1. Introduction

The aim of the paper is to define the relationship between health and income through lifestyle that is a set of behaviors which are considered to influence health and are generally considered to invoke a considerable amount of free choice (Contoyannis and Jones, 2004). The main hypothesis is that individuals are co-producers of their health. The paper is divided into two parts.

First, we consider the ways in which health affects a consumer’s utility, through the formulation of a Health Production Function for which health is the output and consumer goods are the inputs. In this approach, the Lifestyle Return to Scale (LRS) parameter is defined. The first result is that an increase in a consumer’s personal income may have a positive or a negative effect on health. In this context health may be considered a normal or an inferior good, depending on the Lifestyle parameter.

Moreover concerning the empirical evidences, in the literature there are contradictory findings with some cross-section estimates of income and health finding negative income effects, whilst casual observation (e.g. higher mortality rates amongst the poor) suggests a positive relation. The explanation for this lies in the distinction between permanent and current (or evolutionary) income effects. Using longitudinal data (British Cohort Study multiple wave longitudinal survey of people born in one week during April (5th - 11th) 1970, waves at age 26 and 29), we estimate the effects of changes in wage income on changes in health related indicators (with, for comparison purposes, also cross-section estimation) in order to distinguish current as opposed to permanent income effect (most closely related precursor of this analysis is the paper by Dustmann & Windmeijer (1999) which identify transitory income effects through a differencing).

2. The Model

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 flow 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: 1) a vector...
of commodities, 2) a vector of exogenous influences on health; 3) a vector of unobservable influences on health; 4) 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

$$H = h(C, X_u, H_u)$$  \hspace{1cm} (1)$$

Where $H$ is a measure of the individual health, $C$ is a vector of $M$-commodities, $X_u$ is a vector of exogenous variables that influences health, and $U_H$ a vector of unobservable influence on health.

We define the Utility function as:

$$U = u(H, m)$$  \hspace{1cm} (2)$$

where $H$ is Health and $m$ is a commodity vector or commodity bundle. $m_i \in m$ is the single commodity. We assume also that the marginal utility of the Health is not negative:

$$\frac{dU}{dH} \geq 0$$  \hspace{1cm} (3)$$

and the marginal utility of the commodity $m_i \in m$ may be positive or negative

$$\frac{dU}{dm_i} \geq 0$$  \hspace{1cm} (4)$$

There is almost a commodity with a positive marginal utility

$$\exists m_i : \frac{dU}{dm_i} > 0$$  \hspace{1cm} (5)$$

We rewrite the Health Production Function as:

$$H = h(m, \Omega)$$  \hspace{1cm} (6)$$

where $\Omega$ includes the other factors that affect the health. The marginal productivity of the commodity $m_i \in m$ may be positive or negative

$$\frac{dH}{dm_i} \geq 0$$  \hspace{1cm} (7)$$

and there is almost a $m_i \in m$ with a positive marginal utility

$$\exists m_i : \frac{dH}{dm_i} > 0$$  \hspace{1cm} (8)$$

Substituting equation (6) into equation (2), it obtains:

$$U = u(h(m, \Omega), m)$$  \hspace{1cm} (9)$$

with:

$$\frac{dU}{dm_i} = \frac{d[u(h(m, \Omega), m)]}{dh} \frac{dh(m, \Omega)}{dm_i} + \frac{d[u(h(m, \Omega), m)]}{dm_i}$$  \hspace{1cm} (10)$$

The vector $m$ may be so partitioned into 4 sub-vectors

$$m' = [m'_{u+, h+}, m'_{u-, h-}, m'_{u+, h-}, m'_{u-, h+}]$$  \hspace{1cm} (11)$$
where $m'_{u+,h+}$ is a sub-vector of commodities $m_i$ that affect positively both the utility ($\frac{dU}{dm_i} > 0$) and the health ($\frac{dH}{dm_i} > 0$), while $m'_{u-,h-}$ is a sub-vector of commodities $m_i$ that affect positively affects the consumer’s utility ($\frac{dU}{dm_i} > 0$) but negatively his health ($\frac{dH}{dm_i} < 0$).

The total effect of a change of $m$ on utility is equal to:

$$
\frac{dU}{dm_i} = \frac{d[u(h(m,\Omega),m)]}{dh} \frac{dh(m,\Omega)}{dm_i} + \frac{d[u(h(m,\Omega),m)]}{dm_i} \geq 0
$$

The consumer decides how much to consume of the single commodity, through a simple optimization problem:

$$
\max_{m \geq 0} u(h(m,\Omega),m) \quad \text{s.t.} \quad p'm = y
$$

where $p'$ is the prices vector and $y$ is income. The solution of the Lagrangian equation gives the optima $m_i = m(p,y)$ and $H = h(p,y)$ For sake of simplicity let’s suppose there are only two commodities: $x \in m'_{u+,h+}$ and $z \in m'_{u-,h-}$ The Utility function, and the Health Production Function respectively becomes

$$
U = H^\alpha x^\beta z^\delta
$$

$$
H = \Omega x^\rho z^{-\gamma}
$$

Substituting equation (14) into equation (13), it obtains the following utility function

$$
U = \Omega^\alpha x^{\beta + \alpha \rho \gamma} z^{\delta - \alpha \gamma}
$$

Let’s assume that $\Omega$ is constant and equal to 1. The Maximization problem becomes:

$$
\max_{x,z \geq 0} [x^{\beta + \alpha \rho \gamma} z^{\delta - \alpha \gamma}] \quad \text{s.t.} \quad px + pz = y
$$

Solving the Lagrangian equation, the solutions are:

$$
x = \frac{\beta + \alpha \rho}{\beta + \delta + \alpha (\rho - \gamma)} \frac{y}{px}
$$

$$
z = \frac{\delta - \alpha \gamma}{\beta + \delta + \alpha (\rho - \gamma)} \frac{y}{pz}
$$

The "Optimal Health" of the consumer is:

$$
h = \left(\frac{\beta + \alpha \rho}{\beta + \delta + \alpha (\rho - \gamma)}\right)^\rho \left(\frac{\delta - \alpha \gamma}{\beta + \delta + \alpha (\rho - \gamma)}\right)^{-\gamma} \frac{(pz)^\gamma}{(px)^\rho} y^{(\rho - \gamma)}
$$

$(\rho - \gamma)$ are the return to scale of the Health Production Function (14). Let’s define $\theta = (\rho - \gamma)$ the elasticity of health with respect to income and it may be positive, null or negative.
Conclusions: Health may be an inferior "good" ($\gamma > \rho$), even if all the commodities used by the consumer are normal "goods". We develop a consumer’s micro model with health and $n$ commodities. Some of them are positively correlate with the Consumer’s Utility, some of the negatively. Health is the output of a consumer’s production function with the commodities as inputs. The result is that the elasticity of consumer’s health with respect to income on depends on a parameter, named lifestyle Return to Scale, that is equal to the algebraically sum of the commodity’s elasticity. It may be positive, negative or neutral.

3. Empirical Approach

Using longitudinal data we estimate the effects of changes in wage income on changes in health related behaviour (with, for comparison purposes, also cross-section estimates) in order to distinguish the effects of current/transitory income changes as opposed to permanent income effects. Adopting a longitudinal approach also allows us to attenuate the potential endogeneity of income effects. The most closely related precursor of this analysis is the paper by Dustmann & Windmeijer (1999) which identifies transitory income effects on behavior through a differencing approach similar to that adopted here. Specifically, we estimate equations of the form:

\[ z_{it} - z_{it-1} = f\left(\alpha + \beta ((\ln y_{it}) - \ln(y_{it-1})) + D\gamma((\ln y_{it}) - \ln(y_{it-1}))\right) \]

Where $z$ is a health related indicator, $y$ is wage income and $D = [0, 1]$ is a dummy which is = 1 taking a value of 1 if the change in income is negative and is 0 otherwise. The dummy allows us to distinguish between the effects of positive and negative income changes respectively which, given the potentially dependence creating nature of the behaviours, and more generally, the notion that some form of reference-dependence may drive differential reactions to positive and negative income changes, we believe is likely to be important. Using a differenced equation, simplifies the analysis in that all the time invariant variables drop out (thus, for example, excluding the need for individual fixed effects) and we can reasonably assume that the price differences over time are roughly constant across individuals, or at least of minor importance in determining the results. Using the log difference in wage as an explanatory variable implies that, since $(\ln(y_{it}) - \ln(y_{it-1})) \approx$ percentage change in wage, the coefficient $\beta$ measures the effect of wage changes in percentage terms.

3.0.1. Data.

The empirical analysis employs data from of two waves of the British Cohort Study (BCS); a multiple wave longitudinal survey-based study of people born in one week during April (5th - 11th) 1970. The BCS has collected a wide range of information on participants throughout their lives to date. We use data from the two waves undertaken at age 26 and 29.
We consider the effects of the change in wage income for all those who were in dependent employment at both age 26 and 29. The idea being to examine the effects of wage changes but to exclude from the analysis potentially traumatic events such as the complete loss of employment and its attendant effects on behaviour (and health) independent of the income effect in itself.

The dependent variables employed are concerned with two lifestyle behaviours likely to affect individual’s health, as well as one intermediate and one ‘final’ health related outcome variable. Specifically, we consider the effects of wages changes on:

- **Lifestyle**
  - **Smoking** - The base variable uses a 1/0 dichotomy according to whether the person is a regular smoker at time $x$ or not; consequently, in the dynamic (differenced form) this takes we estimate two probit models which estimate:
    - The probability of starting to smoke between ages 26 and 29, given that the person is a non-smoker at age 26; and,
    - The probability of stopping smoking between ages 26 and 29, given that the person is a smoker at age 26;
  - **Drinking** - here, the base variable uses a 1/0 dichotomy according to whether the person is a regular drinker (that is, whether the person drinks every day nearly every day) - again, the dynamic form involves the estimation of two forms which examine transitions from one state to another. Specifically:
    - The probability of becoming a regular drinker between ages 26 and 29, given that the person is not a regular drinker at age 26; and,
    - The probability of stopping smoking between ages 26 and 29, given that the person is a smoker at age 26

- **Health relate outcomes**
  - **Intermediate health indicator = Body Mass Index (BMI).** Here OLS is applied to (changes in) the Body Mass Index between age 26 and 29
  - **Self reported state of health** - based on a four point scale running from 'Excellent' (=1) to 'Poor' (=4), an ordered probit model is estimated here, in the dynamic (differenced) form, this is applied to the change in the self-reported state.

In each case a single explanatory variable, the (change in the) natural log of Hourly Wage Rate of full-time employees is employed.

3.0.2. **Results.**

Table 1 reports the results for smoking. The main results of interest are reported in the first two numerical columns which report the results of the dynamic model, whilst the third and fourth report the corresponding cross-section estimates. Note that the first column reports the value of $\beta$; the effect of the percentage wage change, given that it was positive. The second reports the value of $\gamma$; specifically, the difference between a negative and a
positive wage change in terms of its 'impact' on the dependent variable. Although the effects are often not statistically significant in the differenced equation, the results suggest a consistently negative relation between smoking and income changes; wage changes are positively correlated with stopping smoking and negatively (and statistically significantly) correlated with starting smoking. In both cases, the effects of negative changes are stronger than positive ones, although the difference is not statistically significant in either case. It may also be noted in passing that columns 3 and 4 show the strong and statistically significant negative relation between wages and income at both ages 26 and 29. Hence in this case, all the effects, short- and long-run as well as both positive and negative wage change effects are consistent.

Table 1. Effects of wage changes on smoking. Probit Model

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<tr>
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<tbody>
<tr>
<td></td>
<td>% Δ Wage Δ Wage</td>
<td>% Δ wage (negative)</td>
<td>Log(Wage)</td>
</tr>
<tr>
<td>Stop (if smoker at 26)</td>
<td>Coeff. .03</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. .16</td>
<td>.48</td>
<td></td>
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<tr>
<td></td>
<td>n 951</td>
<td>951</td>
<td></td>
</tr>
<tr>
<td>Start (if non-smoker at 26)</td>
<td>Coeff. -.28**</td>
<td>-.09</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. .14</td>
<td>.25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n 3172</td>
<td>3172</td>
<td></td>
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<tr>
<td>Smoker (at 26 or 29)</td>
<td>Coeff. -.46***</td>
<td>-.28***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. (.06)</td>
<td>(.04)</td>
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<tr>
<td></td>
<td>n 4258</td>
<td>4612</td>
<td></td>
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</tbody>
</table>

Note: Statistical significance is indicated thus: *** indicates $p < .01$; ** indicates $p < .05$; * indicates $p < .10$.

Turning to drinking (table 2), the results are perhaps more interesting in that they are not consistent across the direction of wage changes. Looking first at the estimates of becoming a 'regular' (some might say heavy) drinker, both an increase in the current wage and a decrease in the current wage lead to an increase in the probability of becoming a habitual drinker (given that the person was not one at age 26). Both of the effects are statistically significant (at at least 10%) and, as would be expected given the opposing directions of the effects, is the difference between the effects of positive and negative wage changes; it would appear that young people drink to celebrate their wage gains, but even more so to drown the sorrows associated with wage losses. Although weaker in terms of statistical significance, the effects are closely mirrored in the coefficient estimates concerned with stopping drinking; both wage gains and losses tend to reduce the likelihood of going on the wagon. This contrasts with the long-term relation which is unequivocally positive. Clearly
these results are not explainable in terms of the simple neoclassical (monotonic) utility function outlined above and some modification to take into account reference dependence of some form would be in order.

Table 2. Effects of wage changes on drinking. Probit Model

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<tbody>
<tr>
<td></td>
<td>% Δ Wage/Δ Wage</td>
<td>% Δ wage/Δ Wage</td>
<td>Log(Wage)</td>
</tr>
<tr>
<td>Stop being regular drinker (if one at 26)</td>
<td>Coeff. 0.33*</td>
<td>0.46</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. 0.20</td>
<td>0.45</td>
<td></td>
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<tr>
<td></td>
<td>n 450</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>Become a regular drinker (if not one at 26)</td>
<td>Coeff. -0.28***</td>
<td>-0.66***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. 0.10</td>
<td>0.21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>n 3673</td>
<td>3673</td>
<td></td>
</tr>
<tr>
<td>Regular drinker (at 26 or 29)</td>
<td>Coeff. 0.17***</td>
<td>-0.24***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Std. err. 0.07</td>
<td>0.07</td>
<td></td>
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<tr>
<td></td>
<td>n 4215</td>
<td>4615</td>
<td></td>
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</tbody>
</table>

Note: Statistical significance is indicated thus: *** indicates $p < .01$; ** indicates $p < .05$; * indicates $p < .10$. 

Looking now more explicitly at health related outcomes, table 3 reports the results of a simple OLS of the change in BMI on wages. Whilst the cross-section results are clear and unequivocal – wages are negatively correlated with income - the relation between wage changes and changes in BMI are weak and not statistically significant, although here too the sign of the wage effects changes according to whether the change is positive or negative.

Table 3. Effects of wage changes on BMI. OLS estimation

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<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td>% Δ Wage/Δ Wage</td>
<td>% Δ wage/Δ Wage</td>
<td>Log(Wage)</td>
</tr>
<tr>
<td>BMI</td>
<td>Coeff. 0.11</td>
<td>-0.26</td>
<td>-48***</td>
</tr>
<tr>
<td></td>
<td>Std. err. 0.14</td>
<td>0.31</td>
<td>(.17)</td>
</tr>
<tr>
<td></td>
<td>n 3421</td>
<td>4456</td>
<td></td>
</tr>
</tbody>
</table>

Note: Statistical significance is indicated thus: *** indicates $p < .01$; ** indicates $p < .05$; * indicates $p < .10$. 
For self-reported health, the results are similar albeit clearer, to those for BMI. Note first that the scale used ranges from 1 (excellent health) to 4 (poor health) so that an increase in the scale reflects a worsening of an individual’s health. Consequently, on the reasonable assumption that higher BMI (generally) implies a worsening of health, the results in the table are immediately comparable to those for BMI - at least in terms of the direction of the effects. As before, in the cross-section estimates, self-reported health is negatively related to wage levels. However, in the dynamic model, wage changes are only influential if they are negative. Increased wages produces no beneficial effects on health, but wage falls lead to a worsening. Here two there is clear evidence of reference dependence worthy of further investigation.

**Table 4. Effects of wage changes on self-reported health. Ordered Probit Model**

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</thead>
<tbody>
<tr>
<td></td>
<td>% ∆ Wage</td>
<td>Log(Wage)</td>
<td>Log(Wage)</td>
</tr>
<tr>
<td>Self Reported Health</td>
<td>% ∆ wage (negative)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coeff. .01</td>
<td>-.28**</td>
<td>-36***</td>
</tr>
<tr>
<td></td>
<td>Std. err. (.08)</td>
<td>(.14)</td>
<td>(.05)</td>
</tr>
<tr>
<td></td>
<td>n 4107</td>
<td>4107</td>
<td>4241</td>
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</tbody>
</table>

**Note:** Statistical significance is indicated thus:
*** indicates $p < .01$; ** indicates $p < .05$; * indicates $p < .10$.

4. **Conclusions**

In this paper we have proposed a simple model of health repeated behavior and subjected it to empirical testing using a detailed longitudinal database. The purpose is fairly limited, however, it is clear from the results that the simple utility function considered in the first part of the paper is not always adequate to capture the nature of the effects in wage changes on health related behaviours and outcomes. Specifically, in the case of self-reported health and even more so in the case of (self-reported) drinking behavior, there is clear evidence of reference dependence. In the case of health, this manifests itself in terms of a negative correlation between wages changes and health which is only present for a worsening of income; lowering wages reduces worsens health, but raising them, does not, in the short-run, improve it. Perhaps the most interesting result concerns drinking. Both lowering and raising wages tends to increase alcohol consumption. This may be related to the clear dependence inducing effects of alcohol. Certainly the issue would bear further investigation.
5. References


Borg, V., Kristensen, T.,(2000), Social class and self-rated health: can the gradient be explained by differences in life style or work environment? Social Science and Medicine 51, 1019–1030.


Mas-Colell A., Whinston M. Green J. (1995), Microeconomic Theory, Oxford University Press,


