A Theory of Consumption Norms and Implications for Environmental Policy

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Abstract

In this paper we assume that for some commodities individuals may wish to adjust their levels of consumption from their normal Marshallian levels in order to conform to the consumption norms for a group of people to which they wish to belong. Unlike conspicuous consumption this can mean that some individuals may *reduce* their consumption of the relevant commodities. We first model the decisions of an individual using a two-stage game in which individuals first decide whether or not they wish to adhere to a norm, then decide their actual consumption. Next we assume there is a population of individuals with differing tastes and analyse which consumption norms constitute an *equilibrium* norm, and how many equilibrium norms might exist. Finally we study the *implications* of our model for redistributive policies, environmental policies and econometric analysis of consumer demand. We show that the introduction of consumption norms can have striking policy implications: predicting the use of taxes, subsidies or no policy interventions in contexts where without norms there be either no policy intervention or a tax on consumption; in situations where there are environmental externalities we predict there are cases where Pigovian taxes are either ineffective or welfare-reducing.

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1. Introduction

In this paper we examine the implications for understanding consumer behaviour and the design of public policy of assuming that individual consumption behaviour is influenced by the consumption decisions of other individuals through the existence of *consumption norms*. We begin by setting out how our treatment of consumption norms relates to the broader literature on consumer behaviour and social norms.

First, we distinguish such consumption norms from the interaction between individual consumption decisions through the Veblen effect (Veblen (1924)), whereby individuals' consumption decisions are influenced by those of others in a competitive manner as individuals seek to match their consumption to that of an aspirational group (and differentiate it from that of a distinction group)[1]. The Veblen effect is an externality which can sustain overconsumption and a market distortion that needs to be corrected by a policy such as a tax on goods prone to conspicuous consumption. We consider a different route by which individuals' consumption decisions may be influenced by those of others, namely through a desire to be seen to belong to a group of similar-minded individuals, thereby establishing consumption norms[2]. A key distinction from the Veblen effect is that such a proclivity to conform to a consumption norm can lead some individuals to *reduce* their consumption of a good relative to what they would have consumed in the standard economists' model where consumers take no account of the consumption of others.

Second, we distinguish consumption norms from the broader concept of social norms. Social norms play a number of roles of which we highlight two. As Young (2014) notes a key function of social norms is to coordinate people's expectations in interactions which are characterised by multiple equilibria, for example public good games. Analysis of social norms often involves using evolutionary game theory to predict which of a multiplicity of possible outcomes emerge as stable equilibria and a focus on the design of punishment

[1]For recent analyses of the Veblen effect see Arrow and Dasgupta (2010), Dasgupta, Southerton, Ulph and Ulph (2016) and Ulph (2014). The Veblen effect is invoked to explain the Easterlin Paradox (Easterlin (1974, 2001)) whereby, after a certain level of per capita income, further growth in income per capita seems to have no effect on measures of well-being as captured by surveys of happiness (see for example Blanchflower and Oswald (2004)).

[2] The most influential sociological theories of consumption – especially Bourdieu's (1984) account of taste and distinction and Bauman's (1990) account of neo-tribal lifestyles – both present social norms and belonging as the fundamental mechanisms underpinning its contemporary social patterning (see Southerton (2002) for a full discussion). In our use of the term consumption norms should be interpreted as a subset of the much broader category of social norms which can affect behaviour.

strategies by other players (e.g. Axelrod (1986)).[3] Typically there are multiple stable equilibria, and these often involve discrete choices, such as whether or not to smoke in public (Nyborg and Rege, 2003) whether or not to recycle household waste (Brekke, Kipperberg and Nyborg, 2010).

Another aspect of social norms (dating back to Festinger, 1954) arises from people's uncertainty about their identity or opinions. For activities like provision of public goods, voting, or charitable giving evidence suggests that individuals are more willing to contribute if they know members of their norm group have contributed or think others might match their contributions (referred to as *conditional cooperation*) – see for example Ledyard (1995), Azar (2004), Frey and Meier (2004), Tan and Bolle (2007), Gerber and Rogers (2009), Chaudhuri (2011), Bucholz, Falkinger and Rubbelke (2012), Abbott, Nandeibam and O'Shea (2013).

Applying such concepts to the consumption of private goods, Hargreaves-Heap (2013) and Hargreaves-Heap and Zizzo (2009)) identify a number of benefits from social norms, including (a) observing members of a norm group consuming a product an individual has not experienced can give implicit information about the quality of that product; (b) in a related manner, giving people information about what similar people achieve in saving energy, or retirement savings can significantly increase levels of savings (Allcott (2011))[4]; (c) by developing trust between members of a norm group, consumption norms can reduce transactions costs[5]; (d) for a number of consumption activities, such as reading a book or attending a concert, the benefits are not just the private experience but the subsequent opportunity to share thoughts about such experiences (the 'water cooler' effect) and this requires individuals to have overlapping sets of cultural interests.

In our analysis of consumption norms we assume that individuals are perfectly informed about the characteristics of products. Our concept of consumption norms is closer to that of Akerlof and Kranton (2000), who argued that an ability to identify with a group of people is a

[3] Axelrod's analysis also differs from ours in that he uses an evolutionary game approach, while we assume that individuals are conventional utility-maximisers, albeit with non-standard utility functions.

[4] See Bennett et al (2009) for a comprehensive analysis of the clustering of consumption activities based on overlapping cultural interests in the UK.

[5]This is linked to notions of social capital. It is important to distinguish between group membership developing greater trust between insiders – a positive social benefit – and developing a greater distrust of outsiders – a reduction in social benefit (see Putnam (2000) and Dasgupta (2000) for a recognition that social capital may have negative as well as positive effects) . Hargreaves-Heap and Zizzo (2009) construct a measure to test this distinction, and in their experiments they find it is the negative effect which predominates.

key part of self-identity and yields an important psychological benefit of belonging to a group, what Adam Smith referred to as the ‘special pleasure of mutual sympathy’[6]. It is this pure psychological benefit of belonging to a group that we have in mind in this paper. An important implication is that it is the potential internal loss of such a benefit that provides the incentive to adhere to the consumption norm, rather than the use of punishment strategies by other players.

Much of the literature on consumption norms does not provide a formal model of how consumption norms might influence consumers’ behaviour. The paper that is closest to the model reported here is the study by Bernheim (1994) of conformity. In his model people differ in terms of their types (measured by a single index distributed over some interval). Society has a pre-specified notion of an ideal type and people suffer a loss of self-esteem the further their type is from the ideal. Individual’s well-being depends on the utility they get from their actions, and the esteem in which they are held by others. If an individual’s type was public information, all an individual could do is to act to maximise utility. But an individual’s type is private information, and has to be inferred from one’s actions, so individuals have an incentive to bias their actions towards that which an ideal person would perform; this leads some individuals to do more than they would do to maximise utility and others to do less. There are two possible equilibria: a fully-revealing equilibrium and a pooling equilibrium in which a group of individuals whose types are closer to the ideal type carry out the same level of action – so the equilibrium specifies a common action norm and the group of people who adhere to this common norm.

In this paper we focus directly on consumption behaviour and consumption norms, and we examine how behaviour influenced by such norms relates to traditional analysis of consumer demand captured by Marshallian demand curves. Like Bernheim we want to explain endogenously how consumption norms change individual consumer behaviour, which consumption norms can emerge as equilibrium norms, and how many norms there might be. All behaviour is assumed to be individual – there is no process for communication or coordination. Unlike Bernheim all information is public. In particular, to rule out other channels of interactions, we assume consumers are perfectly informed about the quality of the commodities being consumed and consumption is a private good. The crucial difference is

[6] Hargreaves-Heap and Zizzo (2009) also develop a test to measure this psychological benefit of belonging to a group; they find that it balances out the negative effect of group membership noted in the previous footnote.

that there is no concept of an ideal type of consumption, and the motivation to belong to a group is the pure psychological benefit discussed above.

A final important way in which we seek to distinguish our treatment of consumption norms from that found in the literature is that it is frequently assumed that an individual's utility loss in shifting consumption from the Marshallian demand towards a norm takes a simple quadratic form. This has the implication that people adjust their consumption towards the norm, but the only person who consumes at the norm level for that good is the individual whose Marshallian demand is the norm. This raises the question, often noted in the literature (Manski, 2000), that it can be difficult to identify the effect of consumption norms empirically. In contrast we assume that the utility loss suffered by an individual deviating from Marshallian demand depends on the *absolute* value of the loss. As we will see this implies that there will *always* be a significant group of individuals whose Marshallian demands are closes to the norm who consume the norm *exactly*; there *may* exist a second group if individuals, whose Marshallian demands are further from the norm than the first group, who adhere to the norm by adjusting their consumption towards the norm (increasing their consumption if their Marshallian demand is below the norm, decreasing their consumption if their Marshallian demand is above the norm); and there may exist a third group whose Marshallian demands are even further from the norm who just consume their Marshallian demands. Indeed we will see that there are equilibria of our model where, although Marshallian demands vary systematically across the population, *everyone* consumes the norm level of consumption exactly so there is a striking difference between the pattern of consumption with and without such a consumption norm.

In the next section we set out our model of consumption norms and in section 3 analyse its implications for individual behaviour[7]. In section 4 we determine what norms can emerge as stable equilibria. In section 5 we analyse some public policy implications from our model, in particular that for some parameter values conventional environmental policy recommendations may be ineffective or even welfare-reducing. Section 5 concludes.

[7] In Dasgupta, Southerton, Ulph and Ulph (2016) we presented a brief summary of the model developed in the next section and illustrated its implication for environmental policy in a simple special case. In this paper we set out the model in greater detail and seek to draw more general public policy implications.

2. The Model

There are two consumer goods, the individual consumption of which is denoted by the variables $x \geq 0, z \geq 0$, where *x* is a commodity the level of whose consumption might be a norm[8] and *z* is expenditure on all other goods and serves as numeraire so its price is 1. Good *x* is produced in a perfectly competitive market with constant returns to scale, with price *p* equal to the (constant) unit cost of production.

We take it that what identifies a particular level of *x*, say x^*, as a consumption norm, and gives individuals a sense of group identity by adjusting their individual consumption of *x* towards x^* - what we will refer to as *adhering to the norm*; n^* is the fraction of the population that adheres to the norm. So a consumption norm is characterised by the pair $\left(x^*, n^*\right)$, where x^* is the level of consumption to which individuals may seek to adhere and $n^*, 0 \leq n^* \leq 1$ is the fraction of the population adhering to that norm.

There is a population of individuals each of whom has some income *y*, and a utility function

$$\tilde{u}\left(x, z, \delta; x^*, n^*\right) = ax - \frac{x^2}{2} + z + \delta\left[\sigma\left(n^*\right) - \alpha\left|x^* - x\right|\right],$$

where $\delta \in [0,1]$ is a choice variable that takes the value 1 if the individual chooses to adhere to a norm, and 0 if the individual chooses not to adhere and so behaves in a traditional Marshallian fashion.

Substitute in the budget constraint, and we can express utility in terms of the norm parameters $\left(x^*, n^*\right)$ and the two individual decision variables of interest - δ, whether or to adhere to the norm and *x* consumption of the norm-influenced good – as

$$u\left(x, \delta; x^*, n^*\right) = y + ax - px - \frac{x^2}{2} + \delta\left[\sigma\left(n^*\right) - \alpha\left|x^* - x\right|\right] \quad (1)$$

For an individual who has chosen to adhere to the norm:

- $\alpha\left|x^* - x\right|$ is what we call the *strength of attraction* of the norm level of consumption since, it measures the rate at which utility falls as individual consumption of *x*

[8] In principle this could be an aggregate of goods which act as norms.

deviates in either direction from the norm level. As mentioned in the introduction we have chosen to reflect the strength of attraction by using the absolute deviation rather than the more conventional square of the deviation, since, as we will see, this implies that there will be a mass of individuals who will consume **exactly** the norm level of consumption, whereas under the alternative specification the only individuals who will choose exactly the norm are those whose Marshallian level of consumption would have been $\tilde{x}$. In this way the norm consumption level becomes more perceptible.

- $\sigma\left(n^*\right)$ is what we call the *strength of desire for conformity with a group that makes up a fraction n* of the population*. We assume that

$$\sigma\left(n^*\right) = -\chi + \varphi n^*, \qquad (2)$$

where $\chi > 0$ is a fixed cost (i.e. unrelated to consumption decisions) of adhering to a norm group, which can be thought of as a cost of giving up individuality; while $\varphi > 0$ is the rate at which the strength of the desire to conform grows with the fraction of the population that choose to conform. The variable φn^* can therefore be thought of as measuring the benefit derived from establishing a sense of identity with a fraction *n** of the population. So the strength of the desire for conformity captures a tension between a psychic cost of giving up one's sense of individuality and a psychic benefit/comfort from being part of a larger group.

Obviously for an individual to adhere to any norm it has to be the case that the strength of desire for conformity is positive when the entire population adheres to it – i.e. when *n* = 1 - so we assume that $\varphi > \chi > 0$, and let $\underline{n} = \frac{\chi}{\varphi}$, $0 < \underline{n} < 1$ be the minimum fraction of the population that need to adhere to a norm for that norm to have a positive *strength of desire for conformity*. We can therefore re-write (1) as:

$$u\left(x,\delta;x^*,n^*\right) = y + ax - px - \frac{x^2}{2} + \delta\left[\varphi\left(n^* - \underline{n}\right) - \alpha\left|x^* - x\right|\right]. \qquad (3)$$

We initially make the stronger assumption on $\underline{n}$, namely that

$$0.5 < \underline{n} < 1. \qquad (4)$$

This rules out the possibility of there being a multiplicity of co-existent norms to which individuals would have to consider adhering. In section 4.2 we weaken the restriction in (4) and consider under what conditions there may exist two equilibrium norms.

Finally we assume that the taste parameter, *a*, is uniformly distributed in the population on the interval $\left[\underline{a},\overline{a}\right]$, $0<p<\underline{a}<\overline{a}$.[9] We denote by $\omega=0.5(\overline{a}-\underline{a})$ the width of the distribution of preferences, or the degree of diversity of preferences.

3. **Individual Decisions**

In this section we take as given the existence of some norm $\left(x^*,n^*\right)$ and determine which individuals will choose to adhere to this, and then, in the following section we determine which norms could merge as equilibria. In order to determine which individuals will choose to adhere to a given norm, we first need to determine an individual's consumption-maximising choices conditional on the adherence decision.

3.1 Consumption decisions

3.1.1 Marshallian Consumption

If an individual has chosen not to adhere to a norm - $\delta=0$ - then from (3) the utility-maximising choice of *x* is:

$$x^0=\underset{x\geq 0}{ArgMax}\,u\left(x,0,x^*,n^*\right)\equiv\underset{x\geq 0}{ArgMax}\;ax-\frac{x^2}{2}-px\quad=a-p\,. \qquad (5)$$

For notational simplicity, in what follows we identify individuals in terms of their Marshallian consumption. Given our assumption above about the distribution of *a* we take these Marshallian consumptions to be uniformly distributed on the interval $\left[\underline{a}-p,\overline{a}-p\right]\equiv\left[\underline{X},\overline{X}\right]$, $0<\underline{X}<\overline{X}$, with mean $\mu=\frac{\overline{X}+\underline{X}}{2}$, and $\omega=\frac{\overline{X}-\underline{X}}{2}=\frac{\overline{a}-\underline{a}}{2}$ the *width* of the spread of tastes in the population. This will turn out to be a crucial variable in what follows.

[9] Given the quasi-linear structure of preferences the utility maximising choices of *x* are independent of income, and so the precise distribution of income, *y*, plays no role in our analysis. All we require is that its distribution is sufficiently positively correlated with that of *a* such that for all individuals $y>p(a-p+\alpha)$, and so individuals always buy a positive amount of the numeraire good.

For an individual of type x^0 who has chosen not to adhere to the norm, the level of indirect utility associated with their Marshallian consumption is:

$$v_0\left(x_0, x^*, n^*\right) = \underset{x\geq 0}{Max}\, u\left(x, 0, x^*, n^*\right) \equiv \underset{x\geq}{Max}\; y + ax - \frac{x^2}{2} - px \quad = y + \frac{\left(x_0\right)^2}{2}. \qquad (6)$$

3.1.2 Consumption of individuals who adhere to the norm

If $\delta = 1$ then, taking account of (3) and the budget constraint the utility-maximising consumption is:

$$\hat{x}(x^*, n^*) = \underset{x\geq 0}{ArgMax}\, u\left(x, 1, x^*, n^*\right) \equiv \underset{x\geq 0}{ArgMax}\; ax - \frac{x^2}{2} - px - \alpha\left|x^* - x\right|. \qquad (7)$$

Carrying out the maximisation it is easy to see that for an individual of type x^0 who has chosen to adhere to a norm $\left(x^*, n^*\right)$ chosen consumption is:

$$\hat{x}\left(x^0, x^*\right) = \begin{cases} x^0 - \alpha \Leftrightarrow & x^* < x^0 - \alpha \\ x^* \Leftrightarrow & x^0 - \alpha \leq x^* \leq x^0 + \alpha \\ x^0 + \alpha \Leftrightarrow & x^* > x^0 + \alpha \end{cases} \qquad (8)$$

So when an individual of type x^0 adheres to any norm their chosen level of consumption lies within what we call their *norm-consistent interval of consumption* $\left[x^0 - \alpha, x^0 + \alpha\right]$. This illustrates what can be thought of as the *gravitational pull* of consumption norms:

- if the norm level of consumption is sufficiently close to an individual's Marshallian level of consumption – specifically if it lies inside the individual's *norm-consistent interval of consumption* - the individual will consume the norm level exactly;
- if the norm level of consumption is outside an individual's *norm-consistent interval of consumption* then the individual's consumption will lie at the boundary of the *norm-consistent interval of consumption* that is closest to the norm level.

It follows from the first bullet point that there will be a range of individuals whose Marshallian demands differ from the norm, but nevertheless choose to consume exactly at the level specified by the norm, thus making this norm level of consumption highly perceptible.

For an individual of type x^0 who has chosen to adhere to the norm (x^*, n^*) the indirect utility utility is

$$v_1(x^0, x^*, n^*) = \underset{x \geq 0}{Max}\, u(x, 1, x^*, n^*) \equiv \underset{x \geq 0}{Max} \quad y + \varphi(n^* - \underline{n}) + ax - \frac{x^2}{2} - px - \alpha|x^* - x|. \quad (9)$$

Substitute (8) into (4) to get:

$$v_1(x^0, x^*, n^*) = y + \varphi(n^* - \underline{n}) + \begin{cases} \frac{(x^0 - \alpha)^2}{2} + \alpha x^*, & x^* < x^0 - \alpha \\ x^0 x^* - \frac{(x^*)^2}{2}, & x^0 - \alpha \leq x^* \leq x^0 + \alpha \\ \frac{(x^0 + \alpha)^2}{2} - \alpha x^*, & x^* > x^0 + \alpha \end{cases} \quad (10)$$

3.2 The decision to adhere to a norm

The net benefit to an individual of type x_0 from choosing to adhere to the norm (x^*, n^*) is

$$\beta(x^0, x^*, n^*) = v_1(x^0, x^*, n^*) - v_0(x^0, x^*, n^*). \quad (11)$$

Substitute in (6) and (10) and, after a little re-arranging, we get

$$\beta(x^0, x^*, n^*) = \varphi(n^* - \underline{n}) - L(x^0, x^*), \quad (12)$$

where

$$L(x^0, x^*) \equiv \begin{cases} \frac{\alpha^2}{2} + \alpha\left[(x_0 - \alpha) - x^*\right], & x^* < x^0 - \alpha \\ \frac{(x_0 - x^*)^2}{2}, & |x^0 - x^*| \leq \alpha \\ \frac{\alpha^2}{2} + \alpha\left[x^* - (x_0 + \alpha)\right], & x^* > x^0 + \alpha \end{cases} \quad (13)$$

captures the loss of utility suffered by an individual from making the "wrong" consumption, and shows that there are TWO sources of this welfare loss:

(i) consumption is potentially different from the Marshallian amount;

(ii) chosen consumption may also be different from the norm.

We can write the utility loss in a more compact form as:

$$L\left(x^*, x^0\right) = \begin{cases} -\dfrac{\alpha^2}{2} + \alpha\left|x^0 - x^*\right|, & \left|x^0 - x^*\right| > \alpha \\ \dfrac{\left|x^0 - x^*\right|^2}{2}, & \left|x^0 - x^*\right| \leq \alpha \end{cases} \tag{14}$$

Notice that for all individuals this loss is non-negative and is zero only for an individual whose Marshallian demand coincides with the consumption norm. It is easy to see that the way this loss varies across individuals of different types – i.e. with different levels of Marshallian demand -is as illustrated in Figure 1[10].

Figure 1 here

It follows that an individual will adhere to a norm $\left(x^*, n^*\right)$ iff the net benefit from doing so is positive. This certainly requires that the fraction of consumers adhering to it is greater than the minimum threshold $\underline{n}$ – i.e. it requires $\beta\left(x^0, x^*, n^*\right) > 0 \quad \Rightarrow n^* > \underline{n}$;

Finally we characterise which individuals in the population would adhere to a given norm $\left(x^*, n^*\right)$, i.e. for which types x^0, $\beta\left(x^0, x^*, n^*\right) > 0$. So define by $\underline{x}^0(x^*, n^*), \overline{x}^0(x^*, n^*)$ the range of values of x^0 of individuals who would adhere to the norm (x^*,n^*), ignoring for the moment the need for $\underline{x}^0(x^*, n^*), \overline{x}^0(x^*, n^*)$ to lie in the range [$\underline{X}, \overline{X}$]. There are 2 cases, which are differentiated by whether the gains from adhering to a norm x^* are greater or less than the costs of adhering to the norm when $x^0 = x^* \pm \alpha$.

<u>Case A.</u> $\varphi(n^* - \underline{n}) \leq 0.5\alpha^2$

NOTE: a sufficient condition for this case to arise is $\varphi(1 - \underline{n}) \leq 0.5\alpha^2$;

Then:

$$\underline{x}^0(x^*, n^*) = x^* - \sqrt{2\varphi(n^* - \underline{n})} \geq x^* - \alpha; \quad \overline{x}^0(x^*, n^*) = x^* + \sqrt{2\varphi(n^* - \underline{n})} \leq x^* + \alpha$$

[10] The figures are at the end of this paper.

$$
\begin{aligned}
&x^0 < \underline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^0 \\
&\underline{x}^0(x^*,n^*) \le x^0 < \overline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^* \\
&x^0 > \overline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^0
\end{aligned} \tag{15}
$$

See Figures 2A and 3A:

Figures 2A and 3A here

<u>Case B:</u> $\varphi(n^* - \underline{n}) > 0.5\alpha^2$

Then:

$$
\underline{x}^0(x^*,n^*) = x^* - \frac{\alpha}{2} - \frac{\varphi}{\alpha}(n^* - \underline{n}) < x^* - \alpha; \quad \overline{x}^0(x^*,n^*) = x^* + \frac{\alpha}{2} + \frac{\varphi}{\alpha}(n^* - \underline{n}) > x^* + \alpha
$$

$$
\begin{aligned}
&x^0 < \underline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^0 \\
&\underline{x}^0(x^*,n^*) \le x^0 < x^* - \alpha \Rightarrow \hat{x}(x^0,x^*) = x^0 + \alpha \\
&x^* - \alpha \le x^0 \le x^* + \alpha \Rightarrow \hat{x}(x^0,x^*) = x^* \\
&x^* + \alpha < x^0 \le \overline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^0 - \alpha \\
&x^0 > \overline{x}^0(x^*,n^*) \Rightarrow \hat{x}(x^0,x^*) = x^0
\end{aligned} \tag{16}
$$

See Figures 2B and 3B:

Figures 2B and 3B here

For both Case A and Case B we now take account of the need for $\hat{x}(x^*,x^0)$ to satisfy the condition: $\underline{X} \le \hat{x}(x^*,x^0) \le \overline{X}$. So define:

$$
\underline{\underline{x}}^0(x^*,n^*) \equiv \max[\underline{X}, \underline{x}^0(x^*,n^*)], \quad \overline{\overline{x}}^0(x^*,n^*) \equiv \min[\overline{X}, \overline{x}^0(x^*,n^*)] \tag{17}
$$

Then the two conditions a norm (x^*,n^*) must satisfy to be a *Nash equilibrium norm* are:

$$
x^* = [\int_{\underline{\underline{x}}^0(x^*,n^*)}^{\overline{\overline{x}}^0(x^*,n^*)} \hat{x}(x^0,x^*)dx^0]/[\overline{\overline{x}}^0(x^*,n^*) - \underline{\underline{x}}^0(x^*,n^*)] \tag{18}
$$

$$
n^* = [\overline{\overline{x}}^0(x^*,n^*) - \underline{\underline{x}}^0(x^*,n^*)]/2\omega \ge \underline{n} \ge 0.5 \tag{19}
$$

Condition (18) is just the requirement that average consumption of those adhering to a norm equals the norm (where in constructing the average we need to scale the density function to reflect the fact that we are taking the average over the range of values $[\underline{x}^0(x^*,n^*), \overline{x}^0(x^*,n^*)]$, which may be a subset of the range $[\underline{X}, \overline{X}]$). Condition (19) is just the requirement that the fraction of the population adhering to the norm must be at least $\underline{n}$.

4. Existence of Equilibrium Norms

We fix μ, the mean value of x^0 and in section 4.1 we investigate whether for any parameters $(\alpha, \varphi, \underline{n}, \omega)$ there exists a single equilibrium norm, and if so whether there is a unique value for a single equilibrium norm or there is a range of possible values a single equilibrium norm might take. In section 4.2 we relax somewhat the assumption that $0.5 < \underline{n}$ and consider whether there might exist two equilibrium norms.

4.1 Existence of a Single Equilibrium Norm

In Section 3.2 we analysed the decision to adhere to a norm for 2 cases A and B which depended on whether $\varphi(n^* - \underline{n}) \leq 0.5\alpha^2$ or $\varphi(n^* - \underline{n}) > 0.5\alpha^2$ respectively. Since n^* is an endogenous variable, we now define Cases A and B depending, respectively, on whether $\varphi(1-\underline{n}) \leq 0.5\alpha^2$ or $\varphi(1-\underline{n}) > 0.5\alpha^2$. In this section we analyse what are the single equilibrium norms for Cases A and B in sub-sections 4.1.1 and 4.1.2 respectively. To provide the intuition for the results we will: (i) fix the parameters $(\alpha, \varphi, \underline{n})$ and focus on values of ω for which $x^* = \mu$ might be an equilibrium norm with an associated value of n^*; (ii) then ask, for a given value of ω, for what other values of x^* (with associated values of n^*) might (x^*, n^*) be a norm; (iii) finally consider what happens to as ω varies.

4.1.1 Case A: $\varphi(1-\underline{n}) \leq 0.5\alpha^2$

(i) Suppose we start with a value of ω such that $0.5\omega^2 < \varphi(1-\underline{n}) \leq 0.5\alpha^2$, or equivalently $\omega < \sqrt{2\varphi(1-\underline{n})} \leq \alpha$. The situation is shown in Figure 4. Define $\underline{x}^0(\mu,1) \equiv \mu - \sqrt{2\varphi(1-\underline{n})}$, the value of x^0 for which $L(\underline{x}^0, \mu) = \varphi(1-\underline{n})$ and similarly for $\overline{x}^0(\mu,1)$. Then:

$$\underline{x}^0(\mu,1) \leq \underline{X} \equiv \mu - \omega < \mu + \omega \equiv \overline{X} \leq \overline{x}^0(\mu,1) \qquad (20)$$

As shown in Figure 4 it must be the case that (μ,1) is an equilibrium norm, since for all $x^0 \in [\mu-\omega, \mu+\omega]$ $L(x^0, \mu) \leq \varphi(1-\underline{n})$.

(ii)Are there other values of x^* such that, for the same value of ω, (x^*, 1) is an equilibrium norm? For everyone to adhere to (x^*, 1) we require that:

$$\underline{x}^0(x^*,1) \equiv x^* - \sqrt{2\varphi(1-\underline{n})} \leq \mu-\omega \Rightarrow x^* \leq \mu + \sqrt{2\varphi(1-\underline{n})} - \omega \quad \text{(21a)}$$

and $$\overline{x}^0(x^*,1) \equiv x^* + \sqrt{2\varphi(1-\underline{n})} \geq \mu+\omega \Rightarrow x^* \geq \mu - \sqrt{2\varphi(1-\underline{n})} + \omega \quad \text{(21b)}$$

Define: $$\xi(\omega) \equiv \sqrt{2\varphi(1-\underline{n})} - \omega \quad \text{(22)}$$

where $\xi(\omega)$ is the size of the gap $[\overline{x}^0 - (\mu+\omega)] = [(\mu-\omega) - \underline{x}^0]$ in Figure 4. $\xi(\omega)$ is essentially the 'wiggle room' available to move x^* from μ either up or down such that (x^*, 1) is an equilibrium norm in which everyone adheres exactly to the norm x^*. It is important to note that, given the limit on the size of ω, it would not be possible to have an equilibrium norm (x^*, 1) to which some people adhered exactly and some adhered by adjusting actual demands either up or down by an amount α, because then the average consumption of those adhering to the norm would not be equal to the norm, violating condition (18).

Suppose first that: $\xi(\omega) \geq \omega \Leftrightarrow \omega < 2\omega \leq \sqrt{2\varphi(1-\underline{n})}$; then there is enough 'wiggle room' such that for *any* $x^* \in [\underline{X}, \overline{X}]$, ($x^*$,1) is an equilibrium norm to which everyone adheres.

Now suppose that $0 \leq \xi(\omega) < \omega \Leftrightarrow \omega \leq \sqrt{2\varphi(1-\underline{n}} < 2\omega$. Then for any $x^* \in [\mu - \xi(\omega), \mu + \xi(\omega)]$, which is a strict sub-interval of $[\underline{X}, \overline{X}]$, ($x^*$,1) is an equilibrium norm to which everyone adheres.

(iii)We now consider what happens as ω varies. We've just noted that if $\xi(\omega) \geq \omega$ then for any $x^* \in [\underline{X}, \overline{X}]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres; when ω increases such that $\xi(\omega) < \omega$ then for any $x^* \in [\mu - \xi(\omega), \mu + \xi(\omega)]$ (x^*,1) is an equilibrium norm to which everyone adheres. Now as ω continues to increase, ξ shrinks, until when $\omega = \sqrt{2\varphi(1-\underline{n})}$, $\xi(\omega) = 0$ and the *unique* equilibrium norm is (μ, 1)

Finally we analyse what happens when $\varphi(1-\underline{n}) < 0.5\omega^2 \leq 0.5\alpha^2$. Then there are people at the extremes of consumption for whom the costs of adhering to the norm (μ,1), $0.5\omega^2$,exceed the benefit of adhering to the norm (μ, 1), $\varphi(1-\underline{n})$, that would arise if everyone adhered to that norm. So these individuals do not adhere, implying that n^* would now be < 1. But this causes the benefit of adhering to the norm to fall to $\varphi(n^*-\underline{n})$, so again there are marginal people for whom costs exceed benefits, and n^* shrinks. This continues until $n^* < \underline{n}$. So when $\varphi(1-\underline{n}) < 0.5\omega^2 \leq 0.5\alpha^2$ there is no equilibrium norm.

So we have[11]:

Result 1 Case A. $\varphi(1-\underline{n}) \leq 0.5\alpha^2$.

(i) If $\omega < 2\omega \leq \sqrt{2\varphi(1-\underline{n})} < \alpha$ then for any $x^* \in [\underline{X}, \overline{X}]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres exactly.

(ii) If $\omega < \sqrt{2\varphi(1-\underline{n})} < \min(\alpha, 2\omega)$, then for any $x^* \in [\mu - \xi(\omega), \mu + \xi(\omega)]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres exactly; as ω increases ξ falls.

(iii) If $\omega = \sqrt{2\varphi(1-\underline{n})} < \min(\alpha, 2\omega)$ then (μ,1) is the unique equilibrium norm to which everyone adheres exactly.

(iv) If $\sqrt{2\varphi(1-\underline{n})} < \omega < \alpha$ then there is no equilibrium norm.

4.1.2 Case B: $\varphi(1-\underline{n}) > 0.5\alpha^2$

Suppose we start with a value of $\omega \leq \alpha$. Then the situation is essentially equivalent to Result 1, except that one replaces $\sqrt{2\varphi(1-\underline{n})}$ with α and $\xi(\omega)$ with $\psi(\omega) \equiv \alpha - \omega$ (see Figure 5(i)). So we have:

Result 2: $\varphi(1-\underline{n}) > 0.5\alpha^2 \geq 0.5\omega^2$.

(i) If $\omega \leq 0.5\alpha$ then for any $x^* \in [\underline{X}, \overline{X}]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres exactly.

[11] All proofs are in the Appendix.

(ii) If $0.5\alpha < \omega < \alpha$, then for any $x^* \in [\mu - \psi(\omega), \mu + \psi(\omega)]$, ($x$*, 1) is an equilibrium norm to which everyone adheres exactly; as ω increases $\psi(\omega)$ falls.

(iii) If $\omega = \alpha$ then (μ,1) is the unique equilibrium norm to which everyone adheres exactly.

We now focus on the case where $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$. Define $\overline{\omega}$ as the value of ω for which the loss to the marginal person adhering to the norm, $L(\overline{\omega}) = -0.5\alpha^2 + \alpha\overline{\omega}$, just equals the gain to adhering to the norm when everyone adheres $\varphi(1-\underline{n})$, i.e. $\overline{\omega} = \frac{\varphi(1-\underline{n})}{\alpha} + 0.5\alpha$. We begin by focussing on the case where, for a given ω, $\alpha < \omega < \overline{\omega}$. The situation is shown in Figure 5(ii).

There are now two possible equilibrium norms. First, (μ, 1) is an equilibrium norm to which everyone adheres; people with Marshallian demands $x^0 \in [\mu - \alpha, \mu + \alpha]$ adhere exactly; those with Marshallian demands $x^0 \in [\mu - \omega, \mu - \alpha]$ consume $\hat{x} = x^0 + \alpha$; those with Marshallian demands $x^0 \in [\mu + \alpha, \mu + \omega]$ consume $\hat{x} = x^0 - \alpha$. So the average level of consumption of those adhering to (μ,1) is equal to μ. The situation is shown in Figure 5(ii) and Figure 6(i). (μ, 1) is an equilibrium norm because for all $x^0 \in [\underline{X}, \overline{X}]$ the benefit of adhering to the norm is strictly greater than the loss, and, importantly, the average level of consumption of those adhering to the norm is equal to the norm. μ is the *only* value of x* for which (x*, 1) can be an equilibrium norm. To see why, suppose, x* was slightly greater than μ. (x*, 1) could not be an equilibrium norm, because the set of people with demands $x^0 > x^* + \alpha$ adhering to the norm by setting $\hat{x}(x^0, x^*) = x^0 - \alpha$ will be smaller than the set of people with demands $x^0 < x^* - \alpha$ adhering to the norm by setting $\hat{x}(x^0, x^*) = x^0 + \alpha$. Thus average consumption of those adhering to the norm does not equal the norm, and so (x*, 1) cannot be an equilibrium norm. A similar argument applies if $x^* < \mu$.

A second possibility is that (μ, $n^*(\omega)$) could be an equilibrium norm to which only a fraction $n^*(\omega)$ of the population adheres. For that to be an equilibrium norm, the benefit to the marginal person adhering to that norm, $\varphi(n^*(\omega) - \underline{n})$ must just equal the loss of utility $-0.5\alpha^2 + \alpha n^*(\omega)\omega$ from adhering to the norm, so:

$$n^*(\omega) = \frac{\varphi \underline{n} - 0.5\alpha^2}{\varphi - \alpha\omega} \quad (23)$$

It's straightforward to show that $\alpha < \omega \leq \bar{\omega} \Rightarrow \underline{n} < n^*(\omega) \leq 1$ and $n^*(\omega)$ is an increasing function of ω; note that it does not depend on the *level* of consumption to which people adhere. By the same argument as we used for (μ,1) to be an equilibrium norm, it is clear that the average consumption of those adhering to (μ, $n^*(\omega)$) must be equal to μ. So (μ, $n^*(\omega)$) is an equilibrium norm. The situation is shown in Figures 5(ii) and 6(ii).

However, unlike the first norm, it can be seen from Figures 5(ii) and 6(ii), that (μ, $n^*(\omega)$) is not the only possible equilibrium norm. Again we define the relevant 'wiggle room':

$$\eta(\omega) = \mu + \omega - \mu - n^*(\omega)\omega = \omega(1 - n^*(\omega)) = \omega[\frac{\varphi(1-\underline{n}) - (\alpha\omega - 0.5\alpha^2)}{\varphi - \alpha\omega}] \quad (24)$$

Then for any $x^* \in [\mu - \eta(\omega), \mu + \eta(\omega)]$

$$\mu - \omega \leq x^* - n^*(\omega)\omega < x^* + n^*(\omega)\omega \leq \mu + \omega \quad (25)$$

(x^*, $n^*(\omega)$) is an equilibrium norm; the wiggle room $\eta(\omega)$ is defined by the condition that the marginal individuals who adhere to the norm (x^*, $n^*(\omega)$) lie within $[\underline{X}, \bar{X}]$.

Finally we consider what happens as ω varies between α and $\bar{\omega}$. It is clear from (23) that $n^*(\omega)$ is an increasing function of ω, with $n^*(\alpha) = \frac{\varphi \underline{n} - 0.5\alpha^2}{\varphi - \alpha^2} \Rightarrow \underline{n} < n^*(\alpha) < 1$ and $n^*(\bar{\omega}) = 1$. Hence: $\eta(\alpha) = \alpha(1 - n^*(\alpha)) > 0$ and $\eta(\bar{\omega}) = 0$. This suggests that the wiggle room $\eta(\omega)$ shrinks as ω increases, and that when $\omega = \bar{\omega}$ the *only* equilibrium norm is (μ, 1). However we have not been able to establish that $\eta(\omega)$ shrinks monotonically to zero.

Finally, we note that when $\omega > \bar{\omega} \Rightarrow n^*(\omega) > 1$ so there cannot be an equilibrium norm.

So we have:

Result 3: $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$

Define: (a) $\bar{\omega} = \frac{\varphi(1-\underline{n})}{\alpha} + 0.5\alpha$; (b) $n^*(\omega) = \frac{\varphi \underline{n} - 0.5\alpha^2}{\varphi - \alpha\omega}$; (c) $\eta(\omega) = \omega(1 - n^*(\omega))$

(i) For $\alpha < \omega < \bar{\omega}$ there are two possible equilibrium norms: (μ, 1) and (x^*, $n^*(\omega)$) where $x^* \in [\mu - \eta(\omega), \mu + \eta(\omega)]$.

(ii) For $\omega = \bar{\omega}$, the only equilibrium norm is (μ,1).

(iii) For $\omega > \bar{\omega}$ there is no equilibrium norm.

(iv) In cases (i) and (ii) individuals with Marshallian demands $x^0 \in [x^* - \alpha, x^* + \alpha]$ adhere exactly to the norm x^*; individuals with Marshallian demands $x^0 \in [x^* - n^*(\omega)\omega, x^* - \alpha]$ adhere by setting $\hat{x} = x^0 + \alpha$; individuals with Marshallian demands $x^0 \in [x^* + \alpha, x^* + n^*(\omega)\omega]$ adhere by setting $\hat{x} = x^0 - \alpha$.

This completes our analysis of possible $\underline{n} > 0.5$ single equilibrium norms for all possible values of the parameters $(\alpha, \varphi, \underline{n}, \omega)$.

4.2 Two Equilibrium Norms

We now relax the assumption that $\underline{n} > 0.5$ so that we have the possibility of more than one equilibrium norm; so we now assume that $0.5 > \underline{n} > 1/3$, which is a necessary condition to have two equilibrium norms.

We now consider what further conditions the parameters $(\alpha, \varphi, \underline{n}, \omega)$ need to satisfy to allow for two equilibrium norms. First we will use Result 3 to ensure that we can have equilibrium norms of the form (x^*, $n^*(\omega)$). This requires the following pair of conditions

$$\varphi(1 - \underline{n}) > -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2 \Leftrightarrow \frac{\varphi(1 - \underline{n})}{\alpha} + 0.5\alpha > \omega > \alpha . \qquad (26)$$

More importantly to have two equilibrium norms we need to also ensure that $0.5 > n^*(\omega) > \underline{n} > 1/3$. This can be shown to require that parameters $(\alpha, \varphi, \underline{n}, \omega)$ satisfy two further conditions, namely: $0.5\alpha + \varphi(1 - \underline{n}) / \alpha > \omega > \max[1.5\alpha, \alpha + \varphi(1 - 2\underline{n}) / \alpha]$ and $\varphi \geq 1.5\alpha^2 \Rightarrow \underline{n} > 1/3 \geq 0.5\alpha^2 / \varphi$.

Finally it is intuitively clear that if x^* is located around the median, μ, there will not be enough space to allow for two equilibrium norms. This leads to the following Result 4.

Result 4: Suppose (a) $0.5\alpha + \varphi(1 - \underline{n}) / \alpha > \omega > \max[1.5\alpha, \alpha + \varphi(1 - 2\underline{n}) / \alpha]$ and (b) $\varphi \geq 1.5\alpha^2 \Rightarrow \underline{n} > 1/3 \geq 0.5\alpha^2 / \varphi$ and define: $\rho(\omega) = n^*(\omega)\omega$. Then:

(i) $0.5 > n^*(\omega) > \underline{n} > 1/3$

(ii) If $\mu + \omega - 3\rho(\omega) < x^* < \mu - \omega + 3\rho(\omega)$ then $(x^*, n^*(\omega))$ is the unique equilibrium norm.

(iii) If $\mu - \omega < x^* < \mu + \omega - 3\rho(\omega) \Rightarrow \mu + \omega - (x^* + \rho(\omega)) > 2\rho(\omega)$ - so there is sufficient room for a second norm (*x***, *n*(*ω*)) with *x*** > *x**; similarly if $\mu + \omega > x^* > \mu - \omega + 3\rho(\omega) \Rightarrow (x^* - \rho(\omega)) - (\mu - \omega) > 2\rho(\omega)$ - so there is sufficient room for a second norm (*x***, *n*(*ω*)) with *x*** < *x**.

The intuition $(x^*, n^*(\omega))$ exists such that $1/3 < \underline{n} < n^*(\omega) < 0.5$. Then it is clear that we can have 1 or 2 equilibrium norms depending on the value of *x**. If a norm lies in an interval around $\underline{X} + 0.5\omega$ then there is sufficient space for a second norm of *x**. n an interval around $\overline{X} - 0.5\omega$. However if a norm lies in an interval around $\underline{X} + \omega = \overline{X} - \omega$ there will be insufficient space for a second norm. Since individuals will only adhere to a norm if they are at least as well off as they would be consuming their Marshallian demands then wellbeing must be higher with two equilibrium norms than with one equilibrium norm. Of course this conclusion depends strongly on our assumption of a uniform distribution of preferences.

This completes our analysis of what consumption norms can be considered equilibrium norms.

5. Policy Implications

In this section we consider the policy implications of our analysis of consumption norms. In Section 5.1 we assume again that $0.5 < \underline{n} < 1.0$ so only one equilibrium norm (*x**,*n**) can exist, though there can be range of possible values for that single norm. Because there may be multiple possible values for an equilibrium norm, and individuals simply take such a norm as given, we ask whether from a welfare perspective there is an optimal consumption norm and if so what are the policy implications of how such an optimal norm might be brought about. In Section 5.2 we consider a situation where consumption generates environmental damage and ask what are the implications for the design of environmental policies of the fact that individuals wish to adhere to a consumption norm.

5.1 Optimal Consumption Norms.

In Results 1, 2 and 3 we have shown that, under appropriate parameter values, there are ranges of possible values of *x** for which a single equilibrium norm, (*x**, *n**) exists, where the associated value for n^* is either 1 or the constant $\frac{\varphi \underline{n} - 0.5\alpha^2}{(\varphi - \alpha\omega)}$ independent of x^*. We now consider the following thought experiment: if a policy maker is able to choose one of these values for x^*, which one would be chosen? From (14) the net benefit to an individual with Marshallian demand x^0 of adhering to a norm x^* is given by $\varphi(n^* - \underline{n}) - L(x^0, x^*)$, where $L(x^0, x^*)$ is given by (13). So if we ask which value of x^* maximises the expected net benefit of adhering to that norm, that is equivalent to choosing x^* to minimise the expected value of $L(x^0, x^*)$, denoted $\underset{x^0}{E}[L(x^0, x^*)]$.

We have the following result:

Result 5.

(i) In Results 1 and 2, where equilibrium norms take the form (x^*, 1), the unique value of x^* which minimises the expected value of the utility loss $\underset{x^0}{E}[L(x^0, x^*)]$ is $x^* = \mu$.

(ii) In Result 3, where the equilibrium norm takes the form (x^*, $n^*(\omega)$), there is no unique optimal value of x^*, since the value of $\underset{x^0}{E}[L(x^0, x^*)]$ is the same for all possible equilibrium values of x^*.

The intuition behind these results is that in Results 1 and 2, because everyone adheres to a norm, if $x^* \neq \mu$ the loss of utility from those furthest from x^* outweigh losses from those closer to the norm, so centring the norm on the mean value of Marshallian demand reduces these extreme losses. On the other hand in Result 3 because not everyone adheres to the norm the losses of those adhering to the norm are the same no matter which value of x^* constitutes the norm (x^*,$n^*(\omega)$).

What does Result 5 imply for policy? It is inherent in our analysis that we have treated the norm as exogenously determined outside the model, so policy makers are not able to manipulate the norm. But we assume that policy makers are able to use taxes and lump-sum transfers to shift the Marshallian demand for the norm good. In Results 1 and 2 expected utility is maximised when Marshallian demand of an individual with the mean value of the taste parameter for the norm good is equal to the norm. So if $x^* < \mu$ the optimal policy is to tax the norm good to reduce mean demand to the norm, while if $x^* > \mu$ the optimal policy is to subsidise the norm good to raise mean demand to the norm. In Result 3 there is no role for policy.

We stress that these policy conclusions when there are consumption norms are quite different from models without consumption norms. For example, in a standard model where, as in our model, utility is linear in income, there is no role for corrective taxation, whereas in our model we predict the use of either a consumption tax, consumption subsidy or no corrective taxation. Of course in our model the introduction of a consumption norm generates a form of consumption externality; in standard models where the conspicuous consumption/Veblen effect is present, so there is an externality in which individuals care about their own consumption relative to that of some group, the standard policy prescription is a tax on either consumption (Layard, 2006), or labour (Slack and Ulph, 2016), so again the policy prescriptions from our model differ from the conventional one.

5.2 Implications for Environmental Policy

We now suppose that each unit of consumption of the norm good generates a unit of environmental damage with a constant unit damage cost γ, and the only way of reducing this environmental damage is to reduce the consumption of the norm good. As in Section 5.1 we suppose that parameter values are such that, prior to any environmental policy, in Results 1, 2 and 3, there is a single equilibrium norm, (x^*,n^*), where x^* lies in an interval $[\underline{\zeta}^0,\overline{\zeta}^0]$ where the values $\underline{\zeta}^0,\overline{\zeta}^0$ depend on the parameter values determining which of the Results 1, 2 or 3 apply, and n^* takes the value 1 in Results 1 and 2 and the value $\frac{\varphi\underline{n}-0.5\alpha^2}{(\varphi-\alpha\omega)}$ in Result 3. Prior to any environmental policy being implemented, aggregate emissions are denoted by $\Sigma(x^*,n^*)\equiv\{\int_{\underline{X}}^{\overline{X}}\hat{x}(x^0,x^*)dx^0\}/(\overline{X}-\underline{X})$; and the aggregate net benefit of adhering to (x^*,n^*) are denoted by $B(x^*,n^*)\equiv\{\int_{\underline{\underline{x}}^0(.)}^{\overline{\overline{x}}^0(.)}[\varphi(n^*-\underline{n})-L(x^0,x^*n^*)]dx^0\}/[\overline{\overline{x}}^0(x^*,n^*)-\underline{\underline{x}}^0(x^*,n^*)]$.

To take account of environmental damage costs, individual well-being is now given by:

$$u(x,\delta;x^*,n^*,\Sigma)=y+ax-px-0.5x^2+\delta[\varphi(n^*-\underline{n})-\alpha\left|x^*-x\right|]-\gamma\Sigma(x^*,n^*) \qquad (27)$$

Each individual recognises that her consumption decisions make a negligible impact on $\Sigma(x^*, n^*)$, so treats $\Sigma(x^*, n^*)$ as fixed. Hence the results of sections 3 and 4 are unaffected by the inclusion of environmental damages.

Suppose now the government imposes an emission tax, τ. This will reduce: (a) every consumer's Marshallian demand x^0 by the amount τ; (b) mean Marshallian demand, μ, by the amount τ; (c) the range of values, $[\underline{X}, \overline{X}]$, within which Marshallian demands must lie by the amount τ; (d) aggregate emissions by the amount $\tau(\overline{X} - \underline{X})$. In the absence of consumption norms, the optimal emission tax would be the Pigovian tax $\tau = \gamma$ i.e. the emission tax equals marginal damage cost.

However if there are consumption norms, then, in addition to the impact of the emission tax, τ, on Marshallian demands, the interval within which x^* must lie for (x^*, n^*) to be an equilibrium norm will be reduced from $[\underline{\zeta}^0, \overline{\zeta}^0]$ to $[\underline{\zeta}^1, \overline{\zeta}^1]$, where $\underline{\zeta}^1 = \underline{\zeta}^0 - \tau; \overline{\zeta}^1 = \overline{\zeta}^0 - \tau$. Then it is straightforward to see that:

Result 6. Suppose that prior to any environmental policy there is an equilibrium norm (x^*, n^*). The government then imposes an emission tax τ. There are 3 possible outcomes:

(i) Suppose that parameters $(\alpha, \varphi, \underline{n}, \omega)$ are such that Result 1 or Result 2 apply, τ is sufficiently small that $\underline{\zeta}^0 < \overline{\zeta}^1$, and the pre-policy equilibrium norm (x^*, 1) is such that x^* lies in the interval $[\underline{\zeta}^0, \overline{\zeta}^1]$. Then all consumers continue to adhere to the norm (x^*, 1). So the environmental policy is completely ineffective.

(ii) Suppose that parameters $(\alpha, \varphi, \underline{n}, \omega)$ are such that Result 3 applies, τ is sufficiently small that $\underline{\zeta}^0 < \overline{\zeta}^1$, and the pre-policy equilibrium norm (x^*, n^*) is such that x^* lies in the interval $[\underline{\zeta}^0, \overline{\zeta}^1]$. Then a proportion n^* consumers will continue to adhere to the norm[12] (x^*, n^*), while a proportion (1 – n^*) of consumers will reduce consumption by an amount τ.

(iii) Suppose that for any parameters $(\alpha, \varphi, \underline{n}, \omega)$, τ is sufficiently large that x^* no longer lies in the interval $[\underline{\zeta}^1, \overline{\zeta}^1]$. Then consumers no longer adhere to the norm (x^*, n^*), but consume at their Marshallian levels, taking account of the emission tax τ.

[12] They will not necessarily be the same consumers.

Environmental damage costs fall by $\tau\gamma[\bar{X} - \underline{X}]$ but benefits of adhering to a norm fall by $B(x^*,n^*)$. So if $\tau < B(x^*n^*)/\gamma(\bar{X} - \underline{X})$ the imposition of the emission tax will reduce welfare. If this applies when $\tau = \gamma$, then the imposition of the conventional Pigovian emission tax would *reduce* aggregate well-being.

In summary, when consumers care about consumption norms, the conventional Pigovian prescription of imposing an emission tax equal to marginal damage cost could be (i) completely ineffective; (ii) partially ineffective; (iii) effective in cutting aggregate emissions to the Pigovian level, but could reduce aggregate well-being if the aggregate net benefits of conformity are sufficiently large.

We note two further aspects of Result 6. First suppose environmental policy is 'quantity based' rather than 'price-based', for example, mandating that all individuals consume $x^* - \gamma$. A key issue in assessing how this affects aggregate well-being would be whether the use of such an *injunctive* norm means consumers would view this as losing the net benefit $B(x^*,n^*)$ of voluntarily conforming to the original norm (x^*,n^*), in which case if this is large enough it could offset any benefits to aggregate well-being from cutting emissions. Second, suppose Result 6(iii) holds, so the original consumption norm (x^*, n^*) is no longer an equilibrium norm, but, after a while, a new equilibrium norm (x^{**}, n^{**}) emerges, where x^{**} lies in the interval $(\underline{\zeta}^1, \bar{\zeta}^1)$. As we have emphasised, our model does not specify this might come about. But suppose the new equilibrium norm level of consumption , x^{**}, must be as close as possible to the original norm x^* , i.e. it must equal the new upper limit of equilibrium norms, $\bar{\zeta}^1$. This would mean that while consumers would now experience again the benefit of adhering to a norm, the level of consumption will be higher than the Pigovian level. So it may be necessary to set a pollution tax $\tau > \gamma$ to bring x^{**} closer to the standard Pigovian level of consumption. Clearly this is an area for future research.

5.3 Empirical Analysis of Consumption Norms

We briefly address the issue we raised in the introduction that much of the analysis of consumption norms assumes that the loss of well-being from deviating from Marshallian demand towards a norm is quadratic in the distance between the Marshallian demand and norm-influenced level of consumption. This means that individuals adjust their consumption away from Marshallian demand towards the norm, but only an individual whose Marshallian demand is the norm will actually consume the norm exactly. This makes it difficult to distinguish the effects of a norm unless one knows the distribution of Marshallian demand. Given that our analysis in the previous section suggests some important implications for environmental policy arising from the existence of consumption norms, it would be problematic if policy makers were not able to know whether consumption was being influenced by norms.

By contrast, using our assumption that the welfare loss from adhering to a norm depends on the absolute value of the distance between the Marshallian demand and the demand with a norm. In Results 1 and 2 in this paper, *everyone* consumes the equilibrium norm exactly; in Result 3(ii), a significant proportion of the population consume at the norm level of consumption. Of course our model has a number of simplifications, but it will remain the case more generally that an equilibrium norm will have a range of individuals who exactly consume the norm – i.e. there will be a range of individuals for whom the observed income elasticity of demand is zero. This suggests that it may be possible for empirical analysis of demand, and hence for policy makers, to identify the existence of consumption norms.

6. Conclusions

In this paper we have presented a model of consumption norms in which, for some goods, there may exist a level of consumption to which individuals wish to conform because they benefit from being identified as belonging to a group of like-minded individuals. Unlike the Veblen notion of conspicuous consumption this desire for conformity will lead some individuals to reduce their consumption from the Marshallian level to the norm. Our modelling of the welfare cost of adhering to the norm also has the important implication that a significant number of people, in some cases the entire population, will consume the norm *exactly*. This means that in terms of both econometric analysis of demand and policy design, it may be easier to know when consumption norms are influencing demand. The implications for policies, such as the standard Pigovian taxation of goods which cause environmental damage, is that such policies may be ineffective, if the original, pre-policy, norm remains an equilibrium norm, or even counter-productive in terms of lowering welfare if the consumption norm is no longer an equilibrium norm and the loss of benefits from conformity outweigh the gains in reducing pollution damage costs.

In terms of *which* commodities might be associated with consumption norms, although we emphasise the difference between consumption norms and conspicuous consumption, it has to be the case that it must be possible for others to observe whether or not one is conforming to a norm, so the actual *act* of consumption must be conspicuous even if the *motivation* for adhering to a consumption norm is different from that driving conspicuous consumption.

Our model is clearly extremely simple in at least four aspects.

- Our model of consumer demand uses a simple quadratic utility function (and hence linear demand) for the norm good and linear utility for all other consumption. In earlier work (summarised in Dasgupta, Southerton, Ulph and Ulph (2016)) we used more general utility functions, and showed that the implications for individual behaviour (as summarised in Section 2 of this paper) carry over with more general utility functions.
- Our model of the costs and benefits of conforming to a norm also use particular functional forms. However, in terms of the costs of adhering to a norm, we have argued that our assumption that costs depend on the *absolute* value of the difference in consumption has the important implication that individuals with different levels of income will adhere *exactly* to the norm, which we have argued provides useful evidence that people are adhering to a consumption norm.
- Our model of a uniform density function of Marshallian demands is also clearly a special. In our earlier work (summarised in Dasgupta, Southerton, Ulph and Ulph (2016)) we went to the other extreme of assuming that either *all* consumers were identical or existed in 2 or 3 groups of identical individuals. However, as we argued above, a benefit of the uniform density function is that it does not provide a fairly obvious candidate for a norm, namely the mode, so it is a more open question whether an equilibrium norm exists.
- As we noted particularly in the discussion of Result 6, our analysis does not explain how an equilibrium norm emerges, which, as we said in the introduction, is often studied using evolutionary game theory. An interesting question is whether our notion of an equilibrium consumption norm corresponds to the outcome of an evolutionary game.

However, while we believe there are arguments for using our particular assumptions that go beyond just the benefit of simplifying the analysis, we think it will be important for future work to explore the implications of more general assumptions about these four key features of our model.

Figure 1: Loss of utility from adhering to a norm (*x**, *n**)

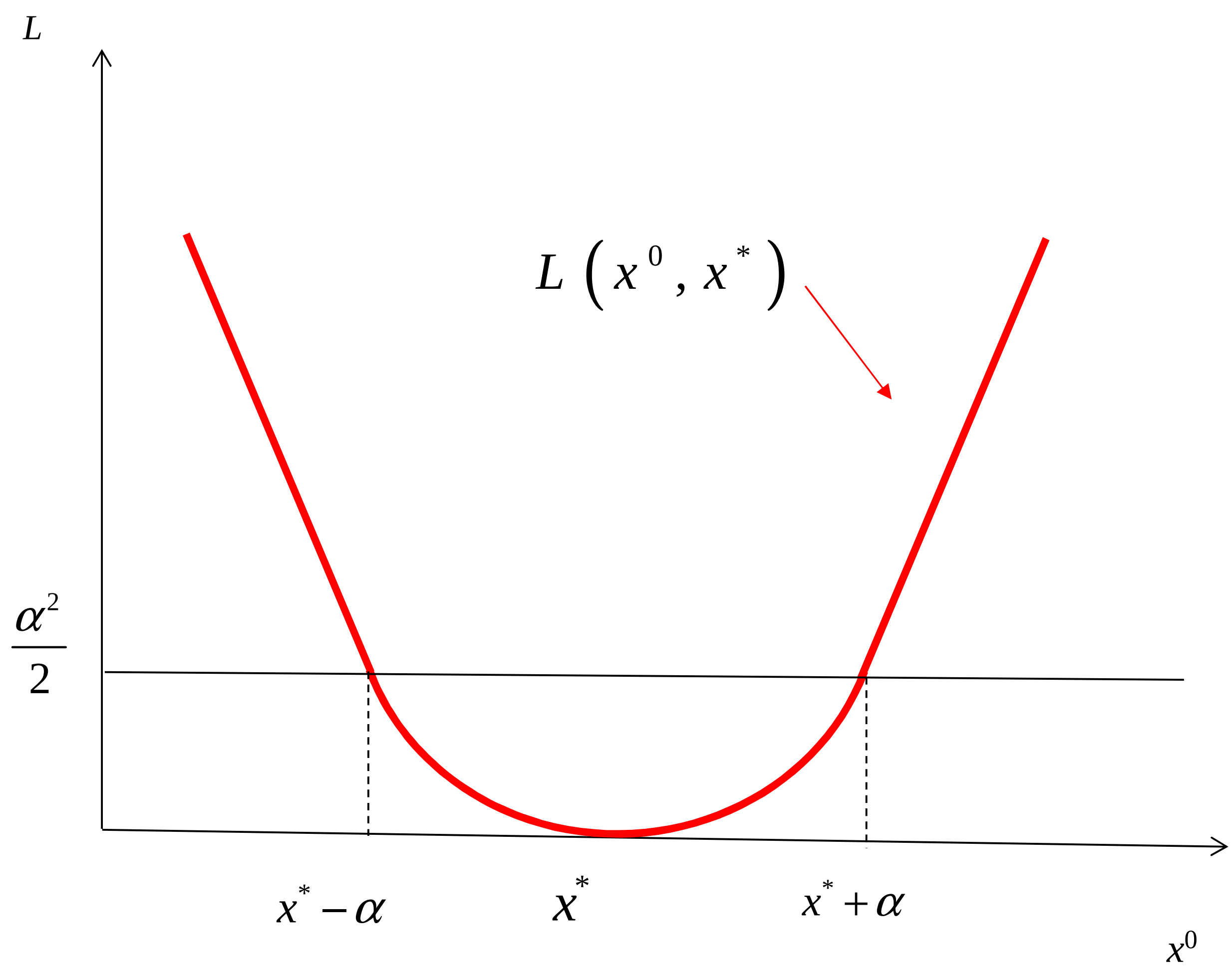


Figure 2(A) Consumption Decisions for those Adhering to Norm: Case A

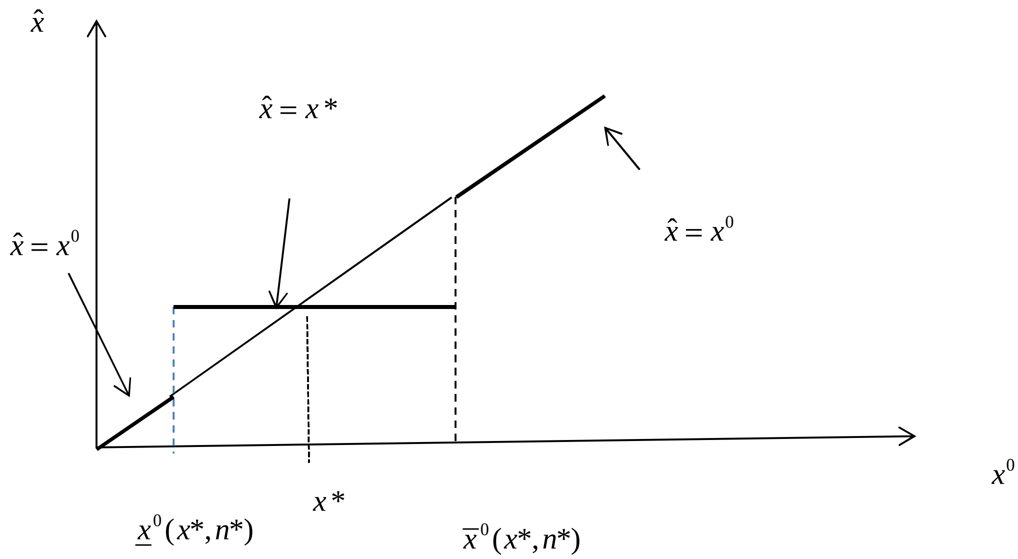


Figure 3(A) Loss of Utility from Adhering to Norm: Case A

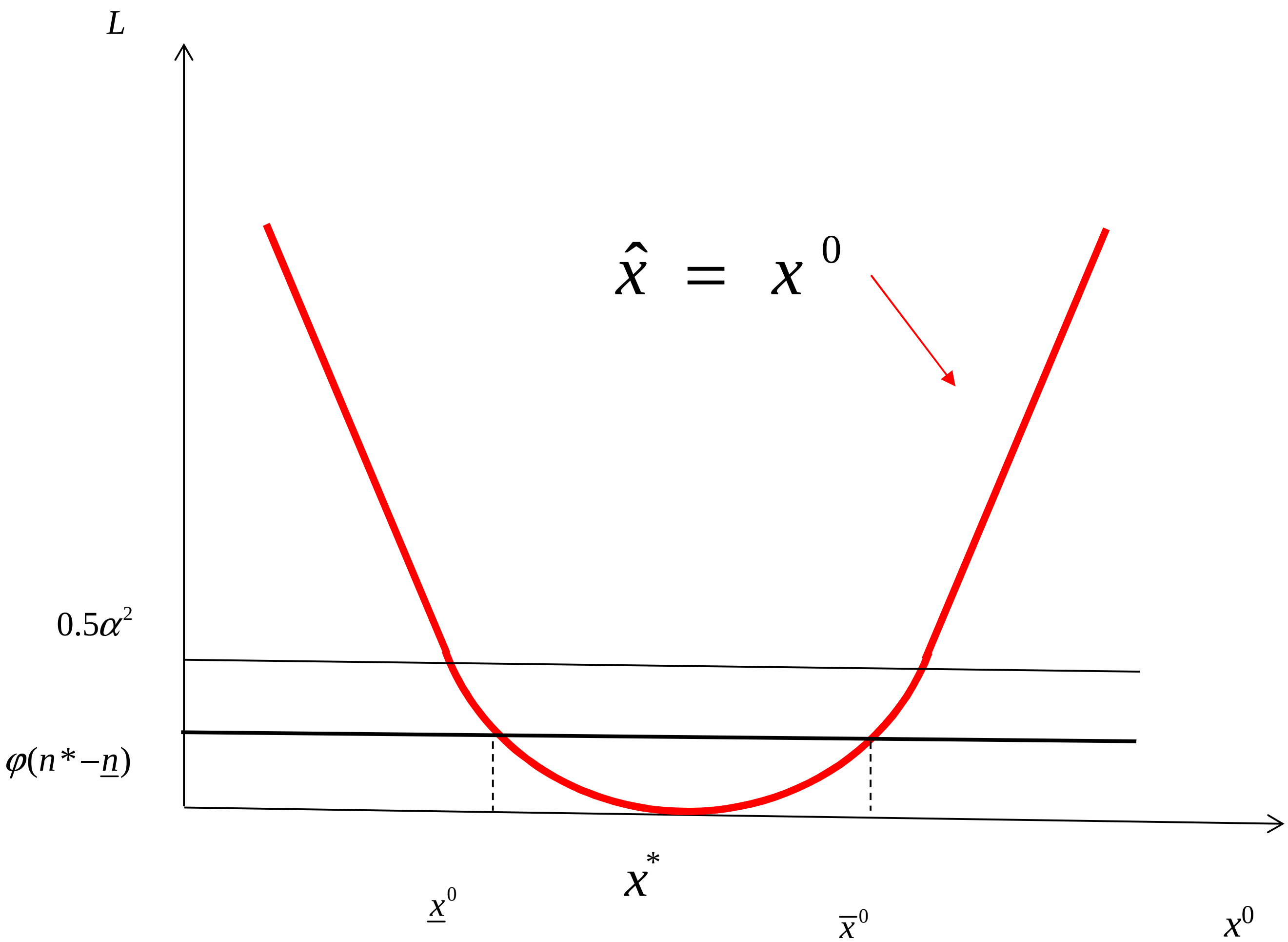


Figure 2(B) Consumption Decisions of those Adhering to Norm: Case B

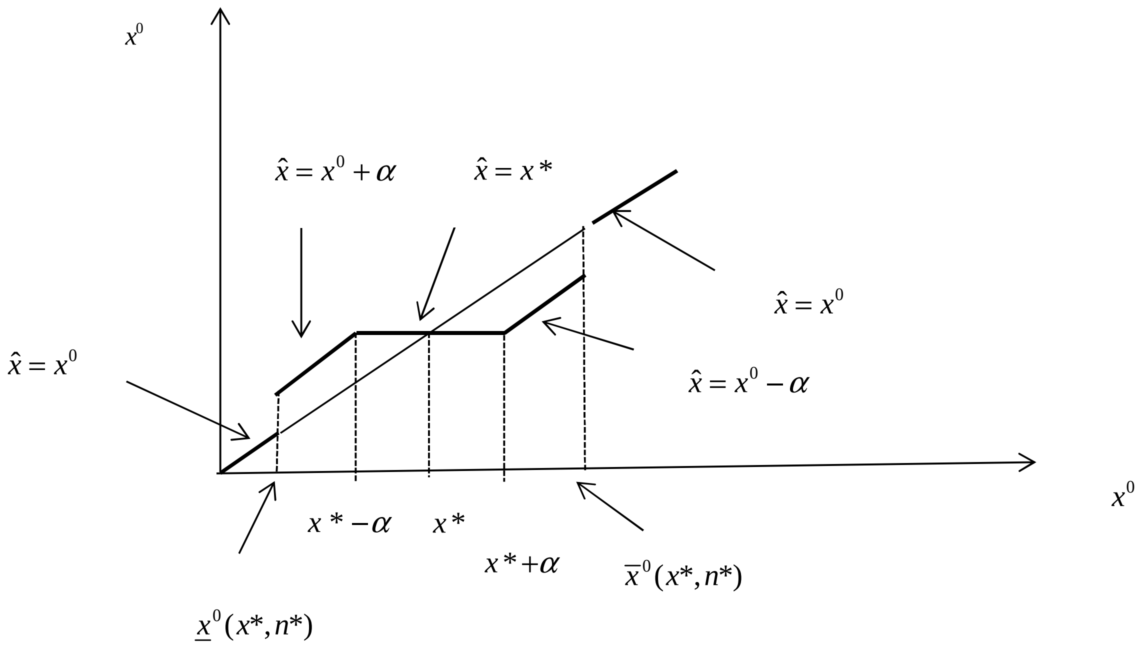


Figure 3(B) Loss of Utility from Adhering to Norm: Case B

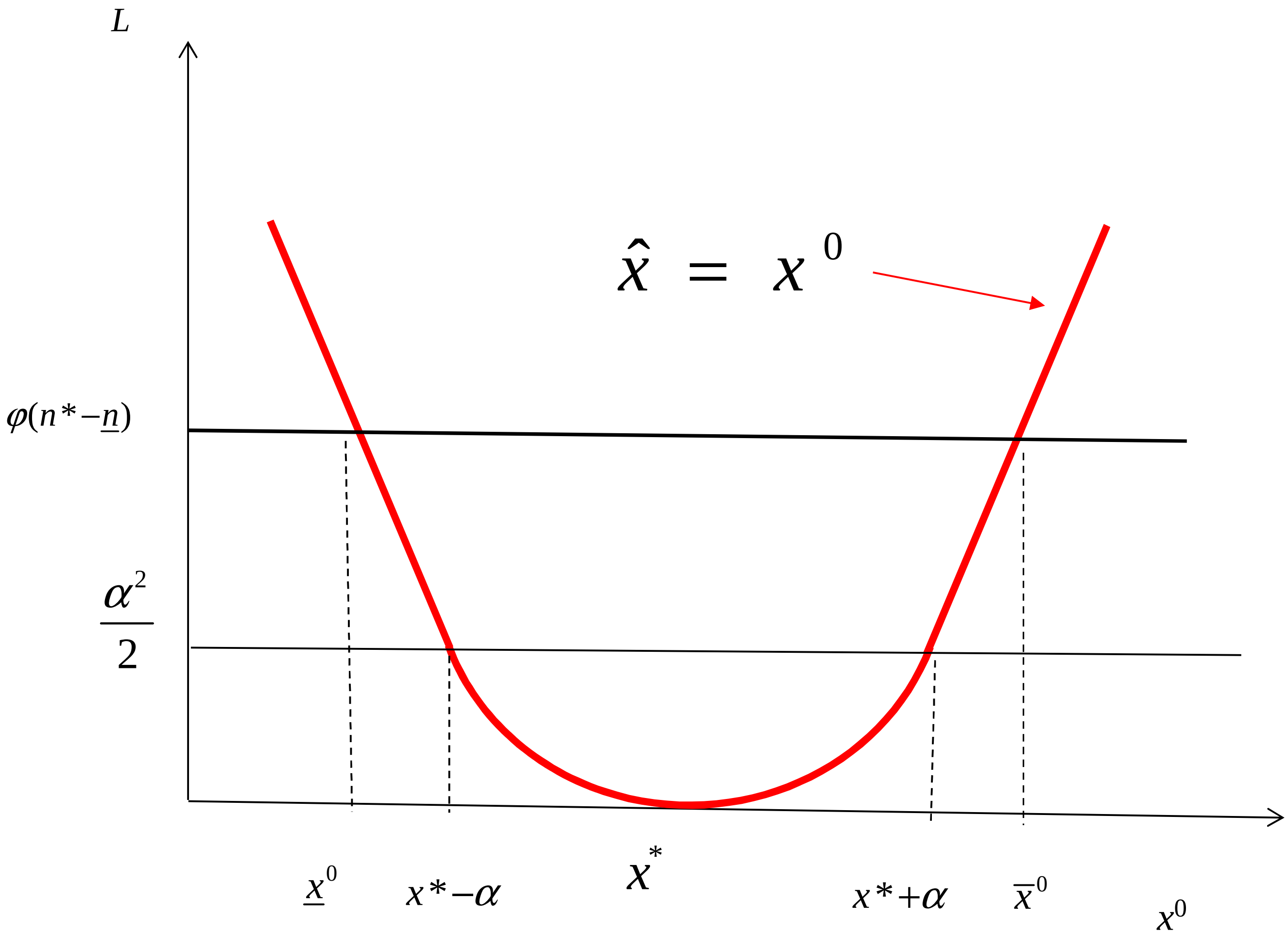


Figure 4: Equilibrium Norms: Case A - $\varphi(1-\underline{n}) \le 0.5\alpha^2$

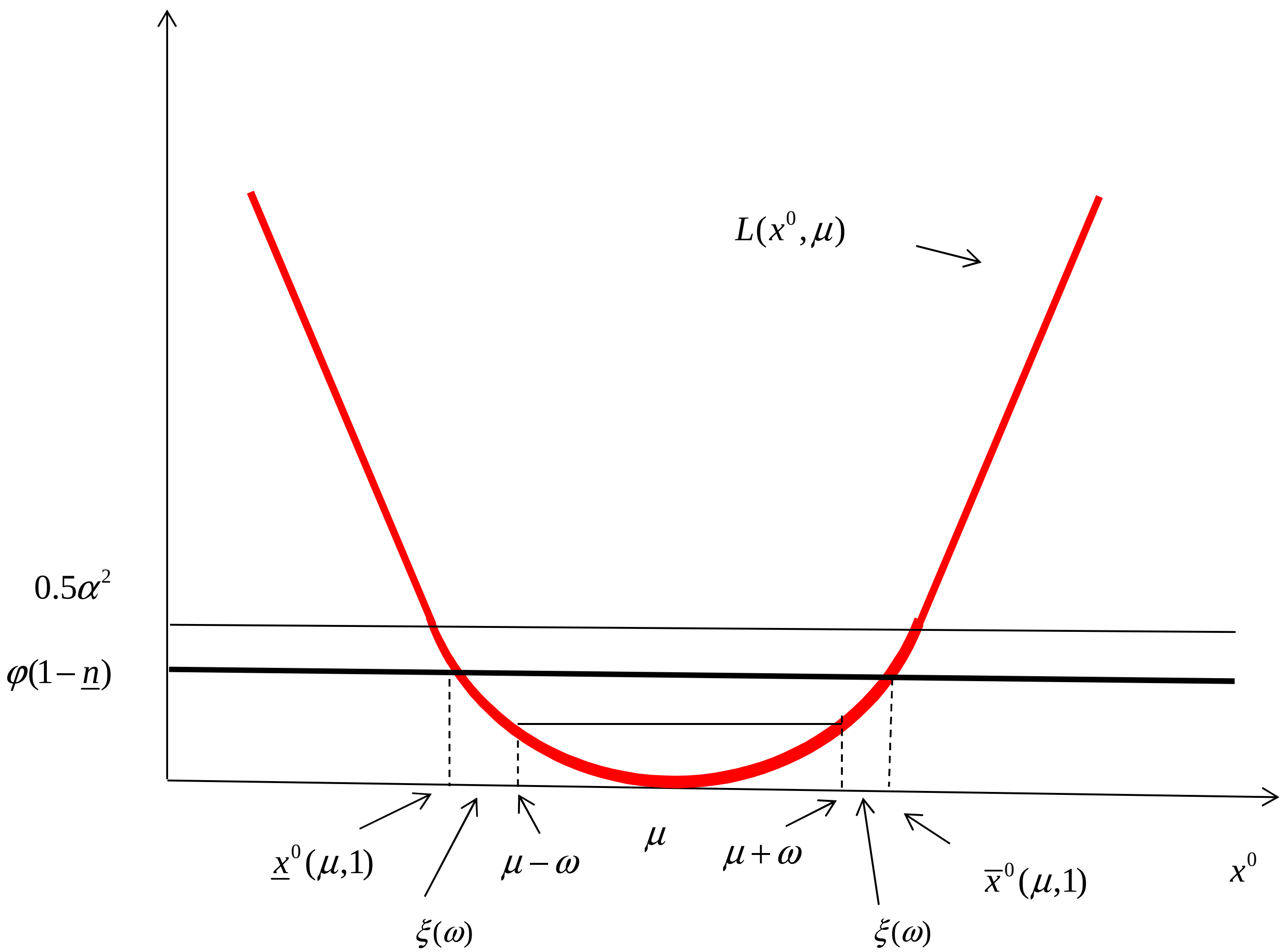


Figure 5 (i): Equilibrium Norms: Case B(i): $\varphi(1-\underline{n}) > 0.5\alpha^2 \geq 0.5\omega^2$

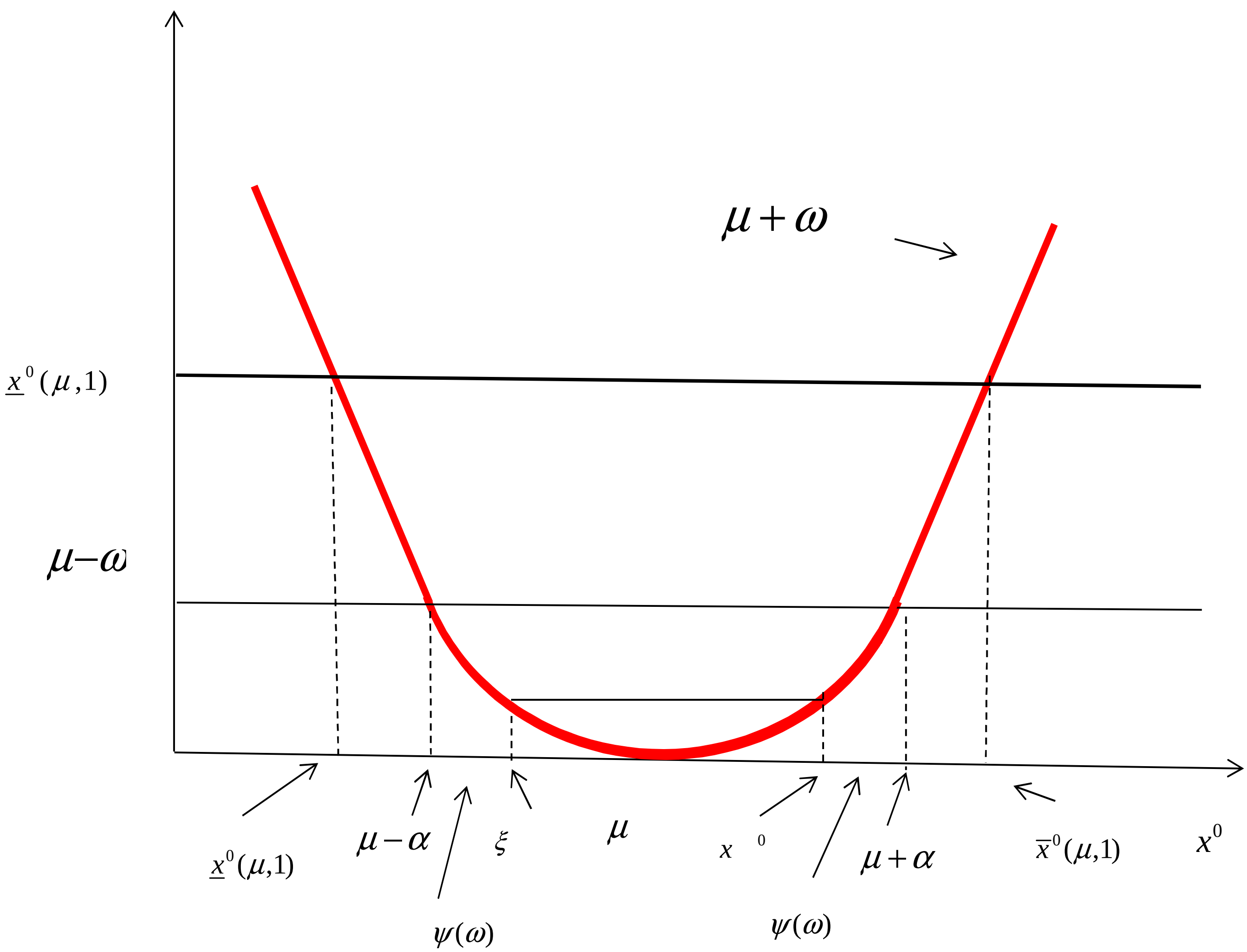


Figure 5(ii): Equilibrium Norms: Case B(ii): $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$

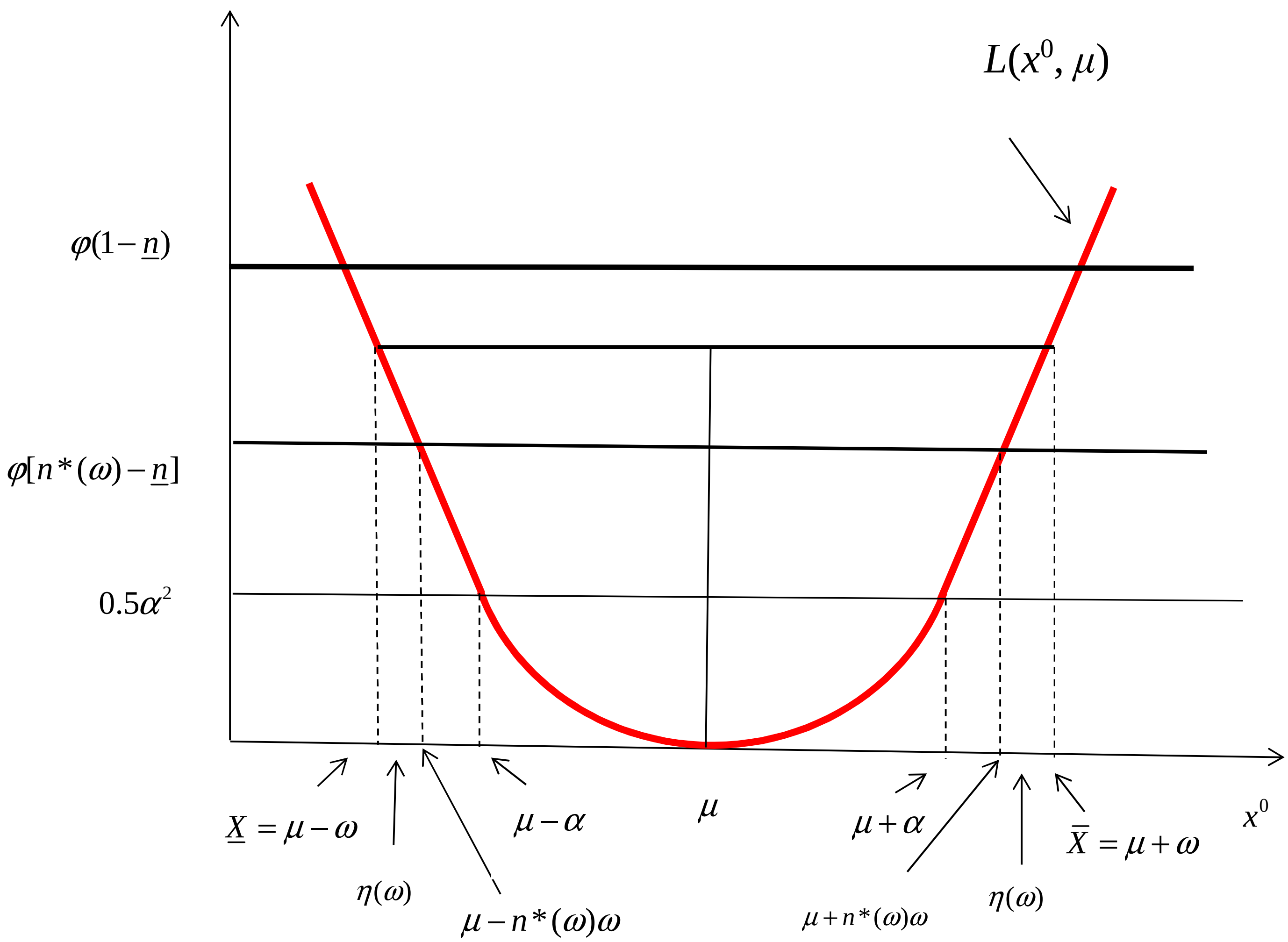


Figure 6(i) Case B(ii): $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$ First Equilibrium Norm

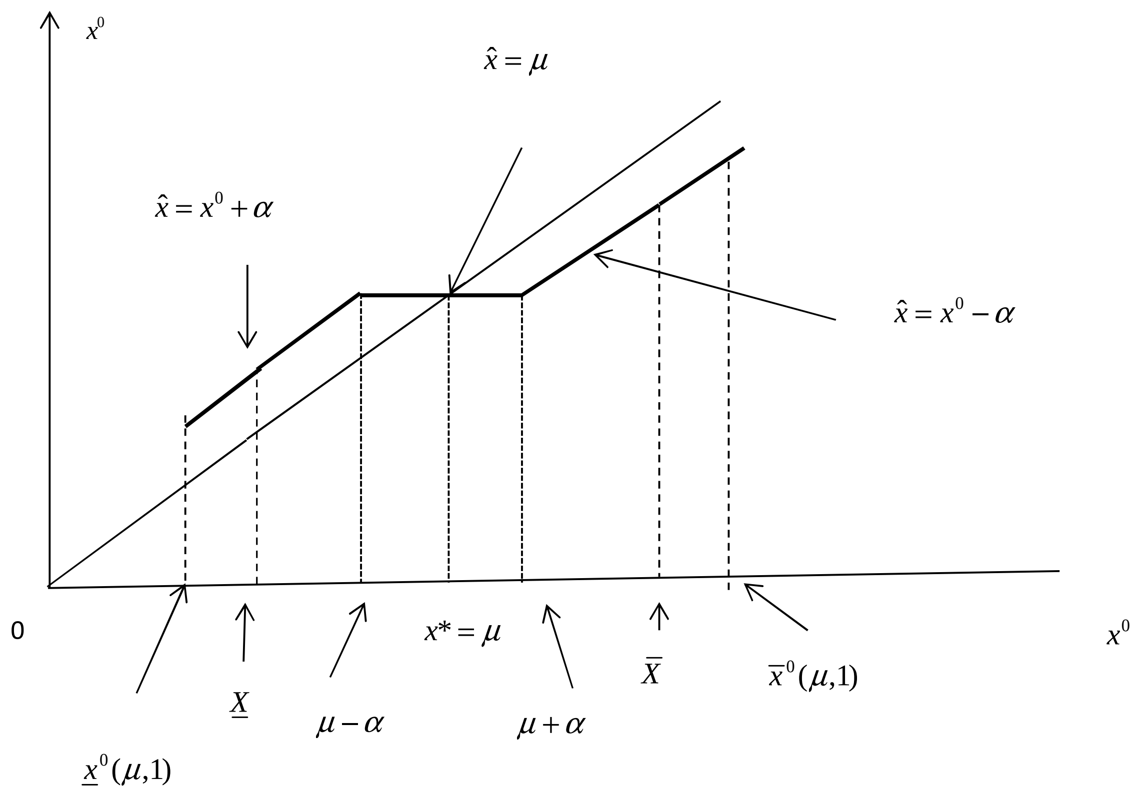
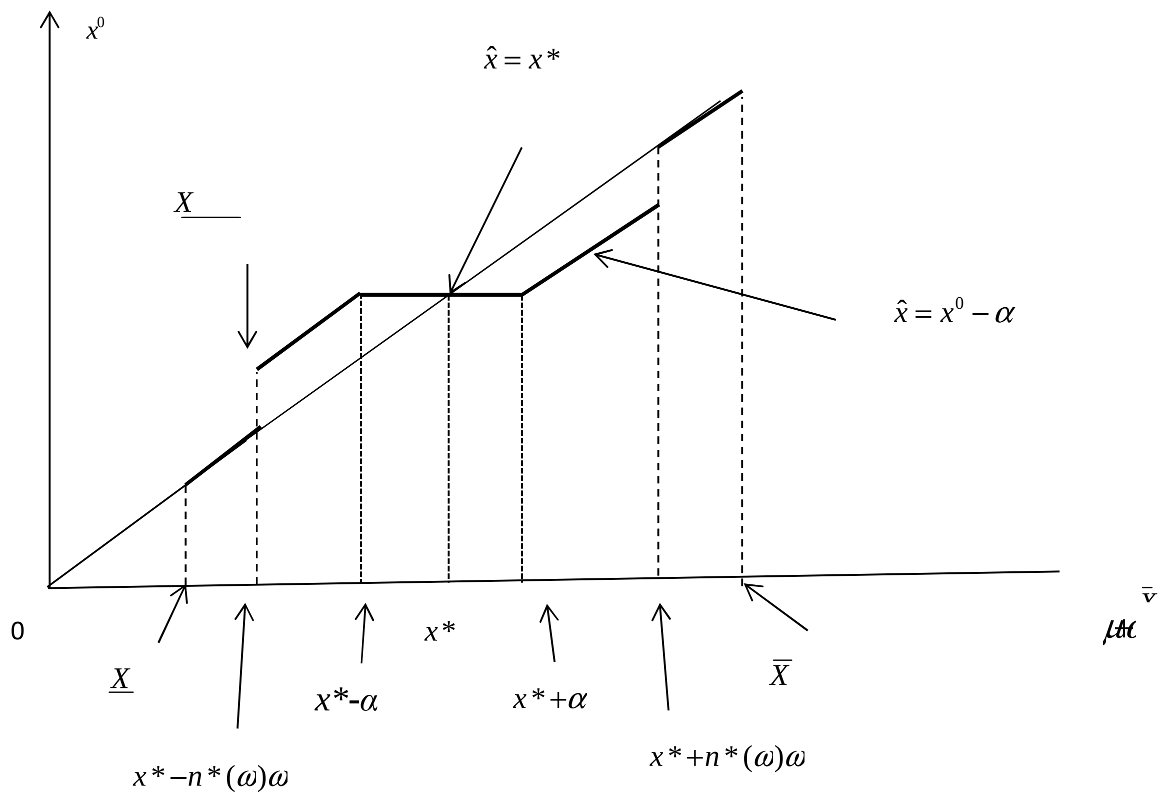


Figure 6(ii) Case B(ii): $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$; Second Equilibrium Norm



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Appendix: Proofs of Results

Result 1: Case A $\varphi(1-\underline{n}) \le 0.5\alpha^2$

Define: $\xi(\omega) \equiv \sqrt{2\varphi(1-\underline{n})} - \omega$

(i) If $\omega < 2\omega \le \sqrt{2\varphi(1-\underline{n})} \le \alpha$ then for any $x^* \in [\underline{X}, \overline{X}]$, $(x^*,1)$ is an equilibrium norm to which everyone adheres exactly.

(ii) If $\omega < \sqrt{2\varphi(1-\underline{n})} \le \min(\alpha, 2\omega)$ then for any $x^* \in [\mu - \xi, \mu + \xi]$ $(x^*,1)$ is an equilibrium norm to which everyone adheres exactly; as ω increases ξ falls.

(iii) If $\omega = \sqrt{2\varphi(1-\underline{n})} \le \min(\alpha, 2\omega)$ then $(\mu,1)$ is the unique equilibrium norm to which everyone adheres exactly.

Proof:

(a) Suppose first that $\omega \le \sqrt{2\varphi(1-\underline{n})}$; then

$$\underline{x}^0(\mu,1) = \mu - \sqrt{2\varphi(1-\underline{n})} \le \mu - \omega = \underline{X}; \quad \overline{x}^0(\mu,1) = \mu + \sqrt{2\varphi(1-\underline{n})} \ge \mu + \omega = \overline{X} \quad \text{(A1)}$$

so $\forall x^0 \in [\underline{X}, \overline{X}]$ benefit of adhering to norm $(\mu,1)$, $\varphi(1-\underline{n})$, is at least as great as cost to marginal individual, $0.5\omega^2$. So everyone will adhere to this norm; i.e. $n^* = 1$ and $\hat{x}(x^0,\mu) = \mu \quad \forall x^0 : \underline{X} \le x^0 \le \overline{X}$, which satisfies the condition $\frac{1}{2\omega}\int_{\underline{X}}^{\overline{X}} \hat{x}(x^0,\mu)dx^0 = \mu$.

So $(\mu, 1)$ is an equilibrium norm.

(b) Suppose again that $\omega \le \sqrt{2\varphi(1-\underline{n})}$; for what other values of x^* would $(x^*, 1)$ be an equilibrium norm? We require that the equivalent condition to (A1) is satisfied; i.e.

$$\underline{x}^0(x^*,1) = x^* - \sqrt{2\varphi(1-\underline{n})} \le \mu - \omega = \underline{X}; \quad \overline{x}^0(x^*,1) = x^* + \sqrt{2\varphi(1-\underline{n})} \ge \mu + \omega = \overline{X} \quad \text{(A2)}$$

i.e.

$$\mu - \sqrt{2\varphi(1-\underline{n})} + \omega \le x^* \le \mu + \sqrt{2\varphi(1-\underline{n})} - \omega \quad \text{(A3)}$$

So:

(i) If $\xi(\omega) \ge \omega \Leftrightarrow \sqrt{2\varphi(1-\underline{n})} \ge 2\omega$ then for any $x^* \in [\underline{X}, \overline{X}]$ $(x^*,1)$ is an equilibrium norm to which everyone adheres.

(ii) If $\xi(\omega) < \omega$ then for any $x^* \in [\mu - \xi(\omega), \mu + \xi(\omega)]$ $(x^*,1)$ is an equilibrium norm to which everyone adheres.

(iii) If $\xi(\omega) = 0$ then $(\mu,1)$ is the unique equilibrium norm to which everyone adheres.

(c) Suppose $\sqrt{2\varphi(1-\underline{n})} < \omega \leq \alpha$ then obviously (A1) is no longer satisfied, so (μ, 1) cannot be an equilibrium norm .

(d) Finally we show that for all values of $\omega \leq \alpha$ there cannot be an equilibrium norm (x^*, n^*) where $\underline{n} < n^* < 1$. We show that this is true for $x^* = \mu$, and by extension this is true for any $x^* \in [\underline{X}, \overline{X}]$.

If (μ, n^*) was an equilibrium norm then the benefit of adhering to this norm must just equal the cost to the marginal individual of adhering to this norm; i.e.

$$2\varphi(n^* - \underline{n}) = (n^* \omega)^2 \Leftrightarrow n^* = \frac{\varphi \pm \sqrt{\varphi^2 - 2\varphi\omega^2\underline{n}}}{\omega^2} \qquad \text{(A4)}$$

We need to check whether $1 > n^* > \underline{n}$. Solving (A4) for n^* we have:

$$n^* < 1 \Leftrightarrow \sqrt{\varphi^2 - 2\varphi\omega^2\underline{n}} < \omega^2 - \varphi \Leftrightarrow \omega^2 > 2\varphi(1-\underline{n}) \qquad \text{(A5)}$$

So this is not the case when $\omega \leq \sqrt{2\varphi(1-\underline{n})} \leq \alpha$. So ($\mu$,$n^*$) cannot be an equilibrium norm with $n^* < 1$ when $\omega \leq \sqrt{2\varphi(1-\underline{n})} \leq \alpha$.

So suppose (A5) holds, i.e. $\sqrt{2\varphi(1-\underline{n})} < \omega \leq \alpha$ Then we need to check whether $n^* > \underline{n}$. We have:

$$n^* > \underline{n} \Leftrightarrow \sqrt{\varphi^2 - 2\varphi\omega^2\underline{n}} > \omega^2\underline{n} - \varphi \Leftrightarrow \varphi^2 - 2\varphi\omega^2\underline{n} > \omega^4\underline{n}^2 - 2\varphi\omega^2\underline{n} + \varphi^2 \Leftrightarrow \omega^4\underline{n}^2 < 0$$

which is not the case.

Putting together (c) and (d) we have shown that the unique equilibrium norms established in cases (i) – (iii) are indeed the only unique equilibrium norms and that:

(iv) If $\sqrt{2\varphi(1-\underline{n})} < \omega \leq \alpha$ then there is no equilibrium norm. QED

Result 2: Case B (i) $\varphi(1-\underline{n}) > 0.5\alpha^2 \geq 0.5\omega^2$.

Define $\psi(\omega) \equiv \alpha - \omega$

(i) If $\omega \leq 0.5\alpha$ then for any $x^* \in [\underline{X}, \overline{X}]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres exactly.

(ii) If $0.5\alpha < \omega < \alpha$, then for any $x^* \in [\mu - \psi(\omega), \mu + \psi(\omega)]$, ($x^*$, 1) is an equilibrium norm to which everyone adheres exactly; as ω increases ψ falls.

(iii) If $\omega = \alpha$ then $(\mu,1)$ is the unique equilibrium norm to which everyone adheres exactly.

Proof: The proof is the same as for Result 1.

Result 3: Case B (ii) $\varphi(1-\underline{n}) \geq -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2$

Define: (a) $\bar{\omega} = \dfrac{\varphi(1-\underline{n})}{\alpha} + 0.5\alpha$; (b) $n^*(\omega) = \dfrac{\varphi\underline{n} - 0.5\alpha^2}{\varphi - \alpha\omega}$; (c) $\eta(\omega) = \omega(1 - n^*(\omega))$

(i) For $\alpha < \omega < \bar{\omega}$ there are two possible equilibrium norms: $(\mu,\ 1)$ and $(x^*,\ n^*(\omega))$ where $x^* \in [\mu - \eta(\omega), \mu + \eta(\omega)]$.

(ii) For $\omega = \bar{\omega}$, the only equilibrium norm is $(\mu,1)$.

(iii) For $\omega > \bar{\omega}$ there is no equilibrium norm.

In cases (i) and (ii) individuals with Marshallian demands $x^0 \in [x^* - \alpha, x^* + \alpha]$ adhere exactly to the norm x^*; individuals with Marshallian demands $x^0 \in [x^* - n^*(\omega)\omega, x^* - \alpha]$ adhere by setting $\hat{x} = x^0 + \alpha$; individuals with Marshallian demands $x^0 \in [x^* + \alpha, x^* + n^*(\omega)\omega]$ adhere by setting $\hat{x} = x^0 - \alpha$.

Proof:

(a) We first show that for $\alpha < \omega \leq \bar{\omega}$ $(\mu,\ 1)$ is an equilibrium norm.

From the assumption on parameter values for Result 3

$$\underline{x}^0(\mu,1) = \mu - 0.5\alpha - \frac{\varphi}{\alpha}(1-\underline{n}) < \underline{X} \Leftrightarrow \varphi(1-\underline{n}) > \alpha(\omega - 0.5\alpha) \qquad \text{(A6)}$$

Similarly $\bar{x}^0(\mu,1) > \bar{X}$. So $\forall x^0$, $\mu - \omega = \underline{X} \leq x^0 \leq \bar{X} = \mu + \omega$ so every consumer the gain from abiding by the norm $(\mu,\ 1)$, $\varphi(1-\underline{n})$, is at least as great as the cost of abiding by that norm, $\alpha(\omega - 0.5\alpha)$; so everyone abides by the norm $(\mu,\ 1)$; hence $n^* = 1$. Average consumption is given by:

$$\begin{aligned}
&\frac{1}{2\omega}\{\int_{\mu-\omega}^{\mu-\alpha}(x^0+\alpha)dx^0 + \int_{\mu-\alpha}^{\mu+\alpha}\mu dx^0 + \int_{\mu+\alpha}^{\mu+\omega}(x^0-\alpha)dx^0\} \\
&= \frac{1}{2\omega}\{0.5(\mu-\alpha)^2 + \alpha(\mu-\alpha) - 0.5(\mu-\omega)^2 - \alpha(\mu-\omega) + 2\alpha\mu \\
&+0.5(\mu+\omega)^2 - \alpha(\mu+\omega) - 0.5(\mu+\alpha)^2 + \alpha(\mu+\alpha)\} \\
&= \frac{2\mu\omega}{2\omega} = \mu
\end{aligned} \qquad \text{(A7)}$$

So average consumption equals the norm. So (μ, 1) is an equilibrium norm.

(b) We now show that (x^*, 1) cannot be an equilibrium norm with $x^* \neq \mu$.

Suppose that x^* shifts slightly away from μ (the same argument applies for more extreme changes in norm, as we shall argue). Then if everyone adheres to the norm (x^* 1), average consumption is now

$$\frac{1}{2\omega}\{\int_{\mu-\omega}^{x^*-\alpha}(x^0+\alpha)dx^0+\int_{x^*-\alpha}^{x^*+\alpha}x^*\,dx^0+\int_{x^*+\alpha}^{\mu+\omega}(x^0-\alpha)dx^0\}$$
$$=\frac{1}{2\omega}\{0.5(x^*-\alpha)^2+\alpha(x^*-\alpha)-0.5(\mu-\omega)^2-\alpha(\mu-\omega)+2\alpha x^*$$
$$+0.5(\mu+\omega)^2-\alpha(\mu+\omega)-0.5(x^*+\alpha)^2+\alpha(x^*+\alpha)\}$$
$$=\frac{\mu\omega+\alpha(x^*-\mu)}{\omega}\neq x^*$$

So (x^*, 1) cannot be an equilibrium norm. Hence (μ, 1) is not a stable equilibrium norm. This argument is even stronger if a possible norm is sufficiently different from μ that one of groups who do not adhere exactly to the norm no longer lies in the range [$\underline{X}, \overline{X}$]. So (μ, 1) is a possible equilibrium norm. But any change in parameter values which led to a different value for μ, call it $\hat{\mu}$, would mean the original norm (μ, 1) is no longer an equilibrium norm.

(c) We now assume $\alpha < \omega \leq \overline{\omega}$ and ask whether (μ, $n^*(\omega)$) could be a stable norm for some value of $n^*(\omega)$.

For that to be an equilibrium norm, the benefit to the marginal person adhering to the norm, $\varphi(n^*(\omega)-\underline{n})$ must equal the cost $-0.5\alpha^2+\alpha n^*(\omega)\omega$, i.e.

$$n^*(\omega)=\frac{\varphi\underline{n}-0.5\alpha^2}{\varphi-\alpha\omega} \qquad \text{(A8)}$$

We first show that $n^*(\omega) \leq 1$. So

$$n^*(\omega)\leq 1 \Leftrightarrow \varphi(1-\underline{n})\geq 0.5\alpha(2\omega-\alpha) \qquad \text{(A9)}$$

which is true by the assumption on parameter values for Result 3. We now show that $n^* > \underline{n}$.

From (A9) $\varphi > \frac{0.5\alpha(2\omega-\alpha)}{1-\underline{n}}$; furthermore $\frac{0.5\alpha(2\omega-\alpha)}{1-\underline{n}} > \alpha\omega \Leftrightarrow \underline{n} > \frac{\alpha}{2\omega}$ which is true since $\underline{n} \geq 0.5$. So $\varphi > \alpha\lambda$. Then:

$$n^*(\omega)>\underline{n} \Leftrightarrow \varphi\underline{n}-0.5\alpha^2>\varphi\underline{n}-\alpha\omega\underline{n} \Leftrightarrow \underline{n}>\frac{\alpha}{2\omega} \text{ which is true since } \underline{n}>0.5>\frac{\alpha}{2\omega} \qquad \text{(A10)}$$

So we have proved $\underline{n} < n^*(\omega) \leq 1$.

To establish that (μ, n*) is a norm we need to show that μ is the average of $\hat{x}(x^0, \mu)$ over the range $[\mu - n^*(\omega)\omega, \mu + n^*(\omega)\omega]$. For ease of notation define $\lambda \equiv n^*(\omega)\omega$. Then the average value of $\hat{x}(x^0, \mu)$ over the range $[\mu - \lambda, \mu + \lambda]$ is:

$$\frac{1}{2\lambda}\{\int_{\mu-\lambda}^{\mu-\alpha}(x^0+\alpha)dx^0 + \int_{\mu-\alpha}^{\mu+\alpha}\mu dx^0 + \int_{\mu+\alpha}^{\mu+\lambda}(x^0-\alpha)dx^0\} =$$

$$\frac{1}{2\lambda}\{0.5(\mu-\alpha)^2 + \alpha(\mu-\alpha) - 0.5(\mu-\lambda)^2 - \alpha(\mu-\lambda) + 2\alpha\mu$$

$$+0.5(\mu+\lambda)^2 - \alpha(\mu+\lambda) - 0.5(\mu+\alpha)^2 + \alpha(\mu+\alpha)\} = \frac{1}{2\lambda}\{2\lambda\mu\} = \mu$$

So (μ, $n^*(\omega)$) is an equilibrium norm.

Finally we show that for any $x^* \in [\mu - \eta(\omega), \mu + \eta(\omega)]$, where $\eta(\omega) = \omega(1 - n^*(\omega))$, ($x^*$, $n^*(\omega)$) is an equilibrium norm. $\eta(\omega)$ is defined by the condition that:

$$x^* - n^*(\omega)\omega = \mu - \omega = \underline{X} \text{ (equivalently } x^* - n^*(\omega)\omega = \mu - \omega = \underline{X}\text{).} \quad \text{(A11)}$$

(d) Finally note that:

$$n^{*\prime}(\omega) > 0; \quad \underline{n} < n^*(\alpha) < 1; \quad n^*(\overline{\omega}) = 1; \ \eta(\alpha) = \alpha(1 - n^*(\alpha)) > 0; \eta(\overline{\omega}) = 0 \quad \text{(A12)}$$

If $\hat{\omega} > \overline{\omega}$ it would have to be the case that $n^*(\hat{\omega}) < 1$ but from (A12) $n^*(\hat{\omega}) > 1$, which is contradiction, so if $\hat{\omega} > \overline{\omega}$ there is no equilibrium norm. QED

Result 4: Suppose (a) $0.5\alpha + \varphi(1-\underline{n})/\alpha > \omega > \max[1.5\alpha, \alpha + \varphi(1-2\underline{n})/\alpha]$ and (b) $\varphi \geq 1.5\alpha^2 \Rightarrow \underline{n} > 1/3 \geq 0.5\alpha^2/\varphi$ and define: $\rho(\omega) = n^*(\omega)\omega$. Then:

(i) $0.5 > n^*(\omega) > \underline{n} > 1/3$

(ii) If $\mu + \omega - 3\rho(\omega) < x^* < \mu - \omega + 3\rho(\omega)$ then $(x^*, n^*(\omega))$ is the unique equilibrium norm.

(iii) If $\mu - \omega < x^* < \mu + \omega - 3\rho(\omega) \Rightarrow \mu + \omega - (x^* + \rho(\omega)) > 2\rho(\omega)$ - so there is sufficient room for a second norm (x^{**}, $n(\omega)$) with $x^{**} > x^*$; similarly if $\mu + \omega > x^* > \mu - \omega + 3\rho(\omega) \Rightarrow (x^* - \rho(\omega)) - (\mu - \omega) > 2\rho(\omega)$ - so there is sufficient room for a second norm (x^{**}, $n(\omega)$) with $x^{**} < x^*$.

Proof:

(i) Result 3 holds iff $\varphi(1-\underline{n}) > -0.5\alpha^2 + \alpha\omega > 0.5\alpha^2 \Leftrightarrow \frac{\varphi(1-\underline{n})}{\alpha} > \omega > \alpha$. (A13)

$$n^*(\omega) = \frac{\varphi\underline{n} - 0.5\alpha^2}{\varphi - \alpha\omega} < 0.5 \Leftrightarrow \alpha(\omega - \alpha) > \varphi(1-2\underline{n}) \Leftrightarrow \omega > \frac{\varphi(1-2\underline{n})}{\alpha} + \alpha > \alpha \quad \text{(A14)}$$

$n^*(\omega) > \underline{n} \Leftrightarrow \underline{n} > 0.5\alpha/\omega$; to ensure $\underline{n} > 1/3$ we require $\omega > 1.5\alpha$ (A15)

Combining these conditions yields conditions (a) and (b) above. Hence if (a) and (b) hold, Result 3 ensures that (x^*, $n^*(\omega)$) can be an equilibrium norm with $0.5 > n^*(\omega) > \underline{n} > 1/3$.

(ii) Note first that $0 < 3\rho(\omega) - \omega < \omega \Leftrightarrow n^*(\omega) < 2/3$, which clearly holds. Then if $\mu + \omega - 3\rho(\omega) < x^* < \mu - \omega + 3\rho(\omega)$, $\mu + \omega - (x^* + \rho(\omega)) < 2\rho(\omega)$ so there is insufficient space for a second norm (x^{**}, $n^*(\omega)$) with $x^{**} > x^*$. Similarly $x^* - \rho(\omega) - (\mu - \omega) < 2\rho(\omega)$ so there is insufficient space for a second norm (x^{**}, $n^*(\omega)$) with $x^{**} < x^*$.

(iii) This follows directly from (ii). QED

<u>Result 5</u>: In Results 1, 2, and 3 there are ranges of possible values for an equilibrium norm x^* (with an associated value of n^* which is either 1 or a constant independent of x^*). In Results 1 and 2 the value of x^* which minimises the expected value of the utility loss $\underset{x^0}{E}[L(x^0, x^*)]$ is $x^* = \mu$. In Result 3 there is no optimal value of x^* - the value of $\underset{x^0}{E}[L(x^0, x^*)]$ is the same for all possible equilibrium values of x^*.

Proof:

In Results 1 and 2 the equilibrium norm x^* lies in a range of possible values , namely $[\mu - \omega, \mu + \omega], [\mu - \xi(\omega), \mu + \xi(\omega)], [\mu - \psi(\omega), \mu + \psi(\omega)]$ with $n^* = 1$, and everyone adheres exactly to the norm x^*. So:

$$\underset{x^0}{E}[L(x^*, x^0)] = \frac{0.5}{(\overline{X} - \underline{X})}\int_{\underline{X}}^{\overline{X}} (x^0 - x^*)^2 dx_0 = \frac{0.5}{(\overline{X} - \underline{X})}\left[\frac{x^{0^3}}{3} - x^* x^{0^2} + x^{*2}\, x^0\right]_{\underline{X}}^{\overline{X}}$$

$$= \frac{(\overline{X}^3 - \underline{X}^3)}{6(\overline{X} - \underline{X})} - \frac{x^*(\overline{X}^2 - \underline{X}^2)}{2(\overline{X} - \underline{X})} + \frac{x^{*2}}{2}$$

Hence:

$$\frac{\partial \underset{x^0}{E}[L(x^*, x^0)]}{\partial x^*} = -\frac{\overline{X} + \underline{X}}{2} + x^* = 0 \Rightarrow x^* = \frac{\overline{X} + \underline{X}}{2} = \mu$$

In Result 3 the equilibrium norm x^* lies in a range of possible values $[\mu-\eta(\omega), \mu+\eta(\omega)]$ with associated $n^*(\omega)=\dfrac{\varphi\underline{n}-0.5\alpha^2}{\varphi-\alpha\omega}$. Define $\varsigma \equiv \dfrac{\alpha}{2}+\dfrac{\varphi[n^*(\omega)-\underline{n}]}{\alpha}>\alpha$; then for those adhering to the norm (x^*,n^*) the chosen levels of demand associated welfare losses are:

$$\begin{array}{lll} x^*-\varsigma \le x^0 < x^*-\alpha & \hat{x}=x^0+\alpha & L(x^*,x^0)=-0.5\alpha^2+\alpha(x^*-x^0) \\ x^*-\alpha \le x^0 \le x^*+\alpha & \hat{x}=x^* & L(x^*,x^0)=0.5(x^0-x^*)^2 \\ x^*+\alpha < x^0 \le x^*+\varsigma & \hat{x}=x^0-\alpha & L(x^*,x^0)=-0.5\alpha^2+\alpha(x^0-x^*) \end{array} \qquad \text{(A16)}$$

Hence:

$$\begin{aligned}\Omega \equiv (\overline{X}-\underline{X})\underset{x^0}{E}[L(x^*,x^0)] = &\int_{x^*-\varsigma}^{x^*-\alpha}[-0.5\alpha^2+\alpha(x^*-x^0)]dx^0+\int_{x^*-\alpha}^{x^*+\alpha}[0.5(x^0-x^*)^2 dx^0 \\ &+\int_{x^*+\alpha}^{x^*+\varsigma}[-0.5\alpha^2+\alpha(x^0-x^*)]dx^0\end{aligned}$$

$$\begin{aligned}\Omega = &[-0.5\alpha^2+\alpha x^*][x^0]_{x^*-\varsigma}^{x^*-\alpha}-0.5\alpha[x^{0^2}]_{x^*-\varsigma}^{x^*-\alpha} \\ &+0.5[\frac{x^{0^3}}{3}-x^*x^{0^2}+x^{*2}\,x^0]_{x^*-\alpha}^{x^*+\alpha}+[-0.5\alpha^2-\alpha x^*][x^0]_{x^*+\alpha}^{x^*+\varsigma}+0.5\alpha[x^{0^2}]_{x^*+\alpha}^{x^*+\varsigma}\end{aligned}$$

$$\begin{aligned}\Omega = &[-0.5\alpha^2+\alpha x^*](\varsigma-\alpha)-0.5\alpha[(x^*-\alpha)^2-(x^*-\varsigma)^2] \\ &+0.5[\frac{(x^*+\alpha)^3}{3}-x^*(x^*+\alpha)^2+x^{*2}\,(x^*+\alpha)-\frac{(x^*-\alpha)^3}{3}+x^*(x^*-\alpha)^2-x^{*2}\,(x^*-\alpha)] \\ &+[-0.5\alpha^2-\alpha x^*](\varsigma-\alpha)+0.5\alpha[(x^*+\varsigma)^2-(x^*+\alpha)^2]\end{aligned}$$

Hence:

$$\begin{aligned}\frac{\partial\Omega}{\partial x^*} = &\alpha(\varsigma-\alpha)-\alpha[(x^*-\alpha)-(x^*-\varsigma)]+0.5\{(x^*+\alpha)^2-(x^*+\alpha)^2-2x^*(x^*+\alpha) \\ &+2x^*(x^*+\alpha)+x^{*2}-(x^*-\alpha)^2+(x^*-\alpha)^2+(x^*-\alpha)^2+2x^*(x^*-\alpha)-2x^*(x^*-\alpha)-x^{*2}\} \\ &-\alpha(\varsigma-\alpha)+\alpha[(x^*+\varsigma)-(x^*+\alpha)] \\ &=0.\end{aligned}$$

QED