DIVISION OF THE HUMANITIES AND SOCIAL SCIENCES
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA 91125

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

Philip T. Hoffman
California Institute of Technology

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ABSTRACT

Using evidence from a sample of over 800 leases, this paper examines the productivity of farming in the Paris Basin between 1450 and 1789. Existing evidence about productivity is unreliable, the paper argues, and the leases provide historians with a new and valuable source for the study of productivity and economic growth. Much of the paper is devoted to a defense of the method employed with the leases, which point to spurts of spectacular growth on local farms but also to stunning setbacks during times of war and increased taxation. The paper concludes with analysis of the causes of economic growth in pre-industrial agriculture.

Like many 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 new leases that tenants agreed to, typically every nine years. As one might expect, the documents concerning Notre Dame's possessions are voluminous. The index alone, compiled by an obsessive archivist in the eighteenth century, comprises thirty manuscript volumes, and for property after property, one encounters strings of leases running from the late Middle Ages up to the end of the eighteenth century.

Such agricultural leases have been employed with profit by a number of enterprising historians.[1] Yet most scholars have been content to use them to study landlords' revenues or to assess the burden placed upon the peasantry. A few researchers, it is true, have attempted to derive an index of agricultural output from series of leases, but they have always done so apologetically, since 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 with the costs of the factors of production to give us a measure of productivity. The measure of productivity here is not merely the partial productivity of land or of labor, but total factor productivity, 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 although their use may at first seem a picaresque adventure in pseudo-statistics, they ultimately furnish us with evidence that is firmer 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 808 leases gathered from the archives of the Cathedral of Notre Dame de Paris from the period 1450-1789. 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 in question lay on average a little less than 40 kilometers from Paris, with the closest only 5 kilometers from the city center and the furthest 96 kilometers away. Most were rented along with only minor rights to collect the local tithe or local seigniorial dues, and none changed significantly in size, for if the size did change appreciably, I began another series of leases for what I considered 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, and they averaged 67 hectares. As one might expect, they were devoted overwhelmingly to grain

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[1] For the Paris region alone, one can count a number of excellent studies using leases: Béatrice Veyrassat-Herren and Emmanuel Le Roy Ladurie, "La rente foncière autour de Paris au XVIIe siècle," Annales E.S.C. 23(1968): 541-55; Jean-Paul Desaive, "A la recherche d'un indicateur de la conjoncture: Baux de Notre-Dame de Paris et de l'abbaye de Montmartre," in Les fluctuations du produit de la dîme: Conjoncture décimale et domaniale de la fin du moyen âge au XVIIIe siècle, ed. Joseph Goy and Emmanuel Le Roy Ladurie (Paris, 1972), pp. 44-57; Gilles Postel-Vinay, La rente foncière dans le capitalisme agricole (Paris, 1974); Jean Jacquart, "La rente foncière, indice conjoncturel?," Revue historique 514(1975):355-76; and the contributions by G. Béaur and J. M. Constant in Prestations paysannes: Dîmes, rente foncière et mouvement de la production agricole à l'époque préindustrielle, ed. Joseph Goy and Emmanuel Le Roy Ladurie, 2 vols. (Paris, 1982).

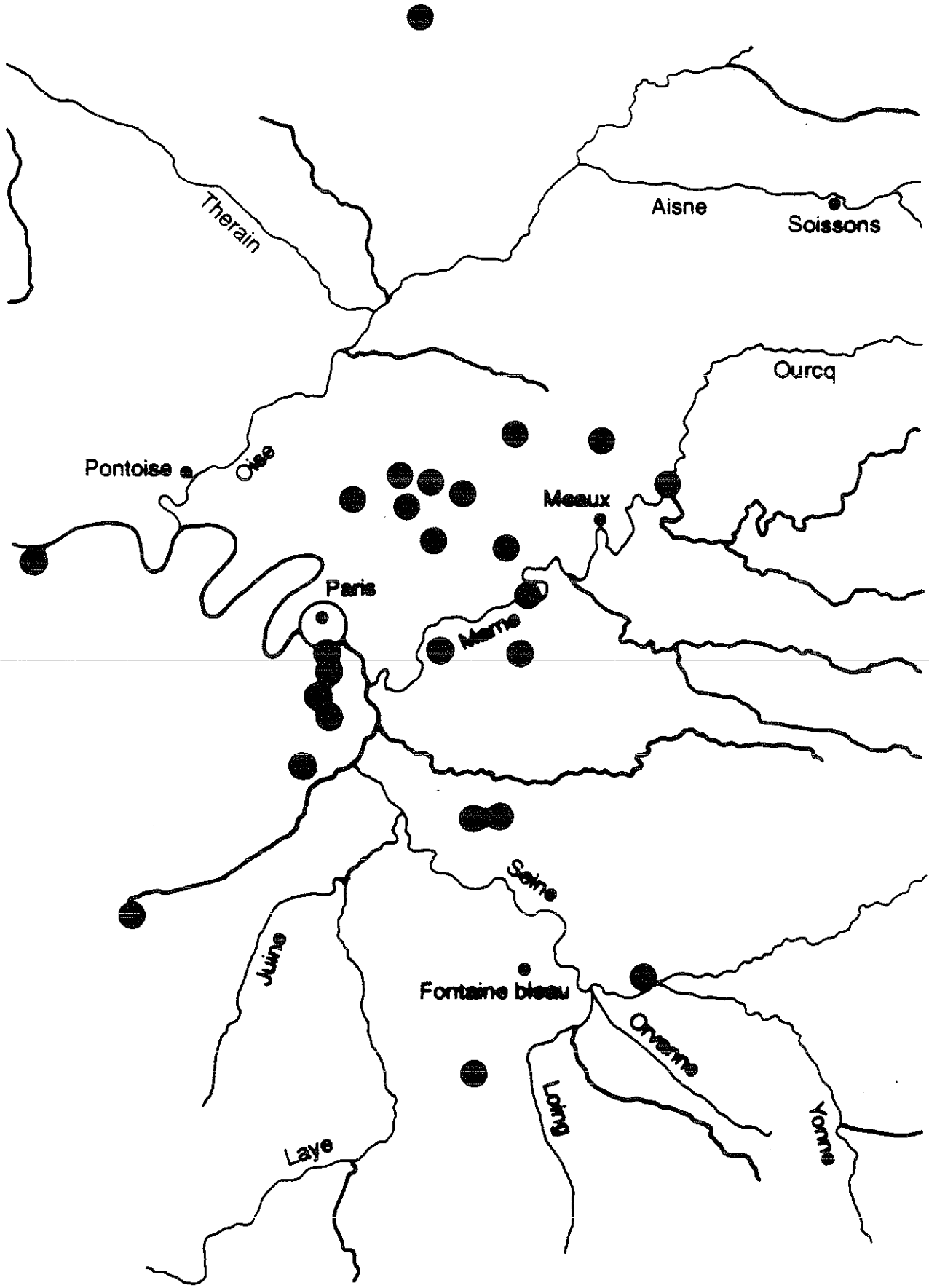

FIGURE I PROPERTY LOCATIONS

production: only 1.4 percent of the land was vineyard and only 4.8 percent natural meadow.[2]

The sample is 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 these 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.

1. Land rents

The first step toward assessing productivity--and one that is 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 other authors limit themselves to simple averages, but since 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 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

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[2] The sources include the index to the actes capitulaires de la cathédrale de Paris in AN LL 319-350/351 and the original leases, property descriptions, and land management records in AN S123-462. J. P. Desaive was first to use AN LL 319-350/51 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 S123-462. All averages here are calculated counting each lease separately; weighting each property by its area would not change the results appreciably.

[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 appendix 1. Cf. Jacquart, "La rente foncière," and Gérard Béaur, Le marché foncier à la veille de la Révolution (Paris, 1984), pp. 231-46.

[4] The relevant property characteristics included soil quality; presence of natural meadow and vineyard, since meadow was scarce and vineyards entailed capital investment; surface area, since 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 on boats. For our properties, however, the shipping costs, as is shown in 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, since historians believe they depressed the rent; and a time trend to capture the effects of inflation and changing prices. See Table 1 and appendix 3 for details.

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

	Leases	Nominal Rent			Ln(Rent)	Price-Cost Index
Decade	in Sample	(1)	(2)	(3)	(4)	(5)
1450-59	2	0.70	0.76	0.57	-0.29	-
1460-69	3	0.72	0.80	0.67	-0.23	-
1470-79	3	0.73	0.94	0.62	-0.07	-
1480-89	4	0.68	0.69	0.79	-0.69	-
1490-99	5	0.94	0.97	0.81	-0.07	-
1500-09	4	1.23	1.33	0.98	0.28	-
1510-19	6	1.74	1.76	1.40	0.50	-
1520-29	11	2.14	2.24	1.82	0.57	0.62
1530-39	14	3.01	2.96	2.23	0.79	0.69
1540-49	13	3.66	4.12	3.11	1.36	0.72
1550-59	20	5.07	5.15	4.72	1.58	0.74
1560-69	13	6.55	7.34	5.86	1.92	0.77
1570-79	23	9.09	8.74	7.28	1.99	0.86
1580-89	24	12.43	10.98	10.40	2.27	0.81
1590-99	26	12.02	12.86	11.92	2.13	1.14
1600-09	31	12.81	11.64	10.53	2.21	0.95
1610-19	35	10.85	11.05	8.96	2.25	0.87
1620-29	38	13.54	13.16	11.61	2.35	0.96
1630-39	38	20.78	20.26	15.79	2.84	1.19
1640-49	32	20.91	20.54	17.40	2.83	1.05
1650-59	27	23.07	22.28	19.14	2.84	1.22
1660-69	33	26.42	26.53	19.55	3.11	1.13
1670-79	25	18.78	17.92	17.12	2.79	0.95
1680-89	24	19.92	19.75	15.88	2.86	1.04
1690-99	26	21.27	21.58	17.49	2.96	1.10
1700-09	35	25.44	23.97	20.83	3.06	1.06
1710-19	31	23.79	23.54	19.12	3.06	1.12
1720-29	30	30.34	27.81	20.55	3.24	1.07
1730-39	32	25.01	23.35	22.17	3.10	1.09
1740-49	32	25.73	25.29	19.03	3.17	1.16
1750-59	29	27.41	27.14	21.20	3.25	1.12
1760-69	27	31.90	28.95	23.75	3.32	1.12
1770-79	19	43.74	43.07	32.44	3.73	1.32
1780-89	30	49.46	47.91	38.40	3.83	1.16

1 Average rent for the leases in the sample
2 Average of quality-adjusted rent for the leases in the sample
3 Area-weighted average of quality-adjusted rent for all leases in force
4 Average of quality-adjusted ln(rent) for the leases in the sample
5 Agricultural price-cost index (mean = 1).

Note: The quality adjustments rely upon regression 1 in Table 2 and begin by correcting ln(rent) lease by lease. Column 4 is the decennial average of

$$z = \ln(\text{rent}) \; - a_1 x_1 - a_2 x_2 - a_3 x_3 - a_4 x_4 - a_5 x_5,$$

where a_1 through a_5 are the coefficients of percent meadow, percent 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); since 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 appendices 1, 3, 6, and 9 for details.

Source: Sample of leases; other sources listed in appendix 14.

growing. During crises, averaging over all the leases in force exaggerates somewhat the rent that was actually paid, while 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, we will therefore eschew it in favor of the average over the leases in the sample--that is, the leases signed in any year. In other words, we will prefer columns 2 and 4 in Table 1 to column 3.[5]

Our rental series, it turns out, matches the evidence unearthed by other historians. If we plot the numbers in Table 1, column 2 versus the figures for the outskirts of Paris published by Béatrice Veyrassat-Herren and Emmanuel Le Roy Ladurie, we get startling agreement (Figure 2). The same chorus of agreement rings out if we compare our evidence with other series from the seventeenth and eighteenth centuries.[6] While the similarity perhaps detracts from the novelty of our numbers, it lends credence to what they say, and in particular to what they reveal about productivity.

2. Using leases and prices to measure productivity

Today we easily measure the productivity of agricultural labor by dividing the quantities of goods produced by the number of agricultural workers. Performing a similar computation for the Old Regime, however, is a hopeless undertaking, and while it has been attempted, the results seem dubious. The problem is determining the size of the agricultural labor force, a calculation that, even when done with nineteenth-century census records, is fraught with difficulty. How does one know what 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 undertaking. 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 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) on poorer soil, then average yields for wheat can stagnate or decline, even though the value of output

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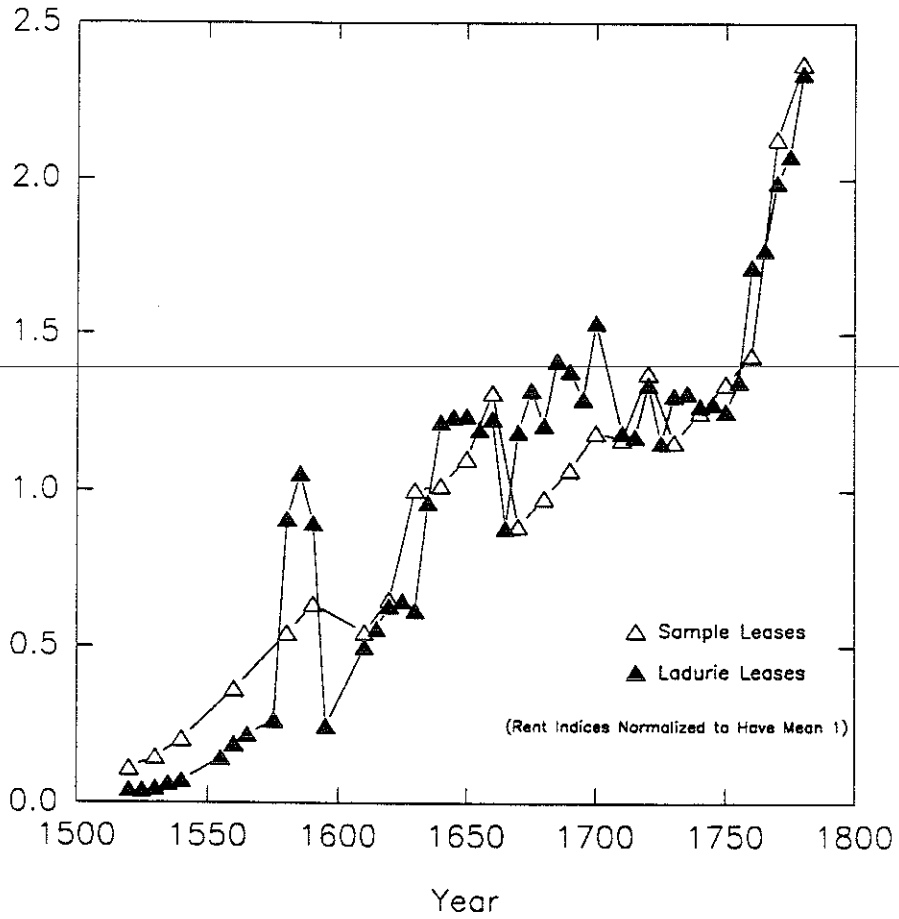
[5] For a discussion, see appendix 3.

[6] Veyrassat-Herren and Le Roy Ladurie, "La rente foncière." Since Veyrassat-Herren and Ladurie 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 appendix 4 for details. For other local rent figures that parallel ours, see Béaur, Marché foncier, pp. 262-68; Jean Jacquart, La crise rurale en Ile-de-France, 1550-1670 (Paris, 1974), pp. 616, 638, 699; and M. Bertrandy-Lacabane, Brétigny-sur-Orge, Marolles-en-Hurepoix, Saint-Michel-sur-Orge (Versailles, 1886), pp. 314-15.

[7] Postel-Vinay, "A la recherche de la révolution économique dans les campagnes (1789-1815)," Révue économique 40(1989): 1029-1033; J. P. Bompard, Thierry Magnac, and Gilles Postel-Vinay, "Emploi, mobilité et chomage en France au XIXe siècle: Migrations saisonnières entre industrie et agriculture," Annales E.S.C. 45(1990): 55-76.

Figure 2: Nominal Rent Indices for Sample and for Ladurie Leases



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 historians rely upon 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]

One therefore cannot easily compute labor productivity or extend yields and other measures of land productivity back into the past. And none of these figures give 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 method to examine the productivity of enclosures and of English agriculture in general in the early modern period.[10]

What McCloskey and Allen rely upon is the fact that total factor productivity (TFP) 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

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[8] For difficulties with comparisons of yields, see Jean Meuvret, Le problème des subsistances à l'époque Louis XIV, 3 vols. (Paris, 1976-88), vol. 1, pt. 1 (Texte): 207-211. For one well known attempt to compare yields, see Michel Morineau, Les faux-semblants d'un démarrage économique: Agriculture et démographie en France au XVIIIe siècle (Paris, 1971).

[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 1713-16 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.

[10] Donald McCloskey, "The Economics of Enclosure: A Market Analysis," in European Peasants and Their Markets, ed. William N. Parker and Eric L. Jones (Princeton, 1975), pp. 123-76; Robert Allen, "The Efficiency and Distributional Consequences of Eighteenth-Century Enclosures," Economic Journal 92(1982): 937-53.

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

Here the y_i's are the outputs produced; the p_is 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 we will specify 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 (1) to get a formula for TFP:

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

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 non-mathematical 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, 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: they 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 it is properly calculated, will remain the same.[12]

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[11] The definition of TFP: Robert G. Chambers, Applied Production Analysis: A Dual Approach (Cambridge, 1988), pp. 235-39. For a derivation of equations 1 and 2, see appendix 5.

[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.

3. What the method of calculating TFP assumes

The whole method of calculating TFP, of course, is open to certain objections. Some are technical and are discussed elsewhere.[13] More important, however, 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 technology can be described with some precision for a period of three centuries, that agricultural markets existed, and that the land rental market was competitive. They obviously deserve detailed scrutiny.

The first assumption 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 we these shares could be recovered from clever regressions with rents, prices, and wages, but such a tactic is doomed to 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, one that was by no means exceptional. And although it lay further from Paris than any of our properties, 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 if we turn to another farm, located some 20 kilometers north of Paris and investigated by Gilles Postel-Vinay and J. M. Moriceau, the numbers turn out 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 effect on the labor factor share was small. Furthermore, if the factor shares of land and labor had shifted drastically, then we should be able to detect it from demographic data, but no such shift is

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[13] See appendix 5.

[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 equations does not resolve the problem.

[15] The Bernonville shares included 14 inputs and 13 outputs; see appendix 6 for details.

apparent, at least 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 additional livestock. Indeed, since much specialization in early modern Europe was driven by workings of the 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 our results to variations in the share values. To do so, we shall rely upon an alternate 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 alternate 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 one might expect between two farms on the outskirts of Paris. Nonetheless, as we shall see below, the alternate 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 these markets, in order to calculate the indexes C and P in formula (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, though, it would be fair to say that the costs and the prices he faced equalled 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 actually measuring wages. Ideally we would like the wage of farm labor, preferably unskilled. Farm wages, though, are difficult to appraise since domestics were often paid a considerable portion of their earnings in kind and since salaries varied from season to season and from 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

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[16] The reason demographic data is 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 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 appendix 6.

[19] Skeptical readers may consult the lengthy discussion in Philip T. Hoffman, "Social History and Agricultural Productivity: The Paris Basin, 1450-1800," California Institute of Technology Social Science Working Paper 742 (June, 1990) [henceforth SSWP 742]

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 other in the city, were identical," says Micheline Baulant, who has studied wages around Paris, and her data support her assertion. An unskilled urban helper earned 2.5 sous a day in 1500-05 and 10.4 sous a day in 1594-98; a hotteur in the grape harvest earned 2.5 sous in 1500-05 and 10 sous in 1594-95.[20]

Even if there were sometimes differences between wages in the city and wages in the countryside, the trend of pay for the unskilled was nearly everywhere the same, and it is this trend, and not absolute prices, that we need 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 moved in parallel--or at least this is what the evidence from the Paris region suggests.[21]

Of course, one should not jump to the conclusion that a national labor market existed. Labor markets were regional, although the one about Paris was undoubtedly large enough to embrace the localities from which our leases were drawn. Nor should one overlook evidence that the labor market was perhaps 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 given the current state of research 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 face of the enormous mobility of labor in the Paris Basin under the Old Regime. Parisian workers, we know, helped take in the harvest. Domestics quit the farm for the city, while paupers fleeing rural poverty did the same. And whole families moved in and out of the small towns about Paris, presumably in search of work. Given such mobility, particularly between Paris and the countryside, it seems unlikely that the regional labor market was partitioned into isolated and mutually exclusive compartments.[22]

As with agricultural labor, our 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 although prices series for livestock are skimpy and one has to be careful of differences between breeds, it is possible to assemble the necessary series of cost trends--or at least gross averages for twenty-five year periods, which is all that is necessary for our cost index C in the

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[20] Micheline Baulant, "Prix et salaires à Paris au XVIe siècle: Sources et résultats," Annales E.S.C. 31(1976):980-86; Guy Fourquin, Les campagnes de la région parisienne à la fin du moyen âge (Paris, 1964), p. 496; Pierre Goubert, Beauvais et le Beauvaisis de 1600 à 1730, 2 vols. (Paris, 1960; reprint ed. 1982), 1:139-40, 547-60; and Jean-Pierre Gutton, Domestiques et serviteurs dans la France de l'ancien régime (Paris, 1981), pp. 111-117.

[21] Baulant, "Prix et salaires à Paris," pp. 980-986; idem, "Le salaire des ouvriers du bâtiment à Paris de 1400-1726," Annales E.S.C. 26(1971):463-83. This is sixteenth-century evidence; for evidence for later periods, see appendix 7. The sources for the wages and the prices that enter into the calculation of the indexes C and P are listed in appendix 14.

[22] See Baulant, "Le salaire des ouvriers," p. 472; idem, "Prix et salaires," pp. 980-87; Marcel Lachiver, La population de Meulan du XVIIe au XIXe siècle (vers 1600-1870) (Paris, 1969), pp. 91-122; Jacques Béaud and Georges Bouchart, "Le dépôt des pauvres de Saint-Denis (1768-1792)," Annales de démographie historique, 1974, pp. 127-43; Hoffman, SSWP 742; and appendix 7.

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. Long run averages can dampen the price volatility, but it is not clear what period one should average over. 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]

The difficulties here, though, are far from insurmountable. While we cannot be absolutely certain about what years to average prices over, employing the current year and the previous eight years (in other words, averaging over the outgoing lease) seems concordant with contemporary practices. 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 is 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 alternate set of prices makes strong demands of our tenant farmers (namely, that they be able to see 8 years into future), but as we shall see below, it does not change the index of TFP greatly.[25]

As for transportation costs, although 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. Around Paris, for instance, grain prices in local markets were lower and more volatile than in Paris in the sixteenth, seventeenth, and eighteenth centuries, but price trends in the local markets up to 100 kilometers away tended to follow the trend of the Paris price, particularly if one examines averages that smooth out local crises. Such parallel movement should hardly be surprising, for there is considerable evidence that merchants and even large scale peasants 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--or 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 with hundreds of minuscule actors, the land rental market in any given village might involve

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

[24] Meuvret, Subsistances, vol. 3. Since much grain reached the consumers in the form of in-kind 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 appendix 8.

[25] See appendix 9. Prices were too fragmentary to calculate P/C before 1520.

[26] Steven L. Kaplan, Provisioning Paris: Merchants and Millers in the Grain and Flour Trade during the Eighteenth Century (Ithaca, 1984), pp. 206, 215-16; Jacquart, Crise rurale, pp. 764-66; Jacques Dupâquier, et al, Mercuriales du pays de France et du Vexin français (1640-1792), p. 233; Micheline Baulant and Jean Meuvret, Prix des céréales extraits de la mercuriale de Paris (1520-1698), 2 vols. (Paris, 1960-62), 1:12, 25. As we shall discuss below, hinterland prices did rise relative to the Paris price between the seventeenth and the eighteenth century: Micheline Baulant, "Le prix des grains à Paris de 1431 à 1788," Annales E.S.C. 23(1968): 520-40.

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 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, the argument being that tenants able to take on a large farm were powerful enough to force down the rental price.[28] To judge from regressions of ln(rent) on variables affecting rent levels (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 that does not depend 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 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 judgement against a tenant or seize his assets. The problem, though, was that only the large scale tenants had assets such as livestock or equipment that a landlord could attach. The landlord could therefore allow big fermiers 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, and his only recourse was to demand a risk premium in the form of higher rent payments. The higher rent was thus compensation for the risks posed by tenants without collateral.

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. They also had large families, and while one could perhaps imagine collusion between two or three tenant patriarchs in order to depress 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 be hard to maintain.

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[27] Hoffman, SSWP 742. A droit de marché did exist in certain areas north of Paris: Postel-Vinay, La rente foncière (Paris, 1974) pp. 44-49; and Jean Vinchon, Le livre de raison d'une famille picarde: Les Vinchon (1488-1947) (Doullens, 1948), 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: Jacquart, "Rente foncière," p. 375.

[28] Postel-Vinay, La rente foncière, pp. 35-54; George Grantham, "Agricultural Supply during the Industrial Revolution: French Evidence and European Implications" Journal of Economic History 49(1989):43-72; Gérard Béaur, Le marché foncier, pp. 263-64.

[29] Charles Estienne, L'agriculture et la maison rustique (Paris, 1564), fols. 8-9; L'art d'augmenter son bien ou règles générales pour l'administration d'une terre (Paris, 1784), pp. 10-17, 171-75; Abbé François Rozier, Cours complet d'agriculture, 10 vols. (Paris, 1781-1800), vol 2, sv "bail"; AN LL337-38, fols. 96-101 (1748), fols. 236-37 (1747); LL 350-51, fols. 122-24 (1761-62); S 242(1754-62); S247 (1693); S 176 (1666-69).

[30] Jean-Marc Moriceau, "Un système de protection sociale efficace: Exemple des vieux fermiers de l'Ile-de-France (XVIIe-début XIXe siècle)," Annales de démographie historique (1985), pp. 127-44. Those tenants who did linger were probably the best, retained by the landlord for their mutual benefit.

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	0.075	0.064	0.056
and After	(0.60)	(1.97)	(1.80)
Dummy: War Years	-0.097	-0.29	-0.28
1589-1597	(-0.71)	(-8.08)	(-8.30)
Percent Meadow	0.39	0.16	0.11
	(2.09)	(3.25)	(2.51)
Percent 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	-0.27	-0.067	-0.070
in Kilometers)	(-6.24)	(-5.94)	(-5.76)
Dummy: Tenant Holdover	0.021	0.019	0.026
from Previous Lease	(0.42)	(1.42)	(2.01)
Time (Units of	0.91	0.061	0.063
100 Years)	(23.11)	(5.49)	(5.82)
Ln(Property Area	-0.085	-0.024	-0.050
in Hectares)	(-3.42)	(-3.68)	(-7.46)
Ln (Area per	–	–	0.043
Property Parcel)	–	–	(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.
Source: Sample of leases and property description; additional sources described in appendix 14.

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 with our sample of leases, the rent never behaves 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 might worry about normal entrepreneurial profits the tenants made, but contemporary evidence suggests that in the long run these were too small to affect our TFP calculations.[31]

While the use of prices and leases to calculate TFP may now seem reasonable, at least with our sample, one doubt may still linger in reader's mind. Accustomed to handling real physical quantities, he might like some reassurance that an index of TFP based on something so intangible as prices would really yield reliable results. Unfortunately, reliable physical measurements are almost always lacking. In one instance, though, where, thanks to an unusual set of family records, one can compare physical quantities produced and factors employed for a real eighteenth-century farm in the Paris Basin, the method of calculating TFP 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]

4. The Notre Dame properties

a. 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 assumption to be corrected below--then the logarithm of TFP will be very nearly equal to $s\ln(r) - \ln(P/C)$, which we can average across properties

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[31] For how rent was set and the size of entrepreneurial profits, see appendices 9 and 10. Our assumption is that tenants earned no more than they would have on the labor market; for a discussion and criticisms, see appendix 5. Note that we need not assume that the land supply is fixed or that the tenant farmers were profit maximizers, although without profit maximization, our definition of TFP has no necessary connection to 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 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 appendix 5.

[32] The example, from data kindly furnished by Gilles Postel-Vinay, concerns the highly productive farm that provided our alternate shares. We can compare its productivity in the 1740s and in the 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 paper--with shares that came from the Bernonville farm--we get very nearly the same thing, 9.03 percent. Clearly, our results are very close to those given by the sophisticated translog; moreover, practically none of the difference between the two numbers was caused by the constant shares assumption. For details, see appendix 11.

Table 3 - REGRESSIONS WITH GROWTH RATE OF RENT AND TFP

Regression Number	(1)	(2)	(3)
Dependent Variable	Rent Growth Rate (Percent per Year)	TFP Growth Rate (Percent per Year)	TFP Growth Rate (Percent per Year)
INDEPENDENT VARIABLES			
Constant	1.23	0.46	0.45
	(5.78)	(1.32)	(1.09)
Growth Rate Price-Cost	0.61	–	–
Ratio	(7.26)	–	–
Growth Rate of Taxes	-0.44	-4.11	-4.44
Relative to Rents	(-0.11)	(-2.00)	(-2.10)
Growth Rate Paris	–	0.24	0.23
Population	–	(6.16)	(5.88)
Dummy: Years 1775	–	1.04	1.03
and After	–	(3.48)	(3.35)
Dummy: War Years	-4.14	-2.44	-2.25
1589-1597	(-4.85)	(-5.85)	(-5.19)
Dummy: Repairs	–	-0.31	-0.56
	–	(-0.85)	(-1.39)
Dummy: Tenant Holdover	-0.17	-0.085	-0.041
from Previous Lease	(-0.58)	(-0.64)	(-0.29)
LN (Distance to Paris	–	-0.074	-0.083
in Kilometers)	–	(-0.71)	(-0.70)
LN (Property Area	–	-0.024	-0.012
in Hectares)	–	(-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 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 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 omitted; T-statistics are in parentheses.
Source: As in Table 2.

for different periods. We can then chart, at least roughly, 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 alternate factor and product shares and with the alternate 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 alternate shares and prices shift the graph of TFP somewhat, but they do not disturb the overall trend. The alternate 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 alternate prices is also similar, except in 1650-74 and 1775-89, when its behavior may well be a fluke.[34] Overall, though, TFP follows essentially the same path, whatever the shares and prices.

Built in to 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 upon the land. The size of the resulting error, though, turns out to be relatively small. It is shown for the Bernonville shares and for prices averaged over the outgoing lease: Figure 3 plots TFP both before and after the tax adjustment. The graphs of TFP with alternative shares and prices include tax adjustments of a similar magnitude.[35]

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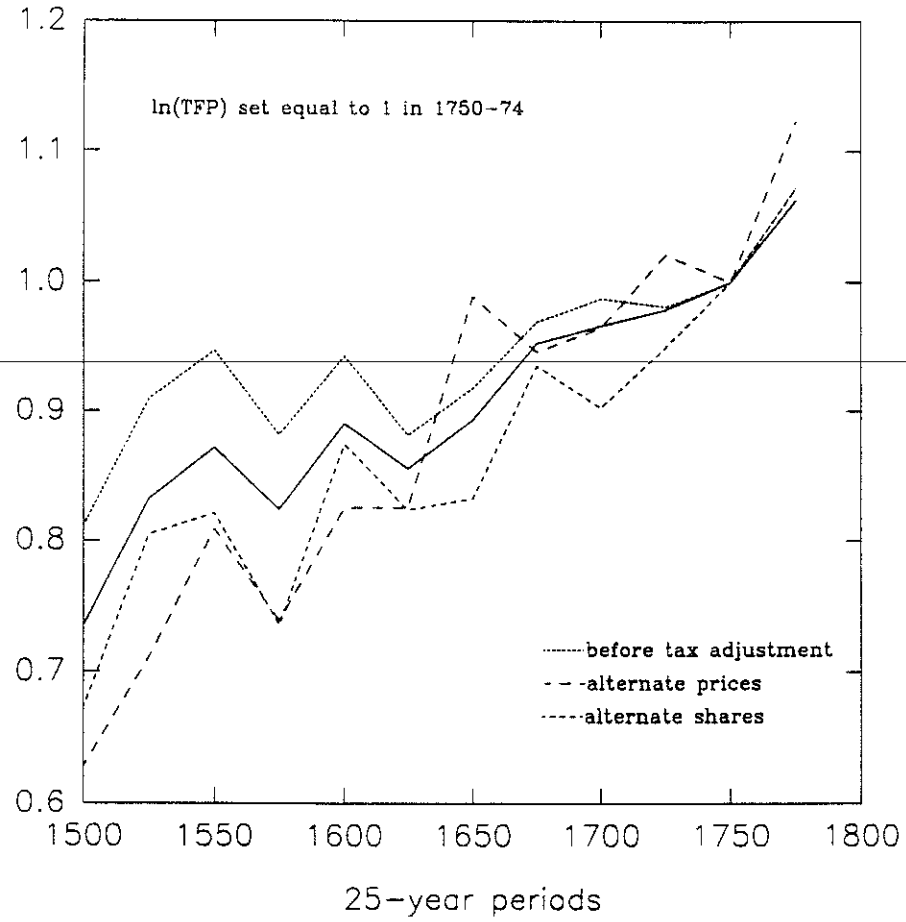
[33] One alternative would be to average sln(r) and ln(P/C) separately, taking the mean of sln(r) over all the leases in each 25-year period and then subtracting ln(P/C) averaged over all the years in the period, rather than over all the leases. This procedure, though, yields results nearly indistinguishable from simply averaging ln(TFP) lease by lease; see appendix 12 for a discussion. We could also average ln(TFP) by decade, but the decennial averages obscure the trend. Finally, although 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 alternate 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. Since 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 from the late 1780s, making the alternate price estimates suspect.

[35] Since TFP = $(r + t)^s C/P$, 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 know precisely, but one reasonable assumption is that for the i-th property the fraction of gross rent (i.e. rent plus taxes) going to the landlord rather than to the fisc is g, where $\ln(g) = b\ln(t_a/r_a) + c_i$. 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 estimatethe magnitude of the error involved in omitting taxes from the formula for TFP. The way to do so, we show in 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, and the error involved in ignoring taxes turns out to be very small, particularly in the case of the growth rate of TFP. See appendix 13 for details.

Figure 3: Ln(TFP) for Alternate Prices and Shares
(Adjusted for Taxes and Land Quality)



The years from 1450 to 1524 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 had 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 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 off to the southeast of Paris, where one of their tenants, Jean Godet, had to reclaim 9 hectares of briar-choked meadow. Godet also had to enclose the meadow with ditches in order 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, then 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 1500-24 and 1550-74, TFP grew between 0.3 and 0.4 percent a year, a brilliant mark by early modern standards and one that compares favorably with the English performance, as we shall see, even two centuries later.[37]

In all likelihood, however, the cause of the higher productivity in 1550-74 lies elsewhere, not in recuperation and improvements after the Hundred Year 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, however, 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 long before in 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 below.

After the heights of 1550-74, TFP plummeted during the Wars of Religion (Figure 3). If we compute the growth rate of TFP from lease to lease and average it across properties, we see that it too plunged, 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. This was a an enormous amount for early modern Europe, where even stunning agricultural productivity growth was eked out a few tenths of a percent per year.

The cause of the collapse was undoubtedly war. The decline was most precipitous during and immediately after the years 1589-94, the period of most intense fighting in the Paris Basin, when undisciplined armies traversed the region, sowing devastation in their wake. It was during these accursed years when 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

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[36] AN S407 (1464), S 272 (1522, 1545), S 409 (1479, 1482, 1483, 1498, 1511). Cf. 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. In calculating the growth rate, I took into account the fact that the leases used to compute TFP in 1500-24 all cluster after 1520.

[38] Fourquin, Les campagnes, pp. 389-97, 430-531; Jacquart, Crise rurale, pp. 42-47.

[39] See Figure A-3 in the appendices.

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 their 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, since 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). Leaping prices, though, were themselves a sign of markets disrupted and of products destroyed.[41]

The peaceful opening years of the seventeenth century brought a brief respite. Productivity growth increased sharply and the average level of TFP rose. Then, in the second quarter of the century, TFP declined (Figures 3). The lower levels of TFP 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 could have also 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 and a series of disastrous harvests in the early 1630s, the tax-provoked 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 (Figure 3). At least 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 reduced rents as one moved away from the city. Since our calculation of TFP is based on Paris prices, and since 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 the higher prices prevailing in Paris.

As long as local grain prices moved in parallel with Paris--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

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[40] AN LL 329-30, La Grande Paroisse (1594); S 242 (25 June 1597); Jacquart, Crise rurale, pp. 171-207. The 24-percent decline in TFP comes from Table 2, regression 2, which is discussed below.

[41] The regression with ln(rent) also suggests that rising prices, rather than declining rents, lay behind the drop in TFP, for the dummy variable for the war years 1589-97 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 as follows: the siege of Paris in 1589-90 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, which suggests that the price increase was not confined to the city: Jacquart, Crise rurale, p. 765. As it turns out, we observe the same decline of TFP with the alternate shares and prices.

[42] Jacquart, Crise rurale, pp. 623-99.

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 further one went from Paris, just as one would expect if the cost of transportation was 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 the Paris price, but since we would be judging rents relative to a Paris price index P, it would seem that TFP was 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 reveal how much of the TFP growth between 1650-74 and 1750-74 actually resulted from 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 Paris was large. Soissons provides a perfect example: at nearly 100 kilometers from Paris, it was farther away than any property in our sample. Not surprisingly, the increase of grain prices in Soissons relative to Paris accounts for a 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 the local prices to the Paris price has much less of an effect on our measurement of TFP. At a market such as Pontoise, approximately 30 kilometers from Paris, convergence of prices explains only a 3.6 percent increase in the same TFP measure over the same period. Clearly, Pontoise provides the example that is relevant to our sample of properties, for they lie on 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. The better transportation should of course not 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, if we measure it with the Bernonville shares and outgoing prices. The spike at the end of the Old Regime stands out even more clearly if we look at rates of growth. They averaged above 0.3 percent a year between 1750-74 and 1775-89 and reached a peak of over 1 percent, rates that are comparable or superior to the pace achieved across the English Channel. Indeed, in the early 18th 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 estimates, 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

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[43] Meuvret, Subsistences, vol. 3, pt. 2: 116-34; Baulant, "Le prix des grains"; AN F11 207 (Soissons price, corrected following the indications in Goubert, Beauvais, 1:408); 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 J. Letaconnoux, "Les transports en France au 18 siècle," Revue d'histoire moderne et contemporaine 11(1908-09): 97-114, 269-92. Part of the improved transportation undoubtedly involved the arduous task of establishing networks of specialized middlemen, a subject I shall pursue further in a forthcoming book. Separating agriculture and transportation here is of course somewhat artificial since much of the grain was carted to market by the farmers themselves.

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

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 with 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 properties than on those near Paris, the opposite of what one would expect with declining transport costs. Local prices, moreover, had by 1750 ceased rising relative to the Paris price, and their movement no longer accounts 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.

The measure of TFP used here, it is true, 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 of productivity could have begun earlier than the graphs suggest.[47]

Whether the upturn began slightly earlier or not, there is nothing to suggest 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's farms the increase was 105 percent (Table 1, column 2). Since 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]

b. Regression results

Regression analysis 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 for land quality and for the use

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[46] N. F. R. Crafts, British Economic Growth during the Industrial Revolution (Oxford, 1985), pp. 83-85; Robert Allen, "The Growth of Labor Productivity in Early Modern English Agriculture," Explorations in Economic History 25(1988): 117-46.

[47] AN S 242, 1754-62 (Dampmart); S 282, 1746-55, and S 460, 1782 (La Grande Paroisse).

[48] Béaur, Marché foncier, pp. 262-68; Bertrandy-Lacabane, Brétigny-sur-Orge, pp. 314-15; Veyrassat-Herren and 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.

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 1589-97 (the period of the most intense fighting around Paris plus the following 3-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 1589-97 and 1775-89, is certainly consistent with our story of rapid gains in the early sixteenth century, a sharp recovery after 1589-97, a crisis in 1625-50, and slow growth for the following century.[50]

Like 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 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 was not the case. The coefficient is negative, and while transportation was growing more efficient, farming did the same.

5. Explaining productivity growth

What then explains the slow growth in TFP that we see in the years 1650-1750 or the rapid increases we observed in the sixteenth century, in the early seventeenth century, and then again after 1775? Part of the growth during the years 1650-1750 reflected improved transportation, while the surge in the early seventeenth century marked 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,

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[49] For the regressions with alternative shares and prices, see 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 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, although one might argue for regressing nominal 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 upon the results with ln(TFP), it does not afflict the regression with the TFP growth rate, which point to the same dip in 1589-97 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 in 1589-97 and soared 1 point after 1775. And everything else in the regression fits our story too. For the condition number and multicollinearity, see George G. Judge et al, The Theory and Practice of Econometrics, 2nd edition (New York, 1985), pp. 896-904. The sample of leases showed no signs of heteroscedasticity or autocorrelation; for details, see Hoffman, SSWP 742, p. 17.

that stresses urban markets in explaining agricultural performance before the technological upheavals of the late nineteenth century.

In the Paris region, where a large and growing market lay next door, we can begin to discern how agriculture benefitted from proximity to the city and from the resultant opportunities for trade that transportation costs ruled out in less urbanized regions. The higher productivity of farming near Paris did not necessarily stem from dramatically higher yields--evidence about the evolution of yields in the Paris region is in any case unclear--but we know that it was at least in part a response to the increasing animal population 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 imposed on traditional agriculture and boosting their grain yields. These changes all tended to be piecemeal and they were all 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 a large effect on 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, a large amount in the early modern world.[52] One cannot rule out influence in the reverse direction--rising TFP making possible a larger urban population--but the evidence is at least consistent with the city's being a motor of agricultural growth.

Small farm size has been invoked to explain the failings of French agriculture ever since the days of Arthur Young, and it would be worth knowing 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 the 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-

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[51] The previous two paragraphs depend upon Jean-Michel Chevet, "Le Marquisat d'Ormesson, 1700-1840: Essai d'analyse économique," 2 vols. (Doctoral Dissertation, Ecole des Hautes Etudes en Sciences Sociales, 1983); George Grantham, "The Diffusion of the New Husbandry in Northern France, 1815-1840," Journal of Economic History 38(1978): 311-37; idem, "Agricultural Supply"; Jacquart, La crise rurale, pp. 321-330; Meuvret, Subsistences; and forthcoming work by Jean-Marc Moriçeau and Gilles Postel-Vinay. 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.

[52] Urban growth rates: Jan de Vries, European Urbanization, 1500-1800 (Cambridge, Mass.; 1984).

Paul Hanoteau and his wife leased Notre Dame's 30-hectare property in Le-Tremblay-lès-Gonesse in 1784, for example, it was not all the 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 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. When we examine such consolidations, we find 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 by absentee landlords, and the tax assessments in any given year turn out to be very nearly proportional to the total acreage the tenant worked. The 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, change in the assessments will then give a relative measure of the increases in the scale of their farming operations. To be sure, the overall tax rate will have changed over the intervening period, but the assessment increase will still yield a relative measure of how much more land a tenant farmed. If he takes on additional hectares, his assessment will rise faster than the tax rate. If not, the assessment will merely keep pace with the tax rate.

Being able to rely upon the 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 both in 1740-41 and in 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]

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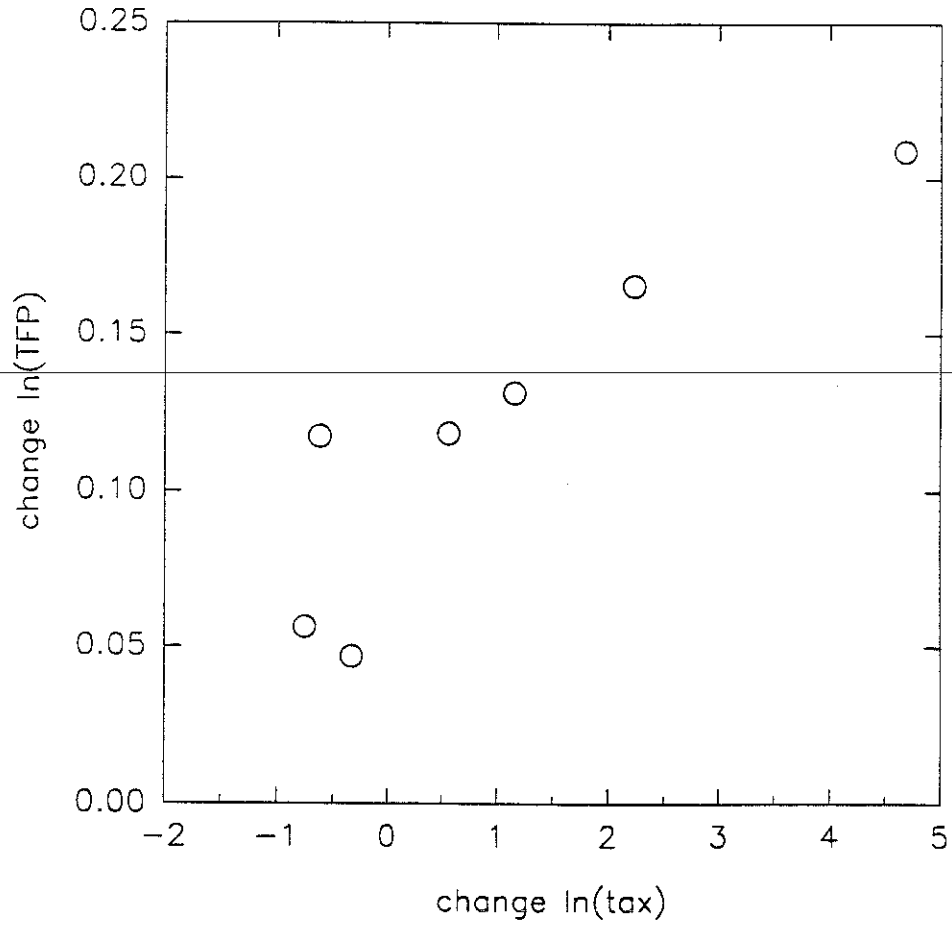
[53] Hanoteau died in 1785 and according to the tax roll of that year he farmed 224 hectares. Records of his estate suggest that he farmed even more--some 400 hectares. I thank Gilles Postel-Vinay and Jean-Marc Moriceau for furnishing this information.

[54] In the eighteenth century, Notre Dame wanted to suppress the buildings on properties no longer large enough to be economical farms: AN LL 332 (1761-62, Larchant); S 320 (26-6-1780, Lizy-sur-Ourcq). One sign of the greater frequency of cumul de baux that the leases began to carry a clause acknowledging it: AN S324A (Le-Mesnil-Amelot, 25-6-1781), S 407 (Viercy, 25-8-1785). For early consolidation, see Jacquart, Crise rurale, pp. 340-48, and for an excellent example, see the forthcoming book by Postel-Vinay and Moriceau.

[55] AN LL 329-30, S 272, S 273 (1636-54).

[56] For the tax rolls, see Jean Guerout, ed., Rôles de la taille de l'élection de Paris conservés aux Archives nationales (sous séries Z 1G) et dans les archives départementales (Paris, 1981). A search at the AN turned up tax assessments for 44 tenants in the series Z 1G, and these assessments bore out the close relationship between the size 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. For only seven of the properties, however, was I able to get leases and useable tax assessments 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

Figure 4: Change of ln(TFP) versus change ln(tax assessment), 1740–41 to 1783–89



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 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]

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.

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 improving 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 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

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appendix 13. Figure 4 here differs slightly from an analogous graph in Hoffman, SSWP 742, because of the addition of new data.

[57] AN Z 1G 291B (1740), 292B (1741), 431A (1786), and 451B (1789). Hanoteau died in 1785, forcing me 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 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.

nearly all the progress of TFP.[58]

Whatever the causes, it is in any case clear that Old-Regime agriculture was capable of astonishing 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 is usually expected on 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 in the Wars of Religion; their recovery in the early seventeenth century, sapped by military taxes and the Fronde. In the end, agriculture near Paris suffered grievously from these setbacks. While 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 a 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.

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[58] Postel-Vinay and Moriceau, [forthcoming]; Meuvret, Subsistences, vol. 1, pt. 1:194-203; George Grantham, "The Growth of Labour Productivity in the 'Cinq Grosses Fermes' of France, 1750-1933," in Bruce Campbell and Mark Overton, eds., Productivity Change and Agricultural Development (Manchester, forthcoming). Chevet, "Le Marquisat d'Ormesson," proposes even larger yield increases than 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.

Appendices

1. Treatment of Leases

Early modern leases bristle with complications, making even the payment of rent an intricate matter. Consider, for example, the lease which the cathedral of Notre Dame and its tenant, Pierre Laudry, agreed to in 1781. Laudry was to continue operating Notre Dame's 95-hectare farm in Mesnil-Amelot for another 9 years and to pay an annual rent of 1200 livres in cash plus 216 Paris setiers (roughly a 1000 bushels) of wheat. The wheat had to be cleaned, ready for market, and delivered to the cathedral in Paris. Alternatively, Notre Dame could demand cash in place of the wheat. In that event, the wheat was to be evaluated at 5 sous per setier below the Paris price for the best quality wheat on the feast of Saint Martin (November 11), the date when the grain was to be delivered; the 5 sous per setier amounted to about a 1 percent discount below the maximum Saint-Martin price. In addition to the wheat, Laudry was to deliver 200 bottes of straw to the cathedral in Paris or to pay cash in place of straw, with the straw evaluated via the Paris market price on the date of delivery. Laudry had a number of other obligations as well--tending to upkeep, for example--and at the beginning of the new lease he was to pay a one-time entry fine amounting to 10 percent of the first year's rent.[60]

There are further complexities in Laudry's lease, but these details suffice to sketch the complexities of the rent payments involved. As with Laudry, Notre Dame's other tenants might owe the cathedral annual rent in cash, in-kind payments, pots-de-vin (entry fines, almost always equal to a one-time payment of ten percent of the first year's rent), or charges (obligations to make cash or in-kind payments for Notre Dame--to a local priest, for example). I spread the pots-de-vin evenly over the life of the lease (without discounting) and converted the in-kind payments into cash. If the in-kind payments entailed delivering grain to Paris (the usual case), they were evaluated using the average Paris price on the feasts of Saint-Martin over the course of the outgoing lease (i.e., the current feast of Saint Martin and the eight previous ones). I chose prices on the feast of Saint Martin because contemporaries used them to evaluate in-kind payments and because grain was typically due then. For wheat and rye, minimum Saint Martin prices were used since Notre Dame expected the grain to fetch a price slightly less than the best quality wheat and rye. For the oats and barley only maximum prices were available, but most in-kind payments involved wheat.

Before 1520 and after 1698, the Saint Martin wheat prices in Paris ceased being available, so I used a proxy constructed by first regressing the Saint-Martin wheat prices on the annual Paris wheat price for the years 1520-1698. The regression was performed without an intercept term, and for the years before 1520 and after 1698, when the annual Paris price existed but the Saint Martin price did not, I simply multiplied the annual Paris price by the regression coefficient to get the proxy. Saint Martin prices were also lacking for the other grains before 1520 and after 1698, which necessitated similar proxies. For rye I regressed Paris Saint Martin rye prices on the annual Paris wheat price without an intercept term in the regression; I then used the regression coefficient to create a rye proxy for the years before 1520 and after 1698. For barley and oats, I simply resorted to 25-year average prices when the Saint-Martin prices were unavailable.

Grain delivered outside of Paris and other in-kind payments--usually very small--were evaluated using cash equivalents found in late eighteenth-century leases. Ideally, one would prefer to evaluate them by multiplying the quantities due by the appropriate local market prices, but the local prices series--say the price of wine in a small market town--might be lacking for a number of years. What I did therefore was to project the late eighteenth-century cash equivalents back into the past using long term trends in Paris prices. I relied upon 25-year average prices of the items concerned. A quantity of wine delivered to a village priest and worth 10 livres in 1750-74, for

[60] AN S 324A, 25 June 1781.

example, I assumed to be worth 10h in 1650-74, where h was the ratio of the 1650-75 Paris price for wine to the 1750-74 Paris price. If the Paris price and the local market price diverged, this method would involve some error, but the error would in any event be minuscule, for most in-kind payments involved wheat delivered to Paris.

I made one change in the procedure for evaluating in-kind payments when experimenting with alternate prices in the agricultural price-cost index. When I averaged the prices and the wages in the index over the new lease (in other words, over the current year and eight years into the future), I evaluated all in-kind payments over the life of the new lease too, instead of over the previous lease. I modified the procedure in an analogous way when I experimented with other prices and wages in the price-cost index.

One might wonder, of course, whether the results were sensitive to the way I evaluated the in-kind payments, but this seems not to have been the case. Regressions with those leases in which all the payments were in cash differed little from regressions that included the in-kind leases, except for a higher R^2. The reason for the higher R^2 with the cash-only leases was that the value of grain payments was volatile and added considerable noise to the dependent variable in the regressions.

One occasional complication with early modern French leases was the practice of using contre lettres: private letters attached to the leases that revised lease terms. Like other landlords, Notre Dame employed contre lettres, but only for minor matters, and unlike many landlords, Notre Dame never used them to disguise the true rent. In the hands of other landlords, contre lettres often served to reduce the tax assessments of large scale tenants, whose tax assessments were based on the artificially low rent in their leases, not the actual rent in the contre lettres. Notre Dame, though, never resorted to such practices. The reason, apparently, was that operating a large farm for Notre Dame typically involved paying sizable charges--typically to the local parish priest. Since these charges did not figure in the tax assessments either, the large scale tenants of Notre Dame enjoyed an automatic tax reduction equivalent to that gained by other landlords via contre lettres.

In addition to farm land, the Notre Dame leases might also involve rights to collect the tithe or seigniorial dues on property other than the land that was to be cultivated. Since these rights did not pertain to the operation of the farm, I subtracted their value from the lease. I determined their value from cash equivalents given in the late eighteenth century, suitably adjusted for changing prices. For none of the properties were such tithe rights or seigniorial dues large. If they or the property area changed by a significant amount (for example, more than a 14-percent change in the property area), I assumed that I was dealing with a different property and began a new time series.

2. Distance as a Proxy for the Cost of Transportation to Paris

The regressions use the logarithm of the distance to Paris as a proxy for the logarithm of the cost of transporting crops to Paris. Ideally, one would prefer the actual cost of shipping 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 on boats. For our properties, though, evidence from the seventeenth and eighteenth centuries suggests that the shipping costs were highly correlated with simple distance from Paris.[61] Indeed, if one figures the cost of shipping to Paris via the cheapest means for the properties in our sample, then the logarithm of the cost is almost perfectly correlated with the logarithm of distance from Paris ($r = 0.99$), and the correlation does not seem sensitive to errors in the shipping cost figures. Using distance from Paris rather than shipping costs therefore seems justifiable.

3. Quality Adjustments and Rent Averages

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[61] Information on the cost of transportation was taken from Meuvret, Subsistances, vol. 1, pt. 1 (Texte): 53-58; pt. 2 (Notes):21-23, 58-62.

The quality adjustment that I employed is discussed in the text; it had a minor effect on the rent (Figure A-1). The same held for other quality adjustments that I tried, all based on regressions with ln(rent). These other adjustments included running regressions with a dummy variable for each property; using locational and land quality characteristics only, but no time dependent variables; and replacing the time trend with an agricultural price-cost ratio. All gave nearly identical results.

The area-weighted average over all leases in force assumes that each lease lasted nine-years or until renewed and that rents remained constant in the interim. Table 1, column 3 calculates such an average, relying on the same regression for the quality adjustment but weighting each lease by the property area. The overall trend with this average over the leases in force is similar to that obtained with the average over the newly signed leases, but there are some differences (Figure A-1). When the fighting during the League ravaged the Paris Basin in the 1590s, for example, ln(rent) fell for the leases signed in the decade (Table 1, column 4). If we average over all leases in force, though, the logarithm, buoyed up by leases signed in the previous decade, actually increases. The increase, however, is illusory, since many of the older leases were in fact no longer in force: tenants had fled before the warring armies, farms lay in ruin, and no one was actually paying rent.[62] Although the difference between the two methods is generally small, the average over the sample leases--the ones signed during the decade--seems a bit closer to reality.

The same holds in the eighteenth century, when rents are increasing. The average over all the leases in force may do a better job of representing the income landlords received, but it lags slightly behind the true rental value of the land. The average over the leases signed in a decade--the sample leases--does not. Between the 1730s and the 1780s, for instance, nominal rents adjusted for quality rise only 73 percent if we average over all leases in force (Table 1, column 3). If we average over the sample leases--those signed during the two decades--the increase is much larger: 105 percent (Table 1, column 2). The 105-percent jump lies in the very center of the range of figures that other historians have unearthed for the Paris Basin: a 79 to 120-percent gain between the 1730s and the 1780s. The close fit with other research argues in favor of using the average over the sample leases, particularly since we are interested not the landlord's income but in true rental value.[63]

4. The Comparison with the Veyrassat-Herren and Le Roy Ladurie Rent Series

Veyrassat-Herren and Le Roy Ladurie published 5-year averages of an index of deflated rent. To deflate, they divided nominal rents by a 13-year moving average wheat price, centered on year five of each lease. To reverse their steps, I multiplied their figures by the average wheat price over each 5-year period of a 13-year moving average centered 5 years in the future. I also assumed that they had used their used their raw wheat price series as it was originally published, without corrections for typographical errors or for the changing size of the setier. Other ways of comparing their rent series and my own, such as subjecting my series to their deflation procedure, led to similar results.

5. Formulas for TFP and Technical Assumptions

Assume the farmer produces outputs $y_1,...,y_m$ using factors of production $x_1,...,x_n$, where x_1 is land. If the outputs can be sold at prices $p_1,...,p_m$ and the factors of production bought at prices $w_1,...,w_n$, then the farmer's profit is

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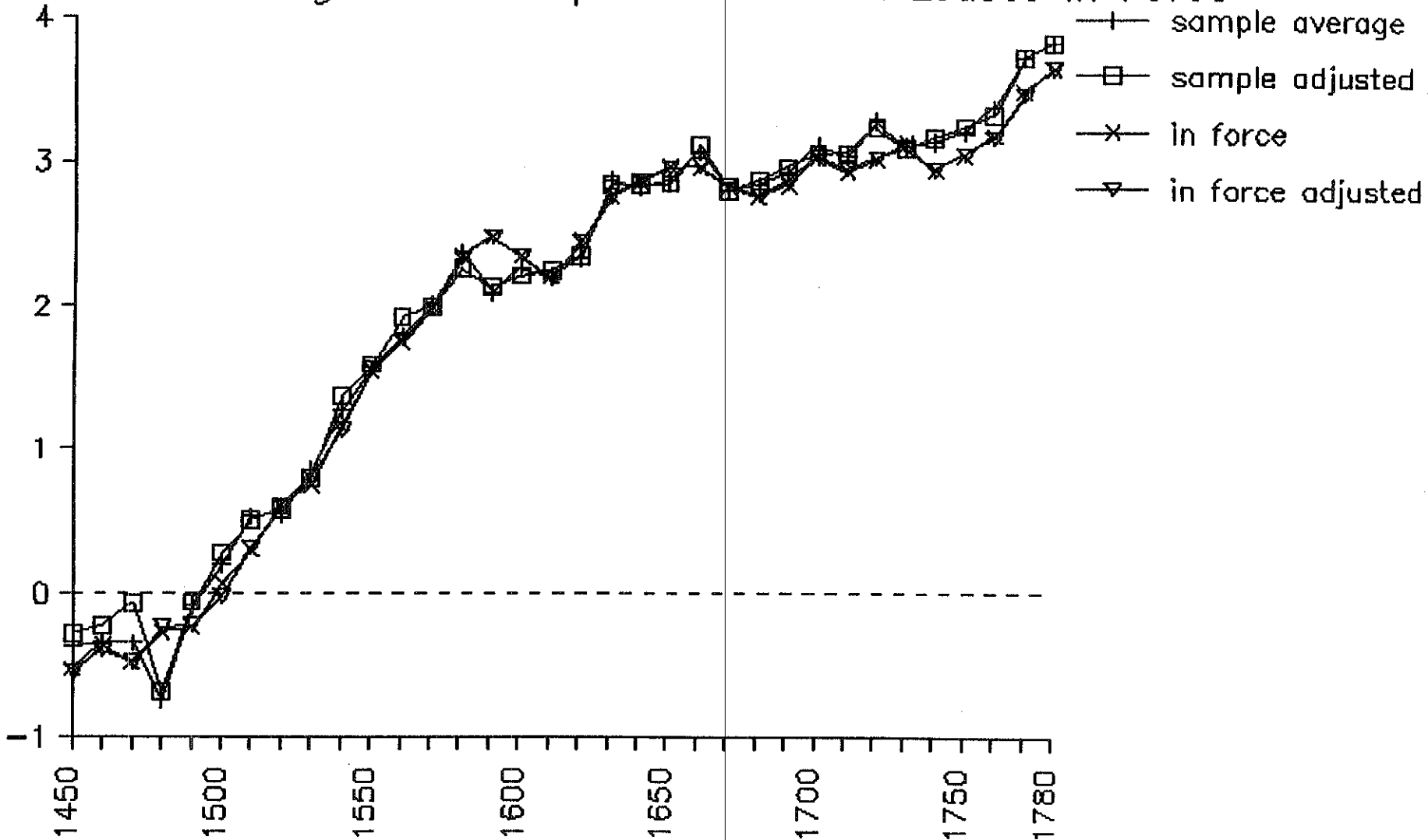
[62] See, for example, AN LL 329-30 (La Grande Paroisse, 1594); LL332 (Larchant, 1596); LL341-42 (Rungis, 1588); and S 242 (Dampmart, 1597).

[63] Béaur, Marché foncier, pp. 262-68; Veyrassat-Herren and Ladurie, "La rente foncière"; Bertrandy-Lacabane, Brétigny-sur-Orge, pp.314-15.

Figure A1: Alternate Averages of Ln(Rent)

Average over Sample and over All Leases in Force



Quality Adjustement as in Table 1

$$\Pi = \sum_{i=1}^{m} p_i y_i - \sum_{j=1}^{n} w_j x_j \tag{3}$$

Although some of the farmer's transactions may have taken place outside the market, we assume that he was at least partially involved in the product and factor markets, so that the prices in (3) are market prices.

If the land and rental market is competitive with free entry and if rents are revised frequently, then the farmer's profits will be driven down to zero: they will all go to the landlord. Therefore,

$$\Pi = \sum_{i=1}^{m} p_i y_i - \sum_{j=1}^{n} w_j x_j = 0 \tag{4}$$

Differentiating the left hand side of (4) with respect to time and regrouping all the terms, we obtain

$$\sum_{i=1}^{m} p_i \frac{dy_i}{dt} - \sum_{j=1}^{n} w_j \frac{dx_j}{dt} = \sum_{j=1}^{n} \frac{dw_j}{dt} x_j - \sum_{i=1}^{m} \frac{dp_i}{dt} y_i \tag{5}$$

Dividing through by total revenue or cost R, where

$$R = \sum_{i=1}^{m} p_i y_i = \sum_{j=1}^{n} w_j x_j \tag{6}$$

yields

$$\sum_{i=1}^{m} u_i \dot{y}_i - \sum_{j=1}^{n} v_j \dot{x}_j = \sum_{j=1}^{n} v_j \dot{w}_j - \sum_{i=1}^{m} u_i \dot{p}_i \tag{7}$$

where the $u_i = p_i y_i / R$ are output shares in total revenue, the $v_j = w_j x_j / R$ are factor shares in total cost, and the dots refer to rates of growth (i.e. time derivatives of the logarithm). The expression on the left of (7) is the growth rate of TFP, the rate at which outputs are growing less the rate at which inputs are increasing, suitably weighted by output and factor shares. Equation (7) simply allows us to calculate the growth rate of TFP using prices instead of quantities, and it is the basis for the calculations of the growth rate of TFP in Figure A-3 and Tables 3 and A-2.

So far we have only assumed that markets exist and that one of the markets, the land rental market, is competitive and open to entry. This assumption allows us to set the farmer's profits equal to zero and makes the tenant's compensation no more than he would earn in the labor market. Although such a treatment of the farmer's profits is obviously open to question--a subject to which we shall return below--it is common in the agricultural productivity literature.[64]

If product and factor shares are constant, then by integrating the right hand side of (7) we have that

$$TFP = \frac{w_1^{v_1} \cdots w_n^{v_n}}{p_1^{u_1} \cdots p_m^{u_m}} = (r + t)^s \frac{C}{P} \tag{8}$$

Here r is per-hectare rent, t is per-hectare taxes, $s = v_1$ is the factor share of land, and we have made the reasonable assumption that the burden of taxation falls on land so that $w_1 = r + t$. The variables

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[64] For an example, see Robert E Evenson and Hans P. Binswanger, "Estimating Labor Demand Functions for Indian Agriculture," in Contractual Arrangements, Employment, and Wages in Rural Labor Markets in Asia, ed. Hans P. Binswanger and Mark R. Rosenzweig (New Haven, 1984). Cf. the criticisms in G. R. E. Lopez, "Estimating Substitution and Expansion Effects Using a Profit Function Framework," American Journal of Agricultural Economics 66(1984):358-67.

C and P are indexes of agricultural costs and prices, given by

$$C = w_2^{v_2} \cdots w_n^{v_n} \qquad P = p_1^{u_1} \cdots p_m^{u_m} \tag{9}$$

As a result,

$$\ln(TFP) = s\ln(r + t) - \ln(\frac{P}{C}) \tag{10}$$

Equation (10) serves as the basis for calculating ln(TFP) in Tables 2 and A-1 and in Figures 3, 4, and A-4.

So far we have not invoked cost minimization or profit maximization, although without some optimizing behavior, our measure of TFP is simply a definition, with no necessary connection to the agricultural technology. We do have to assume the existence of a large number of risk neutral tenants for the tenant farmer's profits to be driven down to zero as in (4), and risk neutrality is not far from profit maximization. Profit maximization is in any case hardly an unreasonable assumption for the large scale tenants who operated farms in the Paris Basin: they owned considerable capital and had chosen to pay a fixed rent rather than to work for a wage.

If we do assume profit maximization, and if (as seems to have been the case) all the product and factor markets are competitive--not just the rental market--then we can demonstrate that the growth rate of TFP is in fact the rate of technical change. Let us suppose that our farmer takes all the prices w_j and p_i as given and that the inputs and outputs are linked via a transformation function F with $F(x_1,...,x_n,y_1,...,y_m,t) = 0$.[65] Here F depends on time t because of technical change. If the technology is well behaved, we can use the implicit function theorem to solve for one output (say y_1) in terms of $x_1,...,x_n,y_2,...,y_m,t$, so that at least locally

$$y_1 = f(x_1,...,x_n,y_2,...,y_m,t) \tag{11}$$

Differentiating (11) with respect to time, we have

$$\frac{dy_1}{dt} = \frac{\partial f}{\partial x_1}\frac{dx_1}{dt} + ... + \frac{\partial f}{\partial x_n}\frac{dx_n}{dt} + \frac{\partial f}{\partial y_2}\frac{dy_2}{dt} + ... + \frac{\partial f}{\partial y_m}\frac{dy_m}{dt} + \frac{\partial f}{\partial t} \tag{12}$$

To avoid problems in the case of constant returns to scale, let us suppose as well that in the short run the farmer takes the supply of land x_1 as a fixed input--say over the course of a lease--and that he maximizes short run profits.[66] Short run profit maximization then implies that

$$p_1\frac{\partial f}{\partial x_j} = w_j \qquad j = 2,...,n \tag{13}$$

and

$$p_1\frac{\partial f}{\partial y_i} = -p_i \qquad i = 2,...,m \tag{14}$$

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[65] For the necessary assumptions, see Chambers, Applied Production Analysis, pp. 260-61. Except for the land rental market, all the other price and factor markets had so many actors that competition seems very reasonable.

[66] Alternatively, if the technology does not exhibit constant returns to scale, then we can let the amount of land vary in the short run and allow the farmer to maximize long run profits. We will in any case end up with the same identity between TFP and technical change. We need not assume, it is worth stressing, that the supply of land is fixed.

We can also characterize the partial derivative of f with respect to land x_1. Over the long run x_1 may vary, but the competitive rental market assures that the landlord will absorb any profits from renting additional land. A simple application of the envelope theorem then yields

$$p_1 \frac{\partial f}{\partial x_1} = w_1 \tag{15}$$

If we use (15) and the first order conditions for profit maximization to express the partial derivatives of f in terms of prices, then (12) becomes

$$\frac{dy_1}{dt} = \frac{w_1}{p_1}\frac{dx_1}{dt} + \ldots + \frac{w_n}{p_1}\frac{dx_n}{dt} - \frac{p_2}{p_1}\frac{dy_2}{dt} - \ldots - \frac{p_m}{p_1}\frac{dy_m}{dt} + \frac{\partial f}{\partial t} \tag{16}$$

Multiplying both sides by p_1/R, where R is total revenue, yields

$$\sum_{i=1}^{m} u_i \dot{y}_i - \sum_{j=1}^{n} v_j \dot{x}_j = u_y \dot{f} \tag{17}$$

where

$$\dot{f} = \frac{\partial}{\partial t} \ln(f) \tag{18}$$

The expression on the left of (17) is the growth rate of TFP; the expression on the right is the rate of technical change, the rate (in percentage terms) at which the production function f is shifting, adjusted for the relative importance of the output y_1. With only one output, for example, $u_1 = 1$ and the growth rate of TFP equals the partial derivative of ln(f) with respect to time. Note that this result does not depend on factor and product shares being constant.

In the context of profit maximization, the assumption of constant product and factor shares amounts to a choice of the form of the profit function. The particular form implied by the constant shares assumption is only a local first order approximation to an arbitrary profit function. Obviously, functional forms capable of providing a local second order approximation (so called flexible functional forms, such as a translog or a generalized Leontief) would be preferable, but the data needed to estimate such profit functions and thereby determine TFP is unfortunately unavailable, for the estimation requires information on both prices and quantities. As is shown in appendix 11, though, the loss of accuracy is minimal, at least in the one instance where we have the information to check it.[67]

6. Product and Factor Shares and the Rental Price of Agricultural Capital

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[67] For the form of the profit function with constant shares, see Allen, "Efficiency and Distributional Consequences." On multi-output profit functions, see Chambers, Applied Production Analysis, pp. 268-81; Lawrence J. Lau, "Applications of Profit Functions," in Melvyn Fuss and Danield McFadden, eds., Production Economics: A Dual Approach to Theory and Applications, 2 vols. (Amsterdam, 1978), 1:133-310; W. E. Diewert, "Applications of Duality Theory," in Michael D. Intriligator and David A. Kendrick, eds., Frontiers of Quantitative Economics, vol. 2 (Amsterdam, 1974), pp. 107-71. In practice it is easier to estimate demand equations derived from profit functions rather than the profit function directly; for examples, see Lopez, "Estimating Substitution and Expansion," and Evenson and Binswanger, "Estimating Labor Demand Functions for Indian Agriculture." Appendix 11 takes up the issue of superlative index numbers--another way to calculate TFP and one equivalent to the use of flexible functional forms--but they too require information on quantities.

The product and factor shares used to calculate TFP were taken from accounts of the farm of Bernonville, part of the village now known as Aisonville-Bernoville near Guise in the department of the Aisne. The Bernonville accounts for the year 1765 were analyzed (along with those of a number of other farms) in Charles Rebeyrol, De la grande et de la petite culture chez les physiocrates (Paris, 1912), pp. 35-44. Rebeyrol relied upon evidence published in 1767 in the Ephémerides du citoyen, a journal that, though polemical, was known for publishing reliable information concerning matters such as farm budgets.[68]

Supplemental information and evidence concerning farms elsewhere in the Paris Basin were gleaned from Alexandre-Henri Tessier et al, Encyclopédie méthodique ou par ordre de matières: Agriculture 7 vols. (Paris, 1787-1821); M. Jouvencel, Modèle de bail à cheptel pour servir d'instruction aux propriétaires ou capitalistes qui voudront établir des troupeaux de bêtes à laine dans les fermes des environs de Paris (Versaille, 1810); S. Hassenfratz, "Mémoire sur la comparaison des produits de la culture du Bourbonnais avec celle de la Picardie," Mémoires d'agriculture, d'économie rurale et domestique (1786), pp. 105-22; Jacquart, Crise rurale, pp. 289-408; Emile Mireaux, Une province française au temps du grand roi: La Brie (Paris, 1958), pp. 97-164, 322-41; Meuvret, Subsistences, vol. 1; and forthcoming work by Gilles Postel-Vinay and J. M. Moriceau. All of these sources are the work either of eighteenth-century experts or of modern authorities and they all draw upon evidence from actual early modern farms.

The Bernonville factor shares were: land, 0.267; labor, including in-kind compensation and labor provided by the tenant farmer, 0.361; wheat seed, 0.058; rye seed, 0.009; barley seed, 0.007; oat seed and feed, 0.109; bean and pea seed, 0.013; linseed, 0.004; horses, 0.044; cattle, 0.015; sheep, 0.052; pigs, 0.011; poultry, 0.013; and equipment, 0.035. Product revenue shares were: wheat output, 0.456; rye output, 0.080; barley output, 0.036; oats output, 0.101; bean and pea output, 0.073; flax output, 0.051; dairy output, 0.035; wool, 0.042; eggs, 0.015; beef, 0.012; mutton, 0.076; pork, 0.015; horses, 0.007.

Here and throughout the paper, the shares for livestock and equipment were calculated using rental prices, set equal to the sales price multiplied by depreciation plus interest. The depreciation rates were derived from evidence concerning the useful life of animals and from costs for equipment replacement and upkeep; they were: horses, 0.111; cows, 0.133; sheep, 0.25; pigs and poultry, 1; equipment, 0.143. The interest rates were the going rate on rentes.[69] A comparison of land rental rates and land sales prices suggests that the rentes did reflect the going rate of interest in the countryside; so do rental contracts for milk cows. In the Brie in the 1660s, for example, rentes paid 5 percent and cows were leased out at 17 percent of their value, to judge from the median of the rental contracts in AN S 471. Our depreciation rate for dairy cattle, from Tessier, sv "Bêtes à cornes," is 13 percent. The price of cattle was appreciating at about 1 percent annually, so we get an implied interest rate of 17 - 13 + 1 = 5 percent, which is precisely the rente rate. Note that the rental cost of

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[68] André J. Bourde, Agronomie et agronomes en France au XVIIIe siècle, 3 vols. (Paris, 1967), 3:1513-14.

[69] Sources for the rente interest rates were as follows: Bernard Schnapper, Les rentes au XVIe siècle: Histoire d'un instrument de crédit (Paris, 1957), pp. 68-72, 100-02, 279; Pierre Goubert, "Le tragique 17e siècle," in Histoire économique et sociale de la France, ed. F. Braudel and E. Labrousse, vol. 2 (Paris, 1970): 343-44; Emmanuel Le Roy Ladurie, Les paysans de Languedoc, 2 vols. (Paris, 1966), 2:1024-25. The rates I used, which were medians for each 25-year periods, were as follows: 0.0833 (1500-99), 0.0625 (1600-49), 0.05 (1650-99), 0.0455 (1700-24), 0.03 (1725-74), 0.0427 (1775-89). Except for Le Roy Ladurie, these were all rates from the Paris area, but the rates he gave (for Languedoc) tended to agree with the evidence in Schnapper and Goubert. Furthermore, all three sources yield rates that agree with those I have found in rural notarial archives from the Paris Basin, including AN S 468-69, 473-75 (La Grande Paroisse); Archives départementales [henceforth AD] des Yvelines et de l'ancien département de Seine-et-Oise, E notaires (Brétigny-sur-Orge).

dairy cattle we would calculate for our cost index C (interest plus depreciation, or 18 percent of the price of a cow) was very close to the true rental cost of capital (17 percent of the price of a cow).

Although one might have doubts about the robustness of the depreciation rates here, very similar rates seem to have applied to most early modern herds. Wilhelm Abel, for example, gives figures for medieval and early modern Germany that a imply a depreciation rate for dairy cattle of 13 or 14 percent.[70] Since the depreciation rates for livestock and equipment exceeded the interest rate by a large margin after 1600, the rental costs of capital we calculated were relatively insensitive to variations in the interest rate.[71]

Seed and feed prices equalled prices of the respective grains multiplied by 1 plus the interest rate because they had been stored for a year. Only net inputs and net outputs were considered, although we did assume the purchase of seed and oat feed. Products consumed on the farm in the form of in-kind wages were evaluated at market prices.

To be sure, some of the product and factor shares from Bernonville might seem questionable. The shares for wheat output and for wheat seed imply a high seed-yield ratio, and the seed-yield ratio was indeed high in Bernonville--better than 8 to 1. However, such seed-yield ratios were far from unusual near Bernonville, where the soil was well suited for cereals. A careful investigation undertaken in the généralité of Soissons in 1716 revealed seed-yield ratios reaching 10 or 12 to 1 in the vicinity of Bernonville (more precisely, in the subdélégation of Guise), and according to the same document, seed-yield ratios of 8 or more were not uncommon throughout the whole généralité. Such a seed-yield ratio, it should be stressed, did not necessarily imply a high wheat yield per hectare, because seeding rates varied greatly. Even the high seed-yield ratios of 10 or 12 to 1 near Bernonville meant yields of only 13 to 15.6 hectoliters per hectare, well below the maximums observed in the Paris Basin in the seventeenth and eighteenth centuries.[72]

One might also worry slightly about oat production on the Bernonville farm. With the product shares of oats and the factor share of oat seed and feed nearly equal, the farm was essentially self sufficient in oats; it consumed too much to be a net exporter. Obviously, other farms in the Paris area exported oats and had higher oat product shares. At Bernonville, though, the stiff soils required a somewhat larger number of plow horses, and the horses consumed oats that would otherwise have been exported. Fortunately, variations in the oat product share had little effect on the index of TFP, because the price of oats was highly correlated with other output prices.[73] The oat shares, in short, are no cause for worry.

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[70] Wilhelm Abel, Geschichte der deutschen Landwirtschaft vom frühen Mittelalter bis zum 19. Jahrhundert, 3rd ed. (Stuttgart, 1978), p. 26.

[71] For example, raising our interest rates to the legal maximum (they were generally a bit below the legal maximum) would have very little effect on the overall trend of TFP. If we recalculate the index of TFP using the legal maximum interest rates and normalize the resulting index to have the same value as the old index in the years 1750-74, then our TFP figures would be almost uniformly 2 percent lower for the years before 1700, 1 percent lower in 1700-24 and 1775-89, and essentially unchanged in 1725-74. In short, there would be slightly more productivity growth in 1700-74 and slightly less after 1775. Otherwise the story would be the same.

[72] Meuvret, Subsistances, vol. 1, pt. 1 (Texte): 196-97.

[73] In Hoffman, SSWP 742, I assumed that the Bernonville accounts were wrong and that the farm actually imported twice the quantity of oats shown in the accounts because of the large number of horses. I made this assumption despite the presence of artificial meadows on the farm, which should have sufficed to feed the farm livestock. Despite the large change in the factor share of oat feed, the TFP figures remained practically unchanged. Making the farm a net exporter of oats would have an equally small effect on TFP.

In general, the technology of the Bernonville farm resembled that found elsewhere in the Paris Basin, not just in the eighteenth century but in the seventeenth and sixteenth centuries as well. If we examine farms in the Beauce in 1787, on the plains north of Paris in the 1740s, in the Brie in the early eighteenth century, and in the Hurepoix south of Paris in the period 1550-1670, we find similar outputs and similar factors of production.[74] Typically, between one quarter and one third of the arable land was devoted to winter grain; in Bernonville, the figure was 24 percent. The acreage devoted to spring grain on the other farms was about the same, though sometimes a bit higher; in Bernonville, it was 29 percent. Although the amount of artificial meadow on the Bernonville farm (15 percent of the arable) was a bit higher than on the other farms, it was hardly unusual for the Paris Basin, and the amount of fallow (30 percent) was perfectly normal.[75]

Labor use on the Bernonville farm was typical as well. If we consider for example the number of plowmen employed on farms in the Paris Basin, it turns out to have varied greatly, but the number in Bernonville was precisely in the middle of the range. On local farms, the number of plowman might range from 1 for every 30 hectares down to only 1 for every 60 hectares, if we assume that all plows listed in death inventories were used. The number also seemed to diminish over time. On the plains north of Paris, for example, it went from 1 for every 30 hectares circa 1700 to 1 for every 50 hectares by 1790. Using 1 plow for every 30 hectares was the average for death inventories in the Hurepoix in the period 1550-1670, but in some of the inventories from the same period the number was as low as 1 for every 60 hectares.[76] In any event, in Bernonville the number of plowman was precisely in the middle of this wide range: 1 for every 43 hectares.[77]

Harvest and temporary labor was also typical on the Bernonville farm. Harvest labor for grain crops typically cost to 8 to 12 percent of their value in the seventeenth century, and if we add other related temporary labor, the figure would rise to about 16 percent, whether we look at evidence from the sixteenth, seventeenth, or eighteenth centuries. On the Bernonville farm, the cost of harvest and related temporary labor was 18 percent of the grain harvest, very close to the 16 percent figure.

Finally, the amount of agricultural capital on the Bernonville farm resembled what one found elsewhere in the Paris Basin. The farm had 12 horses per 100 hectares, versus 8 to 9 on the plains north of Paris in the 1740s, and a median of roughly 8 in Hurepoix death inventories from large farms in the years 1550-1670. Because of the stiff soils, the Bernonville figure is a bit high, but not outrageously so. The farm had 14 cows per 100 hectares, versus 10 in the Beauce in 1787, 12 on the plains north of Paris in the 1740s, 14 in the Brie in the 1730s, and a range of 6 to 15 in the Hurepoix large farm inventories from period 1550-1670. The number of sheep was equally close to the norm: 235 per 100 hectares in Bernonville, 152 in the Beauce, 192 on the plains north of Paris, 218 in the

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[74] Sources for the following discussion include Tessier, Encyclopédie méthodique: Agriculture, sv "Bail," and "Andonville"; forthcoming work by Gilles Postel-Vinay and J. M. Moriceau; Mireaux, La Brie, pp. 97-164, 322-41; and Jacquart, Crise rurale, pp. 289-408; .

[75] Chevet, "Marquisat d'Ormesson," 493-508.

[76] The figures here are for farms with 2 or more plows only.

[77] One complication here is that the Bernonville accounts did not use the local area measure, the jalois, but rather an unspecified arpent, which was probably the arpent de Paris, equal to .34 hectares, rather than the arpent commun, equal to .42 hectares. Using the arpent commun would mean 1 plow for every 53 hectares, still within the range. For the local area measure on the Bernonville farm, see Annuaire statistique et administratif du département de l'Aisne pour l'année 1837 (Laon, 1837), pp. 250-59.

Brie, and a median of 254 in the Hurepoix inventories.[78]

Since the number of animals did not vary greatly from farm to farm or over time, it is also reasonable to assume that animal outputs (chiefly wool and mutton) did not vary much either. Breeding practices did not change drastically, despite much discussion in the late eighteenth century, and there was in any case little reason for farmers in the Paris Basin to shift drastically into stock raising.[79] The price of wool, mutton, and dairy products moved in parallel with that of wheat between 1520 and 1789, and transportation costs always favored grain production in the Paris Basin.

In addition to the farm accounts and death inventories, one can find evidence in favor of the Bernonville factor and product shares by examining sharecropping contracts. Sharecropping contracts were rare in the Paris Basin, but some did exist in parts of the Brie, where they involved a complicated division of outputs and inputs between tenant and landlord. Terms of the sharecropping contracts varied, but examples from the seventeenth and early eighteenth centuries imply that the product and factor shares must have satisfied several restrictions. For example, in one type of contract the landlord furnished nothing beyond the land and received one third of the grain output and one third of the hay. The land share must therefore have been less than one third but greater than one third times the grain product share. For Bernonville, the land share (0.267) satisfied both inequalities: it was less than one third and greater than one third of the grain product share (0.224). Other contracts imply that the land share plus half the expenditure on seed, feed, and harvest labor should be approximately one half. For Bernonville, the numbers add up to 0.53, very close to one half indeed.[80]

One final piece of evidence in favor of our constant shares assumption comes from demographic records. If the land and labor factor shares are constant, then the ratio of rent to wages will be proportional to the ratio of labor to land, which we can reasonably approximate by the rural population, provided that the labor force participation rate and the amount of capital invested in land do not change drastically. We can therefore detect drastic shifts in the factor shares of labor and land (provided they do not both change in a way that keeps their ratio constant) by plotting the ratio of rent to wages alongside a graph of rural population trends. If the land and labor factor shares changed, the graph of the rent-to-wage ratio would presumably diverge from the population curve.

We do not know the rural population precisely, but we might approximate it by rural baptisms, although this represents yet another questionable assumption. If we do so, we see that the curve of baptisms and the graph of the rent-wage ratio move together (Figure A-2). The baptisms here come from a region that is much larger than that of our farms, and the graph only covers the period 1671-1720.[81] Still, despite all the approximations and assumptions, the agreement is impressive. And if we graph the rent-wage ratio over the period 1450 to 1789, it parallels what we know about the trend of the population, at least until the last decades of the eighteenth century.

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[78] All of these calculations are based on an arpent of .34 hectares for the Bernonville farm. The evidence from the Hurepoix comes from Jacquart's death inventories for grandes exploitations in Crise rurale, pp. 355-56.

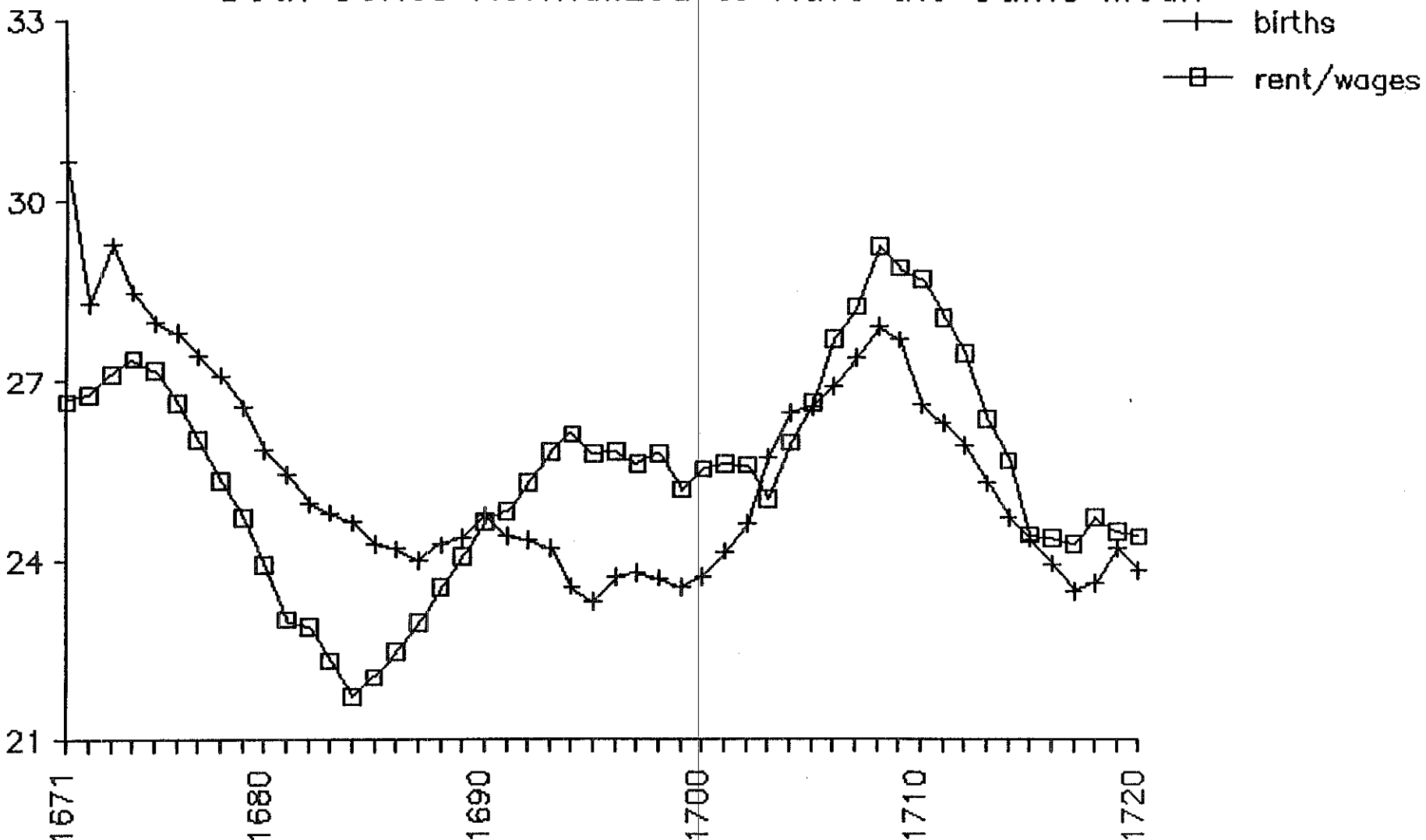
[79] On attempts to reform breeding and stock raising, see Bourde, Agronomie, 2:743-898.

[80] For the sharecropping contracts, see Mireaux, La Brie, pp. 109-11; none of the sharecropping contracts here involved Notre Dame. The factor and product shares from the farm described by Moriceau and Postel-Vinay also satisfy the sharecropping inequalities.

[81] The baptism figures are derived from Jacques Dupâquier, La population rurale du Bassin Parisien à l'époque de Louis XIV (Paris, 1979), p. 239. The baptisms come from an area that extends over 300 kilometers from Paris--much further than any of our properties. Both the rent-wage ratio and the baptism series have been normalized to have mean 1, and both series are averages over the current year and the previous eight years.

Figure A2: Rent/Wage Ratio and Rural Births

Both Series Normalized to Have the Same Mean



All Variables Measured Using Moving Average over Past 9 Years

In the text of the paper, we also calculated TFP using alternate shares from a farm north of Paris, whose accounts have been analyzed by Gilles Postel-Vinay and J. M. Moriceau in their forthcoming study of the Chartier family. The factor shares from the Postel-Vinay and Moriceau farm are as follows: labor, including compensation for the fermier, 0.476; rental cost of livestock, 0.132; equipment rental, 0.022; land, 0.370. Their product shares are: wheat output, 0.473; oats and straw, 0.299; other crops, 0.021; animal products, 0.206. Postel-Vinay and Moriceau's accounts give grain output net of seed, and hence I treated seed as an intermediate product, not as an input. I also refigured their cost of capital goods to reflect the rental cost, using interest and depreciation rates. The depreciation rates were the same as for Bernonville, except for equipment (0.244), which, as in the case of Bernonville, was derived from actual maintenance costs.

Although these alternate shares may at first glance seem very different from the Bernonville figures, most of the difference results from aggregating inputs and outputs and from treating seed as an intermediate product.[82] Had we followed the same procedure with the Bernonville accounts, the Bernonville shares would have been very close to the alternate shares from the Postel-Vinay and Moriceau farm. The Bernonville labor factor share, for example, would become 0.452, and the animal product share would be 0.254, both close to the alternate shares. Apart from the aggregation and the treatment of seed, the differences between the two sets of shares is therefore small, and the aggregation and treatment of seed turn out to have very little effect on the calculation of TFP. Aggregation merely lumps together correlated prices in the indices C and P, and treating seed as an intermediate good merely divides both C and P by very nearly the same number. In both instances the ratio P/C, which is what we need to calculate TFP, remains nearly unchanged.

As noted in the text, the effect of the alternate shares on the path TFP took was not large. The alternate shares had an even smaller effect on the growth rate of TFP (Figure A-3) and they left the regressions with TFP and with its growth rate largely unchanged (Tables A-1 and A-2).

7. Wages in Paris and the Surrounding Countryside

The evidence for the mobility of labor near Paris covers the period from the fifteenth century through the eighteenth century, and in their forthcoming study of the Chartier family, Gilles Postel-Vinay and J. M. Moriceau even suggest that farm labor in the Paris Basin was more mobile in the eighteenth century than in the nineteenth. Such high mobility supports the view that wages in Paris and in the surrounding countryside (at least for the circumscribed area of our sample) tended to be equal. It argues in favor of using the homogenous series of daily wages for unskilled laborers in Paris as the rural price of labor.

Still, one might prefer direct evidence for wage equality. Micheline Baulant's work, which was cited in the text, supports wage equality for the sixteenth century, but there remains the seventeenth and the eighteenth centuries--particularly the latter.[83] Data, unfortunately, is lacking for this period, even in the archives. One reason is that the typical sources for wage data in the Paris Basin--hospitals and ecclesiastical institutions--run dry after the sixteenth century. Detailed accounts disappear, perhaps because the hospitals and monasteries relied more heavily on agents such as

[82] Because of the aggregation of inputs and outputs, I relied on the following prices with the alternate shares: the rental price of horses for the price of livestock, the price of oats for oats and straw, the price of beans and peas for other crops, and the price of meat for animal products.

[83] Baulant, "Le salaire des ouvriers"; idem, "Prix et salaires," pp. 980-86. Baulant notes one major exception to the pattern of wage equality--vignerons--but she relates the peculiar behavior of their wages to their situation and to the way in which they were paid.

Figure A–3: Alternate Growth Rates of TFP

Calculated without Land Quality Adjustment

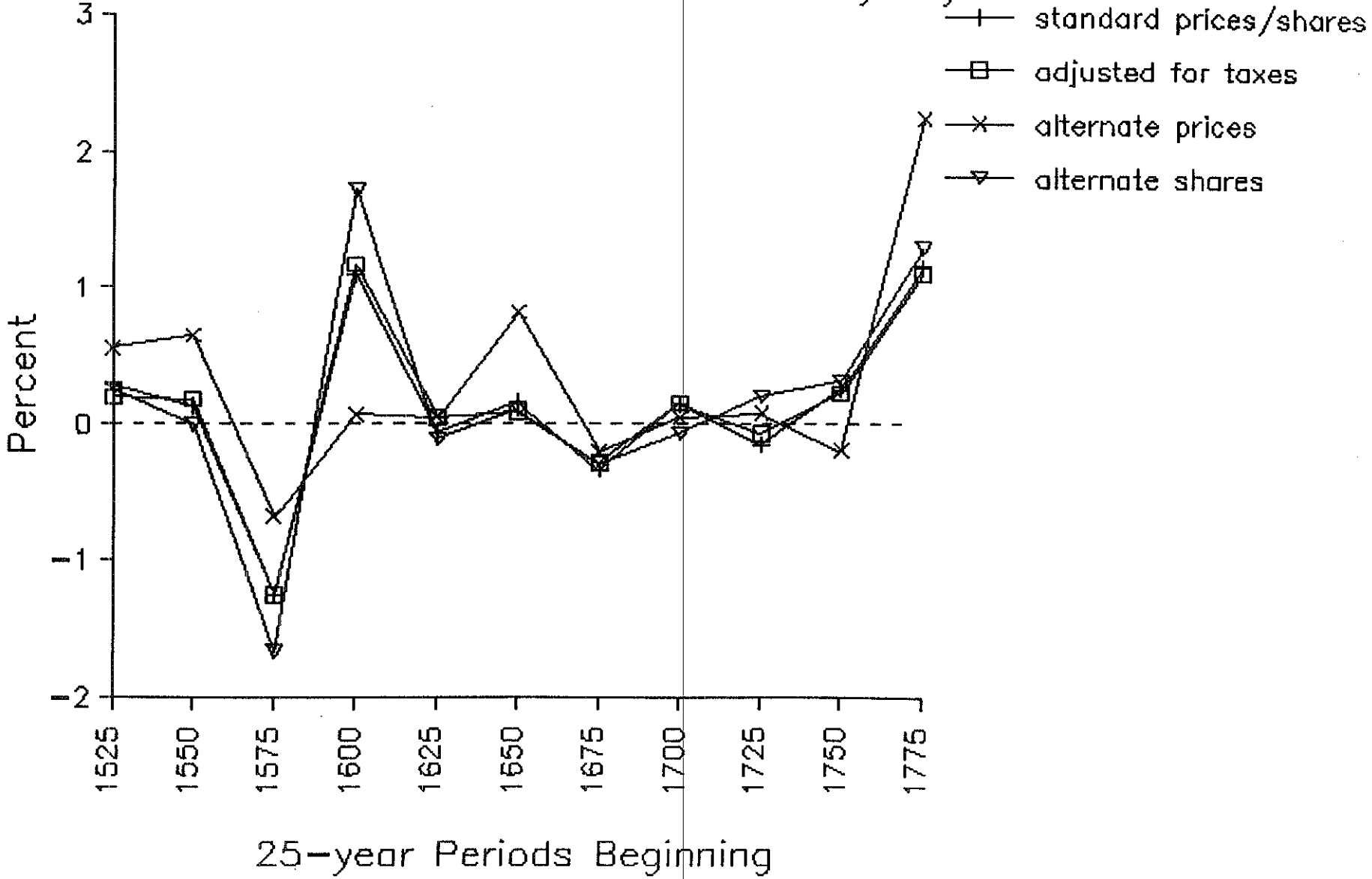


Table A-1 - TFP REGRESSIONS WITH ALTERNATE PRICES AND SHARES

Regression Number	(1)	(2)
Dependent Variable	Ln (TFP) Alternate Shares	Ln (TFP) Alternate Prices
INDEPENDENT VARIABLES		
Constant	0.48	-0.79
	(1.87)	(-4.01)
Dummy: Years 1775	0.10	0.084
and After	(2.33)	(1.54)
Dummy: War Years	-0.42	-0.24
1589-97	(-8.68)	(-6.47)
Percent Meadow	0.21	0.14
	(3.17)	(2.69)
Percent Vineyard	0.012	-0.058
	(0.09)	(-0.50)
Dummy: Good Soil	-0.0016	0.000057
	(-0.08)	(-0.004)
Ln (Distance to Paris	-0.093	-0.078
in Kilometers)	(-6.02)	(-6.45)
Dummy: Tenant Holdover	0.025	0.013
from Previous Lease	(1.38)	(0.91)
Time (Units of	0.064	0.11
100 Years)	(4.20)	(9.36)
Ln (Area in Hectares)	-0.033	-0.019
	(-3.69)	(-2.67)
Observations	638	620
R^2	0.30	0.34
Standard Error	0.23	0.17
Mean of Dependent Variable	1.11	0.67

Note: In regression 1, TFP is calculated using alternate shares described in text. In regression 2, it is calculated using prices and wages for the expected term of the new lease (the year the lease was signed and the next eight years), and in-kind rent payments were evaluated using the same prices. See appendices 6 and 9 for details. In both regressions TFP has been adjusted for taxes. T-statistics are in parentheses.
Source: As in Table 2.

Table A-2 - TFP GROWTH RATE REGRESSION FOR ALTERNATE PRICES AND SHARES

Regression Number	(1)	(2)
Dependent Variable	Growth Rate TFP Alternate Shares (Percent per Year)	Growth Rate TFP Alternate Prices (Percent per Year)
INDEPENDENT VARIABLES		
Constant	0.72	0.12
	(1.53)	(0.32)
Growth Rate of Taxes	-2.25	-9.49
Relative to Rents	(-0.82)	(-4.38)
Growth Rate Paris	0.32	0.21
Population	(6.25)	(5.08)
Dummy: Years 1775	1.15	2.05
and After	(2.89)	(3.95)
Dummy: War Years	-3.28	0.18
1589-1597	(-5.90)	(0.40)
Dummy: Building	-0.46	-0.38
Repairs	(-0.95)	(-1.00)
Dummy: Tenant Holdover	-0.13	-0.20
from Previous Lease	(-0.71)	(-1.41)
Ln (Distance to Paris	-0.13	-0.027
in Kilometers	(-0.93)	(-0.24)
Ln (Area	-0.023	0.036
in Hectares)	(-0.32)	(0.60)
Observations	648	630
R^2	0.21	0.08
Standard Error	2.24	1.76
Mean Dependent Variable	0.19	0.13

Note: Growth rates equal the rate of change of logarithms calculated from lease to lease, and as in Table 3, the TFP growth rates are not adjusted for taxes. TFP was calculated for alternate prices and shares as in Table A-1; see appendices 6 and 9 for details. T-statistics are in parentheses.
Source: As in Table 2.

fermiers and receveurs.[84] When added to the difficulty of dealing with in-kind payments and the enormous variations due to differences in strength and skill, it becomes difficult to find useable sources for rural wages.

Still, there is some evidence for the continuing equality of rural and urban wages. South of Paris, in Brétigny-sur-Orge, for example, a charretier earned 92 livres in 1614, plus in-kind compensation, which we might reasonably suppose was the equivalent of 3 Paris setiers of wheat. If we average the price of wheat over the period 1610-18, his total compensation amounted to 123 livres. In the same year, an unskilled Parisian day laborer, if he worked 200 days (the typical number of days of work in a year for a day laborer), would earn 120 livres, nearly exactly the same amount. In 1622 in the same village, another charretier and his wife earned 72 livres and 9 Paris setiers of grain working for the seigneur, which works out to 186 livres at Paris prices. If the charretier had worked 200 days in Paris and his wife had done the same for half the male wage (a typical figure for female labor), they would have earned nearly the same amount--195 livres.

In 1714-15 unskilled building workers earned 15 to 25 sous a day in Brétigny; at the time, the modal wage for the unskilled in Paris was 20 sous a day. And in the last years of the Old Regime in Brétigny, the unskilled earned between 12 to 20 sous a day in winter and between 25 to 30 sous a day in summer. In Paris in the 1770s and 1780s, the mode of February wages ranged between 18 and 24 sous in February and between 22 and 28 sous in July. The winter wage in Brétigny was lower and the summer wage higher, but the annual earnings were about the same.[85]

One can certainly find examples of wage gaps between city and countryside, but the gap is usually much smaller than the enormous disparity of wages within the city itself or within any village. In 1754-55, for example, the average Paris wage (actually the average of monthly modal wages) was 21 sous per day for an unskilled day laborer. Out in the countryside, the Abbey of Maubuisson in Saint-Ouen, near Pontoise, was hiring workers to fish and to clean the fish pond for an average of 22 sous per day. The gap between the two is small and dwarfed by the range of wages in Paris, where monthly modal wages in 1754-55 varied between 18 and 24 sous a day. Some evidence exists that wages were somewhat lower in the countryside, but none of it is conclusive for the Old Regime.[86]

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[84] Goubert, Beauvais, 1:551; Baulant, "Prix et salaires," p.954-55, 977-979. Cf. Ernest Labrousse, Esquisse du mouvement des prix et des revenus en France au XVIIIe siècle, 2 vols. (Paris, 1934; reprint, 1984), 2:470-74. In the Paris Basin we also lack wage data from the sort of detailed communal archives that exist in market towns and even villages in Provence.

[85] Bertrandy-Lacabane, Brétigny-sur-Orge, p. 340-43; Baulant, "Le salaire des ouvriers," pp. 463-83; idem, "Le prix des grains"; Yves Durand, "Recherches sur les salaires des maçons à Paris au XVIIIe siècle," Revue d'histoire économique et sociale 44(1966):468-80. For the number of work days in the year, see Labrousse, Esquisse, 2:501-03;

[86] AD Val d'Oise, 72H 30, 32, 33; Durand, "Recherches sur les salaires." Wages for the workers who fished and cleaned the fish pond varied considerably in Saint-Ouen as well: between 14 and 35 sous in 1759. The high figure of 35 sous suggests that there was probably considerable skill or difficulty involved, which further complicates the comparison.

As for evidence that rural wages were lower, consider the Abbey of Maubuisson's payments for work on its colombier. In 1739, the abbey paid day laborers an average of 13.4 sous a day for work on the colombier, considerably lower than the Paris mean wage for unskilled workers of 19 sous. In 1740, it paid an average of 17.7 sous, while the Paris mean was 20. Unfortunately, we do not know if the abbey fed its workers (it may well have done so in 1739), and the comparison is further clouded by the seasonality of wages. Work on the colombier might have been done off season, and in that case the difference between the Paris wage and what the abbey paid would be much smaller indeed and hardly conclusive.

The accounts of the Abbey of Maubuisson in AD Val d'Oise 72 H 22-33 cited here seemed

Nor can one demonstrate conclusively that rural wages were rising or falling relative to wages in Paris.[87] Given the overwhelming evidence for labor mobility in the vicinity of Paris, it seems reasonable to assume that wages in the city and in its hinterland moved together.

8. Grain Prices and In-Kind Payments

Much grain seems to have escaped the market, reaching consumers in the form of payments in kind or self production. One might therefore assume that the price of grain on the farm would bear no relationship to the market prices that enter into the agricultural price index P. For the Paris Basin, though, such a view seems untenable: near Paris it is simply absurd to maintain that the payments of grain in kind amounted to a second market, in which the price of grain bore no relation to that in the open market. The canons of the Paris cathedral of Notre Dame, for example, received numerous payments in kind, but they evaluated the grain at the price current in the relevant market--in Paris if the grain was delivered there, in a local market if they took possession in the countryside. And when it came time to sell grain from their stores, the canons watched the market to see what their grain would fetch.[88] The payments in kind, therefore, do not seem to have constituted a separate and unrelated market, all the more so since rights to the grain due in kind (tithe payments, for example) were often purchased for cash. The same logic casts doubt on the assumption that the price of grain on the farm was unrelated to the market price. Most peasants had to buy grain to meet their needs, and among the tenants who ran the farms in our sample there were many large scale farmers who frequently sold on the market.

9. Setting the Rent, Prices in the Indexes P and C, and Alternate Price Averages

When renting out its properties, the Cathedral of Notre Dame did not simply follow local surveyor's indications about what land was worth; rather, it sought to make a profit. It wanted to lease properties "under the best possible conditions" (subject to what the local market would bear) and it made decisions about property management on the basis of profits. A decision to enlarge a barn

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a promising source for rural wages in the Paris Basin, and I examined them for the late seventeenth and eighteenth centuries. Unfortunately, most of the records were silent on essential details, such as in-kind payments to workers or the precise types of workers employed, and worst of all, the useable information was simply too fragmentary to permit the construction of a homogenous rural wage series.

[87] The forthcoming work by Postel-Vinay and Moriceau contains a table of cash payments to male domestics on a single farm during the years 1731-1751. If we assume that their in-kind wages amounted to 3 setiers of wheat a year and if we restrict ourselves to years when figures for both Paris wages and the domestics' wages are available, then we find that the domestics' compensation increased 12.5 percent between 1731-37 and 1738-51, while Paris wages grew only 7.1 percent. The in-kind wages here have been evaluated using local prices from Soissons. The difference would suggest that rural wages were rising more rapidly than urban wages, but if we look at evidence from the Abbey of Maubuisson, the reverse seems to have been the case. There, if we make the same assumptions concerning in-kind compensation, we find that the earnings of the same sort of domestic decreased 3.5 percent between 1727-41 and 1755-64, whereas Paris wages grew 9.9 percent. Given the disparate results and the uncertainties surrounding the in-kind compensation, none of the evidence seems conclusive.

[88] AN S320, 27 November 1486; S324A, 25 June 1781; S 359, 22 November 1496; S380B; Dupré de Saint Maur, Essai sur les monnoies ou reflexions sur le rapport entre l'argent et les denrées (Paris, 1746), p. 127 (1644). The argument that farm gate prices bear no relationship to market prices rests upon a radical misinterpretation of Meuvret, Subsistences, vol. 3.

in 1757 on the cathedral's property in Viersy, for example, hinged on whether the increased rent would yield an investment return greater than that available from rentes. The cathedral did fear that charging exorbitant rents might bankrupt tenants, but such fears were hardly inconsistent with profit maximization. After all, a bankrupt tenant would sap profits in the long run.[89]

When deciding if the rent on a farm should be increased, Notre Dame estimated the tenant's revenues and costs. If the revenues exceeded the costs, the cathedral raised the rent, taking care again that the tenant not be pressed into bankruptcy. During the whole process, the point of reference was the previous lease. Whether Notre Dame was implicitly using current prices or prices averaged over the recent past to calculate profits is not clear, but the calculations never involved guesses about future prices.[90]

Other landlords seemed to do the same. When the knowledgeable agronomist abbé Tessier wrote on leases in the Encyclopédie méthodique, his concerns were nearly identical to those of Notre Dame. He aimed to increase profits, although his own practical experience as a property manager made him realize, as did Notre Dame, that pressing a tenant too hard would backfire in the long run.

When it came to estimating the rent that a property would yield, Tessier urged his readers to follow the analysis of a memoire published in 1789 by Varenne de Fenille, a correspondent of the Société d'Agriculture de Paris. "I have never found anything that shed more light on evaluating the rent that agricultural land could yield," said Tessier, and he quoted the memoir in its entirety.[91]

Varenne de Fenille shared Tessier's concerns about tenant bankruptcy, but what was most noticeable about Varenne de Fenille's memoire was the grain prices that he used in analyzing rental value. He performed his calculations using two different grain prices. One was a low price, a price apparently below the prevailing market price. He used this low price out of a concern that undue pressure not be placed on the tenant farmer; it was in no sense a forecast of the price in the future. The other price he used was a high price equal to the average price over the previous ten years. This ten-year average, he believed, would better reflect the true price that grain would actually fetch, and we can surmise that it would presumably yield a rent figure closer to what a profit-maximizing landlord would charge. Varenne de Fenille's calculation of rent thus seems to have been based on prices averaged over the recent past, and it would seem reasonable that our indexes P and C do the same.[92]

Following Varenne de Fenille and in the spirit of Notre Dame's own practices, I therefore averaged all prices in the indexes P and C over the current year and the previous eight years--in other words, over the outgoing lease.[93] To check how sensitive my results were to this choice of prices, I also computed TFP with prices averaged over the new lease (in other words, over the current year

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[89] See, for example, AN LL329-30 (La-Grande-Paroisse, 1618 and 1689); LL 332 (Larchand, 1762); LL 350-51 (Viry, 1757); S 267, S 457 (Ferrières, 1775); S 247 (Epiais, 1693). On some occasions Notre Dame posted a price for the rental on affiches that were put up locally; if there were no takers, they would lower the rent and put up new affiches.

[90] AN S 242 (Dampmart, 1744-62); S 282 (La-Grande-Paroisse, 1746).

[91] Tessier, Agriculture, sv. "Bail."

[92] Ibid, especially pp. 24-26.

[93] For beans and peas, flax, livestock, and animal products, there was too much missing data to construct annual price series. For these items I first took 25-year averages, which I assumed to be the price at the mid-point of each 25-year period. I then constructed annual series by interpolating between the mid-points; the interpolation was linear in the logarithm of the prices. Since averaging an interpolated price over the life of the previous lease would involve averaging what was already an average, I simply used the price at the midpoint of the previous lease.

and the next eight years), but as noted in the text, the effect on the TFP trend was small. Using prices over the new lease also led to roughly similar patterns for the growth rate of TFP (Figure A-3) and very similar regression coefficients (Tables A-1 and A-2). Other price averages (such as a 3-year moving average centered on the current year) had an equally small effect on our results.

10. Entrepreneurial Profits

While there were certainly farms where the tenants made fortunes, entrepreneurial profits--defined here to be what the tenants earned over what he would have made on the labor market--were probably low on average. In 1784, for example, Boullanger, an ingénieur des ponts et chaussées, provided a detailed analysis of the profits from Paris Basin farming for an article on taxes in the Encyclopédie méthodique.[94] The analysis rested on calculations he had made while levying taxes in order to pay for road building in the Champagne and the Soissonais in the 1750s. It derived from the costs and profits of local farms and was done with extraordinary care. After carefully deriving the profits from a farm of a fixed area, Boullanger compared them with rent and taxes. Before rent and taxes were paid, the profits amounted to 6986 livres; the rent and taxes to be paid out of these profits came to 6232 livres. The remainder, 753 livres or 12.1 percent of the rent plus taxes, was the tenant's profit net of rent and taxes. According to Boullanger, such a figure was typical, for in general the tenant's profits were about 1/8 of sum spent on rent plus taxes.[95]

If we take 1/8 of rent plus taxes as the average for the tenant's entrepreneurial profits, and if we assume that rent and taxes paid for land, then with the Bernonville land share (0.267), the factor share for the tenant's entrepreneurial input would be only 0.267/8, or 0.033 of total cost. This is small, but other contemporary authorities would put it even lower: Lavoisier even claimed that entrepreneurial profits were zero on average.[96]

With a share of only 0.033 of total cost, entrepreneurial profits would have very little effect on our calculation of TFP. Moreover, they would only disturb our calculations if they diverged significantly from the trend of wages. The reason is that we treated compensation for the entrepreneur (i.e, the tenant farmer) as part of the labor input; in other words, we assumed that the tenant would earn no more than he would in the labor market. Even if his earnings did exceed his income as a laborer, our calculation of TFP would involve no error, provided that the trend of entrepreneurial earnings paralleled the trend of wages (i.e., provided that their ratio remained constant). As long as the two moved together, we could simply view his higher wage as compensation for his skill, with a fixed conversion factor between his skilled wage and that of an unskilled laborer. His compensation could then simply be aggregated together with that of the rest of labor in calculating TFP. In mathematical terms, if w_2 is the cost of the tenant's entrepreneurial input, w_3 is wage of unskilled labor, and $k > 1$ is a constant such that $w_2 = kw_3$, then

$$TFP = \frac{w_1^{v_1} w_2^{v_2} w_3^{v_3} \cdots w_n^{v_n}}{p_1^{u_1} \cdots p_m^{u_m}} = k^{v_2} \frac{w_1^{v_1} w_3^{v_2+v_3} \cdots w_n^{v_n}}{p_1^{u_1} \cdots p_m^{u_m}} \qquad (19)$$

and aggregating the entrepreneurial input with the rest of labor only multiplies the TFP index by a

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[94] Rousselot de Surgy, Enclopédie méthodique ou par ordre de matières. Finances, 3 vols. (Paris, 1784), sv. "Charges publiques" by M Boullanger, ingénieur des ponts et chaussées.

[95] Ibid, especially p. 288.

[96] A. L. Lavoisier, Oeuvres de Lavoisier, 6 vols (Paris, 1864-93), 6:451. The assertion is made in a careful attempt to calculate French income, in which Lavoisier allows for the alternative possibility of small entrepreneurial profits from raising livestock.

constant.

There were of course times when wages and entrepreneurial earnings undoubtedly diverged. After many tenants went bankrupt in the late seventeenth century and the first decades of the eighteenth century, those who survived may have earned high returns relative to unskilled wages. But by 1750, Notre Dame had discovered the higher profits and raised the rent, and entrepreneurial earnings by tenants probably returned to a level in harmony with wages.[97] In any event, the effect on our TFP index probably small. Suppose, for example, that the ratio of the tenant's skilled entrepreneurial wages (w_2 in equation 19) to unskilled wages (w_3) varied (in suitable units) from 1.67 to 2.5. This was the maximum range of the ratio of skilled to unskilled wages in the Paris building trades over three centuries; normally the ratio was close to 2.[98] Our TFP index would then err by at most 0.7 percent, very little indeed and not enough to change our story.

If we are still worried about entrepreneurial profits, we can also take comfort from our TFP regressions. Presumably, the farmers who made large profits would be those who repeated as tenants. Their large profits would keep them on the same farm, depress the rent figures and produce lower measurements of TFP and less measured TFP growth. But if we examine the coefficients of the variables for tenant holdovers in Tables 2 and 3, we see that nothing of the sort occurred. If anything, repeat tenants increased the level of TFP and depressed TFP growth by only a minimal amount.

11. A Comparison of Our Productivity Index and the Törnqvist-Translog Index

Appendix 6 described the factor and product shares from a farm whose accounts were analyzed by Postel-Vinay and Moriceau. The factor and product shares come from the farm's accounts for the 1740s, but accounts for the farm also exist for the 1780s.[99] Taken together, the two sets of accounts let us calculate how TFP on the farm changed between the 1740s and 1780s, and since the information in the accounts allows us to calculate TFP with considerable precision, we can use the results to check the accuracy of the TFP index used throughout the text of the paper.

The way to measure TFP precisely is to use the modern theory of index numbers, which permits calculating TFP without estimating production, cost, or profit functions. Let us suppose that we want to compare the productivity of two farms, both of which produce multiple outputs. The two farms can exist at different times, and we can even compare the same farm at different moments. Because of productivity differences, the two farms will have different production functions, but we assume that the two distinct production functions at least share a common functional form, in a sense to be made precise below.

In this situation, if the two farms exhibit constant returns to scale, if all product and factor markets are competitive, and if the two farmers optimize (in the sense that they minimize costs

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[97] AN S 242 (Dampmart, 1744-62); S 282 (La-Grande-Paroisse, 1746). The forthcoming book by Postel-Vinay and Moriceau provides another example of high entrepreneurial profits by a tenant farmer, and it also suggests why entrepreneurial profits may have come back down relative to wages in the late eighteenth century. As more tenant farmers sent their children to collèges in the eighteenth century, it is possible that more of the children learned arithmetic and simple accounting. In the end, competition among the children when they became tenants brought entrepreneurial profits down. Unfortunately, we cannot tell if tenants had such a secondary-school education. It involved much more than simple literacy, which had long been common among local tenants, and it left no traces in Notre Dame's archives.

[98] Baulant, "Les salaires du bâtiment," pp. 480-81.

[99] The farm had changed somewhat between the 1740s and the 1780s, but the kernel of the operation remained the same and the same family operated it.

conditional on output levels and maximize revenues conditional on input levels), then we can compare the productivity of the two farms by using an appropriate index of inputs, outputs, and prices. The choice of a particular index amounts to a choice of the functional form common to the two production function; the ideal index would correspond to a functional form such as the translog that can provide a second order approximation to an arbitrary production function. Such an index is called superlative.[100]

In particular, suppose that we are comparing the productivity of the Postel-Vinay and Moriceau farm in the 1780s with its productivity in the 1740s. Let the production functions for our farms (or strictly speaking, the transformation function, since the farms produce multiple outputs) have the translog form with identical second order coefficients for both farms. The first order coefficients may be completely different. Under these assumptions, the so called Törnqvist index provides a measure of the TFP of our farms, and the ratio of TFP on the farm in the 1780s to TFP in the 1740s is

$$\frac{TFP_{1780}}{TFP_{1740}} = \frac{(\frac{y_1'}{y_1})^{\frac{u_1+u_1'}{2}} \cdots (\frac{y_4'}{y_4})^{\frac{u_4+u_4'}{2}}}{(\frac{x_1'}{x_1})^{\frac{v_1+v_1'}{2}} \cdots (\frac{x_4'}{x_4})^{\frac{v_4+v_4'}{2}}} \qquad (20)$$

Here $y_1,\ldots,y_4$ are the four farm outputs (wheat, oats and straw, other crops, and animal products) in the 1740s; the u_i, the corresponding output shares; the x_i, the four inputs (labor and the tenant's entrepreneurial input, livestock rental, equipment rental, and land) in the 1740s; the v_i, the corresponding factor shares; and the variables with primes are the same quantities in the 1780s.

We can calculate (20) using the evidence from the farm accounts. The accounts give the revenue produced by each output and the cost of each input in the 1740s and 1780s; I divided the revenues and the costs by the appropriate prices to get the quantities.[101] The prices I used included the local price of wheat (rather than the Paris price) for wheat output; the Pontoise price of oats for oats and straw; the interpolated Paris price of beans for other crops; the interpolated price of meat for animal products; the local wage (rather than the Paris wage) for labor; the rental price of horses for livestock; and the rental price of equipment. All rental prices equalled the sales price multiplied by interest plus depreciation, with the depreciation rates given in appendix 6. For land, instead of

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[100] For this and the following paragraph, see Robert C. Allen, "Recent Developments in Production, Cost and Index Number Theory, with an Application to International Differences in the Cost and Efficiency of Steelmaking in 1907/09," in Rainer Fremdling and Patrick O'Brien, eds., Productivity in the Economies of Europe (Stuttgart, 1983), pp. 90-99; idem and W E. Diewert, "Direct versus Superlative Index Number Formulae," Review of Economics and Statistics 53(1981):430-35; Douglas W. Caves et al, "Multilateral Comparisons of Output, Input and Productivity using Superlative Index Numbers," The Economic Journal 92(1982):73-86; idem, "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity," Econometrica 50(1982):1393-1414; W. E. Diewiert, "Exact and Superlative Index Numbers," Journal of Econometrics 4(1976):115-45; and Chambers, Applied Production Analysis, pp. 239-49.

[101] Some of the inputs and outputs are aggregates and so we have to rely on prices to get the composite commodities; in other cases, the farm records mentioned only revenues and costs, not quantities.

dividing costs by a price, I used the ratio of the actual physical quantities of land employed.[102]

If we perform the calculation, we find that TFP increased 9.79 percent on the farm between the 1740s and the 1780s. The 9.79 percent figure is very close to the 9.03 percent that our own TFP index yields when applied to the Postel-Vinay and Moriceau property, even though our index employs Paris prices and factor and product shares from the very different property in Bernonville. The accuracy here is obviously a strong vote of confidence for our method.

It should also be noted that little of the small gap between the two figures derives from our assumption of constant shares. Most of it stems from differences between Bernonville and the Postel-Vinay and Moriceau farms and from the fact that the our method relies on Paris prices.[103] With constant shares mattering little, at least in this instance, the sort of sophisticated flexible functional forms discussed at the end of appendix 5 would seem to have very little to offer us.

12. Averaging TFP

Suppose that we want to average ln(TFP) for each 25-year period in order to chart productivity trends. From equation (10) we know that

$$\ln(TFP) = s\ln(r + t) - \ln(\frac{P}{C}) \qquad (10)$$

One obvious way to proceed would be to average the expression on the right hand side of (10) lease by lease for all leases in a given 25-year period. Alternatively, we could average sln(r + t) over all leases in the period and then subtract ln(P/C) averaged over each of the years in the same period.[104] The two procedures will not necessarily give the same answer, for in the one case we are averaging ln(P/C) over all the leases drawn up in the period, weighting each lease equally, and in the other case we are averaging it over all the years in the period, weighting each year evenly. If all the leases were clustered toward one end of the period, for example, the procedures might yield very different values of TFP.

In practice however, the two procedures yield results that are practically indistinguishable (Figure A-4). The same is true if we average ln(TFP) by decade. Since there is practically no difference between the two methods, we will compute our average of ln(TFP) lease by lease. Working lease-by-lease fits our regressions, and it has the indisputable advantage of allowing direct comparison with the TFP growth rate figures, which must be calculated lease-by-lease and which are the only device we have to estimate the effect of taxes.

In Figure A-4, I adjusted the rent for variations in land quality, but I did not correct either average for the omission of taxes. In other words, both curves assume taxes are zero and simply average sln(r) - ln(P/C) for each 25-year period. Since the tax correction merely involves adding the same term to both averages, it would have an identical effect on each of them and would do nothing to drive them apart.

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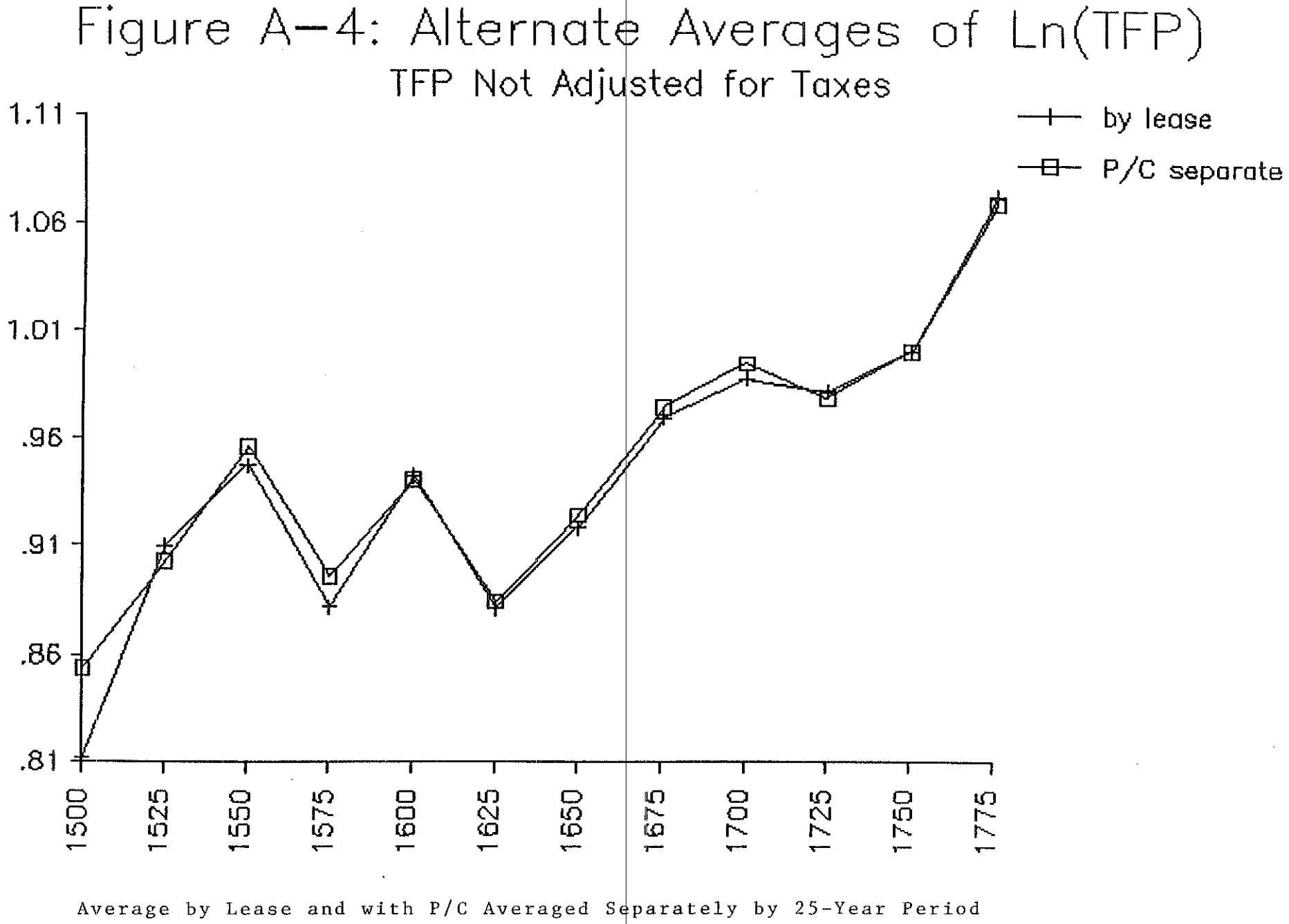
[102] For equipment, the sales price was taken to be proportional to wages, as elsewhere in this paper. All prices were averages over the 1740s and the 1780s.

[103] If we were to assume constant shares yet use local prices and factor and product shares from the Postel-Vinay and Moriceau farm itself, we could calculate a TFP increase of either 9.72 or 10.09 percent, depending on whether we chose the shares from the 1740s or the 1780s. The minuscule gap between these two figures and the 9.79 figure is what is properly due to the constant shares assumption.

[104] We could also calculate the average value of P/C for the 25-year period and take its logarithm, but the result turns out to differ little from averaging ln(P/C) over the same period.

Figure A–4: Alternate Averages of Ln(TFP)



13. Treatment of Taxes

Unfortunately, we do not know precisely what the taxes on an individual farm were, and as a result we first calculate TFP and its growth rate with rent r alone, ignoring taxes t in formulas such as (10). In other words, we begin by using $T = r^s C/P$ as a substitute for $TFP = (r+t)^s C/P$. We then add an adjustment for the omission of taxes. To derive the adjustment, let

$$\frac{r}{r+t} = g \tag{21}$$

where g is the fraction of gross rent w_1 that goes to the landlord rather than to the fisc. Note that the tax rate as a percent of gross rent is simply 1 - g. Since r + t = r/g, we have that ln(TFP) is simply

$$s\ln(r+t) - \ln(\frac{P}{C}) = s\ln(\frac{r}{g}) - \ln(\frac{P}{C}) = \ln(T) - s\ln(g) \tag{22}$$

Similarly, the rate of growth of TFP is

$$\dot{T} - s\dot{g} \tag{23}$$

All we need to know is g or its rate of growth and we can easily correct for the error involved in using T as a substitute for TFP.

We do not know g precisely, and it probably varied from property to property. But one reasonable assumption is that for the i-th property,

$$\ln(g) = b\ln(\frac{t_a}{r_a}) + c_i \tag{24}$$

where b is a negative constant that is the same for all properties, t_a is the average per-capita tax assessment, r_a is the average per-hectare rent in the region, and c_i is a constant that varies from property to property. All equation (24) says is that taxes were apportioned with an eye toward average rent and average population levels and that while tax rates varied from property to property they also rose and fell with average tax assessments and average rent levels.

Note that

$$\dot{g} = b\frac{d}{dt}\ln(\frac{t_a}{r_a}) \tag{25}$$

Suppose we have a linear relationship involving the growth rate of TFP and various explanatory variables $z_1,\ldots,z_k$:

$$\frac{d}{dt}\ln(TFP) = d_1z_1 + \ldots + d_kz_k \tag{26}$$

Then by (23) and (25), we have that

$$\dot{T} = sb\frac{d}{dt}\ln(\frac{t_a}{r_a}) + d_1z_1 + \ldots + d_kz_k \tag{27}$$

According to equation (27), all we need do is regress the growth rate of T, which we can observe since T is simply $r^s C/P$, on the variables z_j, and on

$$\frac{d}{dt}\ln(\frac{t_a}{r_a}) \tag{28}$$

which we can also measure. We will then recover the coefficients in the true relationship between

the growth rate of TFP and the variables z_i, and the coefficient of (28) will be sb, which we can use to correct the growth rate of T for the omission of taxes via

$$\frac{d}{dt}\ln(TFP) = \dot{T} - s\dot{g} = \dot{T} - sb\frac{d}{dt}\ln(\frac{t_a}{r_a}) \qquad (29)$$

In the regressions in Tables 3 and A-2, the rate of growth of taxes relative to rents is (28), calculated from a national average per-capita tax rate by decade and average decennial nominal rents. The coefficient of (28) then allows us to correct the observed growth rate of TFP for the omission of taxes via equation (29). The correction turned out to be minimal: taxes certainly rose, but not by enough relative to nominal rents (Figure A-3).[105] The growth rate of TFP is thus almost exactly the growth rate of T. Note too that using the growth rate of T in place of the growth rate of TFP in Tables 3 and A-2 will not change the resulting regression coefficients. Again, the inclusion of the growth rate of taxes relative to rents among the explanatory variables will make the other coefficients precisely what they would be if the dependent variable were the true growth rate of TFP.

Multicollinearity rules out adding the analogous term to the regression in Tables 2 and A-1 in order to correct the levels of TFP for the omission of taxes. We can, however, derive a correction for ln(TFP) from the growth rates. From (22) and (24),

$$\ln(TFP) = \ln(T) - s\ln(g) = \ln(T) - sb\ln(\frac{t_a}{r_a}) - sc_i \qquad (30)$$

We know T, t_a, and r_a, and the regressions with the growth rate of T yields sb. The only other terms are the sc_i, which varies from property to property but not over time. Since they are constants, they do not affect the trend of TFP. If, for instance, we average ln(TFP) by 25-year periods, the sc_i terms merely add the same constant to the average for each period, and we can ignore them as far as the trend is concerned.[106] In other words, we need only subtract $sb\ln(t_a/r_a)$ from ln(T) to adjust the level of ln(TFP) for the omission of taxes. That is what has been done in Figure 3 and throughout the paper when we calculated relative levels of TFP.

It is still true that the sc_i terms could affect our regression coefficients in the ln(TFP) regressions of Tables 2 and A-1. If the true relationship between ln(TFP) and the explanatory variables $z_1,\ldots,z_k$ is

$$\ln(TFP) = e_1z_1 + \ldots + e_kz_k \qquad (31)$$

then for the i-th property

$$\ln(T) - sb\ln(\frac{t_a}{r_a}) = sc_i + e_1z_1 + \ldots + e_kz_k \qquad (32)$$

We could determine the sc_i by adding a dummy variable for each property to the regressions of $\ln(T) - sb\ln(t_a/r_a)$ on the z_j, but with 39 properties, multicollinearity rules out such a course of action. Unfortunately, ignoring the sc_i amounts to omitting variables in the regression, which might well bias our coefficients e_j. On the other hand, it seems reasonable to assume that the sc_i are uncorrelated with the other explanatory variables z_j. After all, the sc_i reflect idiosyncracies of the

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[105] In Figure A-3, the adjustment for taxes is applied using the Bernonville shares and prices averaged over the outgoing lease. The growth rate curves plotted for alternate shares and alternate prices have not been corrected for taxes.

[106] If properties jump in and out of the sample, the effect of the sc_i terms may vary from period to period, depending on what properties remain in the sample. The effect should be relatively minor, though.

tax system peculiar to each property.[107] If so, then the regression of ln(T) - sbln(t_a/r_a) on the z_j will produce the true regression coefficients e_j, and we can correct ln(TFP) for taxes in the regressions merely by subtracting sbln(t_a/r_a). That is what I have done in Tables 2 and A-1.

It is worth noting one other implication of (22) and (24). If we look at the change in ln(TFP) between two fixed periods for several properties, as we did for Figure 4, then for any property it will equal the change in ln(T) minus the change in sln(g), which from (24) will be the same for all the properties since the sc_i terms will drop out. The tax correction will merely add the same constant to the TFP growth figure for each property, and as long as we are only interested in the relative productivity growth of the properties, we can simply ignore the tax correction. Figure 4 therefore involves no adjustment for taxes.

14. Sources

The prices and wages that enter into the indexes P and C were taken from printed sources. Published price series for the Paris region are excellent for most commodities. They betray a care and a concern for detail that are all too often lacking in collections of rental figures, where details surrounding in-kind payments, variations in land quality, and other complexities are often passed over in silence. The published series merit our confidence, and as for the commodities that are exceptions to this rule--chiefly meat and livestock--they are ones for which further research will likely be of little avail. To be sure, a high quality series of wages from the Paris countryside would certainly be desirable. But as explained in appendix 7, suitable collections of rural wages are hard to find for the region, even in the archives.[108]

The grain prices in the index P were prices in Paris on the feast of Saint-Martin (November 11). As I explained in appendix 1, I selected the Saint-Martin prices because grain payments were due then. Choosing the feast of Saint-Martin also provided a way of dealing with seasonality. The Saint-Martin prices were taken from Baulant and Meuvret, Prix des céréales, 2:142-51. For wheat and rye I used minimum prices on the feast of Saint Martin, as was the case with the in-kind payments; for barley and oats only maximum prices were available.

Since the Saint-Martin prices ceased being available after 1698, I resorted to proxies. For wheat I relied upon the proxy that I used for in-kind payments. As described in appendix 1, it was constructed by first regressing the Saint Martin wheat price on the annual Paris price without an intercept term. After 1698, when the annual Paris price existed but the Saint Martin did not, I multiplied the annual price by the regression coefficient to get the proxy. The annual Paris price came from Baulant, "Le prix des grains."

For rye, barley, and oats, I constructed similar proxies for the years after 1698 by regressing the Paris Saint-Martin price on the Pontoise Saint-Martin price without an intercept. The regressions were limited to the years 1661-98 because the size of the Pontoise setier was in doubt before 1661. The Pontoise prices came from Dupâquier, Mercuriales du pays de France.[109] In constructing the

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[107] An alternative is to look at changes in ln(TFP) relative to the same base period for each property, a standard technique with panel data. It leads to similar results.

[108] My own search for wage series in a suitable archival collection (in the accounts of the Abbey of Maubuisson in the AD Val d'Oise) led nowhere, for the documents needed to construct a homogenous series were lacking.

[109] The rye, barley, and oats proxies in the index P differed slightly from the prices I used for the in-kind payments. For in-kind payments of rye made in Paris, I used a proxy constructed by regressing the Saint Martin Paris price of rye on the annual Paris price of wheat. I did so because to convert in-kind payments to cash in leases before 1520 I needed rye prices before 1520, when the Pontoise prices were not available. For in-kind payments of barley and oats made in Paris, I used the

Paris grain price series, I corrected the published Paris price for two typographical errors, and I also adjusted the price of all grains for an 8 percent increase in the size of the Paris setier between 1573 and 1586.[110]

Since the evidence was fragmentary, the prices of beef, mutton, and pork in the index P were interpolated from 25-year averages.[111] The averages were spliced together from prices in Georges d'Avenel, Histoire économique de la propriété, des salaires, des denrées, et de tous les prix en général depuis l'an 1200 jusqu'en l'an 1800, 7 vols. (Paris, 1894-1926; reprint, New York, 1969), 4:132-179, 586; Labrousse, Esquisse, 1:301-303 (his raw prices rather than his index); Mohamed El Kordi, Bayeux aux XVIIe et XVIIIe siècles (Paris, 1970), pp. 303-05; and Jean-Claude Perrot, Genèse d'une ville moderne: Caen au XVIIIe siècle, 2 vols. (Paris, 1975), 2:1032-1034. Admittedly, the old collection by d'Avenel is far from perfect and the other sources are not necessarily Parisian. Yet the criticisms of d'Avenel are often exaggerated, and most of the non-Parisian prices were taken from nearby provinces such as Normandy, where long-distance trade in livestock would have brought local prices in line with those prevailing in Paris.[112]

For the remaining outputs (beans and peas, flax, dairy products, wool, eggs, and horses), I also interpolated from 25-year averages. The sources for beans and peas included Mantellier, Mémoire sur la valeur, pp. 89-98, 381; Baulant, "Prix et salaires"; and Hauser, Recherches et documents, pp. 127-29. For flax, I relied upon prices of fil de lin in Mantellier, Mémoire sur la valeur, pp. 276-77;

Saint Martin prices; when they were unavailable--before 1520 and after 1698--I relied on 25-year averages. The 25-year averages were calculated using the Pontoise prices and Paris prices in Henri Hauser, Recherches et documents sur l'histoire des prix en France de 1500 à 1800 (Paris, 1936), pp. 114-17, 124-25. Before 1500 I constructed the 25-year average price of oats by multiply the 25-year average annual price of Paris wheat by the ratio of oat prices to wheat prices in the years 1500-24. I did the same for barley before 1525. The difference between the in-kind conversion price and the price in the index P is slight and it cannot affect the results appreciably, for most in-kind payments involved not rye, barley, or oats, but wheat. As for in-kind payments of grain made outside Paris and for miscellaneous in-kind payments, I evaluated them as outlined in appendix 1; my sources included Hauser, Recherches et documents; Dupré de Saint Maur, Essai sur les monnoies; Dupâquier, Mercuriales du pays de France; the Paris wage series to be described below; and, for wine prices, Bertrandy-Lacabane, Brétigny-sur-Orge, p. 329; Baulant, "Prix et salaires"; and P. Mantellier, Mémoire sur la valeur des principales denrées et marchandises qui se vendaient ou se consommaient en la ville d'Orléans (Orléans, 1861), pp. 179-186.

[110] In Baulant, "Le prix des grains," the year 1708 is repeated twice, but the second price is clearly that in 1709. In 1734, the price should be 12.13 livres rather than 17.13; I thank David Weir for providing me this information. Baulant and Meuvret, Le prix des céréales, 1:18-22, give Saint-Martin prices for a setier of constant volume (2.73 hectoliters for oats, 1.56 hectoliters for other grains). They adjust their prices for changes in the size of the oats setier, but they do not correct grain prices for what they admit was probably an 8-percent increase in the size of both setiers between 1573 and 1586, an increase that seems to have been caused by wear of the physical measure. To ensure that the prices in the index P would represent a constant volume, I assumed that the 8 percent increase was spread out evenly over the period 1573-86. It is worth pointing out that the prices used to convert the in-kind payments made in Paris were not adjusted for this change in the setier. Since the in-kind payments were always specified in setiers themselves, unadjusted figures were appropriate.

[111] For the interpolation procedure, see the notes to appendix 9.

[112] For d'Avenel, see the remarks of Labrousse, Esquisse, 1:12-15, especially pp. 14-15. When using d'Avenel, I have tried to work with his raw data rather than his averages. Where I had to use his averages, I checked the results against other available figures.

Baulant, "Prix et salaires"; and d'Avenel, Histoire économique, 5:527-30. For dairy products, I used butter prices gleaned from Hauser, Recherches et documents, pp. 136-38; Baulant, "Prix et salaires"; and El Kordi, Bayeux, pp. 305-306. The sources for eggs were Baulant, "Prix et salaires"; El Kordi, Bayeux, p. 228; Hauser, Recherches et documents, pp. 140-41; Jacques Bottin, Seigneurs et paysans (1540-1650) (Paris, 1983), annex B; and Léopold Nottin, Recherches sur les variations des prix dans le Gatinais du XVIe au XIXe siècle (Paris, 1935), p. 136. For horses, d'Avenel, Histoire économique, 6:455-86; Bertrandy-Lacabane, Brétigny-sur-Orge, p. 331; and Mantellier, Mémoire, pp. 319-23. While some of these prices come from areas other than Paris, the differences turn out to be small, for once again the prices were taken from nearby areas such as Normandy and the transport costs for the commodities in question were generally low. The effect on the index would be smaller still since the product shares for these commodities were all small.

Sources for the prices in the cost index C were as follows. As is discussed in the text and in appendix 7, wages were the modal wages for unskilled Paris day laborers. The sources were Baulant, "Le salaire des ouvriers," and Durand, "Recherches sur les salaires." As explained in appendix 6, the price of seed and feed equaled output prices time 1 plus the interest rate, and prices of capital goods were rental prices, figured from the sales price via the interest rate and a depreciation rate. Sources for the interest and depreciation rates are given in appendix 6. The rental prices of horses, cattle, sheep, pigs, and poultry were interpolated from 25-year averages.

The sales price of equipment was assumed to be proportional to wages, and the sales price of horses was the same as the output price given above. The sales prices of cattle, sheep, pigs, and poultry were spliced together from 25-year averages. The sources for cattle were Bertrandy-Lacabane, Brétigny-sur-Orge, p. 333; d'Avenel, Histoire économique, 4:75-94; and Baulant, "Prix et salaires." For sheep, Hauser, Recherches et documents, pp. 191-92; d'Avenel, Histoire économique, 4:100-15; and Baulant, "Prix et salaires." For pigs and poultry, d'Avenel, Histoire économique, 4:115-30, 585, 591. Again, low transportation costs and small factor weights justified using some prices outside Paris.

Most of the explanatory variables in the regressions were derived using prices and information in the leases and associated property descriptions. The sources for the others are as follows. The index of per-capita taxation (t_a) for the years after 1560 was calculated using decennial averages based on population figures and central treasury receipts from Table 1 of Philip T. Hoffman, "Fiscal Crises, Liberty and Representative Government: The Case of Early Modern France," (forthcoming). For the period before 1560, I spliced the series of central treasury figures to taille levels given in J. J. Clamageran, Histoire de l'impôt en France, 3 vols. (Paris, 1867-76) and used population figures in Jacques Dupâquier et al, Histoire de la population française, 4 vols. (Paris, 1988), 1:513-24, 2:51-68, interpolated and adjusted for changes in frontiers. A local tax series would have been preferable to the central treasury and taille figures, but a suitable series does not exist.

Soil quality was derived from information in Jacques Dupuis, Carte pédologique de la France (Paris, 1967). For the population of Paris, I relied upon a variety of sources, including Jean-Noël Biraben and Alain Blum, "Population Trends in France, 1500-1800: Comparison with other Countries," (unpublished manuscript); Marcel Lachiver, "L'approvisionment de Paris en viande au XVIIIe siècle," in La France d'ancien régime: Etudes réunies en l'honneur de Pierre Goubert, 2 vols. (Paris, 1984), 1:345-54; Dupâquier, Histoire de la population française; E. Charlot and J. Dupâquier, "Mouvement annuel de la population de Paris de 1670 à 1821," Annales de démographie historique (1967), pp. 511-19; and a data base put together by Philip Benedict. The destruction of records makes estimating the population of Paris difficult, but Benedict has assembled what seem to be the most reliable estimates. In "Was the Eighteenth Century an Era of Urbanization in France," Journal of Interdisciplinary History 21(1990):179-215, he faults the accuracy of the Paris population figures in the Histoire de la population française, and I have therefore given preference to his numbers and to those in the articles by Biraben, Charlot, and Lachiver.