The Journal of Socio-Economics 39 (2010) 233–240

Contents lists available at ScienceDirect

The Journal of Socio-Economics

journal homepage: www.elsevier.com/locate/soceco

Can demographic transition only be explained by altruistic and neo-Malthusian models?

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ARTICLE INFO

Article history:
Received 17 September 2009
Accepted 5 November 2009

JEL classification:
J13
O11
O16
O40

Keywords:
Altruism
Demographic transition
Capital
Proletariat
Fertility
Child labor

ABSTRACT

Previous researches on demographic transition are based on models incorporating altruism in their utility function. These models are all neo-Malthusian in their essence, since they assume a positive relationship between income and fertility rates. This paper presents a model which departs from the neo-Malthusian frameworks in its definition of altruism. This framework better fits the data and socio-economic context of the early nineteenth century, a period where fertility rates went up. This paper stresses that the evolution of capital, wages and child labor may provide an alternate explanation for the observed pattern of fertility rates during the early European industrialization.

1. Introduction

In the recent literature on demographic transition, many elements play a preponderant role in the framework analyzing the relationship between fertility rates and economic growth. However, there is one element included in all these models, and which is crucial in determining the structure of these models: it is altruism. Indeed, already in the first model of Becker on family behavior, we find that altruism is the main element explaining the dynamics of the family.

Altruism takes many facets, but in most models the definition of altruism relates to the fact that an individual cares not only on the welfare of his children but more specifically, he cares about the welfare of *each* of his children.[1] Adding to altruism, also the assumption of equality between children, these models generate the result that the number of children positively affects utility.

In consequence, the standard models analyzing fertility rates are based on the view that children are a consumption good, that is, the higher the income level, the higher the fertility rate. It is in the line of thought of the Malthusian concept that claims: "Population will always grow until there is enough misery or enough vice or more likely a sufficient mixture of both to achieve equilibrium".[2] These neo-Malthusian models assert that an increase in income that occurred in the first half of the nineteenth century led to an increase in fertility.[3]

There is, however, a different – non-Malthusian – paradigm to explain this increase in fertility. It was already developed in the nineteenth century, but has been totally ignored by economists up to now: that of Marx.[4] Marx indeed claimed: "In fact . . . the absolute size of the families stands in inverse proportion to the height of wages. . . Misery up to the extreme point of famine and pestilence, instead of checking, tends to increase population" (Marx, 1887, pp. 796–797).

This paper aims at presenting a model that fits the non-Malthusian view presented by Marx: wages and fertility rates are negatively correlated. Its main advantage is that it better fits the data and the socio-economic context of the first half

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[1] There is also a literature on the nature of altruism (see for instance Paolilli, 2009).

[2] Malthus (1798, p. 47).

[3] See Becker (1960), Becker and Barro (1988), and Becker et al. (1990). For more recent works, see Dahan and Tsiddon (1998), Galor and Weil (2000), and Galor and Moav (2002).

[4] Marx views on family economics were avoided by economists, probably because his economic opinions had been put aside. However, they are recognized by demographers, e.g., Caldwell and Schellekens.

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doi:10.1016/j.socec.2009.11.001

of the nineteenth century. The model presented in this paper will view altruism in a totally different way than the Malthusian model.

Indeed, the postulate that altruism towards children is a natural and biological tendency as presented in the standard model has been questioned (see Badinter, 1980; Aries, 1973). There is increasing evidence that conventional-altruism is not a good representation of what occurred in the eighteenth-nineteenth centuries – the centuries during which fertility rates increased. The parent–children relationship is part of a whole set of values and social norms that evolve over time and are affected by changes in the economic environment. Parental care is not an intrinsic value, which is independent and invariant to economic changes. It has evolved over time, and especially in the eighteenth-nineteenth centuries, the period of industrialization.[5]

Focusing more specifically on Europe before the modern times, parental behavior as displayed towards their children is not compatible with conventional-altruism. In France, for instance, Parisian women, but the very poor, sent their children for nursing far away from Paris, even though they knew that the children were likely not to come back. Badinter reports that in the 1780s, 18,000 out of the 21,000 children born each year in Paris were sent away to a wet-nurse; more than two-thirds did not return.[6] Women knew the danger of sending their children for nursing, but nevertheless did it. There are descriptions of women who sent two or three of their children away for nursing, and although they never returned from nursing at a specific location, still sent their subsequent children to the very same place.[7]

The legal system of that time, that somehow reflects the social norms of the period, exposes how society was treating children: parents had rights over children, but children had no rights. In France, a father who killed his son was not in violation of the existing criminal law.[8] The laws enacted by Henri II and Henri III (1556 and 1579) instituted that children who married against parental will or permission, were not only ineligible for an inheritance, but could also be accused of abduction which was legally punishable by the death penalty (see Badinter, 1980, p. 32). Moreover, when parents were not satisfied with their children, the latter could be sent away for deportation (French Law, 1763).

The purpose of this paper is to present a model which aims at fitting these observations on the relationship between parents and children. The conventional-altruistic model in which parents care about the consumption of children is certainly adequate when modeling the family economics of the twentieth century, but it is at odds with nineteenth century behavior. Hence, another utility function should be used to represent family economics, a function which is appropriate for the social norms and values of the nineteenth century.

In the nineteenth century, children of the working class were necessary: "In a quite literal sense, children were an investment good during the early industrial period" (Birdsall, 1983, p. 116). As Marx claimed: "All family ties among the proletarians are torn asunder, and their children transformed into simple articles of commerce and instruments of labour" (Marx and Engels, 1955, p. 28). In consequence, this model assumes that child labor is a necessity, and shows that more hands are needed when wages decrease: this leads to an increase in the number of children.

[5] See Zelizer (1985).

[6] Badinter (1980, p. 57).

[7] Mortality rate of children sent to wet-nurse was much higher than mortality rate of children staying at home.

[8] This law was already enacted in the thirteenth century, and already existed in Greece and Rome: the father had all rights over life and death of his sons; he had also the right to put them in prison (see Cicero, prodomo 3).

Table 1
Correlation between fertility rates and real wages during the nineteenth century.

Time period	(1)	(2)	(3)	(4)
1800–1850	−.36	+.90	−.19	−.49
1800–1840	−.30	+.77	−.76	−.72
1800–1900	−.69	−.43	−.52	−.43

Sources: All correlations are based on the same index of legitimate fertility rate (Ig), from Bardet and Dupaquier (1998). Column (1) is the correlation between Ig and the real wages series based on the wages presented in Mitchell and Deane (1971, p. 349). Column (2) is based on the real wages presented by Feinstein (1998). Column (3) is based on the real wages in the cotton industry as presented Mitchell and Deane (1971); and column (4) on Brezis and Crouzet (2004).

The model I present in this paper not only suits better the social norms of the nineteenth century, but it also permits a closer fit to the data of the nineteenth century. Indeed, in the first half of the nineteenth century, the income of the most important social class – the workers – did not increase, and for some even decreased.[9] Consequently, the correlation between workers' income and fertility rates is negative (see Table 1). Thus, those models that assume altruism predict a decrease in fertility, and cannot, therefore, explain the increase in fertility that occurred during the first half of the nineteenth century.

Hence this paper, unlike neo-Malthusian models, posits a negative relationship between earnings of the proletariat and fertility rates, as expressed by Marx: "In order that the family may live, four people must now not only labour, but expend surplus labour for the capitalist. . . Previously, the workman sold his own labor power, which he disposed of nominally as a free agent. Now he sells wife and child. He has become a slave dealer" (Marx, 1887, p. 395).[10]

This negative correlation between wages and fertility rates is at the root of demographic transition. At the onset of the Industrial Revolution, wages decreased and "neither men nor women could subsist on their pay alone" (Hilden, 1984, p. 364). This led to a fertility increase, since child labor kept family incomes high enough to allow for consumption at the subsistence level. During the second half of the nineteenth century, when wages rose, workers started to reduce the number of children they had: the fertility rate went down.[11]

The dynamics of this model are therefore different than in the standard neo-Malthusian models. In their model, the whole dynamics are driven by human capital, which increases during the process of development. In the first phase the higher income leads to higher fertility rates due to the Malthusian view of altruism. In my model, during the first phase, output increases, but real wages decrease (what happened in the nineteenth century) and therefore the poor increase their fertility rates.

During the second phase, our models are in fact complementary. In the neo-Malthusian models, by introducing education and human capital, they generate a substitution effect between quantity of children and quality. In consequence, fertility rates decrease. In the model presented in this paper, capital–labor ratio increases during the second phase, and therefore wages go up, which reduce

[9] While there is no doubt that total income increased in the first half of the nineteenth century, the income of the most important social class – the workers – did not increase.

[10] See Brezis and Young (2003). Note that the Latin word *proletarii* means "the beggars who have children".

[11] When workers are not constrained anymore – as was the case in the late nineteenth century – child labor is not a necessity and human capital enters in the picture. Thus, this model, and the models focusing on the transition from "child quality" to "child quantity," are not contradictory for the last part of the nineteenth century; they are complementary. Indeed "the rise in real wages released the working class from its dependence on child and adolescent labor and enabled it to change its reproductive behavior. Thus the rise in real wages probably was a *precondition* for a fertility decline among the working class" (Schellekens, 1993, p. 10).

the constraint on child labor. Parents can move towards their optimum level of fertility and reduce the number of children.

In this model, real wages are the key element in the demographic transition. They are however not exogenous; they are endogenously determined by the capital–labor ratio. In order to analyze the endogenous dynamics of wages, this model therefore introduces capital, which is accumulated by the business elite. Thus, the capital–labor ratio, which determines wages – and in consequence also fertility rates – is a function of the quantity of labor (determined by the workers) and the quantity of capital (determined by the business elite), and is the main variables of the dynamics of the system.

The main difference between these two approaches is altruism. However, there are also some other differences added into the model. This paper, concentrates on capital accumulation, and does not deal with human capital, because the central factor of industrialization has been attributed to capital and its accumulation through savings.[12] So it seems difficult to put all the demographic transition on building human capital, when during the nineteenth century human capital was almost inexistent, and capital was the important factor of production. Moreover, the neo-Malthusian models are based on intergenerational flows from parents to children, but the data show that during the nineteenth century, net intergenerational transfers flew from children to parents.[13]

This paper is divided into five parts. Section 2 presents some historical facts related to the model. Section 3 presents the model. Section 4 deals with the equilibrium and dynamics of the model, and Section 5 concludes.

2. Historical context of the model

We first discuss the relationship between wages and fertility rates. We then describe some data on child labor and intergenerational flows. Since industrialization first took place in England, this section mainly focuses on the period of industrialization in Britain.

2.1. Social classes and fertility rates

The literature on fertility rates in the different social classes is not very vast.[14] The data on the fertility rate of the workers is quite well related to the whole population. The index of legitimate fertility rate (Ig) displays an increase in the first part of the nineteenth century and a decline after 1860.[15] But, the Ig data cover the whole population. When the analysis is specifically focused on the factory workers, we get an increase from 3.9 children per family in the period 1787–1816 to 4.4 in the period 1817–1839 (see Horrell and Humphries, 1995, p. 513).

Regarding real wages, the data is more diverse, and sometimes not consistent. However, most of the series show that wages went down over the first half of the nineteenth century: "If the Chartists in 1837 had called for a comparison of their time with 1787, and had obtained a fair account of the actual social life of the workingman at the two periods, it is almost certain that they would have recorded a positive decline in the standard of life of large classes of the population" (Hobsbawm, 1957, p. 61).[16]

In Table 1, we present the correlation between fertility rates and some series of real wages, over different time periods. The correlation is shown to be negative for most of the series and time periods.

2.2. Child labor, and intergenerational flows in the proletariat

Child labor in the nineteenth century amounted to a significant part of the workforce in some British industries. Children under 12 years old constituted 8% of the labor force in the cotton industry, and children aged 13–18 another 10% (see Evans, 1990, p. 250). In 1833, in some regions such as Lancashire and Leeds, 36% of the workforce in the textile industry consisted of children under 16 (see Turttle and Wegge, 2002). Although it was not uncommon to see children aged 4 working as wool-weavers (see Tilly and Scott, 1989, p. 32), children usually began working at the age of six and the incomes of all members of the family were pooled. After 13 years old, children were allowed to retain some of their income in order to build a small capital prior to marriage. It must be noted that, in certain counties in England, there was a positive correlation between fertility and the percentages of children aged 9–14 who were employed (see Birdsall, 1983, p. 116).

Child labor is related to adult's real wages, since child labor was needed in periods in which the salary of one person was not adequate for subsistence. Hence, children brought about an increase in the family income: "At no stage in this family history, had they been able to manage only on the husband's wage" (Meyering, 1990, p. 141).[17] Dasgupta (1995) shows that the need for child labor also exists in developing countries nowadays and depends on real wages. He emphasizes that in some developing countries, children are in effect "working hands"; thus, a reduction in productivity leads to an increase in fertility since more hands are needed. Moreover, using data from the Population Institute's value of children (VOC) project, Caldwell (1983, p. 474) writes that: "The findings indicate that fertility decline is associated with declining economic roles for children".

Regarding intergenerational transfers, the debate on these transfers, as the one on wages, is also tainted with ideology. Nowadays, in developed countries, flows are obviously from parents to children. But, it may have been different in the past. Becker (1960, p. 213) suggests that "in the mid-nineteenth century children were a net producer's good, providing rather than using income".

The data for the nineteenth century is still scarce and more research is needed. However, there are already two types available of data showing that intergenerational flows were from children to parents for most of the nineteenth century. The first data set is related to relative earnings of males as a proportion of the family income; the second concerns a comparison between earnings and spending.

[12] Although there is a debate over whether accumulation of capital was due only to savings or also to inflows of capital from abroad (see Brezis, 1995; Neal, 1990).

[13] These facts contrast with the situation in the twentieth century in which transfers are obviously from parents to children.

[14] See Stevenson (1920), Notestein (1936), Innes (1938), Johnson (1960), Haines (1989), and Woods (1987).

[15] Total fertility rates and GRR would display a similar pattern. See Wrigley and Schofield (1981).

[16] There is a long debate in the literature regarding the evolution of wages and more generally, the standard of living in the first half of nineteenth century England. As emphasized in Taylor (1975) and Feinstein (1998), this economic debate was tainted with philosophical biases and was related to the debate on the benefits of capitalism. There are the optimists (Clapham, 1926; Hartwell, 1972; Lindert and Williamson, 1983) who show that industrialization was equivalent to an increase in the standard of living of the workers, while the pessimists (starting with Engels, Thompson, Toynbee, Hammond, and later Hobsbawm) disagree with this view (see Feinstein, 1998; Brezis and Crouzet, 2004, for a summary of the debate). Taking the confidence interval of Feinstein, and the evidence brought by him on biological variables (height and mortality), the pessimist view for the first half of the century is based on sound ground. Moreover, on the consumption side, the decrease in income has been shown by the decrease in the consumption of meat, sugar, and tea in the first half of the century (see Taylor, 1975, p. xxxi).

[17] Another possibility, raised by Parsons and Goldin (1989), is that parents prefer to put the children to work, giving the parents the possibility of working less. However, Basu and Van (1998, p. 416) take it for granted that "a family will send the children to the labor market only if the family's income from non-child labor sources drops very low".

Table 2
Earnings and cost of living for one worker couple in Bath for the years 1832–1850.

Bath (England)	Earnings (shillings per week)	Cost of living
1832	9s 6d	13s 1d
1840	13s 2d	13s 10d
1850	14s 1d	14s 2d

Source: Neale (1975).
Note: For Bath it is assumed that subsistence for one worker couple includes 28.5 lb of bread, 1.5 lb of meat, 1 lb of bacon, 3 lb of cheese, and 4 lb of potatoes. The cost of this basket for 1832 was 9s 6d. We add to it 1s 4d for clothing and shoes, 3d for candles and soap, 6d for fuel, and 1s 6d for rent, for a total cost of 13s 1d.

During the nineteenth century, "[workers'] earnings declined, and the man's relative contribution fell suggesting the necessity of getting other households members into the labour force" (Horrell and Humphries, 1997, p. 30). More specifically, the share of male factory workers' earnings in the family income went down from 60% in 1800 to 55% in 1820, 42% in 1825 reaching 39% in 1835. However, it increased in the second half of the nineteenth century, to 69% in 1865.[18] It therefore appears that: "the contributions of women and children may have been crucial to most families during certain stages in the family life cycle... In only a few occupations were men earning enough to buy their families sustenance and to provide the roof over their heads; for most households the earnings of women and children were essential" (Horrell and Humphries, 1997, pp. 35–42).[19]

There are also some direct data on earnings and expenditures of couples, which are presented in Table 2. It shows that the earnings of a worker couple did not permit subsistence levels.[20] Moreover, Nardinelli (1980) presenting the Sadler report of 1832, shows that children were supporting their parents.

In France, up to age 5, the cost per annum of a nurse was around 84fs (see Badinter, 1980, p. 65). When considering benefits, the wages received by children who started working at age 6 (and later on, due to legislation, at age 9), were around 450fs a year, around half of adults' earnings. Since they would keep around 20fs for themselves, after a few years of working, children had already repaid expenses.[21] Thereafter, there were net income inflows from children to parents.

Thus, the data – albeit somewhat scarce–leads to the same conclusion: workers' intergenerational income flows during the nineteenth century were from children to parents. This was so because the costs of raising worker's children were very low. Since few proletariat children attended schools and housing standards were poor, food constituted the marginal cost of an additional child. It was thus much lower than the marginal benefit.

However, there was a rise in the costs of raising children in the late nineteenth century, due to the enforcement of restrictions on child labor. At the same time, it also became more expensive to raise children due to the 1868 Poor Law, that made it an offense for parents to fail to supply their children with such necessities as food, lodging, and clothing. Moreover, in 1891, schooling was made compulsory, so that at the turn of the century, the intergenerational flows were changing directions.

[18] Horrell and Humphries (1997, Table 1, p. 31).
[19] See also Schellekens (1993, p.3) who claimed that "men's wages among the working class, and among unskilled laborer in particular, were not sufficient to support a family". Shammas (1984) claims that in the 1790s, adult equivalent caloric intakes were only just at minimum subsistence levels. Since real earnings of men fell until the 1830s, as discussed above, an increase in child labor was a necessity to keep people alive, and out of complete misery.
[20] Data gathered on worker in Lille (France) display a similar pattern (see Brezis, 2001).
[21] In England, in a cotton mill survey undertaken in 1859, men were paid a weekly wage of 18s and boys were paid 7s (see Evans, 1990).

The model presented in the next section examines the relationship between capital, wages and fertility rates.

3. The model

This paper focuses on the two classes that played a preponderant role during the Industrial Revolution: the workers and the business elite. Our assumptions are that workers are constrained, i.e., their real wages does not exceed consumption. The elites are not constrained, and they may save. Moreover, children of the elite do not work, since parents have high income.

In the first part of the model, we show that there exists a negative correlation between wages and fertility rates. In the second part, we develop the relationship between capital and labor, so as to endogenize wages. The structure of the model is dynamic in the sense that there is a continuity of generations; each generation of workers and entrepreneurs, i.e., the business elite, lives one period.

3.1. Output

This paper relates to the factory system, and to the industrial sector in the nineteenth century, where the two main factors of production are capital and labor.[22] The output function takes the regular Cobb-Douglas form:

$$Y_t = AK_t^{\alpha} L_t^{1-\alpha}. \tag{1}$$

Since we assume a constant return to scale Cobb-Douglas function, wages are an increasing function of the capital–labor ratio, and the second derivative is negative:

$$\begin{aligned} &w_t = A(1-\alpha)\left(\frac{K_t}{L_t}\right)^{\alpha} \quad \text{and} \quad r_t = A\alpha\left(\frac{K_t}{L_t}\right)^{\alpha-1}, \\ &\frac{\partial w_t}{\partial (K_t/L_t)} = A(1-\alpha)\alpha\left(\frac{K_t}{L_t}\right)^{\alpha-1} \geq 0, \\ &\frac{\partial^2 w_t}{\partial (K_t/L_t)^2} = -A(1-\alpha)^2\alpha\left(\frac{K_t}{L_t}\right)^{\alpha-2} \leq 0. \end{aligned} \tag{2}$$

3.2. The workers

In Section 2, we pointed out that, during the nineteenth century, child labor was necessary for workers and intergenerational income flows were from children to parents.[23] Our model is based on these stylized facts; consequently, it only analyzes the period where wages were lower than the subsistence level. We start by describing the utility function and the budget constraint. Based on the social norms presented above, we introduce a different utility function than the conventional neo-Malthusian one. Moreover, the budget constraint is also different – while all other models consider that children received more than they gave; this model assumes the opposite. We first define the utility function, and then the budget constraint.

(i) The utility function

The simplified neo-Malthusian models introduce the number of children directly in the utility function: $U(\cdot, n)$.[24] More sophisticated models introduce it through altruism. For instance, Becker

[22] We omit land, since it is not an important factor of production for the industrial sector.
[23] Hazan and Berdugo (2002) present a model where child labor is introduced in a Galor et al. type of framework, but in which child labor is not necessary, since intergenerational flows are from parents to children.
[24] This was done in particular in Becker (1960), and Galor and Moav (2002).

and Barro (1988) assume (i) altruism towards each child, which is:

$$U_0 = U(c_0, U_1) = v(c_0) + \lambda n U_1, \quad (3)$$

where U_j is the utility of generation j, $j = 0, 1$; v is the standard current utility of consumption, c_0; n is the number of children, and λ measures the degree of altruism. But this assumption is not enough to get a positive correlation between an increase in income and increase in fertility rate. The neo-Malthusian models also have to assume that (ii) parents' utility is increasing and concave in the number of children for a given utility per child, and that (iii) the cost of rearing a child exceeds the present value of his lifetime earnings. Under these three assumptions, it is found that "wealthier persons would consume more and also would have larger families" (Becker and Barro, 1988, p. 11).

In the model presented in this paper, the utility function will be such that parents care about children, but it will be different than the conventional-altruism as presented in Eq. (3). The notion of altruism means that parents take into account the well-being of their children, but it does not necessarily mean incorporating the utility function of the child per se. Becker (1981, p. 193) already emphasized that it might be that the parents' benefits from the variables entering the utility function of the children may sometimes be related non-monotonically to the utility function of these variables of the children themselves.

In this model, the utility function of parents will be altruistic by the fact that some of the variables affecting the well-being of children are included in the utility function of parents.[25] But, it will not be the conventional-altruistic form, since the utility function of the children per se is not included, but only some variables related to utility.

The two variables related to the well-being of the children and which are included in the utility of the parents are (i) children's consumption and (ii) the aversion of seeing them working and not having more leisure. This aversion of depriving children from their leisure time is assumed to be more important than the marginal utility of consumption. The reason for it is what has been coined as "loss aversion" in the field of Behavioral Economics. The "loss aversion" theory claims that people care much more about loosing something than gaining it: "loss aversion means that the value function abruptly changes slope at the reference level".[26]

So for parents who send their children to work, depriving children from their liberty is a loss that affects their utility much more than increasing consumption.[27] Thus, the negative effect of compelling children to work on the parent's utility function is incorporated, while the positive effect of children consumption is ignored.[28] Our assumption is that a parent – even if he does not care very much about "giving" to his children – still does not want to hurt them. A way of hurting them would be to deprive them from their liberty and leisure, and oblige them to work, starting at young age.

Therefore, in each period, workers choose to maximize a utility function:

$$U_0 = U[C_0, n\psi(c_i, h_i)] = U[C_0, n\psi(h_i)], \quad (4)$$

where c_i and h_i are respectively the consumption and working hours of children, and n the number of children. The parent's utility from these two variables is represented by the ψ function in Eq. (4); and in the right hand side of Eq. (4) we omit consumption c_i, as explained above. The specificity of this model is that the variables entering the utility function of the parents are different than the elements entering the utility of the child itself.

We assume that $U_1 \geq 0$, $U_2 \leq 0$, $U_{11} \leq 0$, $U_{22} \leq 0$, $U_{12} \leq 0$, and that the working hours are fixed by the employers, and therefore we assume h_i to be exogenous and constant, though it was progressively reduced by successive laws.[29]

Hence, in our model, children indirectly affect their parents' utility function in a specific manner: parents prefer that their children do not work, but have no choice, so that the number of children negatively affects the utility function.

(ii) The budget constraint

The budget constraint of the family in each period is presented in Eq. (5). On the right hand side of Eq. (5) is portrayed the family income; it includes the worker's and children's wages, the latter are a fraction γ of the wages of adults. On the left-hand side, we have the outlays, i.e., the worker's and the children's consumption:

$$C + l(n) = w + \gamma w n \quad 0 < \gamma \leq 1 \quad (5)$$

and

$$C \geq \bar{C}, \quad (6)$$

where C is the consumption of parents, n the number of children, w are the wages, and $l(n)$ is the consumption of children. We assume that $l(n)$ is upward-sloping and concave ($l' > 0$ and $l'' < 0$). The inequality in Eq. (6) means that consumption cannot be lower than the subsistence level of consumption, $\bar{C}$.[30]

The constraint of a minimum amount of consumption, brings about that, even though the worker's utility would have been greater if his children did not work, he was compelled to let his children work, since the salary of one person was not adequate for subsistence. As shown in Section 2, we analyze a period where wages were lower than the subsistence level, i.e., $\bar{C} > w$[31]; having children brought about an increase in the family income.

The top part of Fig. 1 represents the utility function as a function of the number of children n, where consumption is substituted in the budget constraint (5).[32] n_0 is the fertility rate which brings the utility function to maximum. However, the wage rate is so low that

[25] See Altman (2005).

[26] Rabin (1998, p. 14). On the theory of loss aversion see also Bowman et al. (1997), and Kahneman et al. (1991).

[27] However, for the children themselves, when they become adults, their utility function is affected by consumption, but very little by working hours, since they worked during their whole life. Therefore, for matter of simplicity, leisure is not incorporated in the utility of parents, especially that the working hours are fixed by employers. If we do not assume that working hours are exogenous, then the number of children, and the parents' working hours increase when wages decrease. Thus, this does not change the results of our model. Some economic historians have claimed that working hours were indeed endogenous, and have shown that children's work was sometimes a substitute for parents' work (see Parsons and Goldin, 1989).

[28] For matter of simplicity, instead of including consumption and leisure with conditions on the derivatives, reflecting the relative importance of consumption and child labor, we omit child consumption. Based on the social norms presented in Section 2, omitting child consumption from the utility function of parents seems a realistic assumption.

[29] We could have also an additive function so that $U_{12} = 0$, without loss of generality.

[30] One can also assume a minimum subsistence level for children. This would not affect our result, since the household fixed costs leads to worker's wages to be inferior to the subsistence level of consumption, since the latter includes fixed costs. However, the variable costs of living are lower than real wages.

[31] This assumption is related to the fact that transfers are from children to parents. From Eq. (5) and this condition, we get that $\gamma w n > l(n)$, i.e., that children earn more than they consume. In this model, parents' consumption is higher than wages, because of the household fixed costs such as apartment rents and furniture (see Table 2). However, this paper does not claim that transfers from children to parents occur with the first child. However, the transfers are positive for the total number of children, and of course, for the marginal child.

[32] It is easy to show that $U(n)$ has an optimum where $dU/dn = 0$, and that $d^2U/dn^2 < 0$. Indeed, since $U(n) = U(w + \gamma w n - l(n), n)$, when n is small, its derivative takes a positive sign and a negative one when n tends to infinity. Moreover since $d^2U/dn^2 < 0$ then there exists an n such that the FOC is zero.

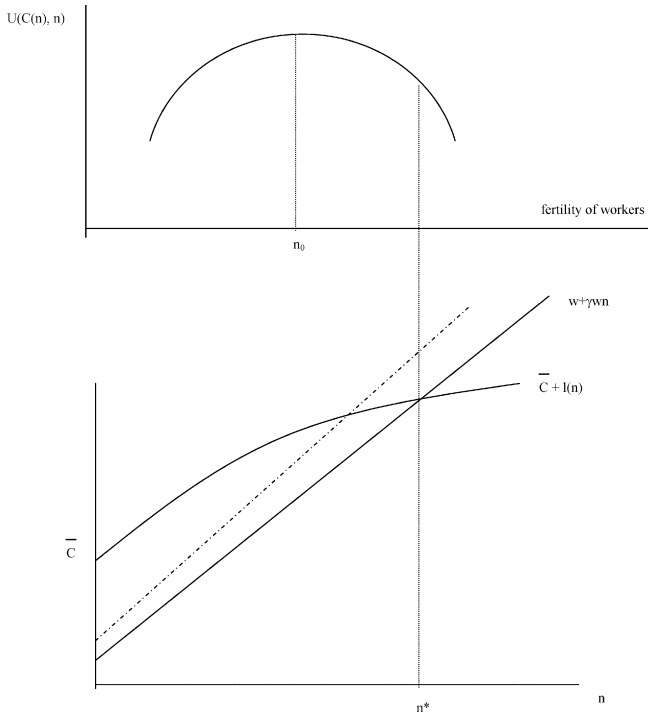

Fig. 1. The optimal fertility rates of the proletariat.

consumption is lower than the subsistence level at the maximum of the utility function (since as shown in the lower part of Fig. 1, at n_0, the curve of $\bar{C} + l(n)$ is higher than $w + \gamma wn$). Eq. (6) is therefore binding, and therefore the number of children at equilibrium, n^* is higher than the optimum, n_0 and is such that:

$$w + \gamma w n^* - l(n^*) = \bar{C}. \tag{7}$$

The optimum number of children is consequently higher than the non-binding maximum.

(iii) The optimal fertility rate of the workers

It is easy to show that the optimal number of children is a negative function of wages. Indeed, when wages increase (a shift to the left of the straight line in Fig. 1), the constraint is reduced, and therefore the fertility rate decreases. The optimal number of children is consequently a negative function of wages as shown by differentiating Eq. (7)[33]:

$$\frac{dn^*}{dw} = \frac{l + \gamma n}{l' - \gamma w} < 0. \tag{8}$$

The interpretation of Eq. (8) is as follows: when wages slightly decreased, as occurred during the first half of the nineteenth century, families needed more children to work in order to survive, and the fertility rate slightly went up. During the second half of the century, wages went up, and therefore workers reduced their fertility rate.

In consequence, this model shows that the correlation between wages and fertility rates are negative. But wages are not exogenous, and are determined by the capital–labor ratio. We now examine the behavior of the business elite, which determines savings and the capital stock.

[33] A necessary assumption in this model is that $l' \leq \gamma w$, that is, the net wages of children at the margin are positive. We also assume that the second derivative of the l function is such that $(l + \gamma n)l''/(l' - \gamma w) \geq 2$. Under this assumption, we obtain that $d^2n^*/dw^2 \leq 0$.

3.3. The business elite

The business elite, unlike the workers have sufficient income, which permit them to save, as in a model à la Kaldor. Moreover, their children do not need to work.[34]

The business elite was concerned about the family business and had an interest in the continuation of the familial enterprise. In this social class, one receives peer respect and honor if one makes his business fruitful. In consequence, the business elites save because they are concerned about increasing the value of the family business and have an interest in the continuation of the familial enterprise.

Hence, the utility function of the entrepreneur is a function of consumption, C_t, and the incremental value of the firm, which is a function of the savings of the entrepreneur, S_t.[35] Assuming an additive and logarithm function, we get:

$$U_t = U(C_t, S_t) = \ln(C_t) + \left(\frac{\beta}{1-\beta}\right) \ln(S_t). \tag{9}$$

The income of the entrepreneur amounts to the rents that he receives on the capital of the firm, $r_t K_t$. He divides his income between his own consumption, C_t, and savings, S_t:

$$r_t K_t = C_t + S_t. \tag{10}$$

The first-order condition is shown in Eq. (11), that determines the quantity of savings, and consumption, chosen by the entrepreneur:

$$S_t = \beta r_t K_t. \tag{11}$$

Eq. (11) indicates that savings are a linear function of rents, $r_t K_t$. We turn now to examine the dynamics of the system.

4. Equilibrium and the dynamics of capital, wages, and fertility rates

In the previous part, we have shown that on the side of the business elite, capital and interest rate determine savings and consumption, at the beginning of each period. For the workers, capital and labor given at the beginning of each period determines the wages received by the workers and their fertility rate (see Eqs. (2) and (7)). In order to examine over time the behavior of the fertility rate, the dynamics of the system must be analyzed.

(i) Dynamics of fertility rates and savings

The number of children in each family of workers determines the workers' population in the next period.[36] The savings of the elite determines the stock of capital, which are described in Eq. (12):

$$K_{t+1} = K_t + S_t; \quad L_{t+1} = L_t(1 + n_t). \tag{12}$$

If the increase in the capital stock is lower than the increase in population, then the capital–labor ratio will decline, and wages in the next period will be lower than in the previous period (see Eq. (2)). As a result, the fertility rate of the workers will increase, and

[34] In this paper, we focus on the increase in the workers' population, and we therefore omit the elite's fertility rates. Brezis (2001) develops a framework in which fertility rates of the elites are endogenously determined.

[35] In the standard model of savings, workers save for their retirement period, in which they do not get any salary. However, the elite can, in each period, use part of the rents on capital to consume. Therefore, this one-period framework is appropriate for analyzing the dynamics of savings and capital accumulation of the business-elite.

[36] Workers' population has also increased due to the emigration from rural areas. This would only accelerate the decrease of wages posited in the model. Marriage patterns would also affect fertility rates and wages (see Foreman-Peck, 2009; Hajnal, 1965).

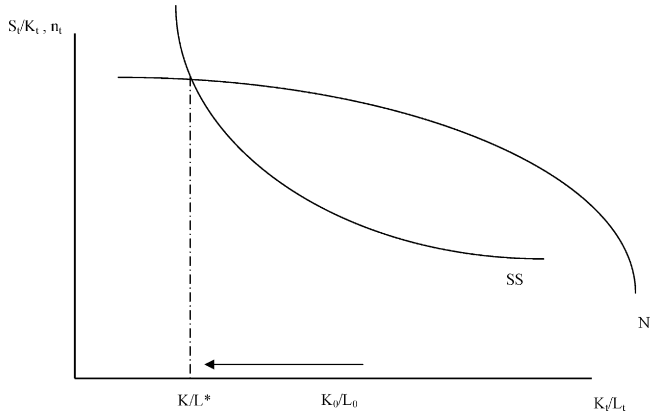

Fig. 2. Dynamics of the model.

the labor supply will go up. When the situation is reversed, there is a decrease in the fertility rate. Therefore, the increase (or decrease) of the capital–labor ratio over time determines the dynamics of the economy. From Eq. (12) we get that:

$$\frac{K_{t+1}}{L_{t+1}} \leq \frac{K_t}{L_t} \Leftrightarrow \frac{S_t}{K_t} \leq n_t. \tag{13}$$

Eq. (13) states that there is an increase in the capital–labor ratio if and only if the savings–capital ratio (S/K) is greater than the increase in population, n. In other words, when $S/K = n$, it means that we are in a steady state, in which K/L in constant and in consequence wages and fertility rates are also constant.

The two elements of Eq. (13), n and S/K, can be compared since the savings–capital ratio and the fertility rate of the workers are a function of the capital–labor ratio, as shown in Fig. 2. About fertility rates, n, the relationship between the fertility rate of the workers and the capital–labor ratio is represented by the NN curve, which is concave.[37]

The saving–capital ratio (S/K), shown in Eq. (14) is also a function of K/L by substituting the interest rate from Eq. (2) into Eq. (11):

$$\frac{S_t}{K_t} = \beta A \alpha \left(\frac{K_t}{L_t}\right)^{\alpha-1}. \tag{14}$$

Eq. (14) is represented by the curve SS. It is easy to show that the first derivative is negative, and the second is positive.

(ii) The steady state of the model

The interaction between capital and labor drives the dynamics of the model. Fig. 2 depicts the NN curve that describes the fertility rate, n, and the SS curve that describes the S/K function. K/L^* is the steady state where capital increases at the same rate as population. During the early eighteenth century, there was an increase in the capital–labor ratio. However, a shock, e.g., the late eighteenth century European wars may have led to an increase in the capital–labor ratio. In that situation, for a given K_0/L_0 at time t_0, which is to the right to the steady state, then we have that the NN curve is above the SS curve and therefore, n is greater than S/K, where the capital–labor ratio will decrease, as shown by the arrow. This trend continues until the system reaches again the steady state at K/L^*, where n is equal to S/K. This is a steady state, a priori, and there are no changes in the capital–labor ratio or in wages. During this whole period, we have a decrease in the capital–labor ratio, in wages and the fertility rates of workers goes up. This is what happened during the first phase of industrialization.

When the economy arrives to the steady state, there is no increase anymore in the fertility rates. At this point, the variable that drives the system to continue to move is the exogenous variable A (technological progress). Since A increases, the SS curve shifts continuously to the right. From then on, the trajectory is a movement along the NN curve. Over time, the capital–labor ratio increases, and as a result, the fertility rate n decreases.

5. Conclusion

The era of industrialization cannot be described as a long and steady increase in real income of all classes. During the whole first half of the nineteenth century, the workers' standard of living decreased, while their fertility rates slightly increased; this was a period of proletarization of the workers. Hence, during the nineteenth century, there was a negative correlation between wages and fertility rates.

The model presented in this paper provides an explanation for the negative correlation between wages and fertility rates of workers, which occurred during the first phase of demographic transition. This model claims that fertility rates of workers increase during the first phase of industrialization because of the necessity for child labor due to a reduction in wages.

This model departs from the neo-Malthusian framework in its definition of altruism. The conventional-altruistic models assume that the utility of children per se enters the utility function of the parents. This assumption is suitable for the twentieth century, but it is not appropriate for the era of industrialization in the nineteenth century, in which child labor is a necessity. The socio-economic context of the nineteenth century, presented in this paper put in evidence the implications of the relationship between the family and the labor market. Therefore, the family structure cannot be analyzed in dichotomy of the labor market, in which child labor is a significant part of it. During the Industrial Revolution, parental behavior towards children was affected by the fact that child labor was necessary.

In consequence, this model incorporating a non-conventional-altruistic assumption is based on the social context of the nineteenth century. The utility function takes into account that child labor is a necessity for survival. This paper shows that demographic transition can only take place when a family can subsist without the need of child labor. Thus, these two orthogonal views on altruism and family behavior predict an opposite correlation between income and fertility rates. While the neo-Malthusian models predict a positive correlation, the non-Malthusian models, a negative one.

In conclusion, models should be adapted to the historical environment. Models suitable for the twentieth century cannot always be adapted to the nineteenth century. This model, which departs from the broader Malthusian view, can be seen as an alternative explanation for the phenomena that occurred in the nineteenth century with regard to industrialization and demography. It is based on the fact that laws governing population decisions are not unrelated to historical processes: "In fact every special historic mode of production has its own special laws of population, historically valid within its limits alone" (Marx, 1887, p. 784).

Acknowledgements

I wish to thank the editor and two anonymous referees for their useful suggestions. I wish to thank Mike Bordo, Daniel Cohen, Francois Crouzet, Steven Durlauf, James Foreman-Peck, Oded Galor, Edward Glaeser, Knick Harley, Samuel Hollander, Peter Temin,

[37] Since fertility rates, n are a decreasing function of wages, and wages are an increasing function of the capital–labor ratio (see Eq. (2)), we obtain that the fertility rate is a decreasing function of the capital–labor ratio. So $n_t = \eta(K_t/L_t)$ while $\eta' \leq 0$, and $\eta'' \leq 0$, assuming that $dn_t/dw/d^2n_t/dw^2 < A\alpha(K_t/L_t)^{\alpha}$.

Thierry Verdier, Eugene White, and Warren Young; as well as conference participants at the European Economic Historical Society Conference, the European Economic Association meetings, and participants at seminars at Carlos III de Madrid, Delta, Haifa University, the Hebrew University of Jerusalem, Rutgers University and the University of Wisconsin for their helpful comments.

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