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Cycles and Stability.  
Italian Population before  
the Demographic Transition  
(225 B.C. – A.D.1900)\*

In the last decades, historical demography has mainly focused on the inner mechanisms governing the growth and fluctuations of past populations. Mortality, fertility and family structure were and still are its main interests.<sup>1</sup> The spread of the method of inverse projection in the late Seventies opened up new paths to research on the size of past populations. Unfortunately, however, this method can be employed only on quite recent periods, usually from the sixteenth-seventeenth centuries onward; periods, that is, for which yearly data on birth-rate and mortality are available. For earlier periods, historians continue to rely on old estimates of the absolute size of past populations. These estimates, ordinarily based on second-hand data, are then cited in third-hand reconstructions, and become the basis for new assumptions about past demography in national and continental estimates. The original source of these data, often buried in old writings, remains completely unknown.<sup>2</sup> This is exactly the case for Italy.

Italy owns some of the earliest information on population – often censuses –, available from Roman antiquity onward. Our present knowledge rests on the estimates from these data worked out by the demographer and ancient historian K.J. Beloch in several essays written from the last decades of the nineteenth to the first decades of the twentieth century. Notably, he devoted two important books to the Italian population, the first on antiquity, the second on the period from the late Middle Ages to 1800.<sup>3</sup> These two studies provide the basis for the overview of a gradual growth of popu-

\* A preliminary draft of this article was read by Salvatore Capasso, Giovanni Federico, Martino Lo Cascio and William Harris. We thank them for their comments.

lation from ancient times. The Italian population was 7 million at the death of the emperor Augustus; after a decline from the second-third century, it regained momentum in the tenth, reaching 11 million in 1300, 13.5 million in 1700, and 18 million in 1800. It attained 26 million in 1861, the year of the first national census after the political unification of the country, and is now 57 million.

Since their publication, Beloch's data on antiquity and early Modern Italy have been the main source of every reconstruction of ancient demography. Beloch's demographic series for the Early Modern period (sixteenth to nineteenth century) provided the basis for the first reconstruction of the demographic history of the early Modern age, published by C.M. Cipolla in 1965.<sup>4</sup> A. Bellettini's continuous century-by-century series of the Italian population, from the birth of Christ to 1970, is also derived from Beloch's data.<sup>5</sup> Bellettini's study, in its turn, has been the basis of every long-term outline of Italian demographic history. The most recent analysis of the Italian population from the early Middle Ages to the present day, by L. Del Panta, M. Livi Bacci, G. Pinto and E. Sonnino, is also based on Beloch, with some minor revisions.<sup>6</sup> Thus, our present knowledge of Italian demographic history is ultimately derived from Beloch. Since population movement is an essential feature of every analysis of past economies, we can say that the indirect influence of Beloch on scholars' progressive view of Italian economic history is still strong. Furthermore, estimates of the population of ancient Italy have been the basis for estimates of the population of the whole of the Roman empire, and these have provided, in their turn, the basis for estimates concerning all of Europe. The conclusion is that the influence of Beloch's data on ancient demography has been and still is much stronger than one would expect.<sup>7</sup>

In the last ten years or so, Beloch's data on Roman antiquity have been repeatedly called into question.<sup>8</sup> The medieval population peak of 1300 has also been reconsidered.<sup>9</sup> Our view of Italian long-run demographic trends is changing, and this change is influencing the way we look at Italian history as a whole.

The purpose of the present article is simply to summarize these recent changes (§ 1); to present a new long-term series and highlight the continuity of some original characters of Italian pre-modern demography (§ 2); to estimate the carrying capacity of Italian traditional agriculture and verify the

compatibility of our demographic estimates with the Italian economy and environment (§ 3). We will then propose a model to explain the Italian demographic trend (§ 4) and the interplay of the variables involved (§ 5). We will see that the perspective of fluctuations around a long-term stability fits the known facts far better than the view of a long-term growth. This revision of the Italian demographic history cannot but suggest a different outline of Italy's long-term past economic history on the whole.

### 1. *The long-term trends*

In order to outline Italy's demographic evolution from Roman antiquity and the debates concerning it, we will follow the conventional division into ancient, medieval and early modern history.

*Antiquity.* It is hard indeed to combine into a single picture the two contradictory sides of the dominant view of the ancient Roman world in the late Republican period. We have, on one hand, an expanding Mediterranean power, the multiplication of settlements in Italy, the introduction of innovations in agriculture, the improvement of power technology, the astonishing demographic growth of Rome and hundreds of other towns in Italy, the progress of slavery, and major changes in land distribution, as well as advancements in agricultural specialization, commercialization, and monetary economy. On the other hand, we have a continuous decline of free peasantry due to a decrease of the birth-rate offset only by the growth of the number of slaves. The result is a long-term stability of population. This is, more or less, the scenario proposed by most Roman scholars for the last centuries of the Republican period.<sup>10</sup> Scholars have hardly noticed the incompatibility of these two sides of the same coin. Beloch's old demographic reconstruction still provides the main foundation for this contradictory edifice which, although criticized by T. Frank in the 1920s and A.H.M. Jones in the 1940s,<sup>11</sup> continued to dominate Roman historiography of the late Republic and Empire until a few years ago. Only recently has criticism intensified, and now, despite some resistance,<sup>12</sup> every day the shortcomings of Beloch's demographic outline are becoming more evident.

Our knowledge of the population of Italy in Roman times is based on censuses.<sup>13</sup> These were periodical assessments whereby Roman citizens were registered and counted, usually every five years. Their purpose was military, fiscal, and political. Censuses were based on declarations presented at Rome by family heads enjoying full juridical capacity (the *sui juris*). These family heads reported themselves and all the members of their families, including their slaves. However, the final count did not include the whole population, but only adult males enjoying citizen status. Thus, all sets of figures available from the sixth to the first century B.C. only concern the *civium capita*, an expression designating Roman adult males.

Nobody doubts that these figures (or at least the figures for the censuses from the late third century onwards)<sup>14</sup> are, on the whole, reliable and significant, whatever confidence one can have in some of the individual figures. But to draw from them acceptable estimates of the population of Italy in the centuries of the Roman Republic, we have to face three problems:

- the first is that from the sixth century onwards the *ager Romanus*, the area whose inhabitants were Roman citizens, was progressively extended, first to the territories north-east and south-west of Rome, then to all of peninsular Italy south of the river Po, and finally, with Caesar, also to the area extending north of the river Po to the Alps. In other words, the proportion of the Italian population made up of Roman citizens kept increasing. And this is borne out by the admittedly spasmodic increase in the number of *civium capita* from the first enumerations to the last Republican census in 70-69 B.C.;

- the second problem is that, even if we limit ourselves to the population of the *ager Romanus* at every stage, we have to estimate the total population – including not only women and children of citizen status, but also resident foreigners and slaves – on the basis of the people who were actually counted, the *civium capita*;

- the third problem is that there must have been a huge underregistration, especially of the *proletarii*, the adult males who were usually not liable for military service and were exempted from taxation. These people, particularly if they lived far from Rome, would have avoided taking the trip to Rome every five years to register, and the Roman authorities would have not insisted upon their coming. Underregistra-

tion must have been on the rise in the last centuries of the Republic, but there is no way we can even try to guess how high it was in different periods.

Given the difficulty of drawing plausible estimates of the population of Roman Italy from census figures, scholars have turned to a famous passage in Polybius about the events of 225 B.C., on the eve of a very alarming invasion of the Italian peninsula by the Transalpine Gauls.<sup>15</sup> This passage – which contains a numerical account of the military strength of the Romans and their allies based, apparently, on official records – has been used to evaluate the population of Italy ever since the controversy between Robert Wallace and David Hume in the eighteenth century about the populousness of ancient vs. modern nations,<sup>16</sup> and with good reason. First of all, it provides a detailed record of the Romans and their allies under arms. Besides, it also lists the potential soldiers who could be enrolled in every region of peninsular Italy, which was by then inhabited either by Roman citizens or by peoples subjected to the Romans (with the exception of the peoples of the southernmost part of peninsula, less threatened by the invasion).

Hence, we can draw from this passage an estimate of all adult males «able to bear arms» (the Roman military age was from 17 to 45) living in a substantial part of peninsular Italy covering an area of about 108,000 sq. km. In 225 B.C. the number of these adult males of military age was more or less 750,000. On this basis, assuming that these men amounted to 75 percent of all adult males and that adult males were more or less 30 percent of the total population,<sup>17</sup> it is possible to estimate the free population of this area of Italy at a bit less than 3,400,000 (with a density of a bit more than 30 inhabitants per sq. km). It must be stressed that these are very conservative estimates, since there must have been strong underregistration of potential soldiers, although we have no possibility whatsoever to calculate its rate. Assuming a similar density for areas of Italy that were still not Roman, or are not taken into account in Polybius' passage (like the southernmost part of peninsula), we arrive at an estimate of the whole free population of Italy (including the Po Valley but excluding the islands) of a bit less than 8 million. Obviously, this estimate can be questioned on several grounds. A lower density in non-Roman Italy could reduce it to less than 6 million, without the islands. If we include the islands, the resulting range between

6 and 8 million can provide, in any case, nothing but a magnitude, to be compared with the estimates we can draw from other, more reliable figures available for the Augustan period.

In his *Res gestae*, Augustus records the censuses he held in 28 and 8 B.C. and A.D. 14 and the number of *civium capita* recorded on each occasion: respectively 4,063,000, 4,233,000, and 4,937,000.<sup>18</sup> These figures are much higher than those of the last Republican census (70-69 B.C.), which was 900,000. The disparity between the figure for 70-69 B.C. and the later ones has always been a problem. Beloch thought it impossible to account for the enormous increase in the number of *civium capita* between 70-69 and 28 B.C., unless one assumed that the criteria for and the aims of counting the *civium capita* had changed. He was convinced that it was impossible to explain this leap forward as a mere consequence of the extension of Roman citizenship to the area north of the river Po to the Alps under Caesar, or to the inhabitants of the new citizen colonies established in the last decades of the Republic and during the Augustan period outside of Italy, combined with the natural increase of the population. He therefore put forward the hypothesis that, while the figures of the Republican period refer to adult males, those in the *Res gestae* refer to the whole population, including women and children. Since by then a substantial number of Roman citizens were established in the provinces, that is outside of the Italian peninsula and the Po Valley, those who lived in Italy in 28 B.C. could not have been, according to Beloch, more than 3,250,000, with a density of 13 inhabitants per sq. km. On this same basis, Beloch calculated that, in 14 A.D., the whole population of Italy, with the islands of Sicily, Sardinia and Corsica, would have amounted to 7 million, including *peregrini* (foreigners) and slaves.

It must be stressed that there is not a shred of evidence in favour of Beloch's hypothesis. Moreover, the hypothesis itself raises serious doubts. Assuming that adult males accounted for 30 per cent of the whole population, in 28 B.C. they would have been 975,000, that is, more or less the number of the adult males in 70-69 B.C., notwithstanding the enormous increase in the number of *civium capita* brought about by the extension of Roman citizenship to the area north of the Po. The 28 B.C. figure of 3,250,000 for the citizen population of an area of 250,000 sq. km is very low when compared with the total free population of the

area of the Italian peninsula under the Romans by 225 B.C., i.e., 108,000 sq. km.<sup>19</sup> Beloch's hypothesis, therefore, obliges us to accept that in the two centuries between 225 and 28 B.C. the free population of the Italian peninsula was shrinking, and that, between the last Republican census and the first Imperial one, the pace of this decrease was incredibly high. Since we know from archaeological and literary evidence that urban population, especially the population of Rome, was increasing enormously,<sup>20</sup> we have to suppose that the free rural population was actually collapsing at the end of the Republic. The plausibility of the whole picture cannot but be extremely dubious.

Everything becomes much simpler and clearer if we admit that the *civium capita* counted in the three Augustan censuses, were, as before, adult males. While in the 70-69 B.C. census, as in the preceding ones, underregistration was high, in 28 B.C. a new criterion was applied, a criterion which facilitated the taking of the census and limited the possibility of citizens escaping registration. We know that an important reform in the procedure of census-taking was introduced at the end of the Republic, under Caesar. The *sui juris* no longer needed to come to Rome to make their declaration before the censor or his deputies. They registered before the highest magistrate of their *municipium* (or *colonia*, or *praefectura*), following the procedure described in the statute reproduced in the *Tabula Heracleensis*.<sup>21</sup> Roman citizens domiciled in Rome were declared by the *domini* of the apartment blocks (*insulae*) where they lived, as described by Suetonius.<sup>22</sup> The fact that the *sui juris* were no longer obliged to come to Rome enormously increased the efficiency of census taking. Underregistration diminished as a consequence.

This simple change in the way we look at the first Imperial censuses entails a correspondingly higher estimate of the population. If we put at 30-32 the percentage of adult males (over 17) in the whole population,<sup>23</sup> it is possible to estimate at 12,700,000-13,500,000 the number of Roman citizens of both sexes in 28 B.C. Of these, perhaps some 11,500,000-12,250,000 lived in Italy, the rest in Sicily and Sardinia and beyond the current borders of peninsula. In A.D. 14 the two figures are respectively 15,000,000-16,400,000, whose 13,500,000-14,500,000 within peninsular Italy.<sup>24</sup> Adding the slaves living in Italy, we reach 15-16 million. Estimating the free population of Italy in 28 B.C. at

about 13 million instead of 3-4 results in more plausible figures for the slave population – at the time perhaps about 10-20 percent of the whole population – and for the urban population of the 430 cities recorded by Pliny the Elder. The urbanization rate may have been around 15-20 percent, as in late Medieval-early Modern Italy;<sup>25</sup> otherwise the figure of the urban population would result too high.

*Middle Ages.* The three Augustan censuses indicate a rising trend. It is possible, however, that the decreasing number of slaves had a curbing effect on the total increase, so that the total population did not exceed 15 million. It seems possible, furthermore, that an ever increasing number of free citizens lived outside Italy, in other regions of the Empire, as a consequence of the generous granting of citizenship to individuals and communities.<sup>26</sup> The level attained by the Italian population at the beginning of the first century of our era is probably the peak of a long growth. One of its results was an increasing pressure on resources. Archaeological evidence shows that uncultivated areas were being brought under cultivation. People noticed the increasing *densitas possessorum*, the high number, that is, of *possessores* in Italy.<sup>27</sup>

A first strong decline took place in the second century, particularly as a consequence of the so-called Antonine plague, probably a smallpox epidemic which lasted from 160 to 180. This demographic shock was supposed to have determined a population drop of 50 percent or even more.<sup>28</sup> It seems now that the decline was lower: 20-30 percent of the population.<sup>29</sup> There was a recovery in the following century, but it was cut short by an outbreak of plague which lasted from 250 to 270. Several cities, including Verona, Bologna, Modena, Rimini, Lucca, rebuilt their walls around a much narrower area than before.<sup>30</sup> For several centuries, the level of population of the early Empire was never attained again.

From the fourth to the tenth century, information is especially scarce. We lack direct data on population. We can only point out the general trend and a few main demographic turning points.

For about three centuries, from the fourth to the middle of the sixth, population recovered without regaining the size of the early Empire.<sup>31</sup> A new age of decline began with the Greek-Gothic war from 535 to 553, a series of famines in

538-42,<sup>32</sup> and the arrival of a new plague epidemic in 541, which became endemic in Italy until 664. After almost a century, a new plague cycle broke out in 747-767, affecting especially Southern Italy.<sup>33</sup>

It is hard to propose figures for the population from the fourth to the eighth century. What is certain is that, if we assume a figure of 15 million inhabitants for the early Empire, the ensuing decline from the second century onward cannot have brought the population down to 4 million, as A. Bellettini assumes for the period from the sixth to the tenth century. A figure of 7-8 million, i.e. half the population at the beginning of our era,<sup>34</sup> seems much more plausible. Otherwise we would have to assume an unlikely rate of decline. We accept the rate of decline hypothesized by Bellettini, but we apply it to the higher figures we have assumed for the population of Italy in the first century.

It is uncertain when the new late-Medieval phase of growth actually began; probably in the tenth century. About this time there are many unmistakable signs of recovery, such as new settlements (*castelli*) and the expansion of many cities.<sup>35</sup> This growth became especially fast in the thirteenth century.

The traditional estimates of the Italian population during the medieval growth were, until a few years ago, of 4.5 million in 900 and 11 million in 1300. Recently G. Pinto revised the figure for 1300, the peak of the late medieval rise. For that period we have much more information about the urban than about the rural population.<sup>36</sup> Now, since at the time the former was more than 2.5 million and large cities were especially numerous in the Centre and North, assuming a total population of 11 million would result in a high, perhaps too high, urbanization rate. In the Centre and North it would have been more than 25 percent. It seems therefore preferable to assume, as Pinto does, a total population «between 10 and 15 million inhabitants: an intermediate estimate of 12.5 million seems likely, especially in the light of the following evolution».<sup>37</sup>

Assuming a figure of 8 million inhabitants in 900 and 12.5 million in 1300, the result is a lower yearly rate of increase during the 400 years of the medieval growth: about 0.11 percent. The rate of growth doubles if we accept the traditional estimates of 4.5 million in 900 and 11 in 1300. At any rate, the population size of the ancient Roman empire was not yet attained after over 1000 years.

TAB. 1. *The Italian population from 1300 to 1861 (000) and its annual rate of increase (per 1000)*

	(000)	Annual rates (per 1000)
1300	12,500	
1350	9,500	-5.5
1400	8,000	-3.4
1450	7,500	-1.3
1500	9,000	3.7
1550	11,500	4.9
1600	13,300	2.9
1650	11,500	-2.9
1700	13,500	3.2
1750	15,500	2.8
1800	18,100	3.1
1861	26,900	6.5

*The early Modern age.* The estimates concerning early Modern Italy (Table 1) are certainly less open to doubt than the ones discussed above. The long-term movement is quite clear.<sup>38</sup> It seems that, as early as the first decades of the fourteenth century, population, especially urban population, began to stabilize or decrease.<sup>39</sup> A sharp drop took place with the arrival of a new plague from Asia. The last epidemics in Europe had occurred in the middle of the eighth century. From then on, for about 600 years, plague disappeared. A new negative trend began in 1347 with the arrival of the Black Death. The plague remained endemic in Europe for about 300 years.

The first outbreak of plague in 1347-48 and the minor epidemics that followed one another for about a hundred years beginning in the middle of the fourteenth century determined a demographic fall to 7.5 million around 1450: 60 percent of the 1300 level. A new expansion followed for 150 years beginning in 1450. Population recovered and eventually exceeded the medieval peak. By 1600, Italian population had reached 13.3 million. Two particularly serious plague outbursts occurred in the seventeenth century, the first in Northern and Central Italy in 1629-30, the second in Southern Italy in 1656-57. By 1660 the Italian population had dropped to about 10 million.<sup>40</sup>

The following demographic phase is well known. Thanks to the disappearance of the plague after the 1656-57 outburst and the decline of other diseases, mortality, especially infant mortality, diminished and population began to rise again.<sup>41</sup> In

1750, for the first time after several centuries, the Italian population reached again the level of the early Roman empire: 15.5 million. It continued to grow, attaining 18.1 million in 1800, 26.9 million in 1861, and 33.6 million in 1900.

## 2. *The overall trend*

We cannot deny that the margins of uncertainty of ancient and early medieval demographic data are quite wide. If we accept, however, the revision of ancient Roman demographic data proposed in these pages, the difference with the earlier estimate is striking. The implications for the long-term economic history of Italy are also striking.

*Two different perspectives.* The old series indicates a progressive trend (Figure 1). The Italian population declined sharply during the second and third centuries, after reaching 7 million at the beginning of the Roman Empire. Later, from the late Middle Ages onward, there was a recovery, interrupted by the plagues of 1347-48, 1629-30 and 1656-57, as well as several less catastrophic epidemics. The upward trend strengthened from the late Seventeenth century onward. One could assume that this evolution was supported by a progress in the exploitation of resources made possible by small, continuous advancements in technology allowing men to deal with the environment more and more efficiently. The recently suggested estimate of the per capita GDP of ancient Roman Europe at one third of that of Western Europe in 1820 is in line with this old reconstruction.<sup>42</sup> Population density grew as the economy became technically more efficient and richer century after century.

The revision proposed here offers a very different perspective (Figure 2). Our new figures do not support the traditional view of a rising trend. They simply indicate some fluctuations around a long-term average of about 10 million inhabitants, in a range between 7-8 and 15-16 million. Each cycle lasted 250-350 years (Table 2 and Figure 3). A long stability characterizes the population of Italy.

The following cycles can be discerned:

- from the third century B.C.(?)<sup>43</sup> to the beginning of the first century A.D.: *growth*;
- from the first century A.D. to 250-300: *stability and decline*;

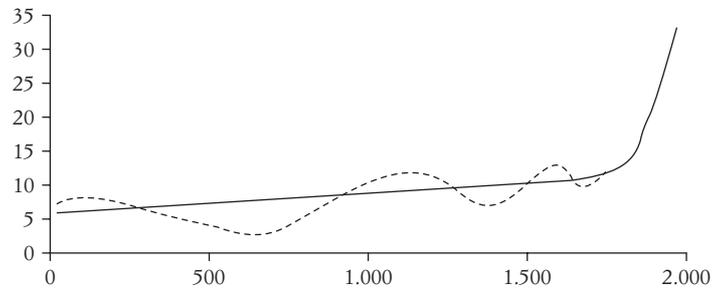


FIG. 1. Old estimates of Italian Population 1-1900.

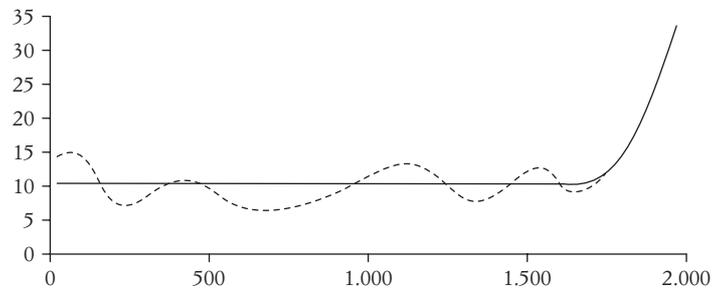


FIG. 2. New estimates of Italian Population 1-1900.

TAB. 2. *The Italian population from 200 B.C. to A.D. 1900 (millions; current borders)*

-200	6-8	900	9
-00	10	1000	10
1	15-16	1100	10.5
100	15-16	1200	11
200	12	1300	12.5
300	9	1400	8
400	10	1500	9
500	11	1600	13.3
600	8	1700	13.5
700	8	1800	18.1
800	8	1900	33.2

- from 250-300 to 550: *recovery*;
- from 550 to the ninth-tenth century: *decline*;
- from the tenth century to 1300: *growth*;
- from 1300 to 1660: *decline* (except for an upward surge in the sixteenth century which regained the 1300 level);
- 1660-1980: *growth*.

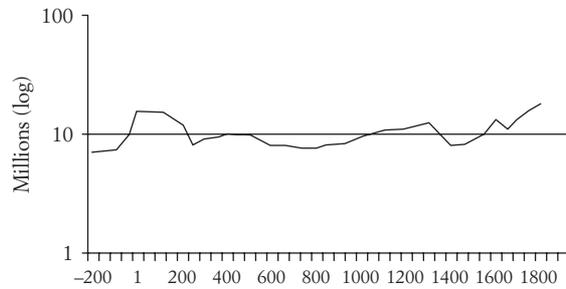


FIG. 3. Italian Population (200 B.C.-A.D. 1800).

Our long-term economic perspective has to change as well. We may assume that we are not dealing with a growing population capable of exploiting the environment more and more efficiently by means of increasingly better techniques or institutions, but with an economy which had already reached maturity in ancient Roman times. It becomes plausible that the ancient Roman economy already possessed the advanced techniques and institutions characterizing the traditional agricultural world. Thus, no further possibilities of significant progress existed within the ancient agricultural system.<sup>44</sup> From Roman times onward, the Italian agricultural civilization stagnated until the new technological spurt brought about by modern growth in the nineteenth and twentieth centuries. The estimates of the ancient Roman per capita GDP recently proposed are not in contrast with this different view. They are close to those advanced by scholars for the late Middle Ages, and perhaps higher than those put forward for the late eighteenth and nineteenth centuries Italy.<sup>45</sup> Income and wealth did not change much in the very long run. Their movement was, at any rate, downward rather than upward.<sup>46</sup>

*Demographic variables.* As far as demographic variables are concerned, one observes the same long-term stability.<sup>47</sup> Life expectation at birth remained within the same range of 25-30 years from ancient Roman times until the nineteenth century. So did mortality and fertility rates. Urbanization, too, was around 15-20 percent in the time of Augustus and was still within the same range in the late Middle Ages and early Modern Period. In 1861, it was 16.2 percent in North and Central Italy.<sup>48</sup>

TAB. 3. *Population density in Europe, Italy, England and Wales, The Netherlands, France, Belgium, Spain and Portugal in 1600 and 1800 (inhabitants per sq. km.)*

	1600	1800
<i>Europe (without Russia)</i>	17.8	29.2
Italy	42.9	58.3
England and Wales	27.1	60.8
France	33.1	47.6
Spain and Portugal	15.4	22.5
The Netherlands	36.4	51.0
Belgium	22.3	41.9

Another important characteristic of the Italian population, an original feature, we could say, is its high density (Table 3).<sup>49</sup> In the late Middle Ages, when the average population density was 14 inhabitants per sq. km. in Europe (without Russia), and did not exceed 30 in the other European countries, in Italy it was 40. Only in 1800 was the Italian high density surpassed by that of England. In the first century A.D. this difference, probably stronger than in the following centuries because of the low density of the population living beyond the Alps, had already been recognized as a structural feature of Italian demography.<sup>50</sup>

### 3. *Potential product*

How many inhabitants are consistent with the resources available in Italy and within the limits of the agricultural technology employed in pre-modern times? What was the potential agricultural product at the time?

It is impossible to provide an incontrovertible answer to these questions. Furthermore, carrying capacity is not a static feature. It depends on many variables and changes over time. Several estimates of the carrying capacity of the Italian environment have been proposed, especially as regards antiquity.<sup>51</sup> This is the reason why we will present a flexible solution to simulate different ratios of population and environmental capacity. This is only a first step to introduce the complex problem of the relationship between population and economy. In this case, as always in similar attempts, we will focus on cereal production, since the production of the staple crop is the critical element of every traditional agriculture. In the perspective set forth by Justus F. Liebig, and

often adopted in similar attempts, the success of a species depends on the critical resource; the basic resource, that is, whose product cannot diminish below a certain level without compromising the subsistence of the species depending upon it.<sup>52</sup>

*Carrying capacity.* We will illustrate the main variables influencing carrying capacity later on. First of all, let us focus on some structural features of the traditional Italian economy. We will assume that wheat was the main crop, along with some other minor cereals, until the spread of maize from the seventeenth century onward. We will consider Italy within the same traditional borders assumed by Beloch in his reconstruction of the Italian demographic history of the late Middle Ages and early Modern age, i.e., a surface of 31 million hectares. The mountains, that is the lands that lie over 600 metres above sea level, cover 11 million hectares of this area: 35 percent. At this altitude, cereal cultivation is ordinarily impossible. In past centuries, however, chestnut tree cultivation could support on the mountains quite a large population. Chestnuts are a good substitute for cereals. We know nothing at all on the quantitative importance of this product before the end of the nineteenth century.<sup>53</sup>

In Italy, hills, defined as lands lying between 300 and 600 metres, account for 42 percent of the whole surface, and plains only for 23 percent. Subtracting mountains from the total area, hills and plains together comprise 20 million hectares. On these 20 million hectares, cereal cultivation is technically possible. The cultivation of hilly areas has long been a distinctive feature of the agriculture of Italy, where peasants habitually transformed slopes into plains by means of terraces. The practice of terracing spread especially under population pressure.<sup>54</sup> However, we have to subtract from these hills and lowlands at least 5 million hectares which were covered partly with forests<sup>55</sup> and partly with buildings, lakes, rivers, and marshes. Since it seems that marshy areas were much more extensive from the late Medieval age onward, ancient Roman peasants must have had more cultivable land than their successors. In any case, after the subtraction of these 5 million hectares, we are left with 15 million hectares on which cereal cultivation was technically possible.

Now, to evaluate carrying capacity, the best solution is to estimate how much soil each inhabitant needed to guarantee his yearly cereal consumption. This is done simply by divid-

ing per capita consumption by per hectare product. We can use the following equation:

$$A = \frac{f}{g \cdot c}$$

where:

$A$  is the area necessary to meet each inhabitant's cereal needs (in hectares);

$f$  is the yearly per capita consumption of cereals (in kilograms or quintals);

$g$  is the yearly net cereal product per hectare, that is total cereal production minus seed (in kilograms or quintals);

$c$  is the actually sown area. Only part of the total available surface was tilled to re-establish fertility. The coefficient is 0.50, for instance, when the two-field agricultural system prevails, and 0.66 in the case of the three-field system.

*Coefficients.* By multiplying the result of the equation by the population, we obtain the total area necessary to support a given number of inhabitants. By assuming different values of coefficients  $f$ ,  $g$  and  $c$ , in various combinations, we can simulate different possibilities.

The less doubtful coefficient is  $f$  (per capita cereal consumption). The range of its possible values is relatively narrow. It is reasonable to assume an annual consumption of 200 to 240 kilograms. The low estimate is preferable when a significant part of the daily caloric intake comes from other foods than carbohydrates.

The other two parameters,  $g$  and  $c$ , are much harder to define.<sup>56</sup> Several different estimates have been proposed for  $g$  (yield per hectare), usually between 4 and 7 quintals. For barley, an especially high value has been suggested for the Roman age.<sup>57</sup> Now, as far as we know, in late Medieval and early Modern Italy the yield of the different species of cereals (with the exception of maize) does not show strong differences.<sup>58</sup> Usually, the yields of minor crops such as barley, rye and oats are a little lower than that of wheat – probably because these crops were grown on inferior, less productive soils.

Even though higher yields have been sometimes assumed for Roman antiquity, an estimate of 4 to 5 quintals per hectare seems the most appropriate. It is certainly closer to the

lower than to the upper limit of the range of possible yields. These estimates, however, include seed and hence do not indicate the actual edible quantities. As regards seed, we know that in the second and first century B.C. it averaged something between 1 and 1.5 quintals per hectare.<sup>59</sup> We will assume the intermediate value of 1.2 quintals often attested in early Modern sources. If we assume an average grain yield of 4.5 quintals, then the edible quantity is 3.3 quintals per capita per year.

As to rotation, necessary to estimate the  $c$  coefficient, a well-rooted opinion is that, while in Roman ancient times the two-field system prevailed in Italy, in the late Middle Ages there was a transition from this system to the three-field one. This is nothing but an often repeated misconception about Italian agricultural history. We know, on the contrary, that as early as the second century B.C. there existed in Italy several different kinds of rotation, corresponding to different degrees of intensification in the use of land: from slash-and-burn in backward mountainous regions to the two and three-field systems, to more elaborate forms of rotation, to the total elimination of fallow land.<sup>60</sup> While the more elaborate forms of rotation probably disappeared in the central centuries of the Middle Ages – replaced, as a consequence of lower population pressure, by simpler forms such as the slash-and-burn and two-field systems – they were revived in the later Middle Ages, when the population began to press on resources. An intermediate coefficient of 0.66 hectares, corresponding to the cultivation of two-thirds of arables, is probably a reasonable choice both for Roman antiquity and late Medieval-early Modern Italy.

If we assume, for example, an annual consumption of 2.2 quintals ( $f$ ), a net yield per hectare of 3.3 quintals ( $g$ ) – which many scholars would consider quite low – equal to a per hectare yield of 4.5 quintals minus 1.2 quintals of seed, and three-field rotation ( $c = 0.66$ ), we arrive at the result that each inhabitant needed about 1 hectare. Thus, 15 million inhabitants were barely compatible with the carrying capacity of the Italian agricultural environment and the extent of 15 million hectares cultivable. This is only an extreme example to be compared with less extreme simulations.

*The results.* Let us look now at the different results obtainable by assuming the following values for our three parameters:

$f$  2; 2.2; 2.4;  
 $g$  3; 3.3; 4;  
 $c$  0.50; 0.66; 0.80.

Assuming only these three values for every parameter, there are 27 possible combinations. We multiply then these 27 results – the hectares, that is, able to support an inhabitant – by the estimate of 15 million inhabitants. Of these 27 different results, 11 markedly exceed 15 million hectares and then are not compatible with the carrying capacity. Eight of these 11 results assume two-field rotation ( $c = 0.50$ ). All the other combinations are compatible with the assumed carrying capacity. We could then summarize by saying that our test is particularly sensitive to the rotation parameter, and hence to the level of agricultural intensification. The lower the intensification, the lower the carrying capacity and, as a consequence, the smaller the area within the production possibility curve. We need to add, however, as we will see later, that the importation of cereals from several Mediterranean regions allowed the Italian population of the early Empire and late Middle Ages to live beyond its productive capability. The Italian population could exceed, as a consequence, the country's carrying capacity.

#### 4. *Population and environment*

A production possibility curve is not a rigid upper boundary impossible to displace. We now need to examine the influence of several variables on its displacement. Our aim is to analyse the population-economy relationship in traditional agricultural civilizations. An in-depth examination of the micro-mechanisms whereby mortality, fertility and nuptiality adapt to changes in income and agricultural prices – topics often discussed by historical demographers – is beyond the scope of our analysis.

*A model.* When examining past agricultural patterns of development and resource-population relationships, historical demography and economic history's traditional resort to Malthusian explanations is nothing but an oversimplifying expedient. The theory of growth is a far more flexible and powerful tool of analysis, allowing much more scope for the investigation of man-environment interrelationships. The classical approach is not lost in this more developed eco-

conomic analysis, but simply set within a wider context.<sup>61</sup> To apply a neoclassical growth model to pre-modern economies, however, we need to make some important changes to the standard version of the theory.

Neoclassical economists' focus on capital, the most mobile production factor in modern economies, does not fit pre-modern economies, where labour is the dynamic and unstable factor.<sup>62</sup> The revised model proposed here allows a clearer view of the influence of population – and hence of labour changes- on the interplay of variables.

The point of departure is, in our model as well, the production function, where output ( $Y$ ) is produced by means of labour ( $L$ ) and capital ( $K$ ):

$$Y = F(L, K)$$

While ordinarily the denominator of the intensive form of the production function is  $L$ , in our model it is  $K$ . Therefore, in our figure (Figure 4), product ( $Y$ ), on the vertical axis, is expressed as a ratio to capital, rather than labour as in the standard neoclassical growth theory. We hence have  $Y/K$  instead of  $Y/L$ . On the horizontal axis, we have the ratio of labour to capital:  $L/K$  ( $L$  is assumed to be a constant percentage of population). Capital includes here not only produced resources, but also natural resources transformed by men (such as arables). We can assume that capital was mainly composed of fertile land and animals, as it is often the case in past agricultural societies.<sup>63</sup>

As we move to the right on the horizontal axis, the labour-capital ratio ( $L/K$ ) increases and, inversely, capital per labourer diminishes. Assuming land as the main kind of capital, as one moves to the right the density of population on arables grows, and per capita arables hence diminish. The ratio of product to capital ( $Y/K$ ), on the vertical axis, increases with the ratio of labour to capital ( $L/K$ ). The shape of the  $Y/K$  curve (concave towards the horizontal axis) depends on the decreasing returns to labour (diminishing marginal labour productivity), which are the derivative of  $Y/K$  to  $L/K$ . The straight line –  $m L/K$  – represents the labour to capital ratio multiplied by the value of a basket equal to the expense needed to support the labourer's consumption: let's call it the survival or poverty line. At this level, the working class is able to reproduce itself without any growth. Curve  $c$   $Y/K$  represents, instead, the actual expense for consumption and

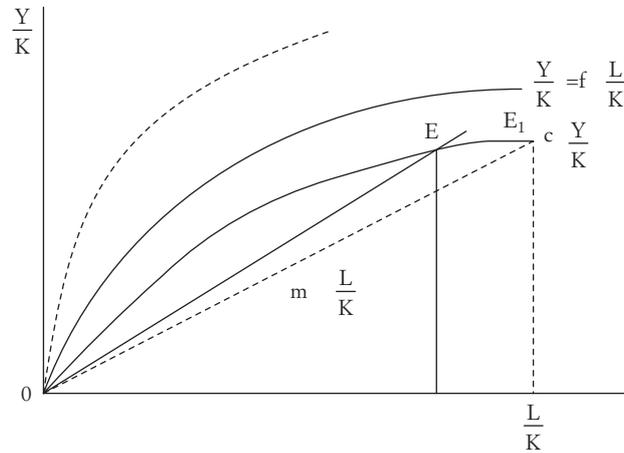


FIG. 4. Production function.

is equal to a percentage ( $c$ ) of the total product. Population increases depend directly on this portion of the demand. Population is here, as a consequence, endogenously and not exogenously determined as in the standard neoclassical version of the theory. Investment, including the substitution of depreciating capital, is equal to the difference between the production and the consumption curve: it is a surplus above the cost of the reproduction of the system. It is hence a stable percentage of  $Y/K$  (since  $c Y/K$  has already been assumed as a stable percentage of  $Y/K$ ). This surplus, however, does not necessarily become investment. It can be employed, instead, for conspicuous consumption (palaces, furniture, servants, churches...) by the highest strata of society.

Proceeding from the origin of the axes, the story this graph tells us is that of an increasing population and the opportunities and obstacles encountered by its demographic growth. When population-labour rises, the  $L/K$  increases (hence capital per worker is diminishing), and the product per unit of capital ( $Y/K$ ) increases as well. Labour productivity (the slope of the  $Y/K$  curve) cannot but diminish as a consequence of the lower and lower availability of capital per worker. The portion of the curve of actual consumption extending to the left of its intersection with the straight line of mere survival represents consumption exceeding the level required to sustain the current population. As a consequence, population grows. When the curve of consumption

intersects the survival line at point  $E$ , the production is barely able to support the current population. When, on the right of the intersection, the curve of actual consumption is lower than the survival line, population growth meets the limits of its expansion. A new equilibrium in  $E_1$  is possible when the value of the basket able to support the existing population diminishes (as happened in early Modern Italy with the introduction of maize, whose price was half that of wheat). The other possibility to support a larger population is when curve  $Y/K$  moves to the left, and the intersection of  $c Y/K$  with  $m L/K$  hence moves to the right. Only with Modern Growth did a continuous displacement to the left of the  $Y/K$  curve (the dotted curve) occur thanks to rapid technological progress allowing an increase in production, investment, consumption and population.

In past agricultural civilizations, instead, the potential for long-term growth was limited. Fluctuations around a long-term stability characterized these past economies. As long as fields, pastures and forests remained the main sources of energy, and the bodies of working animals and human beings the main converters, there existed well-defined limits to the potential for growth. «In general the annual quantum of vegetable growth set a limit both to the material production and to the energy budget of any pre-industrial society». <sup>64</sup> The rise of this annual quantum was always a slow and hard process. Much more frequently, the  $Y/K$  curve swung to the right because of bad harvests: i.e., current consumption fell below the subsistence line, and, as a consequence, population pressure on the economy decreased. The transition to modernity required a new energy basis and the developing of technologies that were out of the reach of the past agricultural world. Technological stability implied the lack of meaningful opportunities and incentives for investment. This is the reason why capital formation was ordinarily slower than population growth. A technical leap forward was required. Minor changes, however, were possible even in early agricultural civilizations through improvements in *resource* availability, in *technology*, as well as in *institutions*. It is at these variables that we need to look now.

*Natural resources.* Since cultivable land is not unlimited, in our graph, as population rises, the rate of production increase ( $Y/K$ ) can only diminish, since labour is provided with less and less capital. Usually investment is unable to

compensate for the relative decline of natural resources vs. labour. Therefore the  $L/K$  ratio increases. This means that the slope of the  $Y/K = f(L/K)$  curve decreases and the rate of consumption also descends below the right side of the  $m$   $L/K$  line. The premises exist for a fall of population in order to re-establish equilibrium.

The assumption behind this reasoning, however, is that the availability of natural resources is stable century after century. This assumption is not correct. Actually, the extent of cultivable land changes over time. It seems certain that marshy areas were much more extensive in Italy from the late Middle Ages onward than during Roman antiquity. Marshes extended along much of the Italian coast, notably along the coasts of Maremma – a large region between Tuscany and Latium – and those of Veneto and the Po Valley.<sup>65</sup> More arable land was available in antiquity than in later times.<sup>66</sup> Land reclamations were carried out in medieval and early modern Italy, but their impact was marginal.

Climatic evolution, furthermore, can play a role in increasing or reducing the availability of cultivable land. Paleoclimatology has made remarkable progress over the last few years. Thanks to the reconstruction of the yearly temperatures in the Northern Hemisphere over a long period from the third century A.D. to the present day, it is now possible to set on a new footing the traditional topic of the influence of climate on the evolution of civilizations. It is hard, however, to evaluate the influence of climate on agricultural production. Temperature is only one among the many variables involved. Information on rainfall would be certainly important to gain a clearer picture of the possible influence of climatic factors on food availability.

What we do know with some reliability is that temperatures slowly increased in the third century B.C., reached a peak around the beginning of our era, and began to decline in the third century.<sup>67</sup> The recently obtained continuous series of annual temperatures from the third century onward clearly shows a declining trend (Figure 5).<sup>68</sup> Temperatures remained low until the beginning of the so-called Medieval Climatic Optimum, which lasted from the Ninth century until 1250-1300. Then the Little Ice Age started. It lasted until the nineteenth century.

Now, we know that the interplay between temperature and agricultural production is far from simple. A lasting higher temperature, as has been suggested, might raise yield.

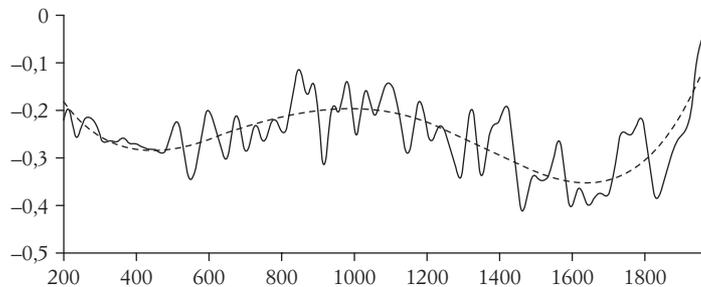


FIG. 5. Northern Hemisphere Temperatures (200-2000) (Winter Temperatures 1961-90 = 0).

Nothing certain, however, can be said on this subject. It is beyond doubt, instead, that long-term cooling moves downward the border of cereal cultivation. A long lasting one-degree decrease reduces the maximum altitude of cereal cultivation by 100-200 metres.<sup>69</sup> Such a change probably would have no significant effect on the agriculture of a quite level country; but in a country like Italy, where hills cover 13 million hectares, things are different. In this case, even in the most restrictive hypothesis, the loss of arables can exceed 5 million hectares. Even supposing a lower yield in the hills than in the plains, this decline may entail a loss of product capable of feeding 3-4 million inhabitants. This is the reason why there is indeed some correlation between the Italian demographic movement and the evolution of temperature. A 1-2 degree higher temperature could allow a free formation of natural capital and thus displace to the left the production possibility curve (our  $Y/K$ ). We may suppose that in late Republican-early Imperial Roman times climatic conditions were more favourable to population growth than during the early Middle Ages; that in the late Middle Ages a favourable climatic phase again allowed the population to grow; and that later, during the long Little Ice Age, circumstances became unfavourable to agricultural production and human reproduction. In the light of what we know today about temperature evolution, the large population size of early Imperial Italy we have suggested above does not seem so unlikely.

Specialization and geographical division of labour certainly also played a role, albeit a lesser one, in determining the availability of natural resources. Italy's specialization in cer-

tain labour and capital-intensive goods and their exportation allowed the importation of land-intensive products, especially cereals. This geographical division of labour certainly played an important role both in Roman antiquity, when wine and manufactured goods such as fine pottery and lamps were exported from Italy and wheat was imported,<sup>70</sup> and in the Middle Ages, when manufactured goods were sold outside of Italy and wheat was imported. This amounted to a net increase of Italian land thanks to trade specialization. The transport costs of those traditional economies, however, always set a limit to this kind of exchange.

*Technology.* In our model, technology is an exogenous factor. It affects interrelationships between variables by pushing the  $Y/K$  curve to the left and increasing potential for consumption and, hence, potential for population growth. The increase of capital often resulting from the introduction of new technology can enhance per worker product.

Today, technology is the main factor in changes in the production potential of the economy. It was not so in past traditional societies. The more we become familiar with ancient agrarian technology, the more we realize how advanced it was as early as the late Roman Republic. To put it simply, the main elements of traditional dry agriculture – the use of animal power, rotation of cultivations, the plough, and even the heavy wheel plough – are already well documented by the second or first century B.C.<sup>71</sup> Even though technology is an exogenous factor, it is likely that, on the left of our graph, when capital per worker is plentiful and labour productivity high, means to save mechanical power are encouraged because of the high labour costs. Slavery can be seen as a technology designed to save labour costs by enlarging the herd, so to speak, of working animals. In the Roman Republic, since military power was expanding and recruitment in the army reduced labour availability in agriculture, hence keeping labour costs high, slavery became the easiest solution. There is no reason to enslave a man unless labour productivity is substantially higher than the cost of feeding him.<sup>72</sup> In this case the value of product per slave is higher than the value of the food he consumes. Slavery was an important novelty in the Roman energy system at a time when labour was productive and hence expensive. The spread of noteworthy innovations in power technology during the last three centuries

B.C. must be regarded as an attempt to cope with the increasing costs of motive power.<sup>73</sup>

There were changes in both crops and tools in the following centuries, but they did not deeply affect productivity. The only major change in Italian agriculture before the introduction of chemical fertilizers and tractors was the arrival of maize. Maize, from the late sixteenth century onward, deeply modified agricultural carrying capacity thanks to its higher productivity, which is double that of the other cereals.<sup>74</sup> Its diffusion accelerated during the eighteenth and nineteenth centuries, especially in the Po Valley, where it became the main cultivated cereal.<sup>75</sup> Its relative impact on agriculture was lower in Central Italy and much lower in the South and the islands, because the crop needs a lot of water in its ripening period and those regions are rather dry, especially in the summer. Maize deeply modified agricultural production in quantitative terms, but not in monetary terms. The volume of calories provided by a field sown with maize was twice that of the same field sown with wheat. The price of maize, however, was half the price of wheat and, since our product is expressed in money, the  $Y/K$  curve did not move. Maize was the main factor in the rapid population increase that began in the second half of the seventeenth century. The price of the subsistence basket –  $m$  in our graph – diminishes and the intersection of the subsistence line with the curve of consumption moves to the right: from  $E$  to  $E_1$ . If the Italian population was able to attain more than 18 million inhabitants in 1800, this depended primarily on the spread of maize.<sup>76</sup>

Intensification has been defined as «the gradual change towards patterns of land use which make it possible to crop a given area of land more frequently than before».<sup>77</sup> Intensification does not necessarily require the resort to new techniques of soil exploitation. Sometimes, however, it is brought about through a series of small improvements in cultivation, or a further spread of already known innovations. Thus, soil is exploited more and more efficiently, peasants spend longer hours on the land, unexploited soil diminishes, and product per unit of land increases. In our model, population growth determines an increase of the product per unit of capital ( $Y/K$ ) and, at the same time, a decrease of the slope of the  $Y/K$  curve, which means a decline of the marginal productivity of labour. Whenever population rises, land productivity grows while labour productivity declines.

Archaeology provides much information on the use of marginal soils and deforestation to extend cereal cultivation in the late Republican age and the first century A.D. We know that forests advanced again from the late Imperial period onward.<sup>78</sup> Beginning in the late Middle Ages, the labour productivity curve decreased, reaching its lowest point at the beginning of the nineteenth century –50 percent less than in 1400. The land productivity curve, instead, rose with the population. By 1800 it was 50 percent higher than in 1400.<sup>79</sup>

*Institutions.* In our model, the effect of efficient institutions is the same as that of technology. They displace the  $Y/K$  curve to the left. Labour productivity rises and thus favours demographic growth.

The term «institutions», intended as «the humanly devised constraints that shape human interaction»,<sup>80</sup> designates both economic institutions such as markets and organizations, on the one hand, and political institutions such as the state and the spatial organization of power, on the other. If we look at the first kind of institutions, it is very hard to decide whether, in the long period under examination, these institutions became more efficient and actually capable of displacing the production function to the left. The topic has been repeatedly discussed, yet little, if anything, can be affirmed with certainty. If we compare the circulation of goods and the extension of the market in Roman antiquity, the Middle Ages, and the early Modern age, it is hard to discern a deep change capable of improving the circulation of commodities in the Mediterranean regions. On the contrary, the unification of these regions following the Roman conquest must have vigorously promoted long distance exchanges of staples and market integration. The establishing of more peaceful and safer conditions must have brought about a marked decrease in transaction costs. The suppression of piracy in the final decades of the Republic, the diffusion of a «technology of measurement» and of common metrological systems, and above all the creation of a unified monetary zone and common laws, especially regarding commerce, all contributed remarkably to this reduction of transaction costs, in so far as they reduced uncertainty and improved access to information. The later dissolution of the Mediterranean Empire must have had opposite effects.<sup>81</sup> As to transportation, as long as it was based on wind power

propelling sailing-ships, or the muscle power of mules and horses – before, that is, the revolution brought about by the introduction of steam power – the circulation of goods did not change significantly. Ships were not decidedly more efficient, say, in the sixteenth century than in the first, in spite of changes in the prevailing shipbuilding techniques; the size and capacity of Roman merchant ships, especially the grain ships, were comparable.<sup>82</sup> The road system, however, was probably more efficient in Roman antiquity than 1600 years later. As far as agriculture is concerned, institutional arrangements and contracts developed over time. In any case, it is hard to say whether they actually contributed to displace outward our production possibility curve. Their contribution was, in any case, scarce indeed until the late nineteenth century.

Things are radically different when one turns to political institutions. The expansion of Rome all over the Mediterranean and part of Central and Northern Europe in the Republican period and the early Empire certainly contributed to move outward our production possibility curve. The political organization of power managed to transfer towards Italy, and especially towards Rome, huge quantities of agricultural products, mainly grain, by means of requisitions and taxes. A high percentage of the inhabitants of Rome (about 1 million in the first century A.D.)<sup>83</sup> was fed with cereals imported from Egypt, Northern Africa, Sicily, Sardinia and other regions of the Empire. While the exports from Sicily and Sardinia can be regarded as mere internal redistribution, when one considers, as we do here, Italy's population as a whole, the importation of foodstuffs and raw materials determined a net accretion of Italy's product. If we accept the estimate that this redistribution towards Italy, assured by Rome's imperial power and through commerce, could support a population of at least 1 million people, we must admit that for a long time Italy consumed more than it produced. Roman imperialism displaced outward the production possibility curve.<sup>84</sup>

No comparable phenomenon is observable in the following centuries. During the late Middle Ages and during the early Modern age, Italian merchants imported cereals from Southern Italy,<sup>85</sup> the Near East, and Northern Africa. This importation was no longer based on the strength of the empire, but on the mercantile exchange of goods. Hence, the volume of these cereals' circulation was probably much infe-

rior to that of antiquity. Moreover, the transition from a Mediterranean imperial power to the regional power of many small states in the early Modern age hindered the inner mobility of agricultural products (limited by regulations and the payment of levies at borders). It did not favour the outward displacement of the production function.

### 5. *Interplay*

As we can see, the interplay of variables in our revised model of growth is more elaborate than in the Malthusian approach. In our model, further population growth is hampered by a combination of decreasing labour productivity, stationary technological level, and decreasing capital per worker.

We can now take a quick look at the interrelationships between the variables during phases of population growth and decline. We assume that in this economy, based on vegetable sources of energy, the rate of technological change is slow. To start Modern Growth, a boundary must be crossed. This transition is not an easy one and cannot be induced merely by population pressure.

Let us examine now the dynamics of each cycle.

*The start of growth.* The start of each cycle is characterized by a favourable  $L/K$  ratio, nearer to the origin of the axes than later. Capital per worker is plentiful. At the beginning of our history of the Italian population, three centuries B.C., density is quite low. In the tenth century, at the start of Medieval expansion, once again there lived in Italy no more than 7-8 million people. Around 1660, the Italian population was 10 million. In these cases labour productivity was high and consumption higher than the survival line. Since labour productivity was high, so were labour costs. This is the reason why, in growth phases like these, attempts were made to save labour through the introduction of labour-saving innovations such as ancient slavery, in antiquity, or water-powered machinery in the late Medieval growth period.<sup>86</sup> In these initial phases, capital productivity (and especially land productivity) was low, so  $Y/K$  was close to the origin of the axes. The conditions were ripe for demographic growth.

*The age of expansion.* Population increases more than capital. Capital per worker diminishes. The  $L/K$  ratio rises and the system moves to the right. Labour productivity diminishes and wages<sup>87</sup> diminish as a consequence. Since the average product of labour is low, there is no reason, in this phase, for enslaving human beings: the advantage you get from their work is hardly higher or it is lower than their product. The number of slaves diminishes from the first century onward.<sup>88</sup> To support the standard of living, every family works more and more. Their members increase, and each one works for longer hours. Per hectare productivity increases. Capital or land productivity rises, but the rise is slower and slower. The slope of the  $Y/K$  curve diminishes.

*The age of maturity.* The consumption curve approaches the line of survival. Living conditions for the majority of population get worse year after year.<sup>89</sup> The rate of growth of  $Y/K$  declines. Labour productivity is low. If consumption moves to the right of  $E$ , investment capability diminishes as well, since the distance between  $Y/K$  and the survival line (beyond their intersection in  $E$ ) is narrowing. Increasing density of population and worsening hygienic conditions, especially in the cities, enhance the probability of epidemics and, hence, of the reversal of the upward trend. A higher probability, however, does not imply any necessity. Population growth always brings with it the increase of mice, fleas, lice, viruses and bacteria. The probability of catastrophic events also arises as a consequence of the instability of the  $Y/K$  curve. Since agricultural production is unstable in this pre-modern world, and hence so is consumption, fluctuations of the agricultural product can result in dramatic waves of mortality. Sharp drops of the population can ensue and, with them, a new accumulation of capital: the  $L/K$  ratio moves towards the origin of the two axes. The conditions now exist for a new fluctuation.

*Population and productivity.* In the model just illustrated, population growth is inversely correlated with the marginal productivity of labour. A recent reconstruction of wages and labour productivity in Central-Northern Italy from the late Middle Ages onward allows us to test this relationship of population and labour productivity over a long period.<sup>90</sup> Since population depends primarily on itself, like an ever growing stream, we will use an auto-regressive distributed

TAB. 4. Regression of population ( $Pop$ ) on the same population a decade earlier ( $Pop_{t-1}$ ) and wage ( $W_t$ ) 1300-1820

	Coefficients	Stand. Err.	Stat t	P-value
Intercept	1308	689,42	1,89	0,063
$Pop_{t-1}$	0,90	0,06	14,81	1,57E-19
$W_t$	-408	201,04	-2,03	0,047

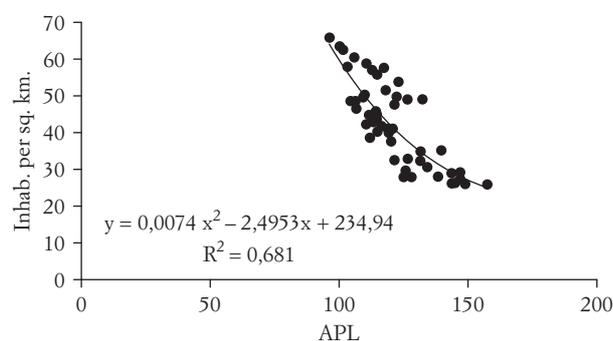


FIG. 6. Population density and per worker product 1310-1820.

lag model, where population  $Pop_t$  is a function of the same population a decade before ( $Pop_{t-1}$ ) and the real wage ( $W_t$ ),<sup>91</sup> assumed as a proxy for the average product per worker at time  $t$ :

$$Pop_t = \alpha + \Phi Pop_{t-1} + \beta W_t + \varepsilon$$

Time is measured in decades and the population is divided by 1000. The results of the regression (Table 4) are statistically significant (and  $R^2 = 0.94$ ), even though the first variable is much more significant than the second.

We could summarize these results by saying that in traditional agricultural societies the rising trend of population – fed, so to speak, by itself – is hindered and brought to a halt by decreasing returns to labour. Whenever population increases, the reduction of capital per worker implies a decline in labour productivity and an intensification of labour on land resulting in a higher per hectare product. If we plot demographic density per sq. km. against labour productivity over the long 1300-1820 period, the inverse relation appears clear (Figure 6). Around a product per worker of 100 and a density of 60-70 inhabitants

per sq. km., population must necessarily drop. A higher demographic density is not compatible with a lower productivity. The fall of population sets the premises for a new cycle. The many fluctuations around a stable mean characterizing the long-run trend of the Italian economy originate from this population-productivity relationship.

### 6. Conclusion

Every cycle has its own history. Yet population-economy mechanics presents strong similarities for about two millennia. On the whole, the level of the Italian population remained within the 7-16 million range for about 1700 years. It surpassed 16 million only in the second half of the eighteenth century, to reach 18 million in 1800. In that period, the growth rate, for the first time, began to change rapidly and radically. From 1700 to 1860, the Italian population grew at an annual rate of 4 per thousand. The novelty this time was that the outward displacement of the production function curve was far superior to those observable for past agricultural civilizations. Product, consumption, capital formation and productivity were growing continuously. While demographic growth was intensifying, the displacement of the production frontier was supporting not only the rise of population, but also the rise of a wealthier population. It was the first time.

- 1 For an extremely critical attitude toward data on the demographic size on the ancient Roman world, see T.G. Parkin, *Demography and Roman Society*, Baltimore and London, 1992, pp. 4 ff.
- 2 A review of debates on ancient population until Beloch can be found in E. Lo Cascio, «Il mondo romano e le indagini demografiche», forthcoming.
- 3 K.J. Beloch, *Die Bevölkerung der griechisch-römischen Welt*, Leipzig, 1886, and Id., *Bevölkerungsgeschichte Italiens*, Berlin-Leipzig, 1937-1961.
- 4 C.M. Cipolla, «Four Centuries of Italian Demographic Development», in D.V. Glass, D.E.C. Eversley (eds.), *Population in History*, London, 1965, pp. 570-87.
- 5 A. Belletini, «La popolazione italiana dall'inizio dell'età volgare ai nostri giorni», in R. Romano, C. Vivanti (eds.), *Storia d'Italia*, 5, I, Torino, 1973, pp. 487-532 (republished in A. Belletini, *La popolazione italiana*, Torino, 1987, pp. 3-51).
- 6 L. Del Panta, M. Livi Bacci, G. Pinto, E. Sonnino, *La popolazione italiana dal Medioevo a oggi*, Roma-Bari, 1996; and also G. Pinto-E. Sonnino, «L'Italie», in *Histoire des populations de l'Europe*, Paris, 1997, pp. 485-508.
- 7 See, as an important example, J.C. Russell, *Late Ancient and Medieval Population*, Philadelphia (Transactions of the American Philosophical Society), 1958.

- <sup>8</sup> E. Lo Cascio, «The Size of the Roman Population: Beloch and the Meaning of the Augustan Census Figures», *Journal of Roman Studies*, LXXXIV, 1994, pp. 23-40; Id., «La dinamica della popolazione in Italia da Augusto al III secolo», in *L'Italie d'Auguste à Dioclétien*, Roma, 1994, pp. 91-125; see e.g. E. Gabba, *Schiavitù nel mondo antico*, in *Enciclopedia delle Scienze Sociali*, VII, 1997, pp. 630-8, at p. 636; M. Tarpin, *L'Italie, la Sicile et la Sardaigne*, in *Rome et l'intégration de l'Empire*, 2, *Approches régionales du Haut-Empire romain*, sous la direction de C. Lepelley, Paris, 1998, pp. 1-70, at pp. 30 ff.; J. Paterson, *Hellenistic Economies. The Case of Rome*, in Z.H. Archibald, J. Davies, V. Gabrielsen and G.J. Oliver (eds.), *Hellenistic Economies*, London and New York, 1998, pp. 367-78, at pp. 375 ff.; J. Cels-Saint-Hilaire, «Citoyens romains, esclaves et affranchis: problèmes de démographie», in *Revue des Études Anciennes*, 103, 2001, pp. 443-79.
- <sup>9</sup> In Del Panta, Livi Bacci, Pinto, Sonnino, *La popolazione italiana*.
- <sup>10</sup> See especially P.A. Brunt, *Italian Manpower 225 B.C. – A.D. 14*, Oxford, 1971 (2nd ed. 1987); K. Hopkins, *Conquerors and slaves*, Cambridge, 1978, ch. 1.
- <sup>11</sup> T. Frank, «Roman Census Statistics from 225 to 28 B.C.», in *Classical Philology*, 19, 1924, pp. 329-41; A.H.M. Jones, *Ancient Economic History*, London, 1948.
- <sup>12</sup> Exemplified now in particular by W. Scheidel, «Human Mobility in Roman Italy, I: the Free Population», in *Journal of Roman Studies*, XCIV, 2004, pp. 1-26, at pp. 2-9.
- <sup>13</sup> On what follows, see esp. E. Lo Cascio, «The Population of Roman Italy in Town and Country», in J. Bintliff, K. Sbonias (eds.), *Reconstructing past Population Trends in Mediterranean Europe (3000 BC – AD 1800)*, Oxford, 2000, pp. 161-171; Id., «Il census a Roma e la sua evoluzione dall'età "serviana" alla prima età imperiale», in *Mél. de l'École française de Rome. Antiquité*, 113, 2001, pp. 565-603.
- <sup>14</sup> On the previous period see A. Marcone, «Popolazione, popolamento, sistemi colturali, spazi coltivati, aree boschive ed incolte», in G. Forni, A. Marcone (eds.), *Storia dell'agricoltura italiana*, I, *L'età antica*, 2, *L'Italia romana*, Firenze, 2002, pp. 19-62.
- <sup>15</sup> Polybius, II, 23-24.
- <sup>16</sup> D. Hume, *Of the Populousness of the Ancient Nations* (afterwords in *Essays Moral, Political and Literary*, T.H. Green, T.H. Grose (eds.), new ed., London, 1889 [1752], I, pp. 381-443); R. Wallace, *A Dissertation on the Number of Mankind in Ancient and Modern Times*, Edinburgh, 1753.
- <sup>17</sup> Both credible proportions considering the age distribution observable in a stationary model of population comparable to the Italian one, and the probable sex-ratio.
- <sup>18</sup> *Res gestae*, 8.
- <sup>19</sup> The extent of Italy within its current borders is 301,000 sq. km.
- <sup>20</sup> The urbanization of ancient Italy is illustrated in R. Laurence, «Roman Italy's Urban Revolution», in E. Lo Cascio, A. Storch Marino (eds.), *Modalità insediative e strutture agrarie nell'Italia meridionale in età romana*, Bari, 2001, pp. 593-611; on the growth of Rome, see E. Lo Cascio, «La popolazione», in Id. (ed.), *Roma imperiale. Una metropoli antica*, Roma, 2000, pp. 17-69.
- <sup>21</sup> E. Lo Cascio, «Le professiones della *Tabula Heracleensis* e le procedure del census in età cesariana», in *Athenaeum*, 78, 1990, pp. 287-317; «Il census a Roma», pp. 591 ff., on the evidence provided by the *Tabula Heracleensis*: M. Crawford (ed.), *Roman Statutes*, I, London, 1996, n° 24, lines 142 ff.
- <sup>22</sup> *Div. Iul.* 41. 3: see E. Lo Cascio, «Le procedure di recensio dalla tarda Repubblica al tardoantico e il calcolo della popolazione di Roma», in *La Rome impériale: démographie et logistique*, Roma, 1997, pp. 3-76.
- <sup>23</sup> A credible estimate, in view of the probable life expectancy at birth of males and females, of the probable sex-ratio, and of the assumption of at best a mod-

- est rate of increase: Lo Cascio, *The Size of the Roman Population*; Id., *La dinamica della popolazione in Italia*.
- 24 The figure we possess for the *civium capita* registered in the census of A.D. 47 (5,984,072, according to Tacitus, *Annales*, 11.25), apart from being less reliable, probably reflects not so much the possible natural increase of the citizen population over 33 years, as the grant of the Roman citizenship to provincial individuals and communities and a high rate of manumission of slaves (it must be remembered that the slave of a Roman citizen, when freed, became Roman citizen as well). The higher figures of the *civium capita* given by Eusebius and Jerome for the same census are much less reliable.
- 25 On medieval and modern urbanization rates, see especially P. Malanima, «Italian Cities 1300-1800. A Quantitative Approach», in *Rivista di Storia Economica*, XIV, 1998, pp. 91-126; and P. Malanima, «Urbanisation and the Italian Economy during the last Millennium», in *European Review of Economic History*, 9, 2005, pp. 97-122.
- 26 See especially A.N. Sherwin-White, *The Roman Citizenship*, Oxford, 1973 (2nd ed.), part II; and the figures tentatively proposed by Scheidel, «Human Mobility in Roman Italy».
- 27 E. Lo Cascio, «Il rapporto uomini-terra nel paesaggio dell'Italia romana», in *Index*, 32, 2004, pp. 107-21.
- 28 See e.g. S. Mazzarino, *L'Impero romano*, Roma, 1956, p. 221 (after Seeck).
- 29 E. Lo Cascio, «Fra equilibrio e crisi», in A. Schiavone (ed.), *Storia di Roma Einaudi*, II, 2, Torino, 1991, pp. 701-31; R.P. Duncan-Jones, «The impact of the Antonine Plague», in *Journal of Roman Archaeology*, 9, 1996, pp. 108-36; for Egypt, W. Scheidel, *Death on the Nile. Disease and the Demography of Roman Egypt*, Leiden-Boston-Köln, 2001, pp. 162 ff.
- 30 G. Pinto, «Dalla tarda antichità alla metà del XVI secolo», in L. Del Panta, M. Livi Bacci, G. Pinto, E. Sonnino, *La popolazione italiana*, p. 18.
- 31 W. Scheidel, «Progress and Problems in Roman Demography», in Id. (ed.), *Debating Roman Demography*, Leiden-Boston-Köln, 2001, pp. 1-81, at p. 69: «the empire ought to have recovered by the early fourth century».
- 32 M. Rouche, *Le Haut Moyen Age*, in *Histoire des populations de l'Europe*, Paris, 1997, p. 148.
- 33 Pinto, «Dalla tarda antichità alla metà del XVI secolo», p. 27.
- 34 Pinto-Sonnino, «L'Italie», p. 486.
- 35 See especially P. Toubert, *Dalla terra ai castelli. Paesaggio, agricoltura e poteri nell'Italia medievale*, G. Sergi (ed.), Torino, 1995.
- 36 On the population of Italian cities at the end of the Middle Ages, see especially M. Ginatempo, L. Sandri, *L'Italia delle città. Il popolamento urbano tra Medioevo e Rinascimento (secoli XIII-XVI)*, Firenze, 1990.
- 37 Pinto, «Dalla tarda antichità alla metà del XVI secolo», p. 42.
- 38 The available figures for Italy's population are presented and discussed in P. Malanima, *L'economia italiana. Dalla crescita medievale alla crescita contemporanea*, Bologna, 2002, App. 1.
- 39 As suggested by D. Herlihy, *The Black Death and the Transformation of the West*, Cambridge (Mass.), 1997.
- 40 In particular for Tuscany see M. Breschi, P. Malanima, «Demografia ed economia in Toscana: il lungo periodo (secoli XIV-XIX)», in M. Breschi, P. Malanima (eds.), *Prezzi, redditi, popolazioni in Italia: 600 anni (dal secolo XIV al secolo XX)*, (SIDES), Udine, 2002, pp. 109-142.
- 41 On this new phase, see A. Bellettini, «L'evoluzione demografica nel Settecento», in Id., *La popolazione italiana*.
- 42 A. Maddison, *The World Economy. A Millennial Perspective*, Paris, 2001.
- 43 We are not sure when this upward trend actually began.

- <sup>44</sup> We will return to this topic later. We subscribe, however, to the opinion on traditional agrarian economies put forward by E.A. Wrigley in several essays, especially those collected in *Poverty, Progress and Population*, Cambridge, 2004.
- <sup>45</sup> Although comparisons of per capita product in different periods are always hard. See especially R.W. Goldsmith, «An Estimate of the Size and Structure of the National Product of the Early Roman Empire», *Review of Income and Wealth*, 30, 1984, pp. 263-88; Id., *Premodern Financial Systems. A Historical Comparative Study*, Cambridge, 1987; P. Temin, «Estimating GDP in the Early Roman Empire», in E. Lo Cascio (ed.), *Innovazione tecnica e progresso economico nel mondo romano*, Bari (forthcoming); and, for a later period, P. Malanima, «Measuring the Italian Economy 1300-1861», in *Rivista di Storia Economica*, XIX, 2003.
- <sup>46</sup> At least from the late Middle Ages onward: Malanima, «Measuring the Italian Economy».
- <sup>47</sup> The main features of ancient Roman demography are summarized by W. Scheidel, «Progress and Problems in Roman Demography», in W. Scheidel (ed.), *Debating Roman demography*, Leiden, Boston, Köln, 2001.
- <sup>48</sup> On Medieval and early Modern urbanization in Italy, see Malanima, «Urbanisation». For a comparison with Roman antiquity, see N. Morley, *Metropolis and Hinterland. The City of Rome and the Italian Economy 200 B.C. – A.D. 200*, Cambridge, 1996, p. 182.
- <sup>49</sup> For the sources of the data in the table, see Malanima, *L'economia italiana*, p. 30.
- <sup>50</sup> Lo Cascio, «Il rapporto uomini-terra nel paesaggio dell'Italia romana», p. 109.
- <sup>51</sup> For a recent example, see N. Morley, «The Transformation of Italy, 225-28 B.C.», in *Journal of Roman Studies*, XCI, 2001, pp. 55 ff.
- <sup>52</sup> The topic has been discussed by J.E. Cohen, *How Many People can the Earth Support?*, New York and London, 1995, ch. 12. Useful H. Le Bras, *Les limites de la planète*, Paris, 1994.
- <sup>53</sup> On the quantitative importance of the chestnut tree for Italian agriculture in 1891, see G. Federico, «Una stima del valore aggiunto dell'agricoltura italiana», in G. Federico, S. Fenoaltea, V. Zamagni (eds.), *I conti economici dell'Italia*, Roma-Bari, 3, 2000, 2, pp. 49-50. Useful information on chestnut production in Italy is also to be found in G. Cherubini, «Le campagne italiane dall'XI al XV secolo», in *Storia d'Italia*, IV, G. Galasso (ed.), Torino, 1981. Chestnut certainly played a role in Roman diet, as borne out by several passages in Pliny the Elder, Columella, and even Apicius' *De re coquinaria*, but it must have been regarded as a humble food, as can be deduced from Martial 5, 78, 15.
- <sup>54</sup> On this topic, see E. Sereni's old but still useful *Storia del paesaggio agrario italiano*, Roma-Bari, 1974 [I ed. 1961].
- <sup>55</sup> Of the 5 million hectares of forests recorded in 1861, only a part was located on the hills and in the plains; the rest were on the mountains.
- <sup>56</sup> Useful on the topic G. Forni, «La produttività», in G. Forni, A. Marcone (eds.), *Storia dell'agricoltura italiana*, I, 2, pp. 431-40.
- <sup>57</sup> By Morley, «The Transformation of Italy», p. 56.
- <sup>58</sup> A. De Maddalena, «L'Europa rurale (1500-1750)», in C.M. Cipolla (ed.), *Storia economica d'Europa*, Torino, 1979, II, Appendix.
- <sup>59</sup> M.S. Spurr, *Arable Cultivation in Roman Italy c. 200 B.C. – c. A.D. 100*, London, 1986, pp. 56 and 103 ff.
- <sup>60</sup> Spurr, *Arable cultivation*, pp. 116 ff., and M. Ambrosoli, *Scienziati, contadini e proprietari. Botanica e agricoltura nell'Europa occidentale*, Torino, 1992.
- <sup>61</sup> See E.A. Wrigley's fine reworking of the classical model, *The Limits to Growth: Malthus and the Classical Economists*, in M.S. Teitelbaum, J.M. Winter (eds.), *Population and Resources in Western Intellectual Traditions*, Cambridge, 1988.

- <sup>62</sup> R. Solow was already conscious of the difficulty of adapting his growth theory to pre-modern economies. See R. Solow, *Growth Theory. An Exposition*, London, 1970, ch. 2.
- <sup>63</sup> In 1861, land accounted for about half of Italy's national wealth: R.W. Goldsmith, S. Zecchini, «The National Balance Sheet of Italy (1861-1973)», *Rivista di Storia Economica*, n.s., XV, 1999.
- <sup>64</sup> Wrigley, *Poverty, Progress and Population*, p. 76.
- <sup>65</sup> Much information on this subject can be found in G. Kron, «The Augustan Census Figures and the Population of Italy», *Athenaeum*, 93, 2005, pp. 441-95.
- <sup>66</sup> P. Horden, N. Purcell, *The Corrupting Sea. A Study in Mediterranean History*, Oxford, 2000, pp. 310 ff.
- <sup>67</sup> An overview is proposed by M. Pinna, *Le variazioni del clima. Dall'ultima grande glaciazione alle prospettive per il XXI secolo*, Milano, 1996, pp. 118 ff. For a recent long-term reconstruction, see B.E. Berglund, «Human Impact and Climate Changes-Synchronous Events and a Causal Link?», in *Quaternary International*, 105, 2003.
- <sup>68</sup> Figure 5 is based on M. Mann, P.D. Jones, «Global Surface Temperatures over the past two Millennia», *Geophysical Research Letters*, 30, n° 15, August, 2003 (data over 2000 years are available from the World Data Center for Paleoclimatology. Data Contribution Series 2003-051. NOAA/NGDC Paleoclimatology Program, Boulder CO, USA).
- <sup>69</sup> On this subject, it is useful to consult the following article by Bohzong Li, although it deals with the Chinese economy: «Changes in Climate, Land, and Human Efforts. The Production of Wet-field Rice in Jiangnan During the Ming and Qing Dynasties», in M. Elvin, L. Ts'ui-jung (eds.), *Sediments of time. Environment and Society in Chinese History*, Cambridge, 1998, pp. 447-83.
- <sup>70</sup> The evidence for exportation of Italian wine towards many regions of the Empire in the Late Republic and at the beginning of the Empire is massive: see e.g. C. Panella, «La distribuzione e i mercati», in A. Giardina, A. Schiavone (eds.), *Società romana e produzione schiavistica*, II, *Merci, mercati e scambi nel Mediterraneo*, Roma-Bari, 1981, pp. 54-80, and 273-5; A. Tchernia, *Le vin de l'Italie romaine*, Roma, 1986, ch. II; the evidence for the importation of grain to places different from Rome is admittedly less conspicuous, but see, e.g., the tablets in the so called «archive of the Sulpicii», which document the arrival of Egyptian grain at Puteoli (G. Camodeca, «Puteoli porto annonario e il commercio del grano in età imperiale», in *Le ravitaillement en blé de Rome et des centres urbains des débuts de la République jusqu'au Haut-Empire*, Naples-Rome, 1994, pp. 103-28), some of which was certainly reserved for local consumption (for instance at Pompeii: see J. Andreau, «Pompeii et le ravitaillement en blé et autres produits de l'agriculture [1er siècle ap. J.-C.]», in *Le ravitaillement en blé de Rome*, pp. 129-36, at pp. 133 ff.) or for consumption in other places than Rome.
- <sup>71</sup> See especially Spurr, *Arable Cultivation in Roman Italy*.
- <sup>72</sup> In this perspective, the following article is still important: E. Domar, «The Causes of Slavery or Serfdom: A Hypothesis», in *Journal of Economic History*, 30, 1970, pp. 18-32.
- <sup>73</sup> On mechanical discoveries and innovations in Roman economy, see especially A. Wilson, «Machines, Power and the Ancient Economy», in *Journal of Roman Studies*, 92, 2002, pp. 1-32 and the papers collected in Lo Cascio (ed.), *Innovazione tecnica e progresso economico* (forthcoming).
- <sup>74</sup> G. Coppola, *Il mais nell'economia lombarda*, Bologna, 1979.
- <sup>75</sup> F. Cazzola, *Storia della campagna padana dall'Ottocento a oggi*, Milano, 1996.
- <sup>76</sup> We do not consider here the spread of the mulberry tree and rice, which were both introduced in Italy in the late Middle Ages, but had no direct connection with demographic evolution.
- <sup>77</sup> E. Boserup, *The Conditions of Agricultural Growth*, London, 1965, p. 43.

- <sup>78</sup> Horden, Purcell, *The Corrupting Sea*, pp. 328 ff.
- <sup>79</sup> G. Federico, P. Malanima, «Progress, Decline, Growth: Product and Productivity in Italian Agriculture, 1000-2000», in *Economic History Review*, LVII, 3, 2004, pp. 437-64.
- <sup>80</sup> W. Scheidel, S. von Reden (eds.), *The Ancient Economy*, Edinburgh, 2002, p. 1.
- <sup>81</sup> See E. Lo Cascio, «La 'New Institutional Economics' e l'economia imperiale romana», in M. Pani (ed.), *Storia romana e storia moderna. Fasi in prospettiva*, Bari, 2005, pp. 69-83.
- <sup>82</sup> «The size and capacity of Roman ships was not exceeded until the introduction of steam power in the nineteenth century AD»: K. Greene, *The archaeology of the Roman Economy*, London, 1986, p. 25.
- <sup>83</sup> Lo Cascio, «La popolazione».
- <sup>84</sup> Many elements on the topic in W. Harris, *War and Imperialism in Republican Rome*, Oxford, 1979.
- <sup>85</sup> This trade was a form of internal redistribution without any influence on production potential.
- <sup>86</sup> P. Malanima, *I piedi di legno. Una macchina alle origini dell'industria medievale*, Milano, 1988; and P. Squatriti, *Water and Society in Early Medieval Italy*, Cambridge, 1998.
- <sup>87</sup> The term wage includes here every kind of labour reward, even the quota of product that the peasant family keeps for itself after paying for the lease on its land (in kind or money).
- <sup>88</sup> The end of the great wars of conquest under Augustus also meant the end of mass enslavements and the necessity to resort to other sources of slaves, like slave-breeding, trade, or the enslavement of exposed children within the Empire. Indubitably there was a fall of the supply of slaves which must have resulted in a strong increase of their price: see E. Lo Cascio, *Considerazioni sul numero degli schiavi e sulle loro fonti di approvvigionamento in età imperiale*, in W. Suder (ed.), *Etudes de démographie du monde gréco-romain*, Wrocław, 2002 (Acta Universitatis Wratislaviensis, ser. Antiquitas 26), pp. 51-65.
- <sup>89</sup> On the unfavourable living conditions of the Roman population in the imperial age, see B.W. Frier, «More is Worse: Some Observations on Population of the Roman Empire», in W. Scheidel (ed.), *Debating Roman demography*, pp. 139-59.
- <sup>90</sup> The data in Tab. 4 and Fig. 6 concern Central-Northern Italy and are based on Federico-Malanima, «Progress, Decline, Growth».
- <sup>91</sup> The lowest value of the index of real wage is 0.73 and the highest 2.79.