lease, and rent without an adjustment for land quality. Alternative prices and shares yield similar results, and we can correct

[47] See AN S 242 (1754–1762, Dampmart); and S 282 (1746–1755), S 460 (1782) (La-Grande-Paroisse).

[48] Béaur, *Le marché foncier*, pp. 262–68; Bertrandy-Lacabane, *Brétigny-sur-Orge*, pp. 314–15; and Veyrassat-Herren and Le Roy Ladurie, "La rente foncière." Historians might wonder whether increased competition among tenants or improved accounting by landlords (an outgrowth perhaps of the oft-discussed "feudal" reaction in the eighteenth century) allowed landlords to squeeze more from their tenants in the late eighteenth century, thus explaining the rent increase we observe. The problem with such an argument is that there is no sign of increased turnover among tenants in the late eighteenth century, which we would expect with increased competition among tenants or excessive pressure from landlords. Furthermore, there are numerous examples of pressure on tenants in earlier periods as well. I will discuss these issues at greater length in a forthcoming book.

for land quality and for the use of Paris prices by including quality and locational measures among the explanatory variables.[49]

The regression with *ln*(TFP) confirms that TFP plunged during the worst phase of the Wars of Religion. The coefficient of the dummy variable for the terrible years from 1589 to 1597 (the period of most intense fighting around Paris plus the following three-year crop cycle) translates into a 25 percent drop in TFP, and the *t*-statistic is too large for it to be a fluke (Table 2, regression 2). Similarly, TFP really does jump after 1775—by 6.6 percent, if we judge from the coefficient of the variable for the years after 1775. As for the rest of the three centuries, the coefficient of the year, which averages TFP growth outside the periods from 1589 to 1597 and from 1775 to 1789, is certainly consistent with our story of rapid gains in the early sixteenth century, a sharp recovery after 1589 to 1597, a crisis in 1625 to 1650, and slow growth for the following century.[50]

As does the analysis of local prices in the seventeenth and eighteenth centuries, the regressions also argue against interpreting the increase in our TFP index exclusively as a decline in transportation costs. If falling transportation costs alone were to explain all the growth of our index of TFP, then the rate of change of TFP would seem higher farther away from Paris. It would be on the distant properties that local prices would rise the most, and rents would follow in their wake. We would therefore expect to measure higher rates of TFP growth on distant properties and hence a positive coefficient for the logarithm of the distance to Paris in the regressions with the rate of change of TFP (Table 3, regression 2). Yet such is not the case. The coefficient is insignificant and negative, and while transportation was growing more efficient, farming did the same.

[49] For the regressions with alternative shares and prices, see Hoffman, "Land Rents," appendices 6 and 9. In Table 2, the level of TFP includes a correction for taxes, but in Table 3 the TFP growth rate does not. The coefficients in Table 3 will not be affected by the failure to correct for taxes, because the growth rate of taxes relative to rents appears among the explanatory variables. See my appendix 13 for an explanation. The TFP growth rate regressions also include a dummy variable for ongoing repairs and for tenants who repeat from previous leases, which corrects for any market power that repeat tenants may have exercised. Finally, though one might argue for regressing nominal or real rents on prices and wages, the regressions swiftly bog down in multicollinearity, and in any event it is not uncommon to regress productivity indexes on explanatory variables. For an example, see Allen, "Efficiency."

[50] One cause for worry is the large value of the condition number, a sign of multicollinearity. Although multicollinearity may therefore cast some doubt on the results with *ln*(TFP), it does not afflict the regression with the TFP growth rate, which points to the same dip in 1589 to 1597 and to the same sharp increase after 1775 (Table 3, regression 2). According to the coefficients, the TFP growth rate fell 2.4 percentage points between 1589 and 1597 and soared a point after 1775. And everything else in the regression fits our story, too. For the condition number and multicollinearity, see Judge et al., *The Theory and Practice of Econometrics*, pp. 896–904. The sample of leases showed no signs of heteroscedasticity or autocorrelation; for details, see Hoffman, "Social History and Agricultural Productivity," p. 17.

EXPLAINING PRODUCTIVITY GROWTH

What then explains the slow growth in TFP that we saw in the years between 1650 and 1750—or the rapid increases we observed in the sixteenth century, the early seventeenth century, and again after 1775? Part of the growth in 1650 to 1750 reflected improved transportation, and the surge in the early seventeenth century signaled a recovery after the Wars of Religion. But what of the other periods of rapid growth? The answer does not lie with a social or technological revolution, for nothing of the kind happened before 1789. No wave of enclosures depopulated the countryside, and no mechanical revolution or drastic change of crops transformed farming, even at the end of the eighteenth century. What change there was probably reflected the opportunities made possible by the proximity of Paris and its growing market. The evidence thus fits the story, told by several historians, that stresses urban markets in explaining agricultural gains before the technological upheavals of the late nineteenth century.

In the region of our sample, we can begin to discern how agriculture benefited from proximity to Paris and from the resultant opportunities for trade that transportation costs would rule out in other, less urbanized areas. The productivity gains on our sample properties did not necessarily stem from dramatically higher yields—evidence about the evolution of yields in the Paris Basin is in any case unclear—but the gains seem to have been at least in part a response to the increasing animal populations in the city. The horses that pulled the newly invented carriages of the privileged and brought food to the officials of the growing state drove up the price of forage and encouraged the production of additional animal feed on grain farms close to the city. Early on, farmers planted artificial meadows to nourish their own livestock and then carted their oats, straw, and hay to Paris. They might then return with loads of manure to spread on their fields, releasing them from the terrible constraint that the lack of fertilizer had imposed on traditional agriculture and boosting their grain yields. These changes all tended to be piecemeal and accomplished on a small scale—in the corner of a field here, on a parcel of land there—rather than on entire farms. They thus did not upset the agricultural technology. Nonetheless, they sufficed to push TFP upward.[51]

The regressions substantiate the important role played by proximity to Paris and by the city's growth. Multicollinearity precludes adding the population of Paris to the regressions with the logarithm of TFP, but the growth rate of the urban population appears to have had a large effect on

[51] The previous two paragraphs depend on Chevet, "Le Marquisat d'Ormesson"; Grantham, "The Diffusion of the New Husbandry"; Grantham, "Agricultural Supply"; Jacquart, *La crise rurale*, pp. 321–30; Meuvret, *Subsistances*; and Moriceau and Postel-Vinay, *Ferme, firme et famille*. That soil quality has no effect on rent or on TFP (Table 2, regressions 1 and 2) is consistent with this story: near Paris enough manure was available to make up for soil differences.

the growth rate of TFP (Table 3, regression 2). In the early seventeenth century, for example, when the population of Paris was gaining 1.3 percent annually—rapid growth by contemporary standards—it added 0.3 percent to the rate of increase of TFP, also a large amount in the early modern world.[52] One cannot, of course, rule out the possibility that rising TFP made possible a larger urban population and not vice versa, but the evidence is at least consistent with the city's being a motor of agricultural growth.

Small farm size has been invoked repeatedly to explain the failings of French agriculture ever since the days of Arthur Young, and it is important to know whether farm size or consolidation affected TFP growth in the Paris area. Large size (as measured by the logarithm of property area) actually diminishes rent and thus our measure of TFP, but the effect, we have argued, is merely the risk premium demanded of small-scale tenants (Table 2, regressions 1 and 2). If we add to the regression a somewhat crude measure of consolidation (the logarithm of the number of hectares per property parcel), it does seem to boost the level of TFP, but the coefficient could be an artifact of multicollinearity (Table 2, regression 3). More convincing perhaps are growth rate regressions, where multicollinearity poses no problems. There, neither the size of the property nor its consolidation seems to affect TFP's advance (Table 3, regressions 2 and 3).

Yet we must be careful here. All that the growth rate regressions really imply is that no long-run obstacles blocked the enlargement or amalgamation of properties. To understand why, we must realize that properties were frequently consolidated by tenants who rented land from different landlords. Although the properties were distinct, the tenant operated them together. When André-Paul Hanoteau and his wife leased Notre Dame's 30-hectare property in Le-Tremblay-lès-Gonesse in 1784, for example, it was not the only land they farmed. Indeed, they worked a total of several hundred hectares in Le-Tremblay-lès-Gonesse and its environs.[53] In the eighteenth century such arrangements—known as *cumul de baux*—grew increasingly common and seemed to capture economies of scale. The practice allowed a tenant to economize on buildings, equipment, and certain tasks.[54] And

[52] Urban growth rates are based on de Vries, *European Urbanization*.

[53] Hanoteau died in 1785 and, according to the tax roll of that year, farmed 224 hectares. Records of his estate suggest that he farmed even more—some 400 hectares. I thank Gilles Postel-Vinay and Jean-Marc Moriceau for furnishing this information.

[54] In the eighteenth century, Notre Dame wanted to suppress the buildings on properties no longer large enough to be economical as farms: see AN LL 332 (1761–1762, Larchant); and S 320 (June 26, 1780, Lizy-sur-Ourcq). One sign of the greater frequency of *cumul de baux* was that the leases began to carry a clause acknowledging it: see AN S 324A (June 25, 1781, Le-Mesnil-Amelot); and S 407 (Aug. 25, 1785, Viercy). For early consolidation, see Jacquart, *La crise rurale*, pp. 340–48, and for an excellent example, see Moriceau and Postel-Vinay, *Ferme, firme et famille*.

it permitted him to spread his skills as an overseer—an important part of early modern farming—over multiple properties.

Notre Dame had so much land that it could occasionally effect a consolidation by leasing two of its own properties to the same tenant. An examination of such consolidations shows some failures but also some striking successes, as in La-Grande-Paroisse in the early seventeenth century, where TFP gained 6 percent.[55] Further evidence emerges from surviving rural tax rolls, which by the late eighteenth century routinely carried information about the total acreage a tenant farmed. Taxes were generally paid by tenants rather than absentee landlords, and the assessments in any given year turn out to be very nearly proportional to the total acreage the tenant worked. Assessments can thus serve as a proxy for the amount of land under the tenant's direction. If we compare various tenants' tax assessments for two fixed periods, the change in assessment will give a relative measure of the increase in the scale of their farming operations. To be sure, the overall tax rate would have changed over the intervening period, but the assessment increase would still yield a relative measure of how much more land a tenant farmed. If he took on additional hectares, his assessment would rise faster than the tax rate. If not, his assessment would merely keep pace with the tax rate.

This ability to employ changes in tax assessments as a proxy for changes in farm scale lets us use the tax rolls from the 1740s, when, at least near Paris, taxes still seemed proportional to the area a tenant farmed even though the areas themselves rarely appeared on the rolls. For a small number of properties we can find tenants' assessments in both 1740/41 and 1783/89. If we plot how much the tax assessment changed for each property between 1740/41 and 1783/89 on a logarithmic scale versus how much the logarithm of TFP changed for the same property over the same period, the relationship between the scale of a tenant's operation and TFP stands out clearly, even though we are dealing with only seven properties (Figure 4).[56]

Again, the overall tax rate per hectare had shifted between 1740/41 and 1783/89, but the change in taxes for a given property still yields a relative measure of how much more land the later tenant farmed. In

[55] AN LL 329–30; S 272; and S 273 (1636–1654).

[56] For the tax rolls, see Guerout, *Rôles de la taille*. A search at the Archives Nationales turned up tax assessments for 44 tenants in the series Z 1G, and those assessments bore out the close relationship between the amount of the assessment and the number of hectares the tenant farmed. Tax assessments may have been misleading in earlier periods and in other regions, but here they seem a reliable guide to the acreage farmed. However, I was able to get leases and usable tax assessments for only seven of the properties in both 1740/41 and 1783/89. When more than one tax assessment was available for a property in 1740/41 or in 1783/89, I averaged the logarithm of the different assessments for each period. There is no tax correction in Figure 4; for an explanation, see Hoffman, "Land Rents," appendix 13. Figure 4 here differs slightly from an analogous graph in Hoffman, "Social History and Agricultural Productivity," because of the addition of new data.

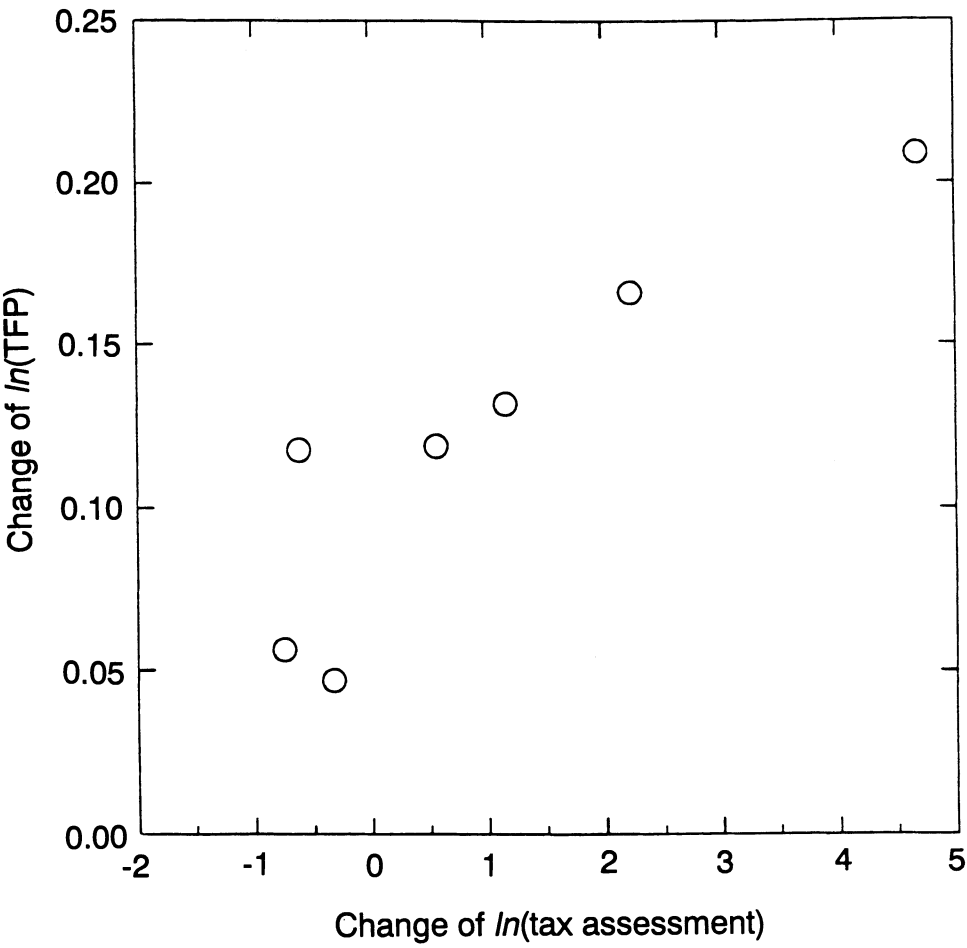

FIGURE 4

CHANGE OF *LN*(TFP) VERSUS CHANGE OF *LN*(TAX ASSESSMENT), 1740/41 TO 1783/89

Le-Tremblay-lès-Gonesse, for example, the scale of the tenant's operation grew appreciably between 1740/41 and 1783/89. Until 1741, a struggling Mathieu Bignon had been farming Notre Dame's property in Le-Tremblay, along with roughly 30 hectares of his own. But by the early 1780s, we know, the property was farmed by André-Paul Hanoteau, who worked much more land. The increased acreage had boosted the tenant's *taille* assessment in the intervening years, and the TFP of the property marched in step, climbing 14 percent.[57]

[57] AN Z 1G 291B (1740), 292B (1741), 431A (1786), and 451B (1789). As Hanoteau died in 1785, I had to use his widow's tax assessment for 1786 and 1789; using his own assessment for 1785 would not have changed matters appreciably. As with all the properties, the change in *ln*(TFP) here was computed between the years 1732/45 and 1777/89. Such long periods had to be chosen because of

Apparently amalgamation via *cumul de baux* did increase productivity: evidence that farm size mattered. The fact that our measures of property size and of property consolidation had no noticeable positive effect in the regressions merely implies that the amalgamation of properties encountered few obstacles, at least in the eighteenth century. Otherwise, the large properties, in effect already consolidated, would have enjoyed a great advantage, and the coefficients of property size and property consolidation would be large and positive in our TFP growth rate regressions. To operate a larger farm, tenants simply amalgamated properties and did so without difficulty, so that the distribution of the true farm size was independent of the distribution of property size. Under such conditions, property size would not be expected to play a significant role in the TFP regressions even if there were increasing returns to scale in farming.

Size and consolidation thus mattered, but near Paris, at least, there were few obstacles to achieving the appropriate scale. Perhaps this scale increased over time, particularly in the eighteenth century. It is true that attempts to amalgamate properties before the eighteenth century had often failed. Perhaps the skills needed to run a large farm had been scarce in the earlier centuries, when few farmers could mobilize the necessary capital or keep the requisite farm accounts. For the farmer with the requisite skills and capital, though, nothing blocked the way. Communal property rights were no barrier to amalgamation; neither was the village community. Had they in fact hindered amalgamation, as historians frequently claim, the coefficients of property size and property consolidation would have been positive in the TFP growth rate regressions.

Weighing the various factors that boosted TFP is treacherous, but we can at least advance some crude guesses for the eighteenth century. Between 1725/49 and 1775/89, TFP climbed roughly 9 percent, if we compute TFP with the Bernonville shares and with prices averaged over the outgoing lease. Perhaps 1 percent derived from improved transportation, leaving 8 percent that reflected the growth of agricultural outputs relative to the factors of production.

Total land and livestock use seem not to have changed appreciably, but the farm accounts analyzed by Postel-Vinay and Moriceau suggest that the amount of agricultural labor employed fell by about 6 percent between 1725/49 and 1775/89, probably because of farm amalgamation. The 6 percent drop would account for a 2 percent TFP gain. As for outputs, animal products in all likelihood remained static, but the

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the volatility of rent payments and because the leases in force in the years 1740/41 and 1783/89 had been drawn up as early as 1732 and 1777.

evolution of grain yields is uncertain. On the one hand, Jean Meuvret and others have suggested that there was no increase in yields near Paris in the eighteenth century and hence no role for grain output in the growth of TFP. On the other, George Grantham has proposed a 15 percent rise in wheat yields between 1750 and 1800, which translates into a 6 percent TFP gain over our period. Grantham's estimate fits the numbers proposed by other recent scholars, and if we accept it, then together with the decline in the use of labor we can account for nearly all the progress of TFP.[58]

Whatever the causes, it is in any case clear that Old Regime agriculture was capable of noteworthy growth, at least near Paris. Admittedly, the region was the most commercialized part of the kingdom, and no other French city could generate the same opportunities for trade. And the innovations that spurred on productivity growth—among them the planting of artificial meadows and the consolidation of properties—faced fewer hurdles in the Paris region than they did elsewhere. Nonetheless, the performance of agriculture near Paris was still stunning. As early as the sixteenth century, local farmers outdid their English counterparts at the task of economic growth, and the progress they achieved was particularly dramatic in the late eighteenth century—not what historians would normally expect for the eve of the Revolution.

The problem was that the French could not sustain their productivity increases. Their gains in the early sixteenth century were dashed by the Wars of Religion; their recovery in the early seventeenth century was sapped by military taxes and the Fronde. In the end, agriculture near Paris suffered grievously from those setbacks. Whereas in the English Midlands farmers maintained productivity growth rates of 0.2 to 0.3 percent over a full two centuries, in the Paris Basin they managed only 0.1 or perhaps 0.2 percent over the long haul. They could push their farms at better than 0.3 percent for 50 or even 75 years, but an exogenous crisis would soon cut short their advances.[59] In the end, it took them three centuries to accomplish what the English did in two. Their productivity, it appears, was hardly static and unchanging; indeed, it proved all too flighty. It moved up and down, dancing to a rhythm set by a variety of forces. Among them we must count not only the opportunities for trade on the outskirts of a large city but the baleful consequences of war.

[58] Moriceau and Postel-Vinay, *Ferme, firme et famille*; Meuvret, *Subsistances*, vol. 1, pt. 1, pp. 194–203; Grantham, "The Growth of Labour Productivity." Chevet, in "Le Marquisat d'Ormesson," proposes even larger yield increases than does Grantham.

[59] Figures for the Midlands are derived from Allen, "The Growth of Labor Productivity." TFP in the Midlands advanced perhaps 30 to 60 percent between 1600 and 1800. In the Paris Basin it took a century longer—from 1500 to 1789—to grow as much.

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