



THE DYNAMICS OF ETHICAL PRODUCT DIFFERENTIATION
AND THE HABIT FORMATION OF SOCIALLY RESPONSIBLE
CONSUMERS

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The dynamics of ethical product differentiation and the habit formation of socially responsible consumers¹

Abstract

In our model of ethical product differentiation two duopolists (a zero profit socially concerned producer and a profit maximizing producer) compete over prices and (costly) "socially and environmentally responsible" features of their products under a given law of motion of consumer' habits.

In a continuous time model in which the location of the zero profit social responsible entrant is fixed and the profit maximizing producer (PMP) limits himself to price competition without ethical imitation, we show that the optimal dynamic PMP's price is always lower than his optimal static price since the PMP producer knows that, by leaving too much market share to the other producer, he will reinforce the habit of socially responsible consumption and loose further market share in the future. We inspect the properties of equilibria when the PMP can ethically imitate the entrant and when the entrant is free to choose his location. We find that, in the first case, the threshold triggering a PMP strategy of ethical imitation and minimum price differentiation is lower in the dynamic than in the static case, depending on the PMP's shadow cost of changes in consumers social responsibility.

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1. Introduction

In the traditional literature of horizontal differentiation localisation is usually referred to as physical location or, more generally, as the space of product characteristics (Hotelling, 1929; D'Aspremont-Gabszewich and Thisse, 1979; Dasgupta-Maskin, 1986; Economides, 1986). One of these characteristics, which is becoming increasingly relevant today, is social and environmental responsibility.

The reduction of distances induced by technological progress has increased the importance of global public goods and the sensitiveness of the public opinion toward the preservation of the environment and the fight to poverty in less developed countries. This increased awareness has generated a series of "grassroot" welfare initiatives which focus on socially responsible (or socially concerned) saving and consumption.

One of them is promoted by zero profit importers, distributors and retailers (called *fair traders*)² of food and textile products which

² The definition of fair trade considered in this paper is quite different from the traditional meaning of "Fair trade" in the field of industrial organization. From the 1930s onward (although there are antecedents going back to 1900), in both the US and the UK, the term refers to schemes of industry trade association to regulate competition among members, usually by requiring that prices be posted in advance and that no transactions take place except at posted prices. During the Great Depression in the U.S., such schemes were part of the National Recovery Act. In the more recent literature fair trade indicates "arguments that relate to certain conditions under which trade, and the production of traded goods, should minimally take place" (Maseland and Vaal, 2002). In this framework fair trade generally refers to the absence of duties, controls and dumping practices in international trade (for a similar use of the term, for example, see also Mendoza and

have been partially or wholly manufactured by poor rural communities in developing countries. To be labeled as such, fair trade products need to respect a series of social and environmental criteria.

Fair trade is just a small part of the market for socially responsible consumption (and savings) which is considerably growing. Fair trade products are beginning to achieve non negligible market shares. They captured around 2.5% of the tea market in Germany, 2.7% of the coffee market in the Netherlands and about 15% of the banana market in Switzerland in the year 2000. The existence of positive market shares for these products, whose price is often higher than that of traditional products, is a revealed preference argument for the relevance of socially concerned consumption and for the existence of ethical or fairness arguments in consumers' utility function.³

Bahadur, 2002; Bhagwati, 1996; Stiglitz, 2002; Suranovic, 2002). The fair trade products we refer to in this paper are on the contrary, food and artisan products which obtain the fair trade label when their production process follow some criteria for social and environmental sustainability established by the movement of fair trade importers and retailers.

³ There is a growing interest for socially responsible savings and consumption also in the institutions. In 1999 the United Nations launched the Global Compact, a coalition of large businesses, trade unions and environmental and human rights groups, brought together to share a dialogue on corporate social responsibility. In the same year the European Commission issued a document on Fair Trade (29.11.1999 COM(1999) 619. In its introduction it is stated that *"Fair trade" is an example of development occurring through trading relationships and improved commercial opportunities to bridge the gap between developed and developing countries and to facilitate the better integration of developing countries in the world economy. "Fair trade" initiatives give consumers the opportunity to contribute towards sustainable economic and social development in developing countries through their purchasing preferences.* More recently, in July 2001, the Commission issued a Green Book COM(2001) 366 to promote firm social responsibility in

The diffusion of forms of socially responsible consumption such as fair trade is accompanied by a wide range of imitation strategies enacted by traditional producers. Many companies are starting advertising not only price and quality, but also their socially responsible actions.⁴ Social labeling and corporate responsibility is gradually becoming an important competitive feature in real and financial markets.⁵

The aim of this paper is to provide a theoretical background for this emerging kind of competition. We do so by adopting a horizontal differentiation approach and by reinterpreting the well known Hotelling line segment in terms of ethical or "social responsibility" space.

The paper is divided into six sections (including introduction and conclusions). In the second section we present the basic features of the horizontal differentiation model. In the third section we

the European framework. Large part of the Green Book deals with fair trade.

⁴ Corporate perception by consumers (90 percent of respondents) is by far the most selected item (against ethical values of managers, tax incentives and relationship with stakeholders) when a sample of interviewed socially responsible companies is asked about reasons for their socially responsible behaviour in the "2003 Corporate social responsibility monitor" (downloadable at <http://www.bsdglobal.com/issues/sr.asp>). This finding is consistent with our hypothesis that ethical imitation is today a relevant competitive feature in product markets.

⁵ In a recent survey the "2003 Corporate social responsibility monitor" finds that the amount of consumers looking at social responsibility in their choices jumped from 36 percent in 1999 to 62 percent in 2001 in Europe. In addition, more than one in five consumers reported having either rewarded or punished companies, based on their perceived social performance and more than a quarter of share-owning Americans took into account ethical considerations when buying and selling stocks. The Social Investment Forum reports that in the US in 1999, there was more

analyse the dynamic model in which a profit maximizing producer (henceforth PMP) competes in prices (but not in ethical location) with an "ethically"⁶ concerned producer (henceforth fair trader or FT). In the fourth section we remove the assumption of PMP's fixed ethical location. In the fifth section we remove the assumption of FT's fixed ethical location so that the two producers jointly choose in continuous time ethical location and prices.

2. The ethical differentiation model: basic assumptions

Most of the hypotheses in the model which follows are standard assumptions in the horizontal differentiation literature. Some others are original and are given by the specific nature of ethical competition.

A "traditional" monopolist sells a good to consumers with inelastic, unit demands. Consumers are uniformly distributed across the line segment $[0,1]$ according to their concerns for social responsibility. The monopolist activity consists of transforming raw materials received from unskilled producers in

than \$2 trillion worth of assets invested in portfolios that used screens linked to the environment and social responsibility.

⁶ In all the paper we will call this player the ethical player for simplicity and convenience. This does not imply any value judgement on the lack of ethics of the other competitor.

the South, paid with a monopsony wage (w).⁷ The final product is sold to consumers in the North. The monopolist maximizes profits by fixing a price P_A for his product. In this first version of the model we assume, for simplicity, and without lack of generality, that the incumbent has no social responsibility and is located at one extreme of the ethical segment (position $a=0$).

Consider now in a fixed location case the effects on the incumbent strategy of the entry of a socially concerned producer which generically takes a different position on the ethical segment and fixes a price P_B for his product. This producer, exactly as the fair traders described in the introduction (this is the reason why we call him also FT), is zero profit and his goal is to maximise transfers to raw material producers in the South to raise their wage from monopsony to competitive levels⁸ and to transfer resources which can be invested in local public goods to improve future market opportunities for these producers.⁹ The socially

⁷ The reality is more complex since under an alternative but equally valid approach fair traders usually break excess bargaining powers of local buyers or transportation intermediaries which force local producers to sell primary or intermediate products at prices below values they would earn in a competitive market with equal bargaining power between sellers and buyers. We believe that our simple approach catches the main point of the issue.

⁸ We take the fair trader as an example of socially responsible producer and identify social responsibility in the resources transferred to producers in the South. Our model may be generalised and applied also to environmentally concerned producers by assuming that there are no "free lunches" in social responsibility and that the adoption of environmentally responsible production processes increases costs exactly as in our fair trader's example.

⁹ The diffusion of producers which create private and social value without being profit maximisers is confirmed by the fact that fair trade producers exist and are growing. In the year 2000 there were

responsible features of the entrant consist of selling his product at zero profit and transferring a "free margin" s to finance investment in public goods and education in the South (exactly as the "fair trader" does). The zero profit condition of the entrant is: $P_B = w(1+s)$.

We assume that social responsibility depends on the amount s transferred to the South. Therefore the amount of this transfer determines the position on the segment.¹⁰ In this first example, for simplicity, fair trader location is exogenously set at $b=1$, the other extreme of the ethical segment.

After FT's entry consumers may choose between two products which differ in prices and socially responsible features.

The difference with respect to the traditional horizontal differentiation models is that opposite locations in the consumers interval do not imply differences in physical distance, but in the psychological perception of the ethical value of the good.¹¹ The

97 fair trade importers from 18 countries and 2740 no profit retailers of fair trade products only in Europe according to the Fair Trade Association. In 2000, in the U.S. and Canada, 600 outlets wholesaled Fair Trade products, while at least 2575 offered retail. In 2001, at least 7000 provided retail.

¹⁰ Consider again that, since environmental responsibility is one of the main features of fair trade products, the reasoning of our model also applies in case we replace the socially responsible (transfer to the South) with the environmentally responsible (adoption of a more environmental product) feature of the ethical entrant. In this case we should assume a trade-off between environmental sustainability and production costs assuming that the producer chooses a technique with an added marginal cost s for any unit sold, generated by the adoption of environmentally sustainable practices.

¹¹ In this model we abstract from considerations of asymmetric information and divergences between consumers' and sellers' perception of the ethical value of the good by assuming that they coincide. To reduce distance from reality it may be interesting in

consideration of ethical instead of physical distance makes an important difference. Consistently with our concept of ethical distance, we assume that the cost of moving along the line segment is positive only for those going from a more ethical to a less ethical point (Figure 1). As a consequence, by considering the extreme right of the segment as the most ethical position, consumers move without costs to the right, while they incur in costs proportional to the "ethical" distance anytime they move to the left.¹²

We assume that consumers utilities are decreasing in product price and also in the distance between consumer's ethical stance and the ethical value incorporated in the purchased product. The psychological cost of buying a product which is below one's own ethical standards is "f" times the ethical distance so that consumer's utility is

$$U_c = R_p - P_i - f(x-a), \text{ if } x-a \geq 0^{13}$$

or

an extension of this model, to analyse market equilibria under asymmetric information and to consider the role of ethical trademarks.

¹² The rationale for these assumptions is that moving to the left implies choosing a product below one's own ethical standards (which is psychologically costly), while moving to the right implies choosing a product above one's own ethical standards (and therefore we assume that it does not give any psychological cost to the buyer).

¹³ The way we design consumers preferences is consistent with empirical evidence and consumers surveys in which values are shown to be a determinant of choices together with prices (see footnote 6 on 2003 Corporate social responsibility monitor). From a theoretical point of view this point has been remarkably analysed, among others, by Sen (1993) showing that people choose also on the basis of their values and, for this reason, they do not always choose what they would strictly prefer on the basis of prices.

$U_c = R_p - P_i$, if $x - a < 0$

where (P_i) is the price of product sold by the i -th seller, (R_p) is the common consumers' reservation price and x denotes generic consumer location on the ethical segment.¹⁴

After the FT's entry the consumer's indifference condition is equal to $P_A + f(x - a) = P_B$, if $x - a \geq 0$, and $P_A = P_B$, if $x - a < 0$. It is therefore clear that the condition for a nonzero market share for the FT is that, for some values of x , $f(x - a) > P_B - P_A$. Since in this first simple case we set $a = 0$, we obtain the following share for the incumbent: $x^* = (P_B - P_A) / f$.

3. An ethical differential model with simultaneous moves and open-loop strategies.

We now analyse what happens if our two agents choose their strategies taking into account that consumers' ethical preferences may change over time as a function of their location strategies. To do so we consider a dynamic model where each player maximizes his objective function (the present value of his profit function in the PMP case and of transfers to the South in the FT case) over

¹⁴ With the specification of the FT's behaviour and of consumer's position on the segment the cost of ethical distance has a clear monetary counterpart. When the producer is located at the right of the consumer this cost represents the distance in monetary terms between the transfer which is considered fair by the consumer (indicated by his location on the segment), and the transfer provided by the producer (indicated by producer's location on the segment). The coefficient f maps this objective measure into subjective consumers' preferences indicating whether its impact on consumers utility is proportional ($f=1$), more than proportional

an infinite time horizon, by designing a strategy for those variables which are under his control.

Control variables are, respectively, location and price for the PMP and location only for the FT. Choices of the two players influence their objective functions as well as the state of the consumers ethical preferences through a differential equation (the "law of motion of consumers' habit for social responsibility").

3.1.1 The dynamic model when FT location is exogenous and PMP's ethical location is fixed

In this first simplified version of the model locations of the two players are fixed. Therefore the PMP does not imitate the FT in social responsibility and competes only in prices.¹⁵ The PMP maximizes in continuous time the following intertemporal profit function

($f > 1$) or less than proportional ($f < 1$) than its amount in monetary terms.

¹⁵ It's possible to show that, in absence of FT's competition, the PMP has not incentive to choose a position different from zero. In fact, when he is alone on the market he is constrained on his price decision only by consumers' reservation price. Therefore his market share will depend on this reservation price and on PMP price and ethical location. With $P_b = R_p$ the joint maximization problem of the PMP is similar to the one analysed in this section with the exception of the law of motion of f which is affected only by the PMP imitation decision. When solving PMP dynamic maximization problem under this condition it is easy to check by inspection of first order conditions that PMP profit is strictly decreasing in a . Intuitively, he will not start ethical transfers to avoid the growth of consumers ethical concerns. Hence, the most profitable choice for PMP when he is alone on the market is to locate in zero and the assumption of considering that PMP does no ethical transfers when he reacts to FT entry is sound. The

$$\text{Max}_{(P_A)} \int_0^{\infty} e^{-\rho t} [P_A - w] \left[\frac{P_B - P_A}{f} \right] dt \quad (1)$$

subject to the following law of motion of consumers' social responsibility

$$f' = -\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) \quad (2)$$

where changes in consumers social responsibility are affected, negatively, by depreciation from current levels of social responsibility (the parameter θ measures consumers' "loss of ethical memory") and, positively, by the habit reinforcement generated by current consumption of socially responsible products.¹⁶

To solve the problem we formulate the following current value Hamiltonian:

$$H_c = [P_A - w] \left[\frac{P_B - P_A}{f} \right] + \lambda \left[-\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) \right] \quad (3)$$

where $\lambda = \mu e^{\rho t}$ and μ is a costate variable which may be interpreted as the marginal value (cost) of the variation in consumers' social responsibility for the PMP.

demonstration on this point is omitted and available from the authors upon request.

¹⁶ We assume that habit reinforcement is determined by the share of socially responsible consumption and, consequently, by the market share of FT products. The rationale for this hypothesis may be that fair trade ads may be positively related to revenues. Fair trade retail shops give high attention to information on social responsibility (leaflets, documentation, etc.) and therefore past consumption may foster future consumption not only for a traditional habit formation process, but also for the effect of additional information and motivation gained when buying fair trade products.

Solutions for this problem include the derivative of the Hamiltonian with respect to the control variable P_A

$$\frac{\partial H_c}{\partial P_A} = \frac{P_B - P_A}{f} - \frac{P_A}{f} + \frac{w}{f} + \frac{\lambda}{f} = 0 \quad (4),$$

the law of motion of consumer's social responsibility (our state variable) as a result of the derivative of the Hamiltonian with respect to the costate variable

$$f' = -\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) \quad (5)$$

and a differential equation for the costate variable including the derivative of the Hamiltonian with respect to the state variable

$$\lambda' = \rho \lambda - \left\{ - \left(\frac{P_B - P_A}{f^2} \right) (P_A - w) - \theta \lambda + \left(\frac{P_B - P_A}{f^2} \right) \lambda \right\} \quad (6).$$

Equation (6) shows that the time variation of the shadow value (cost) of changes in consumers' social responsibility for the PMP is equal to its current discounted value minus current sensitivity of his profits to changes in current consumers' social responsibility.

The last two conditions needed to define optimal solutions to the problem are the initial value of the costate variable and the non transversality condition ¹⁷

$$f(0) = f_0 \quad (7)$$

$$\lim_{t \rightarrow \infty} \mu(t) f(t) = 0 \quad (8)$$

Solving (3) for P_A we get the dynamic price reaction function of the PMP

¹⁷ It is trivial to observe that, as far as t goes to infinity the marginal cost of the variation of consumers social responsibility for the PMP is nil.

$$P_A^* = \frac{P_B + w + \lambda}{2} = w + \frac{sw + \lambda}{2} \quad (9)^{18}$$

with $\lambda=0$ we obtain the static version of the price reaction function. By inspecting it, we find that the incumbent price is obviously increasing in the fair trader transfer to the South. To understand the price strategy of the incumbent after the fair trader's entry we observe that his optimal price is halfway between his zero profit price and the zero profit fair trader's price. This means that the incumbent divides the distance between these two prices in two halves. One of them is his margin and the other is the extent of the price cut.

Since λ is the PMP's shadow value (cost) of a change in consumers' ethical perception, equation (9) tells that, if λ is negative (as expected when the market share effect of a change in social responsibility dominates over other effects), a higher λ implies a higher penalty from changes in consumers' ethical perception and therefore leads to a lower PMP optimal price in the dynamic than in the static case. The rationale is that, by doing this, the PMP may preserve larger market shares and therefore reduce formation of socially responsible consumer habits.

¹⁸ This open-loop solution is clearly subgame perfect since the optimal PMP price does not depend from the state variable f . Our first case therefore falls into the category of perfect or state redundant games (Mehlmann, 1988; Dockner, Long, Jorgensen and Sorger, 2000).

In demonstrating the proposition which follows we show that λ is negative and therefore that the optimal PMP price in the dynamic model is lower than in the static model

Proposition: a positive PMP's market share necessarily implies in equilibrium a negative λ , or a negative shadow value of changes in consumers' social responsibility for the PMP.

To demonstrate this proposition we show that λ needs to be negative when the PMP's market share is nonzero in the steady state. Consider a different system in which we look at market shares instead of PMP's price dynamics. PMP's market share dynamics is given by:

$$z' = d\left(\frac{P_B - P_A}{f}\right) / dt = \frac{-P_A' f - (P_B - P_A) f'}{f^2} \quad (10)$$

Since P_B is assumed exogenous and constant, PMP's market share varies in time only for changes in the PMP price (P_A) and in consumers' ethical perception (f).

To find P_A' we differentiate (9) with respect to time and replace λ' with (6) thereby obtaining

$$\frac{dP_A}{dt} = \frac{1}{2} \left[\rho + \theta - \left(\frac{P_B - P_A}{f^2} \right) \right] \lambda + \frac{1}{2} \left(\frac{P_B - P_A}{f^2} \right) (P_A - w) \quad (11).$$

This equation clearly shows that an increase in prices leads to further positive changes of the optimal price in time if the combined effect on profits (increased margin on a reduced market share) in the second addend dominates the (expected negative) effect generated by the marginal cost in terms of PMP profits of a

change in social responsibility of consumers. By replacing λ from (9) we get:

$$\frac{dP_A}{dt} = \frac{1}{2}[\rho + \theta][(P_A - P_B) + P_A - w] + \frac{1}{2}\left(\frac{P_B - P_A}{f}\right)^2 = 0 \quad (11')$$

By replacing P_A' with (11'), and f' with (2) in (10), we obtain:

$$\frac{dz}{dt} = \frac{-\frac{1}{2}(\rho + \theta)(2P_A - 2w - sw)}{f} - \frac{1}{2}\frac{z^2}{f} - z\left(\frac{-\theta f + 1}{f}\right) + \frac{z^2}{f} \quad (12)$$

Given that, when $\frac{dP_A}{dt} = \frac{df}{dt} = 0$, also $\frac{dz}{dt} = 0$, the steady state of the

(z, f) system corresponds to the steady state of the (P_A, f) system.

In steady-state, for $f \neq 0$, $z' = 0$ implies that:

$$z^2 - 2z(1 - \theta f) - (\rho + \theta)(2P_A - 2w - sw) = 0 \quad (13)$$

We obtain steady state values of the market share and of consumers ethical perception by solving the two equation system made by (13) and $(1 - \theta f) = z$ (14), which is the stationary counterpart of the law of motion in (5). By replacing this last expression in (13), and ruling out negative values of z , we get the following equilibrium value of z :

$$z^* = \sqrt{(\rho + \theta)\left(2\left[w\left(1 + \frac{s}{2}\right) - P_A\right]\right)} \quad (15)$$

Note that this expression establishes that, for having a nonzero market, share the PMP must fix a price below his static optimal price (the first part of the expression under square brackets).

This result also tells us that the shadow value of λ is negative, as expected, since the PMP must increase his price competition if

he want to avoid a path of increasing social responsibility which will lead to further reduction of his market share in the future. ■

3.1.2 Equilibrium and dynamics around the steady state when PMP and FT locations are fixed

Solving for the steady state values of P_A and f in the two differential equation system of (11') and (2) we get:

$$f_1 = \frac{(\rho+2\theta) - \sqrt{(\rho+2\theta)^2 - \theta[w(\theta+\rho)+1](2\rho+3\theta)}}{\theta(2\rho+3\theta)} \quad (16)$$

$$f_2 = \frac{(\rho+2\theta) + \sqrt{(\rho+2\theta)^2 - \theta[w(\theta+\rho)+1](2\rho+3\theta)}}{\theta(2\rho+3\theta)} \quad (17)$$

To obtain real solutions for this equation we need $\rho > \frac{\theta(3\theta w - 1)}{1 - 2\theta w}$ or:

$$\theta < \frac{1 - 2\rho w + \sqrt{1 + 4\rho^2 w + 8\rho w}}{6w} .$$

This implies that, for $w=1$, the loss of

ethical memory must be below around 2/5 for reasonable parameters ranges of the discount rate¹⁹ otherwise the model is not informative about the likely equilibria.

Equilibrium prices are:

$$P_{A1}^* = w \left(1 + \frac{s}{2} \right) - \frac{1}{2(\rho + \theta)} \left[\frac{\rho + \theta + \sqrt{(\rho + 2\theta)^2 - \theta[w(\theta + \rho) + 1](2\rho + 3\theta)}}{2\rho + 3\theta} \right]^2 \quad (17.1)$$

and

¹⁹ Actually θ is 0.42 with $\rho=0.85$ and 0.436 with $\rho=0.95$. With these values we find that P_A^* always respects the condition $w < P_A^* < w + 1/2$ implied by the zero profit condition and by $\lambda < 0$.

$$P_{A2}^* = w \left(1 + \frac{s}{2} \right) - \frac{1}{2(\rho + \theta)} \left[\frac{\rho + \theta - \sqrt{(\rho + 2\theta)^2 - \theta[w(\theta + \rho) + 1](2\rho + 3\theta)}}{2\rho + 3\theta} \right]^2 \quad (17.2)$$

If we analyse properties of the steady state and dynamics around equilibrium we find two equilibria, the first is an unstable node and is obtained at lower levels of consumers social responsibility and PMP price. The second is a saddlepath and is obtained at a higher consumers social responsibility and PMP price. A detailed analysis of properties and implications of this multiple equilibria solution is provided in Appendix 1.

3.2 The continuous time model when the PMP chooses prices and ethical location and FT's ethical location is exogenously fixed

In this version of the model the PMP maximizes the following intertemporal profit function in continuous time

$$\text{Max}_{(a, P_A)} \int_0^{\infty} e^{-\rho t} [P_A - w(1 + as)] \left[\frac{P_B - P_A}{f} + a \right] dt \quad (18)$$

subject to the law of motion of consumers' social responsibility

$$f'' = -\theta f + 1 - \left(\frac{P_B - P_A}{f} + a \right) + a \left(\frac{P_B - P_A}{f} + a \right)$$

(19)

under the nonnegative location constraint $a \geq 0$. Consider also that:

i) to rule out positive values generated by the product of negative margins and negative market shares we only look at solutions under a positive mark-up constraint and that ii) the PMP

price cannot be higher than the FT price for real and positive values of PMP's market shares.

Note that (19) is slightly different from the law of motion (2) of the previous section, as it incorporates that also the PMP may contribute to reinforce the habit of ethically responsible consumption in proportion to its market share weighted by its degree of imitation of the FT.

We may start looking at this problem as an unconstrained maximization problem searching for interior solutions. Therefore we consider the following current value Hamiltonian:

$$H_c = [P_A - w(1 + as)] \left[\frac{P_B - P_A}{f} + a \right] + \lambda \left[-\theta f + 1 - \left(\frac{P_B - P_A}{f} + a \right) + a \left(\frac{P_B - P_A}{f} + a \right) \right] \quad (20)$$

where $\lambda = \mu e^{\rho t}$ and μ is the costate variable associated to $f(t)$.

Conditions for an optimum include first order conditions with respect to the two control variables:

$$\frac{\partial L_c}{\partial P_A} = \frac{P_B - P_A}{f} + a - \frac{P_A}{f} + \frac{w(1 + as)}{f} + \frac{\lambda}{f} - \frac{a\lambda}{f} = 0 \quad (21)$$

$$\frac{\partial L_c}{\partial a} = P_A - w(1 + as) - sw \left[\frac{P_B - P_A}{f} + a \right] - \lambda + \lambda \frac{P_B - P_A}{f} = 0 \quad (22),$$

The law of motion of consumers social responsibility

$$f' = -\theta f + 1 - \left(\frac{P_B - P_A}{f} + a \right) + a \left(\frac{P_B - P_A}{f} + a \right) \quad (23),$$

a differential equation for the costate variable including the derivative of the Hamiltonian with respect to the state variable

$$\lambda' = \left[\rho + \theta - \left(\frac{P_B - P_A}{f^2} \right) + a \left(\frac{P_B - P_A}{f^2} \right) \right] \lambda + \left(\frac{P_B - P_A}{f^2} \right) (P_A - w(1 + as)) \quad (24),$$

plus initial conditions and the transversality condition

$$f(0) = f_0$$

$$\lim_{t \rightarrow \infty} \mu(t)f(t) = 0 .$$

Under the usual assumption of s exogenously set equal to one,

(21) and (22) become respectively

$$\frac{\partial L_c}{\partial P_A} = \frac{P_B - P_A}{f} + a - \frac{P_A}{f} + \frac{w(1+as)}{f} + \frac{\lambda}{f} - \frac{a\lambda}{f} = 0 \quad (21')$$

and

$$\frac{\partial L_c}{\partial a} = P_A - w(1+as) - w \left[\frac{P_B - P_A}{f} + a \right] - \lambda + \lambda \frac{P_B - P_A}{f} + 2a\lambda = 0 \quad (22')$$

We may then rewrite (21') as:

$$\lambda(a-1) = P_B - P_A + af - P_A + w(1+as)$$

and, by replacing in (22'), we get

$$-[P_B - P_A][f - w + \lambda] = af[f - w + \lambda] \rightarrow a < 0$$

This solution is beyond constraints of PMP's ethical location. Therefore there are no internal maxima for this problem. We then look at solutions on the constraints and in particular where the PMP finds it optimal to undercut P_B price and $P_A^* = P_B - \varepsilon$ (which we will further demonstrate to be the optimal corner solution).

Therefore we have to solve

$$\text{Max}_{(a)} \int_0^{\infty} e^{-\rho t} [P_B - \varepsilon - w(1+as)] \left[\frac{\varepsilon}{f} + a \right] dt \quad (25)$$

subject to the usual law of motion of consumers' social responsibility

$$f'' = -\theta f + 1 - \left(\frac{P_B - P_B + \varepsilon}{f} + a \right) + a \left(\frac{P_B - P_B + \varepsilon}{f} + a \right)$$

(26)

Solving the Hamiltonian for first order condition on (a) we get:

$$\frac{\partial H_c}{\partial a} = P_A^* - w(1+as) - \left[\frac{\varepsilon}{f} + a \right] - \lambda + \lambda \left[\frac{\varepsilon}{f} + a \right] + a\lambda = 0 \quad (27)$$

For $\varepsilon \rightarrow 0$ the expression reduces to:

$$-2a - \lambda + 2a\lambda + 1 = 0 \quad (28)$$

and therefore we obtain $a^* = \frac{1}{2}$.

When we replace $P_A^* = P_B - \varepsilon$ and $a^* = 1/2$ in (23) we get

$$5) f' = -\theta f + 1 - \left(\frac{\varepsilon}{f} + \frac{1}{2} \right) + \frac{1}{2} \left(\frac{\varepsilon}{f} + \frac{1}{2} \right) \quad (26')$$

that, for $\varepsilon \rightarrow 0$ becomes:

$$f' = -\theta f + 1 - \frac{1}{2} + \frac{1}{4} \quad (29).$$

By imposing $f' = 0$ we find the steady state level of consumers' social responsibility (P_A^* and a^* are always steady state levels since they are constant and therefore P_A' and $a' = 0$). We then obtain $f^* = \frac{3}{4\theta}$ with f^* being lower, the higher the consumers' loss of ethical memory.

We must check whether this is the maximum profit solution by comparing it with those on the other sides of the "constraint square" whose corners in the $[a, P_A]$ space are $(0, P_B - \varepsilon; 0, w+k; 1, P_B - \varepsilon; 1, w+k)$. Intuitively it is impossible that $P_A = w+k$ (with k small enough) because the corresponding profit would be low and we are in the point of the minimum possible price for the PMP.

The only alternative is the solution in which ethical location is constrained at $a=0$, and the price is optimally set by the PMP (we therefore fall in the first section model in which PMP ethical location was fixed.).

Optimal profit under $a=0$ may be calculated by replacing in the PMP profit function π^* from the first section:

$$\pi^{PMP} = \left[\frac{sw + \lambda}{2} \right] \left[\frac{sw - \lambda}{f} \right] = \frac{(sw)^2 - \lambda^2}{4f} \quad (30)$$

while we can easily check that, under $a^*=1/2$ and $P_A=P_B-\epsilon$, profit tends to $sw/4$ for ϵ small enough.

Therefore the PMP will choose ethical imitation ($P_A^*=P_B-\epsilon$, $a^*=1/2$)

only if the following condition holds: $\frac{(sw)^2 - \lambda^2}{4f} < \frac{sw}{4}$

For $s=1$ this condition may be rewritten as: $w - \frac{\lambda^2}{w} < f$.

This result shows that, with respect to the static case ($\lambda=0$), the PMP is much less reluctant to choose ethical imitation. Consider in fact that, in the equilibrium with PMP ethical imitation ($a^*=1/2$), the PMP market share is around .5 and significantly higher than in the stable equilibrium of the model with fixed ethical locations (between 0.3 and .05). This result confirms that ethical imitation from a PMP is necessary to defend market shares after the entry of a zero profit socially concerned producer. With more ethical imitation, and with a higher market share, the PMP will reduce accumulation of social responsibility in the

future since his contribution to the formation of social responsibility is much lower than that of the FT. The difference between the static and the dynamic case will depend on the PMP cost of changes in consumers social responsibility.

3.3 The dynamic equilibrium with endogenous PMP and FT location

We must jointly solve in this case two intertemporal maximisation problems in which the FT maximises transfers by choosing ethical location and the PMP maximises profits by choosing prices and ethical location. The FT maximises²⁰

$$\underset{(s)}{\text{Max}} \int_0^{\infty} e^{-\rho t} \left[s \left(1 - \frac{P_B - P_A}{f} - a \right) \right] dt \quad (31)$$

under the law of motion of consumer's social responsibility defined in (19), while the PMP maximizes

$$\underset{(P_A)}{\text{Max}} \int_0^{\infty} e^{-\rho t} \left[P_A - w \left[\frac{P_B - P_A}{f} \right] \right] dt \quad (32)$$

subject to $P_A \geq w(1+as)$, $a \geq 0$ and $P_A \leq P_B - \varepsilon$ under the same law of motion of consumer's social responsibility expressed by (19).

We can solve the problem of the FT by writing the following current value Hamiltonian

²⁰ We also assume here that the FT is not completely altruistic since he maximises his own transfers and not total transfers to the South. This assumption is closer to the actual behaviour of FTs. Results from the model with an altruistic FT are omitted for reasons of space and available upon request.

$$H_c = s \left[1 - \left(\frac{P_B - P_A}{f} \right) - a \right] + m \left[-\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) - a + a \left(\frac{P_B - P_A}{f} + a \right) \right] \quad (33)$$

where $m = \eta e^{\rho t}$, with η being the costate variable.

The first order condition with respect to the control variable is:

$$\frac{\partial H_c}{\partial s} = 0 \Rightarrow 1 - \frac{w}{f} - \frac{2sw}{f} + \frac{P_A}{f} - a - \frac{mw}{f} + \frac{amw}{f} = 0 \quad (34)$$

Other conditions include the law of motion of consumers' social responsibility

$$f' = -\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) - a + a \left(\frac{P_B - P_A}{f} + a \right) \quad (35),$$

the differential equation for the costate variable including the derivative of the Hamiltonian with respect to the state variable

$$m' = (\rho + \theta)m - \left(\frac{P_B - P_A}{f^2} \right)s - \left(\frac{P_B - P_A}{f^2} \right)m + ma \left(\frac{P_B - P_A}{f^2} \right) \quad (36),$$

and the transversality condition

$$\lim_{t \rightarrow \infty} m(t)f(t) = 0 \quad (37)$$

By looking now at the PMP, we consider that, when $f > sw - \lambda^2$, the solution of his intertemporal maximisation is the same as in section 3.2 with the difference of $s \neq 1$.²¹ We therefore obtain

$$P_A^* = P_B - \varepsilon \quad (38)$$

$$-a + sw(1-a) - \lambda + 2a\lambda = 0 \quad (39)$$

²¹ By inspecting solutions provided at the end of this section we will see ex post that the FT will always contribute with its location choice to the respect of this inequality since $s^*(f^*)$ is always lower than f^* in equilibrium (see Table 2). Therefore FT location will never cause PMP departure from ethical imitation.

We add to it, from the PMP intertemporal maximization problem, the differential equation for the costate variable including the derivative of the Hamiltonian with respect to the state variable

$$\lambda' = \left[\rho + \theta - \left(\frac{P_B - P_A}{f^2} \right) + as \left(\frac{P_B - P_A}{f^2} \right) \right] \lambda + \left(\frac{P_B - P_A}{f^2} \right) (P_A - w(1 + as)) \quad (40)$$

and the law of motion of consumers' perception of social responsibility as derived in (22). By considering the system of equations (34-40), and replacing P_A^* with his value, we get:

$$s^* = \frac{f(1-a)}{2w} + \left[\frac{P_A^* - w}{2w} \right] - \frac{m}{2}(1-a) \quad (41)$$

$$f' = -\theta f + 1 - a + a^2 \quad (42)$$

$$m' = (\rho + \theta)m \quad (43)$$

$$P_A^* = P_B - \varepsilon \quad (44)$$

$$-a + sw(1-a) - \lambda + 2a\lambda = 0 \quad (45)$$

$$\lambda' = (\rho + \theta)\lambda \quad (46)$$

By replacing (44) in (41), for ε small enough, we get the optimal FT's location

$$s^* = (f - m)(1 - a) \quad (47)$$

In this equation FT's optimal location is increasing in consumers' social responsibility and decreasing in the FT's shadow value of changes in consumers' social responsibility (m). The rationale of this apparently counterintuitive result is that, if the shadow value is higher, it is more important for the FT to generate positive changes in social responsibility which are positively related to positive changes of his market share. To increase his

market share he has to adopt a less ethical stance to conquer more consumers located at his left.

From (48) we obtain, for $w=1$

$$a^* = \frac{\lambda - s}{2\lambda - 1 - s} \quad (48)$$

PMP's optimal location is increasing in consumers' social responsibility and decreasing in the PMP's shadow value (or increasing in the PMP's shadow cost) of consumers' social responsibility. This is because more ethical imitation would reduce FT's market share and reduce overall current social responsibility thereby giving a lower impulse to the law of motion of social responsibility.

The steady state equilibrium implies the following four conditions

i) $s'=0$, ii) $f'=0$, iii) $Pa'=0$, iv) $a'=0$

By differentiating (47) with respect to time we obtain

$$s' = f'(1-a) - m'(1-a) - a'(f-m) = 0 \quad (49)$$

and, by replacing ii) and iv) we get

$$s' = -m'(1-a) = 0 \quad (50)$$

By differentiating (51) with respect to time and simplifying we get

$$a' = \lambda'(s-1) + s'(\lambda-1) = 0 \quad (51)$$

and for $s'=0$ it becomes:

$$a' = \lambda'(s-1) = 0 \quad (51')$$

The reduced differential equation system is made by (50-51' and 42)

By inspecting (51') we find two possible steady-state equilibria. The first, with $s^*=1$ and $\lambda' \neq 0$, coincides with the equilibrium of the previous section (endogenous price and PMP ethical location, fixed FT ethical location). The second, with $s^* \neq 1$ and $\lambda' = (\rho + \theta)\lambda = 0$, implies $\lambda = 0$.

By inspecting this second type of equilibrium and rearranging (45) we get:

$$a^* = \frac{s}{1+s} \quad (45'), \text{ which implies } a^* \neq 1.$$

Consider also that, for $a^* \neq 1$, $s' = 0$ if and only if $m = 0$. Hence, if $\lambda = 0$, it follows that also $m = 0$, or, if the costate variable is zero for the PMP, it is zero also for the FT.

We therefore end up with a three equation system in three unknowns represented by PMP and FT ethical location and by consumers' social responsibility:

$$s^* = f(1 - a) \quad (52.1)$$

$$f' = -\theta f + 1 - a + a^2 \quad (52.2)$$

$$P_A^* = P_B - \varepsilon \quad (52.3)$$

$$a^* = \frac{s}{1+s} \quad (52.4)$$

From this system we find that none of the three steady state values depends from the intertemporal discount rate. We also find that the PMP's chooses minimum price differentiation.²²

The reaction function of the FT's optimal location implies that the FT gets nearer to the PMP, the more he opts for ethical

imitation. Again, the interpretation is that market shares are more important in the dynamic than in the static model given that they crucially affect future consumers' social responsibility through the law of motion of f .

By replacing (52.1) and (52.2) for $f'=0$ in (45) we find the expression for the steady state of PMP's ethical location as a function of the only exogenous parameter:

$$a^4 - 3a^3 + 4a^2 - (3 + \theta)a + 1 = 0$$

This expression is a complex polynomial. We therefore calculate numerically the steady state of a^* and of the other unknowns in the range of feasible values for the ethical loss of memory parameter.

Results presented in table 2 show that, as far as ethical loss of memory gets higher, the FT reduces his ethical location and the PMP his ethical imitation at optimum. As a consequence, the steady state level of consumers' ethical perception (and social responsibility habit creation) is lower. For high levels of ethical loss of memory, we obtain the nearest distance between the two locations. An obvious result is that, when both players are free to locate, a virtuous circle of increasing social responsibility leads to increased social responsibility of producers for given levels of loss of memory with respect to the

²² This result is crucially determined by the assumption that the two players share a common rate of intertemporal preference.

model presented in section 3.1 where locations were fixed.²³ Consider also that the PMP market share varies between .5 to .7 in a range which is superior to that of the model with fixed ethical location.

Table 2 Steady state values of PMP and FT ethical location and PMP price.

Values of the loss of ethical memory (θ)	Equilibrium value of PMP's ethical location (a*) and PMP market share	Equilibrium value of FT's ethical location (s*)	Equilibrium value of consumers' ethical perception (f*)
.1	.71	2.35	7.2
.15	.65	1.82	5.14
.2	.59	1.55	3.79
.25	.56	1.66	3.78
.3	.54	1.15	2.50
.35	.52	1.02	3.14
.40	.49	0.96	1.87

With regard to the stability of this equilibrium consider that, from $a^*=s/(1+s)$, we know that the PMP chooses location and $P_A=P_B-\epsilon$ independently from f . As a consequence, PMP and FT market shares do not vary when f changes. Therefore, also f does not vary since variables affecting its law of motion are fixed. This explains why PMP and FT shadow values are zero in equilibrium, and implies that, whenever consumers social responsibility is such that $f > sw - \lambda^2/sw$, we immediately fall into the above described equilibrium.

²³ This reasoning obviously applies until P_B hits its upper boundary determined by the common consumers reservation price.

4. Conclusions

The model gives tangible predictions on competition between zero profit socially responsible producers and traditional profit maximizing producers. It shows that the PMP reacts in prices and ethical location to the entry of an socially concerned producer. If consumers social responsibility is below a given threshold, he limits himself to price competition, offering his products at a discount with respect to the "socially responsible" product (the discount varies according to the PMP rate of intertemporal preference and to the depreciation rate in the formation of consumers' socially responsible habit).

If consumers responsibility is above such threshold, he is forced to a corner solution to avoid excessive loss of market share. In that case, if a constraint on "negative social transfers exists, he prefers to partially imitate the social responsible producer by choosing minimum price differentiation and about one half of the socially responsible producer's social transfer.

The paper also shows that the present value of the PMP shadow cost of changes in consumers social responsibility crucially determines differences in equilibria between the static and the dynamic game: i) it enhances PMP's price competition in the dynamic with respect to the static game, ii) it lowers the threshold of consumers social responsibility which triggers the PMP's ethical imitation.

The rationale for these differences between the static and the dynamic analysis is that costs of loosing market shares today are

lower in a static than in an intertemporal perspective, since in the latter they enhance formation of socially responsible consumers habits, reinforced by current consumption of socially responsible products.

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Appendix

Steady state properties of the equilibrium when the PMP location is fixed

To analyse properties of the steady state equilibrium in section 3.1.2 we must consider that the two differential equation system, formed by (11') and (2), is highly nonlinear.

Under the condition of $P_A' = 0$, (11') may be rewritten as:

$$[\rho + \theta][(P_A - P_B) + P_A - w] + \left(\frac{P_B - P_A}{f}\right)^2 = 0 \quad (\text{A.1})$$

or

$$a(2x - b) + \frac{(c - x)^2}{y^2} = 0 \quad (\text{A.1}')$$

where:

$$a = \rho + \theta; \quad b = 2w + sw; \quad c = P_B; \quad x = P_A \quad \text{and} \quad y = f$$

Therefore, we need to study the function $y^2 = \frac{(c - x)^2}{a(b - 2x)}$ which, for $y > 0$,

becomes

$$y = \frac{(c - x)}{\sqrt{a(b - 2x)}} \quad (\text{A.2})$$

The intersections of this function with the two axes are as follows

$$A1(0, c/\sqrt{ab}) ; \quad A2(c, 0)$$

Consider that we are only interested to solutions for which $b/2 > x$, since this condition is equivalent to the condition that the PMP price (P_A^*) must be lower than the optimal static price or, in other terms, that $\lambda < 0$. Remember that this condition is always

respected, since it is also the condition for a nonzero market share for the PMP.

To identify the shape of this locus in the $[y,x]$ space consider that

$$\frac{dy}{dx} = \frac{-\sqrt{a(b-2x)} + \frac{2a(c-x)}{2\sqrt{a(b-2x)}}}{a(b-2x)} = \frac{x+c-b}{(b-2x)\sqrt{a(b-2x)}} > 0 \text{ if } x+c > b$$

But this last inequality corresponds exactly to $P_A - w(1+g+d) > 0$.

Therefore the derivative is increasing in the feasible set of P_A values.

Moreover, since

$$\frac{d^2y}{dx^2} = \frac{\sqrt{a(b-2x)^3} + \frac{6a(b-2x)^2(x+c-b)}{2\sqrt{a(b-2x)^3}}}{a(b-2x)^3} = \frac{x+3c-b}{(b-2x)\sqrt{a(b-2x)^3}} > 0 \text{ for } b-2x > 0$$

the $P_A' = 0$ locus is convex in the feasible set $b/2 > x$, and, given that the set of the real numbers is constrained to $b/2 > x$, we are interested only to the area in which the locus is convex.

$$\text{The second locus is } -\theta f + 1 - \left(\frac{P_B - P_A}{f} \right) = 0$$

By totally differentiating this expression we find that:

$$(1-2\theta f)df + dP_A = 0 \rightarrow \frac{df}{dP_A} = \frac{1}{2\theta f - 1} \quad (\text{A.3})$$

which implies that (A.3) decreases for $f < 1/2\theta$ and increases when the inequality is reversed. Hence, when consumers social responsibility is high, an increase in the PMP price is consistent with higher steady state levels of consumers social

responsibility in equilibrium. This occurs because of the increase of FT share after PMP price rise.

On the contrary, for lower levels of consumers social responsibility, the opposite occurs and the steady state in the law of motion of consumers social responsibility is such that higher PMP prices imply lower levels of consumers social responsibility. This occurs because, for low levels of consumers social responsibility, the negative effect of the loss of ethical memory is higher than the positive impact of the increase of FT share after PMP price rise.

To identify the position of the two steady state loci in the $[P_A, f]$

space consider that $\frac{df'}{dP_A} = \frac{1}{f} > 0$ and $\frac{dP_A'}{df} = (P_B - P_A)^2 \left[-\frac{2}{f^3} \right] < 0$. The sign

of the first derivative implies that, as far as the PMP raises his price, his market share tends to shrink and consumers' social responsibility gets higher. The sign of the second derivative implies that, when consumers' social responsibility is higher, the PMP reduces his price not to lose too much market share.

We then have two equilibria, the first is an unstable node and is obtained at lower levels of consumers social responsibility and PMP price. The second is a saddlepoint and is obtained at a higher consumers social responsibility and PMP price.

Figure 1 illustrates the phase diagram in which the two curves intersect each other in two points which correspond to the two equilibria $E_1 = (f_1^*, P_{A1}^*)$ and $E_2 = (f_2^*, P_{A2}^*)$.

Around the first equilibrium social responsibility is so low that the depreciation effect dominates. Going rightward and below the equilibrium point, we may collapse to a point in which social responsibility goes to zero and the PMP price is moderately low. Going leftward and above this unstable node, the rise of social responsibility and/or PMP price leads to the area of the second equilibrium and to his saddlepath. Along this saddlepath we converge to the second equilibrium in which PMP prices are moderately low and consumers social responsibility is above one (the leftward monetary distance between the transfer considered fair by a given consumer and the effective transfer has more than proportional effects on consumers preferences). In this equilibrium f is above one for reasonable parameters ranges of ρ and θ (and tends to be much larger, the lower the loss of ethical memory) and the PMP sells his product at a discount between .5 and .75 of the FT price.

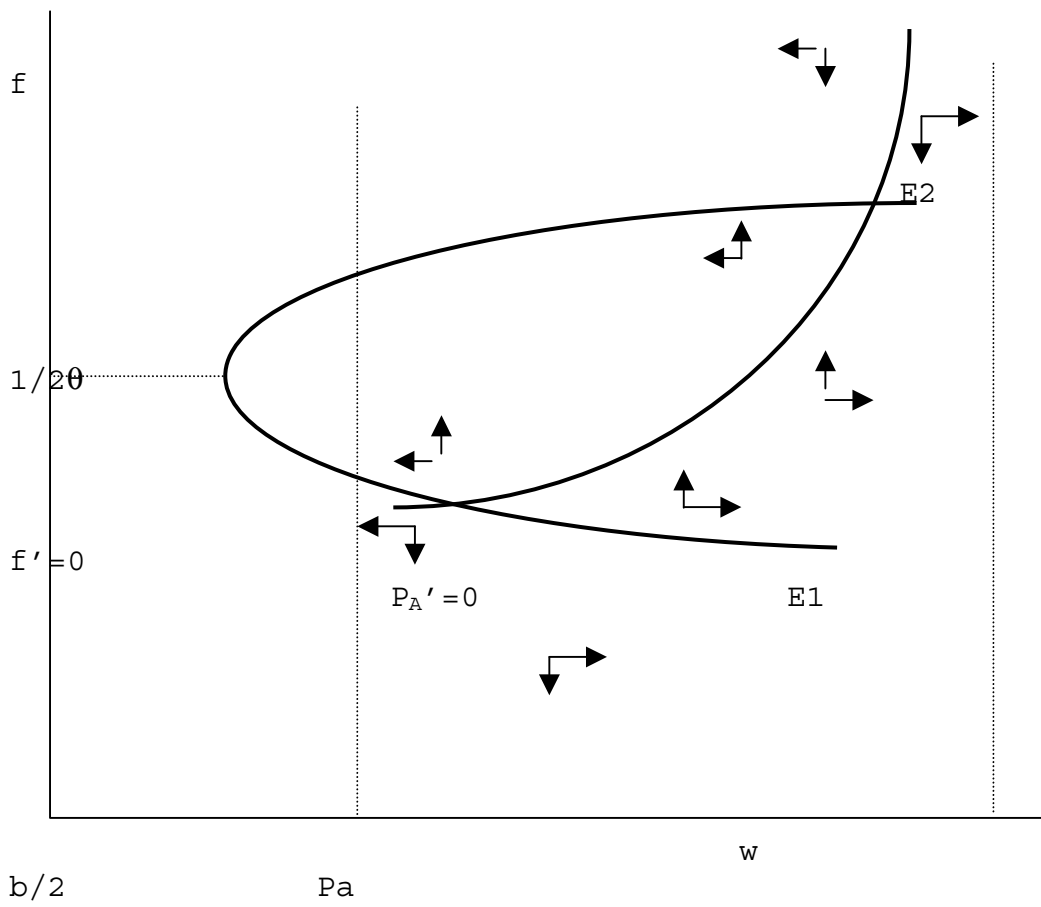


Figure 1. Dynamics around the two equilibria when PMP and FT locations are fixed

Table 1.a Steady state values of PMP price (P_A) for different levels of discount rate (ρ) and loss of ethical memory (θ) when FT and PMP locations are fixed (PMP price is calculated as a percent discount on the FT price) (unstable node equilibrium)

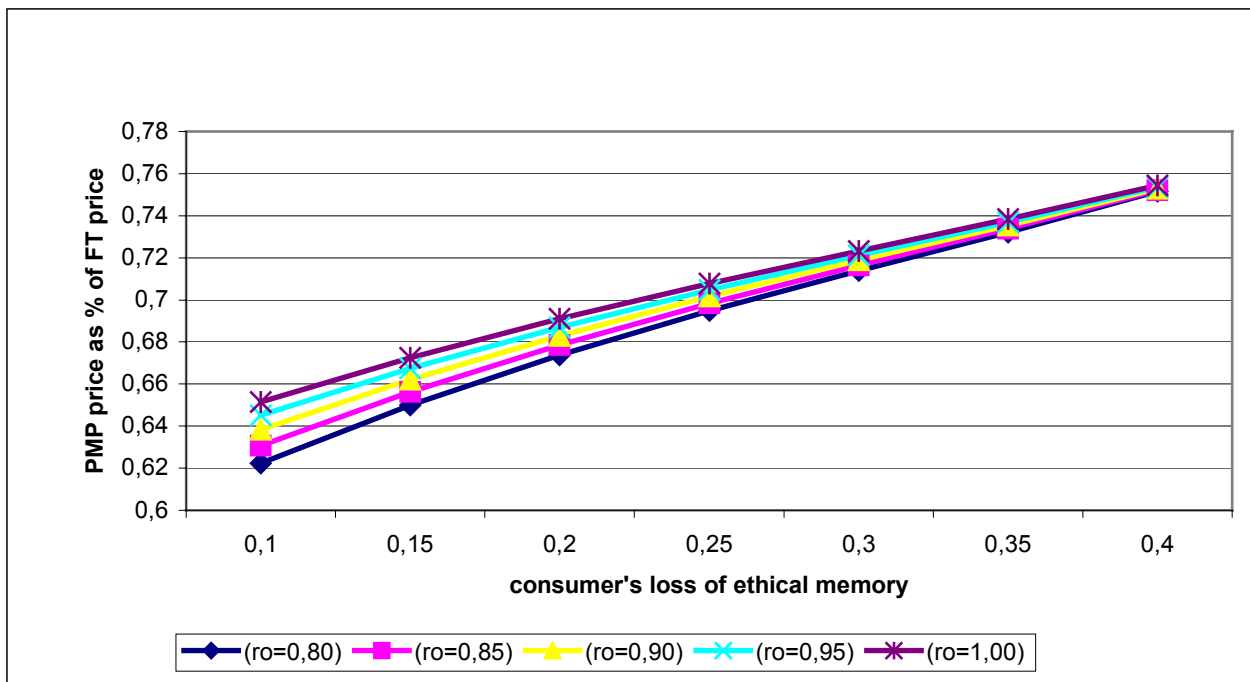


Table 1.b Steady state values of consumers social responsibility for different levels of discount rate (ρ) and loss of ethical memory (θ) when FT and PMP locations are fixed (unstable node equilibrium)

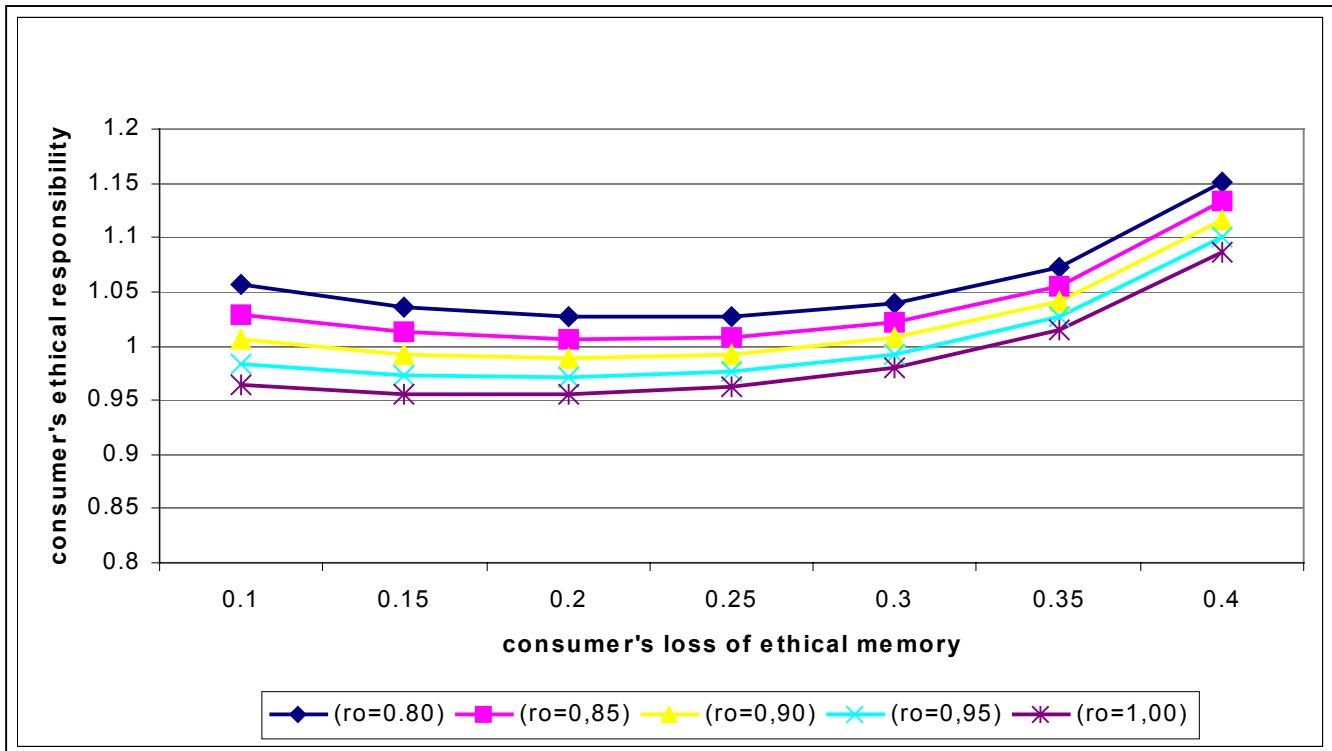


Table 1.c Steady state values of PMP's price for different levels of discount rate (ρ) and loss of ethical memory (θ) when FT and PMP locations are fixed (PMP price is calculated as a percent discount on the FT price) (saddlepath equilibrium)

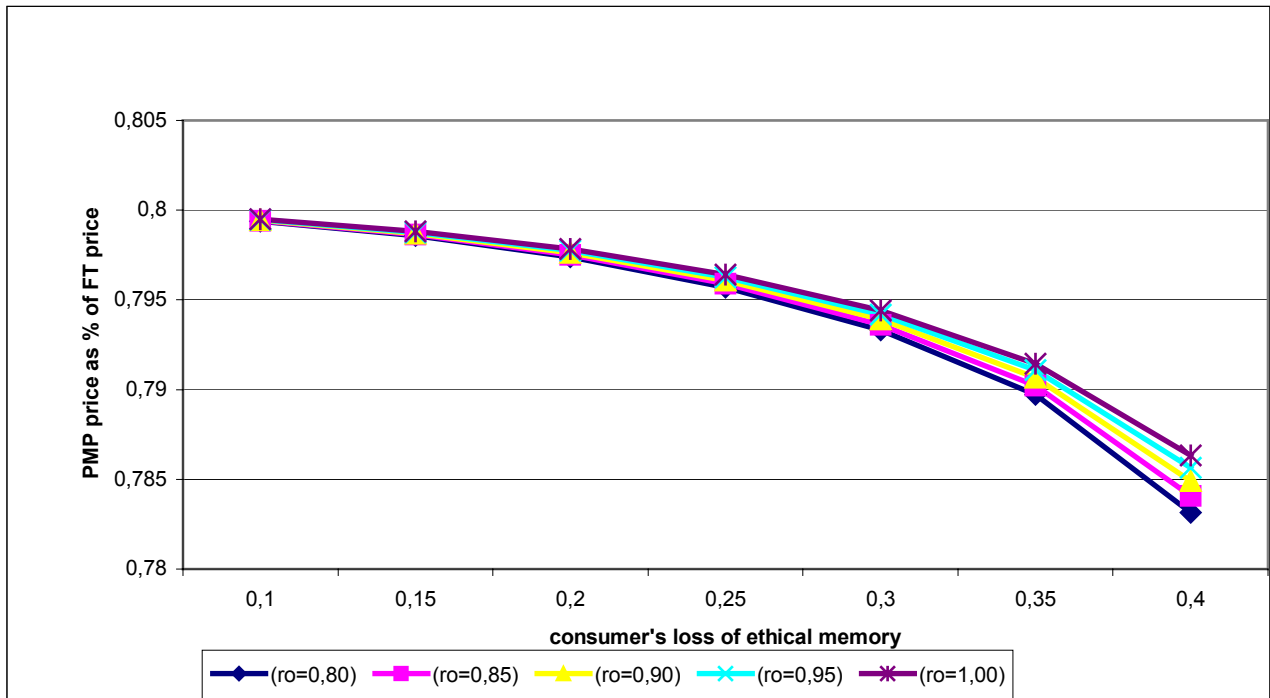


Table 1.d Steady state values of consumers social responsibility for different levels of discount rate (ρ) and loss of ethical memory (θ) when FT and PMP locations are fixed (saddlepath equilibrium)



Tables 1.a-1.d present results of simulations of the values of P_A^* (expressed as a percent discount on the FT's price P_B) and f under reasonable parameter ranges for θ and ρ under the two different equilibria. An apparently paradoxical result is the positive relationship between P_A and consumers loss of ethical memory in the first equilibrium (the unstable node) (Table 1.a) against the negative relationship in the second equilibrium (the saddlepath) (Table 1.c). The rationale is that, in the second equilibrium, the sensitivity of the equilibrium consumer's social responsibility to the consumers loss of memory is very high (reduced loss of memory leads to very high steady state levels of social responsibility). This implies that, at very high levels of social responsibility, the amount of loss of ethical memory is equivalent to additional current contributions to social responsibility from the fact that the FT controls large part of the market. We are therefore near to a saturation point in which social responsibility cannot go further and therefore the PMP may at margin increase a little his prices in equilibrium.²⁴

This does not occur for lower levels of social responsibility in the steady state. In those cases we are far from the saturation of consumers habit and the PMP must keep prices lower for lower levels of consumers' loss of memory, if he want to keep the system in equilibrium.

²⁴ Consider for instance that, in the saddlepath equilibrium, when the PMP price is around .8 of the FT price and f is around 10, we have a tiny PMP's market share of approximately .02. Nonetheless, f is in equilibrium since the loss of ethical memory leads to a

Consider also that, if we compute market shares under the two equilibria, we find that, while under the first (unstable node) the PMP market share is between .9 and .5 according to different levels of loss of ethical memory, it drops to a range between 0.3 to 0.05 in the saddlepath equilibrium. For low levels of loss of ethical memory the PMP producer risks to loose much of his market share. This is one of the reasons justifying the analysis in section 3.2 where we look for model equilibria when the PMP producer may react both in prices and in ethical location.

depreciation of f slightly less than 1, with a contribution from current FT's market share of the same amount.