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HEALTH, LIFESTYLE AND GROWTH

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SOMMARIO

In this paper I try to explain why lifestyle may have a positive impact on economic growth. First of all, I consider health affecting consumer's utility and I define also a Health Production Function where health is the output and the consumer's good are the inputs. In this approach I define a parameter named Lifestyle Return to Scale (LRS). A first result is that an increase of consumer's personal income may have a positive or a negative effect on health. It depends on Lifestyle Return to Scale, According this result, I estimate a health multiplier. Then I modify the Solow Growth Model. I consider health as labour-augmenting. The result is a semi-endogenous model in which the population growth affects positively the income per capita growth, if lifestyle is positive.

To Angelo and Angelica

1 Introduction

At the macro level the stylized facts show big difference in income per capita and in Health status among countries and/or regions. This may imply that low income per capita affects negatively health and vice versa.

It is useful to note that in the last 15 years the literature on economic growth focused primarily on the role of human capital accumulation while Health had a marginal role in the economic analysis. Secondly if the difference among countries are strong (in income and in health), those ones among regions are stronger and also very important for economic growth.

This is essentially a theoretical paper in which the relationship between Health and Growth is built through the consumer lifestyle. Starting from Contoyannis and Jones's hypothesis (2004) a micro model of consumer's choice is introduced in order to better define a measure of lifestyle and then to explain the effects of consumer's choices on his Health status. The first important result is that an increase of consumer's personal income may have a positive or a negative effect on his health if the same consumer has a good or a "bad" lifestyle.

At macro level For Weil (2005) one of the most important questions is the following one: do the forces driving these differences come primarily from the side of health of from the side of income?

In this context I try to give an answer to the last question computing s health multiplier (§ 2) and also developing a simple modified Solow growth model in which health is "labour augmenting" (§ 3). For this reason this model includes the relationship among income, lifestyle and health status first obtained at micro level.

The main result of the model is that lifestyle may be crucial for the growth: a "good" lifestyle can generate a semi-endogenous growth, but a "bad" consumer's lifestyle may have also negative effects on the growth. The model also explains why improving in health have a positive effect on income while increasing in income may have a lower effect on health (Weil, 2005)

2 1.Some Empirical Evidence

There are many empirical evidence that people's lifestyle assumes an importance for the government's decisions.

For example, In England many local governments offer incentives in order to encourage the consumer to have a healthier lifestyle. For example the Financial Times wrote:

In Dundee, smokers are being offered £12.50 a week by the NHS if carbon monoxide testing shows they have quit. In Essex, pregnant women can claim a £20 food voucher from the NHS after stopping smoking for one week, £40 after four weeks and another £40 at the end of a year if they have still quit. Brighton offers children £15 for quitting smoking for 28 days, while overweight patients in Kent are also being offered incentives for losing weight. In the US and other countries incentives have been offered for weight loss, complying with diabetes treatment, or regularly testing negative for sexually transmitted diseases" Financial Times, Cash incentives seen as helping nation's health 11 April 2009)

Moreover in Japan, a national law against the obesity came into effect in 2008. Under this law companies and local governments must measure the waistlines of Japanese people between the ages of 40 and 74 during their annual checkups (New York Times, 2008).

In Italy on cigarette packs (sold by the state under a monopoly) are printed phrases that warn consumers of the damage that smoking causes. On some packages even appear the following sentences: smoking when pregnant harms your baby, smoking kills.

These few examples show how the government is concerned with the lifestyle of people and implement policies to change consumption habits of those persons.

In other words, many governments are taking over the individual choices of people (as over-eating, smoking and drinking).

What determines the intrusive interest by the Government? By reasoning backward, the interest from the government assumes a conflict between individual choices and social choices. This conflict originates in two factors. The first is the rising cost of health care experienced in many Western nations.

The second is that a bad lifestyle may negatively affect labour productivity. At this purpose Zargosky (2005) shows for the U.S., a large negative association between Body Mass Index (BMI) and White female's net worth, a smaller negative association for Black women and White males and no relationship for Black male. He also finds that Individuals who lose small amounts of weight experience little change in net worth, but those who lose large amounts of weight have improved financial position.

Strauss (1986), for the Household of the Sierra Leone shows a highly significant effect of caloric intake on labor productivity, providing solid support for the nutrition-productivity hypothesis. The marginal effect on productivity falls drastically as calorie consumption rises but remains positive at moderately high levels of intake. One result is a fall in the effective price of food, a decline that is larger for households that consume fewer calories.

Generalizing this argument, it can be argued that health has a positive effect on labor productivity of the individual. So the choices relating to lifestyle (smoking, drinking, etc) of the same individual interest to the firm and indirectly the whole of society because they produce effects on labor productivity of that person.

Ultimately the lifestyle generates externalities, if this term indicate possible conflicts not resolved by the market. Externalities have on labour productivity and costs of health care more that the company has to bear. This relatively new concept of externality is well explained by Sassi and Hurst (2008). They write:

"………*Lifestyle choices, as many other forms of consumption, may produce external effects. There are immediate externalities that derive directly from acts of lifestyle consumption, such as passive smoking, violent and disorderly behaviour associated with alcohol abuse, or traffic accidents resulting from reckless driving. There are also deferred externalities, which are generated through the link between lifestyle choices and chronic diseases. Once chronic diseases emerge, and in some cases even before they emerge (e.g. when important risk factors such as hypertension or obesity begin to manifest themselves), the individuals affected will become less productive, possibly entirely unproductive, they will make a more intensive use of medical and social services, which may be publicly funded, they may require care by members of the family and friends. Conversely, a reduced life expectancy may mean a less prolonged use of publicly funded medical and social services at the end of life, as well as reduced pension payments,*

which are not themselves externalities, but would translate into a less onerous fiscal burden and therefore less distortion in the way the economy works. All of these phenomena involve externalities (negative the former, positive the latter) on society at large, family and friends, which can be attributed at least to some extent to the lifestyle choices originally made by the individual. The extent to which externalities can be associated with lifestyle choices depends, of course, on the strength of the link between lifestyles and disease, i.e. by the increase in the risk of developing a chronic disease associated with adopting a particular lifestyle".

3 A Micro Model

In this paragraph I define lifestyle and I also develop a micro-funded model that explains the relationship between health and income, the effect of income on health.

First of all, let's suppose an economy that produces 3 goods: 2 consumption good (*x* and z), and Capital (*K)*. Saving rate (*s*) is exogenous and constant

Starting from Grossman model (1972) the health capital and the demand for health have been widely modelled in economic literature.

Among others, Contoyannis and Jones (2004) develop a static model of lifestyle and health production. In that model the assumptions are: i) income is assumed to be endogenous, but there is no direct influence of lifestyle or health on wages; ii) health affects consumer's utility (unlike Grossman's dynamic model (1972) in which health is considered a stock that produces a flows of pecuniary and non pecuniary benefits as effect on investment on it). *iii*)

health is a result of production function in which the inputs are *i) a* vector of goods, *ii)* a vector of exogenous influences on health; *iii)* a vector of unobservable influences on health. iv) The money budget constraint and the time constraint close the model. The result is that maximizing the Consumer's utility with a Lagrangian function, they obtain the Marshallian demand for the goods, and the level of consumer's Health.

In Contoyannis and Jones (2004) the Health Production Function is equal to

$$H = h(C, X_U, u_H) \quad [1.]$$

Where H is a measure of the individual health, C is a vector of M-goods, X_U is a vector of exogenous variables that influences health, and u_H a vector of unobservable influence on health.

In this paper I simplify and modify Contoyannis and Jones (2004) building-up a model of 2 equations: 1) the consumer's utility function; 2) the health production function.

The consumer's utility function

I assume that the consumer's utility function is a Cobb Douglas where health (*h)* is an input and for this reason it affects the consumer's utility function. The other 2 inputs are the goods *x* and *z*. In Formula the utility function is

$$U(h, x, z) = h^{\alpha} x^{\beta} z^{\delta} \quad [2.]$$

α, β and δ are respectively the elasticity of *h, x* and *z;*

$\alpha \geq 0$ may be considered the weight given to his own health by the consumer. If $\alpha = 0$, health is not important for the consumer. On the contrary if $\alpha > 0$ then health is important

$\beta, \delta \leq\geq 0$. if $\beta < 0$ (or $\delta < 0$) *x*, (or *z*) isn't a good but a "bad" for the consumer (i.e. a medicinal)[1].

The individual consumes a good only if its elasticity is positive. We suppose that $\beta > 0$ e $\delta > 0$-. So we have $\frac{dU(\cdot)}{dx} > 0$; $\frac{dU(\cdot)}{dz} > 0$. We also suppose that $\frac{d^2U(\cdot)}{dx} < 0$; $\frac{d^2U(\cdot)}{dz} < 0$

This is clearly a static equation. There is not dependence, but positive value of the elasticity means that the consumer knows the good's ophelimity.

The health Production Function (HPF)

According Contoyannis and Jones (2004) consumption may affect consumer's health, and for this reason the consumer is a co-producer of his health. For the authors the utility maximisation problem is given by the equations

$$\max_{C,H} U(C, H, C, X_U, \mu_U) \quad [3.]$$

$$H = h(C, X_U, u_H) \quad [4.]$$

Differently from Contoyannis and Jones (2004), I assume that the consumption of a good may not only better, or to be neutral for the consumer's health status, but it may also worsen it. This may be the case of smoking, alcohol and drugs.

[1] In the textbook a "bad" is an externality, something independent form the consumer's decision. Here a "bad" is a good that has a negativity impact on the utility of the consumer, and it can be used by the consumer according his own decision (i.e. a medicinal)

For sake of simplicity, We assume that a good can only better or worsen consumer's health status. In other words, there are no goods that can have a positive impact on health for small quantities and a negative for stronger doses. It assumes also that *x* improve health, while *z* worst health[2]. *x* can be defined as the virtuous good- in the sense of sustainable good - and *x* as the harmful good.

Health also depends on the initial level of health status (h_0), public health (Ψ), time (t) and on a stochastic component ε. The Health Production Function (HPF) is

$$h(x, z, h_0, \psi, t, \varepsilon) = x^{\rho} z^{-\gamma} h_0 \psi e^{\phi t} e^{\varepsilon} \quad [5.]$$

The equation can be split into two parts: $x^{\rho} z^{-\gamma}$ can be interpreted as the consumer's activity while the term $h_0 \psi e^{\phi t} e^{\varepsilon}$ as other factors. For sake of simplicity We put $h_0 \psi e^{\phi t} e^{\varepsilon} = \Omega$ and HPF becomes:

$$h(x, z, \Omega) = \Omega x^{\rho} s^{-\gamma} \quad [6.]$$

$(\rho - \gamma)$ is equal to the *elasticity of scale* and it can be positive, negative or null. Let $\theta = \rho - \gamma$. I suppose that each input exhibits decreasing return to scale, as to say $0 < \rho < 1$ and $0 < \gamma < 1$, Therefore $-1 < \theta < 1$.

For Sassi and Hurst (2008) individual lifestyle are related to those individual behavioural that occupy a central position among health, because of their direct influences on individual health. Also Contoyannis and Jones (2004) define a lifestyle "as a set of behaviours which are considered to influence health"

If $\theta > 0$ an increasing of the consumption has a positive effect on health, while for $\theta < 0$ this effect is negative. With $\theta = 0$ the consumer behaviour has no effect on health. For this reason the parameter θ may be defined as the lifestyle Return to Scale (hereafter LRS).

Substituting $h(x, z, \Omega) = \Omega x^{\rho} z^{-\gamma}$ into $U(h, x, z) = h^{\alpha} x^{\beta} z^{\delta}$, it obtains

$$U(h, x, z) = \Omega x^{\alpha\rho} z^{-\alpha\gamma} x^{\beta} z^{\delta} \text{ or} \quad [7.]$$

$$U(h, x, z) = \Omega x^{\alpha\rho+\beta} z^{\delta-\alpha\gamma} \quad [8.]$$

the *x*'s elasticity become $a\rho + \beta$ and the elasticity of *z* will be $\delta - a\gamma$. The good z will be consumed only if $\delta - a\gamma > 0$. Hence, the choice of consuming *z* depends on 3 parameters: 1) the elasticity δ of the good *z*, as to say the weight that the consumer confers to that good *z*; 2) α, the importance of the health for the consumer, 3) and the measure of the damage of *z* on health (γ).

It is useful to note that consumer can decide to use *z even if* he knows that *z* is dangerous for its health[3]. Following this approach, It does not depend only on the level of education. Even the consumer well aware of the damage that smoking produces may continue to smoke if he likes it very much.

Including health in the consumer's utility function, it increases the consumption of those goods that benefit health and decreases that good which causes damage.

[2] The ancient Romans said "In Medius stat Virtus. That hypothesis doesn't matter in the model.
[3] See (Avitabile, 2009) for the relantionship between health and information

The Utility maximization problem: The optimal choice of x,z and h

Let $\Omega = 1$. $p_x x + p_z z = y$ is the consumer's budget constraint where p_x, p_z are the prices of the goods and y is the disponible income $y = cY$ where c is the average propensity to consume $(0 < c < 1)$. The consumer' maximizes his utility when $\underset{x,z}{Max}\, x^{\alpha\rho+\beta} z^{\delta-\alpha\gamma}$ s.t $p_x x + p_z z = y$ .Solving the Lagrangianian $\max_{x,z} L = U(x,z) - \lambda(p_x x + p_z z - y)$. where λ is the Langrage Multiplier, goods consumed in optimal conditions are:

$$x = \frac{\alpha\rho+\beta}{\beta+\delta+\alpha(\rho-\gamma)}\frac{y}{p_x} \qquad [9.]$$

$$z = \frac{\delta-\alpha\gamma}{\beta+\delta+\alpha(\rho-\gamma)}\frac{y}{p_z} \qquad [10.]$$

The weight of health, α, increases the consumption of "virtuous" good and reduce the consumption of harmful good. In optimal condition, the health level is

$$h = \left(\frac{\alpha\rho+\beta}{\beta+\delta+\alpha(\rho-\gamma)}\frac{y}{p_x}\right)^{\rho}\left(\frac{\delta-a\gamma}{\beta+\delta+\alpha(\rho-\gamma)}\frac{y}{p_z}\right)^{-\gamma} \qquad [11.]$$

or

$$h = \left(\frac{\alpha\rho+\beta}{\beta+\delta+\alpha(\rho-\gamma)}\right)^{\rho}\left(\frac{\delta-\alpha\gamma}{\beta+\delta+\alpha(\rho-\gamma)}\right)^{-\gamma}\left(\frac{(p_z)^{\gamma}}{(p_x)^{\rho}}\right)y^{(\rho-\gamma)} \qquad [12.]$$

Where $\left(\frac{\alpha\rho+\beta}{\beta+\delta+\alpha(\rho-\gamma)}\right)^{\rho}$ and $\left(\frac{\delta-\alpha\gamma}{\beta+\delta+\alpha(\rho-\gamma)}\right)^{-\gamma}$ are respectively the share of good *x* and of good *z* weighted for their own elasticity with respect to health.

The level of health and the price of virtuous good are negatively correlated. If the price of good *x* increases (decreases), it worsens (betters) the level of health while if it decrease then it improves health conditions. On the contrary *h* improves (worsens) if the price of *z* increases (decreases).

The elasticity of health with respect to income is $\rho - \gamma = \theta$, the parameter LRS. Unlike the other parameters that can have only one sign, the elasticity of health with respect to income may be positive or negative. If $\rho - \gamma = 0$ income's growth do not affect the level of health. If $\rho - \gamma < 0$, income affects health negatively. If $\rho - \gamma > 0$ affects it positively.

In other words, an income growth do not always have a positive effect on health. The sign and the amount of the income's effect on health depend on the parameter θ of LRS.

A proxy (or an Index) of the consumer's Lifestyle (hereafter *LI*) may be given by the weighted average of the quantity of goods consumed for the respectively elasticities. The variable is included between by -1 and 1. $-1 < LI < 1$.

$$LI = \rho\left(\frac{\alpha\rho+\beta}{\beta+\delta+\alpha(\rho-\gamma)}\right) - \gamma\left(\frac{\delta-\alpha\gamma}{\beta+\delta+\alpha(\rho-\gamma)}\right) \qquad [13.]$$

Two issues are useful to underline. First, in the simple consumer's model, it is possible to choice between 2 goods. In the "corner" solutions, the consumers choose only one of that 2 goods: the good *x*, that represent the best "lifestyle" (if $\delta - a\gamma \leq 0.$), or the good *z*, that is the worst lifestyle.

In the reality

In the reality, a good may be not consumed for three reasons: 1) the consumer doesn't like that good (i.e. $\delta \leq 0$), 2) even he likes that good ($\delta > 0$) he estimates the health's damage of that good greater than the good's utility, $\delta - a\gamma \leq 0$ and he prefer to not consume that good; 3) he doesn't consume that good, because the relative price of that asset is greater than its income. In the first two cases do not consume the good is the result of free choice, (although painful in the second case) In the third case, the price of the asset and income limits the consumer's access to that good.

Therefore, LRS θ is a crucial variable in the model because it indicates the attitude of the consumer, given his preference and his opportunity, to lead a particular lifestyle. In other words $\theta = \rho - \gamma$ partially and indirectly reflects the consumer's preferences because the health production function contains only those goods that consumer likes or that he can purchase.

4 Comparative Static: the Health Multiplier

In the previous paragraph the effect of income on health has been found. We rewrite the Eq.11 as

$h = \upsilon c Y^{\theta} \varepsilon_h$ [14.]

Where $\nu = \left(\frac{\alpha\rho + \beta}{\beta + \delta + \alpha(\rho - \gamma)} \right)^{\rho} \left(\frac{\delta - \alpha\gamma}{\beta + \delta + \alpha(\rho - \gamma)} \right)^{-\gamma} \left(\frac{(p_Z)^{\gamma}}{(p_x)^{\rho}} \right) c$

Then I assume a production function with constant return to scale where both technology and health are labour augmenting. This may be a Cobb Douglas Production Function (i.e. Weil, 2005, Sala-I-Martin, 2005).

$$Y = K^{a} (AhL)^{1-a} \qquad [15.]$$

From the system given by the equations [14] and [15] it is possible to quantify the impact of a "health shock" $(\Delta\nu)$and/or an "income shock" (ΔA)on health and income .

Solving this system we obtain the effects in terms of elasticity. The results are reported in the following scheme for $0 < \theta < 1$ compared with the case that $\theta = 0$

Scheme 1		
	On Health	On Income
	$-1 < \theta < 1 - \{0\}$	

Health shock	$\frac{d\log h}{d\log v}=\frac{1}{1-\theta(1-\alpha)}$	$\frac{d\log Y}{d\log v}=\frac{(1-\alpha)}{1-\theta(1-\alpha)}$
Income shock	$\frac{d\log h}{d\log A}=\frac{\theta(1-\alpha)}{1-\theta(1-\alpha)}$	$\frac{d\log Y}{d\log A}=\frac{(1-\alpha)}{1-\theta(1-\alpha)}$
	$\theta=0$	
Health shock	$\frac{d\log h}{d\log v}=1$	$\frac{d\log Y}{d\log v}=(1-\alpha)$
Income shock	$\frac{d\log h}{d\log A}=0$	$\frac{d\log Y}{d\log A}=(1-\alpha)$

In terms of elasticity, the health multiplier is equal to $\frac{1}{1-\theta(1-\alpha)}$ for health and $\frac{1-\alpha}{1-\theta(1-\alpha)}$ for income.

For $0<\theta<1$, both of them are positive, and greater than one. As to say, if the lifestyle is positive, a health shock causes a greater effect on health, cause the effect of labour productivity growth.

The effect of a health shock on income depends positively on both LRS and labour elasticity or labour share.

The effect of an income shock on income is equal to $\frac{\theta(1-\alpha)}{1-\theta(1-\alpha)}$ and on health is equal to $\frac{(1-\alpha)}{1-\theta(1-\alpha)}$. Also in this case, for $0<\theta<1$, both of them are greater than zero.

Now It is also possible to give an answer to the question if is a health shock cause a greater effect on income than an income shock on health (Weil, 2005):

both a technological shock than a health shock produces the same effect on income. It is equal to $\frac{(1-\alpha)}{1-\theta(1-\alpha)}$ a that is greater than $(1-\alpha)$ because $\frac{1}{1-\theta(1-\alpha)}>1$

Concerning health, a health shock has an impact equal to $\frac{1}{1-\theta(1-\alpha)}$, greater than an income shock $\frac{(1-\alpha)}{1-\theta(1-\alpha)}$ because $0<\theta<1$

Concerning income, a health shock has an impact on income $\frac{(1-\alpha)}{1-\theta(1-\alpha)}$ greater than an income shock on health $\frac{\theta(1-\alpha)}{1-\theta(1-\alpha)}$

It is possible also to quantify the effect on health of a reduction of the price of the “good“ *x*. The multipliers for income and for health are respectively equal to

$$\frac{d\log h}{d\log p_x}=\frac{d\log h}{d\log \upsilon}\frac{d\log \upsilon}{d\log p_x}=-\frac{1}{1-\theta(1-\alpha)}\rho \quad [16.]$$

$$\frac{d\log Y}{d\log p_x}=\frac{d\log Y}{d\log \upsilon}\frac{d\log \upsilon}{d\log p_x}=-\frac{(1-\alpha)}{1-\theta(1-\alpha)}\rho \qquad [17.]$$

The effect of an *x*'s price shock on health is equal to $-\frac{1}{1-\theta(1-\alpha)}\rho$. It depends on the multiplier $\frac{1}{1-\theta(1-\alpha)}$ and on negatively on the parameter ρ that is *x*'s elasticity on health. The impact on income is $-\frac{(1-\alpha)}{1-\theta(1-\alpha)}\rho$ the product of the impact of *x*'s price on health $-\frac{1}{1-\theta(1-\alpha)}\rho$ and the health on income $(1-\alpha)$. Obviously it has a negative sign because a reduction of the *x's* price, has a positive effect on health and also it has a positive impact on income.

The Scheme 2 reports the health multipliers in level

Scheme 2		
	On Health	On Income
Health shock	$\frac{dh}{d\nu}=\frac{1}{1-\theta(1-\alpha)}Y^{\theta}$	$\frac{dY}{d\nu}=\frac{(1-\alpha)}{1-\theta(1-\alpha)}\frac{Y}{\upsilon}$
Income shock	$\frac{dh}{dA}=\frac{\theta(1-\alpha)}{1-\theta(1-\alpha)}\frac{h}{A}$	$\frac{dY}{dA}=\frac{(1-\alpha)}{1-\theta(1-\alpha)}\frac{Y}{A}$

5 A Growth model with health

In this last paragraph, I develop a Growth Model including health as factor. In literature there are many models that consider health as a factor of growth. Lòpez-Casasnovas and others (2005). Rivera and Currais (1999a) use a conditional convergence regression where the growth of per capita income is a function of the determinants of the steady state and considering health as an important determinant of an enhanced labour force, they obtain the result that health affects income growth both positively and significantly. In an other paper (Rivera and Currais (1999b)) investment in health contributes in a significant way to explain variation in output through in human capital even in those countries which presumably have high level of health.

Heshmati (2001) build up a model that is an extension of the MRW model by incorporating health. The results show that Health Care Expenditure has positive effect on the economic growth and on the speed of convergence

We want to consider the effect of individual lifestyle on economic growth. Let's now consider a Solow Growth Model with constant saving rate *(s)*, diminishing return of capital and labour, Labour augmenting technology, constant return to scale. The production function is

$$Y=K^{a}\left(AL\right)^{1-a} \qquad [18.]$$

where K, A, L are respectively the capital, the technical progress and the labour. α is capital elasticity

Considering that health is labour augmenting (Weil, 2005; Sala-i-Martin, 2005), the production function becomes

$$Y = K^{a}\left(AhL\right)^{1-a} \qquad [19.]$$

Being $h = \upsilon Y^{\theta}$ it obtains

$$Y = K^{a}\left(A\upsilon Y^{\theta}L\right)^{1-a} \text{ or} \qquad [20.]$$

$$Y = K^{\frac{a}{1-\theta(1-a)}}\left(A\upsilon L\right)^{\frac{1-a}{1-\theta(1-a)}} \qquad [21.]$$

The parameter θ becomes crucial in order to determine return to scale. For $0 < \theta < 1$ there are increasing returns to scale because

$$\frac{1}{1-\theta(1-\alpha)} > 1$$

In steady state the Income growth rate is (see appendix for demonstration)

$$\dot{Y} = \left(\frac{1}{1-\theta}\right)\left(\dot{A} + \dot{L}\right) \qquad [22.]$$

and Income per capita growth rate is

$$\frac{\dot{Y}}{L} = \left(\frac{1}{1-\theta}\right)\left(\dot{A}\right) + \left(\frac{\theta}{1-\theta}\right)\left(\dot{L}\right) \qquad [23.]$$

$\dot{Y}, \dot{A}, \dot{L}$ are respectively the growth rate of income, technical progress, and population growth

This is the most important results is that for $\theta > 0$ economic growth is positive correlated with demographic growth and also that growth rate is higher than the Solow model.

The difference with the Solow model is clear. According Solow Model, in Steady State income per capita growth depends only by technical progress. On the contrary in this model also the population growth and variable lifestyle Return to Scale (hereafter LRS) affect the income growth rate.

In other words if LRS is positive the model is a “semi-endogenous” growth model in which the population growth has a positive impact on economic growth. The result is similar to Arrow’s learning by doing model (1962). In that model the technical progress depends on income through learning by doing process, while in the model just developed the income impacts on labour productivity through the variable LRS.

This model may explain also an other stylized fact. In time series there is a positive relationship between population growth and income per capita while the growth rate of income per capita is not on average higher in countries with faster population growth (Romer, 1996). This stylized fact may be explained because during the history lifestyle has improved, while in cross section analysis the sign of the relationship depends on the lifestyle of the geographical area.

6 Conclusions

Jean Anthelme Brillat-Savarin, the author of Philosologie of taste, say that (i) Animals feed themselves, men eat, but only wise men know the art of eating; and (ii) The destiny of nations depends on the manner in which they are fed

In this paper a growth model with Health has been built. The crucial hypothesis are (i) that individuals are co-producers of their health and (ii) health affects positively labour productivity.

First I develop a consumer's micro model with health and two goods. Both of them are positively correlate with the Consumer's Utility. Health is the output of a "consumer's production function" with the two goods are inputs. The first good has a positive impact on health while the second good has a negative impact. The result is that the elasticity of consumer's income on health depends on the parameter θ, named lifestyle Return to scale, that is equal to the algebraically sum of the goods' elasticity with respect to health. It may be positive, negative or neutral.

Secondly, I computed the health multipliers. The main result is that the impact of a health shock on health and/or on income depends on labour share, and it is higher if the parameter named lifestyle is positive.

Thirdly, the micro-behaviour equation is introduced in Solow growth model in which the return to scale are constant. The result is that if lifestyle Return to scale is positive (and less than 1) the growth of income per capita is higher than the technical progress and it depends positively on the population growth rate.

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8 Appendix

In the Solow model:

$$Y = K^m (AL)^n$$
$$Y = K^m A^n L^n$$
$$\dot{A} = \lambda$$
$$\dot{L} = n$$

$$\dot{K} = \frac{dK}{dt}\frac{1}{K}$$
$$\dot{K} = s\frac{Y}{K}$$
$$\dot{K} = s\frac{K^m A^n L^n}{K} = sK^{m-1}A^n L^n$$

In steady state

$\dot{K}, \dot{A}, \dot{L}, \dot{Y}$ are constant

$$\dot{A} = \lambda$$
$$\dot{L} = n$$
$$\frac{d}{dt}K^{m-1}A^n L^n = 0$$
$$\dot{Y} = m\dot{K} + n\dot{A} + n\dot{L}$$

In steady state

$$\frac{d}{dt}K^{m-1}A^n L^n = 0$$
$$A^n L^n (m-1)K^{m-2}\frac{dK}{dt} + K^{m-1}L^n nA^{(n-1)}\frac{dA}{dt} + K^{m-1}A^n nL^{(n-1)}\frac{dL}{dt} = 0$$

$$(m-1)\frac{dK}{dt}\frac{1}{K} + n\frac{dA}{dt}\frac{1}{A} + n\frac{dL}{dt}\frac{1}{L} = 0$$

Growth of K in steady state

$$\frac{dK}{dt}\frac{1}{K} = \frac{n}{(1-m)}\frac{dA}{dt}\frac{1}{A} + \frac{n}{(1-m)}\frac{dL}{dt}\frac{1}{L}$$

Growth of Y in steady state

$$\frac{dY}{dt}\frac{1}{Y}=m\frac{n}{(1-m)}\frac{dA}{dt}\frac{1}{A}+m\frac{n}{(1-m)}\frac{dL}{dt}\frac{1}{L}+n\frac{dA}{dt}\frac{1}{A}+n\frac{dL}{dt}\frac{1}{L}$$

$$m\frac{n}{1-m}+n=\frac{n}{1-m}$$

$$\frac{dY}{dt}\frac{1}{Y}=\frac{n}{(1-m)}\frac{dA}{dt}\frac{1}{A}+\frac{n}{(1-m)}\frac{dL}{dt}\frac{1}{L}$$

$$\frac{\frac{dY}{dt}\frac{1}{Y}}{\frac{dL}{dt}\frac{1}{L}}=\frac{n}{(1-m)}\frac{dA}{dt}\frac{1}{A}+\frac{(m+n-1)}{(1-n)}\frac{dL}{dt}\frac{1}{L}$$

In our case the production function is

$$Y=K^{\frac{\alpha}{1-\theta(1-\alpha)}}(A\upsilon L)^{\frac{1-\alpha}{1-\theta(1-\alpha)}}$$

if

$$m=\frac{\alpha}{1-\theta(1-\alpha)}$$

$$n=\frac{1-\alpha}{1-\theta(1-\alpha)}$$

Then

$$1-m=\frac{1-\theta(1-\alpha)-\alpha}{1-\theta(1-\alpha)}$$

$$1-m=\frac{(1-\alpha)-\theta(1-\alpha)}{1-\theta(1-\alpha)}$$

In steady state

$$\dot{K}=\frac{dK}{dt}\frac{1}{K}=\frac{n}{(1-m)}\frac{dA}{dt}\frac{1}{A}+\frac{n}{(1-m)}\frac{dL}{dt}\frac{1}{L}$$

$$\frac{dK}{dt}\frac{1}{K}=\frac{(1-\alpha)}{(1-\alpha)-\theta(1-\alpha)}\frac{dA}{dt}\frac{1}{A}+\frac{(1-\alpha)}{(1-\alpha)-\theta(1-\alpha)}\frac{dL}{dt}\frac{1}{L}$$

-

$$\frac{dK}{dt}\frac{1}{K}=\frac{1}{1-\theta}\frac{dA}{dt}\frac{1}{A}+\frac{1}{1-\theta}\frac{dL}{dt}\frac{1}{L}$$

The growth rate of Y is

$$\dot{Y}=\frac{\alpha}{1-\theta(1-\alpha)}\dot{K}+\frac{1-\alpha}{1-\theta(1-\alpha)}\left(\dot{A}+\dot{L}\right)$$

$$\dot{Y}=\frac{\alpha}{1-\theta(1-\alpha)}\left(\frac{1}{1-\theta}\right)\left(\dot{A}+\dot{L}\right)+\frac{1-\alpha}{1-\theta(1-\alpha)}\left(\dot{A}+\dot{L}\right)$$

$$\dot{Y}=\frac{\alpha+(1-\theta)(1-\alpha)}{1-\theta(1-\alpha)}\left(\frac{1}{1-\theta}\right)\left(\dot{A}+\dot{L}\right)$$

$$\dot{Y}=\left(\frac{1}{1-\theta}\right)\left(\dot{A}+\dot{L}\right)$$

$$\frac{Y}{L}=\left(\frac{1}{1-\theta}\right)\left(\dot{A}\right)+\left(\frac{\theta}{1-\theta}\right)\left(\dot{L}\right)$$