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# Labour market, obesity and public policy considerations

Konstantinos Eleftheriou
*College of Business Administration, Abu Dhabi University, United Arab Emirates*

George Athanasiou
*Department of Mathematics, National Technical University of Athens, Greece*

Periklis Kougoulis
*College of Business Administration, Abu Dhabi University, United Arab Emirates*

## Abstract

This paper attempts to investigate the relation among wages, unemployment, 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 socially optimality dictates the imposition of a lump-sum tax on all individuals. In the opposite case a subsidy should be given.

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**Contact:** Konstantinos Eleftheriou - k.eleftheriou@adu.ac.ae, George Athanasiou - athansgeo@gmail.com, Periklis Kougoulis - periklis.kougkoulis@adu.ac.ae.
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# 1 Introduction

Obesity is a growing health problem in the developed world[1], as it is related to a number of serious diseases, such as coronary heart disease, type II diabetes, osteoarthritis, hypertension and stroke (NHLBI, 1998).

Apart from the associated health problems, obesity has also significant economic aspects. Obesity has been closely related to labour market outcomes. Morris (2007) showed that obesity has a statistically significant and negative effect on employment in both males and females. Furthermore, empirical studies for both U.S. and Europe, suggest that obesity has a negative impact on wages (Cawley, 2004; Baum & Ford, 2004; Han *et al.*, 2009; Morris, 2006; Brunello & D' Hombres, 2007; Garcia & Quintana-Domeque, 2007; Greve, 2008). Baum & Ford (2004) found among others that obese workers suffer a wage penalty that can be up to 6.3 percent.

The possible explanations for why obese workers might receive lower wages can be categorized as follows. One explanation is that 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). Another explanation is that 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. 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). A final explanation is that obese workers may 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 problem stems from the fact that society bears additional costs in the form of increased unemployment benefits (as obesity is negatively related with employment), medical care expenses, incapacity benefits and foregone tax revenues (due to production loss). The economic costs of obesity are substantial. For instance, 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 a nutshell, the government faces a negative market externality which necessitates the implementation of corrective policy. The policy can take either the form of taxes or subsidies. Along this line a debate regarding the particular specification of the policy under study has emerged. On the one hand, a possible solution could be the imposition of taxes on 'junk food' (Brownell *et al.*, 2009). This proposition is mainly justified by the fact that consumption of junk food products is a major contributor to the obesity problem. On the other hand, taxes could be imposed directly on individuals[2] ('obesity tax') according to various quantitative

[1]Recent research concludes that Americans are more likely to be obese than to smoke cigarettes or use illegal drugs (Philipson, 2001, p.1).

[2]A recent example of moving towards this direction is that of 'fat tax' on obese airline passengers (Daily Mail, 08/02/2012).

measures of obesity, such as the Body Mass Index (BMI)[3] (Mann, 2008). The size of a tax could be determined by the Contingent Valuation analysis (Cawley, 2008). Another policy, directly implementable on individuals, would involve a subsidy for non-obese individuals (Mann, 2008).

In the above debate, the impact of employment on obesity should be considered. If the relationship is positive (i.e., high employment is associated with high obesity levels) then the imposition of taxes could be further justified. Ruhm (2000, 2003) provides empirical evidence in favor of a positive correlation between employment and obesity levels. If the relationship is negative - low employment rates being associated with high obesity levels (Smith *et al.*, 2009) - subsidization might be more appropriate.

In this paper, we develop a search and matching model of labour market to address the economic effects of over-weightness by adopting the obesity tax/subsidy perspective. The contribution of our theoretical model is that it captures the empirical findings in the literature regarding not only the wage differentials between obese and non-obese but also the impact of employment on obesity[4]. We argue that social optimality can be restored by the imposition of a lump-sum tax or subsidy on all employed individuals (obese and non-obese). The choice between tax and subsidy depends on the sign of the relationship between unemployment and obesity level; if it is negative, then a tax should be levied, whereas if it is positive, a subsidy should be granted. Moreover, in our analysis the level of the tax or the subsidy is determined by key labour market variables, such as relative productivity between obese and non-obese, labour market tightness and the fraction of the non-obese in the total population.

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[5]. 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.*, 2009), 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 is 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)[6]. If $p'(u) > 0$, then we assume

[3] Weight in kilos over height in meters squared.

[4] Most of the literature in the field of economics of obesity is empirical. Theoretical studies such as Dragone & Savorelli (2012), mainly deal with behavioural aspects of consumption.

[5] Our theoretical construction is based on Pissarides (2000).

[6] An interesting modification of our model will be to consider that $p'(u) > 0$ for $0 < u \leq \tilde{u}$ and $p'(u) < 0$ for $\tilde{u} < u < 1$, where $\tilde{u}$ is a threshold value for $u$. The rationale behind this assumption is that low aggregate income from high unemployment implies lower household income for food and a smaller tax base to fund

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 $\delta$. 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 is sunk 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 $V$ 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 (2), 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 $W_i(y_i) = 0$.

public provisions. This constitutes a topic for future research.

## 2.3 Firms

### 2.3.1 Vacant

The discounted profit from holding a vacancy can be written as

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

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

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

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

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

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

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

## 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*

$$S_i(y_i) = J_i(y_i) + W_i(y_i) - V - U_i(y_i) \quad (9)$$

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

$$(r + \delta)S_i(y_i) = y_i - rU_i(y_i) \quad (10)$$

*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*

$$y_i^R = rU_i(y_i^R) \quad (11)$$

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

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

*Substituting (12) into (11) gives*

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

*From the above analysis it 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 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 (16), steady state unemployment is a decreasing function of labour market tightness.

**Definition 1** *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. (16)]) 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 $\theta$ 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 $\theta$, since steady state unemployment is a function of labour market tightness.

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

When $p'(\theta) < 0$, an increase in $\theta$ 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:

$$H = \int_0^{\infty} e^{-rt} \left[p(\theta)ka(1-u) + (1-p(\theta))a(1-u) - c\theta u\right] dt \tag{18}$$

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 $\theta$, the measure of vacancies is equal to $v = \theta u$).

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

$$\dot{u} = \delta(1-u) - m(\theta)u \tag{19}$$

Let $\mu$ be a co-state variable. The optimal path of labour market tightness ($\theta$) and unemployment satisfies (19) and the following Euler conditions

$$e^{-rt}[p'(\theta)a(1-k)(1-u) + cu] + \mu m'(\theta)u = 0 \tag{20}$$

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

To derive the conditions for the social efficient level of $\theta$, we substitute $\mu$ from (20) into (21) and we evaluate the outcome in the steady state ($\dot{u} = 0$) to obtain

$$[\delta + r + m(\theta)][c\delta + a(1-k)p'(\theta)m(\theta)] = \{c\theta + a[1 - p(\theta)(1-k)]\}m'(\theta)\delta \tag{22}$$

Solving the above equation with respect to $\theta$ 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 (22) by $\frac{\theta}{m(\theta)}$, and applying Hosios condition we get

$$\frac{\theta[\delta + r + m(\theta)][c\delta + a(1-k)p'(\theta)m(\theta)]}{m(\theta)} = 0.5\delta\{c\theta + a[1 - p(\theta)(1-k)]\} \tag{23}$$

Solving (23) with respect to $c$ we get

$$c = \frac{m(\theta)a\{\delta[1 - p(\theta)(1-k)] - 2\theta p'(\theta)(1-k)[\delta + r + m(\theta)]\}}{\theta\delta[2(r+\delta) + m(\theta)]} \tag{24}$$

As we easily note, (24) 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 $\tau$ and $q\tau$, where $q \in [0,1]$, on obese and non-obese individuals respectively, with

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

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

If $p'(\theta) > 0$, then $\tau$ is a tax, whereas if $p'(\theta) < 0$, then $\tau$ is a subsidy[7]. 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 whether to accept or reject an employment offer, it does not take into account the impact of his decision on the employment probabilities that others face. The same holds for the decision process of firms. In particular, both firms and workers are congesting each other. On the one hand, 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 model with ex ante homogeneous agents and 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 for that 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, a high elasticity of the expected duration of a vacancy (elasticity of the expected duration of unemployment with respect to labour market tightness) suggests 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). The social planner eliminates this externality by "taxing" firms (workers) through the increase of the worker's (firm's) share

[7] Equation (25) can be derived if we equate (24) and the properly transformed version of (17) so as to incorporate the relative tax (subsidy) (see Appendix) and solve with respect to $\tau$.

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 based on 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 occurs because workers and firms have different reservation rules. However, by adding the assumption of free entry for firms in models with 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[8]] even if Hosios holds. As mentioned above, this problem can be solved by imposing a lump-sum tax (subsidy). 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).

# 6 Appendix

If we impose a lump-sum tax equal to $\tau$ 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 $i = b$.

[8] The r.h.s. of (17) is greater (lower) than the r.h.s. of (24) for $p'(\theta) > (<)0$. Moreover, the r.h.s. of (17) is decreasing in $\theta$ 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 $p'(\theta) > (<)0$.

Given A.1, (17) will become

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

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

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

$$\Gamma(\theta) = \frac{a\left\{Z[m^{'}(\theta)\theta - m(\theta)]\Xi + \theta m(\theta)[p^{'}(\theta)(k-1)Z - m^{'}(\theta)\Xi]\right\}}{\theta^2 Z^2} \tag{A.3}$$

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

Expression (A.3) 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 $\lim_{\theta\to 0} p(\theta) = 0$ and $\lim_{\theta\to\infty} p(\theta) = 1$.

*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 $\lim_{\theta\to 0} p(\theta) = 1$ and $\lim_{\theta\to\infty} p(\theta) = 0$.

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

*Q.E.D.*

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