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Abstract

This paper attempts to investigate the relation among wages, unemployment and obesity and to identify public policies to address the problem of over-weightness. To this purpose, a simple search and matching model of labour market is developed. Our framework tries to capture the relationship between obesity and employment/unemployment by assuming that the fraction of obese workers is a function of the ratio of vacant jobs to unemployment (labour market tightness). We argue that if obesity is positively related with employment, then social optimality dictates the imposition of a lump-sum tax on all individuals. In the opposite case a subsidy should be given.

Keywords: Obesity, Taxation, Unemployment, Wages
JEL Classification: I10, I18, J64

1 Introduction

Obesity is a growing health problem in the developed world, as it is related to a number of serious diseases, e.g. coronary heart disease, type II diabetes, osteoarthritis, hypertension and stroke (NHLBI, 1998). In practice, researchers use mainly the Body Mass Index (BMI), i.e. weight in kilos over height in meters squared, in order to quantify obesity. Thus, a Body Mass Index above 30 is a signal for excessive storage of fat in the body (CDCP, 2009). However, recent research criticizes the BMI on the grounds that it does not distinguish between fat and fat-free mass such as muscle and bone (Burkhauser & Cawley, 2008). More specifically, Burkhauser & Cawley (2008) argued that indexes such as Total Body Fat, Percentage Body Fat, Fat-free Mass and Waist Circumference are more accurate measures of fatness.

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Apart from the associated health problems, obesity has significant economic aspects. As to the reasons held responsible for over the normal weight, economists emphasize the role of decreasing food prices due to technological change (Komlos et al., 2004). More specifically, the fall in commodity prices and the decrease in the preparation time of a meal, caused a surge in caloric intake which resulted in an increase in the Body Mass Index (BMI). Another economic aspect of obesity is the relationship between obesity and labour market outcomes, which has been the focus of current research. Empirical work for U.S. (Cawley, 2004; Baum & Ford, 2004; Han et al., 2009) and Europe (Morris, 2006; Brunello & D' Hombres, 2007; Garcia & Quintana-Domeque, 2007; Greve, 2008) has shown that obesity as measured by various indicators has in most cases a negative impact on wages. Baum & Ford (2004) found among others that obese workers suffer a wage penalty in the range of 0.7-6.3 percent. In addition, a large part of the research on this field reports that obese females suffer more of a wage penalty than obese males and that there are differences by ethnicity and/or race. As for employment is concerned, Morris (2007) showed that obesity has a statistically significant and negative effect on employment in both males and females.

The possible explanations for why obese workers might receive lower wages can be categorized as follows: (i) Obese workers may have lower work ability and thereby lower productivity (Baum & Ford, 2004; Burkhauser & Cawley, 2008; Greve, 2008). This fact could reduce the bargaining power of employees', related to hiring, wage-setting and promotion (Puhl & Brownell, 2001) (ii) Obese workers may suffer a wage penalty because they value future utility less. More specifically, economically myopic workers, who have higher marginal rates of time preference, may be less concerned about the possible long-term health effects of obesity. Thus, these workers will consume more high-calorie foods and exercise less at the expense of lower levels of health (Komlos et al., 2004). Hence, these workers face a higher probability of health problems and as a result a higher cost for health care (Baum & Ford, 2004; McCormick et al., 2007) (iii) Obese workers face a handicap in face to face communication with customers (Baum & Ford, 2004).

There is no doubt that obesity has changed from a matter of personal choice to one of government policy, as it is related to increasing government spending. The economic costs of obesity are substantial: medical costs for overweight and obesity are estimated to be $147 billion or 9.1% of U.S. health care expenditures (Brownell, et al., 2009, p.1602). In addition, recent research concludes that Americans are more likely to be obese than to smoke cigarettes or use illegal drugs (Philipson, 2001, p.1). The problem stems from the fact that society bears an extra cost in the form of increased medical care expenses, unemployment benefits (as obesity is negatively related with employment), incapacity benefits, foregone tax revenues (due to lost production) etc., that are provoked by the higher than optimal consumption of the population of obese.

Thus, the government faces a negative market externality which requires correction in the form of taxes or subsidies. A possible solution for the confrontation of obesity could be the imposition of taxes on 'junk food' (Brownell et al., 2009) since the consumption of such products has a major contribution to the problem. However, this policy imposes costs on people who consume these types of products in moderation, too. Another policy could be to tax individuals according to their weight or according to their BMI (Mann, 2008). But, this policy violates the privacy of individuals and is difficult to implement. An alternative policy might be a subsidy which could be given only to non-obese individuals (Mann, 2008). The size of the tax could be determined by the Contingent Valuation analysis (Cawley, 2008). In our model, we seek to propose a policy which takes into account for both the wage differentials between obese and non-obese and the impact of employment on obesity. We argue that social optimality can be restored by the imposition of a lump-sum tax or subsidy on all individuals (i.e. obese and non-obese). The choice between a tax or subsidy depends on the sign of the relationship between unemployment and obesity level; if it is negative then a tax should be levied. If it is positive a subsidy should be given.

The paper is structured as follows. In the next Section the basic model is presented. In Section 3, the steady state equilibrium is defined. The socially optimal form of government intervention is deployed in Section 4. Finally, Section 5 concludes.

2 The Model

2.1 Environment

We consider a continuous-time model with risk neutral and infinitely lived agents. A continuum of workers, normalized to unity, participate in the market. Individuals are of two types: obese (hereafter denoted by b) and non obese (hereafter denoted by nb).

Some studies argue that there is a positive relationship between unemployment and obesity (e.g. Smith et al., 2007), whereas some others argue that this relation is negative (e.g. Ruhm, 2000, 2003). Hence, in order to capture the findings of the literature, we assume that the fraction of obese individuals in the total population is a function of the unemployment rate u and equal to $p(u)$. Furthermore, no assumption is made about the sign of the first derivative of $p(u)$ (i.e. it can be either positive or negative). If $p'(u) > 0$, then we assume that $\lim_{u\to 0} p(u) = 0$ and $\lim_{u\to 1} p(u) = 1$, whereas if $p'(u) < 0$, then $\lim_{u\to 0} p(u) = 1$ and $\lim_{u\to 1} p(u) = 0$.

Workers are either employed or unemployed and jobs are either filled or vacant. The 'death' rate of jobs is exogenous and equal to δ. We assume a free entry regime for vacancies, i.e. vacancies are created, whenever it is profitable to do so. Each firm offers only one job and each individual cannot be employed in different jobs. Moreover, we assume that there is no on-the-job search. Unemployed workers obtain zero utility flow. Firms and workers, discount the future at the same rate r. The cost of holding a vacancy is constant and equal to c. This cost sunks when the job is filled. The production technology is the following:

$$y_i = k_i a \tag{1}$$

where a, k_i are positive constants with $k_i = 1$ for $i = nb$ and $k_i = k < 1$ for $i = b$.

Workers and vacancies meet each other randomly, according to a Pissarides constant returns to scale matching function, $m(u, v)$, where u, is the unemployment rate and v, is the measure of vacancies. Hence, the arrival rate for workers is $m(\theta)$, where $\theta = v/u$, is the measure of labour market tightness. The usual properties hold for $m(\theta)$, i.e. $m'(\theta) > 0$ and $\lim_{\theta \to 0} m(\theta) = 0$. The arrival rate for jobs is $m(\theta)/\theta$ with $[m(\theta)/\theta]' < 0$, and $\lim_{\theta \to 0} [m(\theta)/\theta] = \infty$. Moreover, when a match between a worker and a vacancy is formed the wage is given by the symmetric Nash bargaining solution.

For a worker of type i ($i = b, nb$) with productivity y_i, $U_i(y_i)$ is the value of unemployment, $W_i(y_i)$ is the value of employment, $J_i(y_i)$ is the value to the employer of filling a job and finally V is the value of a vacancy.

2.2 Workers

2.2.1 Unemployed

The value function of an unemployed worker of type i acceptable to employers is equal to

$$rU_i(y_i) = m(\theta)[W_i(y_i) - U_i(y_i)] \tag{2}$$

According to equation (1), the flow value of unemployment for a worker of type i acceptable to employers is equal to the arrival rate of job offers times the capital gain by becoming employed.

2.2.2 Employed

The flow value of employment for a worker of type i is

$$rW_i(y_i) = w_i(y_i) + \delta[U_i(y_i) - W_i(y_i)] \tag{3}$$

where $w_i(y_i)$ is the wage received by a worker of type i.

Equation (3) determines the flow value of employment as the sum of the flow return to employment (the wage) plus the instantaneous capital loss. It is obvious that workers of type i not acceptable to firms have $W_i(y_i) = 0$.

2.3 Firms

2.3.1 Vacant

The discounted profit from holding a vacancy can be written as

$$rV = -c + \frac{m(\theta)}{\theta}\left[p(u)\max\{J_b(y_b) - V, 0\} + (1 - p(u))\max\{J_{nb}(y_{nb}) - V, 0\}\right] \tag{4}$$

The term inside the brackets in (4) denotes the expected capital gain from filling a vacancy. It is clear that given $w_i(y_i)$, a firm will hire a worker if $J_i(y_i) \geq V$.

2.3.2 Filled

Using (1), the flow value to a job filled by a worker of type i is

$$rJ_i(y_i) = k_i a - w_i(y_i) + \delta[V - J_i(y_i)] \tag{5}$$

From equations (1), (2), (3) and (5) we get

$$U_i(y_i) = \frac{m(\theta)w_i(y_i)}{r[r + m(\theta) + \delta]} \tag{6}$$

$$W_i(y_i) = \frac{[r + m(\theta)]w_i(y_i)}{r[r + m(\theta) + \delta]} \tag{7}$$

$$J_i(y_i) = \frac{k_i a - w_i(y_i) + \delta V}{r + \delta} \tag{8}$$

2.4 Wage Formation and Reservation Skill

Lemma 1 *All meetings between workers and vacancies will end up to production.*

Proof. *The surplus produced by the match between a worker of type i and a firm is*

$$S_i(y_i) = J_i(y_i) + W_i(y_i) - V - U_i(y_i) \tag{9}$$

Substituting (7), (8) and free entry condition $V = 0$, in equation (9), we get

$$(r + \delta)S_i(y_i) = y_i - rU_i(y_i) \tag{10}$$

Let' s assume that there is a y_i^R, such that $S_i(y_i^R) = 0$. This implies that if a worker of type i has a $y_i \leq y_i^R$, then he is never employed by a firm. Substituting y_i^R in (10) yields

$$y_i^R = rU_i(y_i^R) \tag{11}$$

Efficiency implies $V = J_i(y_i^R)$. Hence, by (8), (11) and the free entry condition $V = 0$, we get

$$\frac{w_i(y_i^R)}{r} = U_i(y_i^R) \tag{12}$$

Substituting (12) into (11) gives

$$y_i^R = w_i(a_i^R)$$

From the above analysis follows that

$$W_i(y_i^R) = U_i(y_i^R) = w_i(y_i^R) = 0 \tag{13}$$

Hence, $y_i^R = 0$*, for* $i = b, nb$*. But* y_i *is positive by definition.*
Q.E.D. ■

Symmetric Nash bargaining and free entry condition implies that

$$\frac{1}{2} S_i(y_i) = W_i(y_i) - U_i(y_i) = J_i(y_i) \tag{14}$$

Using (6), (7) and (8), we get that the wage earned by an individual of type i is

$$w_i(y_i) = \frac{y_i[r + \delta + m(\theta)]}{2(r + \delta) + m(\theta)} \tag{15}$$

3 Steady State Equilibrium

In steady state the evolution of employed individuals is equal to zero, i.e. the flow of workers out of unemployment should be equal to the flow of workers back to unemployment. We showed previously that all individuals are get employed as soon as they meet a vacancy. Steady state implies

$$\begin{aligned} m(\theta)u &= \delta(1 - u) \Rightarrow \\ u &= \frac{\delta}{m(\theta) + \delta} \end{aligned} \tag{16}$$

As we note from (14), steady state unemployment is a decreasing function of labour market tightness.

Definition 2 *A steady state equilibrium is a four tuple* $y_b^R, y_{nb}^R, u, \theta$*, that satisfy: (i) Free entry, i.e.* $V = 0$*, (ii) 'Balanced flows' ,i.e. , the flow of workers out of unemployment equals to the flow of workers into unemployment [eq. (14)] and (iii) The reservation property in Lemma 1.*

Using equations (1), (4), (8), (15), (16), the free entry condition and *Lemma 1*, we get that the market equilibrium value of θ and hence of steady state unemployment is given by solving the following equation

$$c = \frac{m(\theta)a}{\theta} \left[\frac{p(\theta)k + 1 - p(\theta)}{2(r + \delta) + m(\theta)} \right] \tag{17}$$

where p is expressed as a function of θ, since steady state unemployment is a function of labour market tightness.

Proposition 3 *Equation (17) has a unique solution in* θ*, if* $k > 1/2$ *and* $\epsilon_{m/\theta} > \epsilon_p$ *[where* $\epsilon_{m/\theta}$ *(*ϵ_p*) is the absolute value of the elasticity of* $m(\theta)/\theta$ *(*$p(\theta)$*) with respect to labour market tightness].*

Proof. Case 1: $p'(\theta) > 0$

Differentiating the right hand side (hereafter r.h.s.) of (17) with respect to θ*, and call it* $\Gamma(\theta)$ *we get*

$$\Gamma(\theta) = \frac{a\left\{Z[m^{'}(\theta)\theta - m(\theta)]\Xi + \theta m(\theta)[p^{'}(\theta)(k-1)Z - m^{'}(\theta)\Xi]\right\}}{\theta^2 Z^2} \tag{18}$$

where $Z = m(\theta) + 2(r+\delta)$ *and* $\Xi = 1 - (1-k)p(\theta)$*.*

Expression (18) is less than zero since k*,* $p(\theta) < 1$ *and* $[m(\theta)/\theta]' < 0$*, by definition. Since* $p'(\theta) > 0$*, from (16) and by definition we get that* $\lim\limits_{\theta\to 0} p(\theta) = 0$ *and* $\lim\limits_{\theta\to\infty} p(\theta) = 1$*.*

Case 2: $p'(\theta) < 0$

If $k > 1/2$*, then* $1 - (1-k)p(\theta) > (1-k)p(\theta)$*. Moreover, if* $\epsilon_{m/\theta} > \epsilon_p$*, then* $-m(\theta)p'(\theta)\theta < -m'(\theta)\theta p(\theta) + m(\theta)p(\theta)$*. Under these assumptions, it can be easily proven that* $\Gamma(\theta) < 0$*. Given that* $p'(\theta) < 0$*, from (16) and by definition we get that* $\lim\limits_{\theta\to 0} p(\theta) = 1$ *and* $\lim\limits_{\theta\to\infty} p(\theta) = 0$*.*

Finally, it can be easily postulated that $\lim\limits_{\theta\to 0} \frac{m(\theta)a}{\theta}\left[\frac{p(\theta)k+1-p(\theta)}{2(r+\delta)+m(\theta)}\right] = \infty$ *and* $\lim\limits_{\theta\to\infty} \frac{m(\theta)a}{\theta}\left[\frac{p(\theta)k+1-p(\theta)}{2(r+\delta)+m(\theta)}\right] = 0$ *in both Cases.*

Q.E.D. ■

When $p'(\theta) < 0$, an increase in θ has two opposite effects on the expected revenues from creating a vacancy [r.h.s. of (17)]; A negative one [which decreases the r.h.s. of (17)] due to the congestion externality created in vacant jobs, and a positive one [which increases the r.h.s. of (17)] as a result of the decrease of $p(\theta)$ [this occurs because $k < 1$, i.e. obese individuals are less productive].

4 Social Efficiency

The social planner has the following objective function:

$$H = \int_0^\infty e^{-rt}\left[p(\theta)ka(1-u) + (1-p(\theta))a(1-u) - c\theta u\right] dt \tag{19}$$

The expression inside the brackets is the current value of the net social surplus, which is equal to the total expected output (the sum of the first two terms) minus the total social cost of vacancies (each vacancy costs society c and given the definition of θ, the measure of vacancies is equal to $v = \theta u$).

Moreover, the social planner faces the following restriction, which determines the evolution of unemployment:

$$\dot{u} = \delta(1-u) - m(\theta)u \tag{20}$$

Let μ be a co-state variable. The optimal path of labour market tightness (θ) and unemployment satisfies (20) and the following Euler conditions

$$e^{-rt}[p'(\theta)a(1-k)(1-u) + cu] + \mu m'(\theta)u = 0 \tag{21}$$

$$\dot{\mu} - e^{-rt}\{[1-(1-k)p(\theta)]a + c\theta\} - \mu[\delta + m(\theta)] = 0 \tag{22}$$

To derive the conditions for the social efficient level of θ, we substitute μ from (21) into (22) and we evaluate the outcome in the steady state ($\dot{u} = 0$) to obtain

$$[\delta + r + m(\theta)][c\delta + a(1-k)p'(\theta)m(\theta)] = \{c\theta + a[1-p(\theta)(1-k)]\}m'(\theta)\delta \tag{23}$$

Solving the above equation with respect to θ we get the social efficient value of labour market tightness.

Hosios (1990), demonstrated that a decentralized economy may lead to an efficient outcome in a wide variety of search models of labour market, if the bargaining power of the worker is equal to the elasticity of the expected duration of a vacancy with respect to labour market tightness (or alternatively the bargaining power of the firm is equal to the absolute value of the elasticity of the expected duration of unemployment with respect to labour market tightness). Since, the expected duration of unemployment in our setting is $1/m(\theta)$, and bargaining power of firms is 0.5 by definition, Hosios condition implies that $\frac{m'(\theta)\theta}{m(\theta)} = 0.5$.

Multiplying both sides of (23) by $\frac{\theta}{m(\theta)}$, and applying Hosios condition we get

$$\frac{\theta[\delta + r + m(\theta)][c\delta + a(1-k)p'(\theta)m(\theta)]}{m(\theta)} = 0.5\delta\{c\theta + a[1-p(\theta)(1-k)]\} \tag{24}$$

Solving (24) with respect to c we get

$$c = \frac{m(\theta)a\{\delta[1-p(\theta)(1-k)] - 2\theta p'(\theta)(1-k)[\delta + r + m(\theta)]\}}{\theta\delta[2(r+\delta) + m(\theta)]} \tag{25}$$

As we easily note, (25) is different from (17) and thus the decentralized outcome does not coincide with the social outcome even if the Hosios condition is satisfied.

However, it can be easily shown that the social outcome is equal to the market outcome, if we impose a lump-sum tax (or subsidy) equal to τ and $q\tau$, where $q \in [0,1]$, on obese and non obese individuals respectively, with

$$\tau = \frac{2\theta p^{'}(\theta)a(1-k)[\delta + r + m(\theta)]}{\delta[q + p(\theta)(1-q)]} \tag{26}$$

where $\tau < \frac{y_i[r+\delta+m(\theta)]}{2(r+\delta)+m(\theta)}$.

If $p'(\theta) > 0$, then τ is a tax, whereas if $p'(\theta) < 0$, then τ is a subsidy[1]. If authorities cannot implement an efficient mechanism for 'tracking' obese, then $q = 1$, otherwise $q < 1$. The latter case, when a tax is levied, can be considered as equivalent with imposing a lump sum tax to all individuals and giving a tax refund only to non obese. The lower the value of q, the higher the level of the refund. On the other hand, when a subsidy is given, the fact that obese receive a higher subsidy can be justified on the grounds that an extra amount of money is needed so as to lose weight (e.g. gym subscriptions).

In a standard search model of labour market, when a worker decides wether to accept or reject an employment offer, it does not take into account the impact that this decision has on the employment probabilities that others face. The same holds for the decision process of firms. More specifically, both firms and workers congesting each other. One more hiring firm makes searching workers better off, but it makes other hiring firms worse off. On the other hand, one more searching worker makes hiring firms better off but other searching workers worse off. In a traditional model with ex ante homogeneous agents and a free entry regime for firms, equating the bargaining power of workers with the elasticity of the expected duration of a vacancy with respect to labour market tightness internalizes this congestion externality and leads to an efficient market equilibrium. The reason why this internalization occurs when the aforementioned condition holds is the following: the elasticity of the expected duration of a vacancy with respect to labour market tightness (the elasticity of the expected duration of unemployment with respect to labour market tightness), measures the congestion created by one firm (worker) to others; the higher its value, the higher the externality. Hence, if the elasticity of the expected duration of a vacancy (the elasticity of the expected duration of unemployment with respect to labour market tightness) is high, it is an indication that at the margin firms (workers) are causing more congestion to other firms (workers) than the congestion caused by workers (firms) to other workers (firms). In that case the social planner eliminates this externality by "taxing" firms (workers) through the increase of the worker's (firm's) share in the wage bargain [the increase (decrease) of the bargaining power of worker, will decrease (increase) the equilibrium number of firms entering the market and therefore the congestion externality created by a firm (worker) to other firms (workers) will be decreased].

However, if we have a model with ex ante heterogeneous individuals and no firm entry (e.g. Lockwood, 1986), another kind of externality arises. This type of externality is working through the match acceptance probabilities. More specifically, in such models a number of individuals remains always unemployed (discouraged worker effect) in equilibrium, since no firm accepts them. This basically occurs because workers and firms have different reservation rules in that case. However, if we add the assumption of free entry for firms in models with

[1] Equation (26) can be derived if we equate (25) and the properly transformed version of (17) so as to incorporate the relative tax (subsidy) (see appendix) and solve with respect to τ.

ex ante heterogeneous workers, this externality will be eliminated, reservation rules will be equalized and the equilibrium outcome will be efficient under Hosios condition. Nonetheless, in our model there is one more source of externality which arises from the fact that obese individuals have lower productivity and their number depends on the level of labour market tightness. More specifically, the entry of one more hiring firm creates lower (greater) congestion to other firms regarding their 'encounter' with obese workers than with non obese. Market fails to internalize this externality, which leads to inefficiently high (low) entry of firms [and consequently to inefficiently high (low) labour market tightness[2]] even if Hosios holds. As mentioned above, this problem can be solved by imposing a lump-sum tax (subsidy) as described above. Since a part of the tax burden (subsidy benefit) is transferred by workers to firms through the bargaining process, the number of firms is appropriately controlled (disincentive for firm's entry in case of tax and incentive in case of subsidy) and efficiency is restored.

5 Conclusion

In this article, we utilized search and matching theory to analyze the effect of obesity on labour market equilibrium. We characterize the unique steady state of the market, and show that it leads to an inefficient outcome; there is an excess of obese individuals leading to a sub-optimal level of the ratio of vacancies to unemployment. Social efficiency can be achieved through government intervention. More specifically, if the level of unemployment is negatively correlated with obesity level, then a lump-sum tax should be levied on all individuals. In the opposite case a subsidy should be given. However, the easier to "track" and register obese employees, the higher the tax (subsidy) differentials in favour of non-obese (obese).

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[2] The r.h.s. of (17) is greater (lower) than the r.h.s. of (25) for $p'(\theta) > (<)0$. Moreover, the r.h.s. of (17) is decreasing in θ regardless the sign of $p'(\theta)$, if $\epsilon_{m/\theta} > \epsilon_p$. Hence, the market equilibrium measure of labour market tightness is greater (lower) than its efficient level if $p'(\theta) > (<)0$.

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6 Appendix

If we impose a lump-sum tax equal to τ and $q\tau$ on obese and non obese individuals respectively, then (3) will become

$$rW_i(y_i) = w_i(y_i) - q\tau + \delta[U_i(y_i) - W_i(y_i)] \tag{A.1}$$

where $q = 1$, if $i = b$.

Given A.1, (17) will become

$$c = \frac{m(\theta)}{\theta}\left\{\frac{a[1-(1-k)p(\theta)] - \tau[q + p(\theta)(1-q)]}{2(r+\delta)+m(\theta)}\right\} \tag{A.2}$$