Economy and population in Italy 1300-1913

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Is population positively related to the scale of the economy and to economic development, or rather is it an impediment to economic expansion? On this issue, two different views – the first which considers population as a factor of economic success (*positive view*), the second which sees population as a threat (*negative view*) – have coexisted for long time.

Until three centuries ago the positive view prevailed. Population was ordinarily deemed to be the real wealth of a country, the backbone of its military force and economic strength. Indeed, in agricultural societies, 'number' was at the very root of power in all its aspects, including the economic one.

The negative view was sustained by the classical economists and in particular by D. Ricardo and R.T. Malthus. Their approach became one of the main foundations of modern economics as a science. In the opinion of classical economists, the possibilities of technical progress were limited and, on the whole, unable to provide men with the power to exploit natural resources much further. Population growth inevitably resulted in diminishing natural resources per worker, declining productivity, and finally death, seen as a process of readjustment whereby the compatibility between men and resources was re-established. Capital formation could only temporarily delay this declining trend. These economists were, however, pessimistic about the possibilities of contrasting the inner tendency of any economy towards depression.

Slowly, from the 1960s onwards, a new positive approach on population-growth began to gain success, first of all among the historical demographers. The reconstruction put forward by the agrarian economist E. Boserup in 1965 (Boserup 1965) was deemed convincing by many of these. According to Boserup, population increase, rather than representing a danger to economic progress, fostered or gave rise to agricultural innovation. In agrarian economies the growth in population was, in her opinion, the main cause of a keener exploitation of resources. Demographic growth pushed workers to exploit increasingly natural resources, progressing from superficial exploitation of the soil through to bush-fallow cultivation, to short-fallow cultivation, to annual cropping, to more elaborate kinds of agrarian rotation and on to the introduction of more efficient tools and ploughs. According to Boserup, population rise and technical innovation in agriculture progressed simultaneously. This approach was later extended by the same author from agriculture to any kind of technical innovation; not only in the field of agriculture, but in indus-

SIDeS, «Popolazione e Storia»,
2/2007, pp. 15-40

try and services as well (Boserup 1981). Population was, in any case, a force supporting innovation and development.

Despite the attempts to return to the classical orthodoxy accomplished in the 1970s with the Malthusian revival and environmental economics, the positive approach gained ground. The recent revision of the neoclassical theory of growth, through the endogenous theory of growth, and the more recent so-called unified growth theory, have been the mainstays of a new positive view of the population-economy relationship, although this approach is not directly linked to the boserupian view (Galor, Weil 1999; Galor 2005). The increase in population is now seen by many economists as the root of growth since it increases the human exchange of useful knowledge, strengthens the formation of human capital and enhances technological progress (Kremer 1993). Since economic growth is based on knowledge and knowledge is supported by the human exchange of information, then greater population means further opportunities for growth[1].

It is not our task to discuss such wide-ranging perspectives on the economy-population relationship, which often encompass very long historical periods and the world scale on the whole. Much more modestly we will deal with a shorter, though still relatively lengthy, epoch in the history of a specific country, Italy – from 1300 until the First World War –; and in particular we will focus on the Centre and the North of this country (the areas best enlightened by historical research). We will examine variables such as population, resources, capital formation, technical change, labour productivity and land productivity. The objective is to describe in a simple, but complete, model the dynamics of the population-economy relationship during these centuries. Ordinarily, when dealing with pre-modern centuries, economists and economic historians are used to considering England as a benchmark. This country, however, was the exceptional first comer when considered from a European perspective. Our choice of Italy is advantageous as it represents the norm in respect to the rest of Europe .

The work is organised as follows. We will start (par. 1) by describing the production function in its main components in the way we think characterised this type of pre-modern – mainly agrarian – economy. We will then examine several variables: labour (par. 2), capital and resources (par. 3), human capital and techniques (par. 4), per capita and aggregate product (par. 5) and the interaction of these variables in the complete model (par. 6).

Our approach to the definition of variables and to the determining of the dynamics, is, as we will recall in the conclusions, essentially classical-neoclassical.

1. The starting point: the production function

1.1. The variables. In order to build a simple stylised representation of a pre-modern economy one needs to briefly recall its main characterising features. The economy we are dealing with is essentially agrarian. Both in terms of the share of employed labour and final output, the agriculture sector is indeed the most relevant one. Urban population is quite a small fraction of total population, ordinarily representing 5-20% of the inhabitants. Yet, the percentage of the non-agricultural population is higher[2]. Although we do recognise the presence of an urban population and non-agricultural product, for simplicity's sake we will compress our model into a single sector. After all, looking at a pre-modern economy and especially at its relationship with population, agricultural product should be the central focus. From agriculture it accrues the support for living population and the possibilities for its multiplication.

Animals, physical equipment and especially raw labour are all jointly employed to work land and to produce agricultural output. Such output can be alternatively destined to human consumption, to animal feeding, to investments in as much as reproduction of seed stock and of other resources employed in production, or to unproductive activities. Of course, the produce of agriculture is a compound basket of a wide range of products. However, for the sake of simplification, we describe this economy as a system in which a single agricultural product, let us say a cereal, Y, is produced. This is the only input of biological engines such as men and working animals. By means of the metabolism of this input, matter is modified (in its form or position) in order to face human needs or wishes. In addition, this product can be used as seed. Both labour (L) and capital (K) are converters of this input in useful energy according to the production function

$$Y = AF(K,L) \tag{1}$$

Land and other natural resources are encompassed in K[3].

Indeed, while standard economic literature always considers Y as measured in value (real or nominal), we will instead consider Y as measured in energy, and specifically in joules (or calories, if you like). Such energy can be destined to sustain existing human raw labour (consumption) and to increase it, or to sustain and increase animal stock, to extend physical capital or even land. Indeed, the construction of a new building, for example a barn to store wheat, involves the procurement of the necessary materials (wood) and it requires a specific effort and energy expenditure. Of course, by extending the argument, the same applies to the construction of other objects such as a palace or a church. In these activities we have a change in the matter and the environment by means of the energy provided through the metabolism of the only good produced in this simplified agrarian economy.

Both L and K (energy converters) are *accumulable* factors in the sense that both can be endogenously increased by employing final output, Y. In this context, the possibility to accumulate capital implies that this can change when enough resources in the system are channelled to this objective. However, given that natural usable resources, such as land, cannot greatly change and given that natural resources are jointly employed with labour, only relatively small adjustments are really affordable in terms of energy expenditure. If small changes of capital are affordable with relatively small amounts of energy, large changes are unaffordable in terms of energy outlay. For this reason, we take the stock of capital to be only slightly modifiable. In fact, as we will see in more details, capital during the period we analyse tends to remain constant at a long-term equilibrium value. We also do not exclude the possibility that K can exogenously change because of external factors such as climatic changes (both in the short and long run). Indeed, the opinion held by the classical economists that natural resources are fixed is actually impossible to support, given the influence of climatic changes on the entity of these. Particularly harsh weather, for example, certainly reduces land fertility (that is, the efficiency of this main energy converter). Long-term climatic changes can reduce or widen the extension of arable land if this includes hilly and mountainous territory. In fact, colder weather forces cultivation below heights which would otherwise supply usable land. This is particularly true in the hilly and mountainous Italian landscape. Hence, one can consider the agricultural capital K as a variable which changes over time, like labour, since it includes both natural and manufactured resources.

The state of technology is captured by the parameter A. This incorporates the technical content of tools, as well as the stock of knowledge, expertise and skills employed in the process of energy conversion (production): that is all those factors which are able to increase the efficiency of an energy converter (the ratio of the output of useful energy as to the total energy input). Borrowing more recent terminology, one would call this latter factor human capital. This expertise is essentially uniform among workers and does not change greatly over time in the period we are considering. Certainly, the overall stock of knowledge in this pre-modern economy is not insignificant. Scientific advancement, art and human sciences are not steady. Yet, their application to production process is still not relevant.

1.2. The intensive production function. Following a standard practice in economics, we will assume specific features for this production function:

1) constant returns to scale in its two arguments K and L: doubling the quantities of K and L, with A held fixed (that is technique and human capital), doubles the amount produced;
2) marginal product of both factors, K and L, is positive, but decreasing. In short, $F_K > 0$, $F_L > 0$, $F_{KK} < 0$, $F_{LL} < 0$. Marginal returns to L and K are diminishing.

These features of the production function, among others, offer the clear advantage of permitting us to express variables in intensive form. In fact, equation can be rewritten as:

$$\frac{Y}{K} = AF\left(\frac{L}{K}\right) \tag{2}$$

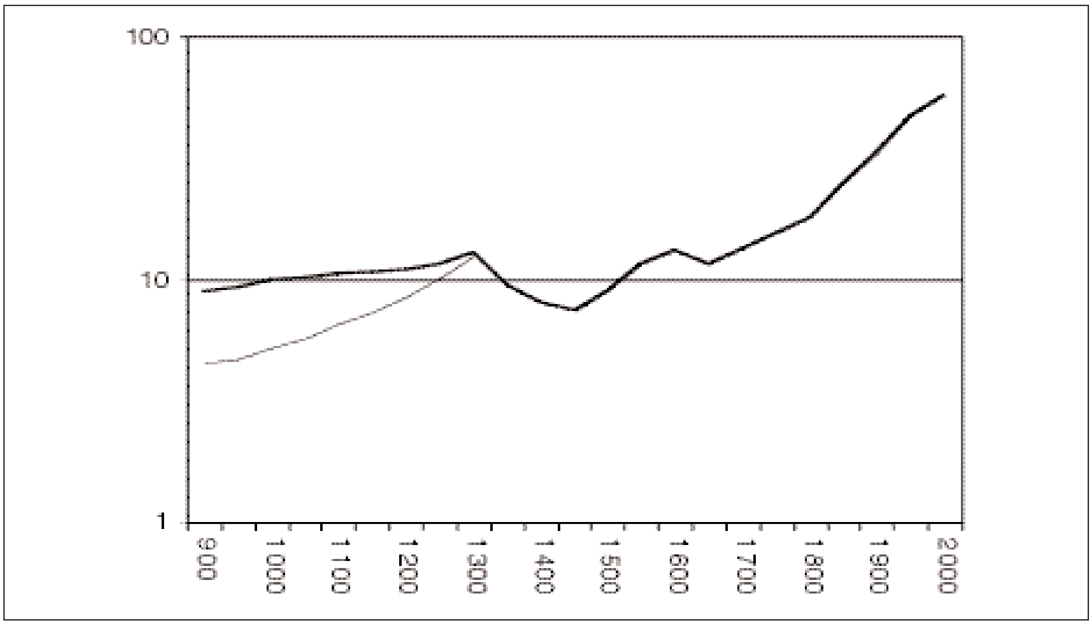
where Y/K is the amount of output per unit of capital and L/K, the amount of labour per unit of agricultural capital[4]. This intensive form of the production function is similar to the one employed primarily by Solow 1956 and 1970. Solow's model assumes population growth as an independent variable characterized by a constant rate of growth. In our model, by contrast, following the classical tradition, population depends on economic variables and is not assumed as a constant.

We now turn to a brief analysis of L, K and A: the right side of the previous function. Later we will examine the left side: product (Y).

2. Population and labour (*L*)

2.1. The last millennium. For Italy as well as for other European regions margins of uncertainty exist about the level and trend of the late medieval and early modern population. For Italy these margins are, however, narrower than for other countries, at least from 1300 onwards (Fig. 1)[5].

Fig. 1. *The Italian population between 900 and 2000 (with two plausible trends for the period 900-1300 (log scale)*



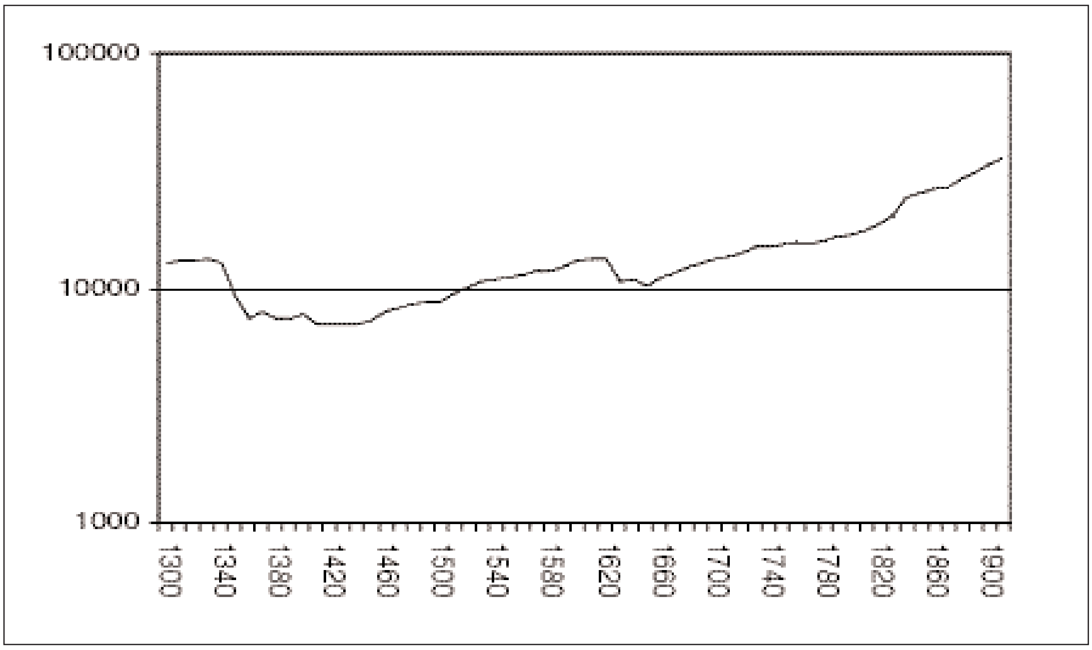
If we look at the last millennium of Italian demographic history, we single out three phases of about 3-4 centuries each:

1) slow progress of the medieval era, starting in the 9th-10th centuries and ending in the first half of the 14th. There is no certainty about the rate of growth during this long epoch; rates between 1 and 2.5 per thousand per year being equally plausible at the present state of research;
2) long stability between 1300 and 1660. If we compare the population in these two years, the rate of growth was negative: Italy lost 0.35 inhabitants per thousand per year;
3) from 1660 until 2000 population grew in Italy at the astonishing rate of 4.5 per thousand per year. Taking migration from Italy into account, the Italian population grew much more.

The period we analyse, 1300-1910, includes the second of the three phases just examined and the start of the third: pre-modern stability, we could call the first of these two periods and the start of modernization or demographic transition, the second (Fig. 2).

2.2. The short period. Over the long term, data referring to Italy show the occurrence of sizeable drops in population size, due to plagues and especially to the three

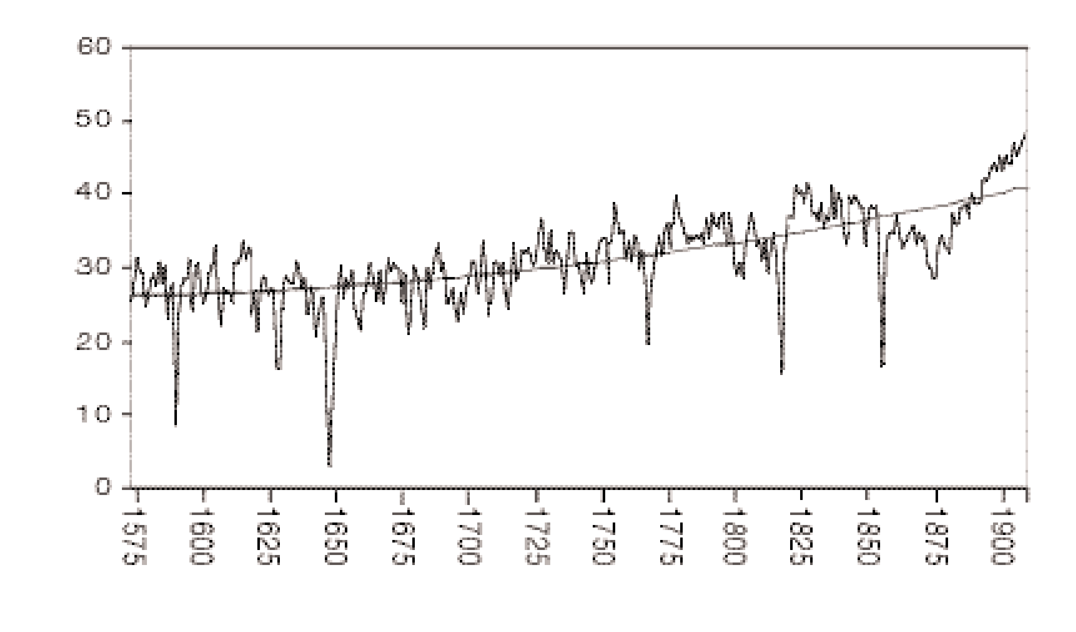
Fig. 2. *Italian population 1300-1910 (000) (log scale)*



big epidemics striking at the same time a wide portion of Italian territory: 1348-49, 1629-30, 1656-58[6]. Long-term figures, however, hide short-term fluctuations due to local epidemics and famines. An exemplification of short-term movements in population can be obtained by examining the demographic history of Tuscany which is better known than that of other Italian regions. The graph of life expectancy in Tuscany in the long period 1575-1910 clearly shows short-term fluctuations due to mortality crises. The sharpest falls are caused by epidemics, while the lesser ones are mainly due to cereal shortages. We see that the rise in life expectancy was a relatively late event in Tuscany (as in Italy on the whole). At the end of the 19th century serious crises were still relatively frequent (Breschi, Malanima 2002)[7] (Fig. 3).

2.3. Labour Although researchers do not know very much about the structure of employment in late medieval and early modern centuries, some estimation of its main features can be drawn from the data of the first national censuses held in 1861, 1871 and 1881[8]. Indeed, modern growth starts in Italy only in the 1880s[9], and up until then, the structure of labour market, as well as population composition, remained virtually unchanged. Therefore, one can argue that the demographic structure and labour market in earlier centuries in Italy must have been similar to that which we find in the first decades after the Unification. At this point in time, population in working age – let's call it labour force – was 55-60% of the total and almost 60% of this population was employed in agriculture. Hence, with a certain degree of confidence, it is possible to deduce that about 50-60% was also the labour force in late medieval and early modern centuries, out of which 60% was employed in agriculture:

Fig. 3. *Life expectancy in Tuscany 1575-1910*



	% on labour force	% on population
Agriculture	60	35-40
Industry and services	40	20-30

Only for the sake of simplification, we will describe this economy as one in which labour represents a fixed percentage of population; being aware, however, that, given population in working age – between 15 and 65 years –, the participation rate notably varied in pre-modern economies. In fact, this was higher in epochs of food shortage, when population was higher too, and lower in periods of low population density. Similar behaviour of the labour market has been noted in modern underdeveloped agriculture economies (Berg 1962). An inverse relationship existed between supply of labour and wage rate at low levels of wage, especially for women. By contrast, in modern economies, there is a positive relationship between labour supply and the wage rate. During the centuries we are dealing with there was, in Italy, a true *intensification of labour* in agriculture, while, as we will see later, wage rates were diminishing. Arboriculture – especially vineyard and mulberry tree cultivation – spread from the late Middle Ages onward. The diffusion of maize as from the 17th century, implied the employment of a much greater labour force in Spring, which was previously a slack season for the peasant family. Later, from the 18th century on, proto-industrial activities also progressed[10]. The idea of an intensification of labour and intensification of land is actually supported by direct and indirect evidence, as we will see.

3. Resources (*K*)

3.1. Land and population. In pre-modern economies, labour as a factor of production, is to be conceived strictly in connection with capital, as classical economists strongly maintain. Production is assumed to be a function of land and a *dose* of labour-cum-capital input (Samuelson 1978). More formally, labour and capital enter the production function in fixed proportion and with a close to zero degree of substitutability. Yet, this is a very strong assumption and one cannot overrule the idea that to some degree labour can be substituted for capital. This is particularly true when, as we do, animal stock or even land are enclosed into capital. Still the ratio of labour to capital remains a crucial feature in this framework since it provides a measure of resources per capita endowment and it needs to be measured.

A first, but imperfect – indicator of the link population-resources is provided by the population density. A comparison with the other European regions reveals the high Italian density (Tab. 1)[11].

With the exceptions of Belgium and The Netherlands, Italy is among the most inhabited areas of Europe. Only from 1800 onwards England begins to overcome Italy.

In terms of arables the density of the Italian population is even higher. Italy shares the character of its physical structure with other Mediterranean regions. Plains are scarce; cereal production per hectare is modest; the lack of arable lands is partially compensated by the availability of soils suitable for the cultivation of trees and in particular for vineyards. In Italy, hilly terrain constitutes 40% of the

Tab. 1. *Density of population in Europe 1300-1870 (inhab. per km²)*

	Km² (000)	1300	1400	1500	1600	1700	1800	1870
Scandinavia	1.198	2.1	1.2	1.3	2.0	2.4	4.4	8.0
England (Wales)	151	29.8	17.9	23.2	29.5	36.1	61.3	152.3
Scotland	79	12.7	8.9	10.1	12.7	15.2	20.6	43.3
Ireland	84	16.7	8.3	9.5	11.9	22.6	61.9	69.0
Netherlands	33	24.2	18.2	28.8	45.5	59.1	63.6	110.6
Belgium	30	41.7	33.3	46.7	53.3	66.7	96.7	163.3
France	544	29.4	22.1	27.6	34.0	39.5	53.3	69.9
Italy	301	41.5	26.6	29.9	44.2	44.9	60.1	93.0
Spain	505	10.9	8.9	9.9	13.5	14.7	20.8	32.1
Portugal	92	14.1	11.4	13.0	14.1	21.7	31.5	46.7
Switzerland	41	19.5	12.2	19.5	24.4	29.3	41.5	65.9
Austria (Czech., Hung.)	626	16.0	14.4	18.4	20.4	24.8	38.8	57.0
Germany	543	23.9	14.7	16.6	29.8	26.0	45.1	75.5
Poland	240	8.3	6.3	8.3	10.4	11.7	17.9	30.8
Balkans	516	11.6	9.7	10.7	13.6	16.6	23.3	45.9
Russia (European)	5400	2.8	2.0	2.8	3.0	2.4	6.5	11.7
Europe	10.383	9.0	6.5	8.0	10.3	11.1	18.2	29.9
Europe (without Russia)	4.983	15.8	11.4	13.6	18.3	20.4	30.8	49.6

surface (between 300 and 6-700 metres on the sea level); another 40% is mountainous (more than 700 metres on the sea level). Only 20% is plain. All in all, arable land covered 45% of the Italian territory in the traditional agriculture of the past: that is all of the plains and part of the hilly terrain (SVIMEZ 1961, I).

If we simply assume that arable land constituted 45% of the whole surface and divide it by the only existing estimate of the agricultural workers (Federico, Malanima 2004) – around 40% of population –, arable land per worker halved from the 15th century until 1800 (Tab. 2).

Tab. 2. *Hectares per worker in Italy 1300-1870*

1300	2.9
1400	4.5
1500	4.2
1600	2.8
1700	2.6
1750	2.3
1800	2.1
1870	1.2

Considering that the other European countries with similar population densities in this long period were endowed with a far higher proportion of arables, land per worker results in Italy sensibly lower than in other regions of the continent and, as a consequence, the pressure on natural resources stronger.

3.2. Investment. A simple ratio workers-arables is, however, far from a complete and satisfactory measure of per capita resources availability. The extent of the arables is not a stable percentage of the total available soil in the period with which we are dealing and we know very little about the working time per year. We have already referred to the intensification of labour on one hand and already said that natural resources were not constant. They can be augmented by exogenous factors, such as climatic changes, and by endogenous factors, that is investment in terms of capital and labour by landowners and peasants. This point requires a specification. Since the only product of our economy is measured in energy content, investments of capital and labour by landowners and peasants merely implies that part of the input of energy is not spent for consumption, but to create or enhance those converters which are different from the human converters: that is arables, tools… Both the endogenous and exogenous factors deserve further investigation if one wants to assess investment and capital formation in agriculture.

Although in agricultural societies the potential for capital formation was high, given the unequal distribution of income, the actual productive investment, was, all considered, relatively low. This has two alternative, though not exclusive, explanations. On the one hand, the low formation of new capital was due to the high level of capital depreciation. The short physical life of capital goods required, in agricultural societies, a high proportion of savings in order to meet the yearly depreciation

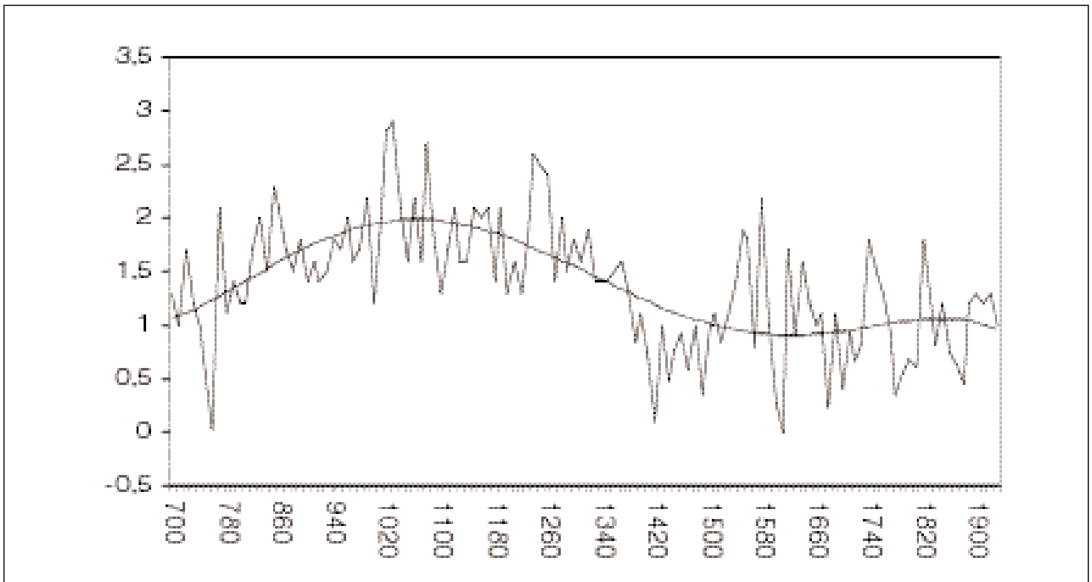
(Kuznets 1968, 48). On the other hand, part of the investment was destined to produce totally unproductive, or low productive, fixed capital – buildings, palaces, churches… – . Given technical stability and low returns to capital in the agricultural sector, investments in this sector were low. To the question, often asked by historians, if capital formation was low because the rich Italian families employed their incomes (in this framework accumulated energy) in palaces, churches and art we could answer that, since the productivity of investment was low, rich families spent their incomes in a more socially attractive way[12]. Buildings and art may thus be considered not the cause of low capital formation, but the consequence.

We know that, especially in periods of demographic growth, arables increased at the expense of woods. While, during the 15th century, lands previously under cultivation were abandoned, in the following centuries the reverse took place. At the end of the 19th century, woods reached their lowest extension under the pressure of rising population. Large investment was directed to land reclamation especially in the second half of the 16th century and then throughout the 18th century[13].

3.3. Climate. Many doubts remain on the efficacy of these investments in contrasting the effects of the exogenous factors in play. As clearly shown by many recent paleoclimatological studies, remarkable changes in temperatures have occurred in Italy over many centuries. Figure 4 represents the change in decadal temperatures during the long period 700-1930 (Mangini *et al*. 2005).

We see that after the so-called Medieval Climatic Optimum, which lasted from the 9th century until the end of the 13th, the level of temperatures dropped sharply for a long period by about 1 degree. It was the beginning of the so-called Little Ice Age. Recent studies, on several different Italian regions from the late 18th century

Fig. 4. *Temperatures in Northern Italy 700-1930 (decadal data)*



onwards, show that a recovery and rise in temperatures began in Italy from about 1820-25 (Brunetti *et al.* 2006).

Although apparently insignificant, a change of only 1 degree in the average temperature, is likely to displace the altitude of wheat cultivation by about 100 metres above sea level and to have a large impact on the usable surface (Galloway 1986). Considering the whole extension of Italy – 31 million hectares – lands between 600 and 700 metres cover more than 2 million hectares (SVIMEZ 1961, I). Hence, following a decrease of 1 degree, cultivation drops from 700 to 600 metres with the immediate consequence that wheat production becomes insufficient for 1-2 million people.

Of course an analysis of the correlation population-climate would require the investigation of many other variables. Among these, of utmost importance is precipitation variability, on which quantitative data only exist from 1800 onwards (Brunetti, Maugeri, Nanni, Auer, Böhm, Schöner 2006). However, on such variables, no information is available for Italy before 1800. What is certain is that for a long part of the period we are dealing with climatic conditions influenced negatively the availability of natural resources to Italian populations. As far as climate is concerned, the denominator of the *L/K* ratio is likely to have diminished rather than increased.

At the moment no possibility exists of quantifying natural resources per worker through direct information (with the exception of the attempt in tab. 2). Yet, indirect information, as we will see, is sufficient to provide some description of the dynamics of the *L/K* ratio in the period we are interested in.

4. Techniques and human capital (*A*)

4.1. The technical system. During these centuries, the Italian economy can be described either as a vegetable-based, or as a biological, or as an organic system, such as the one described by A. Wrigley in many of his contributions (Wrigley 1988, 2004). Its main feature consists in that the amount of energy employed in the production of goods and services is ultimately based on the metabolism of vegetable goods through biological engines i.e. both human beings and working animals. Although in such an economy some form of more complex technology is present, such as the conversion of falling water and wind into labour, the technology based on the principle of heat conversion into organized labour in order to produce goods and services is absent. In other terms, what is lacking, in such a technical system, is the capacity of performing work with the aid of modern machinery. This is the main constraint to the increase in the level of production. Economies such as the Italian one during the centuries we are analysing can thus be defined as *mature agrarian economies*.

This does not imply that in such economies possibilities of innovation are absent, but only that constraint existed on the economic growth path. Historians often recall the meaningful changes taking place in bank, textiles and urban services. During the period we are dealing with human capital formation probably progressed in the cities whereas in the countryside neither human capital nor technology progressed to such an extent.

Growth can only be achieved by introducing a new technical system and not by means of internal adjustments of the vegetable-based system. To our knowledge of the relationship between economy and population in late medieval-early modern Italy, this basic technical change is exogenous and took place in the last decades of the 19^{th} century, just when modernization of the Italian economy was beginning (Malanima 2006).

4.2. Innovations in agriculture. Exogenous is also the main innovation in agriculture, the introduction of maize, coming from America (Coppola 1979). Its diffusion in Northern Italy since the end of the 16^{th} century is well known. Maize was to Italy what the potato was to some Northern European countries, such as Flanders, England, Ireland…

In Italy, from the late Middle Ages until the introduction of modern fertilizers at the end of the 19^{th} century, yield ratios of wheat reveal a long stability of around 4-5 quintals per hectare. However, in terms of calories per hectare, the spread of maize implied the doubling of yields to 10 quintals and even more. In terms of value, however, it was different since its price was half that of wheat for the same weight (De Maddalena 1974). Its progress was rapid especially in the Po Valley where, in the second half of the 19^{th} century, it was by far the dominating cereal. In Central Italy its diffusion was less important, and even less so in the South, where climatic conditions were not so favourable for its cultivation as in the wet soils of the Po Valley. The progress of rice in the North was less important in terms of calories per head and its price far higher than that of wheat.

Another important innovation, less immediately related to demographic trends was the spread of the mulberry tree from the South towards the North. It widened the possibility of producing raw silk and silk textiles. In the Centre and the North, the silk sector accounted for about 5% of the gross product in the 18^{th} and 19^{th} centuries (Battistini 1992, 2003, 2007). Its export could finance importation of cereals from abroad.

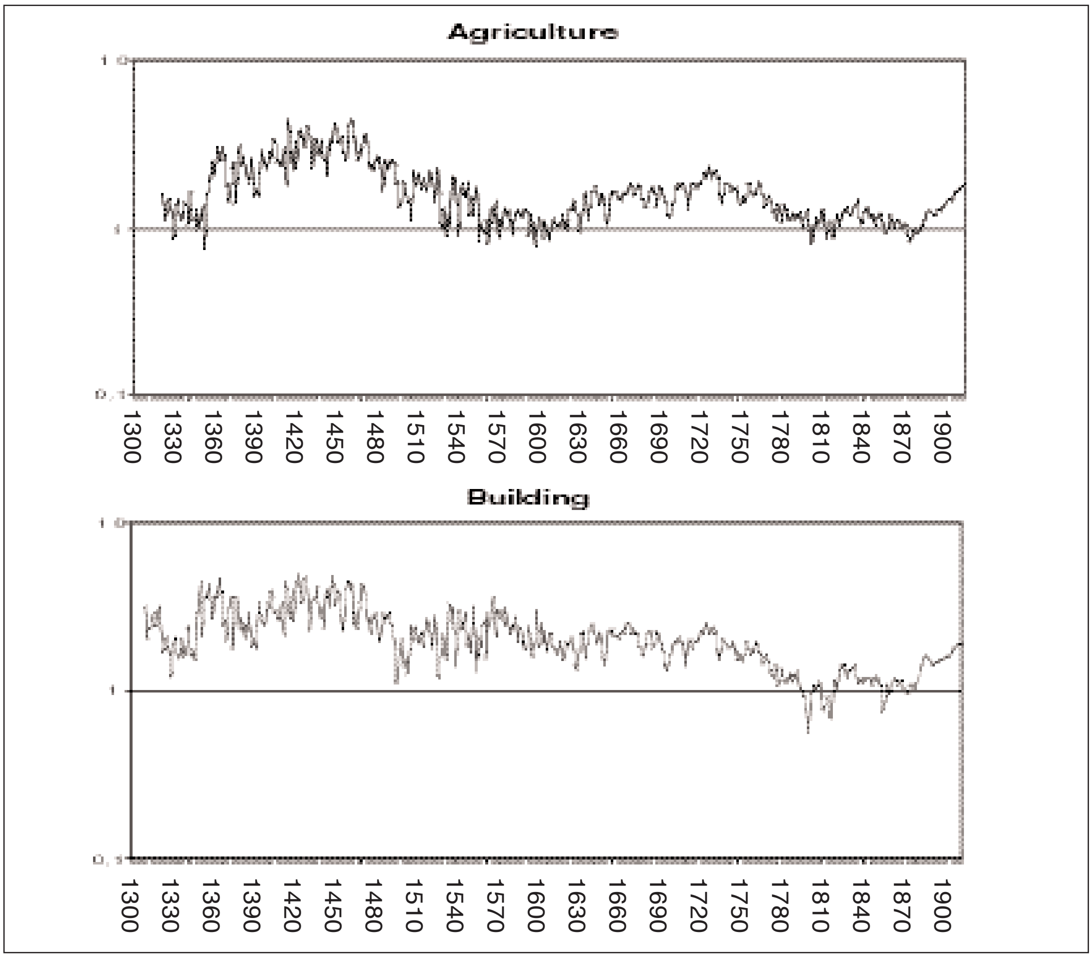
4.3. Labour productivity and wages. Information on both K per worker and A, does not allow us to determine whether the rate of growth of A was higher than that of population or not; that is, if the Italian system was progressing or not. An indirect way for answering this question is by means of quantitative indirect evidence. We can, in fact, rewrite equation, dividing by L:

$$\frac{Y}{L} = AF\left(\frac{K}{L}\right) \tag{3}$$

In this case, labour (average) productivity is function of human capital, capital and natural resources per worker. Whenever the ratio on the right side diminishes, labour productivity also diminishes. As a proxy of labour productivity is normally used real wage rates. The trends of both agricultural and urban wage rates do not allow any doubt on the tendency of resources and knowledge per worker. Their movement was downward bent, although with some difference (Fig. 5) (Malanima 2007).

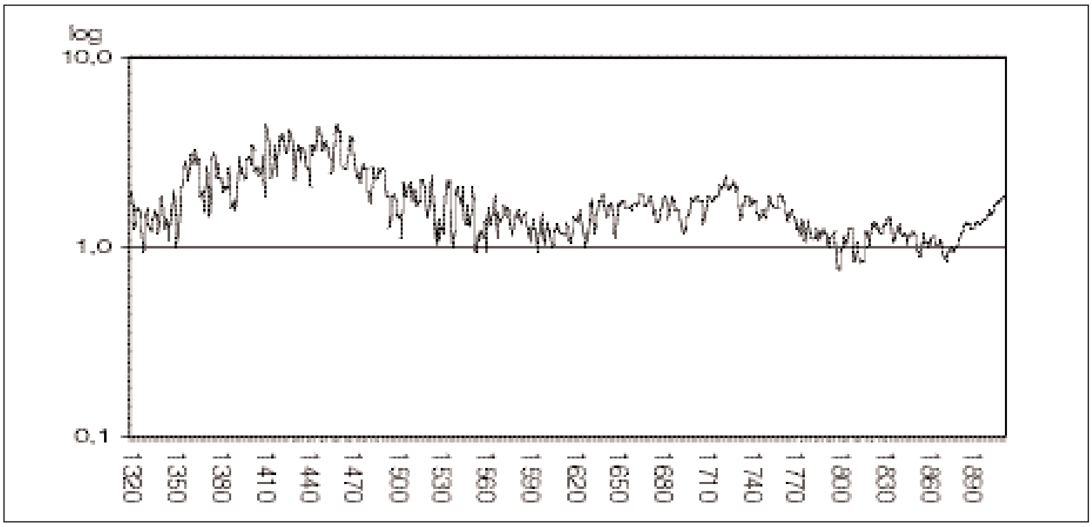
The aggregate trend of real wages, weighted for the relative importance of rural

Fig. 5. *Real wage rates in agriculture and building 1320-1913 (1861 = 1)*



and urban labour through the urbanisation rate, is more similar to that of the agricultural sector than that of the urban sector (Fig. 6).

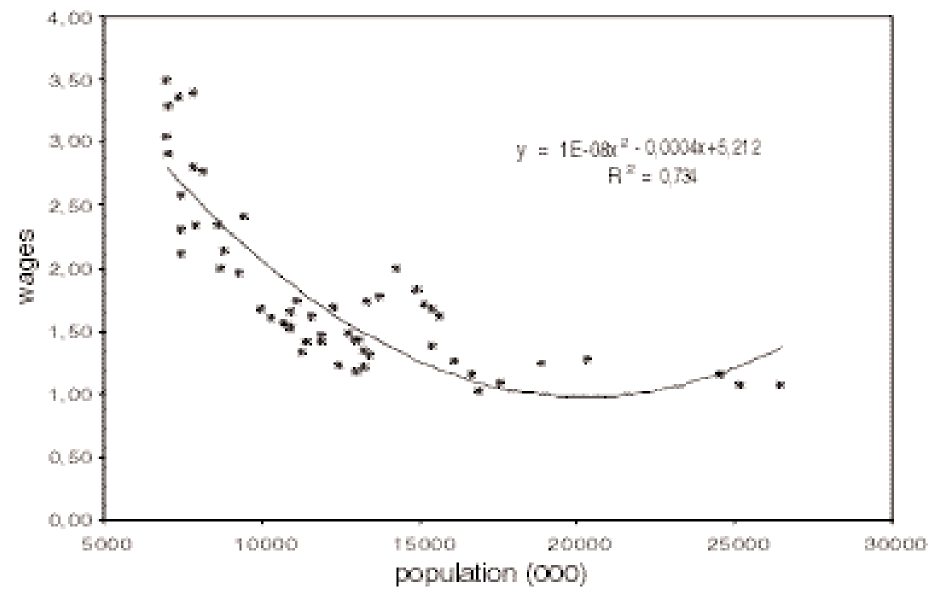
Fig. 6. *Real wage rates in Italy 1320-1913 (1861 = 1)*



Declining real wages in the decades before the Black Death suggests that the *AF(K/L)* ratio was diminishing. It rose rapidly after the Black Death, to decline again in the 16th century, slowly recovering in the 17th and reaching a low level in the second half of the 18th century. After a short-term recovery, it fell again before the start of modern growth in Italy in the 1880s.

On the whole the inverse relationship between population and wages is clearly represented by a non monotonic relationship (Fig. 7).

Fig. 7. *Real wage rates and population 1320-1861 (decadal data)*



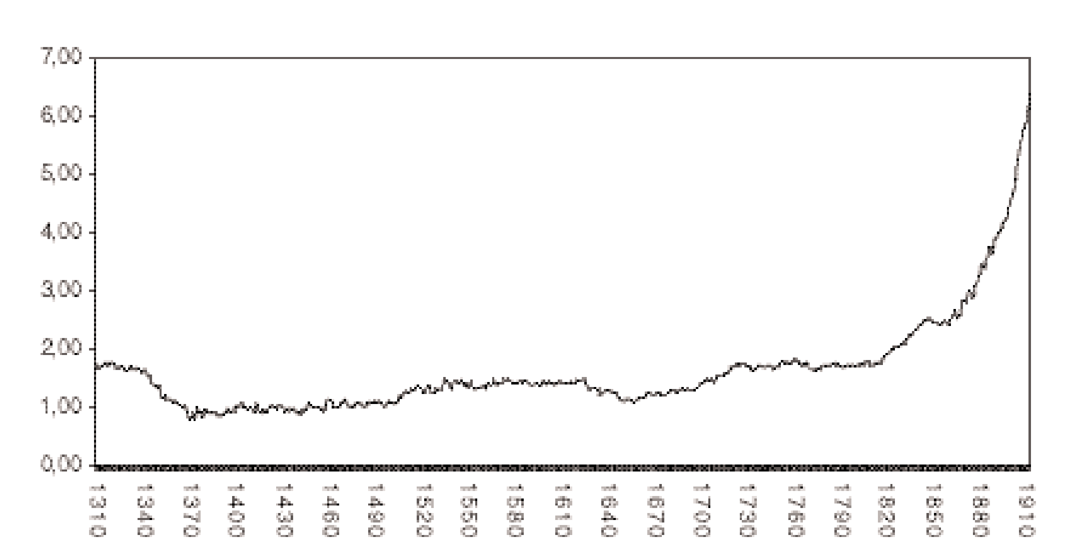
5. Product (*Y*)

5.1. Aggregate product. Having briefly described the right side of the production function (technology and production factors), we now turn to focus the attention on the left hand side: the product.

Aggregate product dynamics reveals in Italy long-term stability. Taking the product in the year 1430=1, it moved within the range of 1 and 2 for, at least, half a millennium (Fig. 8)[14]. This range was only exceeded from 1820 onwards as, on the one hand, the effect of maize spread, especially in Northern Italy, and on the other the expansion of the arables came about. Thus, to recall Boserup's view, there was *intensification of land and labour*. Always intensification of land implies intensification of labour as well (more workers and more hours devoted to the cultivation). Cereal production rose thanks to the clearing of forests and the cultivation of the low hills.

Since aggregate production depends both on per capita product (i.e. average income) and on population, this overall stability could hide sharp falls in population compensated by increase in average income.

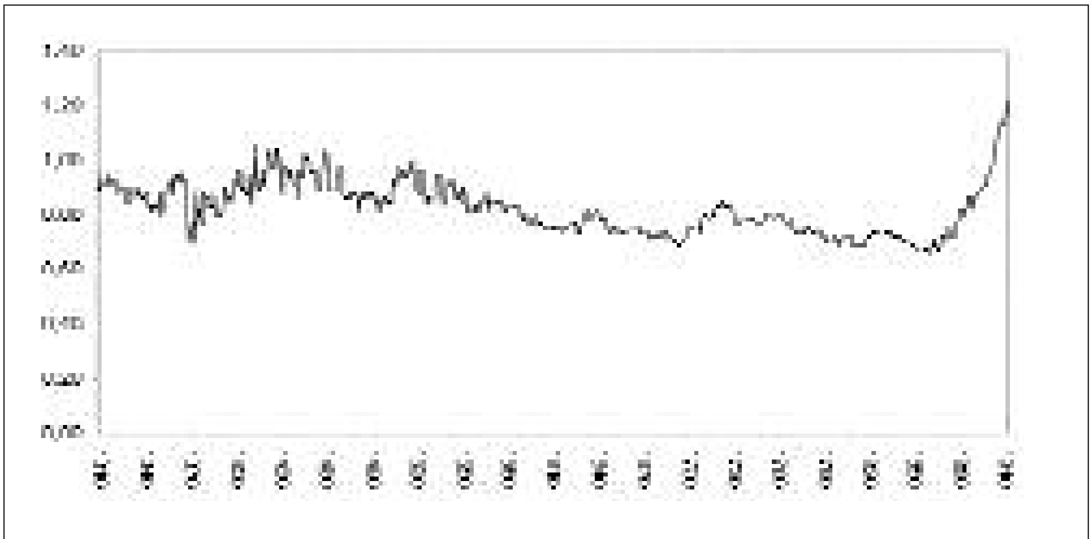
Fig. 8. *Index of product 1310-1913 (1430 = 1)*



5.2. Per capita product. In recent years researchers have provided two different estimates of per capita product in Italy (Malanima 2003, Van Zanden 2005). These show some differences, both in levels and trends, but also similarities, such as the 18th century decline. In the following figure 9 (Malanima 2003) per capita product shows a long-term decline since the late Middle Ages and especially since the late 16th century.

As can be seen, decline was sharp from the second half of the 18th century onwards. An inverse relationship between per capita product and population is quite clear. On the whole, in 1790-1860, the level was 30% lower than in 1400-50.

Fig. 9. *Index of per capita product 1310-1913 (1430 = 1)*



Here we come to the main feature of pre-modern agrarian economies, that is the long-term equilibrium of gross product. This equilibrium is maintained by falls in product per capita (whenever population rises) and increases in product per capita (whenever population diminishes). The main differences between pre-modern and modern economies can be summarized by the two following features:
– in pre-modern economies gross product is stable in the long term, but unstable in the short (because of the frequent famines and epidemics);
– in modern economies product is unstable in the long term (characterized as it is by a strong growth), but ordinarily stable in the short.

Long-term equilibrium due to adjustments in product and population is the feature of our pre-modern Italian economy we have now to explain.

5.3. Mouths. It is now useful to provide a simple formal representation of the movements of population and of its relationship with output. Output is produced according to the production function in (1). This produce, as already argued, is destined to sustain population – pure consumption – and to replace or expand the stock of capital. In fact, capital, as above defined, comprehends animal stock and the amount of natural resources, including land used in production. All these factors of production can be *accumulated* by means of agricultural output which is measured in energy.

The system has, first of all, to face the immediate needs of the population. Hence, very simply, we can write that the energy needed for mere survival of existing population as:

$$\beta L \tag{4}$$

where β is the per capita amount of energy required to keep population constant at L. Dividing the latter by K, we obtain the minimum amount of energy the system requires just to sustain itself in terms of capital:

$$\beta \frac{L}{K} \tag{5}$$

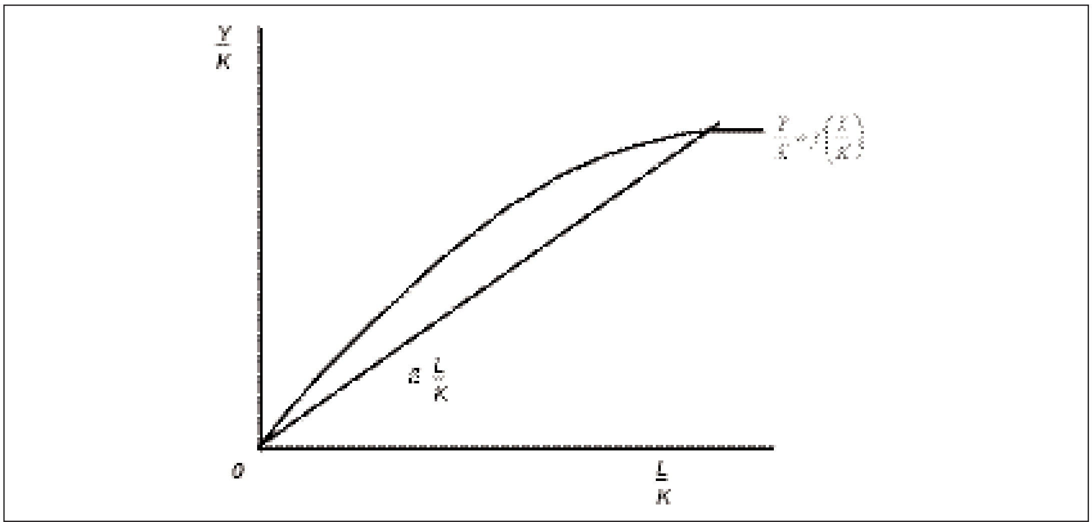
This can be represented as a straight line in a diagram in which we measure L/K on the horizontal axis (fig. 10). The $\beta L/K$ line shows the minimum amount of energy to keep population stable. Using a metaphor, we could call this the 'mouths' of the economy.

5.4. Hands. Whenever the economic system is able to produce more than it is required for simple reproduction, population can grow. We can, therefore, rewrite equation (4) in the following way:

$$\beta(L + \Delta L) \tag{6}$$

where L represents the population existing in the year *t-1* and βL represents the increase in population in a specific year t (that is the net increment of population from time *t-1* to time t). Since in our model population increase depends on the possibilities of consumption, and since consumption is a function of product, Y, the latter will ultimately drives the dynamics of population and of the economy. Production is represented by the *Y* function as given by equation and, in terms of capital, by equation , that is *Y/K*. Because returns to labour are decreasing, this is a concave and upward sloping curve. This curve represents the total energy produced per unit of capital available in the system. Hence, by using an analogous metaphor, we can define this energy as the product of the 'hands' of the economy. It is now clear that the dynamics of the economy is driven by the relationship between the needs and the resources of the economy: the mouths and the hands. The system can grow and develop in terms of population (capital is constant) only if there is sufficient energy. In graphical terms, this implies that population can grow only if the concave production function is above the straight line in figure 10.

Fig. 10. *The intensive production function*



Vice versa, population will shrink and decrease when the straight line is above the concave production function. Having said that, before proceeding to analyse the dynamics of the Italian economy within this model, we need to make some further specifications.

6. The Italian pre-modern economic system

6.1. Equilibrium. Following a standard assumption in the neoclassical growth model, we take that output per unit of capital, *Y/K*, can be divided into two parts representing both a fixed percentage of the aggregate product: consumption and capital formation. Indeed, we know that consumption represents, in a pre-modern agricultural economy about 90% of the total product[15] and this percentage remains constant trough time.

On the back of this empirical evidence, we will assume that a fixed fraction of output, *c*, is destined to feed population. Hence, we write:

$$\beta(L + \Delta L) = cY \tag{7}$$

This equation implies that a fixed fraction of output, cY, is employed to provide the minimum level of energy to permit the survival of the population and in some cases to grow, βL. This also implies that the complement fraction of output, $(1\text{-}c)Y$, is employed in capital formation.

As already argued, capital formation $(1\text{-}c)L/K$ is partly destined to replace the depreciating capital and partly employed in non productive or scarcely productive investments. 'Unproductive' refers to the fact that these activities are not strictly connected to the process of production of agriculture goods. These activities include for example the construction of buildings, palaces and churches, the financing of wars and other (such as works of art). These activities as such are not utilized in order to allow the system to grow and develop. Indeed, as outlined above, this economy grows only when agricultural productive factors, i.e. labour and capital, increase. The fraction of agriculture output (energy) which is not employed in sustaining labour or capital is, in this sense, a waste of energy for the economy and the system. Hence, in order to determine the actual dynamics of the economy, we need to specify how much of agricultural output is employed in these unproductive activities, rather than in accumulating labour and capital.

Population can expand or reduce depending on the amount of available resources. Expressing variables in terms of capital, we can represent graphically the working of the economy in the following way. When population is constant (long-term equilibrium), i.e. $\Delta L = 0$, the amount of output employed in agriculture is just sufficient to allow population to survive. If this is the case, equation 7, can be written as

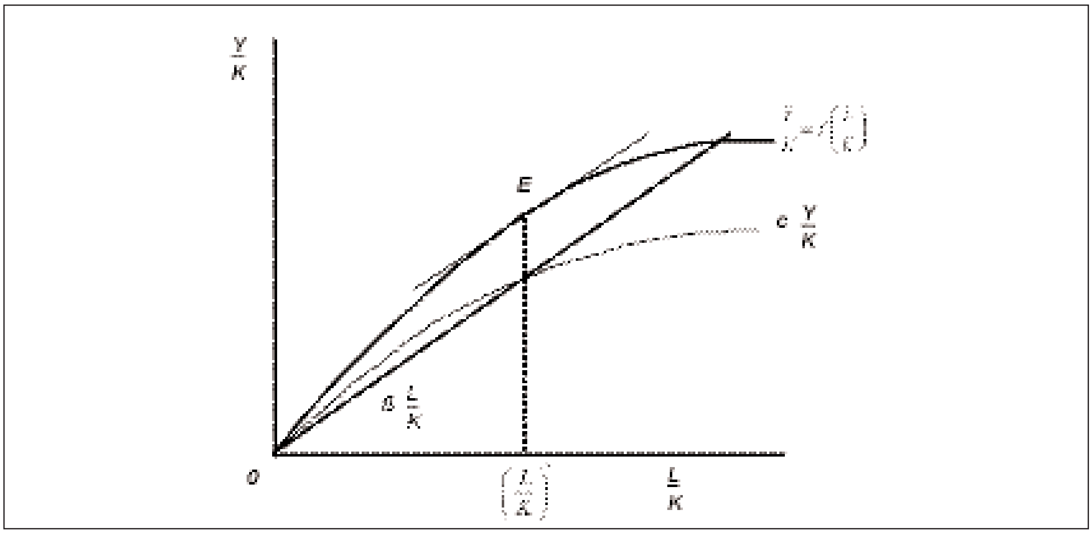
$$\beta \frac{L}{K} = c\frac{Y}{K} \tag{8}$$

Given the concavity of the production function Y/K, the fixed fraction cY/K is represented by a concave curve as well. The relationship between this curve and the line of survival, $\beta L/K$, determines the dynamics of population.

6.2. The dynamics of the economy. The working of the economy is the following (fig. 11). When labour per unit of capital, L/K, is below the level that keeps population at its survival level (equation 8, the cY/K curve will be above the survival line βL / K. This implies that there will be sufficient resources to sustain the existing population and to allow demographic growth. In this case the workers or 'hands' are very productive and can more than sustain the living 'mouths'. Population and labour will then grow and so will the L/K ratio, until equilibrium in the equation 8 will be re-established. The opposite occurs if the number of workers is too high.

6.3. Factor productivity and long-term equilibrium. Labour productivity, though not explicitly represented in the previous diagrams (Figg. 10 and 11), corresponds to the slope of the production function (dY/dL), represented in the graph by the tangent to the Y/K curve. Given concavity, labour productivity (hence wage) diminishes along the production function, while the average product of K (and then the

Fig. 11. *The production function: the general framework*



average land productivity), on the vertical axis, increases thanks to the intensification in the use of land, capital and labour time. *The graph combines the decreasing returns to labour dear to the classical economists with the increasing productivity of land and time dear to the followers of the Boserupian view.*

What will determine the economy to be outside the equilibrium $(L/K)^*$ and make population increase or decrease? The production function depends on many factors, endogenous as well as exogenous. Shocks in the production function, for example in A (the technique and human knowledge) or in the given stock of capital K, will shift the production function and determine a temporary surplus or deficit in the amount of resources required to sustain the system. When this occurs, the economy will move towards the long-term equilibrium in the way we have above described. For example, particularly good weather conditions will generally allow the productivity of land and rural capital to increase (hence K rises). The L/K ratio will shift to the left and the cY/K function will be higher than the level of subsistence. More resources will be available and population will increase, at least temporarily.

We now determine the other features of long-term equilibrium.

6.4. A general framework. This simple model is able to depict many features of the Italian economy during the period we analyse such as the occurrence of epidemics, the flourishing Renaissance economy, or the decline in the early modern age.

One well known fact of pre-modern economies is indeed that wages were often close to the survival rate. If this is the case, one can argue that the equilibrium level of labour must be such that the wage rate, that is the slope of the production function, $Af'(L/K)$, equates the slope of the survival line, $\beta L/K$. This can be clearly seen in fig. 11. In the long run, the equilibrium level of labour per unit of capital, $(L/K)^*$, is such that the slope of the production function in E is β, that is the slope of $\beta L / K$. We are implicitly assuming that the yield of labour per unit of capital, the wage rate, is just enough to sustain living population.

We can also determine how the economy adjusts when it is outside the equilibrium. For lower levels of labour per unit of capital, that is for $L/K < (L/K)^*$, the slope of the production function increases and so does the wage rate. When this occurs more resources can be devoted to increase population, the L/K ratio will increase until we reach long-term equilibrium. Of course the opposite will occur for higher than equilibrium levels of L/K. An important feature of the model is the convergence towards a steady state which occurs when $cY/K = \beta L/K$. At long term steady state equilibrium, the amount of output destined to consumption is just sufficient to cover the needs of a stable population. Decreasing returns to factors of production (the concavity of the production function) ensure convergence towards steady state labour/capital level $(L/K)^*$.

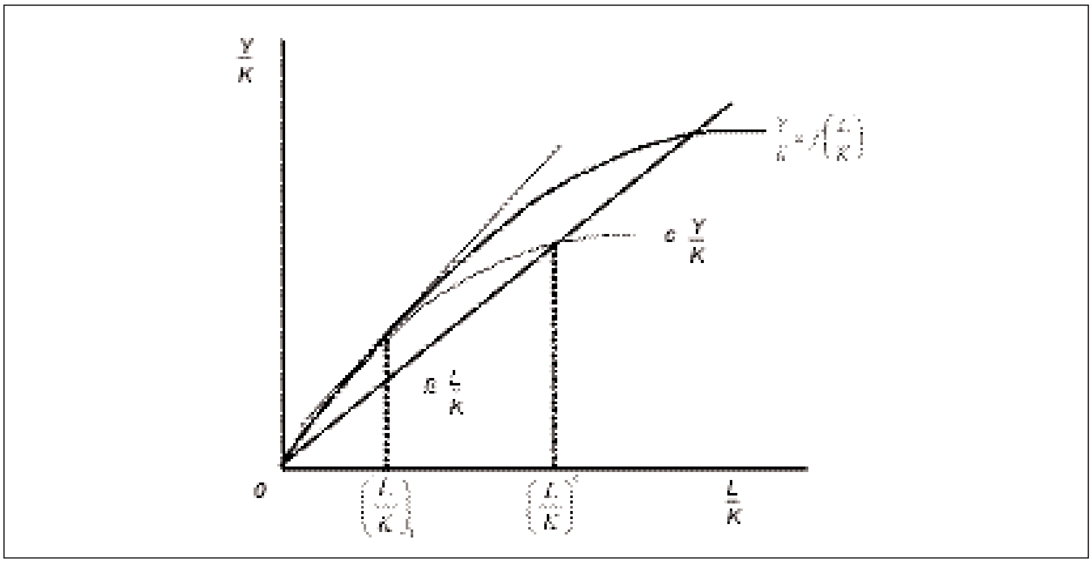
Despite long-term stability, this agrarian system is also characterized by frequent short-term «perpetual oscillation between happiness and misery»[16], as Malthus wrote. Given the great fluctuations in agricultural output year by year, one also needs to argue that the production function and therefore the $f(\cdot)$ function is not stable over time. This can indeed shift upwards or downwards in connection to periods of abundance and shortages in agriculture. Correspondingly, the yield of labour and the amount of available resources to sustain the economy will increase or decrease and so will population (although the adjustments of population throughout the rise of fertility are not so fast as the crises, as a consequence of shortages).

Although in this model population growth is endogenous and depends on the difference between cY/K and $\beta L/K$, a fall in population is only favoured by the rise of the L/K ratio. Epidemics, in fact, are more probable whenever the density of population increases. They are not, however, simply determined by the rising ratio. Many epidemics do not depend on nutritional stress. There is a lot of chance in their occurrence. We can only say that the vicinity of the L/K ratio to $(L/K)^*$ increases the probability or enhances the spread of the epidemic mortality.

We can now turn to analysing some well known historical patterns which have characterised the period we are studying.

6.5. The Renaissance. During the Renaissance the economy was flourishing (fig. 12). A particularly high level of product per unit of labour allowed population growth, as well as providing the resources to enable a boost in art production and the construction of buildings. This occurred because the population per unit of available capital was particularly low. In other terms there was an abundance of capital and, hence, both the productivity of labour and per capita product were higher. Following the theoretical framework we have just developed, this can be described as a situation in which the long-term equilibrium has not been reached: $(L/K)_1 < (L/K)^*$. If this is the case, labour productivity and the slope of the production function (represented by the tangent to the Y/K curve) is higher than the slope of the survival line. An excess of resources can be devoted to population increase and to unproductive activities (for example arts). Population per unit of capital grows and the economy slowly moves towards the long-term equilibrium.

Fig. 12. *The production function: the Renaissance*

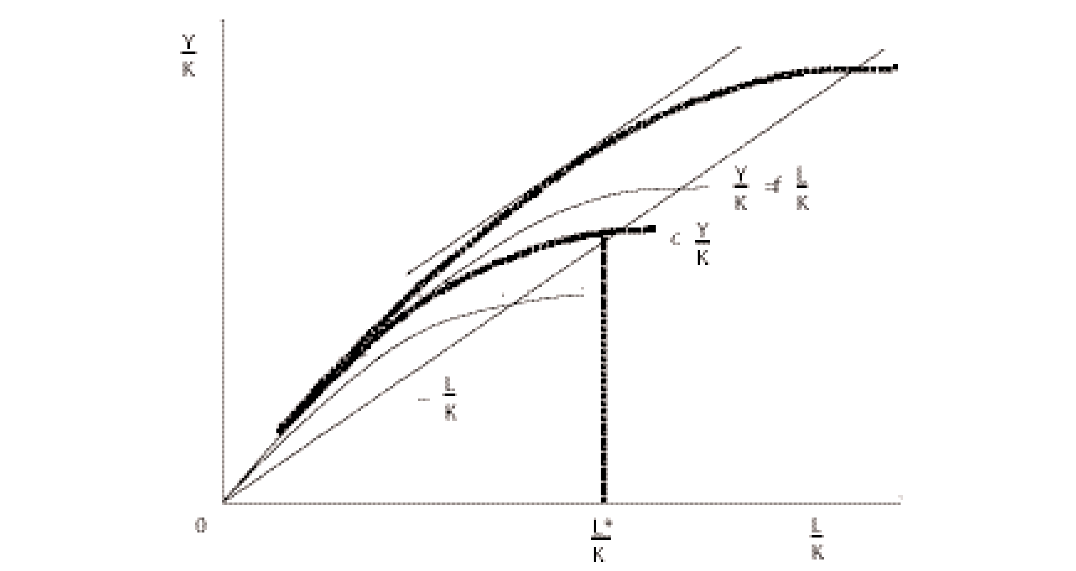


6.6. The decline. As the economy grows, the yield of labour decreases. Population increases from 7 million people in 1400-50 to more than 13 in 1600 and in 1700 and 17 in 1800. In 1600 and during the 18th century, population reached the long-term equilibrium. At this stage, the yield of labour per unit of capital was just sufficient to sustain living population. The relative stability of gross product entailed, in this case, a fall in per capita income. Wages, given the level of capital, were at the subsistence level (with the exception of some periods during the 17th century) and population was striving to survive let alone increase. In graphical terms we can argue that the labour/capital ratio is very close to, or coincides with, the long term value, $L/K = (L/K)^*$.

We can also argue that, in some periods, the Italian economy was even below this level; especially in the decades 1790-1818. The consequence was that, in order to secure the subsistence of the population (βL), the substitution of the depreciating capital by the peasant families was lower than was required to ensure the simple reproduction of the system[17]. It was a period of ecological crisis[18].

Things did not change with the spread of maize between the 1650 and 1850. In fact, maize, which involves a return in terms of calories double than wheat, but which is worth half of what wheat is worth, allowed population to expand even more. Since we have defined production in terms of calories, we can observe the effect of maize introduction in an up-wards shift of the production function (fig. 13) – which, instead would not have moved if measured in values. The $cAf(\cdot)$ curve would shift upwards as well and the equilibrium level of labour/capital ratio increases. After the introduction of maize, therefore, there are sufficient calories to allow the population to increase. Since the slope of the survival curve does not change, the new long-term equilibrium level of population/capital must determine an invariable wage and the slope of the production function must be the same as before the introduction of maize. However, since output is measured in energy as is

Fig. 13. *The production function: the 18th and 19th centuries*



labour productivity and the wage rate, this implies a decrease of wage in terms of value. That is exactly what happened during this period.

As revealed by recent research on the Italian economy (Fenoaltea 2006) it was only from the 1880s that the true Modern Growth took place in Italy as well. The displacement of the *Y/K* to the left became a lasting change in the shape of the production function, as a consequence of technical change and of the increase in capital formation. The consequence was the rise in labour productivity and in GDP per capita. This change continues to characterize the economy and to distinguish it from the pre-modern epoch.

7. Conclusions. The book by Boserup (1965) on *the conditions of agricultural growth* is a great reconstruction of the impoverishment of the traditional agricultural societies. The book describes how a society which is rich in resources and scarce in population ends up by being rich in population and scarce in resources. In the midst of these two extremes, the author explains how, under the pressure of population, people are forced to become industrious[19]; to cultivate soil better and better; to intensify the use of land and its exploitation; to work harder and harder and to be ingenious in the exploitation of new devices, when this is possible. This is just the evolution path followed by traditional agricultural societies. The extreme example is China, where, since the late Middle Ages, under the pressure of the demographic rise, people became obliged to exploit land more and more intensively until the 18th-19th century ecological crisis, and to be more and more industrious. As far as we know, living conditions in China were much better when people was less industrious, as in the late Middle Ages, than in the 19th century, when the lowest level in standard of living was reached.

Italy is another example of this downward sloping path and a new illustration of Boserup's view of the «conditions of agricultural growth»; although, perhaps, not so well-known as the Chinese one. Indeed, in Italy product increased with population from the late Middle Ages thanks to peasants who were obliged to become more and more industrious. It increased, however, less than population. Productivity diminished, wage rates decreased, per capita income underwent a strong decline of about 30% in 600 years; which is perhaps not so much in yearly terms, but is much indeed when the starting point is already low, as in any pre-modern traditional economy; even the richest.

In the previous pages we tried to adapt Solow's neoclassical model to the interrelationships population-economy (or, better, economy-population). While in Solow's framework the growth rate of population is assumed to be exogenous and the rate of capital accumulation endogenous, in our framework the reverse occurs: the rate of growth of capital is exogenous and the rate of growth of population endogenous. This is not the first attempt in this direction. It has been argued (by economic historians and by many economists, among these Lucas, 2002), that the main difference between economic systems prior to the industrial revolution and modern ones is that in the former, technological improvements, and increase in the amount of per capita resources translated into increase in population and not into increase in per capita income. In these frameworks, the rate of population growth is not exogenously given and it depends on many variables, such as individuals' choices, the amount of available resources, and the prevailing technology. We just followed this line of thought. Lucas, Becker (1960) and other economists have modelled these facts by 'endogenising' the rate of population growth: as well as standard variables such as labour and consumption, agents dictate the number of children. The idea is that children increase parents' utility but they are also costly to raise. If this is the case, there might exist an optimal number of children which can be a function of the level of income.

Chance, however, plays an important role in pre-modern economies and in our framework. While increase in population is favoured by a positioning of the variables near the intersection of the axes in our geometrical description, death, and especially epidemics such as, primarily, plague, depend on the density of population but are not determined by population pressure or decline in living standards[20]. Density favours the spread of epidemics, but in many cases does not determine them. Usually, in these cases, the system is around the L/K^* level in our figures. The same happens with short-term falls, caused primarily by meteorological conditions, which become famines whenever population pressure is high and living conditions are near the subsistence line, where starvation is already creeping in. Chance, however, plays a role in this case as well. Deterministic evolution prepares only the background.

We tried to look at the Italian population in this perspective and to establish some connections among the many variables involved. We have discovered that the explanatory value of this attempt helps combine different approaches. Boserup's view is not excluded. This is, however, only a detail in a bigger framework where «land and labour intensifications» play an important role, as the results of a declining path rather than the foundations of a rising one. Italy, as well as many other traditional societies – but not England, on which many economists and economic historians focus – followed this declining path from the Renaissance onwards.

[1] This view, even though marginal, was not missing in the work of the classical economists. Although in the wake of the Ricardian approach, J. Stuart Mill (1848, IV, Chap. I) stressed the «capacity of co-operation» among «civilized beings» as a possible basis for «an indefinite increase of capital and production».
[2] As we will see in par. 2.
[3] Formally, if one considers land as a separate, exogenously given factor, the relationship in would not change its shape but only shift along the axes by changing land.
[4] This possibility was already put forward by Solow 1970, Chap. 1).
[5] Figure 1 and the following figure 2 are based on Beloch 1994; Bellettini 1973; and Del Panta, Livi Bacci, Pinto, Sonnino 1996. On the possible lower rate of increase in the period 900-1300 see Lo Cascio-Malanima 2005.
[6] In figure 3, however, we notice the fall in 1645-48, caused by a typhus epidemics.
[7] Figure 3 is based on this same article.
[8] Data is from *Sommario* (1958 and 1976); and, for 1881, Vitali (1970).
[9] See the recent Fenoaltea (2006).
[10] The topic is discussed in Malanima 2002.
[11] Data on population and their sources are quoted in Malanima (forthcoming).
[12] On the topic see especially the important works by Goldthwaite (1987) and (1993).
[13] Land reclaimations and land-population ratios are recalled in Malanima 2002, Chaps. 1 and 3.
[14] The methods for the calculation of gross and per capita product in Italy are explained in Malanima 2003. In figures 8 and 9 the only difference is the calculation of a yearly index, instead of a decadal one.
[15] See, for Italy, in 1861, Ercolani (1969), p. 422.
[16] Malthus (1798), Chap. 1.
[17] Examples could be the overexploitation of forests, decline in livestock, diminution of seed per hectare, neglect of the maintenance of farms...
[18] We agree with the concept of 'ecological crisis' put forward some years ago by Pomeranz (2000) in a global perspective.
[19] We utilize here – but with a different meaning – the fortunate expression primarily used by De Vries (1994).
[20] See especially the important remarks on living conditions and epidemics and diseases in Livi Bacci (1987).

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