

Was Labrousse Wrong? Seasonality of Grain Transactions in French Marketplaces during the July Monarchy

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With a few exceptions, historians have conceded since the work of Labrousse (1932) that grain markets are characterized by a strong seasonality linked to the need for farmers to sell their wheat quickly after harvest. As recent works indicate, the analysis of price movements makes it difficult both to understand the motivations of the stakeholders and to account for the pace of trade. Using statistical methods applied to volumes on 13 markets located in the supply area of the Paris Basin between 1828 and 1852, the analysis of transactions makes it possible to affirm that the phenomena of seasonality are not universal and that they only very imperfectly reflect the functioning of the cereal markets, in particular for maslin, oats and barley, which sometimes represent the bulk of transactions. Seasonality phenomena only concern certain markets, linked to the main trade routes. This study also makes it possible to demonstrate that the modernization of the grain trade in the Paris Basin precedes the establishment of the rail network. It shows too that such modernization is based on the modernization of the local road network and, to a certain extent, on the elimination of traditional markets, particularly for oats. Finally, it makes it possible to propose a typology of markets that takes into account not only the importance of transactions, but their inclusion in regional exchange systems.

O Labrousse estava errado? Sazonalidade das Transações de Cereais nos Mercados Franceses durante a Monarquia de Julho

PALAVRAS-CHAVE: mercados de grãos, France, século XIX, sazonalidade.

CÓDIGOS JEL: Q02, N53, R12, C22.

Com algumas exceções, os historiadores admitem desde a tese de Labrousse (1932) que os mercados de cereais são caracterizados por uma forte sazonalidade ligada à necessidade de os agricultores venderem seu trigo rapidamente após a colheita. Como artigos recentes indicam, a análise dos movimentos de preços torna difícil entender as motivações dos stakeholders e do ritmo das transações. A análise das transações, utilizando métodos estatísticos aplicados a quantidades, em 13 mercados, localizados na área de abastecimento da Bassin Parisien entre 1828 e 1852, permite afirmar que os fenômenos de sazonalidade não são universais e apenas refletem de maneira muito imperfeita o funcionamento dos mercados de cereais, em particular de mistura de cereais (méteil), aveia e cevada, que ocasionalmente representam o maior parte de transações. Os fenômenos de sazonalidade apenas aparecem nos específicos mercados, conectados às principais vias comerciais. Este estudo também permite demonstrar que a modernização do comércio de cereais na Bassin Parisien antecede a implantação da rede ferroviária e que se baseia na modernização da rede estradal local e, em certa medida, na eliminação de mercados tradicionais, especialmente para aveia. Por fim, permite propor uma tipologia de mercados que considerar não só a importância das transações, mas também suas inserção nos sistemas regionais de comércio.

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1. INTRODUCTION

Since the 2008 crisis, the issue of supply and prices of major edible crops has become a central item on the agenda of the least developed countries. Moreover, lockdown measures on the population as well as restrictions on travel and movement put in place at the start of 2020 have reactivated fears about the continuity and resilience of supply chains in developed countries¹. These two crises make it possible to consider two types of problems which confronted the populations of pre-contemporary periods in terms of supply. The first refers to the periods of price increases that were running a sometimes-vital risk to large segments of the population. The second refers to the fragility of socio-technical supply chains before the advent of railways, and steam navigation, as well as contemporary storage, transformation and conservation systems². This second dimension is the topic of this article from the case of the cereal markets of Oise during the July Monarchy and the Second Republic, that is to say, for the most part, before the opening of the first railway lines³.

Pre-contemporary grain markets have been the subject of numerous works mainly based on price data. These studies analyse the movement of price convergence (*i.e.* market integration) for more or less wide areas and for more or less long periods⁴. A second set of works has intended to measure more specifically the price volatility either linked with the market integration phenomenon (Jacks, O'Rourke & Williamson, 2011) or with the weather shocks or climate change as a variable (Albers, Pfister & Uebele, 2018). Finally, another set of works has been devoted to the understanding of the actors' motivation to sell or stock the grains⁵.

In this article, we do not consider the questions of the volatility of prices and of price convergence. We will focus on the level and the rhythms of transaction. We assume that

1. On the crisis of 2008 see, among the vast literature, HEADEY and FAN (2008) who made a useful overview. On the concerns about the resilience of food supply chain during spring 2020, see TORERO (2020) and HOBBS (2020).

2. This socio-technical system is obviously very different from that exposed by Cronon in his study of Chicago (CRONON, 1991). On the Parisian cereal supply system, see KAPLAN (1984) and BOURGUINAT (2002) for the first half of the 19th century. On the importance of the railways in the process of modernizing the French market system, see PRICE (1983).

3. The term July Monarchy refers *stricto sensu* to the reign of Louis-Philippe (1830-48). The survey covers the period 1828-52, that is, the end of the *seconde* restoration (1828-30), the period of the Second Republic (1848-52) and the very beginning of the Second Empire.

4. For a clarification, see FEDERICO (2012). Studies on France were based on DRAME *et al.* (1984) who recorded wheat prices in 53 markets between 1825 and 1872.

5. See MCCLOSKEY and NASH (1984) and KOMLOS and LANDES (1991).

the focus on the level and the rhythms of transactions, which reflect a certain stage of development of the supply chain for main staple grains, could offer great insights about an issue which has long been debated and about which very little is known. As Brunt and Cannon (2019) point out, price analysis cannot tell us the reasons why farmers marketed their grain at a specific time, or the timing of transactions. Indeed, the debate initiated by the work of McCloskey and Nash (1984), about the rationality of actors has been, up until now, open because it seems that price analyses cannot offer clear answers⁶, despite the increasing sophistication of models. One flaw of this type of approach is that the characteristics of the downstream supply chain, the existence of networks of marketplaces and the relative importance of trading routes, have not been taken into account.

In recent years, some historians have been interested by the issue of the quantities that were traded in marketplaces. One important step in this line of research was the digitalisation of the corn returns and the article of Brunt and Cannon (2013). Herment and Ronsijn (2015), using the data for several English counties, and additionally data from several French *départements* (departments) and several marketplaces in Belgium, showed that during the period 1820-50, depending on the marketplaces and depending on the type of cereals, the seasonality was more or less pronounced. In 2019 a book edited by Ronsijn *et al.* examined the timing and the seasonality of trade with micro-level data for the early modern period and 19th century in several areas including England (Hoyle, 2019; Brunt & Cannon, 2019) and Germany (Scholten, 2019), while Herment, for Paris, and Albrecht, for Vienna, showed that it is necessary to analyse the importance of the supply chain structure to better assess the seasonality and the timing of trade⁷. It is possible to draw two main conclusions from these works. Firstly, in some marketplaces there was a clear seasonality phenomenon, while in other places there was not. Secondly, the behaviour of actors could be better understood if we take in account firstly the downstream of the supply chain, *i.e.* the structure of the milling industry, or brewery, and, secondly, the whole network of marketplaces and the main trading routes.

For French historiography, the seasonality of wheat transactions is an old issue. With a few exceptions, historians have conceded since the work of Labrousse (1932) that grain markets of pre-contemporary periods were characterized by strong seasonality linked to the need of farmers to sell their wheat quickly after harvest (for the payment of rent and

6. It is nevertheless possible to claim that the model put forward by these authors is not valid, at least for the early modern period and the beginning of the 19th century. On this debate, beyond the works already mentioned, see NIELSEN (1997), EJRNAES and PERSSON (1999) and BAUERNFEIND, REUTTER and WOITEK (2001).

7. On the role of millers in Paris grain catchment area, see HERMENT (2019). On the organisation of Vienna's supply, see ALBRECHT (2019).

taxes)⁸. The historiographical significance of the Labrousse model is unavoidable. We find it more or less explicitly mentioned by most authors, whether French or Anglo-Saxon, with some notable exceptions (Grantham, 1989; to a certain extent Meuvret, 1988; Morineau, 1985; Béaur, 2007).

But trade did not only respond to the financial imperatives faced by farmers. It was also driven by the needs met by the different cereals. The requirements of the flour mill were not identical to those of postmasters or brewers for example. Also, before being marketed, these cereals were subjected to a set of complex and related operations (harvesting, bleaching, milling, or barn drying, threshing, transport). Thus, Labrousse's model considers only a part of the pre-contemporary cereal economy which was not necessarily the most important. It should be also noted that this period is characterized, in France, but also in other countries, by the gradual emergence of giant flour milling companies, on the one hand (Herment, 2019), and by the extension of supply catchment area of major European cities on the other hand (see Albrecht [2019] for the supply of Vienna). Finally, as pointed out by Miller (1998), the French supply system is characterized by a progressive movement of acclimatization of economic liberalism, internal and external, which culminates during the "liberal phase" of the Second Empire⁹, but which is already largely implemented under the July Monarchy, at least concerning internal trade¹⁰.

To better assess the seasonality of transaction in grain marketplaces and the influence of the downstream of the supply chain and the proximity of main trading routes, we have used the data provided by the *mercuriales* for 13 French marketplaces located in Oise, between 1828 and 1852, that is, before the construction of the railway network. In the next section we shall describe the sources (*mercuriales*) and the main agricultural aspects of the region under scrutiny. In the third section, we will present the statistical methods used in the context of this article to account for the seasonality of transactions. It will be necessary to explain our method carefully, because, conversely to the price data, the raw data

8. It is important to underscore that in the region under scrutiny, rents were paid in cash from the end of the medieval period (see BLOCH, 1931). Moreover, from the Revolution on, all levies and tithes were abolished. Thus, the farmers paid property taxes (on behalf of the landlords) and rents in cash. But it is also important to recall that numerous small farmers owned their farms either in part or in whole (HERMENT, 2012). Conversely, the larger farmers were, with some exceptions, often tenants, as demonstrated by MORICEAU and POSTEL-VINAY (1992).

9. The literature on the liberalization phase of the Second Empire is immense. We will refer notably to the recent and innovative work of Romain TRICHEREAU (2019), which puts the liberal character of the regime into perspective.

10. On the movement to liberalize markets in Vienna and Paris, see ALBRECHT (2021).

about the level of transaction have to be examined with great caution to avoid artefacts. In the fourth part, we will present an overview of the seasonality phenomenon for all marketplaces and all grains. In the fifth section, we will show that the seasonality is more accentuated where industrial mills were located, and that new channels were open for marketing oats. In the sixth part, we take into account the sub-regional dynamics of the markets before the establishment of the rail network, which has been said to have played an essential role in the marketing of agricultural products during the Second Empire (Price, 1983; Schwartz, 2010)¹¹. We shall show that the seasonality is more pronounced along the main roads before the opening of railway network.

2. SOURCE AND REGIONAL AGRICULTURE

2.1. Pitfalls of the sources

When using *mercuriales* to assess the level and the seasonality of transactions, one has to be very careful. Conversely to price data, not only the reliability of the data has to be assessed, but it is also necessary to make a careful study of the structure of the source. Moreover, if used for price analyses, it is not vital to know the periodicity of the market or to know the market day, for our purpose these questions are essential.

The use of *mercuriales* presents some pitfalls¹². One needs to keep in mind that they did not record all transactions. Some of the transactions were carried out on samples. Another part took place on the premises of production, for example during the payment of agricultural workers at the end of the harvest or the end of a year of work¹³. Formal market transactions, however, were far from negligible. For thirteen markets studied, transactions on bread grain accounted for 100,000 to over 200,000 hectolitres, enough to feed about 30,000 to 60,000 people, or 15 to 30% of the population of the two districts of Beauvais and Clermont. These cereals were used to feed urban populations, and the rural populations who did not have direct access to cereals¹⁴. Lastly, they could be sent to

11. On the very limited structuring effect of the rail network in France in the 19th century, and on demographic dynamics, see MIMÉUR *et al.* (2018). It should be noted that our article does not intend to take a position on the questions raised by the work of FOGEL (1964).

12. For an in-depth analysis of these sources, see RONSIJN and HERMENT (2016).

13. The payment of annual salaries took place, in principle, on Midsummer Day (June 24th). A part of this payment could be paid in kind (in grain). The payment of wages for harvest very often included, for locally recruited labourers, a part in kind.

14. According to the Firmin-Didot directory, in 1836 the Oise (four districts) had 56,506 employees working in industry. As the yearbook states, some of its employees also worked in agriculture

Paris and cities in the Paris region or, again, to Amiens located about 30 kilometres north of the department (Fig. 1).

The annual evolution of the transactions did not reflect the level of production of the past year. On the one hand, the carryovers from one year to another were very important. On the other hand, in difficult years, the volume of transactions could increase up to a certain point, since small and micro-owners, who in an average year managed to feed themselves, were forced to obtain supplies from the markets¹⁵. Moreover, the structure of transactions did not reflect the structure of productions. The farmers could in fact trade wheat and consume maslin or vice versa.

TABLE 1
List of markets, period, frequency and market days

Markets	Period	Market day	Shifted day, or supernumerary market not to be taken into account
Markets in the south of the department (all weekly)			
Beauvais	1828-52	Saturday	If August 15 th is a Saturday, the market is on Friday. If January 1 st is a market day, the market is held on Friday 31 st December (with exceptions)
Clermont	1828-52	Saturday	The Candlemas Fair takes place on the first Tuesday after Candlemas. No grain market on this date. Fair on August 10 th (no grain market) Fair on November 30 th . There doesn't seem to be a grain market
Meru	1828-52	Friday	Fair on Good Friday.
Bresles	1838-44	Thursday	Disappears due to the weakness of transactions
Mouy	1838-52	Saturday	
Noailles	1838-52	Monday	
Markets in the north of the department (all weekly)			
Breteuil	1828-53	Wednesday	
Grandvilliers	1828-53	Monday	
Songeons	1828-53	Thursday	Candlemas Fair which takes place in the week of February 2 nd
Formerie	1838-53	Wednesday	
Crèvecoeur	1838-53	Thursday	
Ansauvillers	1838-53	Monday	
Maignelay	1838-40	Wednesday	Disappears from the mercurial due to the weakness or nullity of the transactions

Note: depending on the market, if the grain market is held on the 1st January, 15th August and 1st November, the market may be shifted either a day earlier or a day later.

Source: Archives départementales de l'Oise (AD Oise) 3422 (1828-41) and 3423 (1842-52).

(HENRICH, 1838: 593). To these people, we must add those employed in the transport sector and commerce for which we do not have data.

15. During the harvest year 1846-47, the level of transactions was relatively low (around 175,000 hectolitres). This would feed around 60,000 people.

Finally, one cannot make conclusions from a single marketplace review. Nothing guarantees that a specific marketplace is representative, either in terms of the structure of the exchanges, or in terms of the calendar of the exchanges. Indeed, a marketplace is only one of the elements of a network of marketplaces (Margairaz, 1988). It is within the framework of the existence of this network that it is necessary to examine the evolution of transactions on the various marketplaces by answering three types of question: What was the frequency of the markets? When did they take place? What distances separated them from each other? Table 1 answers the first two questions, Figure 1 answers the third question.

2.2. The network of marketplaces

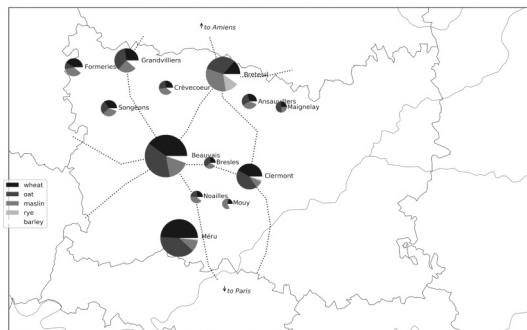
Changes in the structure and content of the source must also be taken into account. From January 1828 to March 1830, the *mercuriales* record the transactions week by week. From April 1830, it includes transactions in different marketplaces every two weeks, but nevertheless indicating the market dates. In some places, such as Beauvais, several markets took place every week. To homogenize the counting, the fortnight will be the basic unit of analysis. On the other hand, to avoid being trapped in very short-term hazards (floods, snowfall, impassable roads, unrest in the markets, etc.), the month will constitute the basic unit.

From 1828 to 1837, the *mercuriales* record transactions in five marketplaces: Beauvais, Grandvilliers and Songeons, in the district of Beauvais; Clermont and Breteuil, in the district of Clermont. From January 1838, the *mercurial* mentions thirteen markets (Fig. 1). In addition to the aforementioned markets, the *mercuriales* records transactions at Bresles, Formerie, Méru and Noailles, in the Beauvais district, and those of Ansauvillers, Crèvecœur, Maignelay and Mouy, in the Clermont district. Figure 1 shows the importance of the various markets in 1840. Beyond this date, the *mercurial* underwent three major changes. Due to the weakness or the nullity of their transactions, the Maignelay and Bresles markets disappeared in January 1841 and July 1844 respectively. The Méru market changed status during the year 1840. The quantities traded decreased drastically. It seems that a large part of the transactions were sample transactions, which explains both the desire to preserve information on the prices of all cereals and the fact that only a part of the transactions, probably destined for local populations, were effectively registered¹⁶.

16. From the autumn of 1847, the level of transactions increased, but did not return to the levels of the years 1838-39.

The situation in 1840 (Fig. 1) is, therefore, representative of maximum marketplaces coverage which will change starting in 1841. It is possible to distinguish two specific areas. The first, in the south of the department, is characterized by the existence of large markets on which wheat is primarily traded. In the second, located to the north, maslin, and to a lesser extent rye, represent a large share of transactions. Transactions in wheat are relatively small without being negligible, particularly from the mid-1840s.

FIGURE 1
Share of different cereals marketed during the period 1838-40



Note: the area is proportional to the total volume traded on the market.
Source: AD Oise, Mp 3422/2.

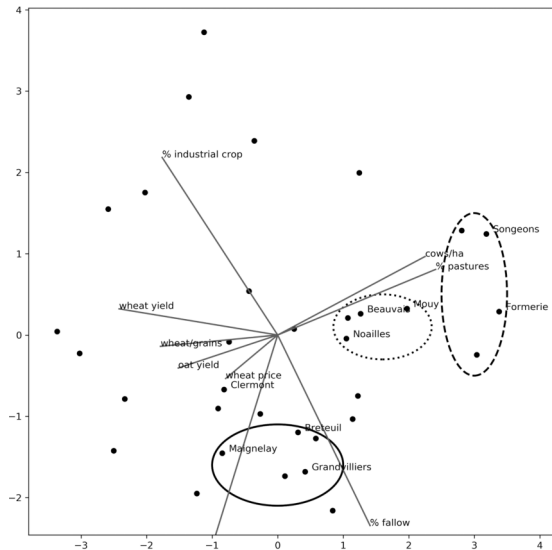
The two marketing areas are organised quite differently. The north is characterized by a network of marketplaces at a distance of about 15 kilometres from one another. This is a classic configuration. No market crushed all the others in 1840. In the south of the department, on the contrary, the density of the network was higher, but three marketplaces, specialized in the marketing of wheat, dominated the small rural marketplaces of Noailles, Mouy and Bresles, to the point that the last one disappears and the other two only represent 2 or 3% of transactions in wheat at the end of the period.

2.3. Agriculture specialisation

Cereals that were not intended for human consumption represent a significant share of the volumes traded (around a quarter to a third of the total value of transactions). This must therefore be taken into account to understand the dynamics of the markets and what they reveal about the cereal economy. Oats, which play a very important role, were exclusively intended for feeding horses. As for barley, it had multiple uses: as feed for donkeys, of which there were quite a few in the central part of the department, as a raw ma-

material for breweries and, finally, as human food in the event of a high-cost crisis¹⁷. Nevertheless, the quantities marketed were relatively small compared to other cereals (Fig. 1).

FIGURE 2
PCA of the main production areas in 1862



Note: the ellipses stand for the three main geographical areas we have identified in this article.

Source: Archives Nationales, F/11/2708

It is not possible to infer the agricultural specialisation of the different areas from the level of transaction. The agricultural survey of 1862 provides a large set of data that allows an accurate description of the different areas of specialisation in the department, a few years after the end of our inquiry (Fig. 2)¹⁸. The region of Formerie and Songeons (called Pays de Bray) presents a very specific profile with a large share of land devoted to pasture, and a high rate of cows by hectare. This region specialised in dairy production. Nevertheless, the acreage devoted to cereals was important specifically for wheat. In Maignelay, Breteuil, Grandvilliers and, to a lesser extent, Clermont, the classical three-field system was predominant (fallow, wheat/maslin, oats). The region of Beauvais (with Mouy and Noailles) was a mix of the two previous regions. None of the marketplaces under study

17. It was only when it was too expensive that barley was intended to feed the poor (ROCHÉ, 1845: 12).

18. While the region has been deeply studied for the seventeenth century (GOUBERT, 1968), extensive works for the 19th century do not exist. For the structure of the agricultural survey of 1862, see HERMENT and MERMET (2018).

was located in the region specialised in industrial crops (sugar beetroots, rapeseed, and potatoes for starch factory).

It is in the south and north-central part of the department that maslin occupied the most space in rotations, whereas wheat was the commercial cereal *par excellence*. In the north-west of the department (Songeons and Formerie), which specialized in livestock farming and dairy production, wheat areas crushed rye and maslin areas. However, in these two cantons, it was maslin that was preferentially marketed. Therefore, it seems that, in this region, the farmers consumed a very large part of the wheat they produced.

3. METHODOLOGY TO ASSESS THE SEASONALITY OF GRAIN TRADE

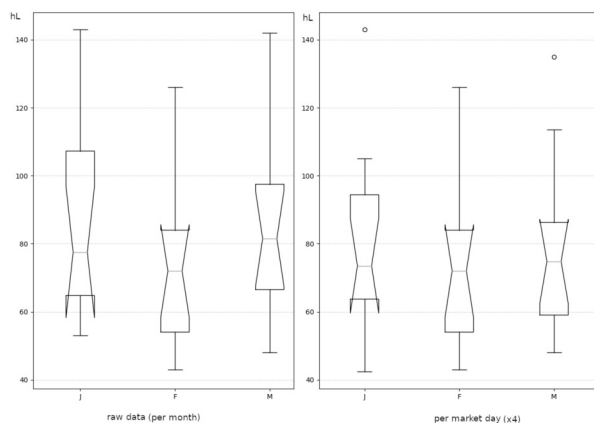
3.1. The constitution of the series

The series on which we are working are taken from the *mercuriales* for the years 1828 to 1852. They indicate, for each fortnight, in the calendar sense of the term, the quantities of cereals traded on the marketplaces during the period concerned. It might be tempting to work directly on these series, but this raises several methodological issues.

The first problem is the fact that the marketplaces are organised according to a weekly frequency and not a monthly one. Thus, the number of markets per month or calendar fortnight is not fixed. The data are therefore twice distorted: on the one hand, it appears to be highly noisy since, at constant real traded volumes, the variation recorded from one month to the next will go from a ratio of $5/4$ to $4/5$ depending on the date of the market day, during the week straddling the two months. On the other hand, an artificial seasonality effect is created in proportion to the number of days in each month, in particular mechanically lowering by 10% the volume of cereals marketed in February compared to January or March (Fig. 3).

Fortunately, we also have on this same document a series of marketplaces dates. We can therefore reduce to a weekly scale, of fixed duration, by dividing for each fortnight or each month the quantity traded by the number of markets having been held during the period in question. This considerably reduces both the noise and the false seasonality mentioned above. However, this is not absolutely without difficulty.

FIGURE 3
Boxplots representing all the quantities of barley (in hectolitres)
sold in January, February and March in Songeons



Note: on the left represented directly, on the right divided by the number of markets and multiplied by 4. We see that the high variance of January and March, as well as the increase in the median over these two months, is a calendar artefact linked to the fact that there are sometimes 5 market days in those months (3 years out of 7 on average).

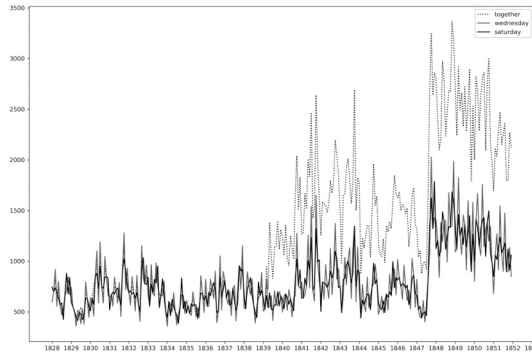
Source: see Table 1.

The first problem relates to the periodicity of certain markets and the possible gap in this area between the source and the fact. Thus, not all the market days mentioned contribute equally to transactions. The most striking example is provided by the wheat series at Beauvais: from April 1839, the number of markets is suddenly halved (the Wednesday market is abolished in favour of the Saturday market alone) even though the quantities exchanged remain stable. It is therefore certain that either all of Wednesday's trade carried over to Saturday (H1), or the Wednesday markets, although counted, were in fact, only zero or entirely negligible volumes, including previous years (H2). To decide between the two hypotheses, we can look at the impact of the elimination of the Wednesday market (*i.e.*, we subtract all the dates which are Wednesdays before carrying out the quantity/market day ratio) over the entire period. If this suppression tends to increase the noise of the series, it is because the first hypothesis is the most probable (H1); if on the other hand, it tends to reduce it, it is the second (H2). In the case of Beauvais, this indeed seems to be the second: the bi-weekly periodicity of the markets in the first years is misleading. Grain markets are held exclusively on Saturdays (Fig. 4)¹⁹.

19. Due to the very low level of trade, the Wednesday's grain market has been suppressed as noted by TREMBLAY (1846: 23).

FIGURE 4

Series representing quantities (hectolitres) of wheat sold in Beauvais between January 1828 and December 1852 compared to the number of markets per month



Note: quantities of wheat sold compared to the number of markets per month, depending on whether we consider a) 2 markets per week; b) 1 market on Wednesdays only; and c) 1 market on Saturday only. The first set diverges sharply, the second has increased noise while the third has reduced noise and is, therefore, less likely to be wrong.

Source: see Table 1.

The second problem is that the periodicity of weeks does not coincide with that of years. It is thus not possible to compare them weekly X , $X + 52$, $X + 104$, etc. because these are shifted by a day and a quarter each year and end up corresponding to different material conditions. Consequently, we are forced to adopt months as scale of comparison, but we must consider for each month an “average” week, the quotient of all the exchanges that have taken place over the month by the number of market days actually taking place.

3.2. Estimation of trend and seasonality

When we talk about trend extraction and seasonality, it is an estimation process. We observe data and we hypothesize that this data is the result of repeated experiments of a random phenomenon with a certain regularity. This phenomenon is, by definition, fictitious and inaccessible, but we can produce an estimator, that is to say, a function that mimics its supposed behaviour, and examine to what extent this estimator correctly accounts for the observed data.

The notion of trend and seasonality comes from one possible model among others, which is particularly suited to series such as those we observe here. This involves breaking down our estimator into the sum of three functions of the time variable:

- a) A trend, which generally takes on this type of series in the form of a piecewise affine function, or a polynomial. It is used to model the variations over a longer time.
- b) A seasonality, which takes the form of a periodic function (period 12 here since our scale is the month and the assumed seasonality is annual). It can for example be a sum of sinusoids (typically if we assume that the variation of a month is dependent on that of the preceding and following months), or simply piecewise constant if we assume that each month has its independent specificity of the previous and following months).
- c) A noise, which will be a random function independent of time; for example, according to a Gaussian law of zero expectation and fixed variance.

The modelling takes place in several stages:

- a) The choice of the model used (*e.g.*, degree of the polynomial).
- b) Optimization of parameters (slope of trend, different values of seasonality).
- c) Testing the model on real data.

The choice of model is made *a priori* and depends on considerations relating in particular to the length of the series but also prior knowledge of the data. Thus, within the framework of our curves of variations of grain quantities exchanged, two reasons push us to favour a tendency affine by pieces:

- a) Choosing a larger model family would allow for a more precise estimator. However, a model that is too precise creates a risk of overfitting. One can for example end up with an estimator which sticks too precisely to the points of the curve and consequently generalizes very badly: in fact, one detects part of the noise at the same time as the signal.
- b) There is no reason to assume that a curve depicting grain trade in a pre-industrial context could explode asymptotically as, perhaps, an industrial production curve in the 19th-20th centuries. Consequently, there is no incentive to look for polynomials of a degree greater than 1. On the other hand, sudden drop-outs are possible (and observed empirically), for example, a marketplace being deserted for several years, or even permanently abandoned; hence the need to allow a limited number of jumps.

During the optimization phase, we start by estimating the trend, by breaking it down into a few intervals and performing a linear regression on each interval (the limits of the intervals and the slopes of the lines being chosen to minimize the total sum of the squares of deviations).

This done, we subtract the resulting trend and construct a very simple seasonality estimator: we simply keep for each month the average over the entire series of the signal subtracted from the trend. The underlying assumption is that each month is studied in isolation from its neighbours.

Finally comes the testing phase. The idea is to check if the residual signal (the initial signal from which we have subtracted the trend estimator and the seasonality estimator) actually behaves like a stationary noise. For that, we study the autocorrelation of this signal and the distribution of its quantiles. If the first is weak and the second very close to the distribution of a Gaussian distribution we keep our model. If this is not the case, we have failed to capture a significant part of the signal, and we go back to the starting point with a new model²⁰.

4. SEASONALITY OF TRANSACTIONS

The seasonality of transactions on the cereal markets, which are at the heart of the Labrousse model, are in fact very poorly understood. If recently several historians have focused on retracing the calendar of transactions of several individual participants in England and Germany, these studies constitute so many special cases that we do not know if they are representative. Also, they are mainly interested in bread grains (wheat or rye). The value of the database on which our work is based lies in the multiplicity of marketplaces and the fact that we consider transactions on all grains. In this section, we will successively examine the case of wheat, maslin and then oats.

Both in value and volume, these three cereals represent the bulk of transactions (Fig. 1). The economic equilibrium of many farms is therefore based on the sale of these three cereals, including in the north-western part of the department, specialised dairy production. Indeed, if it is the financial weakness of farmers that determines the seasonal rhythms of trade, there is no reason to believe that phenomenon of seasonality spares a specific class of farmers or a particular class of marketplaces. Moreover, there is, *a priori*, no reason why farmers should give priority to one cereal rather than another, *i. e.*, sell wheat more quickly than other grain (oats and maslin).

20. See Fig. A-1 at online appendix. doi <https://doi.org/10.26882/histagrar.089x09h>

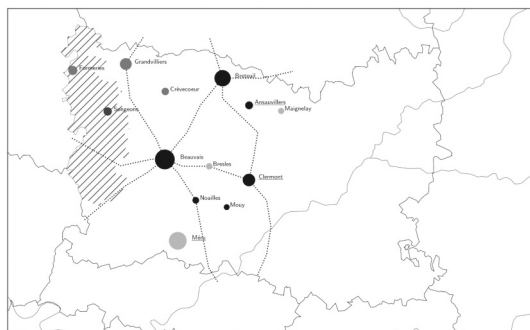
TABLE 2
Summary of the different seasons observed on the markets
depending on the type of cereal

	Oats	Wheat	Maslin
Ansauvillers	Peak Sep.-Nov.	Peak Oct.	Summer> Autumn
Beauvais	Nothing	Peak Oct.	Nothing
Breteuil	Nothing	Peak Oct.	Summer> Autumn
Clermont	Peak Sep.-Nov.	Peak Oct.	Peak Oct. (after 1845)
Crèvecoeur	Nothing	Nothing	<i>Nothing</i>
Formerie	Nothing	<i>Nothing</i>	Nothing
Grandvilliers	Nothing	<i>Nothing</i>	Nothing
Meru		<i>Nothing</i>	Slight peak Oct.
Mouy	<i>Nothing</i>	Peak Oct.	Nothing
Noailles	<i>Nothing</i>	Peak Oct.	<i>Nothing</i>
Songeon	Nothing	Peak Oct.> 1846	Summer> Autumn

Note: the grey boxes correspond to particularly marked phenomena. Conversely, “Nothing” means that no significant seasonality can be detected (the amplitude of the seasonality is smaller than 20% of the median value). In addition, when the letters are in italic font, it means that the residue analysis is not entirely convincing.

Source: see Table 1.

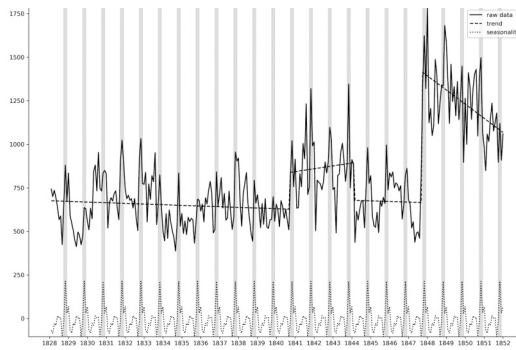
FIGURE 5
Typology of marketplace according to their seasonality



Note: in black, marketplaces with strong wheat seasonality (Beauvais, Breteuil, Clermont, Ansauvillers, Noailles, Mouy); in grey those which do not present any (Formeries, Grandvilliers, Crèvecoeur). In dark grey, the Songeon market which acquired this seasonality in the mid-1840s. In light grey, the marketplaces which disappear or collapse (Méru, Bresles, Maignelay). The black circles indicate a complementary seasonality on maslin (Clermont, Méru) or oats (Clermont, Ansauvillers). The dotted lines represent the royal roads. The dashed zone designates the regions oriented towards dairy farming, but in which cereals are grown in very large quantities.

Table 2 shows that the seasonality is not the same for the three main cereals and that it is not the same on all the marketplaces. If, on the big marketplaces (Breteuil, Beauvais, Clermont), transactions in wheat have a very marked seasonality, with a particularly spectacular peak in transactions in October, the same is not true on marketplaces of local importance of the north of the department (Formerie, Crèvecoeur and, above all, Grandvilliers). The exception is Ansaouvillers, which although of modest importance, mimics the behaviour of the big marketplaces.

FIGURE 6
Seasonality of wheat transactions in Beauvais



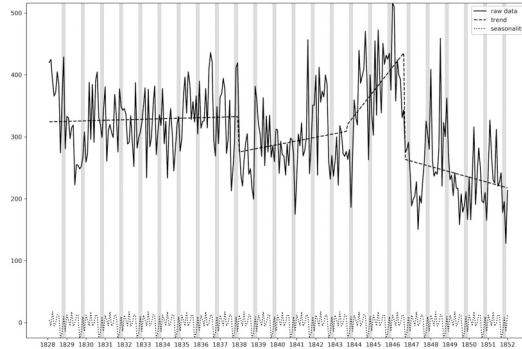
Note: on average over the period, for each weekly market, sales of wheat in October exceeded the sales of weekly markets during other months by around 250 hectolitres. Or for a full month, between approximately 1,000 hectolitres and 1,250 hectolitres.

Source: see Table 1.

Given the importance of maslin sales (particularly in the north of the department), transactions are expected to follow the rules that apply to wheat. If the Labroussian model is to be verified, it would be logical that this cereal, too, should be subject to a very marked seasonal rhythm. This, however, is not the case. Until the end of the 1840s, in no marketplace did maslin transactions follow a very marked recurring seasonal pattern. Neither in the south nor the north of the department do sales of maslin record a particularly significant increase in the fall; on the contrary, we rather see (in three northern markets only) a relative drop in transactions from September compared to a livelier summer. So, should we conclude that the holders of wheat are more in a hurry, or more improvident than the holders of maslin? This is highly unlikely for a very simple reason: in a specific area, these are basically the same actors. To answer with more accuracy, it would be necessary to examine the relative prices of maslin and wheat in all marketplaces. That is beyond the scope of this article which is a first step to better understand the functioning of the grain market. Nevertheless, very preliminary results show that the wheat price/maslin price ratio seems high in autumn especially in Beauvais. If further analysis confirms these

preliminary results, far from being trapped in a seasonal pattern of transactions that would put them at a disadvantage, wheat holders seem to take full advantage of the seasonal movement in the relative prices of wheat as the high seasonality of transaction on wheat and the absence of seasonality on maslin prove (Fig. 6).

FIGURE 7
Seasonality of maslin transactions in Beauvais



Source: see Table 1.

5. THE ROLES OF MILLS AND THE NEW CHANNELS

Maslin and wheat transactions therefore do not follow the same timetable at all. It seems that we have to look for the explanation of these differential timetables on the side of the buyers, and not on the side of the constraints weighing on the sellers. In the south, everything happens as if, a good year or bad year, maslin were sold more or less uniformly throughout the year, no doubt to meet the recurring needs of buyers who obtain their supplies on a “small scale” (*à la petite mesure*), while the month of October represented a high point on the wheat market. In the north (in Breteuil, Ansauvillers and to a lesser extent Songeons), the marketing of maslin seems to follow a specific form of logic with, in each market, a gradual increase in transactions from the beginning of spring to the end of summer, followed by a dip in autumn (of a much smaller magnitude, however, than the phenomena observed on wheat in the south).

5.1. Concentration of milling industry

It is necessary to examine the structure of the downstream of the supply chain to better understand the seasonality of grain trade. Barley devoted to brewery activities constitutes

a good example of grain whose marketing is determined by the requirement of industry. In most parts of England, where the brewery industry was far more important than in France, Ronsijn and Herment have shown, from the corn returns and the accounting book of a Kentish brewery, that most of the barley was marketed between October and May because the “cooler months were the most suitable for the germination process” (Herment & Ronsijn, 2015, 73). They have also demonstrated that in the department of Seine-et-Oise in the vicinity of Paris, the wheat was marketed between October and March. This timetable is linked with the requirement of milling industry which was highly concentrated. The most striking example were the two flour mills of Corbeil and Saint-Maurice, owned by the Darblay family, which could process more than 1,500 hectolitres of wheat each day.

The industrial surveys of 1847-52 provide a clear picture of the milling industry in the districts of Beauvais and Clemont. In these districts, there were not flourmills comparable to those that existed in the vicinity of Paris, where the two Darblay mills were able to supply flour for around 200,000 people. Nevertheless, it is possible to show that the milling industry was highly concentrated in the two districts.

This statistic indicates that there were 114 mills in the district of Beauvais. On average the 107 mills located outside Beauvais could supply flour for some six hundred people. The value of grains processed was 31,736 francs on average for a year, *i.e.* around 1,500 hectolitres²¹. But the seven mills located in the city of Beauvais could supply at least 30,000 people! The two most important mills of Beauvais were able to supply flour for the whole population of the city (12,867 inhabitants in 1831 and 14,216 inhabitants in 1851)²². They processed 395,200 and 345,800 francs of grains respectively, *i.e.*, around, at least, 20,000 and 17,000 hectolitres. This means that these mills had to receive around 50 hectolitres each day. It is quite clear that the big mills had to secure their source of supply as soon as October.

21. This statistic provides the turnover of mills. We have divided the turnover by 20 francs (the price of 1 hectolitre of wheat) and divided the last figure by 2.5 hectolitres (the quantity of wheat necessary to produce a daily food intake of 500 grams of bread). Our estimation is very conservative, taking into account that the price of wheat was lower than 20 francs by hectolitres and that mills could process also maslin and rye (*Statistique de la France*, 1850: 184-85, 188-89).

22. Notice communale de Beauvais (http://cassini.ehess.fr/fr/html/fiche.php?select_resultat=3332).

In the district of Clermont, the concentration was higher than in Beauvais²³, even if the biggest mills of this district lagged far behind the biggest mills of the district of Beauvais. In the Clermont district, the biggest mill processed around 11,500 hectolitres of grains (around 31 hectolitres every day). This is quite an important amount, but far less than the biggest mills of Beauvais. In these two districts, conversely to the smaller millers, larger millers could not secure their provisioning on a daily base. From this point of view, October is a particular moment. Between October and December, the flow of the rivers makes it possible to grind large quantities of grain before possible frosts in January and February.

Some marketplaces, therefore, seem to have a component that we can qualify as *industrial* and another component that we can qualify as *local*. To better understand the importance of the distinction it is necessary to examine the ways grains moved from farm to mills. While all bread grains were to be turned into flour, several routes lead from the farm to the mill. The first, which is a complete mystery to us, is the most direct route. Farmers, and agricultural employees who receive part of their wages in kind, brought their grains (wheat, maslin or rye) to the miller who ground them, most often, against remuneration in kind (a share of the flour and/or bran and rejects). The second path is that of *small-scale sales* (*ventes à la petite mesure*) which took place in marketplaces throughout the year. This was a system that concerned more particularly non-agricultural households who still often baked their own bread. They bought small quantities of grain on the marketplaces more or less regularly and brought them to the miller who transformed them into flour for a system of remuneration similar to that explained above²⁴. The third path was controlled by traders and the big millers. It was fairly typical of the large marketplaces, which supplied Paris and the large cities of the Paris Basin, on which very large quantities of grain were sometimes exchanged exclusively on a sample. It is quite clear that the market of Beauvais is of the *industrial type*, and that the Labroussian model cannot explain the phenomena of seasonality.

5.2. Transactions of oats

In the Paris Basin, oats were not intended to feed humans. Even in bad years, people turned to barley, rye, potatoes and legumes (peas, lentils and beans) which were widely

23. The seven large mills, which represented 6% of the mills in Beauvais district, processed 31% of the grains, while the 4 large mills of the district of Clermont (6.5% of the mills), processed 48% of the grains (figure based on the value of the grains processed).

24. Households that made their own bread did not necessarily have an oven. They would therefore ask a baker to bake their bread. On the other hand, small bakers in rural areas and small towns have much smaller stocks than bakers in large cities (MILLER, 1998; HERMENT, 2019).

grown in the department of Oise. Oats were exclusively intended for horse feed²⁵. The seasonality phenomenon is not marked in any particular marketplace. In Beauvais, Breteuil and Grandvilliers, transactions in oats do not follow a pattern as clear as wheat. It is as if oat consumers were getting their supplies more or less regularly throughout the year.

The only signs of a seasonal phenomenon appear in Clermont and Ansauvillers. In these two marketplaces, the peak in oat transactions occurs at the same time as the peak in wheat. So, it seems that the farmers who operate in these markets were selling their grain massively in the fall. Is this a sign of an exacerbated cash flow requirement during the fall? It is then a specificity of these two markets. It is possible that the agrarian structure of the Clermont region, characterized by the importance of very large farms with very high rents, forced tenants to dispose of a large part of their production in the autumn.

The most spectacular phenomenon, however, is the long-term trend of transactions. Transactions in oats collapsed in the south of the department while in the north they remained at a high level until the beginning of the 1850s. We have here the indication of a transformation of the marketing circuits which was taking place starting in the mid-1830s in the south of the department. The mayor of Beauvais echoed this when, in 1838, he asked the prefect to intervene to put an end to the practices of farmers who, on market days, sold their oats by a sample in inns in the suburbs of the city²⁶.

6. NETWORKS OF MARKETPLACES

6.1. Marketplace areas

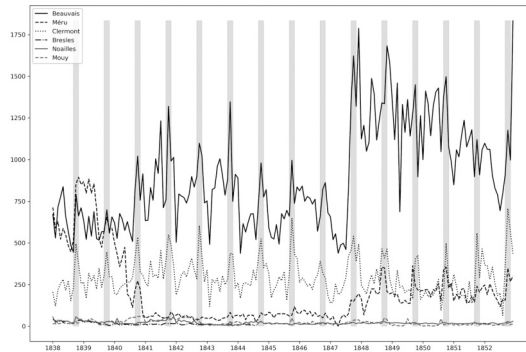
To analyse the dynamics of market areas, we will focus the analysis on the period 1838-52 for which we have a larger set of markets. After a period of stability until 1847, the level of transactions on maslin and wheat increased during the period 1847-52. Moreover, in both zones (north and south), the share of the most important markets was increasing. In the south of the department, after the collapse of transactions in Méru (1840), the Beauvais marketplace polarised around two-thirds of wheat transactions. In addition, Beauvais absorbed most of the massive increase in 1847 (Fig. 8). In this region, the sea-

25. The correlation coefficients between the price of wheat and maslin are very high on all markets (greater than 0.95). The correlation coefficients of barley with wheat and maslin are also very high (greater than 0.8 in all cases). For oats, the correlation coefficients are substantially lower (0.45 to 0.6 depending on the market).

26. AD Oise, Mp 3475/1, Letter from the Mayor of Beauvais to the Prefect, October 16th 1838.

sonal rhythm of wheat sales is therefore controlled by the transactions that take place on this marketplace and to a lesser extent on that of Clermont.

FIGURE 8
Wheat transactions (in hectolitres) recorded on the markets
in the south of the departments (raw data, per market day)

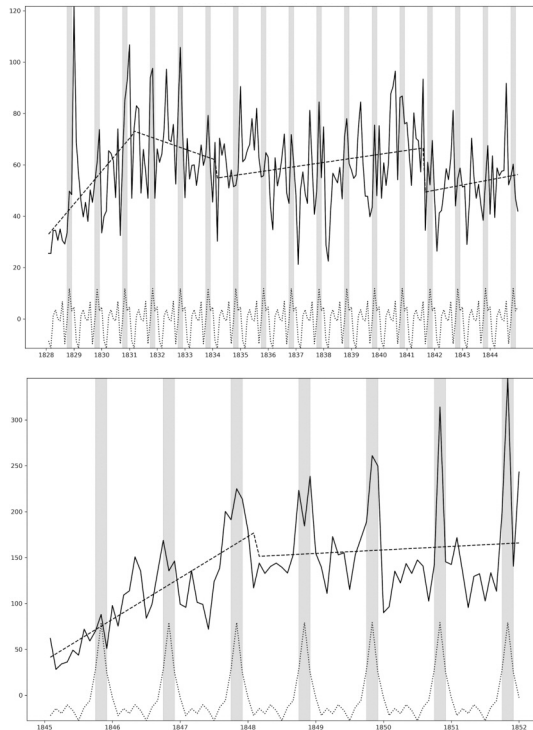


Source: see Table 1.

However, the trajectory of the Clermont market is distinct. This market was increasingly specialized in the marketing of maslin. The predominance of maslin is accompanied by an increase in the seasonality of sales of this cereal from 1845-47 (Fig. 9). It is very likely that the surge in transactions at the beginning of autumn (in principle October) was linked to massive purchases by very important stakeholders: millers or grain merchants who wished to protect themselves against a possible rise in prices or a possible shortage. It is perhaps no coincidence that this phenomenon appears very clearly after the high-cost crisis of 1846-47. Maslin would therefore be, at least on the market of Clermont, an *industrial* cereal.

In the north, the situation is much more complex. Grandvilliers gradually becomes the dominant marketplace for wheat with around 45% of the volumes traded at the end of the period. The Breteuil market represents around 40% of maslin volumes traded at the start of the period and a little more than 50% at the end of the period. However, despite their importance, these two markets could not make their mark, as Beauvais did in the south of the department.

FIGURE 9
Comparison between a model of the series 1828-45
on the one hand and 1845-52 on the other hand



Note: we can simultaneously distinguish a general increase in volumes (hectolitres) and the appearance of a marked seasonality.

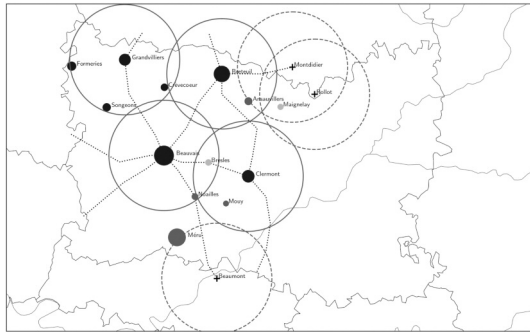
Source: see Table 1.

The map (Fig. 10) shows that the marketplaces in the north of the department form a fairly dense network of places about 15 kilometres apart. None of them succeeded in polarizing the bulk of trade on the two major bread grains. The competition between places was, however, fierce. It caused the disappearance of the Maignelay marketplace which was not only rivalled by Ansauvillers but also by the marketplaces of the neighbouring department of the Somme²⁷. Moreover, little by little, transactions on the Ansauvillers marketplace, in the orbit of Breteuil, were falling. Crèveœur, which is equidistant from Songeons, Grandvilliers and Breteuil, also seems gradually to lose its importance at the end of the period, but the development is less clear. This configuration allows us to con-

27. Minutes of the deliberations of the Oise General Council, 1849, p. 46.

sider two issues: was there a symbiotic interconnection between the markets? And if so, can we, as in the south of the department, bring to light a phenomenon of seasonality in wheat transactions?

FIGURE 10
Area 15 kilometres as the crow flies around major markets



Note: in black, markets whose importance is maintained or even increased (Formerie, Grandvilliers, Crèvecoeur, Breteuil, Beauvais, Clermont); in grey, the markets where the level of transactions is falling (Ansauvillers, Noailles, Mouy, Méru); in light grey, the markets disappear (Bresles, Maignelay).

Area 15 kilometres as the crow flies around major markets. We have added, in dotted-line, the 15-kilometre areas around Rollot and Montdidier (Somme) and Beaumont (Seine-et-Oise) which are mentioned among the large markets near but outside the study area.

Source: see table 1.

In fact, more than a system of inter-annual or intra-annual compensation between marketplaces, which would explain the evolution of the volumes traded on the different places, there is, on the one hand, a general increase in the volumes traded, and, on the other hand, a polarization and market specialization according to cereals: Breteuil and Songeons for maslin, Grandvilliers and Formerie for wheat (Fig. 11).

We can easily explain the lack of intra-annual or inter-annual compensation. The dynamics of a marketplace undoubtedly depended on the habits of buyers and sellers, which change slowly. In order to change such habits, a farmer must be sure that he can find buyers. Likewise, for a buyer to be encouraged to intervene in a marketplace, he must be sure that he is meeting farmers who are willing to sell them the quantities he wishes to buy. While reputations are slow to be established, discredit can happen very quickly. Without doubt, it is these habits and expectations that explain the speed with which certain small marketplaces disappear or die out. Once the spiral was set in motion, it must have been very difficult to get back on track.

FIGURE 11
Transactions in wheat (left) and maslin (right) recorded on the markets
in the north of the department (in hectolitres)



Note: data smoothed as a moving average over 12 months for reasons of readability.

Source: see Table 1.

6.2. Road network

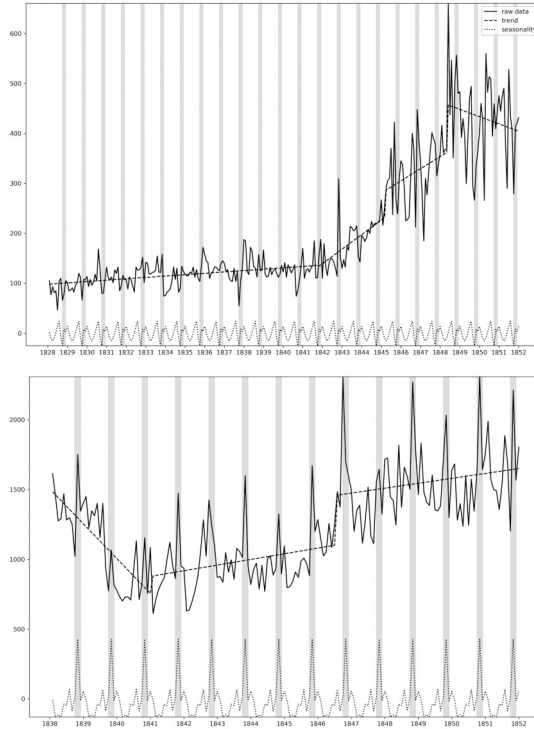
Concerning seasonality, examining the marketplaces one by one does not provide a useful conclusion to the existence of a phenomenon of this type in the north of the department. But the aggregation of the marketplaces still makes it possible to bring to light a seasonal phenomenon specific to wheat. Only the marketplaces of Songeons, Formerie, Crèvecœur and Grandvilliers, all located to the north-west, escape it (see Fig. A-1, online appendix). The phenomenon is particularly clear in Grandvilliers (Fig. 12) where the lack of seasonality is especially striking.

It would then be necessary to admit either that the farmers who supply the marketplaces of the north-west escape, for an unknown reason, the phenomenon of the “hunger gap”

described by Labrousse, or that they supply a non-industrial demand, that is to say, a demand expressed throughout the year. The second explanation seems to us the most likely.

FIGURE 12

Comparison between the seasonality of the series of quantities of wheat exchanged in Grandvilliers (top) and the 6 other northern markets, cumulatively (bottom), in both cases compared to the number of markets



Note: the sum clearly shows a strong fall peak more visible than that examined in the markets taken in isolation (all quantities in hectolitres).

Source: see Table 1.

The case of Grandvilliers allows us to introduce a new geographical approach and to deepen our understanding of the conditions for modernizing trade before the establishment of the rail network. The structure of transactions shows a predominance of maslin in the marketplaces of the north of the department (Fig. 1). Highlighting seasonality phenomena in wheat makes it possible to propose an alternative geographical dynamic for trade. Figure A-1 –online appendix– shows that wheat transactions are seasonal in the centre of the department along a north-south axis that connects Paris and Beauvais to

Amiens (royal roads of the first class). Only the north-west of the department remains away from these major trade routes. Thus, the geography of seasonality phenomena is emerging which contradicts the Labroussian model, and the establishment of the rail network may have accentuated but it didn't create it.

A survey of the prefecture of Oise established at the request of the ministry in 1817 brings some insights about the main commercial routes. The prefect established the list of the main grain merchants of the department, often millers. They operated in the three large marketplaces specializing in the wheat trade: Méru, Clermont and Beauvais²⁸. He stressed that they were in contact with Amiens, Rouen, Soissons and Paris. The pace of their purchases depended quite closely on the potential of the large mills which operated at full capacity between mid-September and January and from mid-March through summer. Frost and floods in autumn and winter as well as low water in summer hampered the operation of hydraulic mills.

Also, our results indicate that the strengthening of seasonality phenomena should not be confused, either in its manifestations or in its causes, with two other phenomena: the erosion of traditional marketplaces, which manifested itself primarily in oats and the polarization of trade in certain marketplaces (Breteuil, Grandvilliers, Clermont, Beauvais). While the growing importance of the main trade routes and the emergence of industrial flour mills may explain the seasonality in wheat, the polarization of trade in a few major marketplaces owed much more to the improvement of royal and rural roads which made the main marketplaces more accessible, including those which met local needs, as the evolution of the Grandvilliers marketplace indicates, where transactions were growing without the appearance of any seasonality phenomenon.

7. CONCLUSION

Highlighting the seasonal nature of the sale of wheat on the large marketplaces linked to the most important trade routes simultaneously makes it possible to reinterpret the notion of the hunger gap season and to establish a typology of marketplaces on solid foundations.

The surge in wheat transactions in autumn owed little to the precarious, if not desperate, financial situation of farmers, as the Labrousse model implies. Indeed, how can we explain that other cereals, which also contributed to the financial balance of farms, were

28. They are also active on the Senlis, Compiègne and Pont-Sainte-Maxence marketplaces, which are not taken into account in this study (Archives nationales [AN], F11/480).

not subject to the same priorities? How can we explain that certain areas, and not necessarily the richest ones, escaped these imperatives? The updating of a marketplace typology helps clarify this. Some are highly seasonal (those located along major commercial axes and intended to supply the industrial flour mills) others operate much more regularly over the year (those intended to supply local populations).

It is also important to stress that this distinction between marketplaces is not essentially linked to the implementation of the rail system. Several decades before the opening of the railway lines, wheat transactions were characterised by very marked seasonal phenomena, undoubtedly linked to the merchants' and the big millers' drive to secure their supplies. At first glance, it is surprising that maslin, given its importance, does not seem to be subject to the same rule. But maslin was the grain of the working classes. Its commercialization missed the boat due, at least in part, to the industrial flour milling which gradually asserted itself during the first half of the 19th century. The rhythms of its commercialization were governed by the needs of the relatively poor populations and of the small bakers in rural areas and small towns who obtained supplies more or less regularly throughout the year. We can, however, note a shift beyond 1847 in one of the important markets. In Clermont, maslin gradually conformed to the wheat model.

Moreover, it is interesting to point out that the seasonality of wheat transactions in the north-south axis concerned small and large marketplaces. This implies that the traditional partition of marketplaces between local, regional and national markets must be amended. In areas where large flour mills and large merchants operated, they operated in all marketplaces, large and small. On the other hand, where local consumption punctuated trade, the phenomenon of seasonality in wheat was almost or entirely absent, regardless of the size of the transactions, as the functioning of the Grandvilliers marketplace indicates.

As for oats, the lack of seasonality can be explained quite well. Urban cavalry and transport workers (postmaster in particular) also obtained supplies regularly throughout the year. If they procured massive supplies during the autumn, they would have had to bear the cost of storage for a year. Also, the high demand for wheat in the autumn and at the beginning of winter required the mobilization of labour for threshing. Oats could, on the contrary, be threshed all year round. Concerning this cereal, the most interesting phenomenon lies in the collapse of transactions which is linked to the establishment of commercial networks freed from traditional marketplaces. Around 1850, a very large part of the volumes traded went directly from producers to consumers.

In any case, it is clear that these developments were at work before the transport revolution of the Second Empire. Thus, the seasonality of the wheat market, far from being

the expression of a sluggish economy, an agriculture prisoner of its debts and of rents, was, on the contrary, perhaps, one of the clearest interpretations of the modernization of the grain-flour-bread sector during the first half of the 19th century.

Finally, we can draw several lessons on the methodological level. We have been able to show that it is possible to better understand the functioning of marketplaces without focusing exclusively or primarily on price developments. As recently pointed out by González Esteban (2021) in his study on international wheat trade, space and distance have a say in this. In addition, we have seen that modelling the signal in trend, seasonality and noise made it possible to highlight phenomena that did not appear easily with a simple observation of the data and to suggest original avenues of analysis –while retaining control tools to assess the reliability of this decomposition and not over-interpret the results. In the process, we were able to use these tools to control and interpret the silences or artefacts of the sources (breaks in the documentation, conflicts between the ways of measuring time). Finally, we believe that a combined use of time series analysis and spatialisation tools can generate an illuminating spatio-temporal representation of the phenomena observed.

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