Comparing the correlation length of grain markets in China and France

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Abstract In economics comparative analysis plays the same role as experimental research in physics. In this paper we closely examine several methodological problems related to comparative analysis by investigating the specific example of grain markets in China and France respectively. This enables us to answer a question in economic history which has so far remained pending, namely whether or not market integration progressed in the 18th century. In economics as in physics, before being accepted any new result has to be checked and re-checked by different researchers. This is what we call the replication and comparison procedures. We show how these procedures should (and can) be implemented.

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1 Introduction: replication and comparison

Having gathered these facts, Watson, I smoked several pipes over them, trying to separate those which were crucial from others which were merely incidental.
Conan Doyle, The adventure of the crooked man (1975)

Experimental research has a dual role in physics: (i) For new phenomena (for which there is no established theory) it permits to separate factors which are of major importance from those which are not. In that kind of investigation comparative analysis plays a prominent role. (ii) For those phenomena for which a theory exists it permits to check its predictions. In both cases the cornerstone of the investigation is the replication of crucial experiments under different conditions. For most physicists (we exclude astrophysics from our discussion) that double role of experiments would probably seem self-evident.

In economics the analog of the operation of repeating an experiment consists in carrying out consistent comparative observations. Unfortunately economists have given very little attention to the methodology of comparative analysis. Even in the “Journal of Comparative Economics” there are few truly comparative studies. The lack of rigorous guidelines for comparative investigation has detrimental consequences which are far-reaching as illustrated by the following examples.

1.1 Physics versus economics: examples

In physics, after a new phenomenon has been observed by a researcher other groups around the world try to repeat the same experiment. If it cannot be repeated it will be attributed (possibly after a period of controversy) to some spurious or factitious effect and will be quickly forgotten. Such was for instance the case of the “discovery” of cold fusion in 1989 by S. Pons and M. Fleischmann. On the other hand, if the experiment can be repeated and confirmed the phenomenon in question will become widely accepted as a new building block of physics; fairly often this will open a new avenue of research. One can mention the following historic examples (i) the Foucault pendulum (1851), (ii) the discovery of superconductivity by Kamerlingh Onnes (1911), (iii) the discovery of the properties of spin glasses (mid-1970s). As an example of a major discovery that has still to be confirmed, one can mention the observation of a plasma of free quarks at the European Center for Nuclear Research (announcement made in February 2000). A first confirmation (or refutation) will come within one or two years from the experiments currently under way at Brookhaven National Laboratory (located on Long Island, New York State). A further check will be obtained in about five years by using the Large Hadron Collider currently under construction at CERN. To sum up, it may take some time, but within a few years the question of the possible existence of a plasma of free quarks will probably be settled in a satisfactory way.

In economics, in contrast, controversies often drag on for years without leading to any specific conclusion. A disenchanted but lucid assessment of this state of affairs has for instance been made in a review article by A. Zellner (1988). As an illustration one can mention the discussion around the so-called Prebisch – Singer conjecture (1950). Basically it posits a secular decrease in the price of primary commodities relative to the price of manufactured goods. In the last 50 years it has fostered numerous statistical tests but its validity still remains controversial (Hagen 1989, Cuddington et al. 1989).

What are the reasons of such an unsatisfactory situation? Broadly speaking, they gravitate around the two problems of replication and comparison. It is the purpose of this paper to examine these

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1 Some social sciences do not share that neglect: for instance, in sociology the methodology of comparative analysis is a key issue which has been extensively discussed (see for instance Mjöset 1997).
questions more closely by carrying out a specific comparative study, namely the comparison of geographically separated grain markets in China and Europe. For the 19th century, due to major advances in transportation technology, it is fairly obvious that there was a strong increase in market integration, but is that also true for the 18th century? To our best knowledge that question has not been clearly settled so far. In the present paper the approach that we use is almost as important as the answer that we arrive at. In the course of the investigation we will set forth a number of rules that more generally can apply to the analysis of other comparative issues as well.

1.2 Replication in physics and in economics

At first sight it could seem that the parallel with physics that we hinted to above is questionable. The obvious objection would be that in physics one can repeat an experiment while in economics one cannot. However a little reflection shows that such an objection does not hold. As a matter of fact the central problems of replication and comparison present themselves very similarly in both fields. Let us briefly see why. In physics these problems are often condensed into the single question: “Can a researcher B repeat the experiment carried out by a researcher A?” For definiteness let us consider the example of the Foucault pendulum. Replication would then mean: “Knowing that Foucault has carried out his experiment at the Panthéon in Paris, can I repeat it at the same location and with the same pendulum?” On the other hand comparability would mean that the same observation can also be made in Brazil with a different pendulum. By stating these questions one immediately understands why they are usually considered together; indeed nobody would try to perform exactly the same observation as Foucault did. In the years after 1851 there were a number of experiments with the Foucault pendulum in England, Germany and indeed in Brazil; not only were the locations different but the technical characteristics of the pendulum (weight, length, nature and diameter of the wire) were not the same either. By so doing one implicitly assumes that these characteristics are not crucial; that is possible because the principles on which the phenomenon relies are fairly well understood. As one knows the outcome of the experiment is of course not the same in Brazil and in Paris but, knowing the theory, it is possible to take into account the effect of a different latitude

On the contrary in economics one does not know in advance which factors are essential and which ones are of little importance. Suppose (for instance) one wants to examine if it is true that the distribution of income follows a Pareto law with an exponent of 1.4. For such a problem the replication and comparison issues are clearly distinct one from another. Replication means that if researcher A claims that result to be true for France in 2000, he (she) must publish his (her) results in such a way that researcher B can perform the same fit on the same data and check if the same results obtain. This implies in particular that the data are made available to researcher B, a condition which is only rarely fulfilled in practice. That obstacle to replication has been deplored by several lucid economists as for instance in the paper by Dewald et al. (1986). Comparability, on the other hand, would mean that if a researcher performs a similar study for the distribution of revenue in Germany (for instance) he (she) will also find a Pareto exponent of 1.4. In general this will not be true of course, but in contrast to what happened with the Foucault pendulum one does not know if the discrepancy should be attributed to the measurement process (other kind of sources had to be used in Germany than in France) or to the phenomenon itself. As a result (in contrast to the experiment performed in Brazil) one is unable to apply to the German data whatever correction factor which would be required in order to make them truly comparable to the French data.

Furthermore a spurious factor called the Puiseux effect had to be discounted. It states that if a pendulum describes an ellipse (and all Foucault pendulums, whatever their technical characteristics, do in fact describe an ellipse) its major axis will turn at a rate which is proportional to the area of the ellipse. It took some time to experimenters to realize which correction had to be performed in order to discard that perturbation.
To our best knowledge few (if any) revenue investigations for different countries are truly comparable; in Atkinson’s words (Smeeding et al. 1990) “professor X will take the household as the unit of measurement, while professor Y will take the nuclear family, and professor Z will take the revenue per head”. That would not be a problem if one had at one’s disposal a reliable correction formula in order to adjust for family size; unfortunately this is not the case.

As an illustrative example one can mention the “comparative” study of income distribution edited by Brenner et al. (1991): six countries are examined by six different authors, but almost none of the data are comparable. The data for Britain are based on wages (which excludes capital gain), those for Germany are based on data from tax authorities (which include capital gains); in some cases a correction was performed which takes into account the distribution of age groups while in others it was not, and so on.

Is the situation hopeless then? Certainly not. For one thing one should consider a phenomenon which depends upon a few parameters only. That is why we selected the distribution of grain prices considered in this paper. Secondly, we will show that it is possible to consider data which make the comparison meaningful.

The paper proceeds as follows. In the second section we list the parameters which affect the phenomenon under consideration; this will help us to define datasets for which a meaningful comparison can be made. In the third section we describe the Chinese and French price data. In section 4 we show that the prices have the same spatial structure in the two countries and we estimate the correlation length in each case. In section 5 we examine whether or not market integration progressed in the 18th century. Finally in the concluding section we summarize our findings along with the precepts which in a general way can improve the reliability of comparative analysis.

2 Comparing two systems of markets

For a cross national comparison to be valid one must ensure that all factors (except of course the factor that one wants to study) are identical. This is undoubtedly a very strong constraint; it is due to the fact that we do not know how to discount the effect of factors which are different. A number of the factors that can be expected to be relevant for the comparison of two systems of markets are listed in Table 1.

Needless to say, this list cannot be exhaustive; one has to posit that all factors that are not explicitly considered play a negligible role. It is only by performing numerous comparative studies for the same phenomenon that one can separate the factors which are important from those which play only a small role. In fact, the situation is the same in physics: when an experiment is carried out for the first time in a new field one does not know which factors are crucial and which ones are not.

In table 1 we made a distinction between factors (labeled by numbers) which are fairly well defined and can therefore be easily controlled, and more complex factors (labeled by capitals). A few words are required to explain the phenomena to which these entries refer. What do we mean by “propensity for trade”? Propensity for trade will for instance be low for fragile goods such as eggs or fresh figs, or for goods which cannot be stored for a long time, or in a general way for all products for which transportation costs are too large compared to their value. Thus, one would expect the propensity for trade to be larger for caviar than for wheat. Another (less exotic) example is wheat versus potatoes. In 19th century Germany one kilogram of wheat was worth at least three times as much as one kilogram

\footnote{May be some truly comparative investigations have escaped our attention; we express in advance our gratitude to those of our readers who would bring such studies to our attention. As a matter of fact we would be more than pleased to see comparative analysis become a key issue in economic research.}
Table 1  Factors which affect the analysis of the spatial distribution of prices

| Well-defined parameters |
|-------------------------|
| 1  Unit of currency     |
| 2  Unit of weight or volume |
| 3  Type and quality of grains |
| 4  Type of prices (market/contract prices) |
| 5  Frequency of prices   |
| 6  Size of the region    |
| 7  Topography of the region (plain/mountain/sea-coast) |

| Broad factors |
|---------------|
| A  Propensity for trade |
| B  Means of transportation |
| C  Business situation |

Notes: For a comparative study to be meaningful all factors must be identical (or at least controlled in the sense that a reliable correction can be performed) except the one under study. That is why this table will subsequently be referred to as the “ceteris paribus” (i.e. everything else being identical) table.

Regarding entry B, a central question is whether a decrease in transport costs will lead to an increase in trade and hence to a stronger market-interdependence. Although the answer could at first sight seem fairly obvious, it is not in fact. Indeed, a decrease in transport cost between two cities $A$ and $B$ leads to a decrease in the price differential $p_A - p_B$, and in the face of such a lower price differential traders will have a lower incentive to trade (assuming that their profit rate is somehow determined by the price differential). To decide which of these opposing effects will prevail is not obvious. In the framework of the stochastic spatial arbitrage model (Roehner 1995, 1996) it is found that a decrease in transport cost leads to a trade increase, a prediction which seems to be confirmed by empirical evidence (Roehner 1995, p.151, and 2000, p.193).

The business situation (that is to say whether or not one is in a phase of recession, whether interest rates are low or high, and so on) undoubtedly plays a role, but in a way which is difficult to specify. Usually, one expects that by considering a sufficiently large span of time (e.g. 50 years or more) these effects can be averaged out.

Note that the previous factors could be replaced by a single variable which is the trader’s profit margin. Unfortunately that kind of information is rarely (if ever) made public and cannot be controlled therefore; this is why one must contend oneself with the indirect criteria listed above.

The previous discussion could well lead to a pessimistic view. In the previous section we claimed that the present problem has been selected on account of its relative simplicity, and yet the above
discussion must necessarily lead to the conclusion that the question is not easy to settle empirically.

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4 The calculation which leads to that estimate goes as follows. In the decade 1891-1900 the average price of wheat in Berlin was 164 mark/ton (Jacobs et al. 1935), while the average price of potatoes was 2.19 mark/50 kg that is to say 43.8 mark/ton, i.e. 3.7 times less than the price of wheat. Needless to say since the prices of wheat and potatoes fluctuate in a fairly uncorrelated manner this price ratio fluctuates as well: it was equal to 4.4 in the decade 1811-1820, and to 5.3 in 1925-1934. For the United States, in the second half of the 20th century that ratio seems to be much lower, of the order of 1.2 to 2.

5 Once again it is because of the ceteris paribus requirement that the question is not easy to settle empirically.
discussion seems to show that it has in fact numerous facets. To get a more realistic perception let us once again consider the example of the Foucault pendulum. Even if the experiment is repeated on two successive days, at the same place and with the same device one could well argue that the conditions have changed. Indeed the position of the Moon (which undoubtedly exercises a gravitational attraction on the pendulum) has changed as well as (though to a smaller extent) the position of the main planets. Furthermore, vibrations transmitted to the pendulum from the outside world are not the same on two successive days. The physicist would answer that the gravitational attraction of the Moon is negligible (it is about $10^6$ times smaller than the attraction of the earth) while outside vibrations will be averaged out. Well and good, but the fact that the precision of the measurement does not exceed 5 percent in the best experiments and is more often of the order of 10 percent clearly shows that there are indeed a number of perturbations which are not well understood and hence cannot be controlled. In spite of such defects the experiment is nevertheless highly successful in demonstrating the rotation of the earth. Similarly, for the economic problem under consideration, one can hope that in spite of the fact that there are some poorly controlled factors, one will nevertheless get a reliable comparison.

3 Grain prices

In contrast to many aggregated macro-variables commodity prices are well defined and can be accurately measured. This does of course not mean that comparisons of price data are ipso facto reliable. As an illustration one can mention the monthly share prices published by the Organization for Economic Cooperation and Development (OECD 1966, 1989): prices for the Milan stock exchange are averages of daily quotations, figures for Oslo give the quotation on the 15th of each month, the data for Stockholm are quotations at the end of each month. Clearly such figures are not comparable. Such a lack of comparability in an official publication is all the more surprising when one considers that daily share price statistics are easily available; if anything, it proves that data-comparability is not of major concern for international statistical organizations.

For 18th century grain prices there are usually two main sources (i) Prices recorded by government officers on each grain market of some importance (ii) Prices at which grains are bought by various institutions such as hospitals, monasteries, and so on. Prices from the second source usually display a smaller volatility (i.e. standard deviation) than prices from the first, but this difference is sizeable only when one considers monthly or weekly prices. For the annual prices that we use in this paper the two kinds of prices would be fairly comparable. However, since we need a comprehensive geographical coverage the prices recorded by government officers will be more homogeneous. The prices that we use subsequently are of that kind; let us describe them in more detail.

3.1 China

At least from the 17th century, a systematic reports of the prices of the major grains was required from every county (xian) magistrate. Prices were recorded at a minimum interval of once per month. The local government of the county was charged with the task of investigating the markets within or serving the main city of the county and recording the selling price of different grains. These reports were subsequently sent to the prefectural city (fu). The county reports were then summarized by two prices for each grain, the highest and lowest price among all the counties. The county reports and the summary were then sent on to the provincial capital, where the provincial governor then used the summaries to prepare monthly price reports to the Emperor. While the county level reports have been

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6 Assuming independent random price fluctuations, the standard deviation of the Milan prices will be five times (i.e. $\sqrt{30}$) times smaller than that of the two other markets.
largely destroyed, copies of the monthly price report summaries at the prefectural level have survived, and it is these price reports, the Grain Price Lists in the Agricultural Section of the Vermillion Records in the Palace Archives [Gongzhong shupi souze, nonye lei, liangjia qingdan], currently kept in the Number One National Archives of Beijing, which are used in this paper.

There were two main reasons why the government collected price data along with local weather reports and local harvest reports. First, to deal with problems of mass riots resulting from food shortages, the government maintained a sophisticated system grain management. Disaster relief institutions included tax relief or tax postponement, cash and grain transfers to local governments, seed loans, and grain disbursal from public granaries. Price data was used to help monitor the market conditions, the local grain supply availability, and the harvest outcomes in local areas. The information was used to preempt potential crises resulting from grain shortage, and, to assess the severity of food shortage and thus the validity of applications for food relief from local officials. Second, the government had to purchase grain for the consumption of its soldiers and the approximately one million bureaucrats residing in Beijing. Price reports allowed government officials to identify which market to purchase from. The fact that the government utilized the price data for comparative purposes strongly suggests that not only is the accuracy of the prices relatively high, but that the prices have been converted into units of silver tael which are comparable in value\[^{7}\]. The reports could not have served their purposes if they were not in comparable units of currency across regions.

### 3.2 France

In France the recording of grain prices goes back to a royal ordinance of 1539. One may wonder why the government monitored so closely grain prices. (i) Grains constituted the main component in the diet of the population; any sudden price increase could lead to riots. (ii) When troops were marched through the country the government had to know at which price grains were available. In short, grain prices were as important in that age as oil or stock prices are nowadays.

The 18th century price series that we use were built for the information of the National Convention (1792). They were subsequently re-published in 1837 (Archives Statistiques) and 1933 (Labrousse). The series give average annual prices for each of the 32 regions composing France at that time. We do not really know how the averages were computed, that is to say which markets were used in each region to define the region-average; however, some tests performed by Labrousse (1933, p.70) show that the data are consistent with control-averages performed using 4 or 5 markets (which means that with 5 terms the convergence towards the expectation is already good enough).

An important point concerns units of measurement. As one knows, back in the 18th century there was a great diversity as to units of measurement. Yet, in the source of 1792 all prices are expressed in livres per “setier de Paris”. How were the conversions performed? In 1755-1756 a systematic survey was carried out from which the required conversion factors could be drawn (Labrousse, 1933).

### 4 Measuring the correlation length

As in statistical mechanics the correlation length, $L$, of a set of markets characterizes the range of the interaction. It is defined through the formula: $\rho(d) = e^{-d/L}$ which expresses the correlation $\rho$, between prices on two markets as a function of the inter-market distance $d$. The operational definition of the correlation length is recalled in Fig.1. Note that for the sake of convenience we will rather use a smaller correlation length $l$ defined by: $l = L/100$ It should be emphasized that the correlation length

\[^{7}\]Prices of grain would have been posted locally in terms of a copper cash price, whereas the standard government unit of price accounting converted all copper prices to units of silver tael (Wilkinson, 1969)
is in many respects ideally suited to the structural comparison of two systems of markets. Because the correlation between two price series is independent of the respective magnitude of the prices, conditions 1,2,3 in Table 1 are automatically satisfied; and since the correlation length characterizes the behavior of the correlation as a function of distance the overall size of the region under consideration (condition 6) does not matter.

In order to ensure that one compares two territories characterized by a similar topography (condition 7) one must restrict the analysis to regions of limited extent. As a result a global comparison of China and France would be questionable; indeed, as each country has plains as well as mountains, the result would be an ill-defined average whose interpretation would be open to debate.

A last remark is in order. In the same way as one expects price correlations to decrease with intermarket distance one would expect price differentials to increase with distance. Why then did we not also study price differentials; in fact we did, but that dependence turns out to be very noisy and chaotic. An obvious reason for the smoother behavior of correlations is the fact that the latter implicitly involve a built-in time average. If adequate time-averaging is performed the differential - distance relationship becomes meaningful as well (see Roehner 1995, p.133-137).

### 4.1 China (Jiangsu)

The most developed economic region of China is generally regarded to be in the Yangzi Delta, a plains area on the eastern coast in the provinces of Jiangsu and Zhejiang and situated at the center of the most important long-distance water routes of the 18th century: the mouth of the Yangzi River, the Grand Canal, and a sea port. The province of Jiangsu is significant because all three of the major water routes, and many tributaries, pass through the province, giving it a natural advantage in transport costs. Table 2a shows the correlation length for two samples. Sample 1 consists of all ten prefectures of Jiangsu province for the series 1742-1795. Inter-market distances are measured from the capital cities of each of the prefectures. For every 4.8 kilometer increase in distance between markets in Jiangsu, the correlation declines by one percent. Figure 3a graphs the relationship between the log of correlations and distance in kilometers.

| Sample | Regions (prefectures)                                      | Correlation length [km] |
|--------|------------------------------------------------------------|-------------------------|
| 1      | Jiangsu Changzhou, Haizhou, Huaian, Jiangning, Sungjiang  | 4.8 ± 2.3               |
|        | Suzhou, Taicang, Tongzhou, Yangzhou, Zhenjiang            |                         |
| 2      | Yangzi Delta Changzhou, Hangzhou, Huzhou, Jianxing        | 4.3 ± 5.9               |
|        | Ningbo, Shaoxing, Sungjiang, Suzhou                        |                         |

Notes: In each region the geographical center has been identified with the capital city. The results in this table refer to rice prices. It turns out that wheat and rice prices (data for both cereals are available for Hunan) per unit of volume or per unit of weight (one liter of rice weighs approximately 81 kg, Chuan et al. 1975) were fairly comparable which means that wheat and rice have almost the same propensity for trade. The error bounds were not obtained in the same way as in the case of France and may be somewhat over-estimated.
4.2 France

Fig. 3b shows the decrease of the correlation as a function of distance for a sample of 10 regions. Subsequently this sample will be referred to as the long-term sample because the data for these regions can be extended to the 19th century. Note that the very fact that there is a well-defined relationship between correlations and inter-market distances is a non-trivial property of the system of markets. It is this structural property which allows a correlation length to be defined. For the long-term sample the correlation length is $l = 16.5 \pm 3.3$ km. One must of course examine to what extent that result is modified when one considers another sample. Table 2b provides the result for three different samples.

| Sample  | Regions                                      | Correlation length [km] |
|---------|----------------------------------------------|-------------------------|
| 1       | Long-term sample Alençon, Amiens, Bourges, Bourgogne, Bretagne, Caen, Lyon, Riom, Rouen, Tours | 16.5 ± 3.3              |
| 2       | Sample 2 Alsace, Bordeaux, Champagne, Franche-Comté, La Rochelle, Limoges, Metz, Poitiers, Soissons | 16.1 ± 4.1              |
| 3       | Sample 3 Auch, Bordeaux, Champagne, Franche-Comté, Languedoc, La Rochelle, Limoges, Montauban, Poitiers | 12.8 ± 2.3              |

Notes: For the sake of homogeneity we have used French spellings even when the English spelling was different (as for instance for Lyons) The first two samples are restricted to the northern part of France, while the third also includes locations from the south (e.g. Auch, Languedoc, Montauban). The fact that the third estimate of the correlation length is somewhat different is hardly surprising since it does not correspond to the same region; it gives a measure of the variability of the correlation length as one shifts from northern to southern France. The geographical center of each region has been defined as the localization of the capital region; for instance for Alsace it is Strasbourg, for Franche-Comté it is Besançon, and so on. The error bars correspond to the confidence intervals at probability level 0.95.

Sample 2 which is made up of non-mountainous regions located in the northern part of France leads to a correlation length which is almost identical to the previous one. Sample 3 consists also of non-mountainous regions but they are located in the northern as well as southern part of France; in this case the correlation length is somewhat lower which suggests that southern France had a lower degree of market integration than northern France.

The correlation length estimates obtained in this section provide a static overall picture of market integration for the second half of the 18th century, but what about the evolution of market integration? To analyze changes in the correlation length between 1750 and 1790 one would have to use a narrower time-window; yet, in order to estimate the correlation with acceptable precision the time-window must contain at least 40 - 50 prices. Thus, to get a dynamical picture one would need monthly or weekly prices. As no high frequency data are available one must use a different approach. This is discussed in the next section.
Did market integration progress in the 18th century?

In order to estimate the degree of market integration for a system of \( n \) markets in a given year \( t \) we propose three different measures.

- The difference between the logarithm of the maximum and minimum prices within the set of \( n \) markets; if the prices on the \( n \) markets are denoted by \( p_i(t) \) this variable reads
  \[
  a(t) = \text{Max}_{1 \leq i \leq n} \ln(p_i(t)) - \text{Min}_{1 \leq i \leq n} \ln(p_i(t))
  \]
  In statistics this difference (without the logarithms) is called the range of the sample.

- The (spatial) standard deviation of the logarithms of the prices on the \( n \) markets:
  \[
  b(t) = \sigma[\ln p_1(t), \ln p_2(t), \ldots, \ln p_n(t)]
  \]

- The (spatial) coefficient of variation:
  \[
  c(t) = \frac{\sigma[p_1(t), p_2(t), \ldots, p_n(t)]}{m[p_1(t), p_2(t), \ldots, p_n(t)]}
  \]
  where \( m[p_1(t), p_2(t), \ldots, p_n(t)] \) denotes the average price on the \( n \) markets.

Let us briefly explain what motivated the choice of these variables. Firstly, it must be noted that \( a, b, c \) are scale invariant in the sense that they do not change when all prices are multiplied by the same constant. As a result, these variables are independent of the choice of the units of volume and currency which makes them well suited for cross-national comparisons. Note that whereas the correlation was “naturally” scale invariant, one has here to use log-prices in order to achieve that invariance (at least for \( a \) and \( b \)). Regarding the definition of \( a \) its main advantage is the fact that it can be computed very easily (almost by mere inspection of the price series); on the other hand it does not use the price data very efficiently since it takes into account only two prices. Moreover, the confidence interval of the range \( a \) is known to be fairly large: for large samples it decreases as \( 1/\sqrt{\ln n} \) instead of the usual \( 1/\sqrt{n} \) (Kendall et al. 1987, p.461).

In what follows we want to study the evolution of the above variables in the course of time, in particular we examine whether or not there is a downward trend. However, it must be noted that if there is a downward trend it cannot be linear because \( a, b, c \) are necessarily positive. As a result a linear regression will not give a good fit. A remedy is to fit instead:
  \[
  A = \ln a, \quad B = \ln b, \quad C = \ln c
  \]
  since \( A, B, C \) are not bounded they can have a linear downward trend in the course of time. More specifically, the regressions performed in the following paragraphs correspond to the determination of the coefficient \( \alpha \) defined as (similar expressions for \( B, C \)):
  \[
  A = -\alpha t + \beta \implies a = Be^{-\alpha t}
  \]
  by their form these regressions parallel in the time domain the regressions previously performed in the spatial domain.

5.1 China (Jiangsu)

Table 3a gives the results for the regressions with respect to time. For the Jiangsu province the regression coefficients are not significantly different from zero (except perhaps the third); this is consistent with the relatively low price dispersion in that province.
Table 3a Trend α for market integration in China: 1742-1795

| Sample     | Regression for A [century⁻¹] | Regression for B [century⁻¹] | Regression for C [century⁻¹] |
|------------|-----------------------------|-----------------------------|-----------------------------|
| 1 Jiangsu  | 0.04 ± 0.1                  | 0.012 ± 0.02                | −0.16 ± 0.08                |
| 2 Yangzi Delta | −0.18 ± 0.1               | −0.04 ± 0.02                | −0.22 ± 0.06                |

Notes: The samples are the same as in table 2a. A, B, C respectively denote the Max-Min, standard deviation of log-prices and the coefficient of variation (see text).

confirmed by the fact that the different criteria lead to conflicting signs. On the other hand for the Yangzi Delta the regression coefficients are significantly different from zero; this is confirmed by the fact that the three criteria lead to consistent signs.

Table 3a does not make full use of all data that are avaible for China. Indeed (see section 3.1) for each prefecture \(i\) the archives give the lowest \(p_{i,\text{lo}}\) and highest \(p_{i,\text{hi}}\) price among all the counties composing prefecture \(i\). So far, for each prefecture, we used the average price \(p_{i,\text{m}} = (p_{i,\text{lo}} + p_{i,\text{hi}})/2\) (that we simply denoted \(p_i\)). However the \(p_{i,\text{lo}}\) and \(p_{i,\text{hi}}\) prices can give us some information about the distribution of prices at a within- (or infra-) prefecture scale. To this end we tentatively introduce the following variables.

(i) The difference between the logarithm of the highest and lowest price within prefecture \(i\) averaged over all \(n\) prefectures in a given region:

\[
\alpha_{wp} = \frac{1}{n} \sum_{i=1}^{n} (\ln p_{i,\text{hi}} - \ln p_{i,\text{lo}})
\]

(ii) The standard deviation of the logarithms of the lowest/highest price averaged over all \(n\) prefectures in a given region:

\[
\beta_{wp} = \frac{1}{n} \sum_{i=1}^{n} \sigma(\ln p_{i,\text{lo}}, \ln p_{i,\text{hi}})
\]

(iii) The ratio of the standard deviation of the lowest/highest price to the average price averaged over all \(n\) prefectures in a given region:

\[
\gamma_{wp} = \frac{1}{n} \sum_{i=1}^{n} \sigma(\ln p_{i,\text{lo}}, \ln p_{i,\text{hi}})/p_{i,\text{m}}
\]

Remark The analog of the variable \(a(t)\) for this data set would have been:

\[
a'(t) = \max_{1 \leq i \leq n}\ln(p_{i,\text{hi}}(t)) - \min_{1 \leq i \leq n}\ln(p_{i,\text{lo}}(t))
\]

but since this data set does not permit to compute the analogs of \(b(t), c(t)\) we rather adopted the above definitions for the sake of homogeneity.

The regressions for \(\alpha_{wp}, \beta_{wp}, \gamma_{wp}\) are given in table 3a’; all coefficients are negative and significantly different from zero at 5 percent significance level which non-ambiguously attests to a downward trend. In other words progress of market integration seems more pronounced at smaller distances (of the order of 50 km) than at distances of several hundredths kilometers.

5.2 France

Table 3b gives the results for the regressions with respect to time. First it can be noted that the...
Table 3a’ Trend $\alpha$ for market integration in Jiangsu within prefectures: 1742-1795

| Sample | Regression (i) $[\text{century}^{-1}]$ | Regression for (ii) $[\text{century}^{-1}]$ | Regression for (iii) $[\text{century}^{-1}]$ |
|--------|--------------------------------------|-------------------------------------------|-------------------------------------------|
| Jiangsu | $-0.0071 \pm 0.002$ | $-0.006 \pm 0.003$ | $-0.026 \pm 0.008$ |

Table 3b Trend $\alpha$ for market integration in France: 1756-1790

| Sample   | Regression for A $[\text{century}^{-1}]$ | Regression for B $[\text{century}^{-1}]$ | Regression for C $[\text{century}^{-1}]$ |
|----------|----------------------------------------|----------------------------------------|----------------------------------------|
| 1 Long-term sample | $-0.72 \pm 0.95$ | $-0.87 \pm 0.96$ | $-0.89 \pm 0.94$ |
| 2 Sample 2      | $-0.39 \pm 1.10$ | $-0.39 \pm 1.10$ | $-0.31 \pm 1.11$ |
| 3 Sample 3      | $-1.25 \pm 1.11$ | $-0.94 \pm 1.05$ | $-1.11 \pm 1.01$ |

Notes: The samples are the same as in table 2b. A, B, C respectively denote the Max-Min, standard deviation of log-prices and the coefficient of variation (see text). The figures give the slope of the regression lines with respect to time expressed in centuries. As shown by the width of the confidence interval the three variables fluctuate markedly in the course of time.

variables $A, B, C$ lead to close results. Secondly, the width of the confidence interval shows that they are highly fluctuating in the course of time (this can also be seen on Fig.4b). The fact that all samples lead to negative regression coefficients shows that the downward trend is a robust property. This leads us to the conclusion that both in northern and southern France market integration made notable progress in the forty years preceding the Revolution of 1789. The rate of the downward trend is between 3 to 8 times faster (according to which sample one considers) than the one observed in the Yangzi Delta region. Naturally, because of the transportation revolution, one would expect that market integration has progressed even faster in the 19th century. This is indeed confirmed by Fig.4b. The decrease rate is almost twice as large in the 19th century than it was in the second half of the 18th century.

6 Conclusions

Two main results emerge from this comparative study (i) In the 18th century the level of market integration in France (expressed by the correlation length of grain prices) was about three times as large as in the plain region of Lower Yangzi, on the eastern coast of China. (ii) Between 1750 and 1800 there was substantial progress of market integration in France; there was parallel progress in the Yangzi Delta and even in Jiangsu province if one takes into account the sub-prefecture distance scale.

Needless to say, it would be of great interest to complement these results with data pertaining to northern China and in particular to the prefectures around Beijing.

The study also lead to other findings, such as for instance the fact that 18th century grain markets were less integrated in southern than in northern France, or the fact that for France progress of market integration in the 19th century was about twice as fast as in the 18th century.

But, beyond these specific results, the main message of this paper was to advocate the definition and adoption of rigorous guidelines for comparative analysis. In particular, we emphasized that (i) at an experimental level the situation is not fundamentally different in physics and in economics
(ii) very little attention has been devoted by economists to the definition of methodological rules for comparative analysis. Hopefully, the present study can serve as a starting point for other cross-national comparisons.
A Appendix A: Price data

It is of crucial importance that other researchers can check our results and convince themselves that our conclusions do not depend on built-in artifacts at the level of data selection or statistical analysis. This is what we called the replication requirement. For that purpose the present appendix provides the primary price data we have used. The Chinese data have never been published and are available only from the archives in Beijing; the French data have been published in a French thesis (Labrousse 1933) which may be difficult to obtain. In order to save space we restricted the Chinese data to Jiangsu and the French data to the 18th century section of the long-term sample. The data for the other samples are available from the authors on request.
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Captions of the figures

Fig. 1 (a) Operational definition of the correlation length. The rectangles schematize grain markets; the interactions between them is represented by the dots; the level of price series they give rise to correlations $c_{12}, c_{13}, c_{14}, \ldots$. (b) Once these correlations are plotted (on a logarithmic scale) as a function of distance the correlation length $\delta$ can be read from the slope $m$ of the regression line as: $\delta = -1/m$.

Fig. 2a Map of South-East China. Within South-East China the provinces of Jiangsu and Yangzi Delta are the main plain regions.

Fig. 2b Map of France with location of markets.

Fig. 3 Correlation as a function of distance in France 1756-1790. The corresponding graph for China would be very similar in shape and has therefore been omitted.

Fig. 4a Trend for market integration in Yangzi Delta 1742-1794. The vertical scale corresponds to the Max-Min variable referred to as $a$ in the text.

Fig. 4b Trend for market integration in France 1756-1900. There is an acceleration in the improvement of market integration between the 18th and 19th century. The vertical scale corresponds to the Max-Min variable defined in the text.
| Date | Jiangning | Suzhou | Sungjiang | Changzhou | Zhenjiang | Huaian | Yangzhou | Taicang | Haizhou |
|------|-----------|--------|-----------|-----------|-----------|--------|----------|---------|--------|
| 1742.2 | 1.40 | 1.43 | 1.31 | 1.38 | 1.44 | 1.47 | 1.50 | 1.54 | 1.62 |
| 1742.7 | 1.49 | 1.76 | 1.73 | 1.70 | 1.60 | 2.03 | 1.70 | 1.95 | 1.73 |
| 1743.2 | 1.45 | 1.53 | 1.47 | 1.55 | 1.53 | 1.67 | 1.59 | 1.62 | 0.88 |
| 1743.7 | 1.40 | 1.49 | 1.47 | 1.40 | 1.46 | 1.35 | 1.25 | 1.60 | 2.05 |
| 1744.2 | 1.35 | 1.62 | 1.53 | 1.47 | 1.47 | 1.38 | 1.30 | 1.75 | 2.00 |
| 1744.7 | 1.30 | 1.38 | 1.52 | 1.40 | 1.40 | 1.32 | 1.24 | 1.65 | 1.87 |
| 1745.2 | 1.30 | 1.45 | 1.45 | 1.27 | 1.38 | 1.15 | 1.27 | 1.50 | 0.95 |
| 1745.7 | 1.22 | 1.42 | 1.48 | 1.31 | 1.32 | 1.33 | 1.24 | 1.50 | 1.94 |
| 1746.2 | 1.13 | 1.35 | 1.36 | 1.20 | 1.25 | 1.35 | 1.24 | 1.40 | 1.78 |
| 1746.7 | 1.12 | 1.40 | 1.52 | 1.33 | 1.25 | 1.30 | 1.30 | 1.47 | 0.80 |
| 1747.2 | 1.24 | 1.47 | 1.52 | 1.40 | 1.43 | 1.40 | 1.41 | 1.55 | 0.85 |
| 1747.7 | 1.55 | 1.83 | 1.67 | 1.57 | 1.60 | 1.55 | 1.36 | 1.88 | 1.70 |
| 1748.2 | 1.67 | 1.80 | 1.70 | 1.70 | 1.82 | 1.63 | 1.63 | 1.91 | 1.73 |
| 1748.7 | 1.68 | 2.12 | 1.83 | 1.70 | 1.78 | 1.77 | 1.50 | 1.94 | 1.75 |
| 1749.2 | 1.74 | 1.95 | 1.72 | 1.67 | 1.90 | 1.52 | 1.69 | 1.88 | 1.69 |
| 1749.7 | 1.33 | 1.58 | 1.40 | 1.45 | 1.43 | 1.43 | 1.33 | 1.67 | 1.47 |
| 1750.2 | 1.37 | 1.67 | 1.50 | 1.52 | 1.52 | 1.25 | 1.31 | 1.73 | 1.57 |
| 1750.7 | 1.33 | 1.70 | 1.77 | 1.48 | 1.45 | 1.42 | 1.17 | 1.70 | 1.67 |
| 1751.2 | 1.37 | 1.66 | 1.58 | 1.48 | 1.60 | 1.51 | 1.37 | 1.83 | 1.65 |
| 1751.7 | 1.72 | 2.51 | 1.83 | 1.95 | 1.98 | 1.57 | 0.00 | 2.55 | 2.05 |
| 1752.2 | 2.20 | 2.42 | 2.15 | 2.10 | 2.38 | 2.03 | 2.00 | 2.02 | 1.92 |
| 1752.7 | 1.87 | 2.33 | 2.25 | 2.10 | 2.12 | 2.06 | 1.90 | 2.44 | 1.78 |
| 1753.2 | 1.65 | 1.80 | 1.75 | 1.80 | 1.88 | 1.94 | 1.83 | 1.98 | 1.81 |
| 1753.7 | 1.60 | 1.80 | 1.73 | 1.65 | 1.70 | 1.85 | 1.77 | 1.95 | 1.00 |
| 1754.2 | 1.58 | 1.62 | 1.62 | 1.48 | 1.65 | 1.83 | 1.81 | 2.08 | 1.91 |
| 1754.7 | 1.42 | 1.60 | 1.58 | 1.45 | 1.55 | 1.65 | 1.59 | 1.98 | 1.91 |
| 1755.2 | 1.33 | 1.55 | 1.50 | 1.42 | 1.45 | 1.51 | 1.50 | 1.72 | 1.54 |
| 1755.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1756.2 | 2.38 | 3.05 | 2.68 | 2.72 | 2.78 | 2.63 | 2.55 | 2.93 | 2.09 |
| 1756.7 | 1.65 | 2.35 | 1.99 | 2.05 | 2.10 | 2.10 | 1.67 | 2.28 | 2.22 |
| 1757.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1757.7 | 1.43 | 1.62 | 1.52 | 1.48 | 1.48 | 1.75 | 1.46 | 1.77 | 2.22 |
| 1758.2 | 1.51 | 1.84 | 1.58 | 1.55 | 1.65 | 1.97 | 1.75 | 2.00 | 2.31 |
| 1758.7 | 1.33 | 1.65 | 1.62 | 1.55 | 1.55 | 1.38 | 1.32 | 1.90 | 2.09 |
| 1759.2 | 1.94 | 1.83 | 1.63 | 1.52 | 1.58 | 1.50 | 1.31 | 1.80 | 2.03 |
| 1759.7 | 1.44 | 2.22 | 1.80 | 1.75 | 1.62 | 1.43 | 1.40 | 2.07 | 1.71 |
| 1760.2 | 1.80 | 2.22 | 2.30 | 2.12 | 2.12 | 1.83 | 1.87 | 2.40 | 1.90 |
| 1760.7 | 1.62 | 2.12 | 2.15 | 2.03 | 1.90 | 1.82 | 1.98 | 2.14 | 1.85 |
| 1761.2 | 1.45 | 1.73 | 1.67 | 1.45 | 1.60 | 1.77 | 1.77 | 1.73 | 1.56 |
| 1761.7 | 1.43 | 1.92 | 1.85 | 1.62 | 1.62 | 1.71 | 1.62 | 1.84 | 1.59 |
| 1762.2 | 1.50 | 1.85 | 1.88 | 1.70 | 1.54 | 1.60 | 1.58 | 1.92 | 1.59 |
| 1762.7 | 1.58 | 1.94 | 1.92 | 1.82 | 1.76 | 1.63 | 1.63 | 1.92 | 1.63 |
| 1763.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1763.7 | 1.60 | 1.85 | 1.88 | 1.67 | 1.72 | 1.69 | 1.63 | 1.94 | 1.77 |
| 1764.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
The decimals .2 and .7 in the date respectively refer to the second and eighth month of the Chinese lunar calendar; a lunar month being shorter than 30 or 31 days some years had 13 months. In the above table, the two decimals are always .1 and .2. See text.

| Date | Jiangning | Suzhou | Sungjiang | Changzhou | Zhenjiang | Huai'an | Yangzhou | Taicang | Haizhou | Ti | 
|------|-----------|--------|-----------|-----------|-----------|---------|----------|---------|---------|----|
| 1765.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 
| 1765.7 | 1.67 | 2.05 | 1.93 | 1.83 | 1.76 | 1.72 | 1.67 | 2.03 | 2.00 | 
| 1766.2 | 1.72 | 2.01 | 2.05 | 1.85 | 1.85 | 1.79 | 1.76 | 2.15 | 1.83 | 
| 1766.7 | 1.65 | 1.99 | 2.05 | 2.30 | 1.77 | 1.81 | 1.62 | 2.06 | 1.99 | 
| 1767.2 | 1.62 | 1.70 | 1.72 | 1.65 | 1.67 | 1.79 | 1.72 | 1.92 | 1.85 | 
| 1767.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 
| 1768.2 | 1.50 | 1.65 | 1.55 | 1.45 | 1.57 | 1.75 | 1.42 | 1.70 | 1.83 | 
| 1768.7 | 1.75 | 1.83 | 1.85 | 1.70 | 1.72 | 1.72 | 1.85 | 1.79 | 1.84 | 
| 1769.2 | 1.77 | 1.82 | 1.80 | 1.90 | 1.85 | 1.95 | 2.03 | 1.97 | 1.96 | 
| 1769.7 | 1.85 | 2.35 | 2.08 | 2.03 | 2.00 | 1.90 | 1.83 | 2.12 | 1.95 | 
| 1770.2 | 1.88 | 1.99 | 1.95 | 1.83 | 1.80 | 1.82 | 1.75 | 2.15 | 1.95 | 
| 1770.7 | 1.55 | 2.04 | 1.95 | 1.72 | 1.76 | 1.80 | 1.55 | 2.26 | 1.96 | 
| 1771.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 
| 1771.7 | 1.27 | 1.59 | 1.77 | 1.45 | 1.50 | 1.74 | 1.41 | 1.83 | 1.88 | 
| 1772.2 | 1.41 | 1.60 | 1.50 | 1.45 | 1.44 | 1.73 | 1.58 | 1.67 | 1.83 | 
| 1772.7 | 1.30 | 1.58 | 1.50 | 1.38 | 1.35 | 1.61 | 1.33 | 1.63 | 1.84 | 
| 1773.2 | 1.20 | 1.39 | 1.35 | 1.30 | 1.27 | 1.45 | 1.22 | 1.50 | 1.70 | 
| 1773.7 | 1.22 | 1.37 | 1.42 | 1.25 | 1.20 | 1.50 | 1.15 | 1.58 | 1.72 | 
| 1774.2 | 1.34 | 1.42 | 1.38 | 1.30 | 1.25 | 1.54 | 1.26 | 1.58 | 1.69 | 
| 1774.7 | 1.55 | 1.75 | 1.50 | 1.80 | 1.67 | 1.58 | 1.66 | 2.03 | 1.71 | 
| 1775.2 | 1.83 | 2.07 | 1.72 | 1.90 | 1.85 | 2.13 | 2.05 | 2.15 | 1.94 | 
| 1775.7 | 2.25 | 2.12 | 1.90 | 2.00 | 2.08 | 2.11 | 2.40 | 2.28 | 1.94 | 
| 1776.2 | 2.30 | 2.12 | 2.12 | 2.30 | 2.26 | 2.22 | 2.35 | 2.40 | 2.00 | 
| 1776.7 | 1.65 | 2.10 | 2.08 | 1.80 | 1.80 | 1.90 | 1.83 | 2.18 | 1.96 | 
| 1777.2 | 1.65 | 1.95 | 1.90 | 1.60 | 1.56 | 1.88 | 1.80 | 2.09 | 1.93 | 
| 1777.7 | 1.58 | 1.88 | 1.95 | 1.62 | 1.63 | 1.65 | 1.53 | 2.07 | 1.95 | 
| 1778.2 | 1.48 | 1.60 | 1.60 | 1.38 | 1.45 | 1.71 | 1.45 | 1.84 | 1.86 | 
| 1778.7 | 1.90 | 1.78 | 1.85 | 1.90 | 1.78 | 1.70 | 1.70 | 2.03 | 1.92 | 
| 1779.2 | 2.32 | 2.57 | 2.25 | 2.45 | 2.65 | 2.35 | 2.30 | 2.47 | 1.98 | 
| 1779.7 | 2.15 | 2.34 | 2.22 | 2.15 | 2.00 | 2.15 | 2.00 | 2.17 | 2.10 | 
| 1780.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 
| 1780.7 | 1.50 | 1.86 | 1.75 | 1.70 | 1.65 | 2.01 | 1.58 | 1.97 | 1.97 | 
| 1781.2 | 1.55 | 1.60 | 1.73 | 1.65 | 1.50 | 1.96 | 1.70 | 1.85 | 1.91 | 
| 1781.7 | 1.60 | 1.78 | 2.03 | 1.80 | 1.55 | 1.78 | 1.78 | 2.05 | 1.94 | 
| 1782.2 | 1.73 | 2.03 | 1.60 | 1.99 | 1.70 | 2.05 | 1.88 | 2.08 | 2.02 | 
| 1782.7 | 1.60 | 1.95 | 1.62 | 1.73 | 1.58 | 2.15 | 1.78 | 2.20 | 2.08 | 
| 1783.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.10 | 2.20 | 
| 1783.7 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 
| 1784.2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.10 | 2.20 | 
| 1784.7 | 1.85 | 1.76 | 1.73 | 1.62 | 1.65 | 2.15 | 2.00 | 0.00 | 0.00 | 
| 1785.2 | 1.85 | 1.77 | 1.65 | 1.60 | 1.60 | 2.24 | 2.05 | 2.00 | 2.24 | 

Notes: The headings correspond to the names of the 10 prefectures composing Jiangsu province. The decimals .2 and .7 in the date respectively refer to the second and eighth month of the Chinese lunar calendar; a lunar month being shorter than 30 or 31 days some years had 13 months. In the above table, the two decimals are always .1 and .2. See text.
| Year | Alençon | Amiens | Bourges | Bourgogne | Bretagne | Caen | Lyon | Riom | Rouen | Tours |
|------|---------|--------|---------|-----------|----------|------|------|------|-------|-------|
| 1756 | 1615    | 1380   | 1405    | 1720      | 1704     | 1670 | 1785 | 1455 | 1575  | 1410  |
| 1757 | 2400    | 2520   | 1330    | 2010      | 2020     | 2385 | 1804 | 1670 | 2905  | 1565  |
| 1758 | 1835    | 1485   | 1505    | 2230      | 1715     | 1854 | 1985 | 1760 | 1850  | 1505  |
| 1759 | 1750    | 1385   | 1590    | 2165      | 1800     | 1585 | 2210 | 1870 | 1890  | 1490  |
| 1760 | 1685    | 1520   | 1410    | 2145      | 1950     | 1555 | 2075 | 1670 | 1950  | 1365  |
| 1761 | 1555    | 1335   | 2075    | 1650      | 1935     | 1570 | 1690 | 1390 | 1580  | 1305  |
| 1762 | 1860    | 1615   | 1215    | 1570      | 1800     | 1854 | 1610 | 1310 | 1745  | 1445  |
| 1763 | 1415    | 1335   | 1005    | 1485      | 1525     | 1505 | 1335 | 1355 | 1430  | 1425  |
| 1764 | 1235    | 1320   | 1170    | 1679      | 1625     | 1115 | 1640 | 1420 | 1405  | 1305  |
| 1765 | 1595    | 1604   | 1335    | 1675      | 1650     | 1710 | 1979 | 1625 | 1675  | 1625  |
| 1766 | 1785    | 1635   | 1935    | 2485      | 2245     | 1925 | 2495 | 2210 | 2035  | 2130  |
| 1767 | 2190    | 2285   | 1940    | 2775      | 2180     | 2015 | 2655 | 2590 | 2400  | 1715  |
| 1768 | 2780    | 2920   | 1920    | 2505      | 2545     | 2510 | 2230 | 2065 | 3015  | 2190  |
| 1769 | 2960    | 2270   | 2035    | 2680      | 2480     | 2360 | 2355 | 2200 | 2730  | 2665  |
| 1770 | 3440    | 2355   | 3405    | 3505      | 3130     | 3230 | 3205 | 3480 | 2990  | 3015  |
| 1771 | 2865    | 2620   | 2795    | 3770      | 2630     | 2730 | 3655 | 3559 | 2850  | 2305  |
| 1772 | 2610    | 3375   | 2695    | 2655      | 2825     | 2710 | 3020 | 3120 | 2650  | 2770  |
| 1773 | 2695    | 2460   | 1950    | 2625      | 2710     | 2495 | 2885 | 2485 | 2850  | 2355  |
| 1774 | 2280    | 2095   | 1715    | 2330      | 2335     | 1950 | 2625 | 2255 | 2320  | 1954  |
| 1775 | 2785    | 2425   | 2350    | 2590      | 3145     | 2555 | 2630 | 2560 | 2765  | 2355  |
| 1776 | 2345    | 1845   | 1750    | 1904      | 2310     | 2000 | 2035 | 1875 | 2515  | 2105  |
| 1777 | 2475    | 1950   | 1679    | 1765      | 2090     | 2165 | 2020 | 2135 | 2520  | 1979  |
| 1778 | 2140    | 1790   | 1665    | 2265      | 2305     | 2075 | 2630 | 2670 | 2215  | 1895  |
| 1779 | 2225    | 1590   | 1690    | 2595      | 2055     | 2405 | 2875 | 2410 | 2095  | 1650  |
| 1780 | 2180    | 1515   | 1640    | 2285      | 2095     | 2395 | 2375 | 2000 | 2080  | 1610  |
| 1781 | 2220    | 1750   | 1790    | 2120      | 2240     | 2195 | 2180 | 1925 | 2230  | 1910  |
| 1782 | 2180    | 1645   | 2475    | 2470      | 2850     | 2385 | 2555 | 2415 | 1960  | 2420  |
| 1783 | 2135    | 1725   | 2340    | 2745      | 2555     | 2205 | 2965 | 2540 | 1975  | 2305  |
| 1784 | 2720    | 2345   | 2070    | 2470      | 2570     | 2540 | 2525 | 2145 | 2875  | 2320  |
| 1785 | 2455    | 1860   | 1925    | 2285      | 2745     | 2605 | 2235 | 1865 | 2195  | 2485  |
| 1786 | 2305    | 1660   | 1915    | 1954      | 2915     | 2485 | 2190 | 1760 | 1920  | 2620  |
| 1787 | 2260    | 1735   | 2100    | 2210      | 2190     | 2060 | 2450 | 1960 | 2135  | 1979  |
| 1788 | 2390    | 2100   | 2310    | 2710      | 2240     | 2290 | 2735 | 2395 | 2495  | 2405  |
| 1789 | 3240    | 3375   | 3440    | 3370      | 3110     | 3215 | 3634 | 3340 | 3384  | 3100  |
| 1790 | 2790    | 2140   | 3270    | 3215      | 3060     | 2750 | 3365 | 3209 | 2750  | 2925  |

Notes: The prices are expressed in hundredth of livres per “setier de Paris” (a unit of volume equal to 156 liters and equivalent to a weight of about 120 kilograms of wheat). The city names refer to the “Généralités” (i.e. districts) of which the corresponding cities were the centers. Source: Labrousse 1933.
Correlation vs Distance

$C_{13}$

$D_{13}$
Correlation vs Distance graph.
Fig Y4a Log price differential in Yangzi Delta, 1742-1795

Max(ln p_i(t)) - Min(ln p_i(t))
