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Calories, Obesity and Health in OECD Countries

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Abstract

Theoretical models suggest that decisions about diet, weight and health status are endogenous within a utility maximisation framework. In this paper, we model these behavioural relationships in a fixed-effect panel setting using a simultaneous equation system, with a view to determining whether economic variables can explain the trends in calorie consumption, obesity and health in OECD countries and the large differences among countries. The empirical model shows that progress in medical treatment and health expenditure mitigates mortality from diet-related diseases, despite rising obesity rates. While the model accounts for endogeneity and serial correlation, results are affected by data limitations.

Keywords: *food consumption, obesity, overweight, health*

JEL classification: *I12, C33*

1. Introduction

It is well known that there is an obesity 'epidemic' in the western world, but perhaps less well known that levels of overweight are already reaching similar proportions in Latin America, the Middle East and the European transition States and that the incidence of overweight has overtaken underweight globally, including China, several other Asian countries and even some of the poorest parts of Africa (Traill and Mazzocchi 2005; WHO, 2006).

Even in the OECD, many countries did not start collecting obesity data until quite recently, but almost all of those countries recorded sharp increases between 1980, 1990 and the present. America leads the way with over 30% of the adult population obese, the other anglo-saxon countries have reached levels of more than 20% and Greece, Hungary, Luxembourg, Mexico and Slovakia are closing in. A large number of countries have around 10% of their populations obese, but only in Japan and Korea is the figure below 5%.

[Table 1 approximately here]

For overweight (BMI between 25 and 30) and obese combined, the United States and the UK 'lead' the pack with, respectively 66% and 62% of adults overweight or obese, whereas in Norway the figure is 43% and in Japan, only 25%. The health consequences of obesity are now widely known: increased risk of heart disease, stroke, type 2 diabetes mellitus and many cancers (WHO, 2003).

Of course the linkages between diet and health are not solely through overweight and obesity; smoking has harmful consequences, exercise is beneficial (in its own right as well as through its impact on obesity); and the composition of the diet also matters. Particular attention has been paid to the fat composition of diets and its impact on Low and High Density Lipoprotein levels in the bloodstream, fruit and vegetables and their protective roles against certain cancers, and salt as a factor in hypertension (WHO, 2003). Individual genetic and perhaps phenotypic factors are important for obesity and health (Schmidhuber and Shetty, 2005).

The wide cross-country differences in obesity and its health consequences are matters of interest and importance but remain largely unexplained. If the wide disparities in obesity and diet-related non-communicable diseases can be better understood, emerging economies will be better able to recognise the likely scale and timing of the problem in their countries and act accordingly with appropriate policies introduced in a timely fashion. Loureiro and Nayga (2005) have modelled obesity in a single equation cross-country relationship with the dependent variable the proportion of the population obese[1] and calorie consumption exogenous. Statistically significant independent variables were: per capita calories consumed, % population living in rural areas, % of individuals older than 65 years, % female labour market participation, per capita GDP, % of GDP dedicated to education, per capita kilometers driven by private vehicles, % of smokers, share of value of agricultural output per worker and agricultural transfers from consumers. Huffman et. al. (2006) estimated supply and demand functions for health in a selection of OECD countries, but did not model obesity.

In this paper we expand these two analyses in an attempt to explain calorie intake rather than assume it to be exogenously determined, to model obesity as well as its health consequences, and to employ panel data for all of the OECD countries. To do so we employ a structural set of relationships rather than the quasi-reduced form equation of Loureiro and Nayga (2005); our model is well founded in economic theory and biology. Because our interest is in trends and developments over time and across countries, we have included a longer than usual discussion of some of the data and their limitations.

We are of course interested in the extent to which trends and cross-country differences in food intake, obesity and health can be explained by economic variables and that is our primary purpose. However, economic variables cannot be expected to explain everything so we also examine briefly whether 'culture', as measured by the Hofstede indices, developed in the psychology literature, can shed additional light on cross-country differences.

2. Economic Theory of Obesity

Suppose that individuals derive utility from eating and drinking, smoking (S), consumption of other goods which do not contribute to health (Z), their leisure (L) and their state of health (H), which is partially a behavioural variable as it relates to smoking and weight (Chen et al 2002; Chou et al 2002). For the sake of simplicity assume that the

[1] Proportion overweight in another version.

utility from food and drink consumption can be represented by calorie intake (K), a common assumption (e.g. Cutler, Glaeser and Shapiro, 2003; Ladwallah and Philipson, 2002; Philipson and Posner, 1999). Leisure may be taken as free time after working and exercise taken for health reasons.

$$U= U(K, S, L, H, Z) \qquad (1)$$

Health is related to weight (W), other aspects of diet quality (D_Q) (e.g. the intake of saturated fatty acids which may have an impact on health independent of weight), smoking, medical treatment (M), exercise (E), which is taken to provide health benefits independent of its impact on weight, and exogenous factors (Ω_H) which include genetic and socio-demographic factors, the latter including education which may affect an individual's knowledge and ability to combine health inputs to optimise the health function (Chen et al, 2002):

$$H=H(W,S,M,E, D_Q, \Omega_H) \qquad (2)$$

In this construction we abstract from dynamics which would recognise that current health also depends on past levels of weight, diet quality, smoking and exercise. It can be thought of as a long-run equilibrium relationship.

Weight gain occurs when calorie intake exceeds calorie expenditure. The latter depends on activity in the workplace, in travel (by foot or bicycle) and at home for leisure and non-leisure exercise; on an individual's metabolic rate (hence the genetic component to overweight and obesity); and on one's weight. Hence, as Cutler, Glaeser and Shapiro (2003) point out, there exists an equilibrium (steady state) weight associated with any level of calorie intake. The achievement of this steady state is not of course instantaneous. Within the behavioural framework established here, exercise itself is endogenous in the sense that an individual may choose to achieve any particular weight either by consuming a large number of calories and exercising a lot or consuming a lower number of calories and exercising less. A reasonable simplifying assumption would be that physical activity at work is exogenous (people don't choose their jobs with a view to weight control). In general terms one may express this as a long-run equilibrium relationship:

$$W=W(K, E, \Omega_W) \quad (3)$$

Where Ω_W represents exogenous factors such as level of physical activity at work and genetic predisposition.

Formally the utility function in (1) is maximised subject to the health function (2), the weight function (3) and a full income budget constraint in which time may be enjoyed as leisure or transformed into income at the prevailing wage rate or exercise for health purposes (as opposed to leisure purposes). Food, drink, cigarettes, health care and other goods up to the level of income may be purchased at prevailing prices.

$$V+W(T-L-E)=P_K K + P_{D_Q} D_Q + P_S S + P_M M + P_Z Z \quad (4)$$

In (4), V is non-labour income, T is total time and L is leisure. Income, leisure and exercise are all endogenous in this framework, as of course are calorie intake, smoking, the level of medical treatment, exercise and health status. Solving the system of equations leads to a set of reduced form equations in which the optimal level of each of the endogenous variables depends on the wage rate and the prices of food and drink (P_K), diet quality (P_{D_Q}), smoking (P_S), medical treatment (P_M) and the price of goods unrelated to health (P_Z) as well as the levels of the exogenous variables (Ω_H and Ω_W).

It is worth exploring intuitively some implications of such a behavioural approach to the subjects of weight, health and eating. Imagine a technological advance in medical treatment, for example better screening and medicine for hypertension. A person could increase his/her utility through consuming unchanged levels of other variables in the health function and therefore having improved health or by taking advantage of the opportunity to consume higher levels of health-reducing activities like smoking, eating and drinking so as to achieve the same level of health as before but gain utility from the extra consumption of cigarettes, food and drink (as well as of the health neutral goods, Z) or a combination of these. Thus an improvement in health technology would likely lead to an increase in utility maximising weight as people take the opportunity to eat more because the risks of doing so are lower. The same would be true if we consider the level of smoking to be at least partially exogenonous—perhaps over time social norms change such that the utility derived from smoking falls. Lower smoking enhances health, again allowing higher levels of other risky activities like putting on weight by eating more (or exercising less). In this framework there is a behavioural explanation for the often observed negative correlation between smoking and weight (e.g. Chou, Grossman and Saffer 2002, Gruber and Frakes 2005, Loureiro and Nayga 2005) though traditional explanations linked to appetite supression and the impact of smoking on the metabolic rate remain relevant. Both of these examples mirror similar evidence with respect to other risky behaviour, for example that safer cars and the compulsory wearing of seat-belts lead motorists to drive faster.

Remember that the cost of food, as specified in the budget constraint (equation 4), includes the time cost of shopping and cooking as well as the direct monetary cost. Technological change which reduces the time of food preparation (convenience foods) lowers the overall cost of food, leading to higher levels of consumption. This has been identified as a major explanation for weight gain in the United States since the 1980s (Cutler, Glaeser and Shapiro 2003, Philipson and Posner 1999, Lackdawallah and Philipson 2002). If, as claimed by nutritionists, convenience foods (including foods from fast food restaurants) are more calorie dense than home prepared foods (Smil, 2000) there is also an adverse impact on diet quality.

3. Main Data Sources

In the empirical model of section 4, compromises are necessary. For example, we cannot assume that all of the variables, for example including income, are endogenous, nor do data exist for variables like the amount of exercise people take. Using aggregate data for cross-country analysis also inevitably involves compromise between quality, comparability and coverage. What we attempt to do is estimate a set of relationships based as closely as possible on the structural equations (2) and (3) above, plus an estimate of the demand for calories, but assuming that prices and income are exogenous to the system, the former a reasonable assumption given the level of intervention in agricultural markets and/or given that the small country assumption is reasonable for most countries. As noted, exercise data are unavailable and so are proxied by urbanisation (assumed exogenous) in the obesity equation. In the health equations, smoking is assumed exogenous and medical treatment proxied by health expemnditure and a time trend for technological development.

The obesity data themselves are described in the introduction. Health and diet data are described in the next sections. Finally other variables employed in the empirical model are presented briefly.

1. Health data

Comparable health data are available only for OECD countries; and they refer only to mortality, not prevalence. By far the highest mortality rate associated with diet-related NCDs is from heart disease; in 2000 the average mortality rate among reporting OECD countries was a little under 120 per 100,000 population compared to less than 10 per 100,000 population for diabetes; although the prevalence of type II diabetes associated with weight has likely increased (Kleinfield, 2006), not many people die from it. The death rate from heart disease has almost halved in OECD countries from its peak in the late 1960s and the variation among countries has decreased dramatically; in the late 1960s the mortality rate was above 300 per 100,000 people in Australia, Canada, Finland and the United States but below 100 in France, Japan, Spain and Mexico. By 2000 only the new member countries Hungary and the Slovak Republic reported mortality rates above 200 per 100,000 population and among the old member countries only Finland and Ireland had mortality rates above 150 per 100,000.

[Table 2 approximately here]

To the extent that these changes are exogenously attributable to advances in medical treatment and detection, the theoretical model would suggest that because the risks from being overweight or obese have fallen sharply, informed individuals would rationally choose to be more overweight; though whether people really are informed about this is debatable given the seemingly continuous flow of scare stories about the dangers of obesity. If not of course, they act on their perceptions of risk. In any case, early death is not the only health risk of obesity, diabetes being a particularly unpleasant disease.

2. Food Consumption

2.1 Calorie Consumption

The only data that are comparable across countries and over time are FAO food availability data from food balance sheets as reported in FAOSTAT. Food availability is derived from a commodity balance, i.e. from production adjusted for trade, industrial usage, stock changes, feed use, processing and an estimate of post-harvest losses[2]. The data therefore represent a national average "apparent" consumption at the retail level rather than actual consumption at the household or individual level.

These data are far from perfect, their most important shortcoming being that they exclude household and retail waste. This is more important for some product categories than others, notably fruit and vegetable availability exceeds intake recorded in household surveys by around 40% (for example in the UK, FAOSTAT show availability in 2002 as 519 grams per capita per day, whereas intake from the Food and Expenditure Survey was 324 grams in 2003-04). Likewise cooking oil is usually discarded after use rather than consumed and fat is often cut from meat and discarded or fed to pets, so the per cent of total energy from fats may be a slight overestimate. An important but unresolved issue relates to the trend in energy availability/intake. Almost always the trend in availability according to FAOSTAT is upwards whereas the trend in intake shown in surveys is often stable or even falling—for example in UK, Japan and Korea. This divergent trend is also apparent in some developing countries, notably China. It is probable that there is an increasing proportion of waste as intake and income rise, but unlikely that the marginal propensity to waste food is higher than one—so it is hard to believe that actual consumption falls while availability increases. Survey data could increasingly under-estimate actual intake over time if the level of under-reporting increases among the overweight; as average weight increases so would the level of under-reporting of consumption. Meals eaten outside the home are often excluded from surveys and even if not, it is likely that snacks and meals eaten outside the home are more under-reported than food eaten at home—and the share of food eaten outside the home is everywhere increasing. The gap between energy availability and energy intake from surveys is also much larger than expected, for example in the UK availability is 3400 calories per person per day, whereas survey data record an average intake of 2100 calories. The authors have found no explanation for these incompatibilities, particularly the divergent trends. Although survey data are considered by nutritionists to be the gold standard, in addition to the likely under-reporting of alcohol, snack foods and meals outside the home, there is the likelihood of changed behaviour during the survey period. So although FAOSTAT

[2] Food supply in the FAO Food Balance Sheets is defined as availability at the retail level. It has been corrected for post-harvest and processing losses but still includes all forms of "post-retail" losses, notably household waste, retailing losses and pet food.

data have their problems, so do the alternatives and FAOSTAT at least has the virtue of employing common methods across countries and over time.

2.2 Diet Components

Table 3 shows calorie availability and the share of calories from fat and sugar as well as availability of fruit and vegetables in OECD countries. Calorie availability has been stable or rising everywhere, with particularly sharp increases in Canada, Denmark, France, Greece, Netherlands, Portugal, Spain and the USA. On average calorie availability has increased over the 20 year period by around 250 calories from a little under 3200 to a little over 3400 calories per capita per day. Only Japan, Korea, Mexico, Poland, Portugal (1980 only) and Turkey have fat intake below the 30% of total energy upper limit recommended by WHO (2003); France (1980 only), Greece, Italy, Korea (1980 only), Portugal, Spain and Turkey have sugar consumption below the recommended 10% of total energy. There is no clear upward or downward trend across countries. The trend in fruit and vegetable intake has been more uniformly upwards and by 2002 only Slovakia fell below the recommended intake, but remember that, given high levels of waste, probably at least 600 grams availabilty is needed to register the recommended minimum of 400 grams per capita per day of actual intake.

[Table 3 approximately here]

3. Other data

Smoking prevalence (S) is the proportion of the population who smoke and health expenditure per capita is a proxy for medical treatment, both from OECD Health Data (OECD, 2005), exercise (E) is proxied by the percent of the population living in urban areas (FAOSTAT)—an imperfect measure, but a recognition that urban employment and transportation generally demand less exercise than rural employment and transport. The real price of food and real per capita income (per capita Gross Domestic Product at purchasing power parity) are derived from OECD data.

Other exogenous variables are represented in all three equations by fixed effect dummies, but, as mentioned above, we are curious as to the extent these reflect cultural differences among countries. We measure the nebulous concept of culture using Hofstede value measures and examine the correlation between the fixed effect coefficients and the four

Hofstede measures. Hofstede is a psychologist whose work has been widely used in the marketing profession to explain and predict product attributes, consumption and advertising effectiveness and to develop marketing strategies in countries with different cultures (Hofstede 1980, 2003). Hofstede developed a model that identifies four primary dimensions to assist in differentiating cultures: Power Distance - PDI, Individualism - IDV, Masculinity - MAS, and Uncertainty Avoidance - UAI.

The Power Distance Index (PDI) focuses on the degree of equality, or inequality, among people. A high PDI indicates that inequalities of power and wealth exist within the society. A low PDI indicates that society de-emphasises the differences between citizen's power and wealth. In these societies equality and opportunity for everyone is stressed. Individualism (IDV) focuses on the degree that society reinforces individual or collective achievement and interpersonal relationships. A high IDV indicates that individuality and individual rights are paramount within the society. A low IDV typifies societies of a more collectivist nature with close ties between individuals. These cultures reinforce extended families and collectives where everyone takes responsibility for fellow members of their group. Masculinity (MAS) focuses on the degree the society reinforces the traditional masculine work role model of male achievement, control, and power. In high MAS cultures, males dominate a significant portion of the society and power structure. A low MAS indicates the country has a low level of differentiation and discrimination between genders. Uncertainty Avoidance Index (UAI) focuses on the level of tolerance for uncertainty and ambiguity within the society. A high UAI indicates the country has a low tolerance for uncertainty and ambiguity. This creates a rule-oriented society that institutes laws, rules, regulations, and controls in order to reduce the amount of uncertainty. A low UAI indicates the country has more tolerance for a variety of opinions. This is reflected in a society that is less rule-oriented, more readily accepts change, and takes more and greater risks.

A survey instrument developed to measure these indices has been administered in a large number of countries and scores are available at http://www.geert-hofstede.com/.

[Table 4 approximately here]

Visual examination suggests that the anglo-saxon countries form a 'group' according to the similarity of the various culture indices. They are particularly high on individuality. Scandinavian countries Norway, Finland, Denmark and Sweden are also similar to one another; they have lower values for Power Distance and Masculinity than any of the other countries—implying equality of opportunity and treatment for all citizens although Norway and Finland have higher Uncertainty Avoidance indicating more regulated societies than Denmark and Sweden. France and Italy are quite similar though Italy emphasises more masculine characteristics and France is less egalitarian. The other Mediterranean countries, Portugal, Spain and Greece show lower Individuality and very high Uncertainty Avoidance. Japan and Korea have in common low individuality (slightly higher in Japan), fairly high power distance and high uncertainty avoidance. Japan also scores very high on masculinity. Within the group of Eastern European Countries, Hungary shows a high Masculinity index (indicating a male-oriented society), while Poland shows persisting inequality in society through a high PDI. .

4. Model and Estimation

The empirical model based on the economic theory discussed in Section 2 and adjusted to cope with the data availability constraints is the following;

$$\begin{cases} CAL_{it} = \mu_{it} + \gamma_1 PRICEF_{it} + \gamma_2 INC_{it} + \gamma_3 FAT_{it} + \gamma_4 SUGAR_{it} + \gamma_5 FRV_{it} + \gamma_6 AGE + u_{it} \\ OBESE_{it} = \delta_{it} + \gamma_7 CAL_{it} + \gamma_8 URB_{it} + \gamma_9 SMOKE_{it} + v_{it} \\ DDIA_{it} = \lambda_{it} + \gamma_{10} OBESE_{it} + \gamma_{11} SATF_{it} + \gamma_{12} URB_{it} + \gamma_{13} HEXP_{it} + \gamma_{14} t + w_{it} \\ DHEART_{it} = \lambda_{it} + \gamma_{15} OBESE_{it} + \gamma_{16} SATF_{it} + \gamma_{17} URB_{it} + \gamma_{18} SMOKE_{it} + \gamma_{19} HEXP_{it} + \gamma_{20} t + z_{it} \end{cases}$$

(5)

where *CAL* is the daily per capita calorie availability; *PRICEF* is an index of real food prices; *INC* is the per capita GDP at purchasing power parity; *FAT, SUGAR, FRV* and *STF* are the shares of energy intake from fats, sugar, fruit and vegetable and saturated fats, respectively; *AGE* is the ageing index (i.e. the share of population about 65); *URB* is the urbanisation index (the share of population living in urban areas); *SMOKE* is the prevalence of smokers, *DDIA* and *DHEART* are the mortality rates for diabetes and ischaemic heart disease, respectively; *HEXP* is the real per capita health expenditure;

OBESE is the percentage of obese individuals; and *t* is a time trend used as a proxy of medical progress.

Estimation of a simultaneous equation system as in (5) with pooled data is subject to several assumptions on how to model country heterogeneity. If no heterogeneity is assumed, then a common constant term appears and coefficient estimates obtained by least squares are consistent and efficient. However, this is unlikely to be the case when the model specification does not account for all sources of heterogeneity. In order to account for omitted variables, we chose a fixed effect linear panel model specification. The country-specific fixed effects are country-specific intercepts. These are assumed to account for any effect which is not explained by the included exogenous variables. An alternative specification is based on random effects as in Louriero and Nayga (2005). The choice on the specification of country-specific intercepts (unobserved effects) depends on whether these can be assumed to be uncorrelated with the existing explanatory variables or not. If there is correlation, then the most appropriate specification is the fixed effect approach. If there is no correlation between the individual effects and the included variables, then the random effect approach could be implemented. In the latter case, the individual effect is modelled through a country-specific random element. This latter specification is more parsimonious, but it presumes that the sampled cross-sectional units (i.e. the countries) were drawn from a large population and no correlation exist between the estimated effect and the included variables. This is unlikely to be the case for model (5), especially considering that some variables are proxies for omitted variables, like urbanisation for physical activity.

The model in (2) is estimated by weighted two-stage least squares with autoregressive errors to account for serial correlation in the residuals using the procedure described in Fair (1984, p. 210)[3]. Weighting takes account of heteroskedasticity, the weights in the second stage given by the inverse residual variance matrix.

5. Empirical Results

Table 5 below shows the empirical model estimates. The endogenous variables in the system are calories, obesity, health, health expenditure and the mortality rates from diabetes and heart disease and the functional form is double-logarithmic, so that

[3] This is the procedure adopted by the software Eviews 4®.

coefficients represent elasticities. Each equation was estimate by W2SLS using all exogenous variables as instruments. For the obesity and health outcome equations the (unbalanced) estimation sample goes from 1990 to 2002, while for the calorie equation the sample can be extended to 1975. One observation for each country is lost to account for serial correlation. There are a limited number of missing data either at the beginning or at the end of the sample for a few countries. Details on the samples are provided in Table 5. Estimates of the fixed effects are shown in the Appendix.

[Table 5 approximately here]

5.1 Calories

Calorie intake is explained by income per capita, the real price of food, smoking prevalance, the shares of fats, sugar and fruit and vegetables in total energy intake, ageing of the population and the fixed effects. The diet component shares are included because calorie density (calories per gram) is thought to contribute to overeating. Fats and sugar have high calorie density whereas fruit and vegetables have low calorie density, thus the first two should have positive coefficients, the latter negative. The price elasticity is relatively low but significant (-0.07), suggesting that a 1% decrease in real prices leads to a increase of 0.07% in calorie intake, while the impact of rising incomes is larger (0.14). The diet components show the expected signs, although only the share of energy from sugar is statistically significant. Ageing of the population, as expected, results in lower calorie intakes.

Considering an individual who consumes about 3,000 calories per day and has an income of about $ 2000 per month, the estimates above suggest that: a) a 1% percentage increase in the sugar share of energy from the recommended 10% level increases calorie intake by around 11 calories; b) an increase in income of $ 100 per month increases calorie intake by around 15 calories per day; c) a price cut of 10% increases the daily calorie intake by 20 calories.

5.2 Obesity

The calories variable is significant at the 10% level with an elasticity of 0.2 implying that at the mean a 100 calorie increase in daily consumption would raise the proportion of obese people in the population by around 0.7%--which is very close to the 0.8%

estimated in Loureiro and Nayga's (2005) model. As expected, urbanisation is associated with lifestyle changes which result in less physical activity and more obesity. At the aggregate level, smoking seems to be unrelated to obesity rates.

We should remind readers that the short time series of available data precludes exploration of the long run relationship between calorie intake and obesity.

5.3 Heart Disease and Diabetes

Ischaemic Heart disease mortality is explained by obesity, smoking, saturated fat share of energy intake (as suggested in WHO, 2003), per capita health expenditure to account for time and geographic differences in the incidence of health care on mortality, and a trend, which serves as a proxy for medical progress. The trend is negative and strongly significant, reflecting the major advances that have seen mortality rates fall at the same time as obesity has risen sharply in many countries. This is also consistent with the significant effect of health expenditure. Considering the OECD average per capita expenditure of about $ 1700 and an average (age-standardised) mortality rate of about 170 per 100,000 inhabitants over the sample period, raising health expenditure to $ 2,000 reduces the mortality rate by about 3 deaths per 100,000 inhabitants. All other variables, including obesity, are non-significant and show the wrong sign. This unexpected result is partly explained by the fact that obesity effects on health are not instantaneous. While this would call for the inclusion of lagged variables, lack of a sufficiently long time series data prevents us from testing the lagged effects of obesity. One attempt to evaluate the relevance of the delayed impact of obesity could be based on the correlation between the estimated fixed effects – which are expected to capture unexplained country-differences over the sample period 1990-2002 – and the absolute level of obesity in 1990. Correlation is positive and high (0.68) and significant at the 99% level despite being based on only 28 observations, suggesting that the link between obesity and heart disease does exist although its macro-dynamics cannot be estimated with precision due to the lack of adequate time series data. According to the above estimate, a 1% difference in the 1990 obesity level leads to a 1.6% difference in the extimated fixed effects (i.e. unexplained mortality rates).

Focusing on the diabetes equation, we also find a strong relationship between mortality and health expenditure, suggesting that countries with a larger per capita health expenditure are more effective in reducing mortality from diabetes. Urbanisation (taken as a proxy for decreased physical activity) is also significant at the 10% level. For example, considering Sweden and Norway, there is a difference of about 12% in the urbanisation rate (higher in Sweden). *Ceteris paribus,* this would explain a difference of about 2 deaths per 100,000 inhabitants between the two countries (which is actually the case). For the diabetes equation, all other variables are also non-significant, although they show the correct sign and are closer to significance. Repeating the correlation exercise we find again a positive relationship (0.17) with lagged obesity, but non-significant. Here the data limitations are made worse by the lack of time series on diabetes prevalence rather than mortality, as the former is sharply increasing as a consequence of changing lifestyles while the latter is decreasing thanks to increased effectiveness of medical treatment as captured by the health expenditure variable (see Wild et al., 2004).

5.4 Culture and country differences

Although the estimation of the structural behavioural equations has stressed the inadequacy of the data, we claim that the fixed effect model is still able to capture the existing trends at macro level, gathering the unexplained country differences into the fixed effects estimates. These country differences can be explained by a number of variables we have not accounted for, mainly those related to cultural and genetic differences. By relating these fixed effects to the Hofstede values reported in Table 4 through a stepwise regression we are able to give some further insight on the country differences[4].

[Table 6 approximately here]

It would seem that countries with a higher uncertainty avoidance index (low tolerance to uncertainty and ambiguity) have higher calorie intakes. The countries with a higher UAI are those in the Euro-Mediterranean area and Eastern Europe, but also Japan and Korea. Instead, anglo-Saxon countries have a relatively low UAI. Other significant relationships were found between individualism and the health outcomes, suggesting a positive relation with heart disease mortality and a negative one with diabetes mortality. Considering the values in Table 4, this suggests that Anglo-Saxon countries seem to be more at risk for heart disease and less for diabetes, while countries like Turkey and

[4] A double logarithmic specification is adopted here, too.

Portugal (but also Japan and Korea) appear to be more resistant to heart disease and less to diabetes.

Conclusions

Modelling nutrition behaviours, obesity and their health consequences is a complex exercise. While other studies have attempted to model these relationship before, we claim that adequate modelling needs to take into account the endogeneity of the decision process. The application of a panel simultaneous equation system to OECD models this endogeneity.

The availability of good quality data at the macro level is far from adequate. Time series of obesity data which are comparable at international level are only available for 15 years at most. Many of the other relevant variables also suffer data limitations. For example, time series data are only available for mortality rates which have fallen but not for prevalence which, at least in the case of diabetes, have almost certainly risen. More reliable series of disease prevalence would greatly improve the quantification effort. Another key variable which is completely lacking is the amount of physical activity over time and across countries. While urbanisation proves to be a relatively satisfactory proxy, a more specific measure is clearly desirable for accurate policy calibration.

Despite these data limitations there are several advantages in the technique adopted for this study. First, pooling cross-section and time series data increases the number of available observations, although this doesn't solve the problem of modelling long-term relationship with short spans of time series data. Second, the fixed effect approach accounts for omitted variable problems, as the country-specific intercepts are expected to capture the amount of heterogeneity not explained by the right-hand side variables. In order to obtain consistent estimates of the behavioural parameter it is also necessary to account for serial correlation in the residuals, which emerges as highly relevant.

One may then try to relate the time-invariant estimates of country fixed effects to other potential determinants. We found that the starting obesity level contributes to interpreting international differences in calorie intakes and health outcomes, suggesting that the availability of a longer time series for the obesity variable would improve the model by accounting for lagged and cumulated effect. Significant statistical relationships were also found between the fixed effects of calorie and health outcomes and some of the Hofstede values. While it would be hazardous to assume a causal link, this highlights a higher sensitivity to heart disease for Anglo-Saxon countries and a higher unexplained mortality for diabetes in Mediterranean countries. Whether this disparity depends on genetic factors or other factors, it remains to be examined with different data or aggregation levels.

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TABLES AND FIGURES

Table 1: Obesity Rates in OECD Countries
(% of population with BMI[1]>30)

	1980	1990	2003
Australia	8.3	10.8[c]	21.7[i]
Austria		8.5[d]	9.1[i]
Belgium			11.7[j]
Canada			14.3
Czech Republic		11.2[e]	14.8[k]
Denmark		5.5[f]	9.5[l]
Finland	7.4	8.4	12.8
France		5.8	9.4[k]
Germany			12.9
Greece			21.9
Hungary			18.8
Iceland			12.4[k]
Ireland			13.0[k]
Italy		7.5[g]	8.5[k]
Japan	2	2.3	3.2
Korea			3.2[j]
Luxembourg			18.4
Mexico			24.2[1]
Netherlands	5.1[a]	6.1	10.0[k]
New Zealand		11.1[c]	20.9
Norway			8.3[k]
Poland			11.4[m]
Portugal			12.8[i]
Slovakia			22.4[k]
Spain		6.8[f]	13.1
Sweden		5.5[c]	9.7
Switzerland		5.4[h]	7.7[k]
Turkey			12.0
United Kingdom	7	13.0[d]	23.0
United States	15[b]	23.3[d]	30.6[k]

[1]BMI=Body Mass Index defined as weight in kgs divided by height in metres squared.

[a]1981; [b]1978 ; [c]1989; [d]1991; [e]1993; [f]1987; [g]1994 [h]1992; [i]1999; [j]2001; [k]2002; [l]2000; [m]1996.

Source: OECD Health Statistics [k]

Table 2: Mortality rates from Ischaemic Heart Disease per 100,000 population in OECD Contries.

	1960	1970	1980	1990	2000
Australia	338	345.8	242.5	179.3	108
Austria	232.8	198.3	147.1	147.3	125.3
Belgium	130.5	158.4	126	83.9	79.0[1]
Canada	351.8	309.4	231.8	154.2	108.4
Czech Republic				297	179.1
Denmark	269.4	276.9	261.2	201.6	106
Finland	330.8	293.8	265.2	229.4	167.7
France	74.4	69.5	73.5	59.5	46.8
Germany	204.3	156.2	162.2	147.4	121
Greece	102.3	66.4	76.3	91.8	82.8
Hungary	259.5	239.4	217	226.5	214.8
Iceland	201.3	262.1	224.5	166.4	116.8
Ireland	319.4	267.3	264.9	228.5	158.7
Italy	232.7	140.1	123.2	90.4	70.2
Japan	91	60	52	36.5	33.4
Korea				17.3	32
Luxembourg	163	215.1	137.6	103.4	78.7
Mexico		54		92.6	106.0[2]
Netherlands	215.9	199.5	167.2	125.9	82.8
New Zealand	308.2	303.9	277.2	200.5	129.7
Norway	211.1	230	200.6	180.3	110.9
Poland	81	77	101.5	112.3	133.4
Portugal	136.9	162.1	89.6	79.6	59.9
Slovak Republic					278.5
Spain	93		75.1	70.5	62.3
Sweden	276.9	280.1	276.8	179.2	118
Switzerland	265.1	107.2	115.6	105.6	86.8
Turkey					
United Kingdom	302.9	254	247.7	207.1	129.0[3]
United States	374	362	237.1	166.7	139.6

[1] Data for 1997

[2] Data for 1995

[3] Data for 2001

Source: OECD Health Statistics

Table 3: Nutrient content of diets, 1980 and 2002

	Calories /cap/day		Fat % of energy from		Sugar % of energy from		Fruit and Vegetable grams/cap/day	
	1980	2002	1980	2002	1980	2002	1980	2002
Australia	3057	3053	33.6	38.7	17.4	13.9	436	509
Austria	3353	3673	39.5	38.8	12.8	11.5	577	617
Belgium/Luxembourg	3300	3584	38.0	40.1	10.7	14.2	436	526
Canada	2946	3589	37.4	36.7	14.7	15.5	584	686
Czech Republic	n.a.	3171	n.a.	33.5	n.a.	12.6	n.a.	389
Denmark	3127	3439	39.6	36.5	14.5	13.4	316	687
Finland	3124	3100	37.8	35.7	11.8	10.3	340	457
France	3376	3654	39.4	42.1	9.5	10.2	489	652
Germany	3340	3496	36.7	37.7	12.4	12.0	471	565
Greece	3216	3721	34.9	36.9	7.8	8.5	995	1130
Hungary	3494	3483	33.7	38.0	12.5	12.7	448	483
Iceland	3252	3249	38.8	36.2	16.2	15.7	237	460
Ireland	3661	3656	35.8	32.6	12.8	10.7	380	501
Italy	3590	3671	32.3	38.8	9.4	8.1	771	773
Japan	2721	2761	22.7	27.6	11.8	10.0	484	446
Korea	2971	3058	11.1	22.7	4.9	11.0	595	756
Mexico	3123	3145	22.7	25.0	14.7	15.2	374	467
Netherlands	3071	3362	38.3	38.6	14.2	14.0	481	626
New Zealand	3123	3219	36.5	32.2	14.0	17.5	490	694
Norway	3350	3484	39.9	37.6	12.5	12.3	402	500
Poland	3597	3375	29.2	30.1	12.2	13.0	390	404
Portugal	2786	3741	27.7	33.6	9.4	8.4	437	859
Slovakia	n.a.	2889	n.a.	34.7	n.a.	10.6	n.a.	341
Spain	3063	3371	33.0	40.3	9.6	9.7	729	729
Sweden	2992	3185	37.2	35.5	14.4	14.1	351	511
Switzerland	3491	3526	41.3	39.9	12.4	15.3	644	518
Turkey	3281	3357	23.0	24.6	7.1	7.2	852	898
United Kingdom	3159	3412	39.0	36.6	13.4	11.7	379	519
United States	3155	3774	36.2	37.3	17.4	17.5	580	652

Source: FAOSTAT

Table 4: Hofstede Indices

	Individualism	Masculinity	Power Distance	Uncertainty Avoidance
Australia	90	61	36	51
Austria	55	79	11	70
Belgium	75	54	65	94
Canada	80	52	39	48
Czech Republic	58	57	57	74
Denmark	74	16	18	23
Finland	63	26	33	59
France	71	43	68	86
Germany	67	66	35	65
Greece	35	57	60	112
Hungary	55	88	46	82
Ireland	70	68	28	35
Italy	76	70	50	75
Japan	46	95	54	92
Korea	18	39	60	85
Mexico	30	69	81	82
Netherlands	80	14	38	53
New Zealand	79	58	22	49
Norway	69	8	31	50
Poland	60	64	68	93
Portugal	27	31	63	104
Slovak Republic	58	57	57	74
Spain	51	42	57	86
Sweden	71	5	31	29
Switzerland	68	70	34	58
Turkey	37	45	66	85
United Kingdom	89	66	35	35
United States	91	62	40	46

Table 5: Structural model estimates

	Calories		Obesity		Diabetes		Heart Disease	
PRICEF	**-0.065**	**(-2.319)**						
INC	**0.143**	**(6.947)**						
FAT	0.011	(0.349)						
SUGAR	**0.036**	**(2.686)**						
FRV	-0.005	(-0.478)						
AGE	-0.047	(-1.528)						
CAL			*0.196*	*(1.752)*				
URB			*2.180*	*(1.681)*	*2.415*	*(1.949)*	-1.531	(-1.419)
SMOKE			0.010	(0.521)			-0.033	(-1.552)
OBESE					0.077	(1.125)	-0.035	(-1.191)
SATF					0.070	(0.543)	-0.052	(-0.794)
HEXP					**-0.145**	**(-5.313)**	**-0.100**	**(-2.462)**
TREND					-0.117	(-0.539)	**-1.327**	**(-3.981)**
Sample	1975-2002		1990-2002		1990-2002		1990-2002	
Obs.	627		321		284		311	
R^2	0.83		0.84		0.52		0.92	
AR(1)	**0.844**	**(38.606)**	**0.880**	**(35.347)**	**0.704**	**(18.268)**	**0.885**	**(33.855)**
DW (mean)	2.08		1.52		2.48		2.22	

Note: Student-t ratios between brackets. Values significant at 0.05 s.l. are reported in bold, values significant at 0.10 s.l. in italics.

Table 6: Fixed effects and Hofstede values

	Dependent variable (log of fixed effects)							
Explanatory variable (logs)	Calories		Obesity		Diabetes		Heart disease	
Constant	6.675	(42.401)	-11.328	(-3.934)	-3.338	(-3.008)	14.082	(15.550)
Uncertainty Avoidance	0.079	(2.081)						
Power Distance								
Masculinity								
Individualism					-0.799	(-2.940)	0.773	(3.486)
Adj R2	*0.11*				*0.22*		*0.29*	

APPENDIX – Fixed Effect Estimates

Country	Calories	Obesity	Diabetes	Ischaemic Heart Disease
	Fixed Effect Estimates			
Australia	6.90 (25.76)	-7.51 (5.46)	-7.16 (4.96)	17.66 (4.23)
Austria	7.05 (26.13)	-7.76 (5.03)	-6.35 (4.58)	17.38 (3.86)
Belgium	7.05 (26.24)	-8.66 (5.48)	-7.54 (5.06)	17.48 (4.28)
Canada	6.95 (25.73)	-7.88 (5.26)	-6.53 (4.81)	17.42 (4.07)
Czech Republic	7.01 (26.12)	-7.71 (5.16)	-7.17 (4.73)	17.61 (3.98)
Denmark	6.96 (25.88)	-8.27 (5.35)	-6.85 (4.91)	17.39 (4.14)
Finland	6.91 (25.72)	-7.53 (4.94)	-6.74 (4.49)	17.40 (3.78)
France	7.06 (26.36)	-8.06 (5.22)	-7.04 (4.75)	16.56 (4.02)
Germany	7.03 (26.20)	-7.84 (5.39)	-6.79 (4.93)	17.82 (4.17)
Greece	7.13 (27.17)	-7.83 (4.92)	-7.03 (4.47)	16.76 (3.78)
Hungary	7.12 (27.28)	-7.29 (4.99)	-6.26 (4.55)	17.80 (3.85)
Ireland	7.08 (26.80)	-7.74 (4.90)	-6.35 (4.44)	17.35 (3.77)
Italy	7.08 (26.56)	-8.10 (5.05)	-6.09 (4.61)	16.74 (3.89)
Japan	6.81 (26.04)	-9.35 (5.03)	-6.89 (4.58)	15.97 (3.87)
Korea, Rep.	6.90 (26.74)	-9.87 (5.28)	-5.86 (4.84)	16.37 (4.11)
Mexico	7.01 (28.03)	-7.49 (5.17)	-4.92 (4.74)	17.46 (4.01)
Netherlands	6.94 (25.66)	-7.93 (5.02)	-6.05 (4.54)	16.81 (3.87)
Norway	6.95 (26.27)	-7.97 (5.34)	-6.80 (4.90)	17.86 (4.15)
New Zealand	6.95 (25.70)	-8.15 (5.24)	-7.06 (4.75)	17.32 (4.04)
Poland	7.08 (27.92)	-7.52 (4.95)	-6.46 (4.50)	17.31 (3.81)
Portugal	7.09 (27.19)	-7.14 (4.82)	-5.23 (4.31)	16.32 (3.70)
Slovak Republic	6.95 (25.84)	-7.04 (4.84)	-6.05 (4.40)	17.95 (3.71)
Spain	7.01 (26.11)	-7.95 (5.20)	-6.66 (4.76)	16.85 (4.02)
Sweden	6.91 (25.65)	-8.32 (5.32)	-7.13 (4.87)	17.54 (4.11)
Switzerland	6.97 (25.55)	-8.51 (5.04)	-6.27 (4.62)	17.05 (3.89)
Turkey	7.17 (29.48)	-7.68 (5.03)	-7.13 (4.55)	16.51 (3.90)
United Kingdom	6.98 (26.04)	-7.69 (5.39)	-7.71 (4.95)	17.79 (4.18)
United States	7.00 (25.77)	-7.28 (5.26)	-6.31 (4.80)	17.83 (4.08)

Note: Student-t ratios between brackets.