The Rise of Obesity in Transition: Theory and Empirical Evidence from Russia

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Contributed Paper prepared for presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009

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Introduction

Since the early 1990s series of political and economic reforms have been implemented in transition economies. As a result, the population experienced dramatic changes in lifestyle and a significant decline in life expectancy. The adverse effects of transition were most severe in the Former Soviet Union. Several studies examine the reasons for the mortality crisis in Russia and other former Soviet republics (Brainerd and Cutler, 2005; Shkolnikov et al., 2004). Greater alcohol consumption and increased stress from the transition to a market economy had dramatically affected the lifestyle and diet of the population, and led to higher mortality in Russia. Furthermore, the authors find that rising human obesity has important health consequences and is a significant predictor of mortality.

Obesity has also become a major contributor to the global burden of chronic diseases and disability. The emerging and transition economies, including Russia, had the highest number of diabetics, a condition closely associated with obesity, in 1995 (WHO, 2006). Therefore, a greater understanding of the rise in obesity and its causes in transition economies could lead to important policy recommendations for reducing the problem and improving the health of the population.

The risk of obesity is strongly influenced by diet and lifestyle which have been changing dramatically as a result of economic and nutritional transitions. However, very few studies have examined the causes of obesity in transition economies in contrast to the large literature on high-income countries (Chou et al., 2004; Lakdawalla et al., 2005; Rashad et al., 2006). Mendez and Popkin (2004) find that the population of low-income countries has also become susceptible to obesity in the process of economic development. Liefert (2004) examines food security in Russia and points that a serious health problem is overweight and obesity "which have increased during transition and currently affect over half of the adult population." Zohoori et al. (1998) find that the prevalence of obesity, as well as the alcohol consumption, has risen significantly in Russia during the 1992-1996 period. Huffman and Rizov (2007) also find that obesity has increased since 1994, over ten years of transition, by more than 30 per cent.

The goal of this paper is to develop theoretical and empirical models to examine human obesity in Russia. Individual and household-level data from the Russian Longitudinal Monitoring Survey (RLMS) for 1995 and 2004 is employed to study the rising obesity in the framework of the productive household model. The derived empirical model is estimated for samples by period – 1995 and 2004, as well as by obesity status subsamples – normal weight, overweight, and obese individuals. The two periods in our analysis are chosen because the first, 1995 is close to the start of the transition and the second, 2004 is a decade into the transition when the effects of (long-term) economic and general lifestyle changes should be apparent. Empirical results strongly support our model of production and supply of BMI (body-mass index) and weight that we develop to explain the phenomenon of overweight and obesity in Russia. The paper continues as follows. Next, the theoretical model is outlined, followed by description of the data and econometric specification, discussion of estimation results and conclusion.

Theoretical model

The productive household models of health developed by Rosenzweig and Schultz (1982) and Grossman (2000), and the agricultural household models developed by Huffman (1991) provide a useful framework for analyzing overweight and obesity. An important proposition in the framework is that the health status of each household member is determined by the degree of overweight and obesity of that member. Therefore in the utility function we can directly introduce a measure of overweight/obesity instead of a measure of health status. Thus, the individual has a utility function

$$U = U(D, C, BMI, L; O)\,. \tag{1}$$

Utility is determined by consumption of food, *D* (including tobacco smoking); consumption of other goods (excluding food) and services, *C*; body-mass index, *BMI*; leisure, *L*; and fixed characteristics, such as age, gender, education, and background, *O*.

The individual has a BMI production function

$$BMI = B(D, L, O, \varepsilon)\,, \tag{2}$$

where ε is the unobservable individual characteristics that affect the individual's BMI; such characteristics may include genetic factors. In large samples ε will likely have a zero mean. Food consumption affects utility directly and indirectly through BMI production, providing energy, vitamins and minerals.

The individual has a budget constraint

$$P_D D + P_C C = W(T - L) + N\,, \tag{3}$$

where P_D and P_C denote the prices of food (*D*), and other goods and services (*C*), respectively; *W* is the wage rate per unit of time, *T* is the fixed time endowment (*T*-*L*=work), and *N* is the non-labour income.

For an interior solution of the model, we substitute equation (2) into (1) and use the budget constraint (3). The individual chooses *D*, *L* and *C* by maximizing his/her utility subject to the budget constraint. The utility maximization problem can be written as

$$\Lambda = U[D, C, B(D, L; O, \varepsilon), L; O] + \lambda(WT + N - P_D D - P_C C - WL), \quad (4)$$

where λ is the Lagrange multiplier representing the marginal utility of individual's full income. The first order conditions for an optimal solution are:

$$U_B B_D + U_D = \lambda P_D, \quad (5)$$

$$U_B B_L + U_L = \lambda W, \quad (6)$$

$$U_C = \lambda P_C, \quad (7)$$

$$WT + N = P_D D + P_C C + WL, \quad (8)$$

where $U_B = \partial U / \partial B,\ B_D = \partial B / \partial D,\ U_D = \partial U / \partial D,\ \ B_L = \partial B / \partial L,\ \ U_L = \partial U / \partial L$ and $U_C = \partial U / \partial C.$ For an interior solution, equations (5)-(8) yield the individual's optimal demand functions for *D*, *L* and *C*:

$$\Phi^* = f_\Phi(P_D, P_C, W, N, O, \varepsilon_\Phi), \qquad \Phi = D, L, C. \quad (9)$$

Therefore, the demand for inputs into the BMI production function depends on the prices of the purchased inputs (P_D, P_C), the wage rate (*W*), non-labour income (*N*), fixed factors (*O*) and unobserved factors (ε), which are assumed to have zero expected mean. After substituting the optimal demand functions D^* and L^* from equation (9) into the BMI production function (2), we obtain the individual's BMI supply function:[1]

$$BMI^* = B_S(P_D, P_C, W, N, O, \varepsilon_B). \quad (10)$$

Note that the BMI supply function (equation 10) is a reduced-form (behavioural) relationship based on the optimal individual's decisions while the individual's BMI production function (equation 2) is a technology relationship. Equation (10) represents the solution to the first-order (Kuhn-Tucker) conditions for the structural endogenous variables (*D*, *L*) in terms of the exogenous factors which include wages, prices, and characteristics of the BMI production and utility functions. This is the most common approach (in the labour supply literature) to make a transition to an empirical framework. An alternative "structural" approach to the transition to an empirical framework can be implemented in two stages, first, estimating the demand functions (9) and second, substituting the predicted values in the technology equation (2).

Given our goal to analyse the factors that led to rise of obesity in Russia and issues with data availability, specifically the lack of direct price information, we adopt the structural approach in this paper. Thus, in the empirical analysis, in a first stage we estimate optimal demand equations for various types of food (demand system) comprising the diet and for leisure (wage equation). We estimate an almost ideal demand system (AIDS) for food (and beverages) following Heien and Wessells (1990) and Shonkwiler and Yen (1999) and a standard wage equation with selection bias (Becker, 1965; Heckman, 1974; 1979). In addition, we also estimate the propensity of smoking as we specify relationships following the literature initiated by Pollack (1970) and Becker and Murphy (1988). In the second stage of our analysis, the predicted values of food expenditure shares, wages, and propensity of smoking are used as regressors, together with the exogenous factors listed in vector *O*, to estimate the BMI supply function:

$$BMI^* = B_S^*(D^*, L^*, O, \varepsilon_B^{'}) \qquad (11)$$

Equation (11) is the focus of our empirical analysis in the following sections.

Data and econometric framework

To investigate the factors contributing to the rising obesity in Russia we employ data from the RLMS spanning a ten year period, between 1995 (round 5) and 2004 (round 13). The

RLMS is a nationally representative household survey that annually samples the population of dwelling units.[2] The data collected include a wide range of information concerning individual and household characteristics such as demographics, income, and expenditure. Data on individuals also include information on employment status, wages and occupation, anthropometric measures, and health status. Our samples consist of all adult individuals, 18 years of age and older who were surveyed both in 1995 and 2004 periods.

We focus our attention on two dependent variables, namely, individual's BMI and as an alternative measure - individual's weight. A standard measure of obesity is based on the BMI, defined as individual's weight in kilograms divided by individual height in meters squared (kg/m^2). The BMI in our analysis is constructed for each respondent from data on weight and height collected by trained personnel. An individual with a BMI over 25 kg/m^2 is defined as overweight, and with a BMI over 30 kg/m^2 - as obese (WHO, 2006). However, the BMI may overestimate body weight in athletes who have a muscular build, and may underestimate body weight in elderly people who have lost muscle mass (NIDDKD, 1996). Hence, we choose both an individual's weight (while controlling for height) and BMI as measures of obesity.

Table 1 presents the definitions and summary statistics for regression variables characterising the individuals in our samples. We also report in table 2 summary statistics by obesity status as defined by BMI thresholds, namely, normal weight (less than 25 kg/m^2), overweight (between 25 and 30 kg/m^2) and obese (more than 30 kg/m^2). Our (weighted) data reveal that the share of the population that is overweight and obese has dramatically increased in Russia between 1995 and 2004. There are important differences in characteristics across obesity-status categories. Women are more likely to be obese while males are more likely to be overweight, which is a situation similar to the one in developed countries. Furthermore, overweight and obesity rates have increased for both genders as over the 1995 – 2004 period. Importantly, considering their characteristics, overweight and obese categories seem to have become more similar in 2004 compared to 1995.

Following our theoretical model, we estimate as a first stage the endogenous demand variables affecting BMI production and supply.

Food demand

The food demand system is specified as a standard AIDS following Deaton and Muellbauer (1980) and estimated following the procedure suggested by Heien and Wessells (1990) as we correct for censoring using the consistent method of Shonkwiller and Yen (1999). The expenditure data are collected on a 7 day recall and are aggregated into the following eight categories: diary and eggs (77.20 per cent), meat and fish (79.71 per cent), fruit and vegetables (63.03 per cent), bread and potatoes (96.03 per cent), fat (64.82 per cent), sugar (73.13 per cent), alcohol (32.70 per cent), and all other food (56.31 per cent). The percentages in parentheses give the average proportion of households that consume the item in question.

The dependent variables of the system are defined as expenditure shares in each individual's budget and are set equal to household expenditure shares, thus assuming equal consumption of each (adult-equivalent) individual in the household. The explanatory variables in each equation are again individual characteristics as specified in vector *O* plus total expenditure, controls for eating out and home produced food, marital status, number of adult household members, number of children, and regional dummies. Regional fixed effects control for relative wages and prices of food and other omitted variables that differ by region.

The food demand system is estimated in two steps, separately, for 1995 and 2004 periods, using probit regressions (with clustering at household level) in the first step and weighted SUR in the second step following Shonkwiler and Yen (1999). A summary of estimation results is reported in table 3.

Propensity of smoking

We also estimate propensity of smoking, for 1995 and 2004 periods, following the literature on myopic addiction initiated by Pollack (1970) and extended by Becker and Murphy (1988), in terms of rational addiction behaviour. The probability of smoking is specified as a function of prices (regional dummy variables) and income (expenditure) as well as of individual characteristics listed in vector *O*. Because smoking is addictive it follows a partial adjustment model (in the case of myopic addiction) where the lagged dependent variable represents a propensity of smoking which is carried over from period to period and its coefficient can be interpreted as an indicator of the strength of addiction. Because of the cross-sectional nature of our analysis and issues with availability of data we include a dummy variable capturing the fact that the individual has smoked in previous periods, at least as long as half of his/her current age, thus capturing the cumulative long-run effect of addiction.

Furthermore, the rational addiction model of Becker and Murphy (1988) implies that the actual value (propensity) of future smoking should be included in the regression as well. Such a specification would result in differential short and long-run price elasticities. Due to lack of appropriate information in our data we are not able to estimate the model of propensity of smoking by fully controlling for rational addiction behaviour. Becker, Grossman and Murphy (1991), however, suggest that the long-run responses obtained from both myopic and rational models are similar.

Leisure demand

As an approximation of leisure demand we estimate a wage equation. Considering that our main goal is to analyse obesity and its determinants, an estimate of opportunity cost of time given that leisure is a normal good is a reasonable control for leisure demand. Wage equation is specified following Becker (1965) and is estimated following Heckman (1974). The predicted wage rate is used to control for leisure demand in the BMI supply equation. The dependent variable in the wage equation is log of the wage rate and the explanatory variables are individual (as specified in vector *O*) and household characteristics plus regional dummies. Number of adult household members, number of children in the household represented by two age categories - up to 7 years of age and between 8 and 18 years of age, marital status, and non-labour income control for constraints and incentives an individual to undertake market employment and are used as identifying variables, in the first step. Regional fixed effects control for relative labour market conditions and prices of food and other omitted variables that differ by region. The wage equation is estimated using the Heckman selection model, for 1995 and 2004 periods. It is noteworthy that education is a more important factor explaining wages in 2004 than in 1995. This fact can be interpreted as an evidence of advancing transition towards market system where skills mater more than administrative seniority and party affiliation.

BMI supply

In a second stage of our empirical analysis, we use the predicted values of food (and beverages) expenditure shares, propensity of smoking, and wage rate to estimate the BMI supply function. As explanatory variables are also included individual characteristics as specified in vector *O*, set of dummy variables controlling for type of occupation (managerial, professional, blue colour - technical and administrative, with a base category manual and self-employed workers), and the reported total calories consumed. The BMI supply equation (11) is estimated by OLS regressions, for 1995 and 2004 periods.

Our view is that equilibrium relationships between obesity and various individual characteristics and environmental factors, at any given point in time, are especially important for long-term policy analysis. In equilibrium, it is reasonable to assume that factors affecting obesity are predetermined, i.e., even though obesity affects an individual's characteristics, an individual's characteristics (and other behavioural and environmental factors) determine obesity. Important in this relationship are the lags of the effects. We argue here that the time lag of the obesity effect on an individual's characteristics is much longer than the lag of individual characteristics' effects on obesity. Therefore, our strategy is to estimate correlations between obesity measures such as BMI and weight and various factors affecting obesity in cross-sections and then compare effects across different dimensions of interest by the means of Wald (Chow) tests.

Estimation results of BMI supply equations

We estimate the BMI supply equations as specified in equation (11) by OLS, for the (balanced) samples in 1995 and 2004.[3] Table 4 presents the OLS estimates for specification where the dependent variable is ln*Weight*. As argued earlier BMI as a measure of obesity may overestimate or underestimate obesity of individuals depending on their muscular build. Therefore, we report here results with weight as a dependent variable, while controlling for height as explanatory variable, which is also an indicator of an individual's genetic potential and early investments in good health, in all specifications.[4] Reported standard errors are robust and have been corrected for clustering at household level. The hypothesis that all explanatory variables are jointly equal to zero is rejected in all regressions.

There are important differences concerning the BMI supply in the two points in time - in 1995, and ten years later, in 2004. In general, the signs of the coefficients are the same in both time periods however, the magnitudes of the effects are larger in 2004. The last column of table 4 where Wald-tests are reported demonstrates the significance of differences in effects over the ten-year period. The results indicate that all three groups of factors – individual characteristics, diet and smoking, and opportunity cost of time (controlling for leisure demand and lifestyle) have possibly contributed to the increase in obesity in Russia.

Individual characteristics have a strong impact on weight. Taller individuals are heavier as the coefficient is close to 2 as implied by the definition of BMI. Age has non-linear effect on weight - at younger ages the relationship is positive and at about 55 years of age the relationship turns negative. It is noteworthy that over the ten-year period the age of maximum weight has decreased, from 56 years to 54 years. Females are more likely to have higher weight, other things equal, compared to males. The magnitude of this effect has more than doubled over the ten-year period. As a component of individual characteristics we also analyse the impact of education on weight. Importantly, higher levels of education are associated with lower weight (and arguably, obesity). The negative effect is most significant for individuals with higher (university level) education. Furthermore, over the ten-year period the magnitude of the effect doubled.

Diet and smoking also have important effects on obesity. Higher fat and sugar expenditure shares, and presumably consumption, positively and significantly affect weight, other things equal, and compared to the effect of the reference category – bread and potatoes. Compared to 1995 the effects in 2004 are much stronger as particularly dramatic is the increase in the impact of sugar consumption – almost threefold. In 2004 the positive effects of consuming diary and eggs and meat and fish on weight also become larger in magnitude and statistically significant. The effect of alcohol consumption is interesting; in 1995 the relationship between consuming alcohol and obesity was positive but not statistically significant while ten years later it turned negative and significant as the magnitude doubled.[5] This effect is likely associated with decline in the share of population that drinks as reported in table 3, which implies an increase in the share of heavy drinkers among drinking population.

Finally, as a control of eating patterns we also include in regressions total calories consumed as reported by individuals at a seven-day recall. Total calories consumed positively affect weight but the effect is quite small and only becomes statistically significant in 2004. We argue here that the level of calorie consumption reflects long-run pattern in consumption of quantity and composition of food and that it is predetermined with respect to an individual's obesity status. We also note that to check for endogeneity of the variable we run regressions without calories consumed and the results remain very similar to the results reported.

Higher propensity of smoking is always associated with lower weight. The effect is highly statistically significant and its magnitude increases over the ten-year period of analysis. Cigarette smoking tends to increase metabolism and suppress appetite, thus having a negative effect on weight. Also, evidence for both developed and developing countries suggest that that smokers consume fewer calories than non-smokers (Perkins et al., 1991).

Leisure demand proxied by wage rate, controlling for opportunity cost of time, and occupation, controlling for lifestyle patters are also found to impact on weight other things equal as the effects become larger in magnitude and statistically significant in 2004. The type of occupation can be considered influencing the patterns of consumption and physical exercise. We find that managers are more likely to be heavier other things equal and in comparison to the base category – the manual and self-employed workers. Individuals in professional and blue colour occupations are characterised by lower weight, in 2004. The evidence suggests that there have been important changes in work and life-style conditions affecting obesity.

Next, we explore further effects of the set of individual characteristics, diet and smoking, and leisure demand and lifestyle on samples defined according to obesity status by the means of quantile regressions. We consider the 30, 60 and 90 per cent quantiles which approximately correspond to the categories of normal weight, overweight and obese individuals. The estimation results of simultaneous quantile regressions for samples in 1995 and 2004 are reported in table 5. Importantly, quantile regressions reveal heterogeneity across categories of individuals by obesity status. The main findings are that the magnitudes of the effects are stronger in 2004, compared to 1995 and that there is a shift in characteristics such that while normal weight and overweight categories were relatively similar in 1995 the similarity in 2004 is stronger between overweight and obese categories.[6] Another general finding is that sensitivity of weight to various factors is the highest within the normal weight category and the lowest within the obese category as this tendency weakens over the ten-year period. Overall, in 2004 overweight individuals are more likely to become obese compared to the likelihood in 1995. There is a shift of overweight individuals towards the obese category and widening the gap in characteristics of normal weight and overweight individuals.

With respect to *individual characteristics*, the turning point of the impact of age on weight is at younger ages for the overweight and obese categories, compared to the normal-weight category, and there is a tendency of decreasing in the turning-point age over the ten-year period. Thus, for obese individuals the turning point is at 53 years of age in 1995 and at 51 years of age in 2004 while for the individuals with normal weight these figures are 57 years and 56 years, respectively. In 2004 for all quantiles males are less heavy than females, other things equal, while this is true in 1995 only for the obese group. Impact of higher education on decreasing weight is much stronger in 2004 as there is evidence that higher education negatively affects weight even in the obese group.

There are important changes in the impact of *diet and smoking* on weight over the ten-year period. In 2004, diary and eggs consumption is positively associated with weight within the 30 per cent quantile while meat and fish consumption positively impacts on weight within the 60 per cent quantile. In 1995, these effects are not significant and diary and eggs consumption positively affects weight within the 60 per cent quantile only. The magnitudes of effects across obesity categories and time differ substantially as well. In 2004 the magnitudes are much larger, especially for sugar, alcohol and fat consumption. The effect of sugar consumption on weight in 2004 is almost two times larger within the 30 per cent quantile, compared to the 90 per cent quantile. Smoking always negatively affects weight as the magnitude of the effect remains about the same over the ten-year period, with the exception of the obese category where the magnitude almost doubled in 2004.

The effects of *leisure demand and occupation* on weight also differ across quantiles. Wage rate affects weight of all individuals and the effect is higher in magnitude and more statistically significant in 2004 compared to 1995. Furthermore, there are important differences in effects of occupation by obesity status. Individuals in professional occupations are characterised by lower weight as the effect is statistically significant in 2004. Normal-weight and overweight individuals in blue collar-occupations are also less heavy, other things equal. In the obese category, individuals in managerial occupations are likely to be heaviest. These results are evidence of important differences in lifestyle that have emerged over the ten-year period.

Conclusions

This paper develops both theoretical and empirical models to explain the increasing human obesity, measured by weight and BMI, in Russia during the transition from planned to market economy. During the ten-year period of transition analysed there was a significant rise in obesity in Russia – a 33 per cent increase by 2004. Empirical results strongly support our model for BMI production and supply. Overall, our findings are similar to findings for developed economies (e.g., Chou et al., 2004; Rashad et al., 2006).

Demographic and anthropometric characteristics such as height, age, and gender significantly influence the degree of overweight and obesity in Russia. Taller individuals are heavier, males are less likely to be obese, and the increase of weight with age continues until about 55 year of age after which point the association turns negative. Importantly, better educated individuals are less overweight and obese and this tendency becomes more pronounced by 2004. Diet also impacts significantly on increases in weight (and BMI) as the most important contributors are the expenditure shares of fats and sugars in consumption. There are also important changes in the effect of opportunity cost of time over the ten-year period as indicated by the positive effect of wage rate on weight, which implies an increase in the cost of physical exercise. This effect is combined with differential effects of occupation on weight. Noteworthy is our finding that individuals engaged in professional occupations are less likely to be overweight or obese compared to manual and self-employed workers.

Furthermore, quantile regression results reveal heterogeneity across categories of individuals by obesity status. The main findings are that the magnitudes of the effects are stronger in 2004, compared to 1995 and that there is a shift in characteristics such that while normal weight and overweight groups were relatively similar in 1995 the similarity in 2004 is stronger between overweight and obese categories. Thus, in 2004 overweight individuals are more likely to become obese compared to the likelihood in 1995. There is a shift of overweight individuals towards the obese category and widening the gap in characteristics of normal weight and overweight individuals.

Understanding obesity in Russia is important in order to define what public policies are most likely to be effective in preventing and reducing obesity. This study indicates that higher education, other things equal, has a significant negative effect on obesity, and thus contributes to good health. Education not only provides economic returns such as increasing earnings and employment, but also improves health and wellbeing. Furthermore, there are apparent differences between individuals in different occupations which are most likely associated with differences in lifestyle and opportunity cost of time. Therefore, interventions which enhance education and awareness of healthy diet and lifestyle could play a vital role in preventing obesity in Russia. People should be educated about the impacts of diet and exercise on health, and therefore about the importance of healthy lifestyles and healthy diet.

Notes

1. This is analogous to the derivation of the supply function for farm output in an agricultural household model (Huffman, 1991).
2. This is not a true panel survey where sample households and individuals are followed and interviewed in each round. After 1999 the original design was modified and some households and individuals who moved were surveyed at their new locations. The analyses of the RLMS data for attrition, carried out by the Institute for Social Research at the University of Michigan, show that the exits can be characterized as random and that the sample distributions remain unchanged (Heeringa, 1997).
3. Results from estimation of unbalanced samples are similar to the reported results for the balanced samples and are available from the authors.
4. The OLS estimates of the BMI supply equations with dependent variable ln*BMI* are available from the authors. The results are very similar to those with weight as dependent variable.
5. Diverse research has shown that alcoholics tend to have lower body weights while the relationship between alcohol consumption and obesity in the general population has not been well established. Studies have yielded varied and inconsistent results, reporting positive, negative or no clear associations (e.g., Hellerstedt, Jeffery, and Murray, 1990).
6. The differences across quantiles are tested using Wald tests, jointly for all explanatory variables. In 1995 the Wald statistics of the difference between 30 per cent and 60 per cent quantiles (Pr>F) is significant at 0.15 per cent while the Wald statistics of the difference between 60 per cent and 90 per cent quantiles (Pr>F) is

significant at 0.07 per cent. In 2004 these figures are 0.08 and 0.12 per cent, respectively.

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Table 1 Variable definitions and summary statistics

Symbol	Definition	1995	2004
		Mean (SD)	Mean (SD)
(1)	(2)	(`3)	(4)
Dependent variables			
BMI	Individual weight divided by height squared (kg/m^2)	26.48 (5.01)	27.65 (5.47)
Weight	Individual weight (kg)	72.26 (13.79)	74.77 (15.04)
Individual and household characteristics			
Height	Individual height (cm)	165.39 (8.99)	164.60 (9.26)
Age	Individual age (years)	43.54 (14.82)	53.54 (14.82)
Male	Dummy variable equal to 1 if the individual is a male and 0 otherwise	0.39 (0.49)	0.39 (0.49)
Prime_Edu	Dummy variable equal to 1 if the individual has only completed primary school and 0 otherwise	0.39 (0.49)	0.39 (0.49)
High_Edu	Dummy variable equal to 1 if the individual has completed high school and 0 otherwise	0.46 (0.50)	0.44 (0.50)
Higher_Edu	Dummy variable equal to 1 if the individual has completed higher education and 0 otherwise	0.15 (0.36)	0.17 (0.38)
Married	Dummy variable equal to 1 if the individual is married and 0 otherwise	0.73 (0.45)	0.72 (0.44)
HH_Size	Number of household members	3.44 (1.55)	2.99 (1.52)
Children<7	Dummy variable equal to 1 if there are children age 7 and less in the household	0.21 (0.41)	0.17 (0.35)
Children>7	Dummy variable equal to 1 if there are children age between 8 and 18 in the household	0.25 (0.43)	0.23 (0.42)
Diet and smoking			
Diary&eggs	Expenditure share of milk, milk products and eggs	0.12 (0.13)	0.12 (0.11)
Meat&fish	Expenditure share of meat and fish	0.25 (0.22)	0.28 (0.18)
Bread&potatoes	Expenditure share of bread and potatoes	0.22 (0.23)	0.22 (0.19)
Fruit&veg	Expenditure share of fruit and vegetables	0.08 (0.12)	0.09 (0.10)
Fats	Expenditure share of various fats and oils	0.09 (0.14)	0.09 (0.08)
Sugars	Expenditure share of sugar and sugar products	0.11 (0.16)	0.12 (0.13)
Alcohol	Expenditure share of various types of alcohol	0.06 (0.12)	0.03 (0.08)
Other foods	Expenditure share of all other types of food	0.07 (0.19)	0.05 (0.10)
Calories	Total calories consumed per day	1858.44 (525.25)	1858.32 (531.80)

Table 1 Continued

(1)	(2)	(`3)	(4)
Eat_Out	Money spent on eating out as a share of total expenditure	0.05 (0.10)	0.07 (0.14)
Home_Prod	Money equivalent of home produced food as a share of total expenditure	0.26 (0.29)	0.16 (0.22)
Smoker	Dummy variable equal to 1 if the individual smokes currently and 0 otherwise	0.27 (0.44)	0.29 (0.45)
Addiction	Dummy variable equal to 1 if the individual has been smoking longer than half his/her age and 0 otherwise	0.15 (0.36)	0.22 (0.41)
Labour market participation and income			
LFP	Dummy variable equal to 1 if the individual is in the labour force and 0 otherwise	0.62 (0.48)	0.55 (0.50)
Wage	Individual hourly wage (real 1995 new Rubles)*	14.96 (25.02)	18.45 (26.85)
Manager	Dummy variable equal to 1 if the individual is in a managerial occupation and 0 otherwise	0.01 (0.09)	0.03 (0.18)
Professional	Dummy variable equal to 1 if the individual is in a professional occupation and 0 otherwise	0.12 (0.33)	0.10 (0.29)
Blue_Collar	Dummy variable equal to 1 if the individual is in a blue collar occupation and 0 otherwise	0.19 (0.39)	0.15 (0.36)
Manual&SE	Dummy variable equal to 1 if the individual is in a manual occupation or self-employed and 0 otherwise	0.68 (0.47)	0.72 (0.45)
Expenditure	Total monthly expenditure per household member (real 1995 new Rubles)	3036.79 (2413.80)	3234.49 (2825.29)
NL_income	Monthly non-labour income per household member (real 1995 new Rubles)	596.06 (1704.08)	1092.50 (1947.12)
Regional fixed effects			
Rural	Dummy variable equal to 1 if the individual resides in rural area and 0 otherwise	0.40 (0.49)	0.40 (0.49)
Moscow&SP	Dummy variable equal to 1 if the individual resides in Moscow or St. Petersburg region and 0 otherwise	0.04 (0.18)	0.04 (0.18)
North_NW	Dummy variable equal to 1 if the individual resides in the North or North-West region and 0 otherwise	0.06 (0.23)	0.06 (0.23)
Central	Dummy variable equal to 1 if the individual resides in the Central region and 0 otherwise	0.21 (0.41)	0.21 (0.41)
Volga	Dummy variable equal to 1 if the individual resides in the Volga region and 0 otherwise	0.22 (0.42)	0.22 (0.42)
N_Caucasus	Dummy variable equal to 1 if the individual resides in the North Caucasus region and 0 otherwise	0.15 (0.36)	0.15 (0.36)
Ural	Dummy variable equal to 1 if the individual resides in the Ural region and 0 otherwise	0.16 (0.37)	0.16 (0.37)
W_Siberia	Dummy variable equal to 1 if the individual resides in the West Siberia region and 0 otherwise	0.08 (0.27)	0.08 (0.27)
E_Siberia	Dummy variable equal to 1 if the individual resides in the East Siberia region and 0 otherwise	0.08 (0.27)	0.08 (0.27)

Note: Number of observations is 3162 in both 1995 and 2004. *The mean of the individual hourly wage is reported only for non-zero observations which are 1386 in 1995 and 1371 in 2004.

Table 2 Summary statistics by obesity-status category

Symbol	1995			2004		
	Normal	Overweight	Obese	Normal	Overweight	Obese
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variables						
BMI	22.20	27.23	33.95	22.33	27.39	34.47
	(1.93)	(1.40)	(3.37)	(1.98)	(1.39)	(3.95)
Weight	62.22	74.65	88.87	62.19	74.55	90.39
	(8.35)	(8.79)	(11.15)	(8.68)	(8.88)	(12.57)
Individual and household characteristics						
Height	167.21	165.38	161.72	166.65	164.76	161.89
	(8.88)	(9.13)	(7.78)	(9.31)	(9.14)	(8.64)
Age	38.55	46.05	49.66	49.88	54.84	56.36
	(14.76)	(13.95)	(12.84)	(15.70)	(14.39)	(13.28)
Male	0.48	0.42	0.18	0.51	0.41	0.22
	(0.50)	(0.49)	(0.38)	(0.50)	(0.49)	(0.42)
Prime_Edu	0.34	0.39	0.45	0.34	0.39	0.40
	(0.48)	(0.49)	(0.50)	(0.48)	(0.49)	(0.49)
High_Edu	0.49	0.45	0.43	0.48	0.45	0.44
	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)	(0.50)
Higher_Edu	0.17	0.16	0.12	0.18	0.16	0.16
	(0.38)	(0.37)	(0.32)	(0.39)	(0.38)	(0.36)
Married	0.69	0.76	0.73	0.68	0.74	0.75
	(0.46)	(0.43)	(0.44)	(0.47)	(0.43)	(0.43)
HH_Size	3.56	3.44	3.19	3.11	2.98	2.86
	(1.49)	(1.58)	(1.62)	(1.54)	(1.55)	(1.47)
Children<7	0.26	0.20	0.14	0.12	0.11	0.09
	(0.44)	(0.40)	(0.35)	(0.33)	(0.31)	(0.29)
Children>7	0.26	0.25	0.23	0.26	0.24	0.20
	(0.44)	(0.43)	(0.42)	(0.44)	(0.42)	(0.40)
Diet and smoking						
Diary&eggs	0.11	0.11	0.11	0.12	0.12	0.13
	(0.13)	(0.13)	(0.13)	(0.11)	(0.11)	(0.11)
Meat&fish	0.24	0.26	0.25	0.27	0.30	0.30
	(0.21)	(0.22)	(0.21)	(0.18)	(0.18)	(0.19)
Bread&potatoes	0.22	0.21	0.22	0.24	0.23	0.22
	(0.22)	(0.23)	(0.23)	(0.19)	(0.19)	(0.17)
Fruit&veg	0.08	0.09	0.07	0.08	0.08	0.08
	(0.12)	(0.12)	(0.11)	(0.10)	(0.10)	(0.10)
Fats	0.09	0.10	0.11	0.06	0.07	0.07
	(0.14)	(0.13)	(0.15)	(0.07)	(0.08)	(0.08)
Sugars	0.11	0.11	0.12	0.12	0.12	0.12
	(0.15)	(0.16)	(0.16)	(0.14)	(0.12)	(0.14)
Alcohol	0.07	0.05	0.05	0.04	0.03	0.03
	(0.13)	(0.11)	(0.11)	(0.09)	(0.07)	(0.07)
Other foods	0.07	0.07	0.07	0.06	0.05	0.06
	(0.19)	(0.20)	(0.18)	(0.09)	(0.09)	(0.11)
Calories	1870.36	1869.08	1867.32	1851.27	1856.28	1859.46
	(514.79)	(522.83)	(548.34)	(532.43)	(525.86)	(530.18)

Table 2 Continued

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Eat_Out	0.05	0.04	0.04	0.08	0.08	0.07
	(0.11)	(0.10)	(0.11)	(0.14)	(0.13)	(0.13)
Home_Prod	0.26	0.26	0.27	0.17	0.16	0.16
	(0.28)	(0.29)	(0.28)	(0.23)	(0.22)	(0.22)
Smoker	0.38	0.24	0.10	0.45	0.25	0.14
	(0.48)	(0.42)	(0.30)	(0.50)	(0.43)	(0.34)
Addiction	0.21	0.14	0.07	0.34	0.20	0.10
	(0.40)	(0.34)	(0.26)	(0.47)	(0.40)	(0.29)
Labour market participation and income						
LFP	0.64	0.65	0.57	0.59	0.55	0.50
	(0.48)	(0.48)	(0.50)	(0.50)	(0.50)	(0.50)
Wage	15.65	15.40	12.66	20.08	20.58	20.79
	(29.72)	(21.69)	(18.22)	(21.89)	(31.30)	(26.61)
Manager	0.01	0.01	0.01	0.03	0.04	0.04
	(0.08)	(0.12)	(0.08)	(0.16)	(0.18)	(0.18)
Professional	0.14	0.12	0.10	0.11	0.10	0.10
	(0.34)	(0.32)	(0.30)	(0.29)	(0.30)	(0.30)
Blue_Collar	0.17	0.19	0.21	0.12	0.14	0.15
	(0.38)	(0.40)	(0.41)	(0.35)	(0.35)	(0.37)
Manual&SE	0.68	0.67	0.68	0.74	0.72	0.71
	(0.46)	(0.47)	(0.47)	(0.44)	(0.45)	(0.45)
Expenditure	2941.28	3141.33	3046.42	4103.52	4406.79	4226.15
	(2152.44)	(2314.96)	(2803.32)	(3035.24)	(3928.48)	(2752.58)
NL_income	549.37	600.24	638.30	1055.83	1142.58	1087.25
	(1278.17)	(1802.05)	(2006.62)	(1817.38)	(2093.44)	(1961.20)
Regional fixed effects						
Rural	0.38	0.39	0.39	0.40	0.40	0.38
	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)	(0.49)
Moscow&SP	0.03	0.03	0.03	0.04	0.03	0.03
	(0.18)	(0.18)	(0.17)	(0.19)	(0.18)	(0.17)
North_NW	0.06	0.06	0.06	0.05	0.06	0.06
	(0.24)	(0.24)	(0.24)	(0.22)	(0.24)	(0.24)
Central	0.20	0.22	0.23	0.21	0.20	0.23
	(0.40)	(0.41)	(0.42)	(0.41)	(0.40)	(0.42)
Volga	0.25	0.20	0.21	0.24	0.22	0.21
	(0.43)	(0.40)	(0.40)	(0.43)	(0.41)	(0.40)
N_Caucasus	0.14	0.16	0.15	0.14	0.16	0.15
	(0.34)	(0.36)	(0.36)	(0.35)	(0.37)	(0.36)
Ural	0.16	0.17	0.15	0.16	0.17	0.15
	(0.36)	(0.37)	(0.36)	(0.37)	(0.37)	(0.36)
W_Siberia	0.08	0.08	0.08	0.09	0.08	0.08
	(0.28)	(0.27)	(0.27)	(0.28)	(0.27)	(0.27)
E_Siberia	0.08	0.08	0.09	0.07	0.08	0.09
	(0.26)	(0.27)	(0.29)	(0.26)	(0.27)	(0.29)
No observations	1389	1089	684	1112	1139	911
Percentage	43.93	34.44	21.63	35.17	36.02	28.81

Note: Total number of observations is 3162 in both 1995 and 2004. *Summary statistics for the individual hourly wage are reported only for non-zero observations which are in total 1386 in 1995 and 1371 in 2004.

Table 3 Summary statistics and estimation results of food demand system

Category	Expenditure share non-zero observations	Proportion non-zero observations	Probit pseudo R^2	Weighted SUR R^2	Predicted expenditure share
		1995			
Diary&eggs	0.158 (0.131)	0.720	0.328	0.194	0.113 (0.038)
Meat&fish	0.343 (0.178)	0.722	0.393	0.281	0.248 (0.114)
Bread&potatoes	0.229 (0.227)	0.937	0.485	0.235	0.215 (0.091)
Fruit&veg	0.143 (0.122)	0.591	0.269	0.179	0.084 (0.034)
Fats	0.175 (0.148)	0.552	0.250	0.174	0.096 (0.026)
Sugars	0.173 (0.164)	0.641	0.254	0.178	0.111 (0.044)
Alcohol	0.155 (0.154)	0.380	0.209	0.165	0.059 (0.025)
Other foods	0.148 (0.247)	0.497	0.150	0.327	0.073 (0.092)
		2004			
Diary&eggs	0.152 (0.102)	0.824	0.373	0.276	0.126 (0.046)
Meat&fish	0.332 (0.157)	0.872	0.300	0.271	0.290 (0.076)
Bread&potatoes	0.230 (0.186)	0.984	0.239	0.323	0.226 (0.088)
Fruit&veg	0.129 (0.102)	0.670	0.209	0.189	0.087 (0.032)
Fats	0.090 (0.079)	0.745	0.175	0.165	0.067 (0.020)
Sugars	0.143 (0.135)	0.821	0.187	0.191	0.118 (0.042)
Alcohol	0.120 (0.110)	0.274	0.211	0.158	0.033 (0.018)
Other foods	0.081 (0.111)	0.663	0.178	0.182	0.054 (0.022)

Note: Total number of observations is 3162 in both 1995 and 2004. Next to expenditure shares in parentheses standard deviations are reported.

Table 4 BMI supply OLS estimates (dependent variable ln*Weight*)

Variable	1995			2004			Wald-test
	Coefficient		SE	Coefficient		SE	(Pr>F)
Individual characteristics (inc. education)							0.0000
Height	1.7910	***	0.0821	1.8656	***	0.0910	
Age	0.0200	***	0.0014	0.0265	***	0.0037	
$Age^2 10^{-2}$	-0.0180	***	0.0015	-0.0245	***	0.0038	
Male	-0.0172	*	0.0099	-0.0445	***	0.0143	
High_Edu	-0.0050		0.0107	-0.0030		0.0099	(0.0052)
Higher_Edu	-0.0481	**	0.0193	-0.0955	***	0.0218	
Diet (food demands) and smoking							0.0022
Diary&eggs	0.3571		0.2323	0.7922	*	0.4538	
Meat&fish	0.0632		0.1224	0.2006	*	0.1214	
Fruit&veg	-0.0989		0.0903	-0.1860		0.2057	
Fats	0.3496	**	0.1581	0.5561	**	0.2409	
Sugars	0.3329	*	0.1828	1.0089	***	0.3237	
Alcohol	0.4600		0.2918	-0.9235	***	0.3624	
Other foods	0.0351		0.1370	-0.1493		0.1992	
lnCalories	0.0174		0.0112	0.0186	*	0.0111	
Smoker	-0.0977	***	0.0145	-0.1220	***	0.0121	
Leisure demand (wage rate and occupation)							0.0007
lnWage	0.0165		0.0265	0.0895	**	0.0404	
Manager	0.0194		0.0181	0.0388	*	0.0211	
Professional	-0.0140		0.0127	-0.0380	**	0.0177	
Blue_Collar	0.0059		0.0103	-0.0239	**	0.0119	
R^2	0.35			0.39			

Note: Number of observations is 3162 in all regressions. For diet reference category is bread and potatoes and for occupation – manual and self-employed workers. Level of significance of coefficients is denoted as follows: 10 per cent *, 5 per cent **, and 1 per cent ***. The Wald tests show the level of significance of joint differences for each of the three groups of variables. In parenthesis the level of significance of differences in the impact of education only is reported.

Table 5 BMI supply simultaneous-quantile regression estimates (dependent variable ln*Weight*)

Variable	1995			2004		
	q30	q60	q90	q30	q60	q90
Individual characteristics (inc. education)						
lnHeight	1.8271***	1.8042***	1.7046***	2.0162***	1.8458***	1.6818***
	(0.0969)	(0.0950)	(0.1280)	(0.1111)	(0.0980)	(0.1458)
Age	0.0188***	0.0193***	0.0220***	0.0249***	0.0226***	0.0245***
	(0.0017)	(0.0021)	(0.0030)	(0.0042)	(0.0052)	(0.0078)
$Age^2 10^{-2}$	-0.0166***	-0.0172***	-0.0208***	-0.0224***	-0.0204***	-0.0241***
	(0.0019)	(0.0022)	(0.0030)	(0.0042)	(0.0052)	(0.0078)
Male	0.0232	0.0006	-0.0546***	-0.0303*	-0.0248	-0.0782***
	(0.0158)	(0.0073)	(0.0212)	(0.0179)	(0.0181)	(0.0262)
High_Edu	-0.0063	-0.0129	0.0323*	-0.0033	0.0001	0.0034
	(0.0112)	(0.0131)	(0.0166)	(0.0106)	(0.0012)	(0.0205)
Higher_Edu	-0.0656***	-0.0640***	0.0037	-0.0964***	-0.0840***	-0.0731**
	(0.0197)	(0.0222)	(0.0272)	(0.0242)	(0.0257)	(0.0334)
Diet (food demands) and smoking						
Diary&eggs	0.3924	0.6263*	0.6419	0.9974**	0.5500	0.6388
	(0.4122)	(0.3738)	(0.4136)	(0.5008)	(0.4682)	(0.9352)
Meat&fish	0.0685	0.0914	0.0708	0.0559	0.2440**	0.1485
	(0.0595)	(0.1115)	(0.0528)	(0.1814)	(0.1109)	(0.1238)
Fruit&veg	-0.1059	-0.0394	-0.0657	-0.2785	-0.1807	-0.0299
	(0.1317)	(0.0379)	(0.0411)	(0.2995)	(0.1638)	(0.0703)
Fats	0.3172**	0.3548**	0.3997**	0.5375***	0.5873**	0.7577**
	(0.1326)	(0.1696)	(0.1924)	(0.2020)	(0.2846)	(0.3590)
Sugars	0.4400**	0.3942**	0.1671	1.1396**	0.9979*	0.6548*
	(0.1922)	(0.1810)	(0.1227)	(0.4963)	(0.5942)	(0.3878)
Alcohol	0.4631**	0.3588	0.4027	-0.9171**	-0.9560**	-0.8154*
	(0.2346)	(0.2872)	(0.3665)	(0.4706)	(0.4124)	(0.5001)
Other foods	0.1910	0.0975	-0.0197	0.1202	0.2264	-0.2364
	(0.1698)	(0.1697)	(0.1266)	(0.2657)	(0.3412)	(0.9419)
lnCalories	0.0279**	0.0112	0.0119	0.0332**	0.0107	0.0233
	(0.0133)	(0.0159)	(0.0197)	(0.0144)	(0.0112)	(0.0208)
Smoker	-0.1238***	-0.1194***	-0.0615*	-0.1341***	-0.1228***	-0.1165***
	(0.0171)	(0.0207)	(0.0350)	(0.0159)	(0.0150)	(0.0221)
Leisure demand (wage rate and occupation)						
Wage	0.0385	0.0241	-0.0475	0.0921**	0.0408*	0.0928*
	(0.0311)	(0.0263)	(0.0296)	(0.0427)	(0.0250)	(0.0569)
Manager	0.0136	0.0412*	0.0174	0.0421	0.0184	0.0792*
	(0.0174)	(0.0239)	(0.0455)	(0.0342)	(0.0259)	(0.0431)
Professional	-0.0069	-0.0185	0.0056	-0.0490**	-0.0209*	-0.0360*
	(0.0072)	(0.0178)	(0.0169)	(0.0244)	(0.0114)	(0.0213)
Blue_Collar	0.0036	0.0053	0.0126	-0.0244*	-0.0270**	-0.0256
	(0.0139)	(0.0131)	(0.0213)	(0.0135)	(0.0126)	(0.0188)
R^2	0.36	0.33	0.30	0.42	0.37	0.32

Note: Number of observations is 3162 in all regressions. For the diet reference category is bread and potatoes and for occupation – manual and self-employed workers. Level of significance of coefficients is denoted as follows: 10 per cent *, 5 per cent **, and 1 per cent ***.