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Notice introductive : **Charlotte Le Chapelain**

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« Dossier Cliométrie »

Notice introductive

C'est en 2004, avec l'arrivée de Claude Diebolt à Strasbourg, que la cliométrie a fait son entrée au BETA. Discipline jeune – elle est née dans les années 1950 aux Etats- Unis - la cliométrie se distingue par une proposition méthodologique nouvelle pour l'histoire économique. L'approche quantitative apparaît, à première vue, comme une caractéristique centrale de cette nouvelle histoire économique ; c'est plus précisément en ce qu'elle articule la théorie économique et les méthodes quantitatives dans l'analyse d'une problématique historique qu'elle se distingue. Mobilisant les outils analytiques et conceptuels de l'économie et ses méthodes quantitatives, la cliométrie a contribué à réinstaller l'histoire économique dans le paysage des sciences économiques partout dans le monde. C'est au Bureau d'Economie Théorique et Appliquée que s'effectue cet ancrage en France, par la constitution, en 2004, d'un axe qui lui est consacré. Ce n'est pas tout à fait un hasard, comme le montrent **Diebolt et Hau (2019)**, si c'est en terre strasbourgeoise que cet enracinement s'est produit. L'école cliométrique marche en effet dans les traces de deux illustres figures de l'Université de Strasbourg : Marc Bloch et Lucien Febvre. Fondateurs de l'école des *Annales*, ces devanciers ont initié une profonde rénovation méthodologique de leur discipline, rénovation dont l'article rappelle les tenants pour mettre en évidence les éléments constitutifs de la filiation qui unit la cliométrie strasbourgeoise à l'école des Annales. Nous en retiendrons ici une caractéristique, celle de défendre une analyse historique qui désormais se distancie du singulier pour assumer l'ambition d'identifier des régularités et s'autoriser même à interroger l'existence de relations de causalité entre les phénomènes historiques.

La rénovation méthodologique engagée par Febvre et Bloch durant leur période strasbourgeoise s'est notamment concrétisée par la fondation, en 1929, de la revue des *Annales d'Histoire Economique et Sociale.* Dans le même besoin de voir se constituer un espace de réflexion et de débat qui accueillerait les recherches les plus novatrices dans la discipline, s'est imposée l'idée de la fondation de la revue *Cliometrica*. C'est en 2006, toujours à Strasbourg, cette fois au BETA et à l'initiative de Claude Diebolt, qu'est née la revue. Son premier numéro est paru en février 2007. Le succès de la revue, qui compte désormais au nombre des revues académiques de haut niveau en histoire et en économie, tient à une ligne éditoriale claire, résolument attachée aux principes méthodologique fondateurs de la cliométrie et ses trois pilliers : l'appréhension précise d'un contexte historique, l'ancrage dans la théorie économique et le recours aux techniques quantitatives les plus récentes. Ceux-ci sont rappelés dix ans après la parution du premier numéro de *Cliometrica* dans le second article qui compose ce dossier **(Diebolt 2016)**. Cette dynamique éditoriale a été complétée depuis par la parution, en 2016 et 2019, de la première édition et de la seconde du *Handbook of Cliometrics*. Sa troisième édition est attendue pour 2024-2025.

La cliométrie a d'abord cheminé seule avant de s'unir, en 2009, aux historiens de la pensée du BETA dans un axe nouveau, l'axe Cliométrie-Histoire de la Pensée Economique co-dirigé par Claude Diebolt et Ragip Ege. La nature historique de leurs interrogations respectives explique certes la proximité des deux champs de recherche. Mais cette proximité n'est pas condition suffisante d'un mariage réussi. Celui-ci s'explique certainement davantage par une assise méthodologique commune, une manière partagée d'envisager l'analyse historique et ses enjeux. L'histoire de la pensée économique au BETA a le souci de tenir à bonne distance les écoles, les traditions - et davantage encore les représentations tronquées de ces écoles et traditions - pour concentrer son attention – en tout premier lieu – sur la théorie des auteurs, leurs concepts, leur raisonnement analytique et ses logiques d'articulation (voir Dos Santos, Ege, Rivot (2020) republié en premier numéro de cette collection des documents de travail hors-série du BETA). Lorsqu'elle mobilise modèles théoriques et séries quantitatives pour revisiter un évènement historique, la cliométrie renonce nécessairement à prendre pour acquises les interprétations existantes - et parfois tout à fait dominantes dans l'historiographie - dudit évènement. Là aussi écoles, interprétations, traditions restent à juste distance, à bonne proximité. Cet ADN commun - la perspective d'abord analytique- est un puissant moteur du rapprochement des deux champs de recherche désormais unis dans un nouvel axe. L'article de **Boyer, Jaoul-Grammare et Rivot (2019)** constitue une illustration marquante de ce dialogue fructueux entre histoire de la pensée économique et cliométrie. Il revisite un débat fondateur dans le développement de l'analyse économique, celui sur la liberté du commerce des grains sous l'Ancien Régime, en confrontant les arguments respectifs des partisans de la liberté et de la réglementation du commerce à l'analyse empirique rendue possible par la reconstitution de séries temporelles, de prix des grains notamment.

C'est enfin une histoire en prise avec les grands enjeux et défis de nos sociétés actuelles, une histoire qui prend au sérieux l'idée de la persistance, de la dépendance au sentier, que défend la cliométrie. Dans un article en l'honneur de Lucien Febvre, publié en 1957 dans les *Annales* et intitulé « Lucien Febvre et l'histoire », Fernand Braudel signait ces lignes :

« Dans cette élaboration de l'avenir, je pense que l'histoire peut jouer un grand rôle, si elle daigne se pencher sur le problème : à savoir comprendre, et faire comprendre, à travers l'étude de la continuité historique, le sens même de notre époque ; percevoir le présent comme un maillon de la chaîne, comme un moment dans une évolution de longue durée. Ou bien l'histoire aboutit à cet élargissement de la vision de l'historien, - et par lui de celle de ses contemporains, - ou bien elle n'est que jeu stérile, jeu de patience pour adultes érudits. »

Les deux derniers articles de ce dossier témoignent de ce que la cliométrie fait sienne cette vision de l'histoire. S'engageant sur des thématiques telles que celle du changement climatique (**Damette, Diebolt, Goutte et Triacca 2020**) ou celle du rôle de l'égalité femmes-hommes dans la croissance de long-terme (**Diebolt et Perrin 2013**), elle révèle une démarche intellectuelle qui n'écarte ni le présent, ni l'avenir de son champ de vision. Tristes perspectives pour le lecteur de 2022 que celles qui émergent de l'entreprise d'identification de liens de causalité entre les changements climatiques liés au petit âge glaciaire (1560-1700) et l'avènement de troubles sociaux (guerres, épidémies…). Ici laboratoire d'expérimentation, l'histoire intéresse nécessairement la politique publique actuelle.

Plus réjouissantes sont les perspectives liées à la mise en lumière du rôle de l'égalité femmes-hommes dans le processus de développement économique de long-terme. L'intraduisible « *female empowerment »* a compté dans la transition démographique et économique qui a ouvert sur le régime de croissance moderne. Là aussi l'histoire regarde vers le présent et l'avenir.

D'une identité singulière, l'histoire économique à Strasbourg poursuivra sa trajectoire en nous réservant, nul ne peut en douter, d'heureuses surprises. Longue vie à l'histoire au Beta !

Charlotte Le Chapelain, Mai 2022.

Jean-Daniel Boyer, Magali Jaoul-Grammare & Sylvie Rivot (2019). "The debate over grain in the 1750s. A cliometric point of view", *The European Journal of the History of Economic Thought*, 26:4, 698-737.

Olivier Damette, Claude Diebolt, Stephane Goutte, Umberto Triacca (2020). "Cliometrics of Climate Change: A Natural Experiment on the Little Ice Age," Working Papers of BETA 2020-20, Bureau d'Economie Théorique et Appliquée, UDS, Strasbourg.

Claude Diebolt (2016). "Cliometrica after 10 years: definition and principles of cliometric research", *Cliometrica*, 10, 1–4.

Claude Diebolt & Michel Hau (2019). "Un héritage des Annales, la cliométrie à Strasbourg," *Working Papers of BETA 2019-32, Bureau d'Economie Théorique et Appliquée*, UDS, Strasbourg.

Claude Diebolt & Faustine Perrin (2013). "From Stagnation to Sustained Growth: The Role of Female Empowerment," *American Economic Review, American Economic Association*, vol. 103(3), pages 545-549, May.

The Debate over Grain in the 1750s. A Cliometric Point of View [1]

Version pre-print

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1. Introduction

The French debate on grain of the 1750s played an extremely important structural role for the birth of economics in France, initiating the constitution of economics as a science (Charles 1999, Depitre 1910, Kaplan 1976). Grain supply was a central issue in Ancien Régime France.[2] In the mid-eighteenth century not only did the general condition of the economy depend upon the price of grain and the provisioning of urban markets, but also social and political order.[3] It is therefore not surprising that the nature of the regulation of the grain trade was of such central importance to political and economic debate.

In order to limit high prices, secure the subsistence of the kingdom, and maintain social order[4] the French monarchy had established an administrative system – at the time referred to as a "police"[5] – which aimed to guarantee the "social pact of

1 We are very grateful to three anonymous referees for trenchant criticism, which was of great help in our final revision of this paper.

2 The generic term "grain" includes the bread grains hard and soft wheat, spelt, rye and barley, from all of which bread can be made, and so all these grains form part of popular nutrition in France. In this article we distinguish lexically between grain, a generic term, and wheat, a particular type of grain. Grain is central to subsistence, and for urban wage-earners a necessity. The availability and price of grain determines the conditions of subsistence, even survival, for the majority of the urban population. The level of wages, the real cost of goods, the competitiveness of national products as well as the general state of the economy and socio-political stability were all thought to flow from the price of grain, the yield from the annual harvest and the way that the harvest is channelled towards urban markets.

3 For the importance of grain for political order see Tilly (1972), Kaplan (1976).

4 Fear of shortage and of high grain prices prompted the French monarchy to introduce related legislation from the later sixteenth century (Delamare 1722: 57ff.). Its importance was given emphasis during the seventeenth century, such that the fate of the French monarchy was thought to be intimately connected to regulation of the grain trade. Any interruption of supply placed in question social and political stability.

5 Delamare's *Traité de la police* (1705) identified twelve domains of intervention for police: "religion, morality, health, the supply of victuals, roads and bridges, public buildings, the liberal arts, trade, manufactures, domestic servants, the poor". The supply of victuals was an essential part of this organised administration of urban social control. The general functions of police ran from the "regulation of both wet-nurses and prostitutes to the control of guilds and prisons and the enforcement of rules pertaining to the observance of religious holidays, the cleaning and lighting of streets, and the production and sale of a host of goods and services. In other words they were concerned with every aspect of daily life, moral and material, not just the affairs of deviance and disorder". (Kaplan 1976: 11-12)

subsistence"(see Kaplan 1976: 5-11). Its importance was constantly emphasised from the end of the sixteenth century and well into the eighteenth.[6] In spite of episodes of dearth and of high prices, this system of regulation encountered little in the way of criticism before the 1750s.[7] On the contrary, it was even thought that regulation was "most valuable and most important for public order",[8] making it possible to work against speculation and the self-interested practices of merchants.[9] But in the early 1750s one section of lettered opinion in frequent contact with the merchant class[10] took up the issue of the regulation of the grain trade, and questioned its capacity to further the reforms needed to revive the kingdom. These writers denounced administrative controls and the constraints with which merchants were burdened. They also sought to justify the economic and social functions of the merchants, pointing out the prejudices and misunderstanding that they encountered. There were very many essays, pamphlets

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6 For details of the administrative organisation of grain police and its activity with respect to the commercialisation of grain see Kaplan (1976: 1-51) and Kaplan (1984). In general, urban provision was organised geographically. "The main rules for local markets were the following: 1. grain had to be sold in the market, and only in the market; 2. final consumers had priority as customers over bakers, merchants and millers; 3. officials were responsible for the use or verification of weights and measures; 4. once grain had been brought to market it could not be withdrawn unsold, whatever its condition; 5. if there was grain unsold after three successive market days it had to be offered for sale at a low price; 6. the only permitted granaries were those belonging to farmers who produced the grain, and only their grain had the right to be kept there; 7. every grain merchant had to register with the police authorities, and every physical movement of grain had to be duly declared to these authorities and recorded." (Charles 2004: 2).

7 On the contrary, these crises tended to add to the legitimacy of grain police, since more relaxed regulation would have seemed incapable of limiting the self-interested claims of corn merchants accused of speculating in cereals and consequently of playing with the lives of the poorest. There were some writings that did question the existence of the grain police – such as for example Boisguilbert (1695), but their impact was limited. Vauban, for instance, who was very critical of the French taxation system and who in this regard shared some of Boisguilbert's conclusions (Vauban, 1707: 2), departed from him over the freedom of trade in defending grain regulation (Virol, 2003, 214-15). In the view of Depitre (1910: VII), before 1750 there was little questioning of police; he regarded Boisguilbert's writings to be the exception, and not representative.

8 D'Argenson, letter of 8 November 1699, cited in M. de Boislisle, *Correspondance des Contrôleurs généraux*, t. II No. 38, cited by Depitre 1910 p. V. Nicolas Delamare's *Traité de la police*, which first appeared in 1705, likewise considered grain police to be the essential guarantee of social order which at the same time was favourable to the conditions of production and commercialisation of foodstuffs in general, and of corn in particular (Delamare 1722: 1).

9 Traders were in effect seen as members of a profession that was prone to vice. Buying and reselling goods, their profits could only come from the trickery of their prices and trumpery.

10 Debate really began with those who were close to the "Gournay circle", among them Herbert (1753) and Gournay himself, who in 1752 had been working on reform of the grain trade in his function as Intendant at the Bureau du commerce. The debate was recorded in the *Journal Œconomique*, which was also a publication with connections to the circle (see Orain 2013). On the connections between the de Gournay circle and the merchant class see Charles, Théré, Lefebvre (2011), Meyssonnier (1989), Skornicki (2011).

and periodical articles[11] along these lines, and they helped shape a developing line of economic argument (Charles 1999, Kaplan 1976).[12]

Liberalisation of the grain trade and suppression of grain police was often treated in this literature as the best means for improvement of grain provisioning, homogenising the price of grain, both in time and space, and permitting the increase of cereal production. To read Depitre (1910) or Kaplan (1976), the superiority of the principles espoused by partisans of free trade in grain over those expressed by defenders of grain regulation seems to go without saying. Principles issued from the Enlightenment, rationally grounded, contrast with principles based on tradition and the dark ages. Free trade would seem a rational necessity. Nonetheless, popular resistance and the shortages of 1768-1769 and 1775-1778 that followed the establishment of free trade raised real doubt about the validity of its principles (Thompson, Bertrand, Bouton 1988). These episodes contradicted the economic rationale for free trade. The return to the previous system of regulation only a few years after liberalization, (between 1770 and 1774, and again after the fall of Turgot in 1776), appears to demonstrate that these initial liberal arguments did not entirely succeed in persuading contemporaries, and that they were often aggressively refuted by the facts.

In this paper, our purpose is to use cliometric tools to assess the positions adopted by these two opposing sides, namely the proponents of the grain police on the one hand and the advocates of free trade on the other. In particular, cliometrics might help to assess whether this debate was economically grounded in echoing real economical problems or, on the contrary, if it was launched for other (social or political) purposes. Indeed, a number of socio-political issues cut across each other here, and this

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11 ---------- As Voltaire wrote, "around 1750 the nation already replete with verse, tragedy, comedies, opera, novels, romantic fiction, moral reflections even more romantic and theological disputes over grace and disturbances – this nation finally threw itself into *arguments about corn*." (Voltaire 1764: 54). For a synthesis of contemporary economic reviews see Steiner (1996).

12 ---------- It was this grain debate that lent shape to new analyses, especially within the Gournay circle and, later, Physiocracy. Jacques Vincent, Marquis de Gournay, was made Intendant at the Bureau de Commerce in 1751. He became the centre of a circle of writers including Véron de Forbonnais, Butel-Dumont, Cliquot-Blervache, Abeille, Plumard de Dangeul, Montaudoin de la Touche and also Turgot. These writers favoured free trade within France and so supported moves to reform grain police in order that freedom of trade might be established for grains. The emergence of Physiocracy is also related to these disputes over grain police. Quesnay's *Encyclopédie* articles - "Fermiers" in 1756 and "Grains" in 1757 – likewise denounced these regulations and promoted free trade of grains. The sect of "économistes" formed around Quesnay, was joined in 1757 by Mirabeau, and this has been widely treated as the first identifiable school of economic thought.

may have helped initiate the debate.[13]

Applying current econometric techniques to the historical database that we have assembled, our main task will be to isolate the determinants of grain prices as well as the determinants of the volatility in these prices. We will then try to focus specifically on the liberalisation issue: is it true that free trade (internal or external, depending on the periods investigated) was capable of stabilising prices? Or on the contrary, was the functioning of the agricultural sector mainly determined by exogenous factors, such as the weather? Our long-term study of grain prices will also try to establish causality between grain prices and agricultural production: were agricultural yields mainly dependent on external factors (as one might guess for a pre-capitalistic economy); or were some internal incentives towards economic growth already at work?

Our argument is organised as follows. In the first part of the paper we synthesise and reformulate the terms of a debate in the early 1750s between two opposing camps regarding the determination of the price of wheat. We also review the consequences of the arguments put forward with respect to economic growth in Ancien Régime France. This is followed by an econometric study of the path taken by grain prices in the eighteenth century in comparison with that of the nineteenth century. By isolating the factors determining fluctuations in the price of wheat our aim is to assess whether it is possible, through cliometric techniques, to resolve the debate on grain at the beginning of the 1750s, and to determine what would have been the most effective policy.

2. The Grain Debate in the 1750s: Synthesising the Positions

Despite differences among various authors, we distinguish two major trends in the grain debate that took place in France during the 1750s: respectively, partisans of grain police, and partisans of grain free trade. In practice, things are more nuanced (See Harcourt 2011, Miller 1999). First of all, police was mainly used during the periods of high prices, and the trade was freer during times of abundance. Moreover, taking account of Miller's analysis (Miller 1999; see also Bourguinat 2001, 2002) we are forced to admit that the

[13] ---------- The grain debate raised questions relating to the place of merchants in the society of Ancien Régime France, and also related to the need for the reinvigoration of French agriculture, and so was part of a wider concern with a revival of the kingdom's fortunes, touching on a much broader debate about the power and political foundations of the French kingdom. See on these questions especially Shovlin (2007).

meaning of free trade is not unambiguous during the 18th and 19th centuries. Free trade can be the right of merchants to act without being controlled by officers, to buy and sell where they want. It can also mean free internal circulation, but not free external circulation. In order to simplify the antagonism we propose two ideal-types.

2.1. The Perspective of Partisans of Grain Police and Regulation

Police has to guarantee the "social pact of subsistence" linking the King and his people (Kaplan 1976: 5-11). To ensure this, promoters of grain police in the Ancien Régime were in favour of both municipal and state regulation of the grain trade. According to Kaplan (1976: 1-51), they represented most members of the monarchic state, regional administrations and municipalities concerned with preserving the political stability of the kingdom. They also included financiers whose business was the administration of the monarchic fiscal order. Barriers to trade made it easier to tax goods (Durant 1980: 101).

More generally, partisans of grain police did not trust the practices of merchants, who they conceived as economic agents dominated by selfishness, cupidity and vice. Merchant initiatives had therefore to be kept in check. That is one of the reasons why they thought that trade could not be allowed to be free. Partisans of police believed that, without regulations and controls, the price of corn would be too vulnerable to the chicanery of merchants seeking surplus profits. According to them, merchants would not hesitate to speculate in taking advantage of any situation of shortage; even seek to create one artificially, by holding back grain in the expectation of a rise in price. One of the roles of police was therefore to counter the corrupt practices of merchants and to guarantee the stability of the social order.

Good police was therefore regulation that succeeded in maintaining affordable prices for the urban consumer, limiting the surplus profits of the merchant, and dealing with the crises created by the caprice of providence. Promoters of grain police favoured regulation and controls aimed at keeping grain in the province and channelling it to urban markets, so that sufficient grain might there be available at a reasonable price. This market model was elaborated in particular by Nicolas Delamare in his voluminous work, *Traité de la police* (1705). The justification advanced by Delamare was repeated by Le Camus in the *Journal Œconomique* (1753a, 1753b, 1754).

For those supporting regulation, the output of wheat was primarily limited by the natural fertility of soil, which was a given, a gift of God. The maximum production was consequently considered as fixed, although constantly threatened by unfavourable meteorological conditions, by damage to sown crops,[14] by the fact that land has to lie fallow, or because the production of grain has to compete against other agricultural products (Delamare 1722: p. 21).[15] Regulation had therefore to ensure that the land was properly used, and that the area under sown crops was adequate. There was also a need to find the most effective means of protecting the harvest. So there was a consequent need to make sure that growing crops were not damaged or destroyed, that harvests took place under the best of conditions, that sufficient seed was held back for future sowing, and that the harvest was properly stored (Delamare 1710: 19-31). Despite all such precautions, harvests were nonetheless constantly threatened by adverse meteorological events (hard winters, drought or very bad weather in the spring, hail, thunderstorms).

Given the limitation set upon production by the natural fertility of the land, and the constant threat of adverse weather, a secondary aim of regulation was to secure the management of grain provision so that it could supply urban markets throughout the year until the following harvest.[16] This is why strict administrative control of the grain trade was required: in order to secure the most regular possible provisioning of urban markets, to limit surges in grain prices, and to prevent their export to other provinces, or abroad. The aim of such regulation was to prevent scarcity. That explains why the regulations sought to keep back as much grain as possible in the provinces, so as to be capable of guaranteeing the constant provisioning of urban markets. Its aim was therefore to restrict domestic free trade, and to forbid external trade. Only on the occasions when there was an abundant harvest, or indeed a bumper harvest, was grain permitted to be moved to other provinces, or to foreign countries.

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14 ---------- Damage to crops being mainly done during hunts (Delamare 1722: 29), by troop movements, and by livestock (Delamare 1722: 19). Agricultural labourers therefore enjoyed royal protection, which allowed them to cultivate their land without having to endure any nuisance that would reduce their harvest.

15 ---------- Following a rise in the consumption of wine in the 1720s land devoted to grain production had to contend with the extension of vineyards. Faced with this threat, an edict of 5 June 1731 prohibited the laying down of new vineyards so as not to threaten the sown area of wheat. On this issue see Dion (1959: 593ff.)

16 ---------- See Kaplan (1984) for an account of the substantive organisation of Parisian markets that police regulation favoured.

Hence, if shortages arose following periods of poor weather, police had to intervene more directly to prevent scarcity and limit grain price increases. Police interventions were especially marked during periods of shortage or dearth, when corn was requisitioned and taken to market. At such times, police was seen as the only means of limiting a strong surge in prices. The authorities had to requisition from private granaries, and import grain from other provinces or from abroad. Strict regulation of grain markets was also used to ensure moderate grain prices.[17] (On the different practical means used by the police during the 18th century, see Miller, 1999: 25-107).

These are the main principles of the subsistence pact that bound the king and his authorities to the urban population.

2.2. The Partisans of Free Trade

Opposition to Ancien Régime police became explicit in the early 1750s. The restraints on the free flow of trade imposed by police were questioned first in Herbert's *Essai sur la police générale des grains* (published first in 1753 and then in 1754 and 1755), by Quesnay's articles in the *Encyclopédie* named "Fermiers" and "Grains', and also by various writings of the de Gournay circle (Forbonnais 1754: 554, Plumard de Dangeul 1754: 20-26, 82-101).[18] The argument put forward was that grain police did not succeed in efficiently securing urban provision in times of shortage and dearth. Administrative complication meant that any response to urgent situations was too slow, and did not foster the optimal allocation of what had been produced (Herbert 1753: 36; 1755: 112). For that reason they were in favour of free trade, essentially conceived as a matter of internal trade and as a freedom for grain owners to sell how, where, and for how much they wished (Miller 1999: 11). But police was also accused of creating prices that failed

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17 ---------- As Edgar Depitre noted, "the farmer is not able to choose the best moment to take his corn to market; he was in principle forbidden from retaining his grain for more than two years; in practice, at the least rise in price of corn the cultivator was forcibly compelled to sell all available grain without delay. Commissioners were appointed to establish the amount of grain possessed throughout the territory by merchants, landowners and farmers. … In the market … the seller was not permitted to do as he liked, if he had not sold off his corn in the course of two consecutive markets he had to pass it on to the third, even at a reduced price; sometimes a maximum price was set for him. Similarly, once a price had been set it could not be raised, not even in the subsequent market. - Sale in the market was overburdened with taxes, with duties payable for access to the town and market taxes themselves accounting, according to Baudeau, for a fiftieth or a sixtieth of the value of corn sold, in general, and one thirtieth in Paris." (Depitre 1910: XV-XVI)

18 ---------- Those in favour of free trade in grain tended to be optimistic. Contemporary enthusiasm for agriculture (agromania) and the positive results shown by new agricultural experiments explain this belief in the possibility of agricultural progress.

to properly remunerate producers. Ancien Régime police was therefore accused of creating the shortages that they claimed to be countering (Herbert 1753: 4-5; 1755: 304, Forbonnais 1754: 552, Plumard de Dangeul 1754: 100; Quesnay 1756). It was also criticized for creating price volatility, as also a price that was too low during periods of abundance, and which provided no incentive for agricultural producers. Regulation was therefore itself to blame for the small amount produced, and for weak economic growth.

Contrary to the partisans of police, those supporting freer trade did not assume that the production of agricultural wealth was fixed. They believe it was capable of improvement, as witnessed by the growth of agricultural production in contemporary Britain (Forbonnais 1754a; Plumard de Dangeul 1754: 82-101. See also Bourde 1967). They considered that the intensification of production, and agricultural progress in general, demanded grain prices that were less volatile, and which gave more to producers.

Less volatility would help agricultural producers in their estimates and expectations, and would provide an incentive to produce more. A reduction in price volatility would also suit urban consumers, urban employers (since the nominal wages that they paid would also be less volatile) and generally promote the stability of the social order. That is why, Herbert wrote, "there are two equally possible pitfalls: a decline in grain prices, and their great dearness." (Herbert 1753: 17) Quesnay also put forward the same argument in his first articles for the *Encyclopédie* (1756, 1757).[19] In his view, price stability meant that on average the urban consumer would not be harmed, while at the same time aiding the farmer in making economic calculations and contributing to the increase of his income (Charles 1998: 51)[20]. As we will see, it was thought that this reduction in price volatility would be achieved by the introduction of free trade, enabling variations in grain prices to be smoothed out. Another means envisaged by some critics of grain police was the development of private granaries, which were thought to be more efficient than public granaries.[21]

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19 ---------- For Quesnay, one feature of a good price is that it is a middling price stable over five years of production, something that Charles emphasises (1998: 49-52).

20 ---------- Quesnay was therefore in favour of homogeneous prices both in time and international space. His "bon prix" corresponded therefore to the international price within a competitive situation of complete freedom of trade.

21 ---------- The creation of magazines and stores was intended to secure more regular supply to markets, and smooth prices by holding back grain in years of abundance and releasing it for sale in those years where supply was more limited. The establishment of public granaries was first introduced by Dupin (1748) to create a more uniform grain price. The policy was questioned by Herbert (1753, 1755)

Those in favour of free trade in grain generally believed that it would reduce price volatility and permit a better allocation of the quantities produced. By removing the constraints preventing the commercialisation of grain, merchant interests – guided both by prices and personal interest – would assure that markets were efficiently supplied, while prices would be subject to less fluctuation. High prices in provinces affected by bad harvests would automatically attract grain sellers – and also grain – from the provinces where the harvest was ample, or from places the grain price was low (on this question see Charles 2008: 73-79). To remedy volatility in the grain price, and to allow cereals to be allocated more efficiently, merchants had to be freed of the administrative constraints to which they were subject.[22] The mechanism would be effective particularly on national territory, but also within an international framework (see for example Steiner, 1994). Thanks to free trade and market mechanisms the price would become more homogeneous, and the allocation of production more efficient.

If everyone did agree on the good effects of internal free trade, not all of these writers went as far as to put their faith in free international trade. Herbert, for instance, adopted a more cautious position, fearing massive exports at cheap prices if external frontiers were opened up. He did not go as far as the Physiocrats, and especially not as far as Quesnay. For them, the "bon prix" of grain would be the price imposed once complete free trade in grains was introduced. The international liberalization of commerce would contribute to this international price – higher than the French price – becoming the prevailing price in France, as soon as the measure was enacted (Charles 1998: 48).

Aside from this creation of a uniform price for cereals, those who criticised grain police were also against the way it produced persisting low prices of grain, and discouraged agricultural producers. Some, like Quesnay, suggested a policy of serving the interests of manufacturers and international merchants, limiting the labour costs of the urban proletariat and favouring a French commercial surplus (Quesnay 1757: 812).

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who queried its effectiveness. He thought that private initiative would be more likely to create grain stores than public commissioners, since they would have better information and a direct interest. On this question see Charles (2008: 75-76).

[22] ---------- Grain dealers should no longer be repeatedly checked by police; . they should be allowed to buy and sell grain wherever they could hope for a price that suited them.

They blamed police for the impoverishment of the countryside and the decline of French agriculture. All writers, from Herbert to Quesnay, via Turgot, shared the idea that the disappearance of low agricultural prices would stimulate the countryside. Moreover, a slight increase in the average price of grain would increase the profits of the farmer and give him an incentive to produce more. It would allow him to invest more easily, in a context where access to credit was problematic. Altogether, slightly raising slightly the price of grain would be more favourable to capitalist production and would provide a stimulus to agricultural production.

By preventing the collapse of prices in provinces enjoying abundant harvests free trade would also enable a price to emerge that would give a better return to producers, providing an incentive for agricultural production and so stimulating general economic growth.[23] Free trade would restrain a decline in prices fatal to agricultural production (Herbert 1755: 109-10).

Let us take stock of the arguments of these protagonists in the debate over grain during the 1750s and reformulate the terms of debate accordingly, even if we must simplify things. If the analyses of those favouring police were right, then the production of grain would was actually fixed, determined by the fertility of the soil (thought to be constant) in the long run, as well as by weather conditions in the short run. Since one can presume that, under the Ancien Régime, the level of population adapted to the level of agricultural production (this opinion is also shared by many writers on political economy from Petty to Cantillon and Mirabeau to Malthus), any short-run fall in output should be reflected in an increase in agricultural prices.[24] Under these conditions, variations in the price of grain would be chiefly determined by weather conditions. Every meteorological catastrophe produces a strong surge in prices. For these reasons, the freedom of trade must be limited otherwise the surge in prices would be more important owing to merchant's speculations. Merchants would indeed take advantage of such a situation. Moreover, supporters of police also assumed that any trend rise in price did not have a positive impact on the potential for agricultural production, which was

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23 ---------- For these writers agriculture was the foundation of the production of manufactured wealth. Among them are Herbert (1753: 1; 1755: 1-2), Forbonnais (1754a: 552) and of course Quesnay and other Physiocratic writers.

24 ---------- According the King-Davenant law, grain prices are very sensitive to quantities. Any decline in supply creates a more than proportional increase in price.

thought to be stable in the medium term. Instead, they considered that such a price rise would destabilise the social order and hinder economic growth by making all goods more expensive. Following a poor harvest, a rise in the price of corn would have harmful short and medium term effects upon the production of manufactured goods, and upon economic growth.

By contrast, for those in favour of the liberalization of the grain market, the volatility of grain prices would be limited by free trade. Bad harvests following bad meteorological conditions would admittedly generate a rise in prices, but a limited one thanks to exchanges of grain between geographical areas permitted by the free circulation of grain. Moreover, according to them, this lesser volatility and also a tendency of a smooth increase of the grain price over a long period would stimulate production. Indeed, production is mostly determined by grain prices in the preceding years. Over the long run we could therefore establish a positive relationship between the increase in the average price over several years and an increase in the volume of grain production. According to the proponents of liberalization, this growth in grain output would in addition have a positive impact upon the production of other goods, and so upon economic growth in general.

3. Empirical Analysis

In order to test these positions empirically we examine fluctuations in the corn price using various econometric methods. We seek to reveal the factors that determined the level as well as the volatility in grain prices. That is the reason why we test the possible relationships between rents, wages and the price of grain. We also examine the influence of the regulation of trade. By present-day standards, the data available for the eighteenth century are scarce and incomplete. Even more problematic is the fact that several important statistical series are missing, especially those relating to agricultural production and GDP.

We try to address these pitfalls as follows. First, it should be noted that from 1726 to 1789 Ancien Régime France benefited from an unusually long period of political stability, together with monetary stability and relatively unchanging techniques of production (Labrousse 1933: xv). This stability does help our study, in that we can focus attention on the functioning of agricultural markets as such.

Second, from 1756 to 1790 the royal administration set up "subsistence tables" so that they might follow the impact of fluctuations in cereal prices. We can also make use of this reliable information regarding the fluctuations of corn prices during that period.

Lastly, the most serious deficiency of our inquiry is the lack of data regarding corn production in Ancien Régime France. However, aggregate data are available for the nineteenth century. Could we make use of this information relating to the nineteenth century to assess our results concerning Ancien Régime France? Labrousse (1970b) makes use of the statistics available during the nineteenth century to evaluate agricultural returns during the eighteenth century. Labrousse referred to Morineau's work to argue for "a parity between the figures of the eighteenth century and those of the great inquiry of the nineteenth century [i.e. of 1840]" (Labrousse 1970b: 444).[25] Indeed, Morineau (1971) established that there was no agricultural revolution, or at least a very slow one, until the later nineteenth century. He establishes in particular that the statistics provided in the 1840 campaign sustain the argument of the lack of agricultural take-off before that time. Labrousse also argues that "contemporaries did not feel a significant change of this kind" (Labrousse 1970b: 445). Moriceau (1994) seems to make a similar case. For him, there was probably a break around 1750 regarding acceleration and the generalisation of agricultural innovations. But this agricultural take-off took about a century to fully disseminate. Before 1880, one cannot speak of a general transformation of methods of cultivation, nor of productivity (Moriceau 1994: 63). There might not have been a revolution, but there was a slow evolution during the eighteenth an nineteenth centuries. Since agricultural take-off came relatively lately in Ancien Régime France we will make use of the data available for the nineteenth century, but only up to 1890.

Following this, our analysis is in three parts. In what follows we will first present our data set. We present our statistical results in the second section, and our methodology in the third. The last section provides the interpretation of our results.

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[25] According to Hobsbawm (1962), it could be said that the French Revolution of 1789 was mainly a political revolution that did not bring about any major change in the pattern of accumulation prevailing during the Ancien Régime.

3.1 The Data

To study fluctuations in the price of wheat in France under the Ancien Régime we constructed our own database, drawing upon several sources that have until now remained unused.

First, we focus on the Parisian area during the eighteenth and nineteenth centuries, while in a second part we extend the analysis to the whole of France. We did not consider the period 1789-1815 because of its political instability. Moreover, as for wheat production, the Paris region seems to have been one of the most productive (Convert 1901), so that we can assume that the Parisian market is a significant indicator of the French market, Paris being the capital city that tended to attract grain from all provinces.

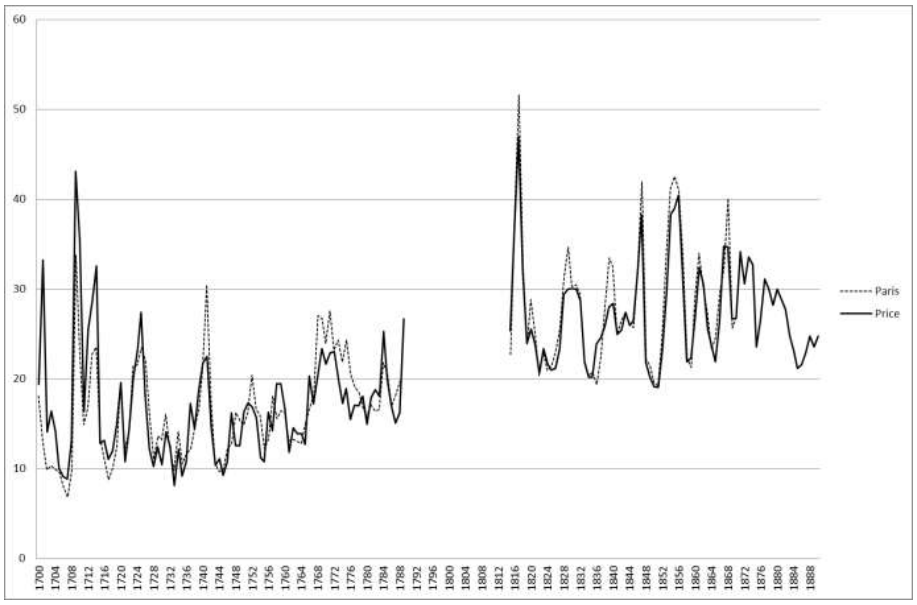
We first detail the sources for Paris, then we present the data sources for France.

The price of wheat – for the eighteenth century, the Parisian data is taken from an article by Baulant (1968) who assembled the path taken by the price of wheat in France at Les Halles in Paris from 1431 to 1789. During the period 1700-1788, quantities were measured in *setiers*, 1 *setier* being about 120 Kg. of grain.[26] Prices were an average of the four seasons, given as *livre tournoi* (1 French germinal franc = 1.0125 LT). From 1815 to 1870 the data comes from Labrousse et al. (1970), and gives the annual average price for a hectolitre (1hl is worth about 75Kg depending on the humidity level) of wheat in francs for the French Department "Seine".

Our final series therefore presents an estimate for the price of a *quintal* of wheat in *francs* from 1700 to 1870 (Fig. 1). The first part of our series has been verified and corrected by Baulant (1968) from many data sources. She provided a reliable series in *livre tournoi* (nominal value). After the Restauration, series are in franc with the official equivalence 1LT= 0,987 franc. This exchange rate rests on a "silver-metal" equivalence based on 4.5g of silver, that is to say 1F=1.0125LT=4.5g silver. This equivalence was in force until 1914.

26 ---------- Although as noted above a *setier* is a measure of volume, not of weight.

Fig. 1 Price of Wheat in Paris 1700-1890 (per *quintal* in *franc*)



For the period 1700-1789 we also use the data from the *Mercuriales* published by Dupâquier, Lachiver and Meuvret (1968) which provide for each year a summary price for each trimester (Spring, Day of St. John (24 June), Martinmas & Christmas) in two different markets (Pontoise, and where data is missing, Chaumont. (Appendix 1)

Finally, for the period 1815-1870, we use the monthly data published in Labrousse et al. (1970), who provide the monthly price of a Hectolitre of wheat in francs (Appendix 2).

From this seasonal series we estimate annual volatility (Fig. 2) of the prices of wheat and oats. We also calculate the volatility during various sub-periods in order to study the impact of free trade (Table 1).

Fig. 2 Annual volatility in Parisian prices of wheat and oats 1700-1870

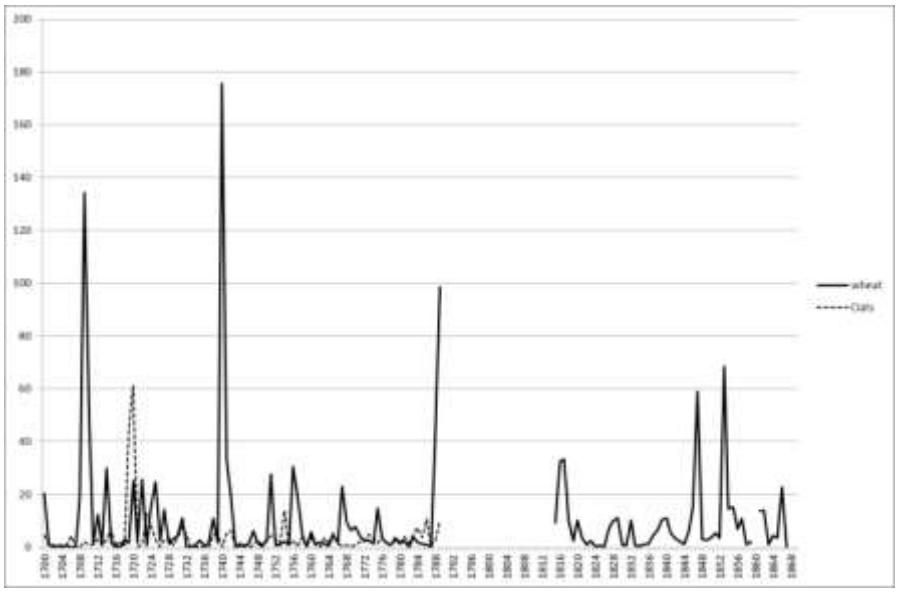


Table 1 Volatility and Free Trade for Paris and France

		France	Paris	
	Description	**Wheat**	**Wheat**	**Oats**
1700-1763	No free trade	-	52,45	13,09
1764-1770	Domestic and partial international free trade	-	39,64	3,46
1771-1774	No free trade	-	5,10	4,34
1775-1776	Domestic and partial international free trade	-	18,05	2,71
1777-1787	No free trade	-	6,15	8,45
1815-1852	Domestic free trade	22.95	34,59	
1853-1870	Domestic and international free trade	17.41	41,26	

Rent of land – For the period 1700-1788 we use the annual index of real land rentals in the Parisian area provided by Leroy-Ladurie and Veyrassat-Herren (1968) (Appendix 3). *Wages* - We use the wages of bricklayers in Paris and Strasbourg since the work was the same from town to town, and because variations in the pay of bricklayers were relatively small over time. Moreover, the prices prevailing in these two cities followed a similar path (Mestayer 1963). From 1700 to 1726 we use the nominal daily wage in Paris calculated in sous tournoi (1 LT = 20 ST) as presented in Baulant (1971); from 1727 to 1789 and for the period 1815-1870, we use the data assembled by Hanauer (1875) which gives the wage in francs in Strasbourg. Our final series provides an

estimate of the wage of bricklayers in sous tournois for the period 1700-1870 (Appendix 4).

Annual rainfall in Paris – We have reconstructed from different sources a series for annual rainfall in Paris for the years 1700-1890. For the sub-period 1700-1754 the data comes from Cotte (1774); in this period the quantity of rainfall was measured in *lignes* (1 *ligne* = 2.256 cm.); for the periods 1773 to 1788 and 1815 to 1890 the data comes from INSEE (1951) and are given in millimetres (Appendix 5).

For the entire France, data used are detailed in the table 2.

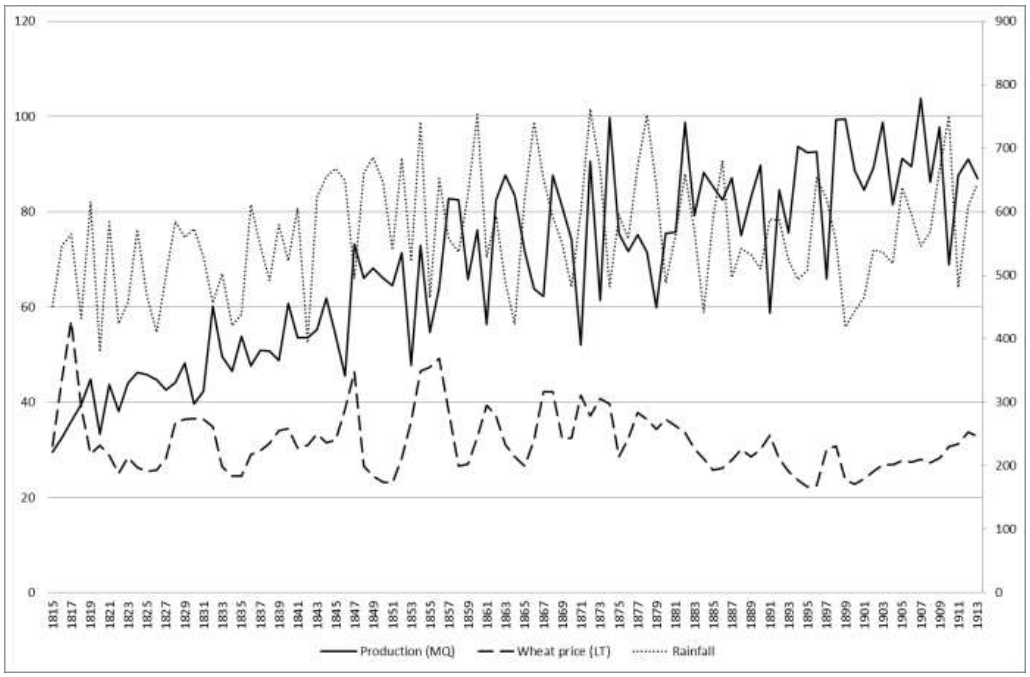
Table 2 Data for the entire France

Variable	Period	Description of the data	Sources
Wheat price	1700-1789	Annual Wheat Price per hectolitre in francs	D'Avenel, T2 (1894)
	1815-1890	Annual Wheat Price per quintal in francs	INSEE (1951)
Land rentals	1700-1890	Annual index of nominal land rentals with 1905 as the base year (Appendix 6)	Rouzet (2005)
Wages	1700-1890	Annual index of nominal wages with 1905 as the base year (Appendix 6)	Rouzet (2005)
Annual Rainfall	1700-1789	Annual rainfall in Paris	Cotte [1700-1754] INSEE [1773-1789]
	1815-1890		INSEE (1951)
Wheat Production	1815-1890	Production in millions of quintals	INSEE (1951)
Price Volatility	1815-1890	Monthly price of an Hl of wheat in francs	Labrousse et al. (1970)

Annual output of wheat – We use the data published by INSEE (1951), which gives annual production in millions of quintals for the years 1815 to 1913 (Fig. 3).

Other prices – We compare the price of wheat with the prices of other manufactured products, such as tallow for candles, wool and linen. The price series covers the period 1726-1913. For the period 1726-1789, data comes from Labrousse's price index (1933). Labrousse's figures have a base of 100 for the period 1771-1789 (Appendix 7). For the period 1820-1913, prices come from INSEE (1951) and are given in francs (Appendix 8).

Fig. 3 French Output, Parisian rainfall and the price of wheat 1815-1913



3.2 Methodology

Our analysis is in two parts. First we study non-structural relationships and especially Granger's causality links. Then we focus our analysis on shocks and the outlier methodology.

3.2.1 Non structural analysis

Granger's causality requires that we work within the framework of the non-structural Vector Autoregressive Model (VAR), introduced into historical research by Eckstein *et al.* (1984). According to them, "*The methodology of vector autoregression appears useful for studying historical series on climatic, economic and demographic variables where we do not yet have a sufficient theoretical foundation for specifying and estimating structural models*". (Eckstein et al. 1984: 295). Causality is often used in the analysis of the agricultural prices (Chevet & Saint-Amour, 1991; Gilbert, 2010) and they appear as useful tool in history (Grenier, 1995).

Non-structural VAR models have the advantage of taking into account the intrinsic structure of the series and the dynamic effects between variables, offering more reliable

analyses at the dynamic level than traditional models.[27] They also offer the possibility of considering all causal relationships between variables without *a priori* considering their potential endogeneity. In a VAR model variables are both exogenous and endogenous.[28]

Despite their historical opposition there is a link between the non-structural and the structural model, and it is easy to move from one to another (Monfort and Rabemanajara 1990, Hendry and Mizon 1993). In such models each equation describes the evolution of a variable as a function of its own lagged values and of the lagged values of other variables of the system[29].

The use of this type of model requires a prior test for various assumptions. First of all, it is necessary to work with stationary variables. Therefore we use the unit root test of Elliott, Rothenberg and Stock (1996) – that is considered more efficient (Salanié 1999) than the classic test of Dickey-Fuller (1979). Once variables are stationary, we select the optimal number of lags, which need to be sufficiently large for residuals to become white noise. Several criteria contribute to the determination of optimal lags. All of them are based on the maximization of the log-likelihood function. Next the presence of cointegration relationship(s) has to be tested (Engle and Granger 1987, 1991) and if necessary corrected (Vector Error Correction Model) in order to avoid any problem of fallacious regressions (Granger and Newbold 1976). To do this we use the Johansen test (1988). Variables are said to be cointegrated if they exhibit long-run stable relationship(s), that is, if they share common trends.

It is then possible to consider the dynamic analysis and the causality analysis (short term relationship). There are two approaches to causality (Granger, 1969; Sims, 1980), which are generally equivalent (Bruneau 1996). We choose here a Granger test (1969). The main difference between correlation and causality is the temporality. Granger-Sims causality relies on the fundamental axiom that '*the past and present may cause the future, but the future cannot cause the past*' (Granger, 1980, p. 330). It is the temporal ordering that allows dependence to be interpreted as a causal relationship (Kuersteiner, 2010). It can be explained by the fact that correlation is a symmetric

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[27] The intrinsic structure of the series is related to its identification in the ARIMA classification (Box and Jenkins, 1976); this methodology has been applied to the price of wheat by Chevet and Saint-Amour (1991) in order to analyse to market integration during the nineteenth century.

[28] Non-structural VAR models are sometimes criticised for requiring a number of variables matching the degree of freedom to be included in the model so as to avoid estimation problems (Johnston 1999), and for the lack of any theoretical foundation.

[29] For the reader interested in the presentation of the VAR methodology, see Boyer, Jaoul-Grammare and Rivot (2017).

concept without information about the direction of influence, whereas the causal direction can be established through 'the arrow of time' (Granger, 1980, p. 349).

To study the direction and sign of causality we investigate how the variable in which we are interested reacts when a change occurs in the second variable.

These developments are studied in depth by dynamic analysis, which considers the effects of exogenous variables on endogenous variables. Although VAR models consider all the variables exogenous and/or endogenous, the dynamic analysis requires that innovations be considered as exogenous variables. The simulation of shocks on innovations for each variable helps us to understand how (impulse response function), and to what extent/proportion (variance decomposition), other variables are affected. In other words, we observe how a simulated shock on the variable X affects the variable Y.

3.2.2. Shock analysis

As an extension of the causality pattern, we introduce here an alternative econometric technique for shock analysis: the methodology of outliers.[30] It consists in the detection of atypical points affecting the evolution of a time series. Contrary to the VAR analysis where shocks are simulated, the outliers methodology relies on real shocks; it is therefore more suitable for historical analysis.

In this paper, three main outliers are classified as:

– ---Additive Outliers (AO) that affect only a single observation at some points in a time series, and not its future values.

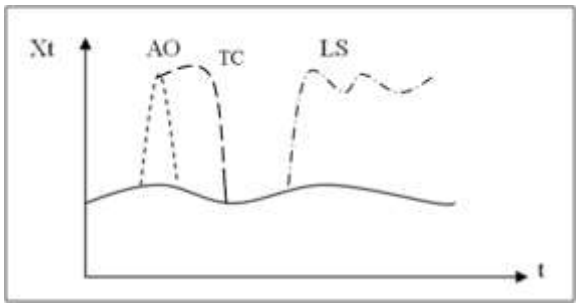
– ---Level Shifts (LS) that increase or decrease all the observations from a certain time point onward by some constant amount.

– ---Temporary Changes (TC) that allow an abrupt increase or decrease in the level of a series which then returns to its previous level rapidly and exponentially.

It is considered that AOs are outliers that are related to exogenous and endogenous changes respectively in the series, and that TCs and LSs are more in the nature of structural changes. TCs represent ephemeral shifts in a series, whereas LSs are more the reflection of permanent shocks (Figure 4).

30 ---------- For the reader interested in the complete mathematical and statistical presentation of the outlier methodology, please see Darné and Diebolt (2004, 2006).

Fig. 4 Different outliers impact on a time serie Xt



3.3. Results

To avoid the French Revolution distorting our findings unduly we analysed two different periods: firstly 1700-1789, and secondly 1815-1890 (1870 for Paris). For each sub-period we first test bivariate causality relationships; when causality tests highlight many bivariate relationships we build a global model, taking into account the different variables. We then present the variance decomposition (the degree of the variance of one variable due to the variations of another) and we analyse what the reaction of a variable is when a positive shock is simulated on other ones (impulse responses).

3.3.1. Causality analysis

First of all, it must be noted that ERS unit root tests establish that, whatever the period, the wheat price in France is a stationary process;[31] for the Parisian market, tests reveal a TS process for the eighteenth century (with a slight positive trend) and a stationary process for the nineteenth century.[32]

Secondly, Johansen tests show that there is no cointegration between variables; this means that there is no long-run stable relationship between the wheat price and other variables. This underlines the importance of the historical and economic context in the development of the series; this context generates events conditioning the evolution of the series (Darné and Diebolt, 2006).

Causality results (short term relationship) show that the path of the Parisian wheat price is influenced by one component: the annual rainfall (Table 3).

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31 ---------- For the period 1700-1789 tests indicate that rainfall in France is a TS process; rentals and wage indexes are DS processes, but they are no cointegrated. For the period 1815-1890, we find the same results, except for wages, which appear as a mixed process (DS and TS).

32 ---------- For the period 1700-1788 ERS tests and the Johansen test highlight the same results for Paris as for France; for the period 1815-1870, rainfall and wages are TS processes, whereas rent appears as a DS process.

Whatever the period, the annual amount of rainfall has a positive causal impact upon the wheat price; this means that the rainfall and the wheat prices follow a similar pattern: an increase in annual rainfall implies an increase in wheat prices. Indeed, a rainy year implies lower production, and so an increase in prices. On the contrary, a drought implies a decrease in prices.

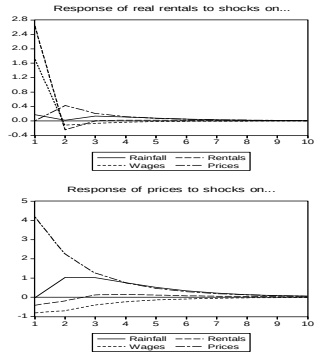
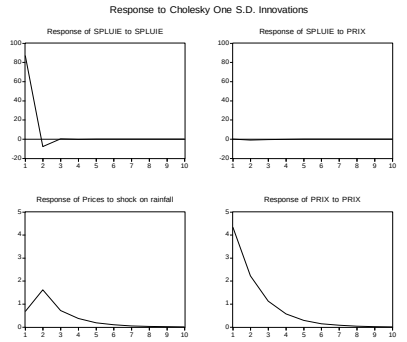
During the eighteenth century it appears that an increase in prices essentially benefits real land rentals. Indeed, we underline a positive causal effect from prices to land rentals: an increase in prices implies an increase in rentals. However, this influence is quite small (2.3%).

This is confirmed by the analysis of France as a whole (Table 4), combining wheat prices, annual wheat production and annual rainfall over the period 1815-1880, showing that the rainfall affects the wheat price through its effect upon output.

What can be established for the second period (because of a lack of data before 1815) is that the second variable influencing the wheat price is agricultural rents. However, this relationship only appears in a bivariate model, and when we take into account the previous ten years; so it cannot be considered robust.[33]

33 ---------- When we take into account all variables all the relationships remain, whereas the relationship from rent to prices disappears; this is due to the optimal lag chosen to build the model. In all bivariate models the optimal lag equals 2, whereas in the global model the optimal lag is 1. This underlines the weakness of this relationship.

Table 3 Causality analysis and variance decomposition for Paris

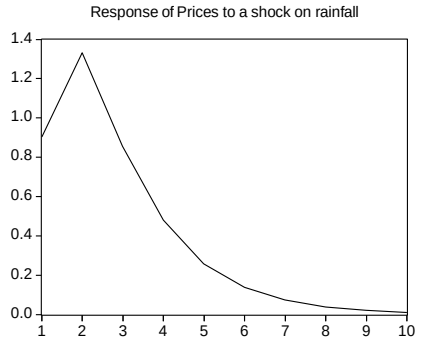
Period	Variables	Causality relationships	Variance	Impulse response
1700-1788	Wheat price, annual rainfall, real land rentals, nominal wages[34]	Rainfall (+)→Wheat price (+)→ Land Rentals (1) (2)	(1) 10%* (2) 2.3%**	
1815-1870	Wheat price and wages	No relationship		
	Wheat price and annual rainfall	Rainfall (+) → Wheat price	13%	

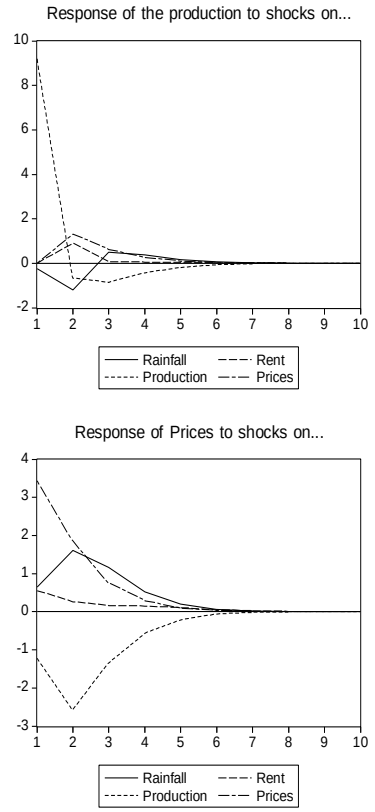
* 10% of the wheat price variance comes from variations in annual rainfall

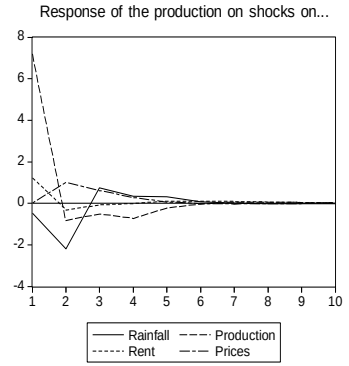
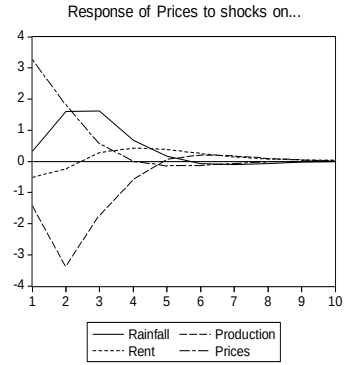
**2.3% of the land rentals variance comes from variations of the wheat prices

34 ---------- Granger tests on bivariate causal relationships show that i) there is a positive causal relationship from rainfall to prices; ii) there is a positive causal relationship from prices to real land rentals; and iii) there is no relationship between wages and prices. Therefore we build a global model taking into account rainfall, wheat prices and real land rentals.

Table 4. Causality analysis and variance decomposition for France

Period	Variables	Causality relationships	Variance	Impulse response
1700-1789	Wheat price and nominal wages ; Wheat price and nominal rent	No relationship		
	Wheat price and Parisian annual rainfall	Rainfall (+) →Wheat price	14%**	
1815-1890	Wheat price and annual rainfall	Rainfall (+) → Wheat price	16%	
	Wheat price and nominal rent	Rent(+) → Wheat price	[7% ; 20%)	
	Price and	Price (+)→ production	7%	

	production	Production (-) → Wheat price	31%	
	Wheat price and nominal wages index	No relationship		
	Rainfall, rent, production and wheat price	Rainfall (+)→ Price (+)→Production (-)	Price variations are due to 33% of the variations of the production, 15% of those of the rainfall and of 1.3% of those of the rent	

1815-1880	Rainfall, rent, production and wheat price	Rainfall (-) →Production + - Price	Price variations are due to 44% of the variations of production, 15% of those of rainfall and of 2% of those of rent; 9% of the production variations are due to rainfall.	 

3.3.2. Outliers detection

We complete our study with outlier analysis on the wheat price series (Tables 4 and 5) and on its volatility (Tables 6 and 7). Contrary to the previous shock analysis, here shocks are not simulated: they are real.

This analysis seems to confirm our previous results concerning the impact of meteorological variables on wheat prices. Even if the causality analysis does not show an impact of temperature on wheat price, it does seem that colder winters have a significant impact on wheat price. According to Le Roy-Ladurie (1960), cold winters favour wheat production, except for very cold winters. However, a rainy winter is always unfavourable to production. In the Seine and Oise "the normal winter being 3.8 degrees, the years when the winter temperature was less than 3 degrees were succeeded by large harvests, while those where the winter temperature was more than 5 degrees were followed by poor harvests". (Sanson 1929: 458) By contrast, a rainy winter has a very bad impact upon the following harvest.[35] According to meteorologists, 1708-1709 is one of the coldest winters (Legrand and Legoff 1987).[36] The winter of 1708-1709 was very cold and rainy, and there were 29,300 deaths in Paris. On 6 January 1709 the temperature fell below -15°C and remained there for 11 days. On 13, 14 and 18 January temperatures fell to under -18°C, and reached -21°C on 13 January. Snow fell on the 8, 11, 12 and 15 January. The thaw began around 25 January and it also began to rain. At the beginning of February 1709 and at the end of that month two new cold spells struck France (the temperature reached -13.5°C on 24 February); during the intervening period it was warmer, with temperatures higher than 12°C. This alternation of frost and thaw was catastrophic for plants,[37] and especially for crops (Cotte, 1774).

Table 4 Outliers detection for Parisian wheat prices

Year	Type	Value	Effect	Event
1709	TC	1.2	Temporary	Very cold winter*

*Rousseau (2013)

35 ---------- In France less than 540 hours of sunshine in spring and a temperature of less than 9 degrees can have an adverse impact upon the harvest (Sanson 1929: 34).

36 ---------- A hard winter is considered to be one with an average temperature below 2 degrees Celsius, and with more than 40 days of frost.

37 ---------- Following the winter of 1709 almost all French vineyards were destroyed, except those in the Mediterranean region.

Table 5 Outliers detection for French wheat prices

Year	Type	Value	Effect	Event
1709	TC	1.2	Temporary	Very cold winter*
1848	LS	-0.58	Permanent	Revolution

*Rousseau (2013)

Table 6 Outlier detection in the volatility of Parisian annual wheat prices

Year	Type	Value	Effect	Event
1709	AO	127.2	Temporary	Very cold winter*
1710	AO	43.2	Temporary	
1740	AO	169.2	Temporary	Very cold winter*
1788	AO	38.8	Temporary	
1816	TC	28.2	Temporary	
1847	AO	52.3	Temporary	Very cold winter*
1853	AO	59.8	Temporary	Free Trade
1866	AO	20.2	Temporary	

*Rousseau (2013)

Table 7 Outlier detection in the volatility of French annual wheat prices

Year	**Type**	**Value**	**Effect**	**Event**
1816	TC	10.7	Temporary	
1817	AO	16.5	Temporary	
1832	AO	7.7	Temporary	
1847	AO	**47.5**	Temporary	Very cold winter*
1853	AO	24.3	Temporary	
1854	TC	3.4	Temporary	
1857	AO	16.3	Temporary	
1866	AO	7.01	Temporary	
1868	AO	17.5	Temporary	
1873	AO	4.5	Temporary	
1874	AO	22.03	Temporary	

*Rousseau (2013)

3.4. Interpretation

According to Le Roy Ladurie (1966, 1977) Ancien Régime France was an economy without growth. There were many reasons for stagnation, and it has been the object of many studies.[38] The Malthusian idea that wages and population were related inversely has been employed to explain this absence of economic growth, demographic growth

[38] See for example Labrousse (1933), Hobsbawm (1962), Kaplan (1976) and Hoffman (1996).

being used to explain the absence of economic growth. It would also be possible to cite the inherent defects of the institutional structure of Ancien Régime France: a society based upon rental payments, with an inefficient fiscal system, with individual initiative discouraged in the productive sphere. The low level of agricultural surplus and the associated low level of capital accumulation likewise would explain the limits to economic growth.

---------- Our idea is that behind the debate of the 1750s between the proponents of the "grain police" and their opponents, one can find an issue regarding the growth pattern of a pre-capitalist society. The grain price was of such critical concern to contemporary political authority that it was the subject of very detailed studies by the King's inspectors (Kaplan 1976). It must therefore be possible to isolate traits particularly characteristic of a precapitalist economy and which can be used as explanatory factors for the absence of growth that was observed in Ancien Régime France.

Our discussion of the results presented below will turn on two questions: first, the specific question of volatility in wheat prices, and the role played by regulations (police or free trade); second, a causal explanation of the price of wheat. For each of these questions we will try to evaluate the positions taken by the partisans of grain police and by their adversaries, those who advocated a free market in grains.

3.4.1. Volatility in the Wheat Price and the Question of Free Trade

As we have shown, climatic conditions had a very marked impact upon the price of wheat. Accordingly, we should consider the possibility that this very strong volatility in the price of wheat reflects above all the speculative activities of sellers able to wait until the end of the season (the notorious gap between two years of harvest) so that they could benefit from very high prices in the years following poor harvests. The phenomenon of stock-building alternating with running stocks down tended to accentuate price fluctuations which would in turn make supply relatively inelastic, although in a more moderated form.

This point seems to support the arguments made by writers like Boisguilbert (1695, 1705) or Delamare (1705) when they pointed to this highly speculative character of grain markets. For the final consumer who had no substitute at his or her disposal, and who was not able to build stocks during periods of low prices; for the small cultivator, the small farmer or the small landowner unable to wait for prices to rise

towards the end of the season to sell his crop at the best price (following a poor harvest), or not able to wait for prices to rise and build stocks while prices were low (as happened when output was higher and meteorological conditions good) – for all these parties price fluctuations were extremely harmful to their living standards, in both relative and absolute terms. It was the largest landowners and major merchants who were in a position to speculate on variations in prices by stocking up or selling off stocks, and who did therefore benefit from this volatility.

What about the opening up of trade? Did the free circulation of wheat, both domestic and external, contribute to price stabilisation? Here, the issue seems to be far from definitely settled. It is from 1700 to 1763 that the volatility in the price of wheat is the greatest. The domestic and partial international free trade that follows from 1764 to 1770 significantly dampens the volatility of prices. But for the other periods, just the reverse is true: barriers to trade dampen the price fluctuations during the periods 1771-74 and 1777-87. Strikingly, the volatility is higher after 1815 than during the pre-revolutionary period.

Depending on the periods considered, our results tend to confirm or to invalidate the argument that free trade would have little impact upon the reduction of short-run price volatility during the Ancien Régime and into the nineteenth century. As it is shown in Table 1, the first period in which trade was liberalised (1764-70) was linked to reductions in price volatility, especially when liberalisation included foreign trade. But for latter periods, fluctuations are lower when the market is regulated. In fact, for the last periods our statistical results seem to provide support for the arguments advanced by supporters of grain police.

We can conclude finally that grain regulation was not of critical significance in Ancien Régime France. Instead, we find that volatility, but also perhaps the entire organisation of grain production and marketing, were essentially dependant on meteorological conditions. And so the question now is: what are the factors that explain the price of grain?

3.4.2. Factors Explaining the Price of Grain

Unfortunately, there are no figures available for agricultural production in Ancien Régime France; statistics were only collected for the prices in different markets, entirely ignoring the information that could have been collected about the volumes transacted. For the Pontoise market, for instance, statistics were collected, but only from 1752 to 1761. The royal authorities were less concerned in collecting information related to fluctuations in agricultural production than they were about the volatility and heterogeneity of prices prevailing in different markets.[39] We do nevertheless have aggregated data on the production of wheat for France from 1815 onwards, data that we use to test the arguments advanced by those participating in a debate that took place during a later period.

During the long period of the Ancien Régime (from 1700 to 1789) our analysis of causality, our decomposition of variance, as well as the analysis of the atypical intervals discussed in the preceding section demonstrates the way in which the price of wheat depended very strongly on climatic conditions, especially that of rainfall. Except for especially harsh winters, it is primarily the quantity of rainfall (during spring in particular) that influences price. The causal mechanism runs as follows: meteorological conditions have a determining influence upon production, which in turn determines price. Given the very high degree of inelasticity of demand, adjustments in quantity demanded were quite small because of the crucial role of wheat in the popular diet and the lack of substitutes. This tends to lend support to the arguments of those in favour of grain police, for whom agricultural production was driven mainly by exogenous factors independent of market mechanisms.

All the same, the data which we have for the period after 1815 allows us to modify this perspective a little. Our analysis of the more recent period shows up a more complex relationship than a simple negative impact of rainfall upon production, and a positive impact upon price. While it seems that production influenced price negatively (good harvests led to low prices), prices did have a positive impact upon production. Strikingly, production has a direct impact on the price level, while the latter influences

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39 ---------- "The collection of agricultural statistics, and especially price statistics, was not done by the Inspector General in a disinterested manner: it helped develop an understanding of varying fiscal capacity, about the volume of agricultural production according to harvest conditions and its product, and according to the prices arising. The outturn of the harvest could only be estimated in a very approximate manner; but price conditions reflected with much greater sensitivity and precision, other things being equal, the supply situation together with local production, and they gave an explanation of the emergent surplus from the fluctuations in recorded market prices." (Labrousse 1933: 19)

the former with some delay of about two years (see table 4). There were certainly some incentive effects here of the kind advanced by those who are opposed to structural low prices of grain. High prices encouraged greater effort in production and the adoption of progressive techniques and of more capital, but also the extension of the sown area. In this context, the production of wealth is not entirely depended on meteorological conditions. An endogenous factor, the level of price, played its role and determined agricultural growth.

Regarding the role played by the costs of production, our empirical results show that the price of wheat is influenced neither by wages nor by nominal rent, in the case of Paris as well as for France considered as a whole, until 1880.[40] But yet we have shown that the price has a positive influence on *real* rent in the case of Paris (for which we have data). This positive relationship between the price of wheat and *real* rent is a good reflection of the ability of the landed proprietor to take advantage of his market power in the course of price fluctuations.

4. Conclusions

Our results might be thought tentative and partial. A reader who expects trenchant and unquestionable results will remain disappointed here, since we find neither totally in favour of one or the other side of the debate. The question is therefore whether one should abandon any attempt to test economic reasoning in a long term historical perspective. To put it slightly differently, the issue is whether cliometrics can help us illuminate economic debates, despite the inevitable limitations of such an approach. Our claim is that cliometrics can provide us with significant assistance in testing economic reasoning. More generally, the indications given to us by cliometrics lead us to question the socio-historical frame that has been provided for the emergence of economic debates. Cliometrics can therefore be of real help for historians of economic thought.

In this article we have shown that both the price of grain and grain production were mainly determined by meteorological hazards during the eighteenth and the nineteenth centuries. More precisely, rainfall more than temperature determined both the level of the wheat price and its volatility

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40 ---------- A relation between wage and price also appears, but with a significance of only 11%.

---------- Thanks to our econometric analysis, we have shown that the cost of production was not the essential determinant of grain price. Indeed, during the eighteenth and the nineteenth centuries the price of wheat was neither determined by the nominal rent nor by wages. The fact that meteorological factors still strongly influenced the price of wheat during the nineteenth century is an indication that the dissemination of innovations in the agricultural sector (which would have weakened the relationship between rainfall and price) was very slow, and that grain had as yet no real substitute in popular nutrition. In pre-capitalist systems based upon agriculture the prospects for economic growth were extremely dependent upon exogenous factors.

But yet we have also been able to demonstrate that the output of wheat in Ancien Régime France was positively influenced by prices, with a significant delay that is worth emphasising. The incentive effect of high prices can be seen as a relationship that supports the arguments advanced by those who were in favour of the liberalisation of grain markets, especially the Physiocrats or Herbert. Prices that are too low are not favourable to grain production. High prices provide incentives to produce more.

Our analysis also shows that free trade has a variable impact on the volatility of grain prices. Only in 1764-1770 does free trade clearly limit the volatility - as the opponents of the police of grain supposed it would. But it was not the case just before the Revolution, nor during nineteenth century, when volatility increases with free trade. So, contrary to economic reasoning, free trade is not always a viable solution to limit volatility. Regulations can be a means to limit speculation. Does this mean that grain regulation had no effect at all on volatility, or on prices? Here the issue cannot be finally decided either way, since we do not have precise data on production and on the quantities of grain that circulated (or were prevented from circulating) in Ancien Régime France. If grain regulations had no critical impact on volatility and prices, then our analysis suggests that the grain debate can best be understood as a debate about changing the rules according to which the products of agriculture were shared among the population and between classes. In a pre-capitalist economy where agricultural production is at least around half of all output (Ridolfi 2016), and where grain is a central part of this production, the issue of price fluctuation plays a crucial part in the stability of the social and political system as a whole, and not only for the strictly economic sphere. The prime beneficiaries of such fluctuation have to be identified. The distribution of wealth, as also the market organisation and regulation, were quite

logically the object of class conflict between landowners, farmers but also merchants and urban manufacturers and workers. It is all the more probable that during the period 1726-1789 there was a conflict between classes over the division of the agricultural product. Rentiers captured the greatest part of the rise in the price of wheat, with the average day labourer lagging behind and gaining a smaller proportion of this general rise. Farmers themselves seemed to have benefited the least from this movement; this impeded their ability to accumulate, and was in itself no kind of incentive to expand production.

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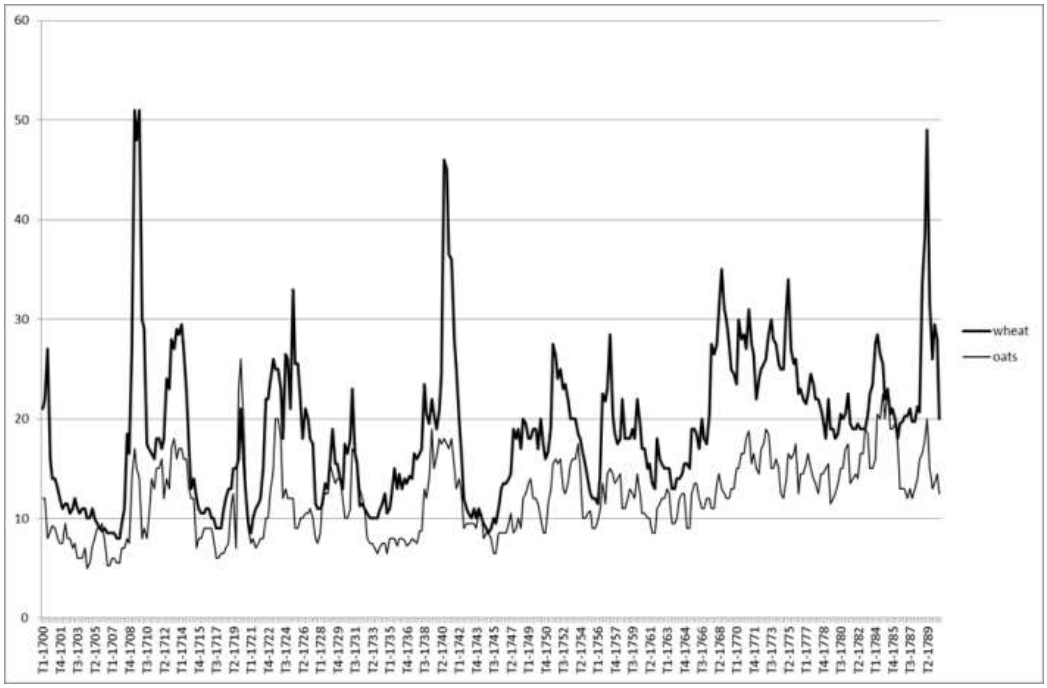
Abstract

During the 1750s the grain debate agitated French opinion and contributed to the creation of the new science of political economy. It was notable as a confrontation between those who defended the regulation of commerce and partisans of free trade. In this paper we test some of the arguments made at that time, using cliometric techniques which we apply to existing data as well as to new, reconstituted data.

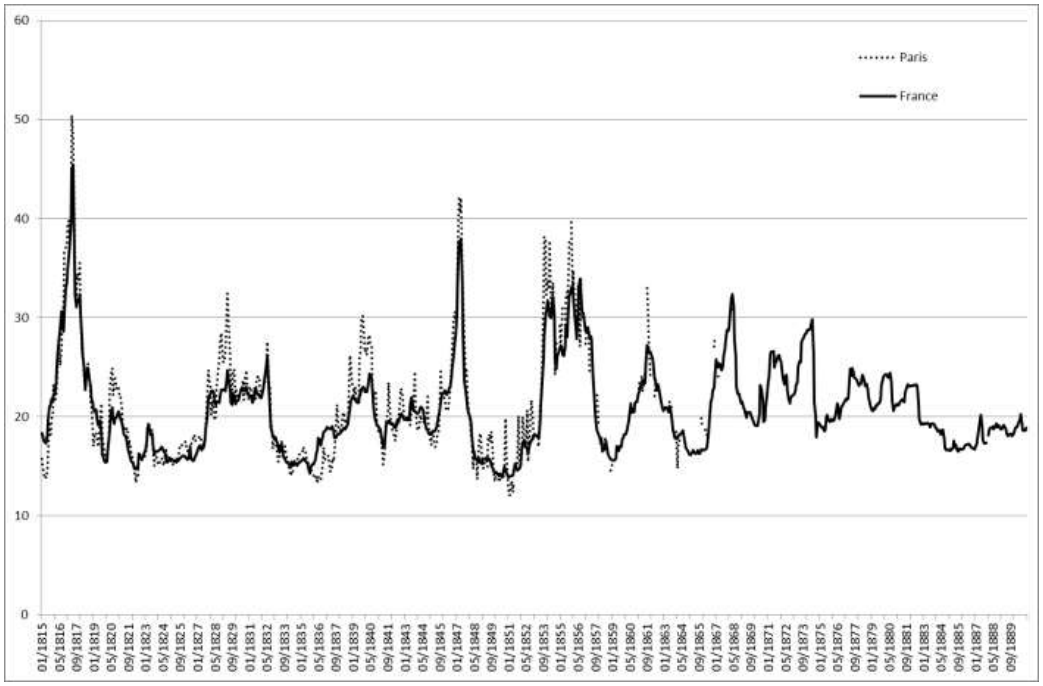
Key words: growth, price of wheat/corn, free trade, the de Gournay circle, Physiocracy, grain police

Appendix

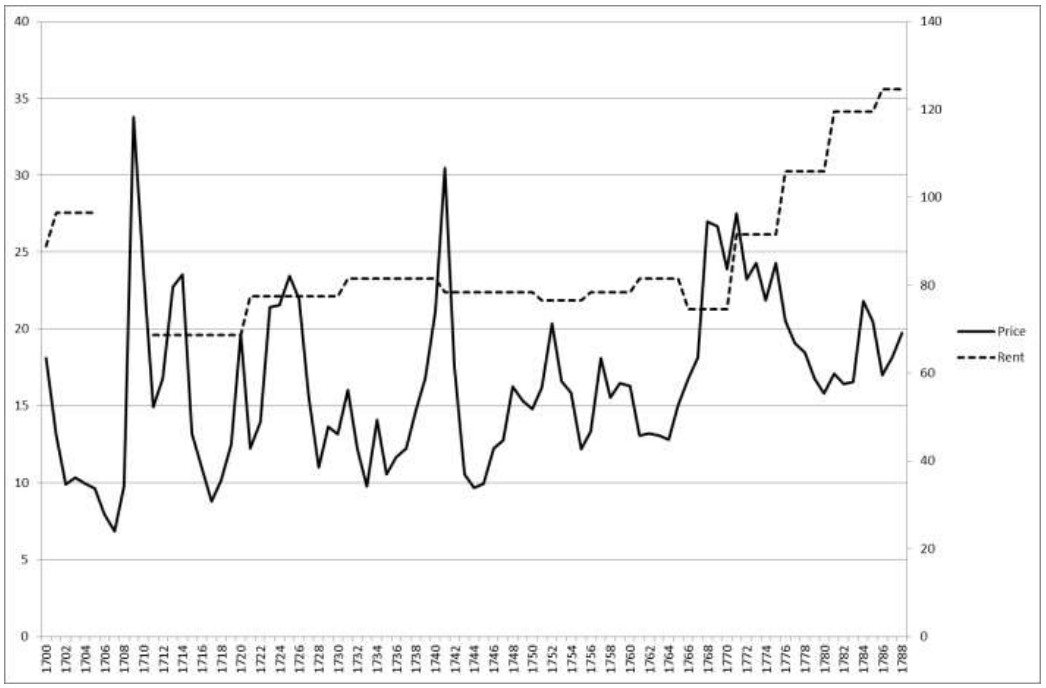
Appendix. 1 Quarterly prices of wheat and oats in Paris 1700-1790 (per *setier* in *livre tournoi*)



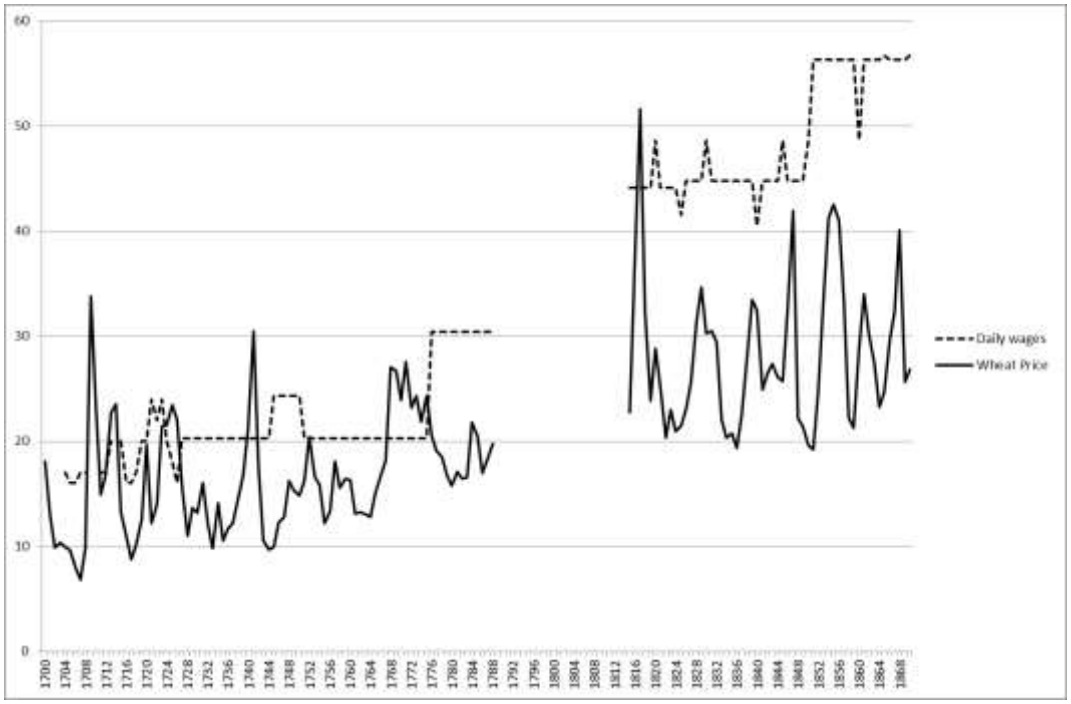
Appendix 2. Monthly wheat prices 1815-1890



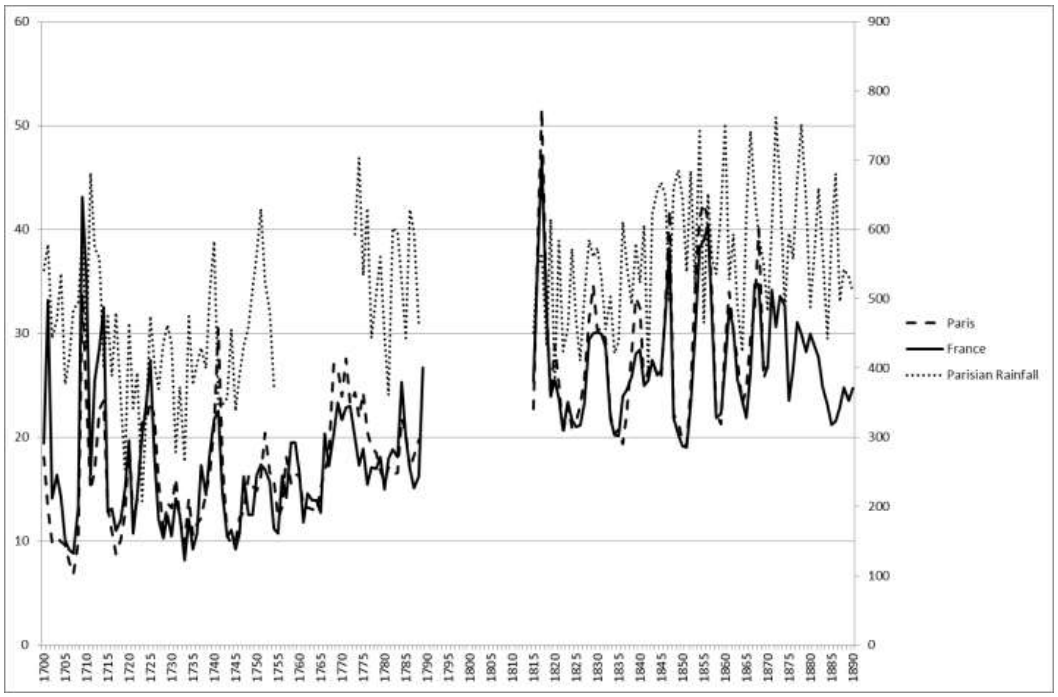
Appendix 3. Prices and annual index of Parisian real land rentals 1700-1788



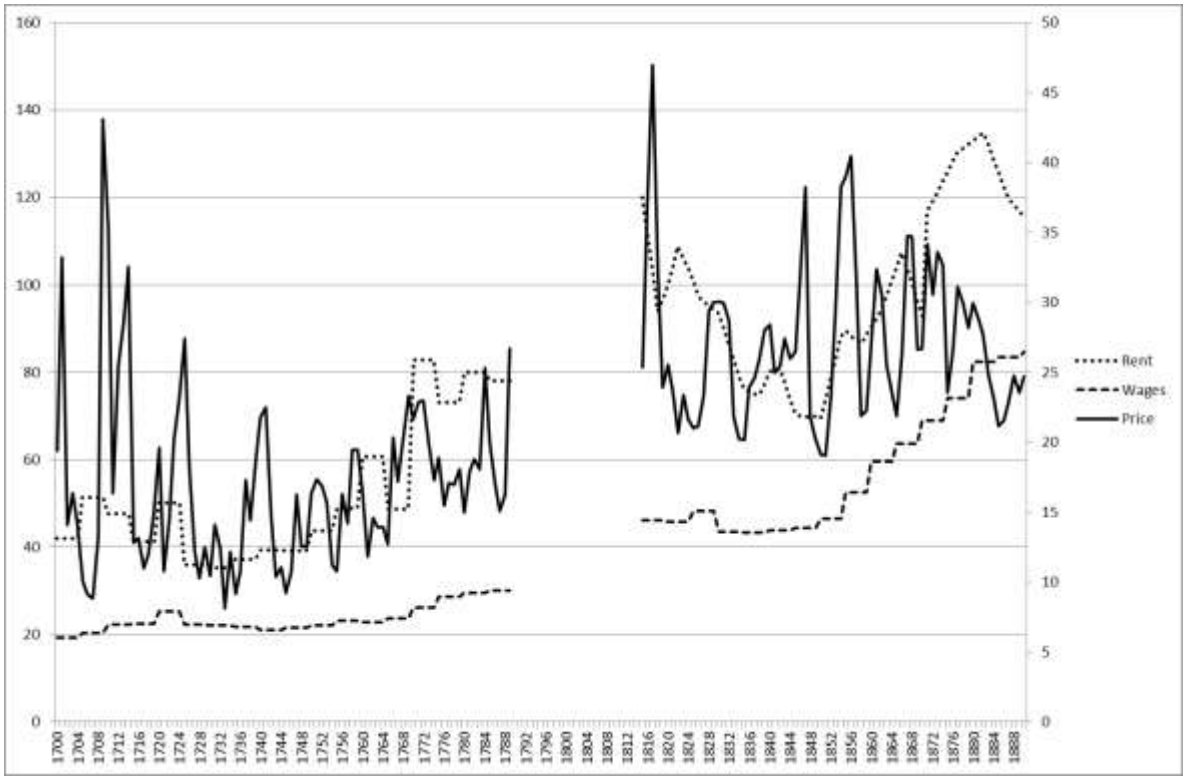
Appendix 4. Wheat prices and wages in Paris 1700-1870



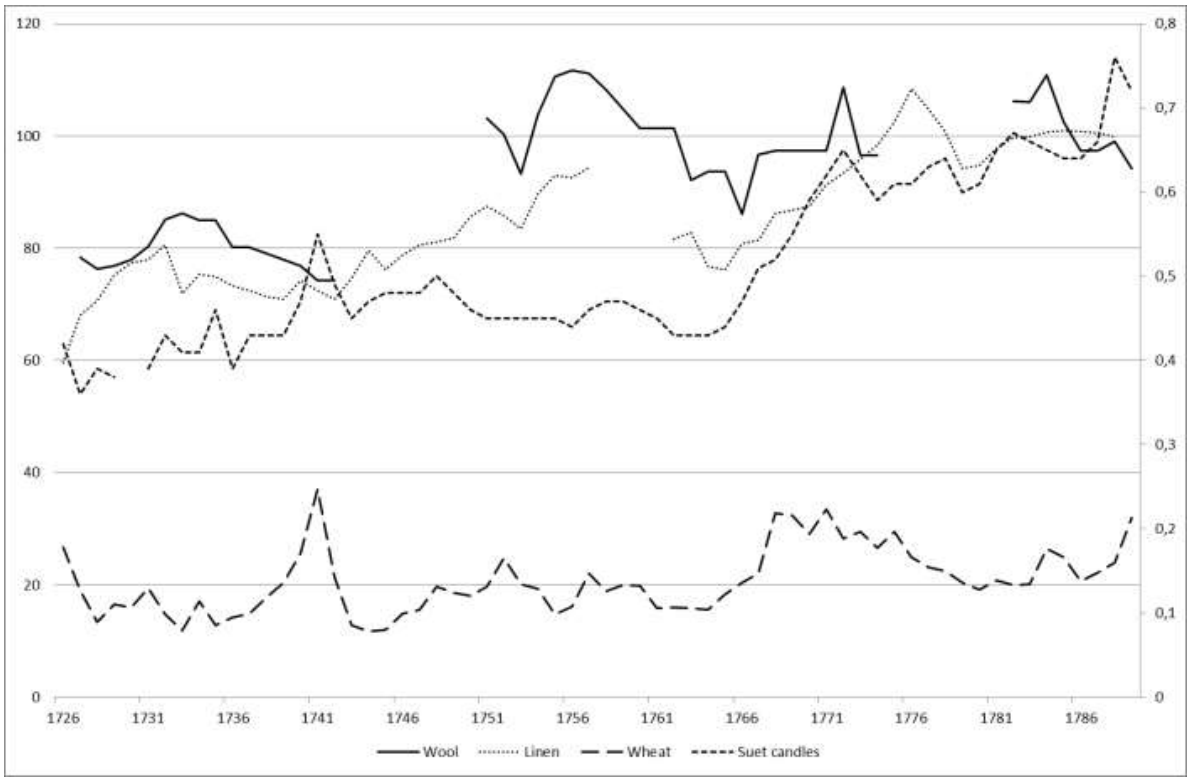
Appendix 5. Wheat prices (in *francs*) and Parisian rainfall (mm.) 1700-1890



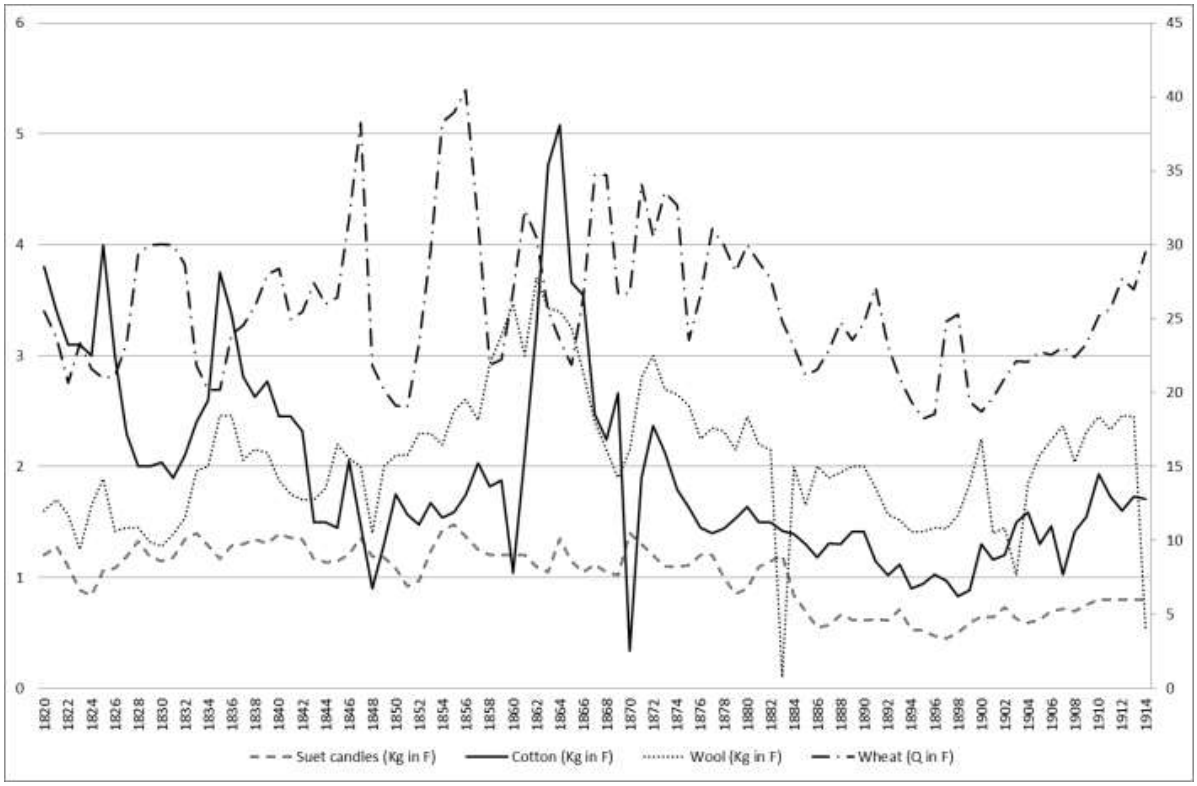
Appendix 6. Annual index of nominal land rentals and nominal wages and wheat prices in France 1700-1890



Appendix 7. Price Index 1726-1789



Appendix 8. Prices 1820-1913



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EDITORIAL

Cliometrica after 10 years: definition and principles of cliometric research

Claude Diebolt[1]

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"[…] cliometricians have been explaining to their colleagues in history the wonderful usefulness of economics. It is time they began explaining to their colleagues in economics the wonderful usefulness of history. […] It is no accident that some of the best minds in economics value it highly. What a pity, then, that the rest have drifted away."
(D. McCloskey, "Does the Past Have Useful Economics?"Journal of Economic Literature, 1976, p. 455).

I define cliometrics as the quantitative projection of social sciences in the past. Cliometrics is, more precisely, the combination of causal explanations embedded in (economic) models, with or without counterfactual speculation, in order to screen the relative importance of various factors, i.e., of forces (in natural sciences) believed to have been operative in a given historical situation. Assessment of cliometrics can proceed only if the nature of causal explanation has been resolved. Is causation only correlation and causal analysis the search for the maximum of consistency of correlations? Or is causation observed correlations, explained in terms of forces or mechanisms at work assuring that similar causes must be followed by similar effects? In response to the cliometric research agenda, methodology (the study of methods) or the methods themselves employed by a science or a discipline (here in history and in economics) become central.

Over the last 10 years, *Cliometrica*, the journal of historical economics and econometric history, follows the cliometric ambition to understand and to explain the complexity of economic growth phenomena in two different but related fields, history and economics.

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Cliometrica's mission is:

- To avoid the development of economic history and measurement without economic theory. The journal displays also a clear line between applied economics and cliometrics. Cliometrics in *Cliometrica* is history, (economic) theory and statistics/econometrics.
- To introduce modern quantitative methods in social sciences. Cliometrics for history as experimental economics for today? Yes. Economic actors are not passive: game theory, analytic narratives. Cliometrics as pure mathematics? No. Cliometrics as physics? Yes. Linking economic theory with observed stylized facts or "laws" to understand and explain how a/the system worked. Cliometrics as biology? Yes. Evolutionary perspective. Cliometrics as political philosophy? Yes. Designing optimal institutions instead of describing the world. Culture and institutions do matter… history matters!
- To produce new statistical datasets, i.e., improving the quality and the controlling of the databases in the tradition of the national institutes of statistics.
- To use the counterfactual approach. First, to underscore the importance of a particular causal factor that was operative in the situation under consideration. If slavery had not existed in the USA, then the Civil War would not have been fought. Alternatively and through the concept of social savings, if railroads had not existed in the USA, then the gross national product in 1890 would have been less than it actually was. Second, to add (rather than to subtract) a particular causal factor and speculate about the impact which that mentally added factor might have had. What if Nazi Germany had won World War II?
- To discuss the multiplicity of erroneous representations in economic history (path dependence, myths, falsifications, etc.).

Cliometrica is concerned with the unique, but also with the average. The ultimate goal, or at least one of its ultimate goals, is to find the underlying regularities in the interaction of economic and social variables, of production and distribution through time.

Since 2007, the articles published in the journal are the result of the combination of "clio" (the muse of history) and "metrics" (the art of measurement). The procedures, concepts, mental rules, postulates, analytical techniques, personal beliefs, generalizations, etc., implemented in cliometric research became therefore central to the journal, also because axioms, postulates, premises, assumptions, and hypothesis were the starting points of most articles, in history to designate the general frame of reference in order to catch the complexity for a field of inquiry, in economics to designate the statements accepted as true without necessarily establishing their complete validity.

Defining the papers published in *Cliometrica* since 10 years is finally as simple as remembering again and again the analytical devices or principles now being employed in cliometrics at the international level.

- Cliometric research is more and more embedded in economic models. The models in turn are combined (or not) with counterfactual speculation to assess the importance of various causal forces observed to operate in a particular historical setting.
- The importance of the production of new databases.
- Quantification, statistics and econometrics, may not bring everything to a certainty, but it can give to many historical debates a perspective that would otherwise be completely lacking.

Of course, these cliometric principles must face general difficulties:

- The imperfection of surviving data. Data must be built and treated carefully, with patience and humility. Like other fragments of surviving historical evidence, data are shot through with biases, mistaken judgments, and errors.
- The uncertain importance of non-operational causal factors. How to organize reality into homogeneous sets or entities? Only by abstraction, i.e., only by ignoring as relevant some of the characteristics of a specific event? Generalizations are incomplete. The reason is simple. All previous experimental situations may have included an unknown but relevant cause, and there is no way to prove that this was not the case. In other words, causal explanation consists of subsuming specific facts under generalization. If one of the causes of World War II was the series of treaties imposed at the end of World War I, does a complete explanation of World War II have to include the causes of war in 1914 and its end in 1918, the causes of those causes, and so on?
- The unknown degree of imperfection in any theoretical model resulting from its neglect of causal factors and its use of assumptions which distort reality.

Cliometrica encourages the methodological debate (not a sterile *Methodenstreit*), the use of economic theory, mathematical model building, and the reliance upon quantification to support analytical frameworks with historical data. Moreover, *Cliometrica* stresses the use of standard historical knowledge, *wie es eigentlich gewesen ist*, to suggest new avenues of research as well as the use of statistical theory and econometrics to combine models with data into a single consistent explanation. While the juxtaposition of cross-fertilization of new ideas—emanating from methodological innovations and from economic theory—form the core of cliometric research, *Cliometrica* aims to forge steps ahead to encourage researchers to devise ever new strategies to reconcile these along the dynamic path of history.

Since its official creation in June 2006 by contract signature in Strasbourg with the Springer Verlag, the main ambition of *Cliometrica* is (and remains) in continuity of Gustav Schmoller's *German Historical School* and of Lucien Febvre's and Marc Bloch's *Annales School* (both also created in Strasbourg, respectively, in 1870–1880 and in 1920–1930), and with the exceptional support of an international editorial board and of reviewers from all over the world, to close the gap between the *Geisteswissenschaften* and the *Naturwissenschaften*, i.e., to move from the historical *verstehen* or understanding side to the economic *erklären* or explaining side or,

much better, mixing both approaches, facts and stylized facts, explaining the economic experience of the past and understanding the ways in which economic factors influence social and political developments, for an increased knowledge of the past, present, and future economic and social development of developed and developing economies, for the achievement of a unified approach of the social sciences.

The recent publication of the *Handbook of Cliometrics*[1] is another original illustration of the validity of this belief.

Happy Birthday to *Cliometrica*!

[1] Diebolt C., Haupert M. (Eds.): *Handbook of Cliometrics*, Springer, Berlin, 2016.

Un héritage des *Annales*, la cliométrie à Strasbourg

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Le 21 août 2019

Résumé :

C'est par sa volonté de combiner la rigueur des modèles théoriques et mathématiques avec la prise en compte, de la façon la plus exhaustive possible, de la complexité de toutes les données (qualitatives et quantitatives) que l'Ecole cliométrique strasbourgeoise reste fidèle à l'esprit des *Annales* et prolonge le mouvement initié en 1929 par Marc Bloch et Lucien Febvre.

Mots-clefs :

Cliométrie, Ecole des Annales, Economie, Epistémologie, Histoire, Histoire économique, Histoire de la pensée économique.

Codes JEL :

A12, A22, A23, B20, B41, C18, C81, C82, N01.

Introduction

L'histoire économique est née à la fin du XIXème siècle, en réaction à un conflit méthodologique majeur (*Methodenstreit*) entre des économistes tenants d'une approche historique, évolutionniste et institutionnaliste et ceux partisans d'une démarche purement théorique dite néo-classique. C'est à l'évidence le triomphe de cette dernière qui conduit l'histoire économique à progressivement s'inventer une nouvelle identité, une relative autonomie en dehors de la science économique, mais aussi, paradoxalement peut-être, en-dehors de l'histoire.

Avant 1914, l'histoire est, encore largement, politique. C'est une histoire évènementielle, à la Ranke, dont l'objectif premier est de reconstituer l'analyse des faits et leur enchainement tels qu'ils se sont réellement passés (*wie es eigentlich gewesen ist*) et ceci sur base d'une investigation de textes au moyen des méthodes de la critique historique et inspirée par les procédures philologiques. Son rôle social est celui de préparer des professeurs de lycée et, au plan de la recherche, de contribuer à la constitution du sentiment national. Bien sûr, cela n'exclut nullement certaines avancées vers l'histoire économique ; pensons simplement aux travaux de l'historien belge Henri Pirenne qui entrouvre, selon l'aveu même de l'Ecole des *Annales*, la porte vers une discipline inscrite dans le récit historique plus global. Cela dit, même si dans certains pays l'histoire économique se développe jusqu'à recevoir une indépendance institutionnelle sous la forme de départements séparés (la *London School of Economics and Political Science* par exemple), dans beaucoup d'autres, son existence sera plus difficile.

En France, l'histoire économique sera d'abord le fait d'économistes tels que Labrousse (1895-1988) ou Simiand (1873-1935), avant que l'Ecole des *Annales* n'aboutisse à dominer les recherches historiques de l'après Seconde Guerre mondiale. Cette *parenthèse enchantée* donnera, dans les années 60 et 70, une place de premier ordre à l'histoire économique dans un grand nombre de pays occidentaux. L'étude des évolutions globales des sociétés sur le long terme, des tendances lourdes, mais aussi des cycles et de la conjoncture, vont dominer. L'ordinateur, la quantification font leur entrée en force, de même que l'ouverture sur des sciences sociales et économiques très déterministes, globalisantes et quantitatives.

Pourtant, cette époque glorieuse ne durera pas. Dès les années 70, l'intérêt pour le quantitatif décroît. C'est vers de nouvelles sciences humaines que l'histoire se tourne. L'anthropologie devient une interlocutrice privilégiée. L'histoire des mentalités et l'histoire culturelle, sans volonté explicite de quantification, prennent des positions de choix. Qui plus est, les approches plus *microscopiques* tendent à remplacer les grands tableaux généraux dont, désormais, on doute de la validité. Micro-histoire, histoire d'entreprises prennent le devant de la scène de l'histoire économique, peut-être en parallèle d'un déclin du marxisme et du renouveau d'un certain libéralisme. Parallèlement, en économie, les approches keynésiennes sont peu à peu disqualifiées. Or, c'est bien ces dernières qui constituaient très souvent le socle théorique des approches macroéconomiques et de l'usage des comptes nationaux en histoire économique quantitative.

Entre une histoire de plus en plus culturelle, qui embrasse le tournant postmoderne et une science économique où même la recherche macroéconomique se construit progressivement sur des fondements essentiellement microéconomiques et des modèles mathématiques d'optimisation, quelle place et surtout quel devenir se manifeste pour l'histoire économique ?

D'ailleurs, comment définir l'histoire économique ? Nous avons cherché une définition récente dans un ouvrage de référence récent lui aussi. Nous avons ainsi opté pour le *New Palgrave Dictionary of Economics* de 2008. Alexander Field[1], un spécialiste de l'histoire macroéconomique des Etats-Unis, nous livre une définition qui risque de faire bondir un historien économiste français :

"*economic history is a sub-discipline within economics and, to a lesser degree, within history, whose main focus is the study of economic growth and development over time*."

Il précise même :

"*studies in economic growth, whether historical or contemporary, develop and analyze quantitative measures of increases in output and output per capita, emphasizing in particular changes in saving rates and rates of technological innovations… Economic development is a larger and more encompassing rubric, also including considerations of the role of cultural changes and changes in formal institutions*."

C'est là, bien entendu, la vision d'un économiste.

Quoi qu'il en soit, elle confirme que toute définition est étroitement dépendante de l'implantation institutionnelle de l'histoire économique qui, elle-même, est fonction d'une histoire particulière propre à chaque pays, voire à chaque institution académique dans les pays moins centralisés que la France.

Ces particularités institutionnelles sont tout sauf anodines. Elles vont exercer une influence déterminante sur le mode de formation des historiens économistes ainsi que sur le poids relatif de la discipline. Lorsqu'elle est intégrée dans les Facultés de lettres, l'histoire économique sera réalisée par des chercheurs ayant eu un certain type de formation avec ses avantages comparatifs propres et au sein d'ensembles qui peuvent être sujets à des modes qui lui sont plus ou moins favorables. En clair, les historiens formés dans ces facultés (comme en France) reçoivent une formation économique et statistique très pauvre, voire inexistante, datée et très éloignée de ce que les sciences économiques sont devenues, c'est-à-dire une discipline extrêmement formalisée, où une majeure partie des professeurs-phares en France sont très régulièrement issus de Normale Sup en mathématiques ou des grandes écoles d'ingénieur comme l'X.

Il en résulte une extrême difficulté à comprendre, dans tous les sens du terme - décrypter les équations, mais aussi comprendre, au sens de l'essence même des travaux menés par leurs collègues économistes dans le champ de l'histoire. Si l'on

[1] Field, A. : "Economic History", in : Durlauf *et al.* (édit.), *New Palgrave Dictionary of Economics*, Palgrave Macmillan, Londres, Seconde édition, 2008, p. 694.

ajoute à cela la tendance indéniable, depuis la fin des années 70, à privilégier les apports de la sociologie à la Bourdieu ou ceux de l'anthropologie, la plus grande valorisation de l'histoire culturelle ou des mentalités et des représentations, et la tendance naturelle à user de ses avantages comparatifs –le métier traditionnel de l'historien est d'abord un travail sur documents écrits, sur des textes et plus récemment des images et des témoignages oraux–, on comprend pourquoi l'histoire économique devient (chez les historiens) progressivement une histoire économique et sociale à connotation culturaliste (par exemple, une histoire des intermédiaires et leur rôle dans le transfert de cultures, des migrations, de la domesticité, etc.) ou une histoire d'entreprises sur le mode monographique, ou encore une histoire (biographique) du patronat, des décideurs économiques, et parfois de la politique économique. L'histoire économique s'engouffre alors dans les préoccupations actuelles de la science historique qui valorise davantage l'histoire culturelle, intellectuelle, sociale, etc.

A l'inverse, quand l'histoire économique est le fait d'économistes, ceux-ci sont également influencés par les modes spécifiques de socialisation et la nature de l'éducation qu'ils ont reçue. La formation en économie est, en effet, très calquée sur le modèle des sciences exactes. Non seulement les cours de mathématiques et de statistiques y sont très nombreux, mais les cours d'économie eux-mêmes y ont pris dès le début du cursus un tour extrêmement formalisé (même si cela prête à débat). Parallèlement à cela, le temps qui reste à la formation culturelle ou plus institutionnelle et événementielle en est d'autant réduit. Présents encore en début de cycles, les cours d'histoire économique et d'histoire de la pensée économique ont, à de très rares exceptions près, complètement disparu du cursus de master, et bien entendu aussi de la formation doctorale. Il en résulte une ignorance quasi complète des débats en histoire, et même des grandes lignes de l'évolution économique du monde avant 1945. Le culte de la mathématisation, l'obligation de produire des articles courts et formalisés, l'écho aussi d'une image déformée et assez négative de l'histoire économique ont mené à un désintérêt croissant des étudiants en thèse pour ce champ, sauf de façon très abstraite au travers des théories de la croissance, et dans certains endroits où cette spécialité existe, en économie du développement. Nous faisons donc le constat que les départements d'histoire économique ont peu à peu disparu, la divergence croissante entre le mode de professionnalisation en économie et en histoire ayant rendu peu séduisante une formation hybride qui n'est ni assez mathématique pour les économistes ni assez culturaliste pour les historiens.

I. Les économistes : des platoniciens très "modernes"

L'histoire économique se situe à l'intersection de deux disciplines bien établies dans le paysage académique, l'histoire et l'économie. Ces deux disciplines ont acquis une identité forte, et comme nous l'avons souligné, de plus en plus distante l'une de l'autre depuis les années 70 et le déclin du marxisme et de l'approche des *Annales* (les deux étant sans doute liés). *Ab initio*, les deux disciplines poursuivent des objectifs finalement très différents.

Même contesté par certains économistes qui voient l'économie comme une science proche de la logique ou des mathématiques pures –une discipline non-empirique, plus à la recherche de théorèmes que de lois au sens des sciences naturelles–, il y a une ambition qui date au moins du XVIIIème siècle (avec Boisguillebert puis Quesnay, et reprise clairement par Smith et Ricardo) de faire de l'économie politique une science du même ordre que les sciences de la Nature. Il y aurait matière, dans le domaine des faits économiques et sociaux, pour une Science capable de dériver des lois de fonctionnement de l'économie.

Les économistes néo-classiques ont poursuivi cette entreprise après 1870, avec une ambigüité réelle quant à savoir si l'économie est une discipline non-empirique comme les mathématiques ou la logique, ou une discipline qui construit des modèles destinés à être confrontés à la vérification empirique. En tout état de cause, cette dimension empirique est, avant 1914, peu présente à quelques exceptions près comme, entre autres Juglar (1862) ou Jevons (1884) dans leurs études du cycle des affaires.

Très platonicienne, la science économique néo-classique tend à se détourner de l'analyse directe des faits –ou croire qu'on peut faire œuvre de science sur base d'une induction, d'une généralisation de faits stylisés mis en évidence par des économistes qui seraient aussi des historiens–, pour privilégier l'analyse mathématique de modèles fondés sur la déduction à partir d'axiomes de rationalité instrumentale, pour reprendre la qualification de Max Weber. Si l'Ecole Classique d'Economie Politique (1776-1870, grosso modo), outre les grandes intuitions de Smith sur l'autorégulation du marché et le modèle des avantages comparatifs démontrant les vertus du libre-échange chez Ricardo, s'est largement consacrée aux questions de ce qui détermine la croissance (l'accumulation du capital motivée par la quête du profit) et si elle va persister (non selon Ricardo à cause des rendements décroissants), les néo-classiques vont dans un premier temps se consacrer à la formalisation de l'intuition première de Smith sur la *Main Invisible*, à savoir préciser mathématiquement les conditions qui assurent l'optimalité du marché et l'allocation efficace des ressources rares entre usages alternatifs. C'est tout le programme de recherche de Walras et Pareto (celui de l'équilibre général), les économistes néo-classiques anglais s'y intéressant aussi (Edgeworth, 1881), mais se centrant sur des approches d'équilibre partiel (Marshall, 1890).

Ces analyses de la concurrence pure et parfaite sont totalement éloignées des préoccupations de l'historien, mais aussi de celles des économistes plus appliqués ou institutionnalistes. À une époque qui vit de profondes transformations liées à la seconde Révolution Industrielle, l'émergence de nouvelles puissances économiques (Allemagne, Japon), l'acuité de la question sociale, la concentration économique de la fin des années 90 du 19ème siècle (concentration et monopolisation), beaucoup sont insatisfaits de l'évolution de la science économique. Les approches marxistes existent, mais elles ne sont pas ou peu représentées dans le monde académique.

Marx (1867) s'inscrit dans la lignée de l'économie classique, mais souligne à la fois la dynamique d'innovation induite par la compétition dans le capitalisme, poussant en avant les forces productives et la destruction inévitable de cette

concurrence de par la concentration du capital, sans parler de la polarisation croissante entre des masses de travailleurs exploités et une minorité de capitalistes qui sont de moins en moins entrepreneurs et de plus en plus administrateurs de grands conglomérats. Les crises périodiques de surproduction et la baisse tendancielle du taux de profit, en partie liée à la mécanisation croissante de l'économie, ne pourront mener qu'à la fin du régime capitaliste et son remplacement par une gestion socialisée de la production qui partagera de façon plus équitable et efficace les fruits du développement technologique. Marx, qui décrit une longue succession de modes de production caractérisés chacun par des institutions spécifiques, peut aussi être rattaché dans un sens à l'Ecole Historique Allemande par cette pensée évolutionniste, en stades.

Certains économistes comme Weber (et plus tard Pareto lui-même) contribueront à fonder une nouvelle discipline : la sociologie. Les mêmes (pour Weber), et d'autres héritiers de l'Ecole Historique Allemande fonderont ce qui sera l'histoire économique à la fin du XIXème siècle (aux Etats-Unis et en Allemagne). La première chaire d'histoire économique est attribuée à Ashley en 1892 à l'Université d'Harvard. A partir de ce moment, histoire économique et science économique vont devenir des disciplines différentes (même si la classification du *Journal of Economic Literature* retient toujours l'histoire économique comme branche des sciences économiques).

Les économistes commencent à s'intéresser à la mesure, à l'étude des cycles, à la conjoncture des grands secteurs de l'économie (pensons simplement au projet du NBER et de Mitchell par exemple) dès les années 20. La Grande Crise verra la naissance de la macroéconomie comme discipline désormais bien distincte de la microéconomie. La crise aurait mis en évidence (Keynes, 1936) que la tendance spontanée de l'économie à s'équilibrer peut tout simplement ne pas exister et qu'une intervention contre-cyclique de l'Etat peut s'avérer nécessaire pour relancer la machine économique. Lié à ce double souci de comprendre les mécanismes macroéconomiques et en faciliter la gestion (Tinbergen, 1939) et pour certains de mieux cerner et prévoir les mouvements des actifs (Cowles, 1933), cette période voit la naissance de l'économétrie. Tout est ainsi en place pour voir émerger, après la Seconde Guerre Mondiale, qui a aussi favorisé le développement d'une série d'outils de mathématique économique comme la recherche opérationnelle et la théorie des jeux (pensons uniquement à Von Neumann et Morgenstern, 1944), un consensus keynésien qui en recourant à une version modélisée de la vision keynésienne (synthèse néo-classique Hicks-Hansen) et aux grands modèles macro-économétriques espère arriver à un réglage fin de la conjoncture et à une croissance continue.

Le formidable développement économique de l'après-guerre (jusque 1970) tend à confirmer cette croyance, qui voit l'économie gratifiée en 1969 d'un Prix de la Banque de Suède remis en parallèle des autres Nobel. C'est aussi la période de constitution (dans les années 50) de la comptabilité nationale, instrument-clé de la politique économique et de la comparabilité internationale des performances économiques. Très cohérente, cette approche de la mesure du revenu national et du produit intérieur (selon les trois optiques des dépenses, de la production et des

revenus) aura un écho majeur sur les travaux de l'histoire quantitative, notamment en France sous l'impulsion de Perroux, Marczewski et Toutain, ou encore Lévy-Leboyer.

Parallèlement à ces travaux de macroéconomie, on voit aussi le développement exponentiel de la microéconomie, de la théorie de l'équilibre général et, dans les années 50 et 60, des travaux importants en théorie de la croissance et du développement. Parmi ces derniers, on peut citer les travaux de Solow (1956, 1957) sur l'explication de la croissance par un taux exogène de progrès technologique (et une méthode de comptabilité de croissance pour mesurer l'apport transitoire de l'accumulation des facteurs sur celle-ci), les travaux de Kuznets (1966) sur les grands secteurs de l'économie comme sources de croissance (secteurs moteurs) et ceux de Rostow (1960) sur les étapes de la croissance économique.

C'est à l'intersection de ces divers courants (approches macroéconomiques de mesures du revenu national, usage de modèles d'équilibre général calculables pour mesurer les effets de divers scenarii d'histoire économique, les fameux modèles contrefactuels, et approches de croissance et de développement), que naîtra, au cœur de la discipline économique et recourant quasi exclusivement à son langage et ses outils, une nouvelle histoire économique : la cliométrie.

La crise pétrolière et les autres chocs sur l'économie au début des années 70 (fin du système de Bretton Woods, flottement généralisé des devises, concurrence accrue des pays émergents, d'abord le Japon, bientôt les quatre dragons, désindustrialisation en Europe occidentale dans les secteurs traditionnels au profit de certains PVD, etc.) vont conduire à un réexamen de la pertinence des approches keynésiennes et, plus globalement, des approches macroéconomiques et macro-économétriques (nous pensons ici à la critique de Lucas, 1976). Friedman reste encore un macro-économiste du même style que les keynésiens, même si son message est diamétralement opposé (politiques de contrôle de la masse monétaire pour contrôler l'inflation), et reste intéressé par l'histoire (monétaire, cf. Friedman et Schwarz, 1963, 1982). Les *nouveaux macroéconomistes classiques* qui vont lui succéder vont contribuer au développement d'une macroéconomie micro-fondée, avec des acteurs parfaitement rationnels (hypothèse d'anticipations rationnelles) et la construction de modèles d'équilibre permanent sur tous les marchés (seuls des chocs extérieurs non anticipés comme des chocs technologiques expliquent les fluctuations cycliques, cf. ici les modèles des cycles réels). Les nouveaux économistes de l'offre se concentrent sur la nécessité de la création d'un cadre macroéconomique stable (sans inflation, avec des comptes publics équilibrés, dans un environnement prévisible pour favoriser les décisions économiques et l'investissement), la baisse de la taxation, l'ouverture des économies au reste du monde pour faciliter un ajustement structurel selon leurs avantages comparatifs, l'ouverture des marchés des capitaux et le développement de la Bourse comme lieu d'évaluation permanente de la profitabilité future des firmes, etc. Le rôle de l'Etat est vu comme plus structurel : outre le gardien de la libre concurrence, il peut se consacrer à des politiques de long terme (investissements publics, infrastructures, recherche, éducation, etc.). On voit ainsi, dans les années 80, la réémergence des théories de la croissance qui cette fois-ci cherchent à endogénéiser une série de décisions comme les

choix d'investissement en R&D ou en éducation pour rendre compte du maintien à long terme d'une croissance soutenue (Lucas, 1988, Romer, 1986, 1990).

Les années 90 verront le grand développement des approches d'organisation industrielle en lien étroit avec la théorie des jeux. Ces recherches irrigueront la théorie du commerce international (Helpman et Krugman, 1987, Krugman, 1994) et une série d'autres domaines (Tirole, 1988), souvent avec un fort accent théorique et peu appliqué (théorie des contrats, théorie de l'information, etc.). On peut aussi percevoir la montée d'une dimension normative forte et le désir d'une science normative des institutions ; toutes caractéristiques rapprochant l'économie de certaines utopies ou d'un constructivisme rationaliste, voire de la philosophie politique (Kolm, 1986). Tous ces champs de recherche sont fortement mathématisés et la part des approches d'économétrie appliquée est longtemps secondaire ; elles reviendront en force dans la seconde moitié des années 1990 et dans les années 2000 dans le champ du test des théories de la croissance et l'analyse de vastes bases de données en micro-économétrie du marché du travail par exemple.

Même si au sein des approches néo-classiques, absolument dominantes depuis le début des années 90, la diversité et les débats sont une réalité, il existe un consensus fort entre économistes sur une conception très *sciences dures* de leurs recherches. Les mathématiques sont devenues le langage unique accepté par quasi tous les économistes, qui dialoguent entre eux via la construction de modèles mathématiques, pas nécessairement toujours testés empiriquement, mais quand ils le sont, l'économiste tend à considérer le chiffre comme seul *réel* acceptable (pas d'analyses d'évolutions historiques ou d'institutions concrètes, pas de contextualisation, les analyses économétriques pouvant se mener sur des groupes très hétérogènes de pays. On pourrait parler ici d'un biais pythagoricien).

À l'exception de quelques courants (North, 1990 par exemple, ou encore Rodrik, 2008, qui réhabilite les études de cas en économie et donc souligne l'importance du contexte), l'économiste fait sienne l'expression *il n'y a de science que du général*, laissant de côté valeurs, culture, contexte historique (ou alors il l'intègre comme simple variable quantifiée sans remettre en compte la structure fondamentale de ses modèles). Il croit aussi en l'existence d'une vérité objective, atteignable par une démarche déductive et mathématisée, accompagnée ou non de tests empiriques quantifiés. L'économiste est donc à la fois platonicien et pythagoricien, et en quête de lois ou de théorèmes à valeur universelle, sans aucun intérêt pour la contextualisation. Cette posture définitivement *moderne* au sens philosophique du terme semble aux antipodes de la culture historique dominante de nos jours.

II. Les historiens : de la modernité à la postmodernité ?

Les historiens ne visent pas à établir une discipline nomothétique. Depuis très longtemps, leur souci est d'abord de reconstituer avec précision une séquence de faits et d'évènements le plus précisément possible par une critique minutieuse des sources et éventuellement (mais tous les historiens ne sont pas d'accord là-dessus) de les interpréter (leur donner sens dans un contexte plus global), voire de déterminer leurs causes et leurs conséquences. Mais là les historiens sont en général extrêmement

prudents. Une des causes de leur opposition à la cliométrie est justement leur méfiance par rapport à ce concept de cause, en tous cas déterministe.

Floud[2] dans son article sur la cliométrie, dans la première édition du *New Palgrave Dictionary of Economics*, notait :

"*more fundamentally, many historians rejected the concepts of causation which they judged to be implied in the closed and deterministic models of the economists; they argued, instead, that historical statements of causation were much weaker, multi-factorial and unsuitable to be tested by the economist's method of removing one possible cause and assessing the outcome, ceteris paribus*" (McClelland, 1975).

On perçoit immédiatement que l'historien a le souci de la spécificité, de la contextualité, de la réalité des faits. Nous sommes en tous cas très loin de l'abstraction et du désir de généralisation de l'économiste. On pourrait noter entre l'économiste et l'historien la même opposition qu'avec le philosophe (avec lequel l'historien ne se sent pas non plus nécessairement beaucoup d'affinités). L'historien a le souci de la contextualité ; il fait sienne l'idée que le passé est unique. Il souhaite comprendre (au sens de *Verstehen* pour reprendre Dilthey (1883), et certainement pas dans celui de *Erklären*) les acteurs du temps passé dans leurs valeurs, leurs représentations, leur culture, sans commettre d'anachronisme. Pour lui, appliquer les catégories de l'économie néo-classique par exemple à l'économie antique relève de l'hérésie la plus pure, aussi parce que la discipline économique présuppose des comportements et des intentions qui ne pourraient pas être ceux de l'homme de l'antiquité (qui vit dans un univers dominé par les notions de statut, de primat du politique sur l'économique, et où les relations marchandes seraient marginales et où l'*homo oeconomicus* n'est pas encore présent). C'est la fameuse thèse de Finley (1973, cf. plus particulièrement l'édition de 1999) du primitivisme contre le modernisme.

Certes, la prééminence de l'histoire positiviste, événementielle, politique a peu à peu cédé le pas à partir des années 30 et surtout après la Seconde Guerre mondiale à l'Ecole des *Annales*[3] avec Bloch (fusillé en 1944) et Febvre (mort en 1956). Cette *Nouvelle Histoire*, influencée par le courant de l'Ecole Historique Allemande et *sotto voce* par un certain marxisme (Bois, 1978) se veut certes une histoire totale de l'évolution des sociétés humaines (l'idée de l'histoire comme *synthèse* entre les diverses sciences sociales émerge peu à peu, une histoire vue comme fédératrice des sciences de l'homme), mais d'abord une histoire de la longue durée et des grandes structures économiques et sociales (Le Goff *et al.*, 1978). Elle a la formidable ambition de comprendre globalement, dans toutes ses dimensions, l'évolution globale des sociétés humaines. Elle est aussi une histoire des phénomènes de masse. Avec cette histoire-là, l'étude précise de l'évolution des prix, des chiffres de population, de la production de biens matériels ainsi que de grands corpus d'archives (requérant un

[2] Floud, R. : "Cliometrics", in : Eatwell J. *et al.* (édit.), *The New Palgrave. A Dictionary of Economics*, Macmillan, London, 1987, p. 452.

[3] "*L'acte de naissance officiel de la nouvelle histoire intervient en 1929 avec la création à Strasbourg, par Marc Bloch et Lucien Febvre, des Annales d'Histoire Economique et Sociale, qui vont donner leur nom à une école d'où sortira l'histoire nouvelle.*" (Coutau-Begarie, 1983, p. 7).

traitement plus quantitatif par nature) devient centrale. L'étude des cycles et de la conjoncture (en écho avec ce qui se développe dans les sciences économiques pendant les années 30, avec les travaux du NBER aux Etats-Unis, mais aussi Kondratieff en URSS) implique un nécessaire recul historique. Ce sont d'ailleurs des économistes arrivés en histoire qui vont développer ces recherches avec, une fois encore, Labrousse (1933) et Simiand (1932). La compréhension de ces grandes tendances économiques est considérée comme centrale pour la compréhension des évènements historiques (par exemple la Révolution française). Comme chez les marxistes, en dernière instance ce sont les éléments économiques qui ont un poids déterminant (sans tomber cependant dans le déterminisme). Ce sera la grande époque de l'histoire économique (surtout après 1945). Les travaux de Braudel (1902-1985), de Chaunu (1923-2009), de Le Roy-Ladurie (né en 1929), etc. illustrent cette tendance.

En parallèle du mouvement en sciences économiques, les historiens économistes développent des mesures quantitatives de l'évolution des richesses dans le passé concomitamment avec les recherches en comptabilité nationale. Pendant toute une période (grosso modo de 1945 au début des années 70) on assiste en France à une convergence de l'histoire (fortement marquée par l'histoire démographique, économique et sociale) et de l'économie (elle-même fortement marquée par le marxisme, diverses hétérodoxies françaises comme les approches centre-périphérie de Perroux, attachant une grande importance à l'étude de l'histoire économique). Mais, à partir du milieu des années 70, l'histoire économique quantitative perd peu à peu de son aura. Il est évident que le travail sur la longue durée, via des outils de plus en plus quantitatifs et sophistiqués (au début des années 1970, Le Roy-Ladurie nous dit que l'historien sera programmateur ou ne sera pas), en relation étroite avec des sciences économiques et sociales à l'époque fort axées sur la modélisation mathématique entraient peu à peu en contradiction avec l'ethos et la formation initiale de l'historien français. Le climat idéologique global, moins axé sur le marxisme, plus centré sur le rôle des individus et ses représentations, ont peu à peu tari les vocations pour des sujets apparemment arides et à la rentabilité maigre.

C'est depuis cette époque que l'histoire culturelle, des représentations et des mentalités a tendance à reprendre le devant de la scène. Par ailleurs, dès les années 80, on voit le retour plus affirmé de l'histoire politique et des relations internationales. La sociologie critique à la Bourdieu, les apports de Foucault, l'anthropologie et l'influence américaine des *cultural studies*, des *gender studies*, vont de plus en plus imprégner les travaux des historiens qui se placent explicitement du point de vue des dominés, des marginaux, de la masse des acteurs, dans leur expérience vécue, et non plus du point de vue surplombant des états ou des puissants, point de vue qui serait selon ses critiques aussi celui de l'économiste. On voit ainsi refleurir les biographies, les travaux concernant les individus aux marges (Geremek, 1976). Il y a donc plus une lente transformation de l'approche des *Annales* qu'une brusque rupture, mais la divergence croissante avec l'économie est incontestable.

Fin des années 70, Jacques Le Goff (1978) note que c'est maintenant l'anthropologie avec laquelle l'histoire a le plus en commun. On verra le retour aux approches plus compréhensives, plus de l'ordre du *Verstehen* que de l'*Erklären*. À

partir de ce moment-là, l'histoire s'écarte de plus en plus de l'économie. Ce n'est d'ailleurs pas un hasard si dans certains pays les cours d'histoire économique ont été renommés *histoire économique et sociale*.[4] Qui plus est, les grandes synthèses ou travaux historiques de la période des *Annales*, ceux de Braudel (1949, édition de 1966) par exemple, n'étaient pas explicitement modélisés. L'économique, le quantitatif servait essentiellement de cadre sur base duquel tenter un récit global, une compréhension de l'évolution par exemple du capitalisme était possible. On trouve là un écho du projet de recherche de Weber qui s'interroge sur la naissance de la modernité occidentale ainsi qu'un prolongement de ce type de travail avec Wallerstein (1992) et son concept d'économie-monde et les tenants de l'histoire globale (Norel, 2009).

On sent donc chez l'historien le retour du refoulé (le particulier, le qualitatif, le culturel et bientôt l'évènementiel). Mais, même durant l'ère de la domination de l'histoire économique française avec les *Annales*, on doit noter que l'objectif de l'historien est toujours resté la compréhension du passé dans la longue durée, tel qu'il s'est vraiment passé, plutôt qu'une réelle modélisation abstraite comme peuvent le faire les économistes. Le quantitatif est accepté, voire revendiqué et utilisé, mais c'est pour rendre compte d'une réalité néanmoins contextualisée : le niveau de vie du paysan français sous Louis XIV par exemple. Quelque part, le *Verstehen* prime l'*Erklären*, le quantitatif est là comme illustration ou support de l'argument. Mais l'analyse elle-même reste rédigée dans le langage naturel et non pas dans le langage formalisé des mathématiques. L'économie, la statistique, la démographie sont des disciplines auxiliaires de l'historien. Son objectif ultime reste la rédaction d'un ouvrage qui est un récit. Bref, même l'Ecole des *Annales*, qui peut apparaître trop économiste à l'historien d'aujourd'hui, reste une approche inductive, relativement descriptive et sûrement interprétative. Même chez les historiens des *Annales* et les partisans d'une histoire sérielle, on constate un refus de théorisations a-historiques. Cela explique sans doute le rejet français de l'approche cliométrique dans les années 70, mais l'acceptation parallèle d'une histoire sérielle, à condition que les chiffres aient été retrouvés dans des recueils d'archives et pas interpolés ou extrapolés par diverses méthodes statistiques, et actuellement des méthodes quantitatives de la sociologie (les analyses de données, la théorie des graphes, quelques régressions et études de causalité) (Lemercier et Zalc, 2008).

Il s'agit en fait de méthodes qui permettent d'ordonner ou synthétiser un corpus d'archives, laissant ensuite l'opportunité à l'historien de rédiger son interprétation au travers d'une argumentation *littéraire*. Le rejet de l'histoire quantitative macroéconomique à la française (Asselain, 2007) nous semble ainsi résulter d'une incompréhension ou d'un excès de fidélité aux sources. La comptabilité nationale n'est après tout qu'un cadre qui n'a pas derrière lui les mêmes hypothèses

[4] Mais c'était bien le nom de la revue *Annales* dès son point de départ. On notera au passage les variations de nom de cette revue-clé : *Annales d'histoire économique et sociale* de 1929 à 1938, *Annales d'histoire sociale* de 1939 à 1941 et en 1945 (entre 1942 et 1944 on la nomme *Mélanges d'histoire sociale*), *Annales. Economie, Sociétés, Civilisations* entre 1946 et 1993, et finalement : *Annales, Histoire, Sciences Sociales* depuis 1994.

comportementales *excessives* de l'économie néo-classique. On reste dans le descriptif et ces approches laissent à l'historien le même espace pour mener sa réflexion interprétative, mais mieux informé du contexte global de l'économie. Bref, cette histoire quantitative-là (qui va pourtant un pas plus loin que l'histoire sérielle acceptée par le courant principal de la Nouvelle Histoire), macroéconomique, irriguée par la rigueur de la comptabilité nationale, reste une approche auxiliaire pour l'historien. Il s'agit de comprendre le contexte global, peu éloigné donc des démarches d'histoire économique traditionnelles qui elles aussi font référence à des périodes de prospérité ou de déclin.

Finalement, tout est question de légitimité. Les uns se retranchent derrière *le chiffre tel qu'il figure dans les registres d'archive*, tandis que les autres acceptent des méthodes d'interpolation ou d'extrapolation, mais on reste quelque part dans le descriptif (quantitatif) et on demeure loin du théorique (général) que les économistes apprécient. On notera que du côté des économistes aussi, le descriptif quantifié a survécu un temps à la défaite de l'Ecole Historique Allemande. Même Kondratieff (1926) et ses cycles de longue durée (dans la continuité du hollandais Van Gelderen, 1913), Labrousse (1933) ou Simiand (1932), cherchent en effet à identifier des tendances, des cycles, des chocs dans l'histoire économique *réellement existants*.

Les historiens peu habitués aux approches strictes d'économie néo-classique contemporaine n'ont pas idée semble-t-il du degré d'abstraction (et d'éloignement *a priori* des faits stylisés) de la théorie économique contemporaine des cycles ou de la croissance. Toutefois, on peut aisément imaginer qu'un historien traditionnel finisse par accepter comme discipline auxiliaire de l'histoire, l'économétrie des séries temporelles (Grenier, 1995) au seuil d'une analyse historique qui se veut globale, interprétative et *in fine* littéraire. Dans cette philosophie, les approches de l'historien traditionnel et les techniques quantitatives descriptives sont clairement complémentaires. Simplement, cette histoire économique-là, dans la lignée des *Annales*, quelque peu modernisée par de nouveaux outils, ne rompt pas avec la pratique des historiens. Elle est simplement moins dominante en histoire aujourd'hui (en comparaison des histoires culturelles, des mentalités, des minorités, etc.). On est toutefois relativement loin de la cliométrie *stricto sensu*.

III. La création d'un institut d'histoire économique et sociale à Strasbourg en 1970

En 1936, Marc Bloch quitta Strasbourg pour Paris, où il succéda à Henri Hauser comme professeur d'histoire économique. Deux années plus tard, pour prolonger ce qu'il avait entrepris en créant la revue *Les Annales*, il fonda au sein de la Sorbonne l'Institut d'Histoire économique et sociale. Dirigé de 1944 à 1967 par Ernest Labrousse, cet institut allait former une pléiade d'historiens économistes, parmi lesquels Jean Bouvier, Pierre Vilar, Emmanuel Le Roy Ladurie, Maurice Lévy-Leboyer, Adeline Daumard. Doyen de la Faculté des Lettres de Strasbourg depuis 1963, Georges Livet, voulut que l'esprit de l'école des Annales se perpétuât dans l'Université qui l'avait vu naître. Avec l'appui de Fernand L'Huillier, professeur d'histoire contemporaine, il

obtint que Strasbourg disposât à son tour d'un institut d'histoire économique et sociale. Ce projet aboutit en 1970 avec la création d'une chaire d'histoire économique et sociale et l'octroi d'une ligne de crédit pour des achats documentaires. Odette Voilliard, maître-assistante, préparait sous la direction de Fernand L'Huillier une thèse sur la bourgeoisie de Nancy au XIXe siècle, qui se plaçait tout à fait dans la perspective de l'École des *Annales*, mais cette thèse ne fut soutenue qu'en 1976[5]. Christian Gras, maître-assistant également venait, quant à lui, de soutenir, sous la direction de Jacques Droz, une thèse sur un militant révolutionnaire[6]. C'est lui qui prit la direction du nouvel institut. En fait, ses recherches l'orientaient davantage vers l'histoire politique[7]. Michel Hau, qui entreprenait une thèse de troisième cycle en histoire quantitative sous la direction de Maurice Lévy-Leboyer, fut recruté cette même année comme assistant pour collaborer avec lui. Il allait plus tard assumer la direction de l'institut, de 1988 à 2011[8].

1. Les indices de production à l'échelle régionale

L'engouement des années 1960 pour la « nouvelle histoire économique »[9] et le regain d'intérêt pour les régions avaient alors conduit Maurice Lévy-Leboyer, directeur de thèse de Michel Hau, à se tourner vers l'histoire quantitative régionale. La région, plus homogène que la nation dans ses diverses caractéristiques physiques et humaines, apparaissait comme l'unité territoriale la mieux adaptée pour étudier la dynamique des territoires[10]. La France se prêtait particulièrement bien à ce type de recherche : l'abondance des statistiques collectées par ses administrations et la stabilité de son découpage territorial rendaient possible le calcul, pour chaque département ou ensemble de départements, de comptes rétrospectifs sous forme d'agrégats, de la fin du Premier Empire jusqu'à nos jours[11]. Maurice Lévy-Leboyer

[5] Odette Voilliard, *Recherches sur une bourgeoisie urbaine : Nancy au XIXe siècle (1815-1871*), Thèse, Strasbourg II, 1976. Odette Voilliard, *Nancy auXIXe siècle 1815-1871 : une bourgeoisie urbaine*, Paris, Ophrys, 1978.

[6] Christian Gras, *Alfred Rosmer (1877-1964) et le mouvement révolutionnaire international*, thèse, Paris IV, 1970.

[7] Les principaux ouvrages publiés par Christian Gras sont : *Alfred Rosmer et le mouvement révolutionnaire international*, Paris, Maspero, 1971 ; *Le mouvement régionaliste français et l'histoire sociale*, Paris, Éditions ouvrières, 1975 ; *Les États marxistes-léninistes de 1917 à nos jours*, Paris, PUF, 1978, réédit. 2016.

[8] L'Institut d'Histoire économique et sociale de Strasbourg est dirigé actuellement par Séverine Marin, maître de conférences d'histoire contemporaine et d'histoire économique et sociale.

[9] Cf. Jean Heffer, *La nouvelle histoire économique*, Gallimard, Paris, 1977.

[10] Bowden Witt, et al., *An Economic History of Europe since 1850,* New York, AMS Press, 1937. Frederic Lane, "Units of Economic Growth Historically Considered", *Kyklos* 15, 1962. Sidney Pollard (éd.), *Region und Industrialisierung,* Göttingen, Vandenhoeck & Ruprecht, 1980, p. 12. Jean Labasse, *Quelles régions pour l'Europe ?*, Flammarion, Evreux, 1994, p. 27. Eurostat, *Régions. Nomenclature des unités territoriales statistiques. NUTS. Mars 1995*, Luxembourg, 1995. Hubert Kiesewetter **:** *Region und Industrie in Europa 1815-1995, Franz Steiner Verlag,* Stuttgart 2001, p. 13-25.

[11] Michel Hau, « L'étude de la croissance régionale de 1810 à nos jours: données et lacunes », INSEE, *Pour une histoire de la statistique*, Paris, INSEE, 1977. Michel Hau, « L'Histoire économique régionale », in Dominique Barjot (dir.), *Où va l'histoire économique ?, Historiens & Géographes* n° 378, juin 2002, p. 145-153.

coordonna la réalisation d'indices annuels de la production agricole de divers territoires français représentatifs (Alsace, Beauce, Champagne, Languedoc, Maine, Vaucluse)[12] ainsi que la création d'indices du produit physique régional pour deux régions, la Champagne et l'Alsace[13]. Maurice Lévy-Leboyer fut secondé dans cette entreprise par Marc Auffret, à l'Université du Maine, et par Michel Hau à l'Institut d'Histoire économique et sociale de Strasbourg. Les résultats de ces travaux ont été résumés dans des ouvrages postérieurs[14].

Ce type de recherche pose plusieurs problèmes. Constituer des séries continues implique de consulter des documents éparpillés dans de multiples archives et publications. Il faut faire face à interruptions de séries et à des changements de nomenclature. Une fois constituée, la masse de données à exploiter est considérable : plus de 18 000 chiffres de production pour l'indice du produit physique de la Champagne sur la période 1810-1969, plus de 7 000 pour celui de l'Alsace sur la période 1803-1939. Les fréquentes ruptures de séries rendent difficile un traitement informatique global de ces données, car il faut réaliser, au coup par coup, de nombreux ajustements de détail. Emmanuel Le Roy Ladurie a fait numériser une partie de la Statistique Générale de la France de 1801 à 1897 sans pouvoir vraiment l'exploiter. Sa phrase célèbre, « l'historien sera programmeur ou ne sera pas », s'est avérée plus difficile à appliquer que prévu. Enfin, il faut passer de la mesure à la quantification, c'est-à-dire du relevé de diverses quantités physiques à des évaluations d'entités synthétiques comme la création de richesse ou le niveau de vie. L'adoption d'un mode de calcul repose alors sur des interprétations qu'il faut justifier. Dans ce cas précis des études de croissance régionale, c'est la méthode de la chaîne d'indices de Laspeyres qui a été choisie pour agréger les divers indices de production en un indice annuel du produit physique (agrégeant lui-même un indice annuel de la production agricole finale et un indice annuel de la production industrielle). La méthode mise au point à l'Institut d'Histoire économique et Sociale de Strasbourg pourrait être appliquée à la vingtaine d'autres régions françaises. Est-il besoin de préciser que, pour rendre les comparaisons possibles, il faut que la méthode de calcul soit rigoureusement la même pour tous les territoires ?

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[12] Marc Auffret, Michel Hau et Maurice Lévy-Leboyer, "Les inégalités régionales de croissance dans l'agriculture française, 1823-1939, essai d'analyse économétrique", in *Seventh Economic History Congress*, Lewis Reprints, 1978, et "Regional Growth Inequalities in French Agriculture, 1823-1975", in P. Bairoch et M. Lévy-Leboyer, *Economic Disparities since the industrial Revolution*, New-York, St Martin's Press, 1981. Maurice Lévy-Leboyer, "Les inégalités interrégionales de revenu dans l'agriculture: leur évolution au XIXe siècle", *Économie rurale*, n° 152, 1982, p. 26-33. Michel Hau, « La résistance des régions d'agriculture intensive aux crises de la fin du XIXe siècle: les cas de l'Alsace, du Vaucluse et du Bas-Languedoc », *Economie Rurale,n° 184-186,* 1988, p. 31-41. Emmanuel Chadeau, *L'économie nationale aux XIXe et XXe siècles*, vol. 1, Paris, Presses de l'École Normale Supérieure, 1989.

[13] Michel Hau, *L'industrialisation de l'Alsace 1803-1939*, Strasbourg, Presses Universitaires de Strasbourg, 1987; *La croissance économique de la Champagne* (nouvelle édition), Sarrebruck, Éditions Universitaires Européennes, 2015. - Michel Hau, « La comparaison des croissances économiques de deux régions industrielles, la Champagne et l'Alsace (1810-1939) », *Histoire Economie et Société* 1989, pp. 459 à 467.

[14] Outre les publications citées précédemment, voir : Bernard Vogler et Michel Hau, *Histoire économique de l'Alsace*, Strasbourg, Éditions de la Nuée Bleue, 1997, 430 p. Michel Hau et Nicolas Stoskopf, « Histoire économique, industrielle et financière de l'Alsace », *Revue d'Alsace* n° 126, 2000, p. 183 à 194.

Une autre approche de la dynamique des territoires est possible grâce aux chiffres départementaux de la consommation de charbon donnés par la *Statistique de l'Industrie Minérale*[15]. L'exploitation de ces données permet de réaliser rapidement une image de l'évolution des disparités économiques régionales. Certes, elle est entachée de biais : le charbon sert aussi au chauffage domestique et les cours d'eau continuent, jusque tard dans le XIXe siècle, à contribuer au bilan énergétique des industries de beaucoup de régions françaises. Néanmoins, l'image des disparités de croissance régionale construite à partir des consommations de charbon s'est avérée, à quelques nuances près, convergente avec les analyses de Michel Quelennec fondées sur les recensements de population[16]. Il restait à passer de l'histoire sérielle à la cliométrie, c'est-à-dire dépasser le stade de la description pour parvenir à celui de la modélisation. Il se trouve que la Statistique de l'Industrie Minérale contient également des données sur les prix et les coûts du transport du charbon. Michel Hau ébaucha une étude de la relation entre ces deux variables, dans une France où l'industrialisation ne pouvait pas s'appuyer autant qu'en Grande-Bretagne sur l'accès à cette source d'énergie bon marché. Il dut constater que le prix du charbon n'était qu'un facteur parmi d'autres et que la relation jouait dans les deux sens (une forte industrialisation pouvant se traduire par un élargissement des zones d'approvisionnement et une hausse des prix de l'énergie) [17].

La coopération entre l'Institut d'Histoire d'Alsace et l'Institut d'Histoire économique et sociale aboutit à la réalisation d'une thèse utilisant toutes les données numériques disponibles sur la petite industrie dans le Bas-Rhin au XIXe siècle. Son auteur, Nicolas Stoskopf, mit à jour un processus d'industrialisation émanant du milieu rural lui-même, en l'absence d'un grand patronat du type de celui existant dans le Haut-Rhin voisin. Il montra la parenté des pratiques de la petite industrie avec celles de la polyculture intensive. Ces activités étaient, l'une comme l'autre, économes en capitaux et à l'inverse, intensives en travail[18]. Elles étaient toutes les deux dans une

[15] Service des Mines, *Compte rendu des travaux des ingénieurs des Mines*, 1834-1846; *Statistique de l'industrie minérale*, 1847 et suiv.

[16] Michel Quélennec, *Analyse structurale du développement économique des régions françaises (1864-1970)*, Thèse de droit, Univ. Panthéon-Sorbonne, 1972. Michel Hau, « La nouvelle géographie industrielle », in Maurice Lévy-Leboyer (dir.), *Histoire de la France industrielle*, p. 214 à 229, Paris, Larousse, 1996. Michel Hau, « Mieux penser l'économie ouverte : pour une relance de l'histoire économique régionale », in: Jean-Paul Barrière, Régis Boulat, Alain Chariot, Pierre Lamard et Jean-Michel Minovez (dir.), *Les trames de l'histoire : entreprises, territoires, consommations, institutions. Mélanges en l'honneur de Jean-Claude Daumas*, Besançon, Presses Universitaires de Franche-Comté, 2017, p. 203-214. Michel Hau, « Four Decades of Study on Growth Disparities across Regions in France : Achievements and Prospects », in : Association Française de Cliométrie, *Working Papers*, 09-2017.

[17] Michel Hau, « Coûts du transport du charbon et industrialisation des régions françaises de 1847 à 1911 », in : Association interuniversitaire de l'Est, *Transports et voies de communication*, Dijon, Société des Belles Lettres, 1977 ; « Energiekosten und Industrialisierung der französischen Regionen von der Mitte des XIX. Jahrhunderts bis zum 1. Weltkrieg", in S. Pollard, *Region und Industrialisierung*, Vandenhoek u. Ruprecht, Göttingen 1980, pp. 239-253.

[18] Nicolas Stoskopf, *La petite industrie dans le Bas-Rhin, 1810-1870*, Strasbourg, Oberlin, 1987. Michel Hau et Nicolas Stoskopf « Labour Intensive Industrialization: The Case of XIXth Century Alsace » in : Gareth Austin & Kaoru Sugihara (eds), *Labour-intensive industrialization in Global History*, London, Routledge, 2013, p. 263-279.

quête incessante de nouveaux débouchés pour assurer la pérennité de firmes à caractère familial. Nicolas Stoskopf glissa d'une étude descriptive à une amorce de modélisation. À l'aide de régressions multiples, il mit à jour l'influence, sur le processus d'industrialisation du Bas-Rhin, de la densité d'occupation des sols et de la prévalence de la foi protestante[19].

Un autre moyen d'observer la dynamique des territoires, à l'échelle européenne, cette fois, consiste à utiliser les données régionales que collecte Eurostat depuis 1973 sur les taux de chômage en Europe par régions. Ces données reposent sur une nomenclature homogène (celle du Bureau International du Travail) et un cadre géographique relativement stable dans le temps (celui des régions NUTS 1 et NUTS 2). C'est donc un instrument de recherche commode à utiliser. L'enquête, menée sur plus de trois décennies par des étudiants de Master[20] et une doctorante, Nuria Narvaiza-Mandon, fait apparaître des espaces transfrontaliers présentant des caractéristiques communes, notamment un bloc de régions rhéno-alpestres qui résiste à la désindustrialisation depuis les années 1970 et enregistre de bas taux de chômage[21].

2. Les diverses approches quantitatives des niveaux de vie populaires

L'exploitation des données des enquêtes agricoles de 1852 et 1862 a permis d'évaluer le revenu de l'agriculteur alsacien au début du Second Empire, tel qu'il peut être calculé à partir des chiffres de production et de population active. Elle a donné un résultat surprenant : ce revenu est, en Alsace, inférieur au niveau atteint dans l'ensemble de la France malgré des recettes à l'hectare doubles de la moyenne française[22]. Cela s'explique par le fait qu'au cours des XVIIIe et du XIXe siècles, le développement de l'agriculture commerciale a offert en Alsace aux familles pauvres la possibilité de survivre sur des exploitations de plus en plus petites, dans un contexte de forte croissance démographique, mais sans leur permettre pour autant d'améliorer leur niveau de vie.

Une analyse de l'enquête agricole de 1852 pour tous les départements français (Seine exceptée) confrontée à l'enquête de 1853 sur les salaires dans la petite industrie[23] fait surgir une corrélation significative entre les variations

[19] Nicolas Stoskopf, *La petite industrie dans le Bas-Rhin..., op. cit.*, p. 200-204.

[20] Nathalie Tavernier, *La résistance des régions européennes à la désindustrialisation de 1968 à nos jours. Étude statistique*, mém. Maîtrise, Université Marc Bloch, 1995. Larissa Mnémosyme, *Chômage et phénomène de désindustrialisation en Europe, une analyse régionale, 1979-2004*, mém. Master, Université Marc Bloch, 2007.

[21] Nuria Narvaiza-Mandon, *L'explosion du chômage en Europe : une analyse nationale et régionale, 1973-2000*, thèse Université Marc Bloch, 2004. Michel Hau et Nuria Narvaiza-Mandon, *Le chômage en Europe : divergences nationales et régionales*, Paris, Economica, 2009. Nuria Narvaiza-Mandon, *Analyse régionale du chômage en Europe occidentale, 1973-2009*, Belfort, Neufchâtel, Presses de l'UTBM / Alphil, 2011.

[22] Michel et Nicole Hau, « La croissance du produit agricole alsacien, 1815-1975 », *Revue d'Alsace*, CVII, 1981, pp. 133-152. Michel Hau, « Überbevölkerung und Industrialisierung im 19. Jahrhundert : der elsässische Fall », *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte*, 88. Band, 2001, pp. 199 à 209.

[23] Cf *Statistique de la France*, 2e série, t 7 et 8, et *Statistique de la France*, 2e série, t 12.

interdépartementales du revenu agricole par agriculteur et celles des salaires urbains moyens[24]. Elle peut inciter à conclure à une influence de la variable démographique sur le niveau des salaires. Dans sa célèbre critique du programme de Gotha, Karl Marx a sévèrement contesté cette idée. Pour lui, c'est le mode de production capitaliste qui seul crée « l'armée de réserve industrielle », cette masse de chômeurs qui exerce une pression à la baisse sur les salaires.

Contrôlée depuis 1986 par un nouveau secrétaire de la rédaction, Bernard Lepetit, la revue *Annales Économie, Société, Civilisations* a refusé la publication de l'étude de Michel Hau, qui lui paraissait trop proche des thèses des classiques anglais et de celles de Ferdinand Lassalle sur la « loi d'airain des salaires ». Depuis la disparition de Jean Bouvier, la rédaction des *Annales* éprouvait un désamour croissant pour une histoire économique et sociale qui, après avoir semblé confirmer les thèses marxistes à l'époque d'Ernest Labrousse, paraissait s'en éloigner sous l'influence d'une *new economic history* venue des États-Unis. La revue n'allait pas tarder à exclure quelques années plus tard le mot économie de son titre[25]. Mais l'article de Michel Hau sur la pauvreté rurale et les bas salaires fut accepté par la *Revue Histoire, Économie et Société*.[26] Les sources et les méthodes de cette étude y sont exposées de façon détaillée. Le débat peut donc avoir lieu.

Une autre approche quantitative du niveau de vie explorée par l'Institut d'Histoire économique et sociale a consisté à étudier l'état physiopathologique de l'ensemble d'une population. La France est le seul pays au monde à disposer, depuis le début du XIXe siècle, de données sur des échantillons de sa population rigoureusement tirés au sort : les registres de la conscription. Dès la fin des années 1960, Emmanuel Le Roy Ladurie avait saisi la richesse exceptionnelle de cette source. En 1972, il avait publié pour la période 1819-1826 une première cartographie des niveaux de vie en France à partir de la fréquence de plusieurs symptômes de sous-alimentation[27]. Mais les statistiques qu'il avait utilisées étaient celles qui étaient disponibles aux Archives Nationales. C'étaient des documents récapitulatifs, présentés sous une forme synthétique, avec une perte d'information par rapport aux listes détaillées conservées dans les archives départementales. Par exemple, la myopie, dont la cause est multifactorielle, et la taie sur l'oeil, qui renvoie à une grave avitaminose, y étaient regroupées dans une même rubrique « maladie des yeux » qui ne signifiait pas grand-chose. Les archives départementales, qui contiennent la nomenclature détaillée, ont

[24] La corrélation entre l'indice du salaire ouvrier départemental et l'indice de la productivité agricole départementale est significative avec une probabilité de l'hypothèse nulle de 0,4%.

[25] En 1994, les *Annales* perdirent leur sous-titre « Économie, Société, Civilisations » qu'elles portaient depuis 1946 pour celui de « Histoire, Sciences sociales ».

[26] Michel Hau, « Pauvreté rurale et dynamisme économique: le cas de l'Alsace », *Histoire Économie et Société* 1987, pp. 113 à 138.

[27]Nicole Bernageau, Emmanuel Le Roy Ladurie, Yves Pasquet « Le conscrit et l'ordinateur. Perspectives de recherche sur les archives militaires du XIX[e] siècle français », *Studi Storici*, 10, 1969, p. 260-308. Jean-Paul Aron, Paul Dumont, Emmanuel Le Roy Ladurie, *Anthropologie du conscrit français d'après les comptes numériques et sommaires du recrutement de l'armée (1819-1826)*, Paris, Mouton, 1972.

un pouvoir de résolution beaucoup plus grand et ce sont celles-ci que tout travail de ce type devra utiliser à l'avenir.

L'Alsace a été la première région où la physiopathologie des conscrits a pu être analysée de manière systématique à partir de ces listes figurant dans les séries R des centres départementaux d'archives. Les études ont été réalisées en retenant tous les symptômes de sous-alimentation ayant abouti à une décision de réforme : le défaut de taille (moins d'1,57 m), le goitre, le crétinisme, le rachitisme, les caries, la taie sur l'oeil, le scorbut, la faiblesse de constitution, l'hydrocèle, les scrofules, les varices et la hernie. Les chiffres sont donnés par communes et par professions. Les premières études, lancées à titre de tests sur différents cantons par des étudiants de Maîtrise[28], ont fourni des résultats suffisamment solides pour envisager d'entreprendre des recherches de plus grande envergure. Parmi elles, la thèse de Jean-Michel Selig sur l'arrondissement de Colmar publiée en 1996 demeure la plus grande enquête physiopathologique menée à ce jour. Elle porte sur 53 053 conscrits examinés dans les 141 communes de l'arrondissement de Colmar et durant quatre décennies (1831-1870) [29].

Une troisième approche des niveaux de vie a été effectuée par Stéphane Muckensturm dans sa thèse de doctorat soutenue à Strasbourg en 1995[30]. Elle a consisté à recenser les indigents secourus par les bureaux de bienfaisance de toutes les communes alsaciennes à plusieurs dates clés du XIXe siècle. L'étude aborde un problème fondamental, celui de la pauvreté extrême, celle qui pousse à demander l'assistance d'autrui, que ce soit sous la forme d'une aide organisée par la collectivité ou d'une aide donnée spontanément, de particulier à particulier. Dans le premier cas, on parle d'indigence. Dans le second, on parle de mendicité. Ces phénomènes sociologiques sont relativement bien saisis en France par les statistiques depuis deux siècles. C'est la Constituante qui, la première, a cherché à les mesurer avec précision, dès l'année 1790. D'autres enquêtes ont été réalisées par la suite, et la France offre ainsi la possibilité d'investigations statistiques dans un cadre territorial remarquablement stable depuis deux siècles, celui des départements. Stéphane

[28] Rachel Caspar-Prange, *Anthropologie des ruraux du vignoble alsacien (1806-1870*), mémoire de maîtrise, Strasbourg II, 1983 ; Bruno Meyer, *Anthropologie des ruraux du Nord de l'Alsace au XIXe siècle. Physiopathologie des conscrits des cantons de Sarre-Union et de Drulingen (1805-1868)*, mémoire de maîtrise, Strasbourg II, 1983. Jean-Michel Selig, *Données physiopathologiques des conscrits du canton de Villé*, 1805-1868, mémoire de maîtrise, Strasbourg II, 1985. « Physiopathologie et niveaux de vie. Les conscrits des campagnes alsaciennes au XIXe siècle », *Histoire moderne et contemporaine informatique n° 9*, 1986, p. 5 à 26. Jean-Michel Selig, *Méthode pour une recherche sur la malnutrition dans l'Alsace du XIXe siècle*, mémoire de D.E.A., Strasbourg II, 1987. Jean-Michel Selig, « Misère et malnutrition dans les campagnes alsaciennes du XIXe siècle », *Revue d'Alsace*, n°114, 1988. Yves Wunsch, *La physiopathologie des conscrits strasbourgeois (1816-1869)*, mémoire de maîtrise, Strasbourg II, 2002. Véronique Schultz, « Les crises économiques à l'épreuve de l'histoire anthropométrique : l'exemple de Strasbourg au XIXe siècle, *Histoire Économie et Société*, 28 / 1, mars 2009, p ; 25-33.

[29] Jean-Michel Selig, *Malnutrition et développement économique dans l'Alsace du XIXe siècle*, Strasbourg, Presses Universitaires de Strasbourg, 1996. Michel Hau et Jean-Michel Selig, « Malnutrition in XIXth Century Alsace » *The Journal of European Economic History*, 31, 2003, pp. 61-75.

[30] Stéphane Muckensturm, *Indigence, assistance et répression dans le Bas-Rhin (1789-1870)*, thèse, Université Marc Bloch, 1995. Stéphane Muckensturm, *Soulager ou éradiquer l misère ? L'indigence dans le Bas-Rhin au XIXe siècle*, Strasbourg, Presses Universitaires de Strasbourg, 1999.

Muckensturm a choisi pour cadre géographique de son étude l'un d'entre eux, le département du Bas-Rhin. Au XIXe siècle, l'effort d'investigation des statisticiens français sur l'indigence et la mendicité s'est poursuivi avec les enquêtes de 1840, 1847, 1850, 1856 et 1866. Cela permet à Stéphane Muckensturm de parcourir une période de longue durée qui englobe le mouvement de forte croissance démographique et de paupérisation rurale de la première moitié du XIXe siècle, suivi de l'industrialisation et de l'amorce d'une décrue démographique des campagnes à la fin du Second Empire. Stéphane Muckensturm a su sortir du cadre régional et étendre, en utilisant plusieurs enquêtes interdépartementales, son étude aux autres départements français.

Le travail de collecte des données quantitatives laisse le chercheur dans l'incertitude et l'ignorance jusqu'à l'apparition des premiers tableaux statistiques et des premières cartes. Le résultat est parfois une surprise. Ce fut le cas pour cette étude menée par Stéphane Muckensturm : quand la première carte de l'indigence alsacienne fut dressée, elle fit apparaître une image de la pauvreté qui était le négatif des cartes de Jean-Michel Selig ! Étendant, son enquête aux autres départements français, Stéphane Muckensturm eut la confirmation que ce n'étaient pas les régions les plus pauvres en termes de physiopathologie des conscrits qui enregistraient les plus forts pourcentages d'indigents dans leur population. En fait, la constatation n'était pas nouvelle : Tocqueville avait déjà remarqué au XIXe siècle qu'il y avait plus d'indigents en Grande-Bretagne qu'en Russie. De fait, l'assistance aux pauvres ne peut se développer que là où les caisses des bureaux de bienfaisance disposent de ressources financières. Nous touchons ici à l'un des noeuds du problème de la quantification : si les comptages donnent des chiffres relativement fiables, la signification des statistiques obtenues n'est pas toujours aisée à déterminer.

Le recrutement, en 1998, de Nicolas Bourguinat à Strasbourg permit d'apporter une quatrième approche de l'étude des niveaux de vie : les fluctuations des prix des céréales dans la première moitié du XIXe siècle. Celles-ci provoquent de très amples variations du pouvoir d'achat des classes pauvres. Sa thèse sur les violences frumentaires dirigée par Yves Lequin et soutenue à l'Université de Lyon II une année auparavant[31] étudiait un élément fondamental du niveau de vie populaire dans la France du XIXe siècle : le prix des céréales. Dans la visée qui était celle des fondateurs des *Annales*, elle offrait une vision globale sur la société et l'État français dans la première moitié du XIXe siècle. Élu maître de conférences l'année suivante en 1999 il apporta ses compétences à plusieurs recherches d'histoire économique et sociale[32], dont une étude importante qui sera évoquée plus loin. Après avoir entrepris pour son Habilitation à diriger des recherches une étude sociale sur la transition post-

[31] Nicolas Bourguinat, *Ordre naturel, ordre public et hiérarchie sociale dans la France de la première moitié du XIXe siècle : l'État et les révoltes frumentaires,* thèse Université Lumière, Lyon, 1997. La thèse a été publiée sous le titre *Les grains du désordre. L'État face aux violences frumentaires dans la première moitié du XIXe siècle*, Paris, Éditions de l'EHESS, 2002.

[32] Parmi les travaux dirigés par Nicolas Bourguinat en histoire économique et sociale, il faut citer le mémoire de Master de Sylvain Cothias, *La grande grève des mineurs de 1963 dans le bassin lorrain*, Université de Strasbourg, s.n., 2011.

napoléonienne en Europe sous la direction de Philippe Boutry[33], Nicolas Bourguinat s'orienta vers l'histoire culturelle[34].

3. La participation de l'Institut d'Histoire économique et sociale au développement de l'histoire anthropométrique en France

L'utilisation des registres de la conscription connut un rebondissement avec l'utilisation des méthodes de la nouvelle histoire anthropométrique[35] mises au point aux États-Unis. Les données françaises sur la conscription contiennent la mesure de la stature de chaque conscrit. Or il est admis aujourd'hui que la stature moyenne des individus est fortement liée au niveau de vie de la population, à tel point que maints auteurs suggèrent de recourir à l'histoire anthropométrique pour évaluer le niveau de vie lorsque les données économétriques font défaut[36]. Cette possibilité peut être utilisée à condition, toutefois, d'interpréter, à l'aide de connaissances en auxologie, les oscillations de séries annuelles dont chaque terme (la taille moyenne de la classe examinée) synthétise en réalité des événements accumulés au cours des vingt années de vie d'une cohorte de conscrits. Jean-Michel Selig a montré que, décalée de dix ans, la courbe de la proportion de faibles de constitution offre de sérieuses analogies avec la courbe du prix du blé[37].

Par un heureux hasard, John Komlos, le spécialiste mondial de l'histoire anthropométrique, avait quitté en 1992 les États-Unis pour venir enseigner à la Ludwig-Maximilians-Universität de Munich, où il resta jusqu'en 2010. La proximité géographique entre l'Alsace et la Bavière permit de créer des liens de coopération étroits. John Komlos vint en avril 1999 à Strasbourg présenter ses travaux et expliquer ses méthodes. Il s'était lancé dans une étude sur l'évolution de la stature des recrues de l'armée française au XVIIIe siècle. Il reçut alors une aide précieuse de Nicolas Bourguinat qui lui communiqua toutes les informations accumulées dans les travaux des historiens français en matière de climat, de démographie et d'économie agricole. Accompagné de Michel Hau et de Nicolas Bourguinat, John Komlos vint présenter en septembre 2001 à Oxford, dans le cadre de la quatrième conférence de l'European Historical Economics Society, sa communication intitulée « Height, nutrition and the biological standards of living in Old Regime France ». Celle-ci fut publiée en 2003

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[33] Nicolas Bourguinat, *Pour une histoire sociale de la culture et des nations européennes du premier XIXe siè§cle : héritages et transitions après la domination napoléonienne*, Université Paris I, s.n., 2009.

[34] Il publia notamment *« Et in Arcadia ego... » Voyages et séjours de femmes en Italie, 1770-1870*, Montrouge, Éditions du Bourg, 2017.

[35] John Komlos, *The Biological Standard of Living in Europe and America, 1700-1900*, Variorum, Aldershot 1984. Stanley L. Engerman "The Standard of Living Debate in International Perspective: Measures and Indicators", dans Richard H. Steckel, Roderick Floud (dir.), *Health and Welfare during Industrialization*, University of Chicago Press, Chicago, 1997, p. 17-46.

[36] John Komlos, Jörg Baten, « Looking Backward and Looking Forward, Anthropometric Research and the Development of *Social Science History* », *Social Science History*, 28 / 2, p. 192.

[37] Jean-Michel Selig, *Malnutrition et développement économique dans l'Alsace du XIXe siècle*, *op.cit.*, p. 204-205, 398-399, 663-664.

simultanément en anglais dans l'*European Review of Economic History*[38] et en français dans la revue *Histoire Économie et Société*[39].

John Komlos accueillit à Munich Jean-Michel Selig et Laurent Heyberger pour des échanges scientifiques. En appliquant les méthodes de l'histoire anthropométrique, Laurent Heyberger soutint à Strasbourg un mémoire de diplôme d'études approfondies[40] puis, en 2004, une thèse de doctorat[41], qui fut la première thèse d'anthropométrie historique soutenue en France[42].

Pour cette thèse, Laurent Heyberger saisit et traita 298 000 dossiers de conscrits, soit l'échantillon le plus grand jamais exploité dans une enquête de ce type. La période examinée, soit cent soixante années, s'étend de la veille de la Révolution à la seconde guerre mondiale et considère toute la diversité régionale de la France, mettant en lumière les contrastes les plus significatifs (rural / urbain, agriculture avancée / retardée, grande culture / polyculture intensive). Les erreurs statistiques sur lesquelles reposait la théorie raciale de Broca furent brillamment débusquées. Sa thèse et les travaux qui ont suivi, menés à partir de données individuelles ont remis en question des premiers travaux d'histoire anthropométrique sur la France menés par Michel van Meerten et David Weir dans les années 1990, et réalisés à partir de données agglomérées. Elle a conduit à nuancer l'affirmation selon laquelle la France n'aurait pas connu pas de baisse de la stature durant la première industrialisation. Une baisse de la stature a bien eu lieu à Mulhouse jusqu'au milieu du XIXe siècle. Des baisses moins marquées ont été observées dans les campagnes (Alsace, Limousin, Brie durant la Grande Dépression). Laurent Heyberger a noté une étrangeté européenne : la hausse soutenue de la stature en Brie (1820-1850), contemporaine de la révolution agricole dans cette région.

Laurent Heyberger quitta Strasbourg en 2009 pour assumer un poste de maître de conférences à l'Université de Technologie de Belfort-Montbéliard. Il y continua ses travaux sur l'histoire anthropométrique de la France. À partir d'un sondage couvrant à l'échelle individuelle plus de 40% de la classe 1868 (née en 1848), il remit en question

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[38] John Komlos, « An anthropometric history of early-modern France », *European Review of Economic History*, Cambridge University Press, vol. 7 (02), p. 159-189, 2003.

[39] John Komlos, « Histoire anthropométrique de la France de l'Ancien Régime », *Histoire, Économie et Société*, n° 22 / 4, 2003, p. 519-536.

[40] Ce mémoire fut aussitôt publié. Cf. Laurent Heyberger, *Santé et développement économique en France au XIXe siècle. Essai d'histoire anthropométrique*, Paris, L'Harmattan, 2003.

[41] La soutenance de la thèse de Laurent Heyberger intitulée *L'évolution des niveaux de vie en France de la fin de l'ancien régime à la seconde guerre mondiale. Approche anthropométrique* eut lieu le 27 novembre 2004 à l'Université Marc Bloch. Le jury était composé d'Emmanuel Le Roy Ladurie, Jean-Charles Asselain, Claude Diebolt, Jean-Pierre Dormois, Michel Hau et Jean Heffer. La thèse fut bubliée l'année suivante. Cf. Laurent Heyberger, *La révolution des corps. Décroissance et croissance staturale des habitants des villes et des campagnes en France, 1780-1940,* Strasbourg-Belfort, Presses Universitaires de Strasbourg, Pôle éditorial multimédia de l'UTBM, 2005.

[42] Il faut toutefois mentionner la thèse de troisième cycle de Guy Soudjian, dirigée par Maurice Agulhon, *La population parisienne à la fin du second Empire d'après les archives du recrutement militaire*, soutenue en 1978 à Paris I. Cette étude a été publiée sous le titre *Anthropologie du conscrit français sous le second Empire*, Belfort, Presses de l'UTBM, 2008.

la thèse formulée par David Weir d'une corrélation positive propre à la France entre urbanisation et stature. En fait il s'agissait d'une erreur classique d'*ecological fallacy*. Plus on descend dans l'échelle d'analyse, plus le lien urbanisation/stature devient négatif, comme dans les autres pays en cours d'industrialisation au XIXe siècle. Le malus urbain suit la hiérarchie urbaine : il culmine à Paris, est un peu moins grand dans les grandes métropoles, et nul dans les petites villes. Conformément à ce que Le Roy Ladurie avait observé, l'alphabétisation est la variable qui explique le mieux les disparités de développement humain au XIXe siècle[43].

Les travaux de Laurent Heyberger comptent aussi beaucoup par leur apport méthodologique Ils ont contribué à la mise au point d'un instrument d'observation qui est adapté à l'ensemble des archives françaises de la conscription. Pour étudier la relation entre prix du blé et stature, Laurent Heyberger suggère un ajustement des courbes de prix aux particularités anthropométriques : chaque point établit une moyenne mobile des prix du blé aux âges de croissance 0-3 et 19-20 ans[44]. Ses travaux ont été prolongés par un manuel qui présente aux chercheurs les méthodes et les récentes découvertes de l'histoire anthropométrique[45]. On a pu se réjouir à cette occasion de voir la recherche historique française prendre pied dans un domaine largement investi par les chercheurs étrangers, alors que la France possède dans ses archives départementales des données anthropométriques uniques au monde.

Un autre chercheur strasbourgeois, Karim Djedid, reprit les données collectées par Jean-Michel Selig sur les communes de l'arrondissement de Colmar et les confronta avec celles sur les statures. Il montra que l'anthropométrie et la physiopathologie faisaient surgir des cartographies très semblables et que la corrélation entre la fréquence des maladies de sous-alimentation et la stature était très significativement négative[46].

La troisième conférence mondiale d'économie et de biologie humaine se tint à Strasbourg du 22 au 24 juin 2006. Emmanuel Le Roy Ladurie fit le discours d'ouverture et John Komlos celui de conclusion. Plus de soixante-dix communications furent présentées. Elles furent publiées en 2007 dans la revue *Economics anf Human Biology*.

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[43] Cf. Laurent Heyberger, "Niveaux de vie biologiques, disponibilités alimentaires et consommations populaires en France au milieu du XIXe siècle, *Annales de démographie historique* 2009, 2, p. 167-191; "Les Parisiens et les banlieusards étaient-ils aussi grands que cela? Stature, nutrition et urbanisation en France au milieu du XIXe siècle", *Annales de démographie historique* 2013, 2, p. 113-140; "Received wisdom versus reality: height, nutrition and urbanization in mid-nineteenth-century France, *Cliometrica* 8, 2014, 1, p. 115-140.

[44] Laurent Heyberger, *Santé et développement économique en France au XIXe siècle. op. cit.*, p.63-69. La meilleure corrélation est obtenue par la prise en compte du prix du blé de la naissance à 3 ans, et de 19 à 20 ans.

[45] Laurent Heyberger, *L'histoire anthropométrique*, Berne, Peter Lang, 2011.

[46] Karim Djedid, *Stature, malnutrition et développement économique dans l'arrondissement de Colmar (1811-1850)*, mémoire de maîtrise, Strasbourg II, 2005. Karim Djedid et Michel Hau, « Stature et malnutrition dans l'Alsace de la première moitié du XIXe siècle », *Histoire, Economie et Société* n° 28, 2009, pp. 35-56.

Les communications concernant la France furent regroupées et publiées dans un numéro spécial *d'Histoire Économie et Société* en 2009[47]

Il reste à souhaiter que les travaux de Laurent Heyberger fassent école en France : L'histoire anthropométrique a profondément renouvelé l'histoire économique et sociale dans les pays anglo-saxons alors qu'elle reste peu pratiquée en France, malgré la richesse exceptionnelle des données conservées dans ses centres départementaux d'archives.

Depuis 2014, Laurent Heyberger a engagé des travaux sur un autre chantier : l'Algérie de l'époque coloniale[48]. Par une analyse croisée des différentes variables (climatiques, agricoles, démographiques, anthropométriques, médicales, mais aussi des données qualitatives) il a remis en question les résultats des recensements de la population indigène antérieurs à 1886 : la population de l'Algérie en 1830 doit être revue en hausse, tandis que la crise démographique de 1867-1868 a été d'une exceptionnelle gravité.

4. Les études sur les croissances nationales

La venue de Jean-Pierre Dormois à Strasbourg en 2003 revitalisa l'orientation vers les études sur agrégats économiques et la croissance. Jean-Pierre Dormois avait été l'assistant de David Landes à Harvard comme *teaching fellow* de 1984 à 1988. De 1991 à 1993, il avait été *supervisor of studies* à Cambridge. Il avait également animé des semestres d'été en 1996 et 1997 à Tübingen et enseigné comme *visiting professor* en 1998-1999 à l'Université d'Iowa. Il avait soutenu, en 1992, une thèse rédigée sous la direction de François Crouzet et portant sur une comparaison des productivités dans les économies française et britannique à la veille de la Première Guerre mondiale[49] publiée sous le titre puis, l'année suivante, il avait soutenu un PhD sur les mesures de la productivité à l'Institut Universitaire Européen de Florence. Il avait poursuivi ses travaux sur la mesure de la productivité en élargissant son domaine de recherches, et présenté ses résultats dans un mémoire d'Habilitation à diriger des recherches en 2001 à l'Université de Nanterre[50]. Il était l'un des rares historiens quantitativistes de la

[47] Laurent Heyberger (dir.), *L'Histoire anthropométrique en France*, *Histoire économie et Société*, n° 28-1, mars 2009.

[48] Laurent Heyberger, *Les statistiques coloniales en question. Niveaux de vie, croissance démographique et économie des populations indigène et européenne d'Algérie au XIXe siècle. Approche par l'histoire anthropométrique,* Presses Universitaires du Midi, 2019.

[49] Jean-Pierre Dormois, *Performance et productivité dans les économies française et britannique à la veille de la Première Guerre mondiale*, thèse Université de Paris-Sorbonne, 1992. Jean-Pierre Dormois, *L'économie française face à la concurrence britannique à la veille de 1914, Paris, L'Harmattan, 1997.*

[50] Jean-Pierre Dormois, *Des machines ou des hommes ? étude des différentiels de productivité entre la France et le Royaume-Uni avant la Première guerre mondiale*, Institut Universitaire européen, 1993. Jean-Pierre Dormois, *Mesurer la productivité au cours de l'industrialisation* . mémoire d'HDR, Université de Nanterre, 2001. Jean-Pierre Dormois, « Protectionnisme et productivité du travail en Europe avant 1914, *Revue de l'OFCE* 2002/3, n° 82, p. 11-47.

génération entrée dans la carrière universitaire dans les années 1980[51]. Il avait publié plusieurs ouvrages d'histoire économique[52].

Durant son séjour à Strasbourg, Jean-Pierre Dormois corrigea l'indice Hoffmann du produit national net de l'Allemagne en retournant aux sources statistiques originales et en se fondant sur une approche inédite consistant à partir, non plus des productions mais des revenus salariaux et de leurs rapports à la valeur ajoutée[53]. Comparant les rythmes de croissance de la productivité des grands pays d'Europe et les niveaux de protection douanière, il montra dans un ouvrage les effets négatifs de la protection douanière sur la productivité[54]. À l'occasion du 3e congrès d'économie et biologie humaine de Strasbourg, il présenta, en coopération avec Jean-Pierre Bassino, une étude critique des sources de l'histoire anthropométrique[55]. Avec l'historien économiste anglais James Foreman-Peck, il réalisa une étude statistique sur les facteurs d'industrialisation des départements français sous Napoléon III en croisant des indicateurs départementaux d'industrialisation (recensement professionnel, registres des patentes) avec diverses variables (taux d'alphabétisation, coût du combustible, données sur le climat, distance à Paris, etc.). Cette étude aboutit à nuancer la thèse de David Landes selon laquelle l'esprit d'entreprise aurait été défaillant au sud la ligne Saint-Malo-Genève. Elle mit à jour des influences exercées par le milieu physique et le taux d'alphabétisation. Elle fut présentée en mars 2014 à la conférence annuelle de l'Economic History Society à Warwick[56]. Jean-Pierre Dormois constitua plusieurs bases de données consultables en ligne[57]. Il dirigea l'Institut

[51] Il a, outre sa thèse, déjà publié trois ouvrages : *Histoire économique de la Grande Bretagne au XXe siècle*, Paris, 1994, *La défense du travail national ? L'incidence du protectionnisme sur l'industrie en Europe (1870-1914)*, Paris 2003, *The French Economy in the Twentieth Century*, Cambridge 2003. À cela s'ajoutent deux ouvrages en collaboration :*The British Industrial Decline* en 1998 et *Vue d'Amérique. La Révolution jugée par les Américains*, 1989. Il a publié en outre plus de trente articles, communications ou parties d'ouvrages collectifs, dont une bonne part dans des revues étrangères.

Jean-Pierre Dormois soutint en 1994 un PhD à l'InstitutUniversitaire européen de Florence, *Des machines et des hommes : la productivité du travail en France et en Grande-Bretagne au cours de l'industrialisation* , puis une habilitation à l'Université de Nanterre en 2001, *Mesurer la productivité au cours de l'industrialisation* .

[52] Jean-Pierre Dormois, The French Economy in the Twentieth Century ; The British Industrial Decline ; Classical Trade Protectionism ; L'économie française face à la concurrence britannique avant 1914 ; La Défense du travail national

[53] Jean-Pierre Dormois, « Revoir les comptes d'Hoffmann : la question de l'ampleur de l'essor industriel dans l'Allemagne wilheminienne », *Revue d'Allemagne et des pays de langue allemande*, 2008 / 1, n° 40, p. 43-74.

[54] Jean-Pierre Dormois, La défense du travail national ? : l'incidence du protectionnisme sur l'industrie en Europe, 1870-1914, Paris, Presses de l'Université de Paris-Sorbonne, 2009.

[55] Jean-Pascal Bassino et Jean-Pierre Dormois, « Comment tenir compte des erreurs de mesure dans l'estimation de la stature des conscrits français ? », *Histoire, Économie et Société*, 2009 / 1, p. 97-122.

[56] Jean-Pierre Dormois, James Foreman-Peck, « What drove (or choked) French entrepreneurship under Napoleon III. A department-level analysis », Conférence annuelle de l'Economic History Society à Warwick, mars 2014.

[57] Sur le cite créé par Jean-Pierre Dormois, on peut consulter des données sur l'industrie française de 1840 à 1963, les tarifs douaniers français de 1860 à 1924, les tarifs douaniers en Europe en 1913 et les salaires moyens par département de 1845 à 1911.

d'Histoire économique et sociale de 2011 à 2015, date à laquelle il partit pour l'Institut d'Études Politiques de Bordeaux.

L'exploitation de la banque de données du Groningen Growth and Development Center créée à l'initiative d'Angus Maddison [58] a donné lieu à plusieurs analyses intéressantes sur les séries de chiffres annuels du PIB. Croisée avec les données de l'Organisation Mondiale du Commerce sur les parts de marché à l'exportation, elle a permis de noter l'influence croissante du commerce extérieur sur les croissances européennes après 1979[59]. Exploitant les mêmes données, Daouda Diop a étudié les disparités de croissance économique en Europe occidentale depuis la signature du Traité de Rome[60]. Il a mis en évidence un phénomène de rattrapage : la croissance du PIB par habitant étant la plus forte chez les pays qui figuraient parmi les plus retardataires en 1957. Il a aussi montré le renversement du classement entre l'Europe occidentale et les États-Unis en 1982. Une analyse sur six décennies des séries tirées de la même banque de données révèle une accélération durable de la croissance au Cameroun après une crise très profonde survenue en 1986[61].

5. L'histoire quantitative est pratiquée partout au sein de la Faculté des Sciences Historiques de Strasbourg

À Strasbourg, l'empreinte laissée par Marc Bloch et Lucien Febvre fait que l'esprit des Annales n'est pas le monopole d'un seul institut. Les travaux de l'Institut d'Histoire d'Alsace se fondent également bien souvent sur l'étude de séries. Après la thèse du géographe Étienne Juillard sur la vie rurale en Alsace[62], l'historien moderniste Jean-Michel Boehler accomplit la même démarche pour une période antérieure,[63] dans le village de Schweighouse sur Moder, la superficie moyenne par exploitation, mesurée de façon presque continue entre 1670 et 1787, diminue après 1690 révélant la « faim de terre » qui s'amplifie en Alsace tout au long du XVIIIe siècle[64]. Quant à Claude

[58] Angus Maddison, *Statistics on World Population, GDP and per capita GDP*, Groningen Growth and Development Center Database.

[59] Claude Michel Adossou, *L'évolution des parts des exportations mondiales détenues par les différents pays d'Europe (Europe de Quinze et la Suisse) de 1973 à nos jours*, mém. Maîtrise, Université Marc Bloch, 2004. Adrien Ehrsam, *Analyse historique et comparée du commerce extérieur et de la croissance économique pour seize pays d'Europe occidentale entre 1957 et 2007*, mém. Master, Université de Strasbourg, 2010.

[60] Daouda Diop, *PIB comparés des différents pays d'Europe occidentale de puis le traité de Rome (1957-2007),* Thèse, Université de Strasbourg, 2011.

[61] Lucie Zouya Mimbang, « Le Cameroun au seuil de l'émergence ? De la lisibilité des séries statistiques du Produit Intérieur Brut (1950-2009), Présence Africaine, n° 185-186, 2012, p. 289-309.

[62] Étienne Juillard, *La vie rurale dans la plaine de Basse Alsace. Essai de géographie sociale*, Strasbourg, 1953.

[63] Jean-Michel Boehler, *Démographie et vie rurale en Basse Alsace : l'exemple du Kochersberg (1648-1836*), Th. 3e cycle, Strasbourg II, 1973. Jean-Michel Boehler, Dominique Lerch et Jean Vogt, *Histoire de l'Alsace rurale*, Strasbourg, Istra, 1983. Jean-Michel Boehler, *La paysannerie de la plaine d'Alsace (1648-1789), Une société rurale en milieu rhénan*, Strasbourg, 3 vol., Strasbourg, Presses Universitaires de Strasbourg, 1994.

[64] Jean-Michel Boehler, *La paysannerie de la plaine d'Alsace op. cit.*, p. 598.

Muller directeur actuel de l'Institut d'Histoire d'Alsace, il a reconstitué une remarquable série de dates de vendanges, qui a servi à Le Roy Ladurie pour réaliser son histoire du climat[65].

IV. La cliométrie au BETA !

La recherche en cliométrie prit son essor à Strasbourg avec la venue de Claude Diebolt en 2004 comme directeur de recherches au CNRS. D'une manière générale, il contribua à développer la cliométrie dans le milieu des sciences économiques, à un moment où l'histoire quantitative connaissait un relatif déclin au sein des sciences historiques.

Claude Diebolt est l'actuel Président de la Section 37 (Economie et Gestion) du Comité National de la Recherche Scientifique (2016-2021). Ancien Président du Conseil d'Administration de la Cliometric Society américaine (2014-2015) et Président fondateur de l'Association Française de Cliométrie (2001), il a été le 40ème Président de l'Association Française de Science Economique (2018-2019).

Claude Diebolt est, par ailleurs, le fondateur et le rédacteur en chef de la revue *Cliometrica* (2007) et l'éditeur en chef du *Handbook of Cliometrics* (2016… les 1768 pages de la seconde édition revue et augmentée sont à paraître). De 2002 à 2015, il a également été le Directeur de la Série AF "Histoire Economique Quantitative" de la revue *Economies et Sociétés*. Depuis, 1998, il est Co-operating Editor de la revue *Historical Social Research. An International Journal for the Application of Formal Methods to History* (de 2001 à 2013, il y a notamment été Special Editor de la rubrique "Cliometrics", qu'il a créée). A ce jour, ses travaux ont donné lieu à 144 articles publiés ou sous presse dans des revues à comité de lecture et à 52 livres, participations importantes à des ouvrages collectifs ou numéros spéciaux de revues. Certaines de ses productions (articles de recherche ou chapitres d'ouvrages) ont, par ailleurs, été traduites et publiées en allemand, anglais, espagnol, taïwanais, tchèque et chinois.

Claude Diebolt est lauréat de la *Médaille George Sarton* (2018-2019) et du *Grand Prix Jean Fourastié d'Economie* (2002). Il a été Fellow de la *Alexander von Humboldt Foundation* (1999-2000) et du *University of Strasbourg Institute for Advanced Study* (2013-2015). Il a été le Directeur adjoint, puis le Directeur (1998-2003) du *Laboratoire Montpelliérain d'Economie Théorique et Appliquée* (LAMETA, UMR 5474) à l'Université Montpellier I, ainsi que le Directeur (2009-2012) du *Bureau d'Economie Théorique et Appliquée* (BETA, UMR 7522) à l'Université de Strasbourg. Pendant 15 ans (en qualité de Privatdozent, 2002-2016), Claude Diebolt a délivré un cours de cliométrie en langue allemande à l'Université Humboldt de Berlin. Il est Docteur en sciences économiques (1994), HDR en France (1998, Université Montpellier I) et en Allemagne (2001, Université Humboldt de Berlin) et lauréat du *Grand Prix de Thèse* de l'Ecole Doctorale de la Faculté des sciences économiques et de gestion de l'Université Montpellier I. Sa thèse a été financée dans le cadre d'une bourse de recherche en cliométrie de l'Union Européenne : Stimulation Plan for Economic Science (1992-1994).

[65] Claude Muller, *Les vins d'Alsace. Histoire d'un vignoble*, Strasbourg, Coprrur, 1999. Emmanuel Le Roy Ladurie, *Histoire du climat depuis l'An Mil*, 3 vol., Flammarion, Paris, 2009.

Venue d'Amérique, la cliométrie développée par Claude Diebolt et son équipe est, avec son arrivée en Europe, empreinte de malentendus, si ce n'est méprisé pour les intentions délibérément nuisibles qu'on lui prête. En France, dès 1977, Jean Heffer livre ainsi, dans les *Annales*, avec clairvoyance et sagacité, les raisons de l'inévitable naufrage, les causes de l'acte manqué, les conséquences des opportunités de recherches ratées.

Littéralement mesure de l'histoire, la cliométrie symbolise la projection quantitative des sciences sociales dans le passé. Elle mobilise des archives historiques, des modèles théoriques mathématisés et les méthodes d'économie et d'histoire quantitative en général.

La cliométrie a pour ambition de discriminer entre des théories alternatives et, ce faisant, de discuter la multiplicité des représentations erronées de l'histoire économique (mythes, falsifications, déformations, négations ou omissions). Elle vise à éclairer la politique économique et sociale passée, présente et future, d'une part en insistant sur la dépendance au passé des réalités économiques et sociales, d'autre part en cherchant à transformer la vision moderne sur un débat historique majeur : les déterminants de la croissance économique d'hier, d'aujourd'hui et de demain.

L'attribution du Prix Nobel d'économie à Robert Fogel et Douglass North, en 1993, pour avoir renouvelé la recherche en histoire économique par l'application de la théorie économique et des méthodes quantitatives aux changements économiques et institutionnels a indiscutablement consacré l'avènement de la discipline.

"*Modern economic historians have contributed to the development of economic sciences in at least two ways: by combining theory with quantitative methods, and by constructing and reconstructing databases or creating new ones. This has made it possible to question and to reassess earlier results, which has not only increased our knowledge of the past, but has also contributed to the elimination of irrelevant theories. It has shown that traditional theories must be supplemented or modified to enable us to understand economic growth and change. Economic historians often consider far reaching problems, the estimation of which demand an integration of economics, sociology, statistics and history. Robert Fogel and Douglass North are the economic historians that have come furthest in such a scientific integration. They were pioneers in the branch of economic history that has been called the "new economic history", or cliometrics, i. e. research that combines economic theory, quantitative methods, hypothesis testing, counterfactual alternatives and traditional techniques of economic history, to explain economic growth and decline. Their work has deepened our knowledge and understanding within fundamental areas of research, as to how, why and when economic change occurs.*" (The Royal Swedish Academy of Sciences, 12 October 1993)[66].

[66] See: https://www.nobelprize.org/prizes/economic-sciences/1993/press-release/

La tenue du 8ème Congrès Mondial de Cliométrie au Palais de la Musique et des Congrès de Strasbourg, du 4 au 7 juillet 2017, est un autre exemple significatif d'une recherche tout à la fois innovante, dynamique et néanmoins ancrée dans une longue tradition.

Les contours de la cliométrie se sont d'ailleurs forgés avant même que la discipline ne naisse officiellement aux Etats-Unis ! Les héritages sont nombreux. Au risque d'oublier l'un ou l'autre des protagonistes, il apparaît que la dette envers l'Ecole historique allemande est énorme. Quant aux Instituts de conjoncture et notamment le National Bureau of Economic Research (NBER), ils auront été, après la Première Guerre mondiale, les véhicules pour l'affirmation du quantitatif en sciences sociales et plus précisément les initiateurs d'une comptabilité de la croissance. Pensons également à la création de l'Econometric Society, en 1930, avec son projet, à travers la revue Econometrica (1933), de concilier la théorie, l'histoire et les statistiques.

L'aventure cliométrique débute véritablement en 1957 à Williamstown avec la conférence Research in Income and Wealth initiée par Fabriquant, Lebergott et Gerschenkron et consacrée aux Trends in the American Economy in the Nineteenth Century. Le manifeste de Conrad et Meyer en 1957 Economic Theory, Statistical Inference, and Economic History, puis l'article du *Journal of Political Economy* de 1958, marquent une seconde étape essentielle.

La première réunion de la société de cliométrie américaine est organisée par Davis, Hughes et Reiter à Purdue en 1960. Intitulée Conference on the Application of Economic Theory and Quantitative Methods to the Study of Problems of Economic History, cette conférence est devenue progressivement la Cliometrics Conference que nous connaissons aujourd'hui et qui est organisée sous l'égide de la Cliometric Society américaine, fondée en 1983.

Quant aux thèmes fondateurs de la cliométrie, il faut mentionner l'impact des chemins de fer sur la croissance américaine, l'esclavage comme institution économique rentable, l'anthropométrie ou encore les causes et le coût de la guerre de Sécession. Les raisons du succès de la discipline sont certes liées à la vogue de l'économétrie, mais aussi à la réaction de défense d'une catégorie professionnelle menacée, celle des enseignants-chercheurs en histoire économique. Notons ici que l'influence de Samuelson et ses *Foundations of Economic Analysis* (1947) aura été considérable avec le passage de l'après seconde guerre mondiale vers la production de modèles mathématisés en économie.

Rappelons également que le premier survey consacré à la cliométrie *Econometric Studies of History* a été rédigé par Wright et discuté par David en 1971. En 1973, Temin édite un ouvrage collectif consacré à la *new economic history*. Dès 1975, Van der Wee et Klep publient un état des savoirs, largement méconnu, en termes d'histoire économique quantitative européenne. Crafts, en 1987, livrera un autre survey, publié dans le *Journal of Applied Econometrics*. Enfin, nous n'oublions pas l'ouvrage de McCloskey de 1987 *Econometric History*, l'état des savoirs de Goldin de 1995, le meeting de 1997 de l'American Economic Association *Cliometrics after 40 Years* et,

tout récemment, la publication du *Handbook of Cliometrics* par Claude Diebolt et Michael Haupert (2016, la deuxième édition revue et augmentée est à paraître).

Avec le 21ème siècle, plusieurs revues dont principalement *Cliometrica*, créée par Claude Diebolt à l'Université de Strasbourg affichent, plus que jamais, pour ambition de pérenniser les acquis du passé, tout en stimulant les recherches cliométriques à venir.

1. Epistémologie de la cliométrie strasbourgeoise

Souvent, les économistes sont du seul côté de l'*Erklären* (expliquer), de l'analyse du réel via le modèle mathématique, en quête d'objectivité pure, sans référence à toute information non-quantifiable et intégrable dans une construction formalisée. Le produit final est alors un modèle, exprimé en termes de systèmes d'équations. Certes, il y a des exceptions, mais il s'agit soit d'économistes hétérodoxes (comme le courant régulationniste en France), soit d'économistes que la profession qualifiera vite d'historiens. Le langage est, dans l'écrasante majorité des productions économiques contemporaines, mathématique du début à la fin. L'économiste est aussi clairement du côté du pôle *moderne* pour parler comme les philosophes. L'historien, même l'historien économiste présenté ci-dessus, est du côté du *Verstehen* (comprendre), de l'interprétation du réel via l'intégration d'une somme variée de sources documentaires directes ou indirectes traitées via diverses sciences auxiliaires, dont la statistique peut faire partie. Pour lui, toute source d'information, quantitative ou qualitative est bonne à prendre (*faire feu de tout bois*). Son produit final est le plus souvent un texte, il raconte une histoire et il accepte pleinement l'idée que ce qu'il fait est une interprétation. Il est dans ce sens plus près du pôle *postmoderne*, et en tout cas sa conception de la scientificité est moins étroite. Si l'économiste tend à disqualifier toute assertion qui n'est pas démontrée mathématiquement (faisant sienne la phrase de Wittgenstein : *ce dont on ne peut parler, il faut le taire*) l'historien quant à lui est prêt à tenter des interprétations dont le degré de vraisemblance n'est jamais total. Il argumente en mobilisant un ensemble de faits reconstitués, de données, de chiffres, afin de convaincre le lecteur de sa thèse. L'économiste dira lui qu'il cherche à démontrer des théorèmes et propositions pour prouver ses assertions, en ne laissant aucun espace au doute (notons cependant que certains disent que l'économiste, malgré sa mobilisation des outils mathématiques et de l'économétrie, cherche aussi à convaincre ; McCloskey (1994) sur la rhétorique économique est ici incontournable).

La cliométrie strasbourgeoise apparaît selon ces points de vue des deux côtés de cette barrière épistémologique. La mobilisation de techniques économétriques sophistiquées pour décrire des séries chronologiques de prix, de population, de production matérielle, de capital humain, de taux d'intérêt, etc. et y identifier tendance, cycles, points de retournement, peut parfaitement s'intégrer dans une approche traditionnelle du travail d'historien (synthétiser et interpréter). Mais entendu dans son sens strict, la *cliométrie* strasbourgeoise sous-entend beaucoup plus : la mobilisation de la théorie (économique) en vue de confirmer ou d'infirmer sa pertinence en la confrontant à des données du passé pour mieux comprendre le présent, voir anticiper sur l'avenir.

L'ambition peut ici être théorique (le questionnement est en partie issu de la discipline économique) et l'histoire économique est ici plutôt un matériel. Notons tout de suite que même dans ce cadre, la mobilisation d'outils issus de la théorie économique néo-classique peut aussi servir à trancher des débats de nature historiographique ou du moins ambitionne de le faire. Bref, on peut aller dans des degrés d'abstraction différents : utiliser la théorie néo-classique pour comprendre (ou plutôt expliquer) le passé ou pour résoudre des débats contemporains de théorie économique ; l'histoire n'étant qu'une extension du domaine de la lutte économétrique pour tendre vers des vérités économiques mieux assises. Dans les deux cas cependant on change radicalement de style de narration. La cliométrie vise à *expliquer* via la modélisation mathématique et le recours systématique aux techniques économétriques de pointe. Elle ne cherche pas l'interprétation mais l'analyse, et vise comme les autres sciences le cumulatif (et donc le dialogue) au sein d'une discipline caractérisée par un consensus sur les méthodes de travail et les grands principes de base. On notera en effet que dans les arts et humanités la citation réciproque des articles est beaucoup plus faible (euphémisme) que dans les sciences physiques par exemple. Il est évident que cette vision-là de l'histoire économique (et tout simplement de l'histoire) est assez révolutionnaire, en rupture avec l'idée de l'histoire comme science interprétative. Une idée sous-jacente à la cliométrie est de ramener l'histoire dans le courant général des approches de sciences exactes.

Notons ici que l'histoire positiviste du 19ème siècle avait aussi quelque part cette ambition et bien que *littéraire*, elle se voulait très hostile aux interprétations. La différence est que la cliométrie fait sienne les acquis des sciences sociales quantitatives et principalement économiques, alors que pour les historiens positivistes, *dire le vrai* se limitait à dire ce qui s'était réellement passé. Pour la cliométrie, il s'agit aussi de mettre en évidence des structures mathématiques cachées qui rendent compte de ce qui s'est passé et dont le déroulement transparaît au travers de séries chiffrées. Il est certain qu'une telle approche modélisatrice, quantifiée, mathématique, démonstrative explicative et non-interprétative, privilégiant la mesure, ne pourra que heurter les partisans du tournant post-moderne.

Ce faisant, il ne s'agit nullement de détruire l'édifice néo-classique qui a été construit, mais plutôt de l'aménager (voire en sortir à la marge) en prenant consciemment en compte l'histoire (et la conception du temps irréversible), cet effort devrait être dirigé vers la démarche cliométrique. Cela signifie d'une part de tester, plus systématiquement et sur le long terme, la validité (stabilité) des énoncés théoriques et d'autre part de bâtir des modèles théoriques davantage en adéquation avec les faits stylisés dégagés d'une analyse sérieuse de l'histoire économique. Cette ferme fondation de l'économie sur une base empirique de long terme nous semble fondamentale, aussi pour l'économiste appliqué, ou le décideur au cœur de l'action (l'économiste étant tourné vers l'aide à la prise de décision, à l'action, la définition de scenarii d'avenir possible reste donc chose centrale pour lui). En effet, nous pensons que le futur ne peut être conçu que dans un certain degré de continuité historique, c'est-à-dire par rapport à un passé qui l'a forgé et en fonction d'un présent qui l'explique tout en le déterminant en partie (bien sûr jamais totalement). La connaissance historique en économie doit cependant faire prendre garde aussi aux

extrapolations trop simplistes car les brusques ruptures (les non-linéarités) sont aussi du domaine du possible. Il est tout aussi dangereux d'ignorer l'histoire que d'imaginer le futur à l'image de celle-ci. Certes, le présent (mais aussi le passé) peut conditionner l'avenir de la même manière que le passé explique — en partie — le présent (dès que nous quittons le monde de la théorie pure et que nous prenons au sérieux le temps historique, c'est-à-dire irréversible). Le thème de la dépendance à la trajectoire (David, 2007) devient dès lors central. Ceci dit, n'oublions pas que les comportements économiques sont complexes, et que les agents économiques ne sont pas stupides. Si le passé conditionne le présent et parfois l'image qu'on se fait de l'avenir (anticipations, adaptatives dans ce cas), les anticipations de l'avenir, l'image qu'on s'en fait, peuvent à leur tour conditionner les décisions présentes. Ce serait ici le futur (la façon dont on l'anticipe) qui conditionnerait en partie le présent, et par son impact sur les décisions, la trajectoire économique future effective. Ainsi donc l'économie n'est pas le lieu de l'intemporalité, elle possède une historicité irréductible et très complexe, le passé pesant sur le présent comme l'image de l'avenir conditionne les choix actuels. Elle est, sans doute davantage en macroéconomie que dans la théorie microéconomique, une lecture (interprétation) de l'histoire économique influencée par le contexte présent et les nécessités de la prise de décision pour l'avenir. Les théories en macroéconomie cherchent donc à rationaliser des évènements historiques passés (crises, mouvements de croissance…) et à en rendre compte par une modélisation qui devrait aider le décideur dans le présent. On pourrait même dire qu'elle cherche à rendre compte de faits historiques par des modélisations a-historiques (jusqu'ici) – car sa vision de la science reste celle de la physique et la quête de régularités. Les approches d'économétrie (développées en parallèle de la recherche macroéconomique) cherchent à extraire le maximum d'information de séries quantitatives qui, par la force des choses, concernent toujours le passé (toute économétrie est donc toujours de l'histoire quantitative). Il faut insister sur cette dimension historique. Toute négligence sur ce plan serait à l'origine d'incompréhensions et souvent de décisions inopportunes (pour l'économiste comme « conseiller du prince »). Si l'on se contente, pour étudier un système économique, de mesurer sa composition présente, on néglige le fait que ses structures, comme ses caractéristiques (et les institutions qui l'encadrent), résultent d'une longue histoire qui influencera directement son avenir.

Ne perdons cependant pas de vue qu'une Ecole Historique Allemande a existé au 19ème siècle, qui n'excluait pas nécessairement la mesure et la statistique (pensons à la loi de Wagner sur l'évolution des dépenses publiques) et que plus tôt encore, à l'époque mercantiliste, c'est par l'observation de séries chiffrées sur horizon long que Bodin a tenté de mettre en lumière et expliquer le phénomène d'inflation par la première formulation de ce qu'on appellera théorie quantitative de la monnaie…

La naissance de la cliométrie a marqué une *révolution*, une rupture (totale ?) avec l'histoire économique traditionnelle. Que cela soit vrai ou non, la chose est, aujourd'hui, sans doute de peu d'importance. Un défenseur de la nouvelle école aussi

éminent que Robert Fogel[67] perçoit lui-même une évidente continuité entre l'histoire économique ancienne et la nouvelle. Ce qui ne fait aucun doute c'est que, depuis la fin des années 1950, l'histoire économique accorde une place de plus en plus importante à la théorie. Elle a aussi recours à une analyse statistique et économétrique de plus en plus rigoureuse pour la simple raison qu'un bon nombre des problèmes non résolus de l'histoire économique sont tels que les seules réponses intellectuellement satisfaisantes sont, par définition, quantitatives.

La cliométrie n'intéresse pas uniquement l'histoire économique au sens limité et technique du terme. Elle modifie la recherche historique en général. Elle représente la projection quantitative des sciences sociales dans le passé.

La question de savoir, par exemple, si l'esclavage a profité ou non aux Etats-Unis avant la guerre de Sécession ou si les chemins de fer ont eu d'importantes répercussions sur le développement de l'économie américaine[68] est aussi importante pour l'histoire générale que pour l'histoire économique et elle pèsera obligatoirement sur toute interprétation ou évaluation (anthropologique, juridique, politique, sociologique, psychologique, etc.) du cours de l'histoire américaine. Bien entendu, jusqu'ici, la cliométrie est plutôt envisagée comme discipline auxiliaire de l'histoire. Nous laissons pour plus tard la question de sa pertinence pour l'économiste, en notant simplement ici que les types de questions posées par la nouvelle histoire économique ne peuvent que parler très fort aux théoriciens du développement économique (et sans doute, mais cela viendra plus tard, de la croissance).

En outre, la cliométrie s'inscrit en faux contre l'une des hypothèses fondamentales de l'histoire traditionnelle selon laquelle l'histoire ne peut jamais apporter de preuves *scientifiques* parce qu'il ne serait jamais possible de soumettre à l'expérimentation des événements historiques par définition uniques (on gardera cependant à l'esprit que les faits historiques peuvent être plus facilement soumis au principe de réfutation de Popper que les énoncés probabilistes très généraux des économistes : si on peut réfuter la thèse que Staline a régné sur l'URSS jusque 1990, il est plus difficile de tester empiriquement l'existence et l'unicité d'un équilibre général compétitif). La cliométrie croit cependant que l'histoire (économique) peut et doit s'inspirer des raisonnements des économètres et que donc il est, au contraire, possible, au moins dans les cas favorables, de construire une situation fictive (contrefactuelle) grâce à laquelle on peut mesurer le décalage entre ce qui s'est réellement produit et ce qui aurait pu se produire dans des circonstances différentes.

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[67] Prix Nobel d'économie en 1993, avec Douglass North, pour *avoir renouvelé la recherche en histoire économique par l'application de la théorie économique et des méthodes quantitatives aux changements économiques et institutionnels.*

[68] Fogel remet en cause l'interprétation communément admise de la croissance économique aux Etats-Unis à la fin du 19ème siècle. Auparavant on avait prétendu que le chemin de fer avait été le facteur déterminant parce qu'il ouvrait de nouveaux territoires et permettait de grandes possibilités d'investissement. Fogel a contesté cette argumentation et a mis au point un modèle statistique complexe qui montrait ce à quoi l'économie américaine aurait ressemblé en 1890 s'il n'y avait peu eu de chemin de fer. Il est arrivé à la conclusion que le revenu national aurait été inférieur de 5 % au plus. Bien loin d'être indispensable, le chemin de fer avait été un facteur secondaire dans le processus global de la croissance aux Etats-Unis.

Ce principe méthodologique, c'est-à-dire la mesure de l'influence d'un facteur sur une évolution par la différence entre l'évolution réellement observée et celle hypothétique, à laquelle on aurait assisté si le facteur concerné n'avait pas existé (analyse contrefactuelle), est peut-être, avec l'économétrie historique des séries temporelles, ce que la cliométrie a apporté de plus important aux chercheurs en sciences sociales en général et aux historiens en particulier.

2. Diebolt et la cliométrie

Le programme d'enseignement et de recherche de Claude Diebolt et de son équipe[69] est clairement énoncé, dès 2001, sur le website de l'Association Française de Cliométrie :

« *Faut-il employer la cliométrie en sciences humaines et sociales ? S'agit-il d'une discipline qui marierait harmonieusement théorie et analyse empirique ? S'agit-il d'abord d'une branche de l'histoire ou de la science économique ? Quel crédit faut-il accorder à cette démarche de recherche ? Quel type de méthodes cliométriques doit-on employer ? Les sciences humaines et sociales deviendront-elles pour autant plus scientifiques ? Quel rôle la cliométrie peut-elle et doit-elle jouer dans la formation des jeunes étudiants et doctorants engagés dans des recherches universitaires de sciences humaines et sociales ? Enfin, que faudrait-il faire pour surmonter le problème de communication, réel mais souvent latent, créé par l'intrusion des méthodes systématiquement quantitatives dans la littérature en sciences humaines et sociales lorsque ces dernières sont en voie de devenir techniquement beaucoup plus élaborées et qu'il est difficile de croire que ce mouvement se renversera ? Mes enseignements visent à apporter quelques éléments de réponse et ceci, même si je m'étonne qu'il y ait encore aujourd'hui un débat actif sur les questions mentionnées plus haut, puisque depuis toujours (ou presque), la quantification est partie prenante des recherches historiques en sciences humaines et sociales. Avons-nous d'ailleurs le choix entre employer des méthodes quantitatives et ne pas le faire ? J'estime que non et cela pour une raison essentielle : le quantitatif est présent dans toutes les approches, mais sans doute de manière plus implicite qu'explicite. Certes, les méthodes quantitatives sont, depuis toujours, la particularité intrinsèque des recherches notamment françaises en sciences humaines et sociales, mais leur utilisation a été pour l'essentiel, en dehors de l'économie, secrète et subliminale. Puisque beaucoup de questions qui reposent sur des dimensions quantitatives sont déguisées par des mots, la quantification n'est pas apparente. J'illustre régulièrement cette proposition en défiant mes étudiants à choisir une page au hasard d'un de leur livre préféré d'économie, d'histoire, de sociologie etc. et leur demande de déterminer si vraiment la quantification est implicitement présente dans ce qu'ils viennent de lire. C'est effectivement très souvent le cas. Ma réponse à la première question, serait dès lors de dire que c'est une perte de temps que de se disputer pour savoir si vraiment il faut favoriser la quantification en sciences humaines*

[69] Le lecteur intéressé trouvera sur le site de l'Association Française de Cliométrie, une liste quasi complète de l'ensemble des travaux cliométriques menés par Claude Diebolt et son équipe depuis 2004 à Strasbourg : https://www.cliometrie.org/en/

et sociales, aussi parce qu'il n'est, à l'évidence, pas possible (ni nécessaire d'ailleurs) d'exorciser ce soi-disant démon ! Au niveau international cette question me parait d'ailleurs tranchée depuis longtemps. La véritable question à poser est finalement toute autre : comment employer la quantification au meilleur avantage ? En effet, à moins de s'accompagner d'un traitement statistique et/ou économétrique et d'une analyse quantitative systématique, la mesure n'est rien de plus qu'une autre forme d'histoire narrative. Elle remplace certes les mots par des chiffres, mais elle ne fait intervenir aucun facteur nouveau. En revanche, la cliométrie innove lorsqu'elle s'efforce de formuler les explications du développement économique passé en termes de modèles hypothético-déductifs valables qui, eux-mêmes, appellent aux techniques les plus fines de l'économétrie ; le but étant d'établir, sous forme mathématique, l'interaction des variables dans une situation donnée. Quand la question est posée de cette manière, il devient évident que des positions trop rigides ne sont plus défendables, mais que les travaux de recherche sont aussi beaucoup plus rares ! » (Diebolt, 2001).

C'est à partir de la citation ci-dessus que Claude Diebolt a dégagé les caractéristiques épistémologiques et méthodologiques de la cliométrie strasbourgeoise.

Les enseignements et le programme de recherche en cliométrie de Claude Diebolt sont centrés sur les théories de la croissance et des cycles économiques. Sa démarche est historique et comparative. Sa démonstration est quantitative et principalement macroéconomique ou macroéconométrique. Son ambition est de favoriser la rencontre entre la théorie macroéconomique, l'économétrie des séries temporelles et la cliométrie dans le triple but de dégager une caractérisation plus adéquate des données afin de construire de meilleures équations de prévision, de discriminer entre des théories alternatives et de discuter la multiplicité des représentations erronées de l'histoire économique (dépendances au sentier, mythes, falsifications, déformations, négations ou omissions). Par l'intermédiaire de tests économétriques et cliométriques, il s'agit également de donner des micro-fondements à la macroéconomie et d'acquérir de meilleures connaissances factuelles susceptibles d'éclairer la politique économique et sociale passée, présente et future. Pour ce faire, il mobilise systématiquement des archives historiques, des modèles théoriques mathématisés, des modèles appliqués et des études empiriques transversales et longitudinales sur certains domaines jugés prioritaires : le capital humain, la démographie, la finance et la propriété intellectuelle (les brevets) plus particulièrement. Ses analyses portent sur différents espaces européens et non européens, pour l'essentiel aux 19ème et 20ème siècles, avec la comparaison France-Allemagne comme premier laboratoire d'expérimentation.

Parmi les récents ouvrages publiés par Claude Diebolt ou sous sa direction, citons :

Handbook of Cliometrics (Editor), Editions Springer, Collection "Springer Reference", Berlin, 2019, 1768 pages (avec M. Haupert). 1ère édition, 2016, 590 pages.

Cliometrics of the Family (Editor), Editions Springer, Berlin, Collection "Studies in Economic History", 2019, 366 pages (avec A. Rijpma, S. Dilli, C. Störmer et S. Carmichael).

Bildungsökonomie. Eine Einführung aus historischer Perspektive, Editions Springer-Gabler, Wiesbaden, 2017, 102 pages (avec R. Hippe et M. Jaoul-Grammare).

Understanding Demographic Transitions. An Overview of French Historical Statistics, Editions Springer, Collection "Population Economics", Berlin, 2017, 176 pages (avec F. Perrin).

Dynamics of Distribution and Diffusion of New Technology. A Contribution to the Historical, Economic and Social Route of a Developing Economy, Editions Springer, Collection "Indian Studies in Business and Economics", Berlin, 2016, 236 pages (avec T. Mishra et M. Parhi).

Business Cycles in the Run of History, Editions Springer, Berlin, Collection "SpringerBriefs in Economics", 2016, 94 pages (avec T. Aimar, F. Bismans et la collaboration de R. Majetti et Z. Rabah).

Citons aussi quelques thèses, HDR et chercheurs encadrées par Claude Diebolt au sein du BETA à Strasbourg :

Le Chapelain Charlotte : *Industrialisation et capital humain en longue période*, HDR - Soutenance le 24 novembre 2017.

Jaoul-Grammare Magali : *Cliométrie des inégalités. L'enseignement supérieur français aux XIXème et XXème siècles*, HDR - Soutenance le 18 octobre 2017.

Mattei Clara : *Market Fetishism and Repressive Politics in the European Austerity Thinking after World War I*, Thèse de doctorat - Soutenance le 13 juin 2016.

Igersheim Herrade : *Libéralisme de la liberté. Fondements, analyses, expérimentations*, HDR - Soutenance le 23 avril 2015.

Perrin Faustine : *Gender Equality and Economic Growth in the Long Run - A Cliometric Analysis*, Thèse de doctorat - Soutenance le 2 décembre 2013. Prix du Groupement d'Intérêt Scientifique - Institut du Genre du CNRS.

Hippe Ralph : *Human Capital Formation in Europe at the Regional Level - Implications for Economic Growth*, Thèse de doctorat - Soutenance le 30 octobre 2013. Prix de l'Université Franco-Allemande, Prix Koch du Chapitre de Saint-Thomas, Prix de la Société des Universités de l'Académie de Strasbourg et de la Reutlinger Wirtschaftstreuhand.

Nguyen-Van Phu : *The Economy-Environment Nexus Revisited. Empirical and Theoretical Reappraisal*, HDR - Soutenance le 17 octobre 2013. Médaille de Bronze du CNRS 2015.

Rivot Sylvie : *Analytical Foundations for Policy. Keynes and Friedman*, HDR - Soutenance le 11 juin 2013.

Barbier-Gauchard Amélie : *Fédéralisme budgétaire, discipline et croissance dans une UEM hétérogène*, HDR - Soutenance le 17 juillet 2012.

Robin Stéphane : *Essays on Innovation. An Empirical Perspective*, HDR - Soutenance le 29 mai 2012.

Cornand Camille : *Macroéconomie monétaire, coordination et information hétérogène. Une analyse de la communication des banques centrales*, HDR - Soutenance le 24 juin 2010. Médaille de Bronze du CNRS 2011.

Accueil et encadrement de deux enseignants-chercheurs en délégation CNRS : Antoine Parent (2005-2007) et Charlotte Le Chapelain (2016-2017).

Accueil et encadrement de quatre post-doctorants : Tapas Mishra (2005-2006), Luca Pensieroso (2007-2008), Giacomo Sbrana (2009-2011) et Faustine Perrin (2013-2014).

Claude Diebolt considère comme fondamental le fait que la cliométrie privilégie la mesure et qu'elle reconnaisse l'existence de liens étroits entre la mesure et la théorie. Il ne fait aucun doute que c'est la seconde caractéristique et non la première qui distingue la nouvelle école strasbourgeoise, née en 2004 avec l'arrivée de Claude Diebolt en qualité de Directeur de Recherche au CNRS. En effet, à moins de s'accompagner d'un traitement statistique et/ou économétrique et d'une analyse quantitative systématique, la mesure n'est rien de plus qu'une autre forme d'histoire narrative. Elle remplace certes les mots par des chiffres, mais elle ne fait intervenir aucun facteur nouveau. En revanche, la cliométrie innove lorsqu'elle s'efforce de formuler toutes les explications du développement économique passé en termes de modèles hypothético-déductifs valables. En d'autres termes, la caractéristique essentielle de la cliométrie strasbourgeoise est le recours à ces modèles hypothético-déductifs qui appellent aux techniques les plus fines de l'économétrie, le but étant d'établir, sous forme mathématique, l'interaction des variables dans une situation donnée et dans le but d'établir des corrélations et/ou causalités pour mesurer l'importance relative de chacun des facteurs sur une période de temps donnée. A ce jour, les modèles hypothético-déductifs élaborés par Claude Diebolt et son équipe ont été principalement employés pour déterminer les effets des innovations, des institutions, du capital humain, de la démographie, de la finance etc. sur la croissance et le développement économique. Au stade actuel, le principal acquis de la cliométrie portée par Claude Diebolt est donc d'avoir lentement, mais progressivement, constitué, grâce à la mesure et la théorie, un ensemble solide d'analyses économiques de l'évolution historique. En extension, plus la quête des faits est dominé par la conception des problèmes, plus le travail de recherche se rapproche de ce qui constitue la véritable fonction de l'histoire économique au sein des sciences sociales.

Le cas de Diebolt et ses travaux de cliométrie théorique sont toutefois rares. La cliométrie reste essentiellement une entreprise appliquée qui s'intéresse avec les outils de la science économique à des questions historiographiques. Une certaine ambigüité demeure tout de même quant à l'utilité de ces recherches pour la science économique, un certain nombre d'économistes assumant une cliométrie qui serait essentiellement une discipline auxiliaire de l'histoire, tandis que d'autres gardent une ambition d'utilité pour le cœur de la discipline économique elle-même.

L'historien ne doit pas toujours penser que l'économiste fait étalage d'impérialisme. Il y a des économistes et des économètres modestes, qui pensent simplement que leurs outils sont aussi utiles à la compréhension de l'histoire que ne le seraient le recours au carbone 14 en archéologie ou l'ordinateur pour traiter un ensemble de fiches décrivant des conscrits afin d'en donner une image synthétique. Ils veulent apporter leur pierre à l'édifice de la connaissance historique. D'autres économistes, en pénétrant le champ de l'histoire économique, poursuivent ceci dit parfois leur propre agenda : identifier les causes profondes de la croissance économique pour comprendre par exemple le pourquoi de la stagnation actuelle des économies africaines, si ce n'est la possible stagnation séculaire. Ils ne désirent nullement envahir le champ de l'histoire. Ils utilisent ici le langage des économistes pour parler aux économistes.

Un groupe important d'historiens économistes cherche, quant à lui, le plus souvent à réellement comprendre une réalité bien contextualisée dans le passé et répondre à des questions historiographiques. Ils parlent aux historiens et utilisent le plus souvent dans leur produit final un langage qui leur est accessible, même si certains parmi eux, de formation plus économiste ou économétrique, ont eu recours dans leur argumentation à des outils plus sophistiqués. Ces économistes-là ne prétendent pas révolutionner l'histoire économique, simplement l'améliorer à la marge par le recours à des outils plus sophistiqués. Il y aurait quelque part deux cliométries, l'une modeste, qui travaille en coopération avec les historiens plus traditionnels (un peu comme l'a toujours fait la cliométrie anglaise, plus ouverte que la cliométrie américaine, essentiellement économiste) sur des questions historiographiques, et une autre, plus abstraite, qui recourt systématiquement au langage des économistes et tantôt vise à réécrire l'histoire économique dans un style nouveau (en faire une branche de la science économique), voire l'utiliser dans la construction de théories économiques plus générales. Cette opposition n'est d'ailleurs pas neuve et remonte aux années 60-70 au moins:

"*Early studies in cliometrics in the United States were written by economists and principally for economists; its frame of reference was neoclassical economics and its protagonists were seeking to establish themselves within the economics profession. Contacts with historians were limited. In Britain, by contrast, cliometrics developed more slowly than in the United States but always remained in contact with historians; it was often carried out in university departments of history or economic history, only rarely by economists. Its style and theoretical origin were more eclectic, its topics for research closer to the interests of historians*" (Floud, 1987, p. 453).

En somme, il faut à notre sens juger les auteurs par leurs intentions et non celles qu'on leur prête. En ce sens l'usage de l'histoire économique peut être soit le fait d'historiens ou d'économistes soucieux de comprendre le passé, via des méthodes diverses, toutes légitimes (si elles sont pertinentes par rapport à l'objectif poursuivi), pouvant être qualitatives ou quantitatives (ou les deux) ; soit le fait d'économistes soucieux ou bien de tester divers modèles ou diverses théories sur un horizon temps plus long, ou bien de trouver un matériel de faits stylisés destinés à rendre plus réalistes leurs théories (ces dernières devant se soumettre en parallèle, dans le cadre

du paradigme néo-classique, à la contrainte de s'encastrer dans les postulats de base de l'approche : micro-fondations, individualisme méthodologique, rationalité instrumentale, recherche d'équilibre, modèles mathématiques, etc.). Dans ce dernier cas, l'intérêt renouvelé des économistes pour l'histoire économique doit être souligné après une longue période d'éloignement (réciproque). Même si c'est de matière très fruste aux yeux des historiens économistes traditionnels, on doit constater du côté des économistes un intérêt renouvelé pour l'histoire et ce même avant la crise économique et financière de 2008 qui a ébranlé bien des certitudes.

En 1985, Arrow soulignait déjà que l'histoire économique est une condition nécessaire (même si insuffisante) d'une théorie économique pertinente (Arrow, 1985). En 1993, le prix Nobel de sciences économiques couronne les contributions pionnières de Douglass North et Robert Fogel. Le très grand renouveau de l'intérêt des économistes pour les questions de croissance et les questionnements renouvelés sur les marchés financiers ont, au cours des années 90 et 2000, ouvert la voie à un intérêt croissant pour l'histoire économique. *Princeton University Press* a lancé une collection destinée à publier des ouvrages dans ce domaine. Une autre consécration récente pour les économistes qui prennent l'histoire au sérieux a été la nomination de Bernanke, un spécialiste de la crise de 1929 (cf. Bernanke, 2004), à la tête de la Federal Reserve.

L'histoire économique des économistes peut choquer parfois les historiens, mais même si on se place de leur point de vue, la proportion des travaux cliométriques réellement théorique est assez mineure face à l'ampleur de travaux méticuleux, sérieux, mobilisant des outils sophistiqués pour répondre à des questions circonstanciées d'intérêt commun aux économistes et historiens. Au niveau international, la cliométrie, modestement, a pris sa place parmi les approches d'histoire économique et beaucoup de questions, qu'on le veuille ou non, sont de nature quantitative. Ce faisant, la cliométrie est aujourd'hui incontournable !

Conclusion

Malgré un mouvement de divergence croissant entre les méthodes, intérêts et agendas de recherche du noyau central de la science économique et de l'histoire, on doit bien constater le maintien et, ces dernières années, l'expansion d'un champ de recherche à l'intersection de ces deux univers. A l'université de Strasbourg, la recherche historique a continué à collecter et exploiter des variables numériques, au moment même où l'intérêt pour le quantitatif commençait à décroître chez les historiens français. L'histoire quantitative continue d'y être cultivée avec l'ambition de créer des séries suffisamment fiables pour qu'elles méritent d'être exploitées avec les méthodes de la cliométrie. Dans la même université, la recherche économique s'intéresse aux évolutions de longue durée et travaille à faire entrer dans les modèles mathématiques les plus sophistiqués des données tirées de statistiques anciennes. Si l'histoire économique des historiens comprend toujours une large part de travaux traditionnels, pensons ne fût-ce qu'aux travaux en histoire sociale, en histoire de l'innovation, en histoire d'entreprise, les biographies de banquiers ou d'hommes d'affaires, l'étude de leurs réseaux de socialité, ils peuvent aussi inclure de notre point

de vue une certaine partie de travaux quantitatifs plus complexes, que ce soient, par exemple, les approches d'histoire macroéconomique quantitative ou des approches recourant à davantage d'économétrie. Mais il s'agit toujours d'un objectif de compréhension d'une réalité historique donnée. On a aussi noté une histoire économique plus théorique, une histoire économique d'économistes, en lien avec la réémergence de leur intérêt pour les questions de croissance de très long terme et un souci empirique plus prononcé après l'efflorescence de multiples schémas théoriques dans le cadre des théories de la croissance endogène.

S'il y a une influence nette de la théorie économique sur la vision de la croissance de long terme, il y a aussi eu une influence nette de l'histoire (même traditionnelle) sur la science économique depuis les années 90. Cela a amené les économistes à raffiner leurs schémas théoriques, voire à revaloriser les travaux d'études de cas. Le rôle-clé des institutions a aussi été mis en avant. Par ailleurs, le recours à la théorie des jeux donne libre cours au récit analytique. Bref, l'économiste est bel et bien de nos jours présent sur le terrain de l'histoire (jusqu'à l'histoire antique, cf. Temin, 2006). Souvent, cependant, ces approches sont (sur le continent européen, et en France plus particulièrement) ignorées de la communauté des historiens économistes, à cause des frontières institutionnelles mais aussi, semble-t-il, du manque de culture économique et quantitative de beaucoup d'entre eux. On assiste certes à un retour de ces démarches, mais il s'agit le plus souvent, dans le sillage d'une sociologie influencée par Bourdieu, de techniques quantitatives du sociologue, développées dès les années 70, comme les analyses de données ou la théorie des réseaux sociaux recourant à la théorie des graphes.

L'étude approfondie d'un système économique, surtout quand elle sert de point de départ à l'élaboration de prévisions, passe par le respect d'un certain nombre de précautions. La première d'entre elles est la capacité à prendre du recul. La référence au passé n'a pas seulement un intérêt historique, anecdotique. Les enseignements que l'on en tire sont très précieux pour éviter de généraliser trop rapidement des observations particulières, et cela d'autant plus, que l'économie s'inscrit dans la longue durée. La discipline économique ne peut pas être statique ou dynamique (au sens de statique comparative) en ne tenant pas compte de l'irréversibilité du temps. La méconnaissance des événements ayant abouti à la situation observée à un moment donné empêcherait d'en saisir toute la signification. L'observation du passé montre aussi, qu'il n'est pas possible de généraliser la situation vécue par une génération, de l'extrapoler dans le temps. L'historien économique ne dit pas que l'avenir est à l'image du passé. L'économiste (surtout celui qui fait face à la décision dans le monde réel) fait face à un système complexe, dont la théorie n'épuise pas tout. C'est pourquoi, nous estimons, que la connaissance historique (qui inclut des phénomènes dont nos théories ne rendent pas — encore ? — compte) est indispensable pour compléter l'analyse logique fournie par des modèles qui ne sont souvent que l'abstraction de situations particulières en un temps et un lieu donné. Certaines variables influentes sont très difficiles à quantifier, mais renoncer à les faire figurer dans les modèles aboutit à les traiter à tort comme des constantes. Compte tenu de cette complexité, la discipline économique est donc certainement aussi un art et pas uniquement une

science. Anticiper les tendances futures des économies relève sans doute autant de l'art, d'un mixte optimal de notre savoir théorique, de nos connaissances sur le système étudié et d'une part d'intuition, qui serait la résolution non encore consciente d'un problème hautement complexe. C'est l'art de reconnaître les points sur lesquels doit porter l'effort principal afin d'atteindre les objectifs visés. Dire qu'il s'agit d'un art, c'est admettre que les choix ne sauraient être dictés par la seule mise en œuvre de techniques statistiques sophistiquées. Aussi, prévoir l'avenir — ou plutôt les avenirs possibles — c'est d'abord fixer les objectifs que le développement des différents systèmes économiques devrait s'efforcer d'atteindre. Le futur dépend aussi de nos choix, y inclus politiques, avec la part d'idéologie ou de philosophie que cette dépendance implique. Ce choix, cette décision n'est pas complètement *Wertfrei*. Elle manifeste aussi des valeurs, des objectifs politiques, eux-mêmes influencés par un contexte plus large (groupes d'intérêt en présence, institutions), et par l'histoire. Les contraintes majeures étant celles qui découlent des moyens financiers disponibles, de la démographie, des besoins de l'économie, de la demande sociale et des stratégies politiques.

C'est par cette volonté de combiner la rigueur des modèles théoriques et mathématiques avec la prise en compte, de la façon la plus exhaustive possible, de la complexité de toutes les données (qualitatives et quantitatives) que l'Ecole cliométrique strasbourgeoise reste fidèle à l'esprit des Annales et prolonge le mouvement initié en 1929 par Marc Bloch et Lucien Febvre.

Cliometrics of Climate Change: A Natural Experiment on the Little Ice Age

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Abstract

This paper presents the findings of climate change impact on a widespread human crisis due to a natural occurrence, focusing on the so-called Little Ice Age period. The study is based on new non-linear econometrics tools. First, we reassessed the existence of a significant cooling period using outliers and structural break tests and a nonlinear Markov Switching with Levy process (MS Levy) methodology. We found evidence of the existence of such a period between 1560-1660 and 1675-1700. In addition, we showed that NAO teleconnection was probably one of the causes of this climate change. We then performed nonlinear econometrics and causality tests to reassess the links between climate shock and macroeconomic indicators. While the causal relationship between temperature and agricultural output (yields, production, price) is strongly robust, the association between climate and GDP identified by the MS Levy model does not reveal a clear causality link. Although the MS Levy approach is not relevant in this case, the causality tests indicate that social disturbance might also have been triggered by climate change, confirming the view of Parker (2013). These findings should inform current public policies, especially with regard to the strong capacity of climate to disrupt social and economic stability.

Keywords: Little Ice Age, climate change, non-linear econometrics, Markov Switching Levy, Causality, Economic cycles, Social crisis
JEL classification: C22, C53, E32, E33, F00, Q00

1 Introduction

In a recent paper, Hsiang and Kopp (2018) stressed the important role of economists to complement climatologists in order to gain a better understanding of global climate change. Since we can expect a growing impact of global warming in the near future (see the latest IPCC reports for example), it is important to investigate the vulnerability of both developing and developed economies to such changes in climate conditions. One way to approach this would be to analyze how economies have historically been affected by strong climate shocks through an assessment of the links between climatic shocks and macroeconomic indicators (both economic and social variables) and how pre-industrial economies adapted to climate change shocks in the past. In a recent book, the historian Geoffrey Parker (2013) suggests examining the potential links between climate and major disruptions or calamities in human activity (wars, social disturbances, famines, invasions) over the course of the seventeenth century.

However, studies assessing the impact of climate on macroeconomic and social events are very scarce, especially by econometricians who have not been particularly interested in the topic. The purpose of our paper is thus to reinvestigate the link between climate and macroeconomic and social indicators using advanced time series econometrics.

Very broadly, our paper relates to the emerging literature on climate econometrics (see for instance Deschenes and Greenstone (2007), Dell et al. (2012, 2014), Hsiang (2016)) that empirically explores the effects of year-to-year fluctuations in temperatures or precipitations on economic or social outcomes like agriculture production, conflict, health and economic growth among other indicators. More recently Burke et al. (2015) and Kahn et al. (2019) outlined climate growth causality in both developing and developed countries; Colacito et al. (2019) stressed the special case of the USA.

However, empirical evidence of long-term and dynamic effects of climate on economic outcomes remains very limited. It is a crucial question regarding the global warming issue since long-run, historical investigations can give us some insights into the potential adaptation of the population and the economy to climate shocks. Recently, Behrer and Park (2017) found evidence that US regions with a hotter climate were better adapted to heat. Understanding long-term adaptation is crucial if we are to adapt policies in response to ongoing climate change (Bastin et al., 2019).

The economics literature focusing on historical analysis with long horizon data appears to be very scarce. Waldinger (2015) conducted panel econometrics to assess the economic impact of long-term and gradual climate change over the period 1500-1750 when people had time to adapt. However, she focused on panel data of major European cities with a very low time series dimension to explore the city dimension of the data. The evidence indicates that decreased temperatures led to shorter growing periods and more frequent harvest failure in this period. Using historical wheat prices, the author shows that temperatures affected economic growth through its effect on agricultural productivity.

Auray et al. (2016) built a growth model to assess the impact of temperatures and precipitation in pre-industrial England over the period 1669-1800. Using historical data on real wages and real rents, they extracted the productivity variations that could be due to the reallocation of labor and land and climatic factors as a residual. They show that a 2-degree rise in temperature would reduce the TFP by 11% and so wages would follow the same pattern. Furthermore, they noted that temperature might have a non-linear effect on productivity and thus on growth: low variations have a positive effect, while wide temperature variations have a negative impact.

Other scholars, such as geographers, have been more interested in the link between climate and socio-economic outcomes from a historical perspective. The closest papers to our study are those of Zhang et al. (2007, 2011, 2015) and Pei et al. (2014) which found evidence that climate change exerted causal effects on social and economic fluctuations in China and European pre-industrial societies using correlations and bivariate Granger causality tests. Zhang et al. (2011) tried to identify potential links between temperature anomalies and wars/social disturbances during the pre-industrial era in Europe and show that cooling from 1560 to 1660 caused successive agro-ecological, socioeconomic and demographic catastrophes, leading to the General Crisis of the Seventeenth Century. Pei et al. (2014) and Zhang et al. (2015) focused on the links between climate and macroeconomic cycles in the agrarian society of pre-industrial Europe through a temporal-scale analysis. Their main conclusion is that climate change can only impact the macroeconomic cycle in the long-term and that short-term effects are less significant due to possible social adaptation methods and self-adjustment mechanisms.

In these studies, they conducted statistical analysis using Butterworth filters (30 or 40 years) to get low-pass and high-pass filtering series and to find evidence of a positive significant correlation between temperatures, grain prices and wages, but only for high-pass filtering data (long-run). These results are confirmed by bivariate Granger causality tests to identify a set of causal linkages.

However, after examining the statistical chronology of the little ice age period thanks to a battery of temperature and precipitation datasets over the 1300-1800 period, Kelly and OGrada (2014) argued they were skeptical of the existence of a Little Ice Age period. In a more general way, they questioned the frequent statistical use of filtered climatic series in some disciplines. For instance, common evidence in the climatology literature about the existence of a Little Ice Age and climate-economics relationship probably finds its origin in a so-called Slutsky effect stemming from the use of smoothed instead of unsmoothed data when correlation and causality were performed:

"contrary to the existing consensus of a European Little Ice Age, we can find little evidence for change points or temporal dependence in the weather series (...) may reflect the fact that our analysis is based on unsmoothed data. This is in contrast to the common practice in climatology of smoothing data using a moving average or other filter to extract long run climate signals from noisy local weather observations. When data are uncorrelated, as the annual European weather series we examine appear to be, such smoothing can introduce

the appearance of irregular oscillations: a Slutsky effect". In addition, the use of filtered series could lead to spurious stationarity.

this paper, we propose computing a new nonlinear econometric methodology to reassess 1) the potential existence of a Little Ice Age period regarding long- run temperature dynamics 2) the causal importance of this potential climate change on macroeconomic activity and social disturbance over the period 1500-1800. To this end, we use a novel Markov Switching (MS hereafter) with Levy process to take a variety of nonlinear patterns in the time dynamics of our series into account. One advantage of the MS Levy method performed in this paper is that it avoids the Slutsky effect described by Kelly and Ograda (2014) since we only focus on the exploitation of raw/untransformed data. The second advantage is that we can investigate nonlinear effects in the time series and closely identify different, more or less long, regimes with different levels of causality between climate and macroeconomic conditions. Finally, we use two different types of Granger causality methods to assess the causal linkages between climate change and economic cycles on the one hand and climate change and social outcomes like social disturbances on the other.

Our MS Levy results clearly detect some regime changes in 1550-1700 and note evidence of a Little Ice Age period with a strong cooling period. Focusing on the NAO (North Atlantic Oscillation) teleconnection, we show that a change in NAO is likely to be at the origin of this climate change. However, our data also show that this period is not uniform. Indeed, we identified some specific sub-regimes with strong changes in both temperature and grain prices, and even societal outcomes within this period. Using historical sources, we noted the relevance of the sub-regimes identified by our methodology. During the Little Ice Age period, we also show that some changes in grain prices, wages, GDP and social disturbances are partially coincident with climate changes. Some causal linkages between climate and grain prices, and thus climate and societal disturbances in the sub-periods identified by our econometric methodology, are plausible. Nonetheless, our results nuance the previous literature by finding strong evidence for only a subset of variables. Most of the series we used do not appear to be stationary and exhibit nonlinear patterns in contrast to what has been assumed in the earlier literature. Omitting non-linearity and unit roots may be the cause of some overestimations in previous papers.

Section 2 presents the data and the econometric methodology, especially the MS Levy model. Section 3 attempts to answer the following question: Did the Little Ice Age exist? In section 4, we discuss whether climate cooling during the plausible Little Ice Age period is likely to have impacted economic and societal cycles. Section 5 concludes.

2 Data and econometric framework

2.1 Data

We collected different types of historical data over the potential Little Ice Age period but for comparative purposes, decided to focus on data between 1500-1800 in similar vein to the previous literature. In particular, we followed Zhang et al. (2011) in collecting a large part of our dataset series (for more detailed information, please read the appendix on Zhang et al. (2011)).

We first collected two anomaly series of temperatures for the whole of pre-industrial Europe and several series concerning macroeconomic and social indicators on long-run temperature data reconstructions stemming especially, but not only, from the celebrated work of Luterbacher et al. (2004).

The *Eurtemp* climatic variable denotes the European anomaly temperature series calculated by Zhang et al. (2011). This variable was derived from two authoritative annual scale temperature reconstructions by Luterbacher et al. (2004) for European land areas (25oW to 40oE and 35oN to 70oN) over the period 1500-2003 and part of the series from Osborn and Briffas (2006) over the 800-1995 that are most relevant for the European region. Since the two temperature reconstruction series were derived from different proxies and reconstructed using different methods, each of them was normalized to homogenize the original variability of all the series. Note that the series are detrended to better focus on the stochastic dynamics.

The second climatic variable called *winter_europe_lut* consists of Luterbacher et al.s (2004) winter temperature data to better capture the potential Little Ice Age period by focusing on cooling anomalies in winter periods.

We completed our climatic variables set by adding the NAO (North Atlantic Oscillation) teleconnection variable. As we will explain later, NAO (North Atlantic Oscillation) is the most active climatic teleconnection in the North Hemisphere and is likely to explain European winter temperatures to a large degree. Here, we use reconstruction data from The North Atlantic Oscillation Index based on three academic studies, multi-proxies by Cook et al (2002), tree-ring records by Glueck et al (2001), and speleothem records by Trouet et al (2009). These three curves cover the study period of 1500-1800 AD. To increase reliability of the NAO index, the three curves were first standardized. They were then calculated to get the mean value.

We also used agricultural data to investigate the link between temperature and agricultural yields identified for instance by Waldinger (2015): grain yields and grain prices series come from Zhang et al. (2011) and Pei et al. (2014). Grain yield is based on the old Dutch Van Bath dataset (also used by Waldinger (2015)) and is calculated as a ratio of grain harvest to seed amount using data from 18 countries: wheat, rye, barley and oat yields are arithmetically averaged to give a synthetized aggregate for pre-industrial Europe.

Additionally, we used several economic variables from Pei et al. (2014): real wages as a proxy of income and purchasing power that used two seminal sources: the first is an annual dataset of real day wages for laborers in England and the

second source of data is from Allen (2001).

For the first time, we also used GDP data reconstructions by Fouquet and Broadberry (2015) to proxy global production and wealth of nations. Only Holland, UK and Italy were considered as good candidates to represent the economic situation in pre-industrial Europe and we left Spain, Portugal and Sweden out of the dataset.

Finally, we collected conflict and violence data and constructed three different variables in the vein of Zhang et al. (2011): social disturbances, war and war fatality. War denotes the number of wars and is obtained from the Conflict catalogue drawn up by Brecke (1999, 2001). As explained by Zhang et al. (2011), the catalogue documents a total of 582 wars fought between 1500-1800. Social disturbance data were obtained from Sorokins book (1937), volume III, entitled Social and Cultural Dynamics that recorded the most significant internal disturbances in both Central and Eastern Europe for an aggregate total of 205 social disturbances during our study period. Political disturbances (change to political regimes), socioeconomic disturbances (change to existing economic or social order), national and separatist disturbances, religious disturbances are all recorded. Since Sorokin gives the magnitude of each disturbance considerable detail including duration, location, masses involved, etc., the magnitude has been divided by its duration (number of years) to get a magnitude/year ratio and the annual magnitude is then calculated on a yearly basis and finally divided by the number of countries in Europe (Zhang et al., 2001).

Raw time series are presented in Appendix in figures 1 to 4. Taking a quick look at all the series, it is possible to identify some clear and interesting trends. - The first two series, though from different sources, display some similar patterns: a decreasing trend from 1500 to 1600 with a peak around 1600-1650 followed by an increasing trend. The last two raw series from Luterbacher et al. (2004), especially the winter temperatures series, display more noisy dynamics. It is interesting to compare the ability of MS Levy to detect regimes in all the different temperature series and in heterogeneous dynamics. - The green yield series exhibit three distinct sub-periods: a decreasing trend between 1500 and 1600, a stable period with very low yield levels between 1600 and 1700 and an increasing trend from 1700. The grain price series exhibits the exact opposite, except that the stable period with high price levels is concentrated in the 1620-1650 period. So, graphically, there is simultaneity between part of the low yields period and the high grain prices period. - The wage and famine series show a peak for the 1600-1660 period corresponding to a low wages period in the same sub-period (after and maybe consecutive to a decreasing trend between 1500 and 1600). - Trends for GDP growth rates series are less clear-cut. Some facts are particularly notable: there is a more volatile period in the 1600-1650 period for Hollands GDP growth rate and, in contrast, a less volatile period in 1570-1670. Finally, the 1550-1700 period seems to be more volatile for the UK. In contrast, between 1500 and 1560, volatility is highest in Italy and the rest of the period appears to be a more stable period.

In the Table 1 below, we calculated some simple correlation coefficients to get a brief idea of the potential correlations between our variables. We can see that

European temperatures are positively associated with grain yield, agricultural production, wages but negatively with grain prices and number of famines or plagues, in line with the studies by Zhang et al. (2007, 2011). In addition, European temperatures are negatively associated with wars, in line with the literature on climate and conflicts (e.g., Tol and Wagner, 2010, on the same period). However, the link between European temperatures and GDP (UK, Italy, Holland) is not clear-cut. In similar vein, the link between temperatures and social disturbances do not seem significant. When winter temperatures are used instead of aggregate European temperatures, the level of significance tends to decrease quite strongly. All in all, the causal link between cooling temperatures and social and economic crises do not appear totally evident.

Table 1: Correlation coefficients matrix

	EUR_TEMP	WINTER_TEMP	GRAIN_YIELD	GRAIN_PRICE	AGRI_PROD	WAGE	FAMINE	PLAGUE	DISTURB	WAR	UK	HOLLAND	ITALY
EUR_TEMP	1.000000												
	—												
WINTER_TEMP	0.547125	1.000000											
	11.28346	—											
GRAIN_YIELD	0.446746	0.144629	1.000000										
	8.620073	2.523216	—										
GRAIN_PRICE	-0.530140	-0.124771	-0.495335	1.000000									
	-10.79317	-2.170842	-9.843212	—									
AGRI_PROD	0.496411	0.104670	0.503182	-0.805460	1.000000								
	9.871567	1.816866	10.05146	-23.46137	—								
WAGE	0.467655	0.110529	0.532325	-0.750121	0.649069	1.000000							
	9.133235	1.919790	10.85520	-19.58126	14.72886	—							
FAMINE	-0.463500	-0.019816	-0.450234	0.639696	-0.466263	-0.524999	1.000000						
	-9.029758	-0.342152	-8.704395	14.36700	-9.098501	-10.64842	—						
PLAGUE	-0.461925	-0.098895	-0.361973	0.583495	-0.307445	-0.545917	0.516459	1.000000					
	-8.990747	-1.715610	-6.703167	12.40299	-5.577462	-11.24796	10.41146	—					
DISTURB	-0.088272	0.023696	-0.088978	0.270143	-0.222901	-0.156502	0.156583	0.180979	1.000000				
	-1.529783	0.409179	-1.542124	4.843472	-3.947167	-2.735341	2.736805	3.176638	—				
WAR	-0.273324	0.017186	-0.260654	0.572519	-0.412866	-0.304122	0.569202	0.269891	0.223303	1.000000			
	-4.905078	0.296717	-4.660686	12.05428	-7.825249	-5.510998	11.95085	4.838593	3.954674	—			
UK	0.030084	-0.004094	-0.031122	0.076080	-0.091060	-0.106188	-0.034190	-0.011208	0.015829	-0.032062	1.000000		
	0.519573	-0.070678	-0.537506	1.317161	-1.578495	-1.843507	-0.590559	-0.193490	0.273287	-0.553755	—		
HOLLAND	0.025913	0.030076	0.054643	-0.004623	-0.042380	0.002805	-0.011027	-0.021112	-0.012531	-0.032261	-0.110665	1.000000	
	0.447480	0.519432	0.944697	-0.079808	-0.732242	0.048418	-0.190369	-0.364538	-0.216327	-0.557194	-1.922188	—	
ITALY	0.067848	0.071724	-0.001949	0.010331	-0.059035	-0.044706	-0.032558	-0.014040	0.008513	-0.021992	0.057699	-0.026357	1.000000
	1.173942	1.241340	-0.033645	0.178346	-1.020887	-0.772524	-0.562332	-0.242394	0.146967	-0.379726	0.997696	-0.455157	—

Note: Numbers below coefficients are p-values of the F-test for statistical significance

Finally, temperatures and economic time series tend to move hand in hand to some extent. In the rest of the paper, we compute MS Levy regressions to take this stylized fact further. Indeed, nonlinear phenomena may play an important role in the climate-economics relationship due to complex reallocations of resources by agents in good (normal temperatures) or bad (very cold during this period, but also very hot temperatures more generally) economic conditions. This implies dynamic relationships that cannot be captured by the contemporaneous correlations displayed in Table 1 and need to be investigated through more complex approaches.

2.2 The MS Levy methodology

As previously mentioned, the MS Levy methodology has several advantages. First, it is a suitable method to describe many nonlinear patterns in certain time series. Second, the MS Levy model uses the data without transformation and so avoids the Slutsky effect. This methodology allows both identification of dynamics' break or change and capture of pure jumps and spikes in the series.

Let $(\omega, \mathcal{F}, P)$ be a filtered probability space and T be a fixed terminal time horizon. We model the dynamic of a sequence of historical values of time series - both climate and economic or societal outcomes - using a regime-switching stochastic jump-diffusion. This model is defined using the class of pure jump processes such as Lévy processes.

Definition 1 *A Lévy process L_t is a stochastic process such that*

1. *$L_0 = 0$.*
2. *For all $s > 0$ and $t > 0$, we have that the property of stationary increments is satisfied. i.e. $L_{t+s} - L_t$ as the same distribution as L_s.*
3. *The property of independent increments is satisfied i.e. for all $0 \leq t_0 < t_1 < \cdots < t_n$, we have $L_{t_i} - L_{t_{i-1}}$ independent for all $i = 1, \ldots, n$.*
4. *L has a Cadlag path. This means that the sample paths of a Lévy process are right continuous and admit a left limits.*

Remark 2 *In a Lévy process, discontinuities occur at random times.*

Definition 3 *Let $(Z_t)_{t\in[0,T]}$ be a continuous time Markov chain on finite space $\mathcal{S} := \{1, 2, \ldots, K\}$. Denote $\mathcal{F}_t^Z := \{\sigma(Z_s); 0 \leq s \leq t\}$, as the natural filtration generated by the continuous time Markov chain Z. The generator matrix of Z, denoted by Π^Z, is given by*

$$\Pi_{ij}^Z \geq 0 \quad \text{if } i \neq j \text{ for all } i, j \in \mathcal{S} \quad \text{and} \quad \Pi_{ii}^Z = -\sum_{j\neq i} \Pi_{ij}^Z \quad \text{otherwise.} \tag{1}$$

Remark 4 *The quantity Π_{ij}^Z represents the switch from state i to state j.*

Let us define the regime-switching Lévy Model:

Definition 5 *For all $t \in [0,T]$, let Z_t be a continuous time Markov chain on finite space $\mathcal{S} := \{1,\dots,K\}$ defined as in Definition 3. A regime-switching model is a stochastic process (X_t) which is solution of the stochastic differential equation given by*

$$dX_t = \kappa(Z_t)\left(\theta(Z_t) - X_t\right)dt + \sigma(Z_t)dY_t \tag{2}$$

where $\kappa(Z_t)$, $\theta(Z_t)$ and $\sigma(Z_t)$ are functions of the Markov chain Z. Hence, they are constants which take values in $\kappa(\mathcal{S})$, $\theta(\mathcal{S})$ and $\sigma(\mathcal{S})$

$$\kappa(\mathcal{S}) := \{\kappa(1),\dots,\kappa(K)\} \in^{K^*}, \quad \theta(\mathcal{S}) := \{\theta(1),\dots,\theta(K)\},$$
$$\sigma(\mathcal{S}) := \{\sigma(1),\dots,\sigma(K)\} \in^{K^+} .$$

where Y is a stochastic process which could be a Brownian motion or a Lévy process.

Remark 6 *The following classic notations apply:*

- *κ denotes the mean-reverting rate;*
- *θ denotes the long-run mean;*
- *$\sigma_.$ denotes the volatility of X.*

Remark 7

- *In this model, there are two sources of randomness: the stochastic process Y appears in the dynamics of X, and the Markov chain Z. There is one randomness due to the market information which is the initial continuous filtration $\mathcal{F}$ generated by the stochastic process Y; and another randomness due to the Markov chain Z, $\mathcal{F}^Z$.*
- *In our model, the Markov chain Z infers the unobservable state of the economy, i.e. expansion or recession. The processes Y^i estimated in each state, where $i \in$, capture: a different level of volatility in the case of Brownian motion (i.e. $Y^i \equiv W^i$), or a different jump intensity level of the distribution (and a possible skewness) in the case of the Lévy process (i.e. $Y^i \equiv L^i$).*

We recall the main properties of the Normal Inverse Gaussian (NIG) distribution. Indeed, we assume that a Lévy process L follows a Normal Inverse Gaussian (NIG) distribution. The NIG family of distribution was introduced by Barndorff-Nielsen and Halgreen (1977). The NIG density belongs to the family of normal variance-mean mixtures, i.e. one of the most commonly used parametric densities in financial economics.

Taking $\delta > 0$, $\alpha \geq 0$, the density function of a NIG variable $NIG(\alpha,\beta,\delta,\mu)$ is given by

$$f_{NIG}(x;\alpha,\beta,\delta,\mu) = \frac{\alpha}{\pi}\exp\left(\delta\sqrt{\alpha^2-\beta^2} + \beta(x-\mu)\right)\frac{K_1\left(\alpha\delta\sqrt{1+(x-\mu)^2/\delta^2}\right)}{\sqrt{1+(x-\mu)^2/\delta^2}} . \tag{3}$$

where K_ν is the Bessel function of the third kind with index ν. It can be represented by the following integral

$$K_\nu(z) = \frac{1}{2}\int_0^\infty y^{\nu-1}\exp\big(-\frac{1}{2}z(y+y^{-1})\big)dy \ .$$

For a given real ν, the function K_ν satisfies the differential equation given by

$$x^2 y^{''} + xy^{'} - (x^2+\nu^2)y = 0 \ .$$

This class of distribution is stable by convolution as the classic normal distribution. i.e.

$$NIG(\alpha,\beta,\delta_1,\mu_1) * NIG(\alpha,\beta,\delta_2,\mu_2) = NIG(\alpha,\beta,\delta_1+\delta_2,\mu_1+\mu_2) \ .$$

Lemma 8 *If $X \sim NIG(\alpha,\beta,\delta,\mu)$ then for any $a \in^+$ and $b \in$, we have that*

$$Y = aX + b \sim \left(\frac{\alpha}{a}, \frac{\beta}{a}, a\delta, a\mu + b\right).$$

The log cumulative function of a NIG variable is given by

$$\phi^{NIG}(z) = \mu z + \delta\left(\sqrt{\alpha^2-\beta^2} - \sqrt{\alpha^2-(\beta+z)^2}\right), \quad \text{for all } |\beta+z| < \alpha \ , \quad (4)$$

The first moments are given by

$$[X] = \mu + \frac{\delta\beta}{\gamma} \ , \quad \mathrm{Var}[X] = \frac{\delta\alpha^2}{\gamma^3} \ . \quad (5)$$

with $\gamma = \sqrt{\alpha^2-\beta^2}$. And finally the Lévy measure of a NIG$(\alpha,\beta,\delta,\mu)$ law is

$$F_{NIG}(dx) = e^{\beta x}\frac{\delta\alpha}{\pi|x|}K_1(\alpha|x|)\,dx \ . \quad (6)$$

Remark 9 *An interesting point of the NIG distributions is that each parameter in $NIG(\alpha,\beta,\delta,\mu)$ distributions can be interpreted as having a different impact on the shape of the distribution: α - tail heaviness of steepness; β - skewness; δ - scale and μ - location.*

We apply the statistical estimation process initiated by Chevallier and Goutte (2017a) and developed by Chevallier and Goutte (2017b) in the application to modeling of CO2 and fuel-switching prices.

This methodology is a two-step approach by estimating in (2) *(i)* the model parameters in a regime-switching Brownian process, and *(ii)* the distribution parameters. We fit a regime-switching Lévy model such as (2) where the stochastic process Y is a Lévy process that follows a Normal Inverse Gaussian (NIG) distribution. Thus the optimal set of parameters to estimate is $\hat{\Theta} := \left(\hat{\kappa}_i, \hat{\theta}_i, \hat{\sigma}_i, \hat{\alpha}_i, \hat{\beta}_i, \hat{\delta}_i, \hat{\mu}_i, \hat{\Pi}\right)$, for $i \in \mathcal{S}$. So we have the three parameters of the dynamics of X, the four parameters of the density of the Lévy process L, and the transition matrix of the Markov chain Z. The results and their interpretations are stated in Section 5.4.

Table 2: Breaks tests results

Variables	Dates	Type	Delta	Size	t-stat
Average European Temperatures (Zhang et al., 2011) Eur_Temp	No outliers detected				
Average European Temperatures $Annual\_Temp$ (Luterbacher et al., 2004)	No outliers detected				
Winter European Temperatures $Winter\_Temp$ (Luterbacher et al., 2004)	No outliers detected				
Grain Price	1622	TC		0,30906	8,11
Wage	1534	AO		1,1978	4,76
Wage	1537	TC		1,4153	4,34
Wage	1547	TC		0,32606	4,23
Social Disturbances	1648	TC	-0,37		-6,97
War	1648	AO		6,57	4,61
Holland GDP	1568	AO		-862,42	-5,8
Holland GDP	1617	AO		1008,8	6,25
Holland GDP	1576	AO		622,26	4,19
Holland GDP	1619	AO		-643,7	-3,99
UK GDP	1628	AO		-243,89	-3,67
Italy GDP	1533	AO	88,134	192,47	4,13
Italy GDP	1504	TC	-80,252	-153,21	3,7
Italy GDP	1546	AO			-3,34
Italy GDP	1525	TC			-3,33

3 Did little ice age exist?

In line with Kelly and OGrada (2014), we first applied some outliers and tests for breaks to our temperature variables to help us detect a potential Little Ice Age period. Though descriptive and graphical analyses seem to show a period of strong cooling between 1600 and 1660, the question of the existence of a Little Ice Age period is still debateable and needs further investigation.

We first computed the Chen and Liu (1993) outliers test using the TRAMO Seats software. Chen and Liu (1993) developed a break detection from AutoRegressive Moving-Average (ARMA) models, and considered three types of breaks (see for example Charles et al. (2018) for a formal description): an additive outlier (AO), a level shift (LS) and temporary change (TC). As Charles et al. (2018) explained, AOs are outliers related to an exogenous change in the series with no permanent effects, whereas TCs and LSs are more in the nature of structural change. TCs represent short-lived shifts in a series with a return to previous levels while LSs are more the reflection of permanent shocks.

We then applied the Bai and Perron (1998, 2003) procedure to detect potential outliers: this method is useful as it captures structural changes in both mean and variance.

Table 2 shows that it is impossible to detect some breaks (both in mean and in variance) in the three temperature anomaly variables we used. Thus, in line with Kelly and OGrada (2014), we did not find evidence of a Little Ice Age from this statistical methodology. However, this is not enough to definitively conclude that there was no major cooling period in the 1500-1800 period. The conclusion of the outlier tests only implies that special warming or cooling did not emerge as a strong exogenous shock. However, other forms of statistical patterns such as smooth and persistent ones might be at work.

We thus went further than the outlier tests and applied the MS Levy methodology for the first time to identify the potential existence of a Little Ice Age era and some coinciding regimes between our climatic, social and economic variables.

We began by using the reconstruction of winter temperatures for Europe drawn up by Luterbacher et al. (2004) over the 1500-2004 period (winter luterbacher in appendix). This series exhibited the best statistical score according to our MS Levy model to identify different clear-cut regimes (hotter and cooler) over the period studied. Based on this variable, we outlined the existence of two clear different regimes (see detailed results displayed in Table 2): a cold (negative temperature mean value of -0.87) regime and a hot regime or at least a less colder one (positive mean: 0.3055). Regime 1, which is represented by negative values, is three times more volatile than regime 2, which suggests the existence of extreme winters with probably highly negative temperature values in contrast to normal winter temperatures.

We also computed the proportion of cold observations described by regime 1 in the total number of observations for each century and obtained the following results. They are clearly in favor of the existence of an over-representation of cooler winter observations (regime 1) during the 1500-1700 period:

- 33% of regime 1 over the 1900-2000 period
- 74% of regime 1 over the 1800-1900 period
- 42% of regime 1 over the 1700-1800 period
- 77% of regime 1 over the 1600-1700 period
- 61% of regime 1 over the 1500-1600 period

We next turned to the reconstruction of average temperatures across all of Europe using Annual Europe temperatures (for autumn, winter, spring and summer as a whole) from Luterbacher et al. (2004), called annual europe lut in our appendix. The global temperatures are less clear-cut regarding the existence of the Little Ice Age and it is more difficult to identify different regimes, probably due to compensation effects between positive temperature variations in summers and negative variations in winters. However, the MS Levy was able to identify the 1500-1772 period as a colder period, while the 1773-1830 period was identified as a less cold one, which seems to confirm the existence of a Little Ice Age period between 1500 and 1772 as a very broad view.

To keep the sample consistent with other series (1500-1800) and for comparative purposes, we used the European Temperature anomaly computed by Zhang et al. (2011, 2014), called Eur Temp anomaly in the appendix as the benchmark temperature anomaly series. The results from the MS Levy estimates applied to the temperature series are presented in the first four lines of Table 3. They clearly show the existence of two different regimes in the European temperature dynamics with a colder regime prevailing in the 1563-1659 and the 1674-1701 periods.

Overall, the MS Levy approach globally appears in favor of the existence of significant cooling episodes during the period under study and hint at the existence of a Little Ice Age. More interestingly, the MS Levy model appears to indicate that the global cooling period was not entirely uniform: the end of the 16th century to 1660 and then 1674-1700 seem to be marked by the coldest periods. We go further by applying and discussing the regimes identified by the MS Levy method for all the variables in our dataset in the following section.

4 Did climate negatively impact economic and social environment during the Little Ice age?

If climate affected pre-industrial European societies, we would expect some correspondence between the regimes identified in the temperature series (section 3) and the potential regimes the MS Levy model identified in the social and macroeconomic series. Therefore, we apply the same methodology as previously for a set of different series (see again Table 3): grain yield, grain price, wages, social disturbances and war, in line with Zhang et al. (2011). Like Pei et al. (2014), we also wanted to measure the potential correspondence and causality between climate, grain yield, grain price, wages and economic activity/production. Instead of using population growth, however, we preferred to use the GDP series recently drawn up by Fouquet and Broadberry (2015).

At first glance and before analyzing the MS Levy results, we tried to find some consistence in the results of the outliers tests for all the macroeconomic and social series. As previously noted, Table 2 did not reveal the presence of outliers in the temperatures series. However, some outliers appear to be present for the other series. Table 2 did not reveal clear links between the outliers or breaks detected by our tests. The only remarkable result was that a temporary change was detected in 1622 for grain price which could be linked to additional outliers in Holland and UK GDP in 1617 and 1628 respectively.

To get a more precise picture, we then applied the MS Levy methodology for all the social and macroeconomic series in our database. Hereafter, we separately comment (in detail) on the results for each series regarding the presence and nature of the different regimes. Table 3 synthesizes all the estimated results and Table 4 outlines the main historical regimes identified by the MS Levy estimates and is used as an overall picture for our general discussion.

Table 3: MS Levy estimates

Variables	Regime	Mean	q_ii	P(R)=i	Theta	Kappa	Sigma	Alpha	Beta	Delta	Mu
Eur_Temp	State 1	-0,61	0,96	0,48	-0,61	0,77	0,35	25,14	-22,52	1,37	2,75
	State 2	0,51	0,96	0,52	0,51	0,71	0,23	25,53	0,26	14,88	-0,15
Winter_Temp	State 1	-0,88	-0,74	0,57	-0,88	1,20	1,10	23,13	-17,78	1,91	2,30
	State 2	0,31	0,66	0,43	0,31	0,96	0,52	22,91	20,09	1,75	-3,21
Grain Yield	State 1	3,76	0,99	0,35	3,76	0,64	0,09	10,07	-0,21	0,22	0,00
	State 2	5,65	0,99	0,65	5,65	0,22	0,18	3,94	-1,01	0,39	0,10
Grain price	State 1	-0,09	0,92	0,47	-0,09	0,31	0,00	40,32	24,82	0,02	-0,01
	State 2	0,11	0,93	0,53	0,11	0,20	0,00	10,81	1,78	0,04	-0,01
Agricultural Prod	State 1	-25,44	0,75	0,78	-25,44	0,19	3802,07	0,01	0,00	68,05	0,98
	State 2	89,18	0,11	0,22	89,18	0,20	13203,26	0,01	0,00	250,64	33,69
Wage	State 1	0,04	0,93	0,56	0,04	0,09	0,05	0,96	-0,25	0,82	0,22
	State 2	-0,06	0,91	0,44	-0,06	0,21	0,25	14,01	10,25	4,49	-4,82
Famine	State 1	9,27	0,95	0,44	9,27	0,01	0,00	0,07	0,02	0,08	-0,03
	State 2	-0,97	0,96	0,56	-0,97	0,01	0,14	21,20	19,74	1,04	-2,67
War	State 1	2,19	0,95	0,27	2,19	0,44	0,99	19,29	11,33	5,64	-4,09
	State 2	8,68	0,98	0,73	8,68	0,23	4,01	2,89	0,23	1,50	-0,12
Social Disturbances	State 1	1,63	0,65	0,60	1,63	0,73	5,05	98,93	97,62	0,31	-1,91
	State 2	12,31	0,48	0,40	12,31	0,52	17,15	42,56	39,01	0,60	-1,37
UK GDP	State 1	0,41	0,64	0,73	0,41	1,52	5286,16	0,02	0,00	77,57	10,26
	State 2	25,52	0,00	0,27	25,52	0,72	6625,12	0,04	0,02	200,40	145,30
Holland GDP	State 1	4,40	0,97	0,78	4,40	1,33	21795,74	0,01	0,00	252,10	9,50
	State 2	1,32	0,90	0,22	1,32	1,26	136935,27	0,00	0,00	611,64	-81,84
Italy GDP	State 1	-1,04	0,99	0,80	-1,04	0,89	1477,96	0,06	0,01	81,48	7,55
	State 2	0,85	0,98	0,20	0,85	0,98	7066,17	0,02	0,00	165,12	1,73
NAO	State 1	0,22	0,97	0,75	0,22	0,49	0,20	2,37	0,92	1,80	0,76
	State 2	0,59	0,91	0,25	0,59	0,92	0,29	21,21	-15,08	2,94	2,98

4.1 Grain yield dynamics :

The observation distinctions between the two regimes is clear with an alternation of relatively long periods containing at least a dozen observations in each regime. This is reinforced by the value of the jump parameter which is above one. In other words, a major stochastic shock is needed to switch from state 1 to state 2 since the q_{ii} probability (probability to remain in the current regime) is high (0.99 in each regime). Regime 1 exhibits the lowest mean value at 3.76 (versus 5.65 in regime 2). However, regime 2 is the most volatile. This tendency is confirmed when we look at the $Sigma$ volatility parameter: its value is twofold in the second regime (0.18 versus 0.09). In addition, the mean reverting speed ($Kappa$) is higher in the first regime (probably "normal"/"fundamental" regime).

4.2 Grain price :

Again, the classification is good and a major shock is needed to switch from one given regime to another. The first regime has a negative price value (-0.09) and the second regime has a positive price value (0.11). The mean reverting speed ($Kappa$) is virtually the same in each regime but slightly higher in the first regime (associated to a fundamental regime). Observed volatility is however weak in both regimes.

Both dynamics are clearly Gaussian with a NIG parameter superior to 1 in compliance with the apparent dynamics of the series. If we look at the correspondence/match between the temperature anomalies and grain price (see Table 4), regime 2 with the highest grain prices is related to the periods of cooler temperatures. We can thus suggest that grain prices increased in periods of cooling temperatures. Historically and with regard to our datation: 1555-1649, 1674-1700 (especially 1674-1685) and 1787-1800 appear to be periods that correspond to lower temperatures and increasing prices (regime 2).

4.3 Wage :

In comparison with the previous series, identifying significantly distinct regimes is less clear-cut (52% of in sample forecasting?). However, the probability of staying in one regime is important (over 91%). Again, an important shock was needed to generate a switch of the series from one regime to another. Regime 1 denotes the regime with the highest wages and the second denotes the regime with the lowest payroll values. The first state is highly volatile and clearly exhibits some jumps (alpha=0,96) that probably explain why the identification rate is only 52% . The asymmetry is important in the regime 2 with lowest wages.

4.4 Holland economic growth :

Good classification (rate 78%) and the probability of remaining in the same regime is over 90%. Regime 1 denotes a relatively significant growth rate (mean

Table 4: Identification of historical regimes

	Regime 1	**Regime 2**
European Temperatures	Low 1541-1546 1563-1659 1674-1701 1739-1745	High 1500-1540 1547-1562 1660-1673 1702-1738 1746-1798
Grain Yield	Low 1600-1706	High 1500-1599 1707-1800
Grain Price	High 1555-1649 1674-1699 1787-1800	Low 1500-1554 1650-1657 1700-1786
Wage	Low 1597-1651 1667-1690 1712-1794 1795-1800	High 1500-1562 1568-1576 1585-1596 1652-1666 1691-1710**
Social Disturbances	Too much volatility to identify clear periods	
War	High 1500-1689 1701-1719 1789-1800	Low 1690-1700 1720-1688
Holland GDP	Low 1565-1580 1601-1632** 1701-1706	High 1500-1564 1581-1600 1633-1699 1707-1800
UK GDP	Distinction between regimes not significant	
Italy GDP	Low 1564-1579 1588-1670 1694-1800	High 1500-1563 1580-1587 1671-1693
Famine	High 1576-1605 1626-1655 1676-1685 1716-1745	Low 1500-1505 1516-1575 1606-1625 1686-1715 1746-1765 1776-1795

Note: the most coincident sub-periods identified among the series are reported in red color.

4.40) in comparison with regime 2 (1.32), The speed of adjustment is almost the same in each regime. Regime 2 clearly exhibits more volatility and thus, in times of relatively low economic growth, the Dutch economy was more unstable. This variable is more volatile than the other series and exhibits a lot of jumps.

If we correlate this with the temperature dynamics (please refer to Table 2), the following mechanism holds: when the climate is cooler and especially during the coldest phases of the Little Ice Age period, the Dutch economy seemed to switch from a normal economic growth regime to a more volatile regime with lower growth. The GDP growth results confirm the previous results of Zhang et al. (2011), Pei et al. (2014) and Waldinger (2015) that used population growth rates concerning a potential negative impact of temperatures on agricultural yield and so on the entire economic production. This is not altogether surprising since the share of the agricultural sector in pre-industrial economies was very high.

We also performed the same exercise for Italy and the UK but the results are less evident or not significant. We nonetheless noted some interesting facts: in the first part of the sample there was strong synchronization of GDP cycles in Holland and in Italy, which progressively disappeared over time.

4.5 Social Disturbances :

The quality of in-sample forecasting was moderate (only 54%) with probabilities remaining in the same regime at around 50%, making is a relatively unstable variable. The model switched more frequently from one regime to another one and it was difficult to clearly identify different regimes. However, the values in regime 1 are relatively low and seem to correspond to a normal regime. They are lower than the values of regime 2 (1.63 versus 12.31) which consists of periods of increasing social disturbance. Both regimes exhibit Gaussian distributions.

4.6 War :

Regarding the War variable regimes, we noted that in regime 2 (i.e. the regime in which Social Disturbance is ten times more than in the normal regime), the war variable value was four times more than normal (8.68 against 2.19). A link between climate, war and social disturbance is thus plausible in some regimes. Moreover, the intensity of jumps is much higher in the unstable regime state corresponding to economic crises periods since the parameter *Alpha* equals 2.89 against 19.29. All these results indicate that regime 2 exhibits an unstable crisis period where both Social Disturbance and War values increase. It is not surprised since climate-induced economic crises can lead to social crises with riots and social unrest at the same time as wars, with each type of "conflict" reinforcing each other. From a statistical point of view, the jumps have much greater intensity than in standard normal time periods.

5 General discussion

Given the detailed results in Tables 2 and 3, we find evidence that the MS Levy approach is able to detect coinciding regimes for both climatic and socio-economic series. Thus, it offers a new way to investigate the impact of the cooler Little Ice Age period on the economy and society of pre-industrial Europe, complementing previous correlations and bivariate Granger causality tests by taking nonlinearity patterns into account. The different regimes and sub-periods identified by the MS Levy model during the 1500-1800 period are an informative complement to previous graphic and outlier analyses. Though the1600-1660 period graphically appears as a singular cooling period with a potential impact on society, the MS Levy model gives us further information about regime switching and identifies some sub-periods within the periods under study. In contrast to Zhang et al. (2011) who only take 1560-1660 as the central cooling period, but consider 1661-1800 as a homogeneous mild phase, our MS Levy model identified different sub-regimes. Our method probably identifies more complex and lasting/diffuse effects of climate on macroeconomics that a simple graphic and correlation analysis is unable to detect. Indeed, a climate shock in period t may generate economic and social consequences in the contemporaneous period t but also during $t+k$ periods since the dynamic effects of climate on economics should also be taken into consideration (Dell et al., 2014). Hence, potentially declining European temperature between 1563-1659 (Eur_temp temperatures) might be viewed as the main kernel of the Little Ice Age period which, in that sense, is in line with Zhang et al. (2011). Moreover, this cooling regime seems to more or less coincide with lower grain yields (1600-1706), higher grain prices (1555-1649), lower wages (1597-1651) and lower GDP growth rates in Holland (1565-1632 and, above all 1601-1632), in Italy (1588-1670). In this way, the emergence of episodes of famine (1576-1605 and 1626-1655) may potentially be a consequence of climate shock and its contagion on the macroeconomic cycle.

Furthermore, and this result is maybe more surprising, several variables also seem to have aligned at the end of the 17th century: average European temperatures once again declined over the 1674-1701 period, while grain prices rose and were more volatile in 1674-1699 and probably led to lower wages (1667-1690), generating a new episode of famine detected by the model in virtually the same time interval (1676-1685).

Investigating these regimes in greater depth, we can see that all the high volatility regimes - whatever the variables (climatic or socio-economic) considered began at the end of the 16th century and mainly covered the seventeenth century, with a stronger significant impact on the first half of the 17th century in line with the narrative writings of Parker (2013). If we look at the first set of synchronized periods for both weather and socio-economic variables, we find that 1650 appears to correspond to a higher volatility (both climate and economic variables) peak. The MS Levy model appears to detect a change in the dynamics of the series around 1650 for temperatures (1659), wages (1651) and famine (1655), even though the model seems to identify a new turbulent period between 1670 and the beginning of the 18th century.

Regarding our methodology, the second sub-period 1670-1700 appears, as in seismic dynamics, to be an aftershock. Going further, we try to explain the climatic origins of this regime switching. Parker (2013) stressed the potential causal role of higher volcanic activity (in 1640 for instance) and of the ENSO (El Nino Southern Oscillation) teleconnetion that occurred twice as often in the mid-seventeenth century (1638, 1639, 1641, 1642-46, 1648-50, 1651-52, 1659, 1660, 1661). Admittedly, historians cannot blame El Nino for everything. Some regional climates are El Nino sensitive, while others, even though contiguous, are not. As a consequence, ENSO is probably not at the origin of all weather disturbances, especially in Europe. Indeed, ENSO is mainly active in the Pacific Ocean, even though it is a teleconnection that impacts the weather and socio-outcomes everywhere. Moreover, the effect of ENSO teleconnection on local weather conditions is strongly spatially and temporally heterogeneous. Consequently, we decided to apply the MS Levy method to identify regimes in NAO teleconnection. Indeed, NAO (North Atlantic Oscillation) is the most active climatic teleconnection in the North Hemisphere, and can explain 30% of the variability of local weather conditions such as precipitation, but especially European winter temperatures (see Pozo-Vasquez et al., 2001 or Hurrell, 1995).

The MS Levy results show an alternation between the different regimes during the 1571-1650 period. The model detects two episodes of negative NAO values in 1571-1591 and 1628-1650 that cover an episode of positive values (1628-1650). We once again find the previous break around 1650 in the dynamics of NAO. We know that positive phases of NAO lead to cooler and drier winters in Western Europe (see for example Hurrell, 1995). Some recent papers (Heino et al., 2018 and Kim and Carl, 2005) using contemporaneous data have emphasized the role of large-scale climate oscillations, especially NAO, on crop productivity, agricultural value added and the whole economic performance. There is very strong synchronization between the regimes detected for NAO and the regimes detected for European temperatures and the other series. As a consequence, these results seem to confirm the substantial role of NAO oscillations and thus provide another example that North Atlantic Oscillations are among the potential origins of the emergence of a Little Ice Age period and a global crisis during the seventeenth century.

In a more general manner, our results on NAO and average temperatures seem to be consistent with historical records. When we look at the historical analysis of Parker (2013) regarding the global crisis in the seventeenth century, our detected regimes over the same period appear to be in line with many of the historical records. If we only focus on European countries, some remarks by Parker (2013, p.5) are very enlightening as the whole of Europe experienced an unusually cold winter in 1620-1: many rivers froze so hard that for three months they could bear the weight of loaded carts (...) and people could walk across the ice between Europe and Asia"; "English men and women noted the extraordinary distemperature of the season in August 1640, when the land seemed to be threatened with the extraordinary violence of the winds and unaccustomed abundance of wet", "October 1641 began what contemporaries considered a more bitter winter than was of some years before or since seen in

Ireland (...) Hungary experienced uncommonly wet and cold weather between 1638 and 1641. (...) In the Alps, unusually narrow tree rings reflect poor growing seasons throughout the 1640's (...) In eastern France, each grape harvest between 1640 and 1643 began a full month later than usual and grain prices surged, indicating poor cereal harvests (...) Central Germany recorded in his diary in August 1640 (...) while 1641 remains the coldest year ever recorded in Scandinavia". Parker (2013) noted that the decade ended with another bout of extreme weather around the globe", by giving some historical records in England, in France or in Dutch Republic: "226 days of rain or snow according to a meticulous set of records from Fulda in Germany (compared with an upper limit of 180 days in the twentieth century) followed by 'a winter that lasted 6 months'. In France, appalling weather delayed the grape harvest into October in 1648, 1649, 1650, and drove bread prices to the highest levels in almost a century (...) In the Dutch Republic, so much snow fell early in 1651 that the state funeral of Stadholder William II had to be postponed".

All in all, the period between 1620-1650 seems to have experienced dramatic temperatures and weather conditions. It is very interesting to note that the period of famine between 1626-1655 detected by our MS Levy model corresponds almost exactly to this period. Thus, the global crisis in the 17th century is likely to be strongly correlated with climatic variations.

From an historical point of view, the period around 1630 (1630-1650) identified by our quantitative analysis coincides perfectly with a lot of social disturbances and war events in Europe. In Britain, there was the English Civil War (1642-1651) and more generally the Wars of the Three Kingdoms between 1639 and 1651, with several civil conflicts in England, Ireland and Scotland. In France, the so-called Fronde (1648-1653) is perfectly coincident with one significant period identified by our quantitative analysis. Antoine and Michon (2006) explained that the food riots were an important model of violence and public demonstration. France experienced a lot of temporary (or short-term) riots that were linked to years with high grain and bread prices (for example 1630 and 1661-1662, according to Antoine and Michon). Sometimes, fears of a price hike or the dealings of grain merchants were enough to provoke social demonstrations. Based on the studies of Jean Nicolas studies (2002) on the French Revolution or "disorder", some historians mention the occurrence of 200 local revolts in France during the "Ancien Rgime".

Finally, our climatic study suggests that the dramatic climate changes around the globe in the seventeenth century underpinned the global crises and the high grain and bread prices crises (for example in 1630 and in 1661-1662 in France). It is likely that food riots or some important wars (the Wars of the Three Kingdoms between 1639 and 1651 or the so-called Fronde in France over 1648-1653) are coincident with one significant period identified by our quantitative analysis. However, our quantitative framework is not clear-cut on these aspects. Linking climate in the Little Ice Age to social disturbance and frequency of wars in the same way as Zhang et al. (2011) is more delicate, and the synchronization between social disturbances and climate variables is less clear-cut. While our model detects an increasing regime of wars in the seventeenth century, it

does not distinguish clear social disturbance sub-periods; the model continuously jumps from one insignificant regime to another. The MS Levy model thus leads to a more cautious conclusion compared to Zhang et al. (2011) who established correlation and causality tests on filtered data between climate on the one hand and social riots and wars on the other. Several explanations may be considered: the quality of social disturbances and war data and, notably, the lower frequency that reduces the number of observations and the accuracy of the MS tool and the presence of delayed effects, that is the possibility that the causal links emerge only a few decades after a climatic shock.

6 Causality analysis

Going beyond the detection of some potential coincident regimes between climatic and economic variables, we performed Granger causality tests to identify causal linkages between climate, economic and social variables. We focused on the sub-samples corresponding to the regimes identified by the MS Levy model. We thus choose the 1550-1700 sub-period, which yielded 151 observations exhibiting reasonable statistical properties. The investigation was designed to confirm or infirm the causal and theoretical framework outlined by Pei et al. (2014, see figure 1): $climatevariations \rightarrow grainyield \rightarrow grainprice \rightarrow inflation \rightarrow realwage \rightarrow population$. However, contrary to Pei et al. (2014), we prefer to substitute population by Uk and Holland GDP data obtained from Fouquet and Broadberry and we only focus on the precise Little Ice Age detected by the MS Levy model around 1550-1700. In addition, in line with Zhang et al. (2011), we wanted to investigate if temperature changes during the Little Ice Age period were likely to beat the origin of large human crisis.

Prior literature (Zhang et al. (2011), Pei et al. (2014)) applied Granger causality to scrutinize the link between climate and macro cycles and climate and social outcomes. Their analysis showed that temperatures Granger cause grain prices and that grain prices may have impacted the number and intensity of social disturbance events such as war, nutritional status, famine, epidemics and migration dueing the period in question. In this paper, we reinvestigate the link between climate and social disturbances. However, in contrast to Zhang et al. (2011), we believe that it is not useful to conduct similar analysis on famine, epidemics or migration given the low frequency of these series and the low statistical power of Granger causality analysis when series with a low number of observations are used. As a consequence, we only investigated social disturbances and war variables in the present paper.

We first computed ADF and ADF-GLS unit root tests and found that not all series are stationary in levels (presence of a unit root). This result is in contrast with Zhang et al. (2011) that found stationarity for most of the series. Though the period under study was slightly different, the statistical filtering they used was probably the cause of these diverging results. This point is very important however since conventional Granger causality analysis should be computed on stationary series.

We first computed bivariate Granger causality with first-difference variables. The results, using 2 and 4 lags respectively (Table 5), suggest the existence of a strong causal relationship from temperatures to Grain Price, and from temperatures to Agricultural Production and wages over the Little Ice Age period selected. As a consequence, the coinciding regimes previously identified also show some causal relationships, with climate change affecting agricultural prices and production during the period under study. However, the results are less clear-cut regarding the climate impact on social disturbances and are not conclusive with respect to a direct impact of climate on the war index and GDP. Our results nuance previous conclusions in the literature.

Nonetheless, despite the fact that temperature does not seem to directly Granger cause GDP and social disturbances, it is possible that temperature Granger causes GDP through a third, omitted variable (see Triacca (2001)). For instance, if $Temp \nrightarrow GDP|I_{Temp,GDP}(t)$ and $Temp \rightarrow GDP|I_{Temp,AgriYield,GDP}(t)$ so $AgriculturalProduction \rightarrow GDP$ and so agricultural GDP would be a third omitted variable that establishes a causal bridge between temperatures and GDP. As a consequence, we also test (Table 6) whether grain prices, agricultural production and wages can cause GDP and social disturbance by modifying the set of information (and variables) from two to three variables and then run the bivariate Granger causality tests again. The results reveal clear causality from temperature to UK GDP through grain prices, wages and agricultural production, but not for Holland GDP and social disturbance.

Finally, given the potential drawbacks and limitations of the Granger analysis, we performed an alternative causality analysis using the Toda Yamamoto (1995) methodology (TY hereafter). The conventional Granger causality tests consist of an unrestricted VAR framework and are conditional on the assumption that the underlying variables are stationary; otherwise, the Wald test statistic has a nonstandard asymptotic distribution. In particular, He and Maekawa (2001) pointed out that the use of the F statistic to test Granger causality often leads to spurious causality between two independent and irrelative processes where one of or both of them is or are non-stationary. In the case of non-stationary time series, we should investigate cointegration and, if it exists, should proceed with a vector error correction model instead of unrestricted VAR with variables in level. The TY procedure avoids the bias associated with cointegration tests as it does not require the pre-testing of cointegrating properties of the system (see Zapata and Rambaldi (1997) and Clark and Mizra (2006)).

It is important to note that the TY procedure also has some weaknesses. The approach suffers from loss of power since the VAR model is intentionally over-fitted (Toda and Yamamoto (1995)). However, according to the Monte Carlo experiments on bivariate and trivariate models performed by Zapata and Rambaldi (1997), despite the intentional over-fitting, the TY procedure also performs similar but more complex test procedures in samples of at least fifty (in our case the sample size is 151).

The TY results confirm that temperature probably impacted on agricultural production and grain prices during the Little Ice Age period. Moreover, climate change is likely to have led to some social disturbance and reduced GDP but to

a lesser extent. The results are robust to third variable omitted bias: both grain price and grain yield have been used as a third variable. As a consequence, our results confirm the link between climate and grain prices suggested by the earlier literature; the link between climate and grain prices or agricultural production is entirely robust. However, our findings understate previous results concerning the existence of a strong link between climate and social disturbance or conflict and other social outcomes as suggested by the climate-conflict literature (Tol and Wagner, 2010, Hsiang and Carleton, 2016). Finally, our analysis fails to demonstrate the existence of a causal relationship between climate and GDP over the period under study.

Table 5: Unit Root tests

	LEVEL		**1st DIFF**	
	ADF	**ADF-GLS**	**ADF**	**ADF-GLS**
EUR_TEMP	0.3738	0.6020	0.0000	0.0000
GRAIN YIELD	0.4185	0.2621	0.0000	0.0000
GRAIN PRICE	0.3801	0.5073	0.0671	0.0000
AGRI PROD	0.3131	0.7365	0.0003	0.0000
WAGE	0.0001	0.4452	0.0000	0.0000
SOCIAL DISTURBANCES	0.0000	0.0094	0.0000	0.0000
WAR	0.0046	0.0000	0.0012	0.0000
UK GDP	0.9759	0.5007	0.0000	0.0000
HOLLAND GDP	0.0021	0.5146	0.0000	0.0000
ITALY GDP	0.1610	0.0385	0.0068	0.0000

Table 6: Bivariate Granger Causality tests with a two variables information set

	F Stat	**Prob**	**F Stat**	**Prob**
GRAIN PRICE does not Granger Cause EUR_TEMP	0.91333	0.4035	0.26773	0.8983
EUR_TEMP does not Granger Cause GRAIN PRICE	**4.79535**	**0.0096**	**2.09181**	**0.0850**
AGRI PROD does not Granger Cause EUR_TEMP	0.73250	0.4825	0.33330	0.8552
EUR_TEMP does not Granger Cause AGRI_PROD	**4.36337**	**0.0144**	**2.52844**	**0.0432**
WAGE does not Granger Cause EUR_TEMP	1.00285	0.3693	0.62516	0.6453
EUR_TEMP does not Granger Cause WAGE	**3.30467**	**0.0395**	1.93026	0.1086
SOCIAL DISTURBANCES does not Granger Cause EUR_TEMP	0.40641	0.6668	0.30901	0.8716
EUR_TEMP does not Granger Cause SOCIAL DISTURBANCES	0.21163	0.8095	**2.55326**	**0.0416**
WAR does not Granger Cause EUR_TEMP	1.23442	0.2940	1.57975	0.1829
EUR_TEMP does not Granger Cause WAR	0.11612	0.8904	0.67234	0.6122
UK GDP does not Granger Cause EUR_TEMP	0.89635	0.4103	0.98389	0.4184
EUR_TEMP does not Granger Cause UK GDP	1.35012	0.2624	1.07304	0.3722
HOLLAND GDP does not Granger Cause EUR_TEMP	0.00491	0.9951	0.21718	0.9285
EUR_TEMP does not Granger Cause HOLLAND GDP	0.30726	0.7359	0.91946	0.4545
ITALY GDP does not Granger Cause EUR_TEMP	0.45381	0.6361	0.31635	0.8667
EUR_TEMP does not Granger Cause ITALY GDP	0.14977	0.8610	0.17505	0.9509

Table 7: Bivariate Granger Causality tests with a three variables information set (2)

	Prob	**F Stat**
AGRI PROD does not Granger Cause HOLLAND GDP	**2.92374**	**0.0569**
HOLLAND GDP does not Granger Cause AGRI PROD	0.45735	0.6339
GRAIN PRICE does not Granger Cause HOLLAND GDP	1.22245	0.2975
HOLLAND GDP does not Granger Cause GRAIN PRICE	0.77952	0.4605
WAGE does not Granger Cause HOLLAND GDP	0.40514	0.6676
HOLLAND GDP does not Granger Cause WAGE	1.53075	0.2198
AGRI PROD does not Granger Cause UK GDP	**2.68357**	**0.0717**
UK GDP does not Granger Cause AGRI PROD	**3.25840**	**0.0413**
GRAIN PRICE does not Granger Cause UK GDP	**2.28501**	**0.1054**
UK GDP does not Granger Cause GRAIN PRICE	6.06442	0.0030
DE_WAGE_IDX does not Granger Cause UK	**5.78500**	**0.0038**
UK does not Granger Cause DE_WAGE_IDX	19.0358	5.E-08
DE_AGRI_PROD_IDX does not Granger Cause SOCIAL_DISTURB	1.76935	0.1741
SOCIAL_DISTURB does not Granger Cause DE_AGRI_PROD_IDX	0.03110	0.9694
GRAIN PRICE does not Granger Cause SOCIAL DISTURBANCES	**3.62265**	**0.0291**
SOCIAL DISTURBANCES does not Granger Cause GRAIN PRICE	0.10190	0.9032
WAGE does not Granger Cause SOCIAL DISTURBANCES	1.80287	0.1685
SOCIAL DISTURBANCES does not Granger Cause WAGE	1.44242	0.2397

Table 8: Bivariate Toda Yamamoto causality procedure

	F Stat	**P-value**	**Order VAR**
EUR_TEMP does not Granger Cause GRAIN PRICE	**2.571**	**0.056**	3
EUR_TEMP does not Granger Cause AGRI PROD	**3.123**	**0.027**	3
EUR_TEMP does not Granger Cause WAGE	1.272	0.283	2
EUR_TEMP does not Granger Cause SOCIAL DISTURBANCES	**2.045**	**0.091**	4
EUR_TEMP does not Granger Cause WAR	0.174	0.840	2
EUR_TEMP does not Granger Cause UK GDP	0.933	0.426	3
EUR_TEMP does not Granger Cause HOLLAND GDP	0.309	0.818	3
EUR_TEMP does not Granger Cause ITALY GDP	0.979	0.404	3

Table 9: Trivariate Toda Yamamoto causality procedure

	Conditional to	**F Stat**	**P-value**
EUR_TEMP does not Granger Cause GRAIN PRICE	AGRI PROD	**3.024**	**0.031**
EUR_TEMP does not Granger Cause DE_AGRI PROD	GRAIN PRICE	**2.634**	**0.0052**
EUR_TEMP does not Granger Cause WAGE	AGRI PROD	1.680	0.189
EUR_TEMP does not Granger Cause WAGE	GRAIN PRICE	1.587	0.195
EUR_TEMP does not Granger Cause SOCIAL DISTURBANCES	AGRI PROD	0.986	0.375
EUR_TEMP does not Granger Cause SOCIAL DISTURBANCES	GRAIN PRICE	**2.097**	**0.103**
EUR_TEMP does not Granger Cause WAR	AGRI PROD	0.270	0.763
EUR_TEMP does not Granger Cause WAR	GRAIN PRICE	0.134	0.939
EUR_TEMP does not Granger Cause UK GDP	AGRI PROD	2.159	0.119
EUR_TEMP does not Granger Cause UK GDP	GRAIN PRICE	0.975	0.400
EUR_TEMP does not Granger Cause HOLLAND GDP	AGRI PROD	0.548	0.579
EUR_TEMP does not Granger Cause HOLLAND GDP	GRAIN PRICE	0.235	0.871
EUR_TEMP does not Granger Cause ITALY GDP	AGRI PROD	1.311	0.272
EUR_TEMP does not Granger Cause ITALY GDP	GRAIN PRICE	1.826	0.145

7 Conclusion

The impact of climate change on economic performance in the future is likely to increase, affecting not only the agricultural sector but all aspects of economic growth. Indirect effects on social disturbance, war and violence as well as epidemics, and thus on the way society overall works, could be significant.

In this paper, we assess the impact of major climate shocks on several societal and economic outcomes by considering the historic Little Ice Age period, and thus the pre-industrial economy, as a case study. We used nonlinear econometrics, especially MS Levy estimates, to identify potential common regimes for climate, economic and societal outcomes. Finally, we performed both conventional and TY Granger causality analysis over the periods identified by the MS Levy model.

More specifically, our paper contributes to the literature on the existence of a Little Ice Age period and the effects of climate change on social and economic outcomes during this period in the vein of Zhang et al. (2011) and Pei et al. (2014). In contrast to these studies conducted by geographers, we did not use statistical filters to avoid the so-called Slutsky effect outlined by Kelly and OGrada (2014). We instead computed a non-linear time series methodology with raw data to detect potential links between climate and socio-economic variables using Markov regime-switching with a Levy process, reinvestigating the causal linkages between climate and socio-economic variables.

Our findings point to the existence of a strong cooling period and thus a Little Ice Age between 1560 and 1700 through two major episodes: 1563-1659 and 1674-1701. The Little Ice Age period was thus shown to be non uniform. Using historical sources, we discussed the relevance of the sub-regimes identified by our methodology. Since ENSO is a potential driver of the Little Ice Age, we

also found that some changes in North Atlantic Oscillation (NAO) dynamics coul have been one of the causes of this climate change. In this way, our analysis demonstrated the likely existence of a Little Ice Age. This finding appears robust since the so-called Slutsky effect is explicitly taken into consideration. In addition, non-stationarity, nonlinearity and causality issues were also addressed.

Our estimates show that the grain markets, wages, the famine index and GDP of some major European countries such as Holland appear to share common statistical trends and coincident regimes. These coinciding regimes and the association between climate and other variables could indicate some causality links. We derived a robust strong causality between temperature, grain prices and agricultural production over several decades; thus, climate could have lasting effects, while the adaptation of countries might be relatively slow.

The impact of climate on agricultural production is very clear, but the impact of climate on GDP is less robust. The effect of climate on social disturbance is plausible, but again needs more investigation to be entirely robust. However, the possible association between climate and social disturbance is in line with the recent climate-conflict literature although we did not find a significant link between climate and wars.

More generally, our findings suggest that climate can have a certain impact on macroeconomics. With todays trends expected to increase in the near future, agricultural yields and production are liable to decline in vulnerable countries, at least in the short-run. Considerable time (several decades) is likely to be needed to adapt without other mitigation policies. From a methodological point of view, simple linear correlation and bivariate Granger Causality tests used in the previous literature might have over-estimated the impact of climate as the main driver of large-scale human crisis. We used new econometric tools to further examine and check the robustness of previous results, but a more general causality analysis, including nonlinear causality patterns with a broad set of variables, might be a further way to extend this analysis in the future.

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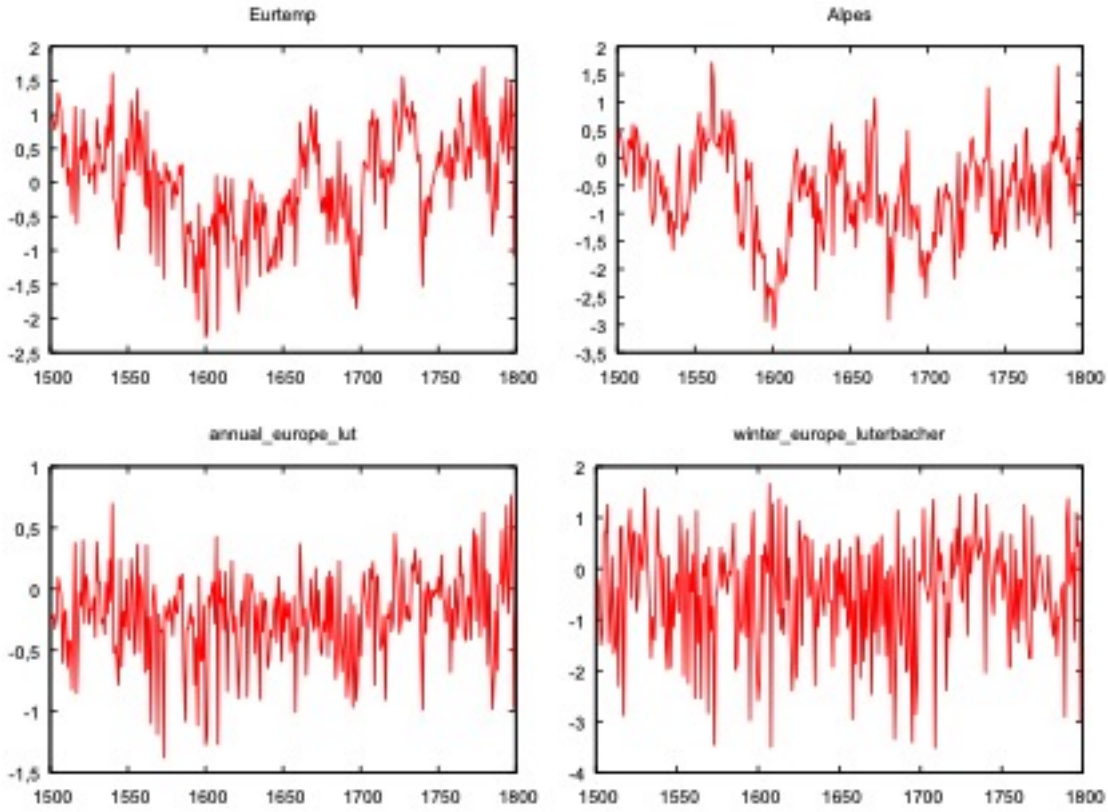

Figure 1: Temperatures variables dynamics

Appendix

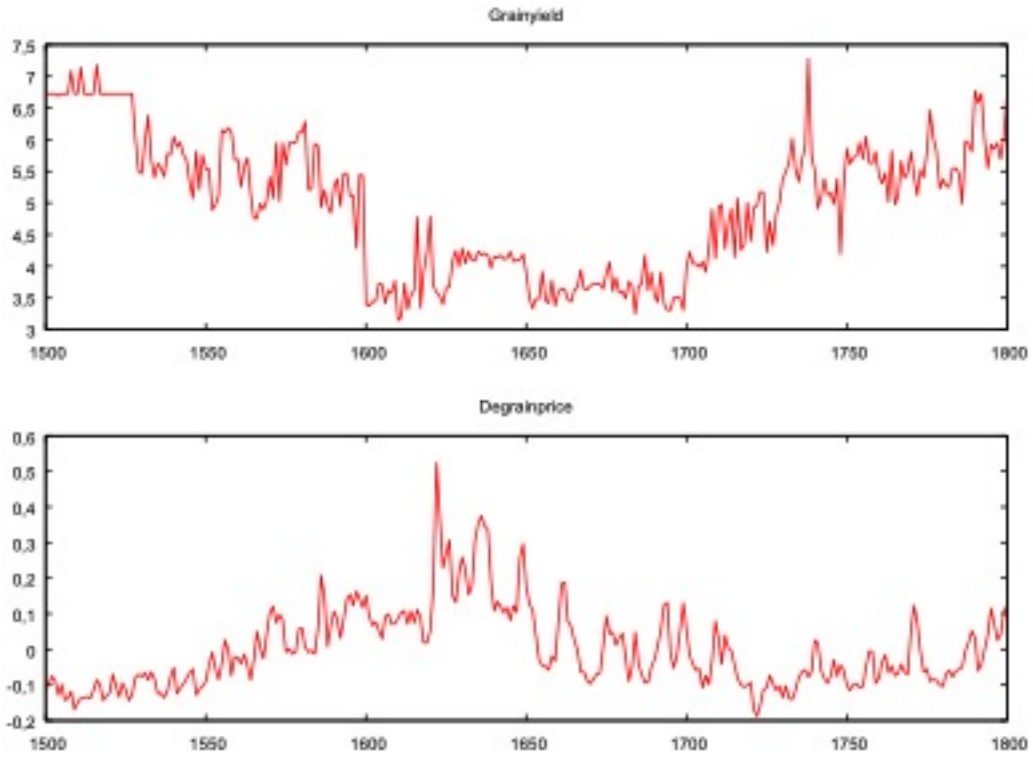

Figure 2: Grain yield and price dynamics

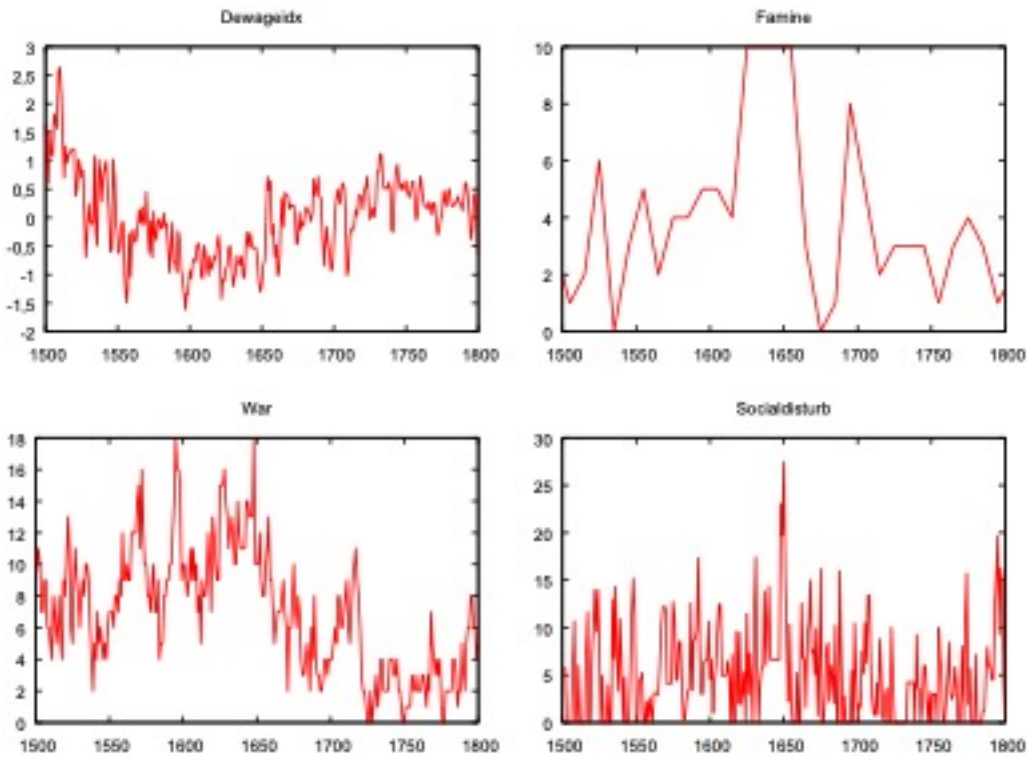

Figure 3: Wage, Famine, War, Social disturbances dynamics

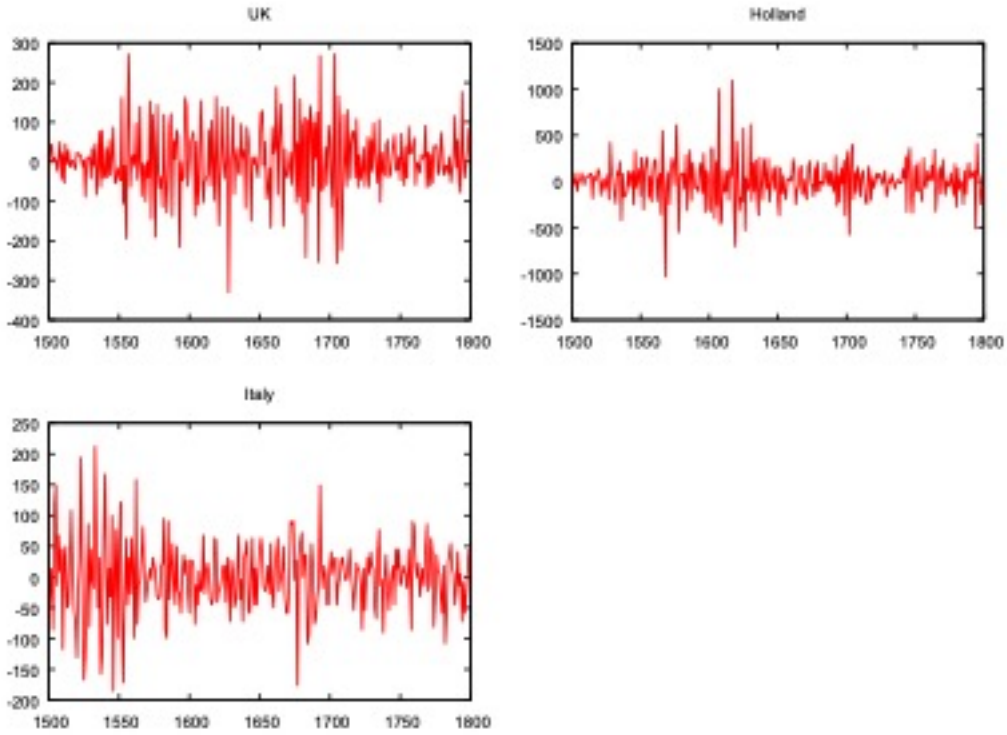

Figure 4: GDP growth dynamics for UK, Holland, Italy

From Stagnation to Sustained Growth: The Role of Female Empowerment

Claude DIEBOLT and Faustine PERRIN*

This paper explores the role of gender equality over long-run economic and demographic development path of industrialized countries. It accounts for changes in fertility, technology and income per capita in the transition from stagnation to sustained growth. Our unified cliometric growth model of female empowerment suggests that changes in gender relations, triggered by endogenous skill-biased technological progress, induce women to invest in skilled education and engage a process of human capital accumulation. In parallel, a higher time spent by women in education increases the opportunity cost of having children and reduces fertility. This positive feedback loop generates both a demographic and an economic transition.

Keywords: Cliometrics, Economic Growth, Gender, Fertility, Human Capital

JEL Classification: J1, N3, O4

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Contents

That cliometrics is an indispensable tool in the study of long run economic growth is no longer a very controversial statement. It is now generally agreed that economic theory, combined with historical, statistical and mathematical methods are necessary. At the theoretical level, it enables us to formulate problems precisely, to draw conclusions from postulates and to gain insight into workings of complicated processes. At the applied level, it allows us to measure variables, to estimates parameters and to organise the elaborate calculations involved in reaching empirical results. This article is an illustration of our belief in this principle. It explores the role of gender equality over long-run economic and demographic development path of industrialized countries.

The relationship between gender equality and long-run economic growth has received little attention from theorists so far. Understanding gender roles is difficult in that it requires a global understanding of family organization and its interaction with the marketplace. However, we strongly believe that changes in gender roles have played a key role in the economic development of modern societies. Insights from economics suggest the role of women to be a strategic variable in economic development, through its effects on demographic behavior as well as on human-capital formation in the next generation.

During the past two centuries, Western world witnessed dramatic economic, demographic and cultural upheavals. This period marks a turning point in historical economic and demographic trends. Western countries experienced similar patterns of economic and demographic transition, despite some variations in terms and timing and speed of changes (Galor, 2012). Before the Industrial Revolution, all societies were characterized by a very long period of stagnation in per capita income with high fertility rates. Since this fateful period, Western countries observed a complete reversal with high sustained income per capita and low fertility (Becker *et al*., 2012, Klemp, 2012). In parallel to economic and demographic transitions, we note profound changes in the structure of the population: formal education became accessible to a vast majority of the population while drastic changes occurred in gender relations.

Observed empirical regularities raise numerous questions about the potential interaction between female empowerment, demographic transition and economic development; and about its role in the transition from the epoch of Malthusian stagnation to the Modern Growth Regime (Galor and Moav, 2002). Therefore, what can explain the dramatic reversal of the relationship between output growth and population? What are the underlying behavioral forces behind the

demographic transition? What are the endogenous interactions between education and fertility that result in the transition phase? Could female empowerment account for the observed take-off from stagnation to sustained growth in Western countries?

The theories which aim to explain development and economic growth have, for a long time, found their inspiration in Malthusian and neoclassical conceptions. Without technological progress, Malthus' theory suggests that the size of the population self-balances either under biological constraint or individuals' rationality. On the other hand, Solow's model (1956) deals with the demographic growth as an exogenous variable, independent of wages, incomes and prices. Without technological progress, the income per capita converges towards a stable steady-state but independently of the population size. These two theoretical axes do not address the proper effects of family behavior on the macroeconomic environment (and inversely). Initiated by Becker (1960, 1965), Leibenstein (1957) and Mincer (1962), the "new home economics" extends the domain of microeconomic analysis to a wide range of behavior and human interaction, such as demographic behavior, investments in human capital, intergenerational transfers and so on (including the distribution of work and allocation of time in the family). A decade later, Nerlove (1970), Razin and Ben-Zion (1975) or Srinivasan (1988) link demographic behaviors to macroeconomic evolutions in order to analyze their implications on the general equilibrium[1]. Inspirited by these papers and by the endogenous growth models of Romer (1986, 1990) and Lucas (1988), growth models with explicit microeconomic foundations of family have then progressively been developed (Barro and Becker, 1989; Becker, Murphy and Tamura, 1990, Ehrlich and Lui, 1991; Galor and Weil, 1996; Dahan and Tsiddon, 1998; Iyigun, 2000). The progress of endogenous neoclassical growth models may provide plausible explanations of the modern experience of economic growth in developed economies. Nonetheless, they do not provide a global understanding of the development process as a whole (mysteries persist about some of the most fundamental features of the process of development). This led growth theorists, such as Galor, to advance the idea of a theory that could captures in a single framework the transition from Malthusian stagnation to sustained economic growth, as well as the associated phenomenon of great divergence and

[1] Within the framework of neoclassical growth model with endogenous fertility, the authors attempt to determine the optimal population growth rate.

demographic transition. Galor and Weil (2000)[2] emphasize the existence of three stages within the development process through the evolution of the relationship between the level of income per capita and the population growth rate. During the Malthusian Era (stagnation), population growth was positively affected by the level of income per capita. The absence of significant changes in the level of technology trapped the income per capita around a subsistence level and population size remained relatively stable. The Post-Malthusian Regime (take-off) is characterized by a significant increase in the output growth, driven by technological progress, and by an unprecedented increase in population growth. Finally, the Modern Growth Regime shows a reversal of the relationship between income per capita and population growth which signed the transition toward a state of sustained economic growth. Common to most unified models is the rise in the rate of technological progress (through the emergence of new technologies) during the process of industrialization which increases the demand for human capital and induces parents to invest more in the education of their offspring. Investing in education increases the opportunity cost of having children and implies for parents to choose between number and education of children (the child quantity-quality trade-off[3]), what ultimately triggers to economic and demographic transition.

This paper contributes to this literature on unified growth theory by bringing to light new determinants of the long transition process. Our model incorporates novel and additional mechanisms consistent with observed stylized facts, emphasizing the importance of the role played by women in the development process. Rare are growth models that differentiate the role of men and women in their analysis, considering rather the effect of household decisions on fertility. We choose here to tackle the issue of the development process by a renewed gendered approach. The main concern of the study is precisely to show to what extent and through which mechanisms gender equality affects decisions taken by members of the household and acts on long run economic development. We examine mechanisms that are likely to have played an important role in the sequence of events leading to the transition from high birth and death rates to low birth and

[2] The seminal work of Galor and Weil was quickly followed by new contributions *f*or example, Jones (2001), Lucas (2002), Hansen and Prescott (2002), Galor and Moav (2002), Doepke (2004), Galor (2005), Cervellati and Sunde (2005), Strulik and Weisdorf (2008).

[3] Becker (1960) was the first to introduce the distinction between child quantity and child quality.

death rates as countries developed from a pre-industrial to an industrialized economic system.

We develop a unified cliometric growth model that captures the interplay between fertility, technology and income per capita in the transition from stagnation to sustained growth. The theory suggests that female empowerment has been at the origin of the demographic transition and engaged the take-off to Modern economic growth. In line with empirical evidence, the theory characterizes the conditions under which the process of human capital accumulation initiated. Changes in the shares of population acquiring skilled human capital have substantial effects on fertility patterns and affect individuals' living conditions.

In particular, we consider a two-sex overlapping-generations framework with two types of human capital and integrating aspects of gender relations/equality. Households' members receive utility from their own consumption and from the potential lifetime income of their children. Therefore, they decide about the amount of time to invest in the education process and the number of children they want to raise. We consider all childrearing completely done by women. The key state variables for individuals' decisions are the technological environment and the power-imbalance ratio between sexes. A rapid change in technological environment increases the return to skilled education and increases both boys' education and fertility through an income effect. Higher gender equality (triggered by the acceleration of the pace of technological progress) increases girls' education and reduces the total number of children, through a substitution effect. Furthermore, given the assumption that all childrearing is done by women, maternal endowment in human capital is recognized as being primordial in the educative development of children. Ultimately, higher gender equality changes the trade-off from quantity of children toward quality of children. The average level of fertility therefore depends on the skill composition of the population.

The different elements of our model lead to a positive feedback loop. At the dynamic level, the increase in gender equality and the rise in technological progress create higher opportunities for women to invest in skilled human capital. The negative correlation linking maternal investments in human capital and fertility encourages families to have fewer children but better educated ones. Dynamically, it affects the incentive for individuals to acquire skilled human capital. Human capital being a factor with increasing returns to scale, the

reallocation of resources toward this factor sets the economy on a growing path dependency.

The paper is structured as follows. First, we present the stylized facts of economic and demographic transition; and empirical regularities regarding changes both in the educational structure of the population and in gender relations in France (section 1). Second, we present the theoretical background of the model (section 2). Then, we present the model (section 3). Next, we investigate the dynamic evolution of the economy (the development process) (section 4). Finally, we document the long-run effect of investments in human capital on fertility changes, from a gendered perspective (section 5).

1. The Stylized Facts – Gender, Fertility and Growth

In this section, we document the stylized facts and empirical regularities of demographic and economic transitions. Similar patterns emerge across countries despite some variations in terms and speed and timing (Galor, 2005). We briefly discuss current cross-country evidence of the relationship between gender equality and economic and demographic transition. Then, we describe French evidence of demographic and economic patterns, as well as regularities on skill composition of the population and on gender relations.

1.1 Gender Equality, Fertility and Development

We first observe current correlations linking the Gender Gap Index (GGI) subsequently with the Total Fertility Rate (TFR), the Human Development Index (HDI) and the Gross Domestic Product per Capita (GDP per capita) for 114 countries in 2006.

1.1.1 Gender Equality and Fertility

Figure 1 shows the correlations linking the Gender Gap Index (GGI) with the Total Fertility Rate (TFR) in 2006. The GGI examines the gap between men and women in four fundamental categories: economic participation and opportunity, educational attainment, health and survival, and political empowerment. A GGI

equal to 1 reflects perfect gender equality while 0 perfect inequality. The TFR of a population is the average number of children that women would have over their lifetime.

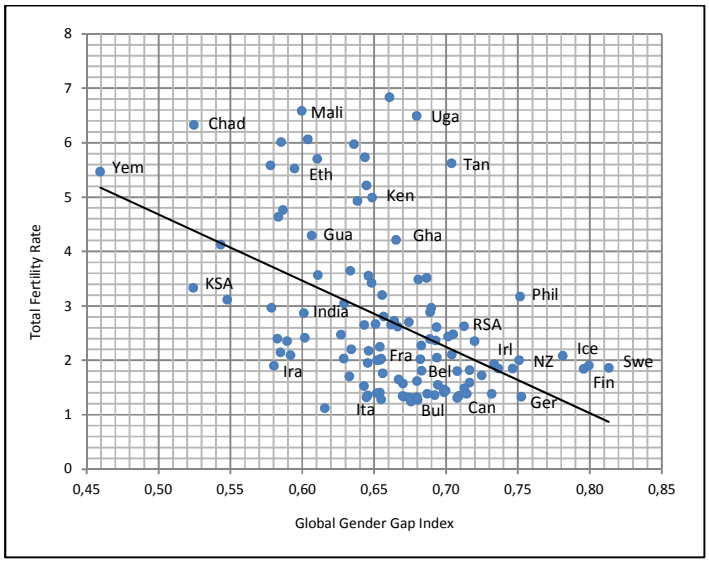

FIGURE 1. THE CROSS-COUNTRY PLOT OF TOTAL FERTILITY RATE AND GENDER GAP INDEX IN 2006

Notes: The data is for a set of 114 countries in 2006 (Global Gender Gap Report, Total Fertility Rate Report, World Bank) – details in Appendix.

The plot highlights the existence of a strongly negative correlation between the GGI and the TFR. Countries with a high level of equality between males and females have a low level of fertility. This is the case of countries such as Australia, Canada, Croatia, Denmark, Finland, Germany, Iceland, New Zealand, Norway, Sweden etc. (mainly OECD countries) – which are located in the high left part of the graph (number of children between 1.3 and 2 per women and gender gap between 0.7 and 0.85). Inversely, countries, in which the gender gap is high, experience high fertility level. This is the case of countries such as Angola, Ethiopia, Mali, Nigeria, Turkey, Yemen, Zambia etc. (Arabic countries, Sub-Saharan Africa, South and East Asia) – which are located in the high left part of the graph (number of children around 6 per women and gender gap between 0.46 and 0.64).

1.1.2 Gender Equality and Human Development

In contrast with the previous illustration, gender equality (measured by the GGI) is highly positively correlated with human development (measured by the Human Development Index). The Human Development Index (HDI) is a comparative measure of life expectancy, literacy, education and standards of living. This index allows measuring the quality of life within a country.

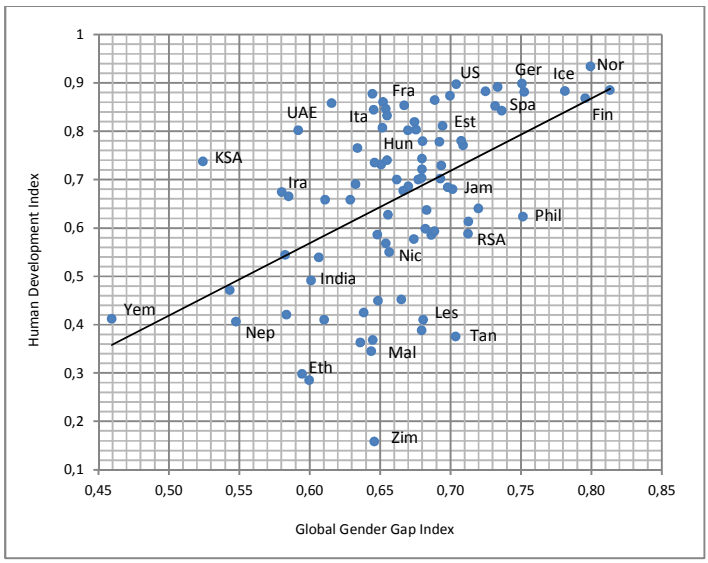

FIGURE 2. THE CROSS-COUNTRY PLOT OF HUMAN DEVELOPMENT INDEX AND GENDER GAP INDEX IN 2006

Notes: The data is for a set of 114 countries in 2006 (Global Gender Gap Report, Global Human Development Report, World Bank) – details in Appendix.

The plot highlights the existence of a positive correlation between the GGI and the HDI. Countries with a high level of equality between males and females have a high level of human development, notably characterized by high education, high literacy and high life expectancy. This is the case of OECD countries such as Australia, Canada, Croatia, Denmark, Finland, Germany, Iceland, New Zealand, Norway, Sweden etc. – which are located in the high right part of the graph (index of human development around 0.8 and gender gap above 0.7). Inversely, countries, in which the gender gap is high, have a low development index. This is the case of countries such as Afghanistan, Angola, Ethiopia, Mali, Nigeria,

Turkey, Yemen, Zambia, Zimbabwe etc. – which are located in the low left part of the graph (human development index below 0.6 and gender gap between 0.46 and 0.64)

1.1.3 Gender Equality and Economic Development

Similarly to what has been shown in the previous sub-section, gender equality (measured by the GGI) is highly positively correlated with growth (measured by the log GDP per capita).

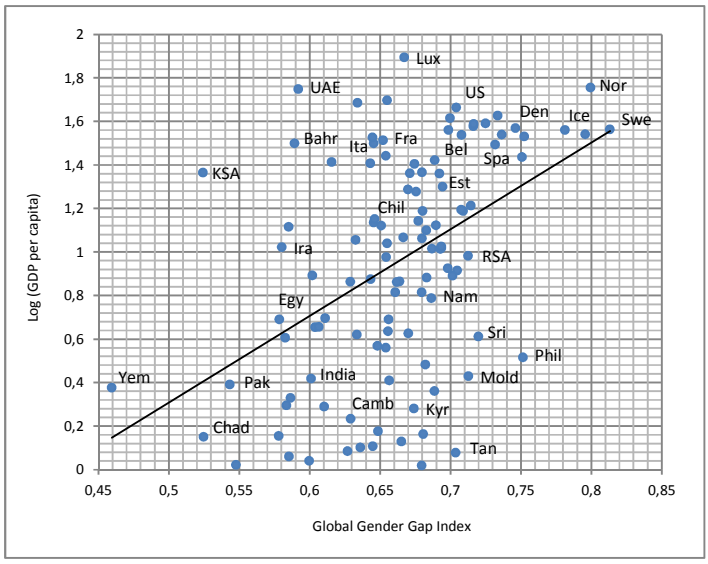

FIGURE 3. THE CROSS-COUNTRY PLOT OF PER-CAPITA GDP AND GENDER GAP INDEX IN 2006

Notes: The data is for a set of 114 countries in 2006 (Global Gender Gap Report, Per-Capita GDP Report, World Bank) – details in Appendix.

Countries with a high level of equality between males and females have a high level of GDP per capita. This is the case of OECD countries such as Australia, Canada, Croatia, Denmark, Finland, Germany, Iceland, New Zealand, Norway, Sweden etc. – which are located in the high right part of the graph (log GDP per capita around 1.5 and gender gap above 0.7). Inversely, countries, in which the gender gap is high, have a low development index. This is the case of countries such as Afghanistan, Angola, Ethiopia, Mali, Nigeria, Turkey, Yemen, Zambia,

Zimbabwe etc. – which are located in the low left part of the graph (log GDP per capita below 1 and gender gap between 0.46 and 0.64)

In other words, countries with a higher status of women are richer; more developed and have fewer children. Inversely, countries with stronger gender disparities are poorer; less developed and have more children[4].

1.2 Demographic and Economic Long-run Trends

Since the late eighteenth century, Europe experienced major economic and demographic changes. The demographic transition occurred in Western countries simultaneously to the transition from stagnation to growth. This led researchers to investigate the causal relation between demographic and economic transition. What are the underlying forces behind economic and demographic development? What are the endogenous interactions between education and fertility that result in the phase transition[5]?

1.2.1 Demographic Changes

The typical pattern of demographic transition begins with a mortality decline followed by a decrease in fertility. At the last stage of the process both mortality and fertility remain in balance at low rates. For France, the pattern is somewhat different. Both mortality and fertility rates dropped simultaneously. Figure 4 gives a broad picture of French demographic experience on the period 1740-2010.

In more detail, Figure 4(a) shows that after a first phase of decrease during the early 19th Century, French fertility stabilized before reaching a second phase of decline from the last quarter of the Century. Life expectancy at birth and infant mortality evolved symmetrically. As reported by Figure 4(b), life expectancy at birth started first to increase slowly and then at an increasing rate from the last decade of the 19th Century (and remains always higher for women than for men), while by contrast, infant mortality dropped substantially at the same period.

[4] Also documented by Klasen (2002), Dollar and Gatti (1999).

[5] See Galor (2005) and Doepke (2007) for recent survey.

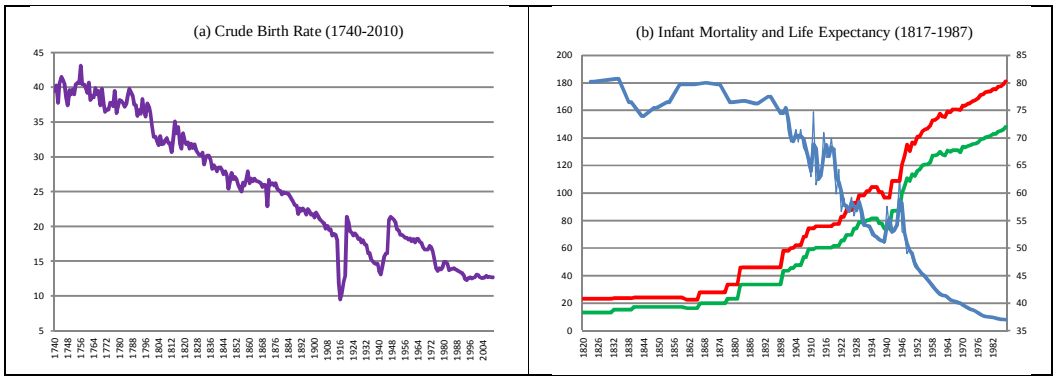

FIGURE 4. THE STYLIZED FACTS OF LONG-RUN DEMOGRAPHIC CHANGES, FRANCE

Notes: The crude birth rate and infant mortality data, respectively Figure 1(a) and 1(b), are taken from Chesnais (1992). Life expectancy at age 0 data in Figure 1(b) are taken from Insee (*Bilan démographique*, 2007). Missing intermediate values are obtained by linear interpolation.

Western countries' demographic profiles are similar but they witnessed the demographic transition with different synchronization. The comparison between the French and the English case constitutes an interesting paradox. While the Industrial Revolution begins in the 18th Century and the demographic transition in the 19th Century in England, inversely France experiences first its demographic revolution and then the Industrialization (Chesnais, 1992).

1.2.2 Economic Changes

France is thereby the first country to experience a fertility decline while Great-Britain is the first to experience the Industrial Revolution. The development pattern in France exhibits an increase in individual longevity, measured in terms of life expectancy at birth. The French transition scenario begins with a mortality decline which, very rapidly, is followed by a reduction in fertility. Owing to the onset of demographic changes, real product and per capita income levels start to increase slowly, and then face an extraordinary take-off in the second half of the 20th Century.

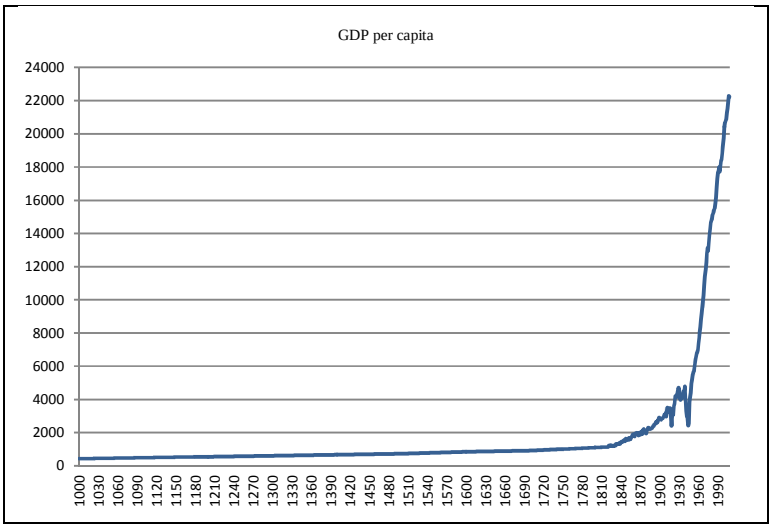

FIGURE 5. LONG-RUN ECONOMIC CHANGES IN FRANCE (1000-2008)

Notes: The GDP per capita data are taken from Maddison (2008).

Therefore, in association with demographic changes (observed Figure 4) is the take-off of GDP per capita – the economic transition. As illustrated in Figure 5, France witnesses its economic transition from mid-19th Century; after a very long period of stagnation in income per capita. For comparison, the first case of economic transition occurred in England with the Industrial Revolution in the second half of the 18th Century (see Cervellati and Sunde, 2005 for more evidence on the English case).

1.2.3 Educational Changes

In addition, we note profound changes in the composition of the population, notably in the proportion of people acquiring formal education. While a huge proportion of the population was illiterate before the demographic and economic transition, only a very small fraction of people were still not able to read and write in the late 19th Century (Figure 6(a)). During the different stages of transition, enrollment rates in primary and secondary schools increased dramatically for both boys and girls. Primary education rose significantly during 19th Century, always in a stronger proportion for boys compared to that of girls (always one step ahead

for boys' enrollment). In comparison, secondary education was delayed and less pronounced – almost absent for girls before 1881 – in a first step and increased drastically from the end of 19th Century – as can be seen in Figure 6(b).

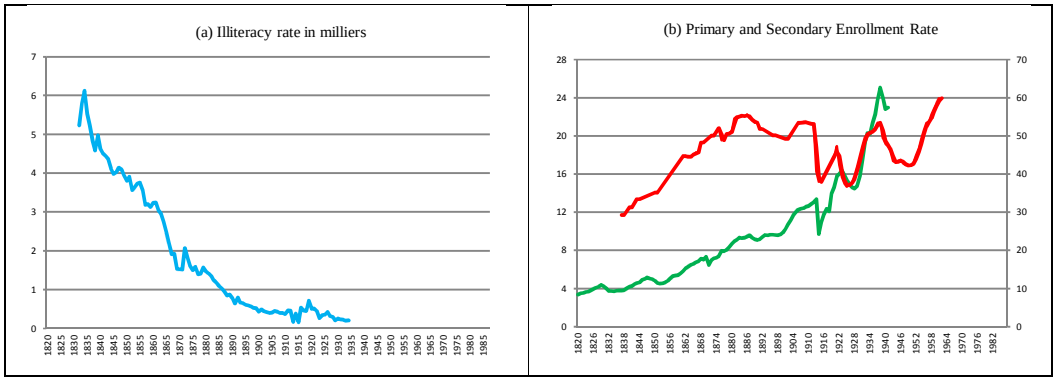

FIGURE 6. THE STYLIZED FACTS OF LONG-RUN EDUCATIONAL CHANGES, FRANCE (1817-1987)

Notes: The illiteracy rate consists in the share of illiterates – people unable to read and to write (taken from Blum and Houdaille). Boys and girls enrollment rates in primary and secondary schools data are taken from Diebolt. Missing intermediate values are obtained by linear interpolation.

Development patterns highlight a rapid increase in schooling enrollment rate for both boys and girls (at a faster rate for boys). While the vast majority of the population was illiterate before the economic and demographic transition, basic education, measured as the elementary school enrollment, increased substantially around the time of the take-off. Public secondary (Figure 6(b)) and high school enrollment was delayed but equally without precedent.

1.3 Gender Relations over the Long-Run

In parallel to demographic, economic and educational evolutions, we observe drastic changes in gender relations. Throughout history, women have always worked. However, the bargaining position of women within the household[6],

[6] Defined as a cooperative economic unit aimed at the fulfillment of the needs of its members (De Moor and van Zanden, 2009)

evolved over time according to socio-economic and ideological factors[7]; impacting over time the structure of women's work.

1.3.1 The Traditional Role of Women

The sharp distinction between the role of wife and husband within the household arise in the 19th century, when industrialization leads to a greater separation of home and professional sphere. The role of women in the workplace declines in comparison with previous periods. Women's reproductive duties occupy a significant share of their marital life. Thereby, the commonly accepted pattern as the most rational is that of men specialized in paid market work and women in unpaid reproductive and maintenance work in the domestic sphere. It is then very difficult, or impossible, for women to achieve a high position in the labor market.

> "*As long as women bear a disproportionate burden in raising children, the labor market will reflect these differences.*" (Goldin, 1990)

The organization of the society, dividing the work by gender and confining women inside the family in a situation of economic dependency and of subordination to men dominated most human history. This pattern, based on the existence of a clear demarcation between family and labor market is the result of a division of labor between gender aiming to combine the possibility of having a maximum of children and income within the household, the so-called *patriarchal model*.

1.3.2 The Emergence of New Economic Role of Women

The access for single women to salaried jobs in western countries starts during the 19th century. The vast majority of women workers are poorly educated. The access for married women, particularly those with young children, into the labor force only arise from the early 20th century, in parallel to the increase in technological progress in the market sector and in household production technology (basic facilities). From around the 1930s, the labor force participation

[7] Such as new religious movements, institutional changes/law (inheritance systems) or the access to the labor market (see De Moor and van Zanden, 2009)

of married women increases substantially. Nevertheless, despite the time saved achieving domestic duties and the access for women to paid jobs, women's employments remains concentrated in sectors requiring few qualifications, in the continuity of domestic labor, and offering low wages[8].

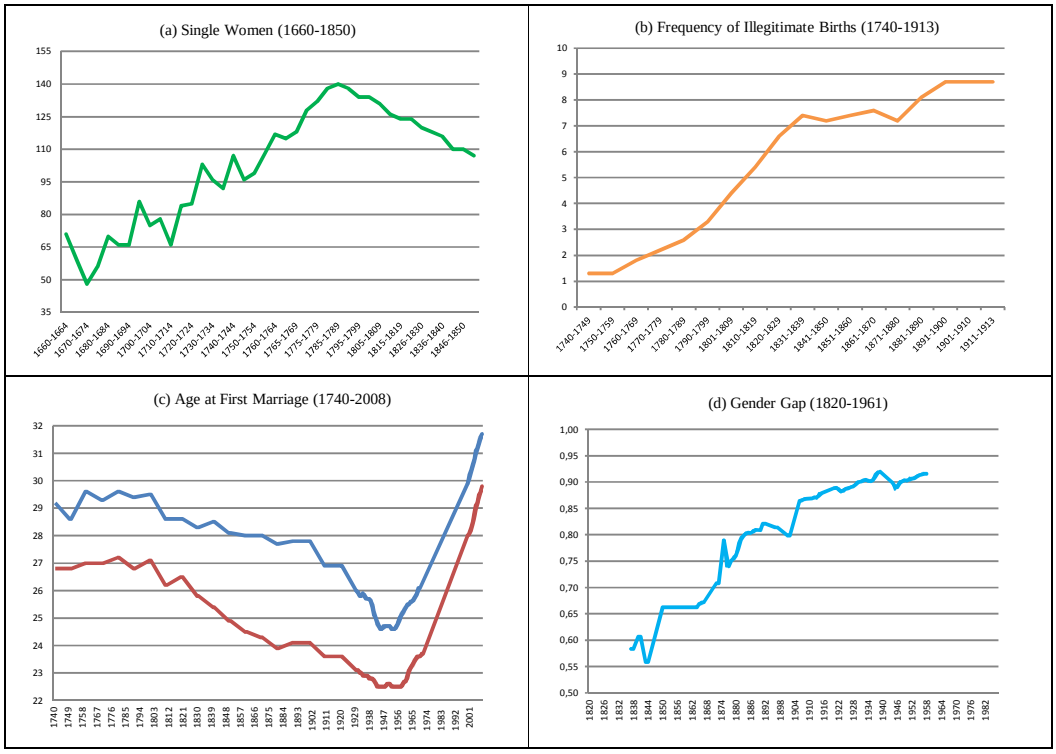

FIGURE 7. THE STYLIZED FACTS OF LONG-RUN GENDER RELATIONS, FRANCE

Notes: Data about the share of single women aged 50 and above (Figure 7(a)) and Age at first marriage (Figure 7(c)) come from Henri and Houdaille (1978, 1979). Data about the frequency of illegitimate births (Figure 7(b)) are taken from Fine (1988). The gender gap index (Figure 7(d)) consists in the female-to-male enrollment rate in primary school, data taken from Diebolt. Missing intermediate values are obtained by linear interpolation.

According to Hajnal (1965), three principal features emerge from the Western European Marriage Pattern (EMP) which characterized western society in the Early Modern Period: a high proportion of females never marrying a low rate of illegitimate births and an unusually late age at first marriage for females. Figure 7 offers a brief picture of a set of related changes in the French case. The number of

[8] The average married women workers were less educated than the average population.

single women (women never marrying) increases substantially from the mid-17th century until to the French Revolution (at the end of the 18th century); period from which the trend experiences a complete reversal (Figure 7(a)). The frequency of illegitimate birth increases sharply between the mid-18th century and the beginning of the 20th century. Close from 1% on the period 1740-45, it reaches almost 9% in 1911-13 (Figure 7(b)). Finally, the long-run evolution of the median age at first marriage for both males and females follows a U-shaped curve. Relatively late during the second half of the 18th century (around 27 for females and above 29 for males), it drops at the turn of the 19th century; to a greater extend for women. The age at first marriage attains the lowest points in the 1950s with 22.5 and 24.6 before experiencing a sharp reversal and to reach almost 30 and 32 in 2001, respectively for females and males (Figure 7(c)).

The marriage pattern found in Western Europe seemed as having possibly stimulated the investment in human capital for both men and women and participated to changes gender relations. Figure 7(d) displays the evolution of the gender gap index measured as the female-to-male enrollment in public primary school. While at the beginning of the period the gender gap index is relatively low around 0.56, at the end of the period it reaches around 0.92[9].

The implications of the marriage pattern highlight a relatively more equal position between men and women within the household, notably due to the integration of women into market activities. The marriage pattern could be considered as having built the foundations of the female emancipation movement which occurred during the 19th and 20th Century.

1.3.3 The "Quiet Revolution[10]"

The situation starts to change deeply from the middle of the sixties. Violent protests from the United-States and Sweden are at the origin of a veritable cultural revolution in western countries, transforming profoundly the status of women in the society. Part of the economic, social and cultural upheaval of the 20th century in western countries is undoubtedly attributable to the control of procreation[11] and to the legalization of abortion.

[9] An index equal to 0 means perfect inequality between boys and girls. The perfect equality between boys and girls is characterized by a gender gap index equal to 1.

[10] Goldin (2006).

[11] In 1956, the combined oral contraceptive pill, or birth-control pill, is developed by the doctor Gregory Pincus.

Many fundamental changes occurred in women's life. Reliable and easy to use, the Pill plays a decisive role in the decision of millions of women to invest in long-run vocational training and to build careers without having to pay high social costs in case of unplanned pregnancies (Goldin and Katz, 2001). In addition to financial costs of education and short run income loss, women who choose to invest in education have also to take into account social consequences of their decision.

Time represents for women a real constraint. The time of schooling has to be managed simultaneously to that of professionalization and the project of having children (Langevin, 1984). The plurality of this pattern that has widely dominated in our society implied for women to elaborate real strategies of conciliation between professional and family roles (Commaille, 1992). If men's career is positively correlated with the fact of being married and having children, in contrast, women's career is negatively associated. Women have to face a trade-off: either they choose to privilege first their professional career, delay childbearing and have more chances to get a stable job, losing in the same time opportunities to have children (because of the decrease in fertility after thirty years old), either they first privilege family by having children but as a consequence will have in majority an unstable job (as partial time) or will even renounce to work on the labor market (Pailhé and Solaz, 2007).

The time constraint is a real obstacle for women's career. Invisible and artificial barriers created by behavioral and organizational prejudices prevent women to reach the highest responsibilities in the professional sphere (BIT, 1997). This is the process of women empowerment that marks the rise toward a new family organization (toward a modern economic role of women), that will ultimately lead women to integrate massively higher paid-jobs. Between 1975 and 2005, the female labor force increases for all age groups, except for the 12-24 because of the increase in schooling. With more accurate expectations, girls can better prepare their educational investments. At the same time (since the end of the sixties), the female average wage improves strongly, and at an increasingly rate from the eighties thanks to a better training of girls and due to the generalization of stable jobs.

In developed countries, the increase in female investments in education changes deeply the nature of available work for women. The dominant model becomes the expression of a rapprochement and a homogenization of males' and females' behavior/decisions regarding their activity (Maruani, 1996). Henceforth,

women do not stop anymore their professional activity on the occasion of the birth of their children. There is no more choice, neither alternation, but a plurality between family and professional spheres: this is the blossoming of the *dual-earning model*. Each member of the household pursues a professional career, inducing a higher standard of living[12].

Human history can be clearly divided into two distinct eras. Before the Industrial Revolution all societies were characterized by a very long period of stagnation in per capita income with high fertility rates, the dominance of physical over human capital and strong gender gap. Since this fateful period, Western countries have observed a complete reversal with a high sustained income per capita, low fertility, human capital as an important source of income and improvement in gender equality.

Central to this paper is the consideration that the stylized facts of the development pattern, characterizing western society, are linked with households' behavioral patterns and more specifically with the changing economic role of married women over time (based on the evolution of gender relations/power-imbalance between generations and sexes).

2. Related Literature

If empirical literature on the link between gender equality and economic development is rather abundant (Schultz, 1995; Klasen, 2002; Knowles, Lorgelly and Owen, 2002, among many others), theoretical literature remains scarce. Galor and Weil (1996), Lagerlöf (2003), or more recently De La Croix and Vander Donckt (2010), are part of the few growth theorists having integrated gender differentiation in their model.

2.1 Theoretical Foundations of the Development Process

Theories which aim to explain economic growth and development have for a long time been inspired by Malthusian and Neoclassical conceptions (Solow).

[12] Let's note that men and women always achieve unevenly domestic duties – around 30% to 50% for men and 50% to 70% for women.

World economic history has been dominated by the Malthusian stagnation. The Classical growth theory developed by Malthus in 1798 in *An Essay on Principle of Population* matches pretty well with empirical evidences of the relation between income and population dynamics prior to the Industrial Revolution. According to this theory, the effect of population growth would be counter-balanced by the expansion of resources, reflecting in such a way the fluctuations of the income per capita around a subsistence level. In other words, without changes in the level of technology (resources) the population size would remain stable as well as the income per capita, while periods of technological progress (expansion of resources) would lead to an increase in population growth, triggering ultimately a decline in income per capita. Despite the capacity of the Malthusian theory to capture the characteristics of the epoch of stagnation, its predictions appear inconsistent with the features of the post-demographic transition era as well as that of the modern growth regime.

Exogenous growth models such as Solow's model (1956) deal with demographic growth as an exogenous variable and assume that demographic behaviors are independent of wages, incomes and prices. Without technological progress, the income per capita converges toward a stable steady-state independently of the size of the population. The lack of consideration of family behavior and its impacts led to the creation of a new stream of research: the "New Home Economics" (Becker, Mincer). This latter extends the domain of microeconomic analysis to a wide range of behavior and human interaction, such as demographic behavior, investments in human capital, intergenerational transfers and so on (including the distribution of work and allocation of time in the family).

A decade later, Nerlove (1970), Razin and Ben-Zion (1975) or Srinivasan (1988) link demographic behaviors to macroeconomic evolutions in order to analyze their implications on the general equilibrium[13]. Inspirited by these papers and by the endogenous growth models of Romer (1986, 1990) and Lucas (1988), growth models with explicit microeconomic foundations of family have then progressively been developed (Barro and Becker, 1990; Becker, Murphy and Tamura, 1990; Ehrlich and Lui, 1991; Galor and Weil, 1996; Dahan and Tsiddon, 1998; Iyigun, 2000).

[13] Within the framework of neoclassical growth model with endogenous fertility, the authors attempt to determine the optimal population growth rate.

2.2 Theories of Demographic Transition

From a theoretical point of view, different factors could have triggered a demographic transition, i.e. a period of significant reduction in fertility rates and population growth following the unprecedented increase in population growth.

Theorists have examined a set of plausible explanations being at the root of the demographic transition and the reversal in the relation between income and population growth. Among these potential factors, we came across the decline in child mortality rates leading to a corresponding decrease in total fertility rates. Some researchers (Becker, 1981) argued also that the rise in per capita income had an effect on both the household's income and the opportunity cost of raising children. In both cases, historical (and empirical) evidences contradict these potentialities. First, in Western countries the decline in mortality started a century before the decline in fertility. Secondly, the demographic transition occurs simultaneously across countries that significantly differ in their income per capita.

The gradual rise in the demand for human capital along the process of industrialization has been seen by some researchers as a prime force leading to the onset of the demographic transition, specifically during the second phase of the Industrial Revolution. Taking family as a single decision-maker, Becker models manage to generate the demographic transition but do not differentiate between the behaviors of males and females. Becker *et al.* (1990) study model the relationship between human capital, fertility and economic growth. In this "one sex" model with altruistic parents, higher productivity leads to higher wages and favors human capital accumulation which in turn raises the opportunity cost of children. This feature highlights the existence of two locally stable steady-states: a Malthusian steady-state with many children and little human capital and a steady-state with few children and high human capital (same result in Tamura, 1994). In the interpretation of the model, they consider changes in female labor force as implicit.

The decline in the gender gap is another argument advanced as a reinforcing mechanism impacting fertility rates. Galor and Weil (1996) investigate the relationship between fertility, gender gap in wages and economic growth by assuming explicitly that men and women have different abilities and do different kinds of work. According to Galor and Weil, technological progress and capital accumulation positively impact the relative wages of women along the process of industrialization what increases the opportunity cost of raising children, and

ultimately leads to a reduction in fertility. In a dynamic model with endogenous fertility, Iyigun and Walsh (2007)[14] explain the decline in fertility through the evolution of the spousal bargaining power within the couples' decision-making problem. Similarly, De La Croix and Vander Donckt (2010) employ the notion of intra-household bargaining power (called "welfare weight") and analyze how its variations may affect demographic and economic outcomes.

The progress of neoclassical growth models with endogenous fertility may provide plausible explanations of the modern experience of economic growth in developed economies. Nonetheless, they do not provide a global understanding of the development process as a whole (mysteries persist about some of the most fundamental features of the process of development). This led growth theorists, such as Galor, to point out the importance of a theory that could captures in a single framework the transition from Malthusian stagnation to sustained economic growth, as well as the associated phenomenon of great divergence and demographic transition.

2.3 The Unified Growth Theory

Galor and Weil (1999, 2000) emphasize the existence of three stages within the development process: the Malthusian Era (stagnation), the Post-Malthusian Regime (take-off) and the Modern Growth Regime (sustained growth).

Figure 9 illustrates the evolution of the relationship between the growth rate of GDP per capita and population over the course of human history in Western countries. Three specific eras can be distinguished: the stagnation, the take-off and the sustained growth. During the period of stagnation, population growth was positively affected by the level of income per capita. The absence of significant changes in the level of technology trapped the income per capita around a subsistence level and population size remained relatively stable. As depicted by Maddison's data (2001), the average level of world per capita income fluctuated around $670 per year from 1000 until the end of the 18th century. The monotonic increase in income per capita during the Malthusian era was associated with such a uniform evolution of the average population growth rate in the world while it did not result in variations in the standard of living (Galor, 2011).

[14] In this paper, the authors do not focus on economic development and leave aside the question of how changes in gender heterogeneity may affect long-run growth.

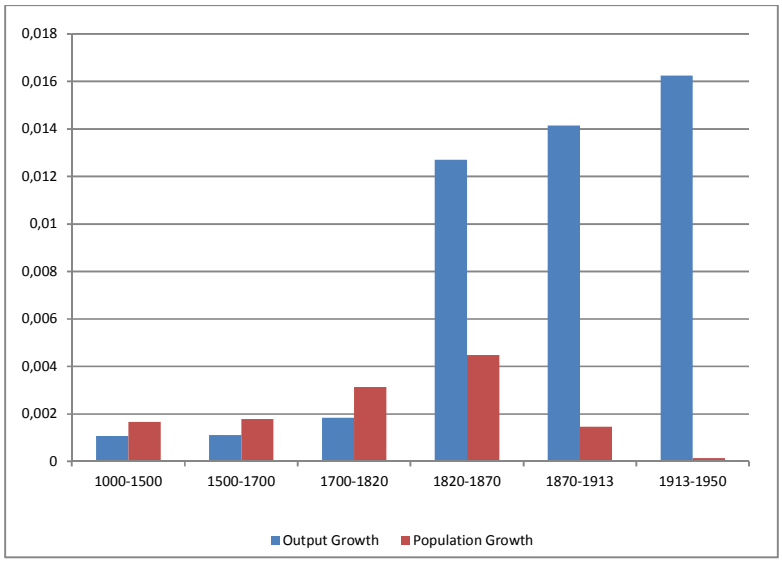

FIGURE 7. THE THREE PHASES OF THE DEVELOPMENT PROCESS, FRANCE

Notes: Data from Maddison (2008).

Over the course of the 18th and 19th Century, Western countries experienced a take-off from Malthusian stagnation with different timings. This shift took place along with the increase in the pace of technological progress and marked the onset of the Industrial Revolution. During this period, income and population growth were still positively correlated. Thereby, the significant increase in the output growth has brought an unprecedented increase in population growth. Based on Maddison's data, the French average growth rate of output per capita increased from 0.17% per year for the period 1500-1820 to 1.30% per year during the period 1820-1870, and 1.20% per year in the years 1870-1913. Similarly, the average rate of population growth in France increased continuously from 1500 to 1870 (0.34% per year in the period 1500-1820, 0.46% per year in the years 1820-1870). At the global level, output growth passed from 0.05% per year for the period 1500-1820 to 0.54% per year during the period 1820-1870, and reached 1.3% per year in the years 1870-1913. On the other side, world population growth increased (continuously as well) from 1500 to 1913: 0.27% per year in the period 1500-1820, 0.4% per year in the years 1820-1870, and to 0.8% per year in the interval 1870-1913. The timing of the take-off then differs across regions. In less

developed countries[15], the take-off occurred progressively with a one-century delay, from the beginning of the 20th century. The decline in population growth marked the end of the so-called Post-Malthusian Regime towards the end of the 19th century in Western countries and in the second half of the century in less developed regions.

The acceleration of the technological progress in the second phase of industrialization (second half of the 19th Century), its interaction with the human capital accumulation and the reversal in the relation between income per capita and population growth signed the transition toward a state of sustained economic growth. The phenomenon of demographic transition occurred in the course of the last century as countries developed along the industrialization. This process accounts for the transition from high birth and death rates to low birth and death rates. In pre-industrial society, both death and birth rates fluctuated around a high level (depending on food supply, diseases, natural events…). During the 19th century in Western countries, mortality rates dropped rapidly while birth rates remained high, involving an increase in population. In the following stage, birth rates fell and population growth began to level off. According to Maddison's data, a reversal in the rate of population growth occurred by the end of the 19th century-beginning of the 20th century for particular regions of the world (Western Europe, Western Offshoots and Eastern Europe). Population growth decreased also in France (from an average of 0.18% of growth per year in the period 1870-1913 to an average of 0.06% per year in the years 1913-1950), while it continued to grow in other parts of the world. At the same time, the world average growth rate of GDP per capita kept on increasing (reaching an average of 2.92% per year on the period 1950-1973).

Galor and Weil (1999, 2000) develop the idea that the acceleration in the rate of technological progress gradually increases the demand for human capital, inducing parents to invest in the quality of their offspring rather than in the quantity. Ultimately, the process of human capital accumulation induces a reduction in fertility rates as far as the growth rate of technological progress increases, what leads to a demographic transition, and sustained growth. The model therefore generates a transition from the Malthusian stagnation to the Modern growth regime. Later on, models incorporating new mechanisms emerge. Galor and Moav (2002) and Lagerlöf (2003) share similar intuitions, by

[15] By less developed countries, we mean Latin America, Asia and Africa.

suggesting the existence of innate/inherited preferences in terms of children quality. Based on a unitary approach of the family, Lagerlöf (2003) explains how high-quality preferences may have spread over time and generate higher prosperity and lower fertility (considering the evolution of gender discrimination in education but without explaining it). In Cervellati and Sunde (2005), the authors introduce complementary mechanisms/channels based on the relations linking life expectancy, human capital and technological progress. However, common to all these models (and to ours) is the central/key role played by the quantity-quality substitution in the phase transition. Empirically, the existence of a negative correlation between education and fertility has notably been demonstrated by Becker, Cinnirella and Woessmann (2011) with county-level evidence for Prussia in 1816.

As highlighted previously (section1), Western countries experienced similar patterns of economic and demographic transition, despite some variations in terms and timing and speed of changes (Galor, 2005b). The trends upheaval strongly question on the possible existence of an interaction between the rise in gender equality, decline in fertility, increase in human capital and the onset of sustained economic growth. Women related issues have become central to the field of labor economics and economic history (Goldin, 2006); nevertheless it remains rare in the field of economic growth. In what follows, we develop mechanisms linking (endogenously) gender equality, human capital and technological progress. Therefore, through the construction of a unified growth model, we emphasize the importance of gender empowerment as a key ingredient of the transition to sustained economic growth.

3. The Model

We consider an overlapping-generations model in which the activity extends over infinite continuous time, denoted by $T \in \mathbb{R}^{+}$. The economy is made up of a discrete number of overlapping generations. In every period, the economy produces a single homogenous good, using efficiency units of labor.

Each generation is populated by two kinds of individuals: males (m) and females (f)[16]. Each males and females are endowed with one unit of time that they split up between market work, education, having and rearing children. In the first period of life, individuals only consume a fraction of parental time endowment. We assume that the time cost of childbearing is greater for women[17], so that $\tau^f \equiv \tau > \tau^m = 0$ (as in Iyigun and Walsh, 2007), with τ the cost of rearing one child. In the second period of life, agents match (randomly) into couples with someone of the opposite sex belonging to the same generation. All adult-members of the households make decisions regarding their own education[18], work and fertility. Each household is therefore composed of several individuals: a man and a woman, with different preferences; and their children. Men and women of generation t face a deterministic level of gender equality θ_t.

3.1 Production

3.1.1 Production of Final Output

The production occurs according to a constant-return-to-scale technology that is subject to endogenous technological progress. The unique consumption good (output) is produced using two factors of production: skilled labor (L^s)[19] and unskilled labor (L^u). The aggregate production function at time t, Y_t, is given by the following CES production function:

$$Y_t = A_t Y(L^u, L^s) = A_t\left[(1-\alpha_t)L_t^{u\rho} + \alpha_t L_t^{s\rho}\right]^{\frac{1}{\rho}}, \tag{3.1}$$

where $\alpha_t \in (0,1)$ is the relative productivity share, $A > 0$ represents the endogenously determined technological level at time t (total factor productivity) and $\rho \in (0,1)$. All factors of production are assumed to earn their marginal

[16] Males and females have the same abilities and preferences (contrary to Galor and Weil, 1996) but differ in terms of time cost of childbearing.

[17] A recent study of the *Observatoire des inégalités* (using the Insee "*Emploi du temps 2009-2010*" survey) shows that women still spend twice more time than men taking care and rearing children.

[18] Contray to most papers with quantity-quality trade-off, in which education is a decision taken by parents (see for example Galor and Moav, 2002 or Lagerlöf, 2003), we consider that educational investments are those of individuals themselves (as in Cervellati and Sunde, 2005).

[19] Skilled labor constitutes adult workers who have invested a fraction of time in schooling when young.

products. The returns from each type of labor at time t, respectively unskilled labor, w_t^u, and skilled labor, w_t^s, are:

$$w_t^u = \frac{\partial Y_t}{\partial L_t^u} = A_t(1-\alpha_t)L_t^{u\rho-1}\left[\alpha_t L_t^{s\rho} + (1-\alpha_t)L_t^{u\rho}\right]^{(1-\rho)/\rho}, \quad (3.2)$$

$$w_t^s = \frac{\partial Y_t}{\partial L_t^s} = A_t(\alpha_t)L_t^{s\rho-1}\left[\alpha_t L_t^{s\rho} + (1-\alpha_t)L_t^{u\rho}\right]^{1-\rho/\rho}, \quad (.33)$$

3.1.2 The Production of Human Capital

Human capital can be defined as the stock of (accumulated) knowledge, skills, competencies, attributes embodied in people that improve their ability to perform labor so as to produce economic value. The benefit from embodying additional knowledge in a person may depend positively on the knowledge he or she already has (Becker, Murphy and Tamura, 1990). In order to earn an income y_t^i and to consume, individuals have to acquire human capital and supplied this human capital to the labor market. The acquisition of human capital requires time. We model the production of human capital as the outcome of an education process involving decisions of parental (maternal) investments in education and of individuals themselves in their own education.

At birth, every individual is endowed with a certain amount of incorporated form of cultural capital, $h_{t-1} \in [0,1]$. This cultural capital is characterized by a set of intellectual qualifications resulting from family environment, and more specifically from parental endowment in human capital. Human capital can be accumulated over time through the education process (that is the institutionalized form of human capital). The effect of parental human capital is reflected by the higher productivity of the share of time unit spent by children in education. The amount of human capital acquired throughout the education process depends therefore on parental endowment in human capital. The larger the human capital embodied in parents (h_{t-1}^i), the larger the effectiveness of the education process, and the larger the impact on resulting human capital (h_t^i).

We assume that the time cost of childbearing is greater for women so that $\tau^f \equiv \tau > \tau^m = 0$, with τ the cost of rearing one child. Therefore, it results that the human capital of each child depends on the incorporated form of human

capital of its mother (maternal endowment in human capital) rather than of its father.

We denote e_t^i the amount of time invested by an individual in his own education in either type of human capital, $i = u, s$, unskilled or skilled[20]. The education process differs between these two types of human capital with respect to the time intensity of the education process. There exists a fix cost $\underline{e}$ (in terms of time units) that agents need to pay when acquiring human capital[21]. The acquisition of skilled human capital involves a larger fix cost of education than the acquisition of unskilled human capital, $\underline{e}^s > \underline{e}^u$. As a consequence, the number of year spent working is also lower for a skilled individual. We assume that cultural capital (maternal endowment in human capital) is more important when acquiring advanced skills. For simplicity, we assume that $h_{t-1}^{f,s} = \hbar$ and $h_{t-1}^{f,u} = 1$.

The human capital production function can be written as follows:

$$h_t^i = \beta^i \left(e_t^i - \underline{e}^i\right)\left[h_{t-1}^{f,i}\right], \tag{3.4}$$

with $\forall e \geq \underline{e}^i$; $i = u, s$ and β, the productivity of a unit of education.

An individual that have received an inherited human capital of type i and acquired human capital by investing e_t^i in education of type i can earn the lifetime income $z_t^i(\hbar)$, such that :

$$z_t^i \equiv z_t^i\left(\hbar, e_t^i\right) = w_t h_t^i\left(\hbar, e_t^i\right)\left[1 - e_t^i\right], \tag{3.5}$$

The lifetime income results from supplying human capital on the labor market, itself function of maternal human capital. A World Development Report already emphasized in 1993 the importance of women's income on children welfare. The report highlights a stronger effect of the income of mothers on the welfare of children than does an increase in the husbands' income. The concept of human capital (quality) in addition to abilities, competencies or knowledge embodied in individuals also includes health. Educational investment is a source of labor productivity that positively impact wages. Through this channel, it is very likely

[20] Galor and Moav (2002) already introduced two types of individuals: a quality type, *a*, and a quantity type, *b*, of adult individuals, as a determinant of offspring's quality.

[21] Such as in Cervellati and Sunde (2007).

that women education also have a stronger effect on children's health than do men education (see Currie and Moretti, 2003).

3.1.3 Technological Progress

The technology evolves endogenously. Technological progress is assumed to raise the value of education in the production of human capital[22]. According to Lucas (1988) and Romer (1990), human capital accumulation is an engine of growth. It occurs through the acquisition of education and training which increases the skills and the productivity of the labor force (and promotes the adoption of new ideas and technologies). This implies that technological progress is biased toward high-skill intensive production and depends on the stock of human capital available in the economy. The arrival of new technologies involves larger factor productivity.

$$g_t = \frac{A_t - A_{t-1}}{A_{t-1}} = F(\Lambda_{t-1}, A_{t-1}), \tag{3.6}$$

The more individuals of a generation invest in skilled education, the more effective is the accumulation of skilled human capital for future generations.

3.2 Individuals

The members of generation *t* lives for two periods: childhood and adulthood. In the first period of life, individuals are children. They consume a fraction of the parental time endowment. We assume that individuals make no decisions during childhood but they receive parental education. In the second period of life (adulthood), individuals make decisions regarding their own education and fertility (time invested in having and rearing children). The remaining period of time is spent on the labor market (either as skilled or unskilled worker).

As already stated previously, agents of both genders are assumed to be identical except in their time constraint, in that only women endorse the time cost of childbearing. In the model, women decide endogenously what portion of their lifetime to devote to child rearing. Throughout their strategies of life, females

[22] Technological progress reduces the adaptability of existing human capital for the new technological environment. Education lessens the adverse effect of technological progress.

choose the optimal mixture of quantity and quality of children[23] and allocate the rest of their time working on the labor market and consuming their wage. The number of efficiency units of labor is therefore determined by individuals regarding their level of human capital, and number of children.

3.2.1 Preferences and Budget Constraint

Multi-person Dimension Household. – We assume that all individuals get married in the second period of life. The utility function captures the two-sex dimension of the household. Individuals care about their own consumption and about the potential lifetime income of their children[24]. Household preferences are represented by the following *weighted* utility function, which is monotonically increasing, concave and satisfies the standard boundary conditions insuring interior solutions,

$$U\left(c_t^m, c_t^f, y_{t+1} n_t^i\right) = (1-\theta_t) ln c_t^m + \theta_t ln c_t^f + \gamma ln\left(z_{t+1}^i n_t^i\right), \tag{3.7}$$

where c_t^f and c_t^m represent respectively the consumption level of the female (wife) and of the male (husband), n_t^i is the total number of children of the couple, z_{t+1}^i denotes the lifetime income of children[25], $\gamma \in (0,1)$ measures the value attached to the number of offspring relative to the labor-force participation and θ_t represents the female bargaining power within the household decision process.

The bargaining power of the wife in the household decision process is endogenous and assumed to be a function of human capital stock of the spouses. It shows how human capital affects the bargaining power of the female in the decision process. This parameter can be interpreted as a measure of gender equality within the household and is given by:

$$\theta_t = \frac{w_t^f h_t^f}{w_t^f h_t^f + w_t^m h_t^m} \equiv \varphi(h_t^f, h_t^m), \tag{3.8}$$

[23] We will talk here about fertility as quantity and human capital as quality.

[24] The utility function reflects the trade-off between the resources devoted to own consumption and to raise children.

[25] This generates a link between generations (altruistic preferences).

with h_t^f and h_t^m, respectively, the female and male endowment in human capital. $\theta_t \in (0,1)$, $\theta_t = 0$ implies total decision-making power for the husband within the household, $\theta_t = 1$ total power for the wife and $\theta_t = 0$ characterizes a perfect equality within the couple (the perfect equality between spouses is reflected by $\theta_t = 1/2$).

Budget Constraint. – Individuals consume according to the time spent on the market. For women, investment in own education and raising children represent costs in terms of time, time which is not available for market work. Let $\tau n_t^i + e_t^{f,i}$ be the time cost for a female member of generation t of raising a children, getting a level of education e_t^i of type i. Thereby, the time spent by women on the labor market is what remains after investing in education and raising children. Men only face a cost of time in terms of education. The time spent by men on the labor market is what remains after getting educated. Let $e_t^{m,i}$ be the time cost for a male member of generation t of getting a level of education e_t^i of type i. The potential income of men and women is allocated to the consumption, respectively c_t^m and c_t^f. Wife and husband jointly face the following budget constraint, integrating individual time constraints:

$$c_t^m + c_t^f \leq \left(1 - \tau n_t^i - e_t^{f,i}\right) w_t^{f,i} h_t^{f,i}(\cdot) + \left(1 - e_t^{m,i}\right) w_t^{m,i} h_t^{m,i}(\cdot), \quad (3.9)$$

Similarly to Becker (1960), Barro and Becker (1989) and Galor and Weil (2000), our model integrates quantity-quality considerations as the household chooses the number of children and their quality, regarding the constraint on the total amount of time individuals can devote to raise children and to work on the labor market. However, unlike existing models, the trade-off relies here on females' decisions making in the face of the trade-off between fertility and own investment in education.

3.2.2 The Household Choice Problem

Optimization Problem. – Members of a household of generation t have to choose the type of human capital (through educational investments) they want to acquire,

the number of offspring and their own consumption. In period t, the household solves the following optimization program:

(3.10) $$\{e_t^{fi*}, e_t^{mi*}, n_t^{i*}, c_t^{f*}, c_t^{m*}\} = \text{argmax}\, U_t(c_t^{f*}, c_t^{m*}, y_{t+1}^i n_t^i)$$

subject to:

$$c_t^m + c_t^f \leq (1 - \tau n_t^i - e_t^{f,i}) w_t^{f,i} h_t^{f,i} + (1 - e_t^{m,i}) w_t^{m,i} h_t^{m,i},$$
(4) and (5) for $i = u, s$

We derive the optimal choice and we get the following set of first order conditions with respect to the spousal consumption levels, optimal fertility and optimal investment in education, conditional to the acquisition of a particular type of human capital, i, given by:

(3.11) $$c_t^m = (1 - \theta_t)\left[(1 - \tau n_t^i - e_t^{f,i}) w_t^{f,i} h_t^{f,i} + (1 - e_t^{m,i}) w_t^{m,i} h_t^{m,i}\right],$$

(3.12) $$c_t^f = \theta_t\left[(1 - \tau n_t^i - e_t^{f,i}) w_t^{f,i} h_t^{f,i} + (1 - e_t^{m,i}) w_t^{m,i} h_t^{m,i}\right],$$

(3.13) $$e_t^{m,i} = \frac{1 + \underline{e}^i}{2},$$

(3.14) $$e_t^{f,i} = \frac{1 + \underline{e}^i - \tau n_t^i}{2},$$

(3.15) $$n_t^i = \frac{\gamma}{(1-\theta_t)} \frac{c_t^m}{\tau w_t^{f,i} h_t^{f,i}},$$

The first order conditions illustrate that the consumption levels of the husband and the wife are proportional. Everything else equal that: the trade-off faced by women between acquisition of own human capital and fertility implies that the optimal number of children is decreasing with the time invested by women in education. Thereby, having more children decreases the time invested in own education for women. In addition, a higher fix cost of education with the acquisition of skilled human capital requires a larger time investment in education.

Optimal Solutions. – The household optimal choices of c^f, c^m, n, e^f, e^m conditional to the type human capital acquired is obtained solving the system of equation. We can establish that:

Consumption levels of the husband and the wife are proportional and depend on the bargaining power distribution within the household.

(3.16) $$c_t^{m*} = \frac{(1-\theta_t)(1-\underline{e}^i)}{(2+\gamma)}(w_t^{f,i}h_t^{f,i} + w_t^{m,i}h_t^{m,i}),$$

(3.17) $$c_t^{f*} = \frac{\theta_t(1-\underline{e}^i)}{(2+\gamma)}(w_t^{f,i}h_t^{f,i} + w_t^{m,i}h_t^{m,i}),$$

The female optimal consumption is increasing with the female marital bargaining power. On the contrary, the male optimal consumption is decreasing with the female bargaining power. Each spouses contributes to a fraction of the household labor earning according to the value of the parameter θ_t. In other words, the distribution of the consumption between spouses is function of the level of gender equality within the household.

At the extreme case $\theta_t = 0$, for instance, the husband contributes fully to the household labor earnings; There is a strong gender gap between spouses. In the opposite case, since $\theta_t = 1/2$ – there is perfect gender equality, both spouses contribute equitably to the household labor earnings.

Educational optimal choices for both member of the household are given by the following equations:

(3.18) $$e_t^{m*} = \frac{1+\underline{e}^i}{2},$$

(3.19) $$e_t^{f*} = \frac{(1+\underline{e}^i)}{2} - \frac{\gamma(1-\underline{e}^i)}{2\theta_t(2+\gamma)} = e_t^{m*} - \frac{\gamma(1-\underline{e}^i)}{2\theta_t(2+\gamma)},$$

Male optimal level of education is function of the fix time cost of education. A higher cost of education in terms of time units requires a larger time investment in education. The optimal female education displays a similar positive impact of the educational cost on the amount of time invested in education. In addition, female

optimal education is increasing with the female marital bargaining power. Stronger is the power of the wife within the household, higher is the time she invests in education.

The household optimal fertility is given by:

$$n_t^{i*} = \frac{\gamma(1-\underline{e}^i)}{\tau(2+\gamma)} \frac{\left(w_t^{f,i} h_t^{f,i} + w_t^{m,i} h_t^{m,i}\right)}{w_t^{f,i} h_t^{f,i}} \equiv \frac{\gamma(1-\underline{e}^i)}{\theta_t \tau(2+\gamma)}, \tag{3.20}$$

The inspection of the optimal fertility choice of the household highlights the central role played by the wife within the household decision-making. The optimal fertility is decreasing with the female marital bargaining power. Lower is the bargaining power (*male-breadwinner model*) of the wife within the household, higher is the number of offspring. Inversely, higher is the gender equality (*dual-earning model*), lower is the optimal number of children. Furthermore, we note from the equation (3.20) the existence of a negative relationship between quantity and quality of children. The fix cost of education impacts negatively the optimal number of children.

3.2.3 Choice of Human Capital and Fertility

We consider two types of human capital: the skilled and the unskilled human capital. The choice between each type of human capital depends partly on the level of wages (so as on returns from education, technology). The approach used in what follows shares similarities with Galor and Moav (2002) and Cervellati and Sunde (2007). Substituting $e_t^{m,s*}$ and $e_t^{m,u*}$; as well as $e_t^{f,s*}$ and $e_t^{f,u*}$ in the expression of the human capital production function, we obtain the respective male and female levels of human capital:

$$h_t^{m,i*}(\hbar) = \beta^i \frac{(1-\underline{e}^i)}{2} h_{t-1}^{f,i}, \tag{3.21}$$

$$h_t^{f,i*}(\hbar) = \beta^i \frac{(1-\underline{e}^i)}{2} \left(1 - \frac{\gamma}{\theta(2+\gamma)}\right) h_{t-1}^{f,i}, \tag{3.22}$$

For any male and female endowed with parental (maternal) human capital, $\hbar$, there exists unique levels of education $e_t^{m,i*}$ and $e_t^{f,i*}$, and level of fertility n_t^{i*} maximizing their utility, conditional to the type of human capital acquired. Individuals with higher maternal human capital have a comparative advantage in acquiring skilled human capital. Therefore, the amount of individuals endowed with skilled type of human capital increases in $\hbar$. On the contrary, unskilled human capital does not depend on parental human capital. There exist a unique threshold of parental human capital, $\hat{\hbar}_t$, such that individuals are indifferent between acquiring skilled or unskilled type of human capital (equalizes their utility).

$$\hat{\hbar}_t = \beta \frac{w_t^u}{w_t^s} \left(\frac{1-\underline{e}^u}{1-\underline{e}^s} \right)^{2+\gamma}, \tag{3.23}$$

For a given distribution of parental human capital $d(\hbar)$[26], the threshold $\hat{\hbar}$ determines the fraction of individuals that choose to acquire skilled human capital. This threshold is a monotonically increasing function of the relative wage between unskilled and skilled human capital, (w_t^u / w_t^s).

$$(1 - \Lambda_t) = \int_0^{\hat{\hbar}} d(\hbar) d\hbar = \hat{\hbar} \text{ and } \Lambda_t = \int_{\hat{\hbar}}^1 d(\hbar) d\hbar = (1 - \hat{\hbar}), \tag{3.24}$$

Thereby, all agents with $\hbar > \hat{\hbar}$ acquire skilled human capital (a fraction Λ_t of the population) while all agents with $\hbar < \hat{\hbar}$ acquire unskilled human capital (a fraction $1 - \Lambda_t$ of the population). Higher is the skilled wage, lower is the relative wage and bigger is the fraction of people acquiring skilled human capital. For any level of parental human capital there is a unique optimal level of education and level of fertility which maximize the utility function. According to equation (3.29) and (3.30), the acquisition of skilled rather than unskilled human capital induces individuals to spend more time on education $(e_t^{s*} > e_t^{u*})$ and to have a lower number of children $(n_t^{s*} < n_t^{u*})$. The difference of fertility obtained according to the type of education is one of the most (if not the most) fundamental ingredient in the model.

[26] $d(\hbar)$ denotes the distribution of "cultural capital" within a given generation of new individuals.

The maternal human capital is conditional to education and fertility choices which depend on *cultural* and technological environment. One of the key determinants of educational investments is the rate of technological progress. Through this channel, the rate of technological change affects gender roles by increasing female marital bargaining power (what drives to higher equality between men and women).

Choices of human capital type and optimal fertility are function of the time spent by individuals in education. The acquisition of skilled rather than unskilled human capital induces individuals to spend more time on skilled education and to have a lower number of children. Inversely, individuals choosing to invest in unskilled education have a higher number of children. Differential fertility emerges since the acquisition of skilled human capital induces girls to substitute utility from number of children with utility from consumption. Ultimately, this mechanism drives to a fertility transition.

The threshold level of parental human capital making an individual indifferent between acquiring skilled or unskilled human capital, $\hat{\hbar}_t$, is decreasing in gender equality θ. It induces a larger share of the population to optimally acquire formal education Λ_t. Any change in the fraction of individuals acquiring skilled and unskilled human capital (skill composition of the population, Λ_t) impacts the average fertility of the population. For any $\{A_t, \theta_t, g_t\}$, the average fertility is given by the following equation:

$$n_t^{i*} = (1-\Lambda_t)n_t^u + \Lambda_t n_t^s \equiv \frac{\gamma}{(2+\gamma)} \frac{\left(1-\underline{e}^u(1-\Lambda_t)-\Lambda_t \underline{e}^s\right)}{\tau\theta_t}, \tag{3.25}$$

with $\frac{\partial n_t^*}{\partial \theta_t} < 0$.

Gender equality is a key determinant of the average fertility. The fertility rate is negatively correlated with the level of gender equality within the population. Improvements in θ induce more people to acquire education (especially girls). Henceforth, improvements in gender equality induce a generalized decline in fertility. An economy with lower gender equality is characterized by lower fertility rate. Gender equality in the form of female marital bargaining power affects fertility by inducing a change in the female optimal choice of education time and in the type of education. Finally, an increase in female human capital is

associated with reduction of the number of children and an increase in their quality. Associated together, the different effects of technological progress and gender equality can account for the demographic and the economic transition, such that fertility decreases, education expands and growth reaches a sustained level.

3.3 Distribution of Labor Types

The aggregate levels of each type of human capital are given by:

$$L_t^u = H_t^u\left(\hat{\hbar}\right) = N_t \int_0^{\hat{\hbar}} h_t^u\left(\hat{\hbar}\right) d(\hbar) d\hbar, \tag{3.26}$$

$$L_t^s = H_t^s\left(\hat{\hbar}\right) = N_t \int_{\hat{\hbar}}^1 h_t^s\left(\hat{\hbar}\right) d(\hbar) d\hbar, \tag{3.27}$$

There exists a unique threshold of "cultural capital" (derived from maternal endowment in human capital) that splits the population between individuals acquiring skilled and unskilled human capital. From (2) and (3), we determine the unskilled-to-skilled wage rates on competitive markets.

$$\frac{w_t^u}{w_t^s} = \frac{1-\alpha_t}{\alpha_t}\left(\frac{L_t^u}{L_t^s}\right)^{\rho-1}, \tag{3.28}$$

The wage rates ratio depends itself on the ratio of the aggregate level of unskilled and skilled human capital.

4. The Dynamic Evolution of the Economy

4.1 Dynamic Evolution of the Key Variables

The evolution of the economy is characterized by demographic and economic transitions. In particular, the development of the economy is characterized by the evolution of educated people, technological level and gender equality. The global dynamics of the economy is described by the trajectory of gender equality θ_t, the

share of the population acquiring skilled human capital Λ_t and the total factor productivity. We can study the dynamic development of the economic by analyzing the evolution of the key state variables over generations. The evolution of the economy is fully described by a sequence $\{\Lambda_t, \theta_t, \alpha_t\}_{t=0}^{\infty}$, resulting from the evolution of the three-dimensional nonlinear first-order system.

4.1.1 The Fraction of Skilled Individuals

The equilibrium fraction of the population acquiring human capital is monotonically increasing in θ_t. The higher the gender equality, the more people invest in the acquisition of skilled human capital. Intuitively, for low levels of gender equality the fraction of skilled individuals is small. There is no accumulation of human capital and the returns from investing in skilled education do not worth the effort. Very large improvements in gender equality are necessary to make individual invest in skilled education and then to allow for human capital accumulation. The equilibrium fraction of the population acquiring human capital also depends on the technological environment – is increasing in the relative productivity of skilled human capital intensive sector, α_t. The labor market condition equilibrium is given by:

$$\Lambda_t = \boldsymbol{\Lambda}(\theta_t, \alpha_t), \tag{4.1}$$

which is an increasing and S-shaped function of θ_t.

4.1.2 Dynamic Evolution of Gender Equality

Based on historical evidence, we suggest that gender equality is function of the stock of skilled human capital of spouses (measuring human capital on the bargaining power distribution), such that gender equality increases with individuals human capital. In particular, gender equality is linked with the distribution of knowledge embodied in individuals in the previous generation, $t-1$ (function of the average stock of female skilled human capital), through the time invested in skilled education (e_{t-1}^{S}). The dynamic evolution of gender equality can be expressed as:

(4.2) $$\theta_t = \boldsymbol{\Theta}(\theta_{t-1}, \Lambda_{t-1}),$$

This expression involves that gender equality is increasing with the share of individuals (within the parental generation) acquiring skilled human capital.

4.1.3 Process of Technological Process

The process of technological change depends on the stock of skilled human capital (biased toward skill-intensive sector of production). The available stock of human capital in a generation t makes human capital more profitable to acquire for future generations. The dynamic evolution of technological progress is given by:

(4.3) $$g_t = \boldsymbol{G}(\Lambda_{t-1}, A_{t-1}),$$

which implies that the productivity A_t increases with the aggregate level of skilled human capital of a generation using the previous technology available in the economy. This level of technology is then function of the fraction of skilled people in the parent generation, as well as the level of productivity achieved in $t-1$.

4.2 The Dynamical System

In order to characterize the dynamic development of the economy, we study the trajectory of three key variables over generations. The path of the economy is entirely described by the sequence $\{\Lambda_t, \theta_t, \alpha_t\}_{t=0}^{\infty}$, according to the evolution of the nonlinear first-order dynamic system of equations:

(4.4) $$\begin{cases} \Lambda_t = \boldsymbol{\Lambda}(\theta_t, \alpha_t) \\ \theta_t = \boldsymbol{\Theta}(\theta_{t-1}, \Lambda_{t-1}) \\ g_t = \boldsymbol{G}(\Lambda_{t-1}, \alpha_{t-1}) \end{cases},$$

The dynamic path of Λ, θ and α describes the joint evolution of the share of individual acquiring skilled education, gender equality and the relative

productivity share (of each type of labor), given initial conditions Λ_0, θ_0 and α_0. The dynamic path does not depend on population size (no scale effect). We focus on the sub-system of equations, conditional on the value of the productivity share, α_t, in order to illustrate the development dynamics. It results from the labor market equilibrium and the intergenerational externality on gender equality:

$$\begin{cases} \Lambda_t = \boldsymbol{\Lambda}(\theta_t, \alpha_t) \\ \theta_t = \boldsymbol{\Theta}(\theta_{t-1}, \Lambda_{t-1}) \end{cases}, \tag{4.5}$$

The system delivers the dynamics of human capital formation and gender equality for a given relative productivity share $\alpha > 0$. Any steady-state of the sub-system of equation is characterized by the intersection of $\boldsymbol{\Lambda}$ and $\boldsymbol{\Theta}$.

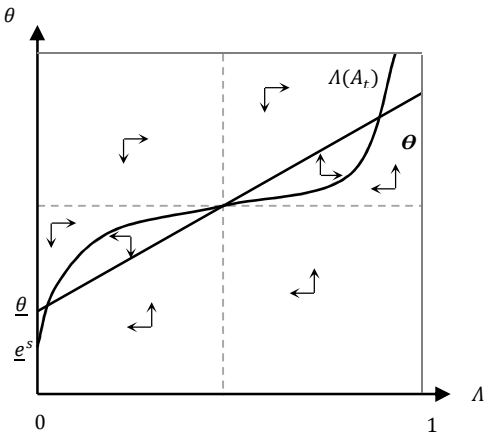

FIGURE 8. THE CONDITIONAL DYNAMIC SYSTEM

Given the non-linearity of $\boldsymbol{\Lambda}$ (S-shape trajectory), the dynamic sub-system is characterized by three different configurations that exhibit from one to three steady-state equilibria (see Figure 8 for the latter case). There are two stable and one unstable steady-state. The low steady state equilibrium is characterized by low gender equality and a small share of population acquiring skilled human capital. On the opposite, the high steady-state equilibrium is characterized by high gender equality and a relatively large fraction of population acquiring skilled human capital. Figure… illustrates the system under the existence of three steady-state equilibria. The state of the value of the productivity affects the relative

returns from skilled human capital. A higher productivity, A, increases the returns to skilled human capital and the associated equilibrium fraction of individuals, Λ.

4.3 The Global Dynamics of Development

The evolution of the economy has to account for the evolution of all state variables. We focus here on the entire path of development: from stagnation to sustained growth. Then, how can economies move from the Malthusian trap of stagnation (with high fertility) to an era of sustained growth (with low fertility)?

We emphasize the existence of three main stages of development: the early stage of development ("*Non-developed economy*"), the transitory stage – toward the development ("*Transitory economy*") and the final stage of development ("*Developed economy*").

4.3.1 Non-Developed Economy

Non-developed economies are characterized by low gender equality $\underline{\theta}$ (close to its minimum) and low value of productivity A_0 (initial level). According to these conditions, investing in skilled human capital is costly for a large majority of the population. Thereby, the fraction of individuals acquiring skilled human capital Λ is very low. The corresponding average fertility reflects those of individuals acquiring unskilled human capital (high fertility).

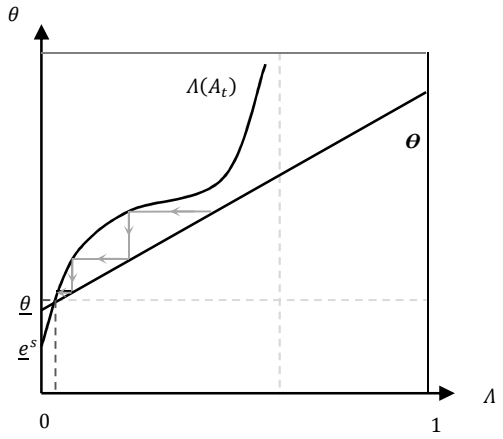

FIGURE 9. THE EARLY STAGE OF THE PROCESS OF DEVELOPMENT

Graphically, every intersection of the locus $\boldsymbol{\Theta}$ and $\boldsymbol{\Lambda}$ represents an equilibrium. With initial low level of gender equality and low changes in technological progress, the dynamic system exhibits a unique globally stable steady-state equilibrium.

In a non-developed economy, gender equality and technological progress are close to their minimum, $\theta_0 \simeq \underline{\theta}$ and $A_0 \simeq 0$. The conditional system exhibits a unique steady state with few individuals acquiring skilled human capital h^s, $\Lambda_0 \simeq 0$, and with large fertility rates.

(4.6) $$n \simeq \frac{\gamma}{\underline{\theta}(2+\gamma)} \frac{(1-e^u)}{\tau},$$

At this stage of development, the economy is characterized by an extended phase with low living standards, low gender equality and large fertility.

4.3.2 Transitory Economy

As emphasized previously, Western countries experienced both an economic and a demographic transition. This transition account for a switchover from an environment characterized by low income per capita, low investments in education and high fertility to economy characterized by high living standards, a high share of the population investing in education and low number of children per women. Endogenous skill biased technological change leads to a monotonic increase in the importance of skilled human capital for production (by reinforcing the adoption of new ideas and technologies). Therefore, as generations pass, productivity growth makes investing in skilled education more profitable. However, as long as a certain level of gender equality is not reached, the process of human capital accumulation cannot start.

Graphically, productivity growth increases the convex part of the curve $\boldsymbol{\Lambda}$. The dynamic equilibrium moves along $\boldsymbol{\Theta}$ triggering improvements in gender equality. Fertility remains high since the fraction of skilled individual is low. $\boldsymbol{\Lambda}$ slowly shifts downwards and after sufficiently many generations $\boldsymbol{\Lambda}$ exhibits three intersections with $\boldsymbol{\Theta}$, that is multiple equilibria: two locally stable steady-states

and an interior unstable steady-state. In the absence of large shocks, the economy remains at the low steady-state equilibrium.

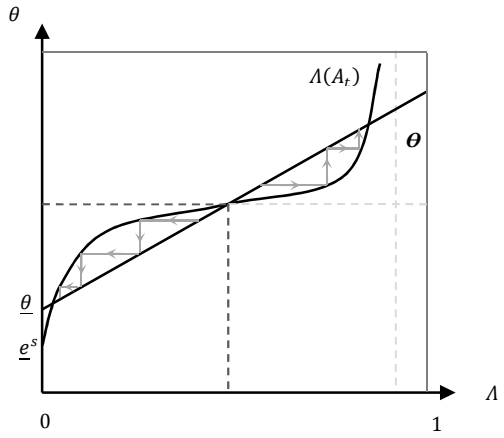

FIGURE 10. THE TRANSITORY STAGE OF THE PROCESS OF DEVELOPMENT

During this stage of development, the economy experiences increases in θ_t, Λ_t, income per capita (y_t) and technological level A_t. At this transitory stage of development, the economy is characterized by improvements in living standards, low gender equality and large fertility.

4.3.3 Developed Economy

In contrast to early stages of development, mature stages of development are characterized by advanced technology and high living standard. Gender equality is high, close to its maximum $\overline{\theta}$. Given these characteristics, investing in skilled human capital is much cheaper than in less advanced economy. As a consequence, the very large majority of the population acquires skilled human capital. Thereby, the fraction of individuals acquiring skilled human capital Λ is very high. The corresponding average fertility reflects those of individuals acquiring unskilled human capital (low fertility).

In other words, the reach of a specific threshold in gender empowerment engages the process of human capital accumulation. Due to larger educational investments (in terms of time units), the female opportunity cost of having children increases and average fertility declines. Accordingly, households have

fewer children but each of them is endowed with a higher quality of parental human capital – what *de facto* increases the ability of children to succeed in education and allow them to become in turn skilled individuals. From generations to generations, the fraction of skilled individuals increases and generates a positive feedback loop, impacting positively the rate of technological progress and the value of productivity. Ultimately, the economy experiences both a demographic and economic transition driven by improvements in gender equality.

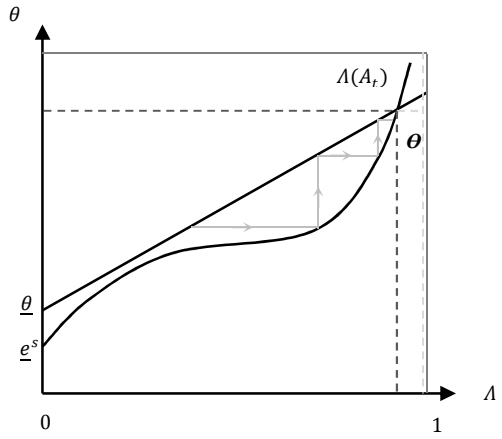

FIGURE 11. THE LATE STAGE OF THE PROCESS OF DEVELOPMENT

Graphically, as $\boldsymbol{\theta}$ and $\boldsymbol{\Lambda}$ shift downwards, the dynamic equilibrium exhibits a unique globally stable steady-state (a single intersection between the two curves). Once gender equality growth to a high level, $\overline{\theta}$, a substantially large fraction of the population decide to acquire skilled human capital. Therefore, it triggers to a period of rapid development (transition in living conditions) and the economy converges to the globally stable steady-state.

In a developed economy, with $A_0 \simeq 1$, the conditional system exhibits a unique steady state where almost all the population acquire skilled human capital, $\Lambda \simeq 1$; gender equality is high $\theta \simeq \overline{\theta}$ and fertility rates are low,

$$n \simeq \frac{\gamma}{\overline{\theta}(2+\gamma)} \frac{(1-e^s)}{\tau}, \tag{4.7}$$

At this mature stage of development, the economy is characterized by an extended phase with high living standards, high gender equality and low fertility.

The development process is therefore characterized by the evolution of economies from an era of stagnation to the demographic transition and the Modern Growth through the post-Malthusian Regime (such as in Galor and Moav, 2002). Our model provides a new approach (complementary to existing unified models, and notably those of Galor) with new mechanisms and new answers on how economies managed to escape the Malthusian trap to reach a state of sustained growth and to experience a demographic transition. In our model, the prime driving forces in this transition emerge from gender empowerment, as depicted by the phase diagrams (Figure 9 to 11).

The rise in the rate of technological progress (through the emergence of new technologies) during the process of industrialization increased the demand for human capital and together raised the level of gender equality. Gender empowerment induces changes in gender relations. This gave greater opportunities for women to have access to higher education. Therefore, investing in education increases the opportunity cost of having children and implies for women to face a trade-off between education and fertility (professional versus family sphere). This is the so-called quantity-quality (Q-Q) trade-off[27]. This process ultimately triggers to the demographic transition.

5. Empirical Validations

Empirical evidence of the relation linking the quantity and the quality of children is still scarce and does not bring yet clear conclusions. In this section, we estimate the long-run relationship between education and fertility behavior during the French demographic transition (in 19th century), from a gendered perspective.

[27] Becker (1960) was the first to introduce the distinction between child quantity and child quality, followed by Becker and Lewis (1973) and Willis (1973).

5.1 A County-level Database for France in 1851

We consider the relation between child quantity-quality trade-off for 19th century France. We use regional data collected from diverse publications of the *Service de la Statistique Générale de la France.* Our dataset covers information about aggregated individual-level behavior for 86 French counties[28] (*départements*). At the dawn of the nineteenth century, France was the largest European country with about 29.4 million inhabitants. The French Statistical Office publishes data from 1800. Nevertheless, it is from 1851 that published data rank population by age, gender, marital status and other essential information to study the evolution of fertility behavior and habits regarding education.

The major part of the dataset is constructed from General Censuses, Statistics of Primary Education, Population Movement and Industrial Statistics conducted in 1851 (1850 for Education, 1861 for Industrial Statistics). The rest of the data stems from diverse sources. A part of fertility data was available from the Princeton European Fertility Project (Coale and Watkins, 1986), while data on migration and life expectancy at birth come from Bonneuil (1997). A combined use of the various Censuses allows us to construct a dataset with detailed information on fertility, mortality, literacy rates, enrollment rates in primary schools for both boys and girls, employment in industry and agriculture by gender, level of urbanization and stage of industrialization[29]. In addition, we use data from French Censuses for the years 1821, 1835, 1861, 1881 and 1911 to get more demographic and socio-economic information necessary to carry out our analysis.

We use the crude birth rate as measure of fertility, which is defined as the number of births[30] per 1000 inhabitants. We also use one measure of education for both boys and girls: the enrollment rates in public primary school in 1850, defined as the number of children attending school divided by the number of children aged 6-14.

[28] 1851 France consists of current metropolitan French *départements* ; except Alpes-Maritimes, Savoie and Haute-Savoie.

[29] To our knowledge, these data have not yet been used for micro-econometric analysis.

[30] As specify by BCW (2010), children aged 0-5 allows to capture surviving children (Galor 2005b).

TABLE 1
SUMMARY STATISTICS

	Mean	Std. Dev.	Min	Max
Crude birth rate	26.95	3.597	18.717	34.275
Boys enrollment rate	0.544	0.211	0.188	1.059
Girls enrollment rate	0.356	0.259	0.003	0.997
Female in industry	0.036	0.070	0	0.552
Female in agriculture	0.615	0.179	0.037	1.054
Male in industry	0.057	0.081	0	0.636
Male in agriculture	0.737	0.171	0.046	1.135
Urbanization	0.059	0.083	0.007	0.736
Population density (km²)	1.011	3.166	0.219	29.907
Life expectancy at age 0	38.792	6.115	25.8	50.8
Share Protestants (1861)	2.258	5.332	0.003	31.298
Crude birth rate (1881)	0.024	0.004	0.017	0.035
Crude birth rate (1881-1911)	-0.245	0.092	-0.405	-0.002
Marital fertility rate (1881)	0.473	0.130	0.266	0.819
Marital fertility rate (1881-1911)	-0.290	0.091	-0.476	0
Boys enrollment (1851-67)	0.600	0.342	-0.076	1.624
Girls enrollment (1851-67)	1.067	1.962	0.017	17.485
Male literacy (1856-66)	0.113	0.092	-0.093	0.358
Female literacy (1856-66)	0.271	0.213	-0.085	0.956

Sources: Data for 86 counties from the French Censuses and demographic data for different years; See Appendix for details.

Table 1 reports descriptive statistics of the variable used in our analysis. In 1816, the literacy rate was about 51% for males and 30% for females on average. In 1851, 54.5% of boys aged 6-14 were enrolled in public primary school, while the enrollment rate in public primary school for girls was 36%. Yet, there is a strong heterogeneity in education across counties. It goes from a minimum of about 19% to a maximum of 105%[31] for boys and from 0.3% to 99% for girls . These variations can be explained by several factors: diffusion of the official French language, difference in attitudes toward education between Catholics and Protestants (Becker and Woessmann, 2009), wave of spreading ideas coming from Prussia (Luther), insufficiency of educational resources deployed in rural areas (in terms of teachers, financial spending).

[31] This is due to the possibility that children below 6 years old and above 14 years old might have been enrolled in public primary schools.

5.2 Empirical Model

We investigate the long-run effects of investments in human capital on fertility by estimating the impact of changes in literacy rates between 1856 and 1866 (as a measure of variations in human capital) on the decline in crude birth rate at the turn of the 20th century in France.

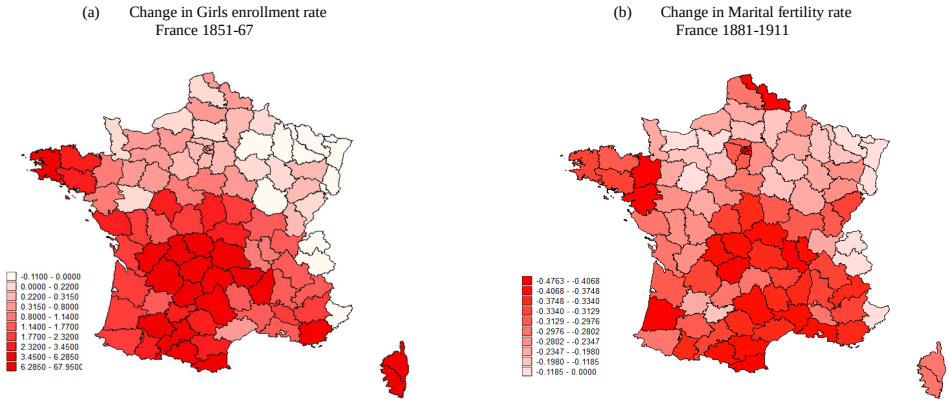

FIGURE 8. GEOGRAPHICAL DISTRIBUTION, FRANCE

The geographical distribution of percentage change in girls' enrollment rates between 1851 and 1867 is shown in Figure 8. The figure also displays the subsequent percentage change in marital fertility rate over the period 1881-1911. The more industrialized area (North-East part in France) shows lower variations in girls' enrollment rates over the period studied[32]. In contrast, the agricultural/rural – North-West, Middle and South France – tends to show higher percentage changes in girls' schooling. Comparatively, the highest and the lowest percentage change in marital fertility over the period 1881-1911 are located in the same areas where girls' enrollment rates are respectively higher and lower.

We use equation 1 to test the hypothesis that human capital accumulation and especially female human capital was a key ingredient allowing for the demographic transition. We choose literacy[33] rates as a measure of the value of a region's human capital. Therefore, we estimate the impact of both the percentage

[32] The enrollment rates in North-East France (in more urbanized counties) increased at a higher pace before the period studied. This is why the percentage change is lower is this part than in the rest of the country.

[33] Literacy refers to the ability to read and to write. Literate people can be more easily trained and enjoy better health and employment opportunities than illiterate people.

change in males' and females' literacy rates between 1856 and 1866 on the fertility decline over the period 1881-1911 during the French demographic transition:

$$(5.1) \qquad fertility_{i,1881-1911} = \alpha_1 \, education^{j}_{i,1856-66} + \boldsymbol{X}_{i1}\delta_1 + e_{i1}$$

where the subscript j refers to the gender of individuals (either male or female) and i refers to the counties. The percentage change in the crude birth rate (1881-1911) is the dependant variable; and is function of the percentage change in literacy rate (1856-66). The coefficient α_1 is our parameters of interest. $\boldsymbol{X}_1$ is the vector of control variables (see in appendix for a description of the variables). We estimate equation (1) using ordinary least squares (OLS).

We introduce various specifications to study how males and females endowments in human capital affect their future fertility. The covariates used in the regression analysis are: *(i)* a proxy for the level of industrialization specified as the share of people employed in manufacturing by gender, *(ii)* the share of people making their living of agriculture by gender, *(iii)* the urbanization, *(iv)* population density, *(v)* the share of Protestants, *(vi)* life expectancy at age 0, *(vii)*, *(viii)* the crude birth rate in 1851, *(ix)* the crude birth rate in 1881.

5.3 Results

Table 2a and 2b report OLS estimates of equation 1 where variations in crude birth rate are respectively function of variations in males' literacy rates and females' literacy rates.

We control for socio-economic factors adding successively control variables for employment opportunities and urbanization (column 1), religion (column 2), life expectancy (column 3) and crude birth rate in 1881[34] (column 4). The estimates show that counties where the percentage variation of investment in human capital is higher between 1856-66 experience higher variations in fertility on the period 1881-191 – during the French demographic transition.

[34] In order to test for robustness, we add the initial level crude birth rate in 1881.

TABLE 2A
THE LONG-RUN EFFECT OF MALES HUMAN CAPITAL ON THE FERTILITY TRANSITION

Dependent variable	Crude birth rate (% change 1881-1911)			
	(1)	(2)	(3)	(4)
Male literacy (% change 1856-66)	-0.123	-0.162	-0.152	-0.119
	(0.083)	(0.083)	(0.084)	(0.084)
Crude birth rate	-0.014***	-0.013***	-0.014***	-0.019***
	(0.003)	(0.002)	(0.003)	(0.004)
Male in industry	0.070	0.070	0.076	0.029
	(0.075)	(0.080)	(0.081)	(0.095)
Male in agriculture	-0.187**	-0.170*	-0.171*	-0.186**
	(0.067)	(0.067)	(0.069)	(0.065)
Urbanization	-1.013	-0.873	-0.805	-0.763
	(0.636)	(0.615)	(0.586)	(0.605)
Population density	0.017	0.014	0.012	0.011
	(0.014)	(0.013)	(0.012)	(0.013)
Share protestants		-0.003**	-0.003**	-0.004*
		(0.001)	(0.001)	(0.002)
Life expectancy: age 0			-0.001	-0.000
			(0.002)	(0.002)
Crude birth rate (1881)				6.279
				(3.961)
Constant	0.294***	0.273***	0.321*	0.286*
	(0.065)	(0.065)	(0.129)	(0.130)
N	83	83	83	83
R^2	0.517	0.541	0.542	0.564
F	28.583	26.007	23.288	20.878

Notes: OLS regressions. Dependent variable: % change crude birth rate. Robust standard errors in parentheses - * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Male literacy rate is number of males able to read and to write over total number of males.

Source: County-level data from French censuses.

In particular, we find very interesting results in terms of gendered impact. Investigating the effect of changes in males' literacy rates on the fertility transition; we observe that, no matter the specification, the negative correlation remains always non-significant (Table 2a). In contrast, the estimates are particularly robust and significant (probability of error inferior to 0.001) when percentage change in fertility is function of females' literacy rates (Table 2b). The coefficients indicate that the fertility transition is stronger in areas where individuals are more oriented toward agriculture[35]. The transition is also more

[35] Note that agricultural areas are also those where education levels were historically the lowest and where fertility was the most important (in comparison with industrialized areas).

important in counties with a higher share of Protestants (see Table 2a and 2b – Column 2, 3, 4). More specifically, in the richest specification (column 4 – Table 2b) an increase in the variation of females literacy rates by 10 % is associated with a negative variation in fertility by about 1.5 children.

TABLE 2B
THE LONG-RUN EFFECT OF FEMALES HUMAN CAPITAL ON THE FERTILITY TRANSITION

Dependent variable	Crude birth rate (% change 1881-1911)			
	(1)	(2)	(3)	(4)
Female literacy (% change 1856-66)	-0.158***	-0.156***	-0.155***	-0.148***
	(0.033)	(0.033)	(0.036)	(0.037)
Crude birth rate	-0.013***	-0.013***	-0.013***	-0.017***
	(0.002)	(0.002)	(0.003)	(0.003)
Female in industry	-0.003	0.005	0.006	-0.027
	(0.124)	(0.125)	(0.129)	(0.133)
Female in agriculture	-0.144**	-0.141**	-0.142**	-0.146**
	(0.045)	(0.045)	(0.048)	(0.047)
Urbanization	-0.925	-0.798	-0.783	-0.729
	(0.526)	(0.500)	(0.494)	(0.528)
Population density	0.016	0.013	0.012	0.011
	(0.012)	(0.011)	(0.011)	(0.012)
Share protestants		-0.003***	-0.003**	-0.004**
		(0.001)	(0.001)	(0.001)
Life expectancy: age 0			-0.000	0.000
			(0.001)	(0.001)
Crude birth rate (1881)				5.327
				(3.284)
Constant	0.249***	0.241***	0.255*	0.218
	(0.057)	(0.057)	(0.121)	(0.121)
N	83	83	83	83
R^2	0.606	0.628	0.628	0.644
F	44.057	43.032	37.989	34.719

Notes: OLS regressions. Dependent variable: % change crude birth rate. Robust standard errors in parentheses - * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Female literacy rate is number of females able to read and to write over total number of females.

Source: County-level data from French censuses.

In terms of explanatory power, the richest model (column 4 – Table 2b) accounts for more than 64% of the variations in crude birth rate across counties. Therefore, our results are coherent with the interpretation of the unified growth theory (Galor, 2005b; Galor and Moav, 2002) and especially with Diebolt and

Perrin (2012). According to the latter, female empowerment as well as technological progress increased returns to education for girls because of complementarities between technological changes and human capital. As a consequence, girls could invest more in their own education and limited their fertility (due to higher opportunity costs of having children). In other words, girls with higher endowments in human capital have fewer children. As a consequence, as far as females human capital increases, fertility declines and ultimately lead to the fertility transition.

5.4 Final Remarks

In agreement with the unified growth model presented above, the preference for child quality rather than child quantity as a result of improvement in female human capital is likely to be a key ingredient allowing economies to experience a transition from a very long period of stagnation to a stage of sustained growth. Using a dataset of 86 county-level observations built up from Population and Education Censuses conducted in 1851, we document the existence of a child quantity-quality trade-off for France. We find the existence of a negative correlation between education and fertility during the demographic transition. More precisely, we show that variations in female literacy rates (1856-66) have a robust and significant impact on fertility transition between 1881 and 1911: counties with higher improvements in female literacy rates between 1856 and 1866 show a stronger fertility decline at the turn of the 19th century.

Therefore, our estimates suggest that females with higher levels of human capital have stronger preferences for a lower number of children.

Conclusion

This paper shed lights on the importance of the role played by female empowerment (changes in gender relations) on the development process. We argue that gender empowerment have been necessary to allow economies to move from stagnation to sustained growth. Our intuition is that the transition from a "*Patriarchal*" organization of the society (male-breadwinner model), characterized by a sexual division of labor with a desire for households to

maximize both their income and the number of children, toward a “Modern” organization of the society (dual-earnings model), characterized by a better distribution of duties within the household, where both men and women work on the labor market, is at the heart of both the process of human capital accumulation and the demographic transition that occurred during the process of development in Western countries.

More specifically, we develop a unified cliometric growth model that encompasses the interplay between income, gender equality and fertility. Our model suggests that gender empowerment is a crucial factor of both demographic and economic transition. In particular, the theory points out that the acceleration of skill-biased technological progress generates a positive externality on the level of gender equality. Both wages and gender equality are key variables in the education decision process of individuals. More specifically, higher gender equality reinforces individuals’ incentives to acquire skilled human capital. In turn, female choices in terms of time and quality of educational investments increase their endowment in human capital and impact positively the fraction of the subsequent generation of individuals acquiring skilled education. In other words, improvements in technological progress, gender equality and skilled human capital reinforce each other. Ultimately, the presence of a sufficiently high fraction of skilled individuals in the population yields to sustained economic growth.

In the early stage of development, the low rate of technological progress does not provide any incentive to invest in skilled education. Therefore, the fraction of skilled individuals is low and the economy remains trapped in a Malthusian steady-state equilibrium, with low education, low living standard and low gender equality. Technological progress is assumed to increase monotonically from generation to generation. Thereby, as technological progress grows, we observe a qualitative change, and the subsequent income effect triggers (temporarily) to higher fertility rates. After sufficiently many generations, increases in the returns from investments in skilled education (productivity growth) – driven by the rise in technological progress – makes investing in skilled education more profitable so that gender equality improves. The dynamical system of skilled human capital and gender equality is therefore characterized by multiple steady-state equilibria. Since gender equality becomes high enough, a substantially larger fraction of individuals acquires skilled human capital what triggers to rapid developments and reinforces gender equality. Due to larger educational investments (in terms of

time units), female opportunity cost of having children increases and average fertility declines: the demographic transition occurs along with the process of human capital accumulation. Ultimately, in later stage of development, gender equality and the fraction of skilled individuals converge towards their maximum. Thereby, the economy is characterized by a Modern Growth steady-state equilibrium, where living standards are high, gender equality is high and fertility is low.

An empirical verification of the effect of female education on fertility transition based on past data is conducted in section 5 – in order to investigate the relevance of our theory. Using a dataset of 86 county-level observations built up from Population and Education Censuses in the 19th century, we document the existence of a quantity-quality trade-off for France. In accordance with our theory, we find the existence of a negative correlation between female education and fertility during the demographic transition. One next step is here to explain why the demographic transition occurs first in France.

More generally our research had the ambition to be an original illustration of the main achievement of cliometric research in the recent years, i.e. to slowly but surely establish a solid set of economic analyses of historical evolution by means of measurement and theory. A future objective is to consolidate this research agenda, i.e. to contribute to close the gap between theoretical growth models and economic history and, in so doing, encouraging economists to examine more systematically these theories grounded upon history and nevertheless aiming at determining general laws. This middle road might open the door to a better economic theory, enabling economists to interpret current economic issues in the light of the past and to understand more deeply the historical working and path dependence of the socio-economic processes (Diebolt, 2012).

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APPENDIX

Section 1. *The Stylized Facts*

Data used for Figure 1 to 3 is for a set of 114 countries, referenced below, in 2006.

Eastern Europe	Asia	Europe	Latin America and Carribean	Middle-East and Arab World	North America	Oceania	Sub-Saharan Africa
Bulgaria	Bangladesh	Austria	Argentina	Afghanistan	Canada	Australia	Angola
Croatia	Cambodia	Belgium	Bolivia	Algeria	United States	New Zealand	Benin
Cyprus	China	Denmark	Brazil	Bahrain			Botswana
Czech Republic	Georgia	Finland	Chile	Egypt			Burkina Faso
Estonia	India	France	Colombia	Israel			Cameroon
Hungary	Indonesia	Germany	Costa Rica	Jordan			Chad
Latvia	Iran	Greece	Dominican Republic	Kuwait			Ethiopia
Lithuania	Japan	Iceland	Ecuador	Morocco			Gambia
Macedonia	Kazakhstan	Ireland	Guatemala	Saudi Arabia			Ghana
Malta	Korea, Rep.	Italy	Honduras	Tunisia			Kenya
Moldova	Kyrgyz Republic	Luxembourg	Jamaica	United Arab Emirates			Lesotho
Poland	Malaysia	Netherlands	Mexico	Yemen			Madagascar
Romania	Mongolia	Norway	Nicaragua				Malawi
Russia	Nepal	Portugal	Panama				Mali
Slovak Republic	Pakistan	Spain	Paraguay				Mauritania
Slovenia	Philippines	Sweden	Peru				Mauritius
Turkey	Singapore	Switzerland	Trinidad and Tobago				Namibia
Ukraine	Sri Lanka	United Kingdom	Uruguay				Nigeria
	Thailand		Venezuela				South Africa
	Uzbekistan						Tanzania
							Uganda
							Zambia
							Zimbabwe

Section 5. *County-level Data for France in the 19th Century*

The data used in this paper are mainly extracted from books published by the *Statistique Générale de la France* (SGF) on population, demographic and public education censuses, between 1800 and 1925 (1821, 1851, 1861, 1867, 1881, 1911 Censuses). Almost all data are available for 86 counties.

1851 Census

- **Crude birth rate.** Number of birth over total population (per 1000 inhabitants).
- **School enrollment rate.** Number of children enrolled in public primary schools over the total number of children aged 6-14.
- **Girls (Boys) enrollment rate.** Number of girls (boys) enrolled in public primary schools over the total number of girls (boys) aged 6-14.
- **Share in industry.** Number of individuals employed in manufacturing over total population. Manufacturing refers to all types of industry: textile, metal sector and other factories (food, wood, construction…).
- **Female (Male) in industry.** Number of women (men) employed in manufacturing over total number of women (men) aged 15-60. Manufacturing refers to all types of industry: textile, metal sector and other factories (food, wood, construction…).
- **Share in agriculture.** Number of individuals employed in agriculture over total population. Agriculture refers to all positions within agricultural sector: owners, farmers, sharecroppers and others.
- **Female (Male) in agriculture.** Number of women (men) employed in agriculture over total number of women (men) aged 15-60. Agriculture refers to all positions within agricultural sector: owners, farmers, sharecroppers and others.
- **Urbanization.** Number of towns populated with more than 2000 inhabitant (per km²).
- **Population density.** Number of people per km².
- **Life expectancy at age 0.** Updated C7 tables published in Bonneuil (1997). Calculation of life expectancy by calculating the area under the survival function.

- **Marital fertility rate.** Index of marital fertility from Princeton European Fertility Project. I_g index compares the observed number of marital births to the number of marital births expected if the standard fertility rates applied.
- **Share married women.** Number of married women per women in age of being married (15 years old and above). Number of married women refers to the sum of married women at each age (from 15 years to 100 years and above).

1861 Census

- **Share Protestants.** Number of Protestants over total people within the different religions (per hundred people). Protestants refers to all types of Protestants: Lutherans, Calvinists and other Protestant sects. Religions refer to all types of Protestants, Catholics, Israelite and other non-Christian cults.
- **Female (Male) workers.** Number of female (male) workers in textile industries over total female (male) population.

1881 Census

- **Crude birth rate.** Number of birth over total population.

Percentage Changes

- **Crude birth rate (1881-1911) - % change.** Percentage variation of the number of birth over total population in 1881 compared to 1911.
- **Marital fertility rate (1881-1911) - % change.** Percentage variation of index of marital fertility in 1881 compared to 1911, from Princeton European fertility project
- **Girls (boys) enrollment rate (1851-67) - % change.** Percentage variation of the girls (boys) enrollment rate between 1851 and 1867.
- **Female (Male) literacy rate (1856-66) - % change.** Percentage variation of the female (male) literacy rate between 1856 and 1866. The literacy rate consists in number of individuals able to read and to write over total population.