

## COMPETITION WITH PRICE-DEPENDENT PREFERENCES

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In this paper, I develop a duopoly location model of differentiated products in which consumers' product preferences vary positively with product prices. The level of preference price-dependence ("PPD") is allowed to vary across consumers. I find that equilibrium prices increase with the PPD level of the marginal, or "just indifferent," consumer, but are not influenced by the PPD levels of other consumers. The marginal consumer's PPD increases the effect of exogenous product differentiation on price. When product differentiation is a choice variable of the firms, firms invest more in differentiating their products when the marginal consumer's PPD level is higher.

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## 1. Introduction

This paper examines the effects on competitive market equilibrium of consumer product preferences that depend positively on prices. The idea that product preferences may be influenced by prices goes back to Veblen (1899), who recognized that many people derive satisfaction from the conspicuous consumption of high-priced luxury goods. For such people, preferences for high prices relate to an underlying desire to credibly signal wealth or success to others (Bagwell and Bernhiem 1996, Corneo and Jeanne 1997). By virtue their ability to convey a signal, high prices provide utility to the product user.

In cases where prices do not provide utility *per se*, they may still indicate, or signal, a product whose quality is perceived to be likely to confer greater utility. Because rational consumers know that others in the market also value higher quality, and moreover that quality improvements are usually costly to achieve, they will expect higher-priced versions of a product to have higher quality in situations where quality is uncertain (Scitovsky 1945; Stiglitz 1987; Rao and Monroe 1989).

In still other cases, prices may affect preferences by altering subjective perceptions of what the preference object is. For example, offering to pay an individual more to do a job or perform an activity may adversely affect his views about the intrinsic desirability of the job or activity. The effect is not necessarily because the wage or payment acts as a job-quality signal; rather it may have to do with the effect of external rewards on one's evaluation of reasons for engaging in the activity (Deci 1971, 1972), or

on the inferences that people draw about the nature of activities based on social norms of pricing structure (Gneezi and Rustichini 2000).

Some studies of prices and perception have found dramatic measurable effects. In neurological studies of wine consumption employing fMRI, Plassman et al. (2008) found that pleasure centers in the brain displayed greater activation when consumers were told the wine they are drinking was expensive. In a set of experiments, Shiv et al. (2005) found that the consumption of energy drinks had a reduced effect on workout intensity and puzzle-solving performance when subjects paid a discounted price for the drinks as opposed to the regular price.

While it appears relatively clear that price can matter to product preferences for various reasons, it is less clear how the resulting equilibrium price levels might be affected. A trivial realization is that when consumers value high prices, prices will tend to be higher. But an important complicating factor is the likely heterogeneity of consumers with respect to the extent of their preference price-dependence (“PPD”), and how PPD in turn relates to the consumers’ intensity of relative product or brand preference.

Consider first a market in which product quality is uncertain. Many such markets involve products for which subjective taste, or alternatively an objective understanding of the relative value of competing brands or products, needs to be developed or learned. Relevant products range from wine and fine food to computer operating systems. An experienced consumer (“sophisticate”) in such markets tends to have stronger preferences, knowing well what he likes and/or what is good, while an inexperienced consumer (“neophyte”) may not have a strong sense as to how to pick a good brand. Given his product knowledge, the sophisticate will not typically need to rely on price as a

signal of quality. Meanwhile, the neophyte will.<sup>1</sup> It follows in this case that PPD will tend to be greater for those with a lower intensity of brand or product preference. Quality-signaling theory suggests, and supporting empirical evidence has shown, that the use of reference prices as quality signals diminishes as consumer experience with a product category grows (Erdem et al. 2010).

Now consider the market for an exclusive luxury good, such as a diamond necklace or foreign sports car. For some aspiring individuals, interest in social status – and conspicuous, pricey goods as a signal of status – looms large, while others may place little value on the cachet that high-status goods and their high prices impart. Status-conscious individuals (“zealots”) tend to be highly brand-aware and therefore have a strong preference between available options; for example, it matters a lot to the status-conscious person whether the watch is a Rolex or a Timex. Meanwhile a less status-motivated individual (“cool-head”) would not care as much about brand. It follows in this case that PPD will tend to be *lower* for those with a lower intensity of brand or product preference.

It should be evident from these examples that the way in which price affects product preferences is something that will tend to vary across consumers, and that a clear picture of a market only emerges when one understands how this variation relates to variation in relative product tastes. Will prices, for instance, be higher in a world of goods for which the discernment and appreciation of quality must be learned, or in a world of status goods with loyal status-bound followers?

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<sup>1</sup> For instance, Kamenica (2008) notes the tendency of wine neophytes to select the second-cheapest bottle on the wine list, presumably as an attempt to optimally trade off obtaining a low price against obtaining greater quality, as indicated inversely by price.

This paper uses a location model of differentiated products to examine how preference price-dependence affects the price levels found in a competitive market equilibrium. I model the distribution of price sensitivity of product preference across a mass of consumers who are distinguished by the intensity of their preference for one product versus another. Through appropriate parameterization, I am able to view the effects of variations in *relative* price sensitivity across consumers, as relates to their intensity of brand preference, and as distinct from variation in the *absolute* price-sensitivity level of the benchmark marginal (i.e., “just indifferent”) consumer. This allows me to address the role of interaction between preference intensity and PPD in mediating the effect of PPD on price levels.

Another complication concerns how the extent of product differentiation relates to the effect of PPD on price levels. When consumers view competing brands as more distinct and differentiated, do firms find it profitable to raise price in response to consumer PPD more than when brands are perceived as quite similar? And, where firms have the ability to manipulate consumers’ perceptions of product differentiation, as through advertising and product design decisions, is it more profitable to do so when consumers value high prices? To address these questions, I employ two versions of the model – one in which the level of product differentiation is an exogenous parameter, and the other in which it is a choice variable of the competing firms.

I find, not surprisingly, that prices increase with the intensity of the PPD intensity of the marginal consumer. However, perhaps more surprising, the PPD levels of *inframarginal* consumers have no effect on prices. Meanwhile, exogenous product differentiation increases the effect of the marginal consumer’s preference price-

dependence on price. Firms facing more intense PPD will engage more intensively in differentiating their products when such differentiation is a choice variable of the firm.

In a well-known paper, Milgrom and Roberts (1986) analyze the role of price and advertising as complementary potential indicators of product quality. They observe that a separating equilibrium may result in which a high-quality firm can credibly signal its “type” by setting price and advertising levels that differ from those it would offer if it were a low-quality firm. Correspondingly, consumers rationally look to price as a signal of quality; under certain circumstances, a higher price may be the indicator of higher quality and may therefore be preferred by consumers. The paper thus offers a rationalization of preference price-dependence and predicts the price levels that might result in equilibrium.

Milgrom and Roberts’ analysis is insightful. However, they treat only one narrow situation in which consumers’ product preferences might respond to price levels – one in which that response is perforce homogeneous across consumers. The present paper does not seek, as Milgrom and Roberts did, to develop an explanation of PPD from primitives. Rather, its focus is on modeling PPD’s effects across the broader array of situations where PPD results. In particular, in allowing for consumer heterogeneity with respect to PPD, I seek to understand an important dimension of the effects of PPD that Milgrom and Roberts ignored.

The idea of a utility function incorporating price conflicts directly with the traditional model of consumer behavior, in which prices figure only into the budget constraint, therefore cleanly appearing only on one side of the consumer’s optimization problem. When this assumption is violated, changes in price may shift both budget lines

*and* indifference curves simultaneously. This complicates the revealed preference approach, making it potentially impossible to identify the position of a consumer's indifference curve (Frank and Nagler 2012). Issues such as these have rendered price-dependent preferences controversial. Bilancini (2011) declares price-dependent preferences to be “illegitimate under the scientific commitments of revealed preference theory.” Other authors have noted problems for welfare analysis (e.g., Pollak 1977). Yet empirical evidence suggests that the tendency for prices to shift preferences is something that occurs across a broad array of products, rather than being merely an interesting anomaly (Bassman et al. 1988). Thus one may be motivated to take account of preference price-dependence in economic modeling, despite its potentially challenging implications for existing methods of theoretical analysis.

Preference price-dependence is a reflection of a larger concept: that a consumer's preferences reflect his frame of reference on, or *attitude* toward, each object of choice. To account appropriately for the forces that impact decisions, the consumer's attitude toward the action-object must be viewed as variable, as itself an object of choice, and as a potential function of market variables (Nagler 2013). Failure to account for the effects of external influences, such as prices, on attitudes may lead to inaccurate predictions of the outcomes of firm strategies and public policies. This paper represents a modest attempt to begin the process of attitude accounting in economic modeling.

The next section sets forth the basic model with exogenous product differentiation. Section 3 incorporates endogenous product differentiation. Section 4 concludes.

## 2. A Model with Exogenous Product Differentiation

Consider a market in which two firms compete in producing and selling a product. Each firm sells a differentiated version of the product, but the firms are otherwise identical, with zero production costs. A mass of heterogeneous consumers decides which firm to purchase from. Consumers' preferences between the firms consist of two components. A *fixed* valuation component varies across consumers but is invariant to states of the world; the mass of consumers is assumed uniformly and symmetrically distributed with respect to their fixed valuations of the two firms' products. A *variable* valuation component, or *attitude*, varies across consumers *and* states of the world. Specifically, it varies with price, such that consumers, to varying degrees, consider higher-priced products more desirable, irrespective of the firm producing the product. Because this component is price-driven and firm-agnostic, it is perforce symmetric with respect to the firms.

The assumption of identical firm characteristics and symmetric distribution of consumer preferences will allow us to focus on the symmetric equilibrium in which both firms price equally and consumers are divided equally between the firms. Thus we will be able to abstract from irrelevant aspects of the competitive problem and restrict attention to the pure effects of PPD, as revealed through comparative static analysis of the equilibrium.

### 2.1 A general specification of preference price-dependence



To fix ideas, let the two products, A and B, be sold at prices  $p_A$  and  $p_B$ , respectively. Consumers are distributed uniformly on the interval (0,1) based on their fixed valuation of A versus B, with the total number of consumers normalized to 1. Consumers choose whether to purchase A or B; each consumer will choose at most one unit of one of the two products (i.e., there is no outside good). The firms simultaneously set their respective prices to maximize profits, each taking the other's pricing decision as given.

A consumer receives utility

$$U = \begin{cases} F_A + V_A - p_A & \text{if adopts A} \\ F_B + V_B - p_B & \text{if adopts B} \end{cases}$$

where  $F_i$  and  $V_i$  ( $i = A, B$ ) are the fixed-valuation and variable-valuation components of product  $i$  respectively. For a consumer located at a point  $j$  ( $1 \geq j \geq 0$ ), let  $F_A = v - tj$  and  $F_B = v - t(1 - j)$ . Here,  $v$  represents the component of the value of the product that is shared across all consumers, and  $t$  represents the extent of product differentiation ( $t > 0$ ).

Meanwhile let

$$V_i = \begin{cases} \theta p_i h(a, j) & \text{if } j \in [0, \frac{1}{2}] \\ \theta p_i h(a, 1 - j) & \text{if } j \in [\frac{1}{2}, 1] \end{cases} \quad (1)$$

for  $\theta \in [0, 1)$ , where  $h$  is a real-valued function defined on compact support  $[0, 1] \times [0, \frac{1}{2}]$  with range  $[0, 1]$ . We do not require  $h$  to be differentiable or even continuous in  $a$  and  $j$ , except within a neighborhood of  $j = \frac{1}{2}$ .

The specification of consumer PPD given in (1) is quite general. Here,  $a$  parameterizes variation in the pattern of PPD across the mass of consumers. For a given

$a$ , values of  $h$  reflect the PPD of each consumer over the range of  $j$ . The pattern is allowed to vary with  $a$  without restriction.<sup>2</sup> The versatility of the formulation is also notable. It can describe a world in which consumers at each level of preference intensity  $j$  are homogeneous with respect to their PPD intensity, but where the latter varies continuously, as dictated by  $a$ , over different values of  $j$ . Or it can describe a “binary” world in which consumers either have price-dependent preferences or do not, and where these two types exist in a continuously varying distribution along the segment, with the distribution at any given point  $j$  varying as dictated by  $a$ . For ease of exposition, we will speak from here on in terms of the first case.

Without loss of generality let us set  $h(a, \frac{1}{2}) \equiv k \in (0,1)$  for all  $a$ . This is a simple normalization. In effect, we are setting a benchmark level of PPD  $\rho \equiv \theta k$  for the median consumer at  $j = \frac{1}{2}$ . The PPD levels for other consumers ( $j \neq \frac{1}{2}$ ) can then be seen as being arrayed relative to the median consumer, based on the pattern given by  $a$ . Note that in symmetric equilibrium the median consumer at  $j = \frac{1}{2}$  also happens to be the *marginal* consumer, that is, the consumer who is just indifferent between A and B given (equal) equilibrium prices.

Given symmetry, we need examine only firm A’s optimization problem. Let us assume  $v$  is large enough that all consumers choose to purchase A or B at equilibrium prices, that is,  $Q_A + Q_B = 1$ , where  $Q_A$  and  $Q_B$  are the quantities sold by firms A and B, respectively.<sup>3</sup> Making substitutions

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<sup>2</sup> In the next subsection, I work through the model’s results using an example of the  $h$  function in order to provide additional clarity and intuition about the general specification.

<sup>3</sup> One may derive  $\bar{v}$  satisfying this requirement (i.e.,  $\min\{U_A(j)|\bar{v}, U_B(j)|\bar{v}\} > 0$ ) as follows. As shall be observed,  $Q_A + Q_B = 1$  implies  $v$  does not appear in the first-order conditions for A’s profit

$$U = \begin{cases} \theta p_A \cdot h(a, j) + (v - tj) - p_A & \text{if adopts A, } j \in [0, \frac{1}{2}] \\ \theta p_A \cdot h(a, 1 - j) + (v - tj) - p_A & \text{if adopts A, } j \in [\frac{1}{2}, 1] \\ \theta p_B \cdot h(a, j) + [v - t(1 - j)] - p_B & \text{if adopts B, } j \in [0, \frac{1}{2}] \\ \theta p_B \cdot h(a, 1 - j) + [v - t(1 - j)] - p_B & \text{if adopts B, } j \in [\frac{1}{2}, 1] \end{cases}$$

A consumer located at  $j$  is therefore indifferent between products A and B if, for

$$j \in [0, \frac{1}{2}],^4$$

$$\begin{aligned} \theta p_A \cdot h(a, j) + (v - tj) - p_A &= \theta p_B \cdot h(a, j) + [v - t(1 - j)] - p_B \\ \Rightarrow H(a, \theta, t, p_A, p_B, j) &\equiv [\theta \cdot h(a, j) - 1](p_A - p_B) + t - 2tj = 0 \end{aligned} \quad (2)$$

With a specific functional form for  $h$ , this could be solved for the  $j^*(p_A, p_B)$  at which a consumer is indifferent between A and B given price levels  $p_A$  and  $p_B$ .

In spatial models without PPD, relative product preference normally varies monotonely with  $j$ , allowing one to interpret such a  $j^*$  as  $Q_A$ , the quantity of  $Q_A$  demanded in the market.<sup>5</sup> However, allowing consumers to exhibit heterogeneous PPD creates the risk that, for some profile  $a$ ,  $p_A > p_B$  will correspond to a consumer at some  $j_1 < j_2$  having a level of PPD so much lower than the consumer at  $j_2$  that she prefers B while the consumer at  $j_2$  prefers A. This would invalidate the interpretation of  $j^*$  as  $Q_A$ , requiring that an alternative, perhaps complex, conceptual expression for  $Q_A$  be developed for use in firm A's optimization problem.

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maximization. This means  $(p_A^*, p_B^*) \Big|_{Q_A + Q_B = 1}$ , the firms' profit-maximizing prices subject to all consumers choosing to purchase A or B, is a function of exogenous parameters other than  $v$ . Given symmetry,  $p_A^* = p_B^*$ . Thus the expression  $\bar{v} \equiv \frac{t}{2} + p_A^* \Big|_{Q_A + Q_B = 1}$  satisfies.

<sup>4</sup> Given symmetry, we need only analyze the case  $j \in [0, \frac{1}{2}]$ .

<sup>5</sup> See, for example, Nagler (2011).

Fortunately, because of the symmetry of the setup, all we need is an expression for  $Q_A$  that can be used within a neighborhood of the symmetric equilibrium  $j = \frac{1}{2}$ . The following lemma allows us to salvage the use of  $j^*$  for this purpose:

*Lemma.* Let  $h$  be continuous in  $j$  within a neighborhood  $n(a)$  of  $j = \frac{1}{2}$ . It follows that there exists a neighborhood  $n_0(a) \subseteq n(a)$  such that any  $j^*(p_A, p_B)$  within  $n_0(a)$  corresponds to  $Q_A \equiv j^*$ .

*Proof.* At equal prices, relative preference for A clearly increases monotonely with decreasing  $j$ . But, since  $h$  is continuous within a neighborhood  $n(a)$  of  $j = \frac{1}{2}$ , preference monotonicity must hold within some neighborhood, no larger than  $n(a)$ , for a sufficiently small price differential,  $\varepsilon = p_A - p_B > 0$ . Call this neighborhood  $n_0(a)$ . One can see in fact that there exists  $\varepsilon > 0$  for which *any* smaller price differential corresponds to preference monotonicity in  $j$  within  $n_0(a)$ . It follows that any  $j^*$  corresponding to  $\varepsilon$  or a smaller price differential would have the property that  $Q_A \equiv j^*$ . ■

Of course, without a specific form for  $h$ , we do not have a closed form expression for  $j^*$ , only the implicit function shown in (2). Therefore, implicit techniques must be used to obtain expressions needed for the comparative static analysis of firm A's optimization problem.

The general expression for firm A's profit is  $\Pi_A = p_A Q_A = p_A j^*$ . The first-order condition with respect to price is thus  $p_A^* \frac{\partial j}{\partial p_A} + j^* = 0$ . This expression does provide the potential for obtaining a closed-form expression for  $p_A^*$  as a function of the model parameters. Solving for  $p_A^*$  we obtain

$$p_A^* = -\frac{j^*}{\frac{\partial j}{\partial p_A}} \quad (3)$$

Given symmetry,  $p_A^* = p_B^*$ , hence  $j^* = \frac{1}{2}$ . It remains to determine  $\frac{\partial j}{\partial p_A}$ . Using Cramer's rule on (2):

$$\frac{\partial j}{\partial p_A} = -\frac{\frac{\partial H}{\partial p_A}}{\frac{\partial H}{\partial j}} = -\frac{\theta \cdot h(a, j) - 1}{\theta \frac{\partial h}{\partial j}(p_A - p_B) - 2t}$$

Substituting  $p_A^* = p_B^*$ ,  $h(a, \frac{1}{2}) = k$ , and  $\rho = \theta k$ , this simplifies to  $\frac{\rho-1}{2t}$ . We substitute this expression and  $j^* = \frac{1}{2}$  into (3) to obtain

$$p_A^* = p_B^* = \frac{t}{1-\rho} \quad (4)$$

We may state the following results:

*Proposition 1.* Equilibrium prices rise with  $\rho$ .

*Proposition 2.* Equilibrium prices are independent of  $a$ .

Proposition 1 embodies the intuition that prices should be higher when consumers value higher prices intrinsically. Indeed, the proposition boils down to just this when all consumers have identical PPD values. However, when PPD varies across consumers,

Proposition 1 indicates more precisely that equilibrium prices rise with the PPD of the *marginal* consumer.

Complementing this result is the perhaps more surprising finding of Proposition 2. Since the PPD levels of all consumers other than marginal consumer are indexed only by  $a$ , the intensity of PPD for *any* inframarginal consumer will not have an effect on prices.

Our next result concerns the effect of PPD on how prices are influenced by the degree of product differentiation or, alternatively, the intensity of competition between the two products:

*Proposition 3.* Prices in equilibrium increase faster with  $t$  the greater the level of  $\rho$ .

In other words, product differentiation has a greater positive effect on price levels for products whose marginal consumers' preferences exhibit greater price-dependence.

Figure 1 illustrates the relationship of prices to marginal consumer PPD. One can observe that prices increase at an accelerating rate with the marginal consumer's PPD level for a given level of product differentiation ( $t$ ). Higher levels of  $t$  lead to a higher and more vertically stretched distribution of prices for each level of PPD.

Meanwhile, Figure 2 illustrates the relationship of prices to product differentiation for different levels of marginal consumer PPD. As the figure indicates, higher levels of PPD ( $\rho$ ) lead to a steeper linear relationship between product differentiation and prices.

## 2.2 *A specific functional form example*

To gain further intuition, consider a specific functional form for  $h$ :

$$h(a, j) = a + j - 2aj$$

As  $h$  is continuous and differentiable on the whole support  $[0, 1] \times [0, \frac{1}{2}]$ , it satisfies our minimal requirements for  $h$ . Setting  $j = \frac{1}{2}$  yields  $h(a, \frac{1}{2}) = \frac{1}{2} \equiv k$ , so the function observes our normalization convention. Of course, this is only one of a wide array of possible forms that  $h$  can take.

Different values of  $a \in [0, 1]$  correspond to different, conceptually sensible distributions of PPD relative to the consumers' product preferences. Specifically, higher values of  $a$  correspond to a greater relative intensity of PPD for people with *stronger* exogenous preferences for the chosen product. Consider the case of  $a = 0$ : then  $h(0, j) = j$  for  $j \in [0, \frac{1}{2}]$ , and  $h(0, j) = 1 - j$  for  $j \in [\frac{1}{2}, 1]$ . This implies consumers with the most intense preferences for A or B have the lowest intensity of PPD – a world of “sophisticates” and “neophytes” as in the introduction. At the other extreme,  $a = 1$  yields  $h(1, j) = 1 - j$  for  $j \in [0, \frac{1}{2}]$ , and  $h(1, j) = j$  for  $j \in [\frac{1}{2}, 1]$ . In this case consumers with the most intense preferences for A and B have the lowest intensity of PPD – the world of “zealots” and “cool-heads” from the introduction. Meanwhile the median value  $a = \frac{1}{2}$  corresponds to all consumers having an equal intensity of PPD, regardless of the intensity of their preference for A or B. Figure 3 illustrates  $h(a, j) = a + j - 2aj$  for two intermediate cases,  $a = \frac{1}{6}$  and  $a = \frac{5}{6}$ .

Our proposed specific form for  $h$  sheds light on the ramifications of the result in Proposition 2. Consider the case involving sophisticates and neophytes ( $a = 0$ ). Only the

neophytes' PPD level has any role in the determination of prices; the PPD level of sophisticates has no effect on prices, because these consumers are relatively committed to one of the two products. On the other hand, in the case of zealots and cool-heads, where  $a = 1$ , only the cool-heads' PPD level affects prices. Zealots, who are inframarginal, have no effect on prices through PPD.

An expression for price based on  $h(a, j) = a + j - 2aj$  can be arrived at by substituting  $k = \frac{1}{2}$ , hence  $\rho = \frac{\theta}{2}$ , into (4):

$$p_A^* = p_B^* = \frac{2t}{2 - \theta} \quad (5)$$

Figure 4 illustrates the relationship of prices,  $t$ , and marginal consumer PPD specified in (5), as Figure 1 did for (4) in the general case. Here,  $\theta$  replaces  $\rho$  on the horizontal axis, given the fixing of  $k$  to  $\frac{1}{2}$ . The observed patterns are similar to those in Figure 1, except that the growth of price is bounded from above.

### 3. A Model with Endogenous Product Differentiation

Now let us complicate the model by making  $t$  a choice variable of the firms. Assume two stages. In the first stage, each firm  $i$  chooses a strategy  $t_i$ , where product differentiation in the market becomes the sum of the strategy choices  $t \equiv t_A + t_B$ . Thus product differentiation is essentially a public good to which each firm contributes. The firms act simultaneously, each taking the other's strategy choice as given. However, each firm  $i$  recognizes that its choice of  $t_i$  will influence the later selection of  $p_A$  and  $p_B$ . In the second stage, the firms set prices, each taking the other's price decision, and  $t$ , as



given. Let firm profits now be specified  $\Pi_i = p_i Q_i - ct_i^2$ . That is, firms face an increasing cost to investing in a higher level of product differentiation – say, through advertising.

The model may be solved recursively. Because product differentiation strategies are taken as given as Stage 2, each firm's price decision process is unchanged relative to the model in Section 2. Consequently, prices are given by (4).

Turning to Stage 1, it suffices for us to consider Firm A's optimization problem, given symmetry. Firm A knows that its choice of  $t_A$  in the first stage will not affect the division of sales between the firms; that is, it knows  $Q_A = \frac{1}{2}$ . Firm A's problem therefore is to choose  $t_A$  to maximize

$$\Pi_A = p_A Q_A - ct_A^2 = \frac{t_A + t_B}{2(1-\rho)} - ct_A^2$$

The first-order condition is  $\frac{\partial \Pi_A}{\partial t_A} = \frac{1}{2(1-\rho)} - 2ct_A^* = 0$  which yields  $t_A^* = \frac{1}{4c(1-\rho)}$ . Thus, by symmetry,  $t_B^* = \frac{1}{4c(1-\rho)}$ , implying

$$t^* = \frac{1}{2c(1-\rho)} \quad (6)$$

We may state:

*Proposition 4.* The firms choose higher levels of  $t$  in equilibrium the greater the level of  $\rho$ .

Consider the implications of the proposition for prices. Substituting (6) into (4), we obtain

$$p_A^* = p_B^* = \frac{1}{2c(1-\rho)^2} \quad (7)$$

Viewing (7) in the context of (4) and (6), we see that prices increase directly with  $\rho$  (i.e., proportional to the inverse of  $1 - \rho$ ), but also indirectly with  $\rho$  through the latter's effect on  $t$  (also proportional to the inverse of  $1 - \rho$ ). Thus the firms' ability to control product differentiation amplifies the effect that PPD has on prices, causing them to increase proportional to the inverse of  $(1 - \rho)^2$ .

Figure 5 provides a summary illustration of the relationship of prices,  $t$ , and marginal consumer PPD in the endogenous  $t$  case. The amplifying effect of endogenous product differentiation can be observed when Figure 5 is contrasted with Figure 1.

#### **4. Conclusion**

This paper has examined how competition in differentiated product markets is affected when consumers' product preferences are influenced positively by the price charged. It has considered, in particular, the role of the distribution of PPD across consumers relative to the intensity of their preferences for one product versus another. It has also considered the mediating role of the extent of product differentiation. The results indicate that prices increase with the PPD of the consumer who is just indifferent between products, but they are unaffected by the PPD of inframarginal consumers. Product differentiation increases the effect of the marginal consumer's PPD on price. When product differentiation is endogenous, PPD gives firms an extra incentive to increase differentiation.

The result for endogenous product differentiation has the important practical implication that firms operating in contexts exhibiting price-influenced product attitudes,

such as those that produce luxury goods with respect to which consumers engage in conspicuous consumption, will likely engage more intensively in product-differentiating strategies. They may advertise more, or they may invest heavily in product “improvements” intended to distinguish their products from competitors’ offerings. While increased price levels follow from preference price-dependence in cases where product differentiation may not be practically manipulated by the firms, the ability to manipulate the extent of differentiation acts as an accelerant to price levels, as indicated by (7) and in Figure 5.

The findings indicate the need for further empirical research on people’s tendencies toward price-influenced product attitudes. There may be a particular role for more precise neuroeconomic studies – or, alternatively, survey studies – than those previously undertaken. It is indeed interesting to observe, as Plassman et al. (2008) did, that consumers experience greater consumption pleasure when they believe the product they are consuming is more expensive. However, it would be useful to know whether *all* consumers experience the same increase in pleasure. If not, then one would want to know which consumers experience a greater increase in pleasure. Relevant questions include:

- Are inexperienced product consumers more or less prone to having their product attitudes – as revealed by consumption pleasure in neuroeconomic studies, or by survey responses in conventional studies – influenced by prices?
- Does the tendency toward price-influenced product attitudes vary with demographic factors, such as income or social class identification, that might be correlated to the intensity of underlying brand or product preference?

- Does the tendency vary with membership in loyalty programs, commitments such as contracts with termination fees, or other manifestations of lock-in?

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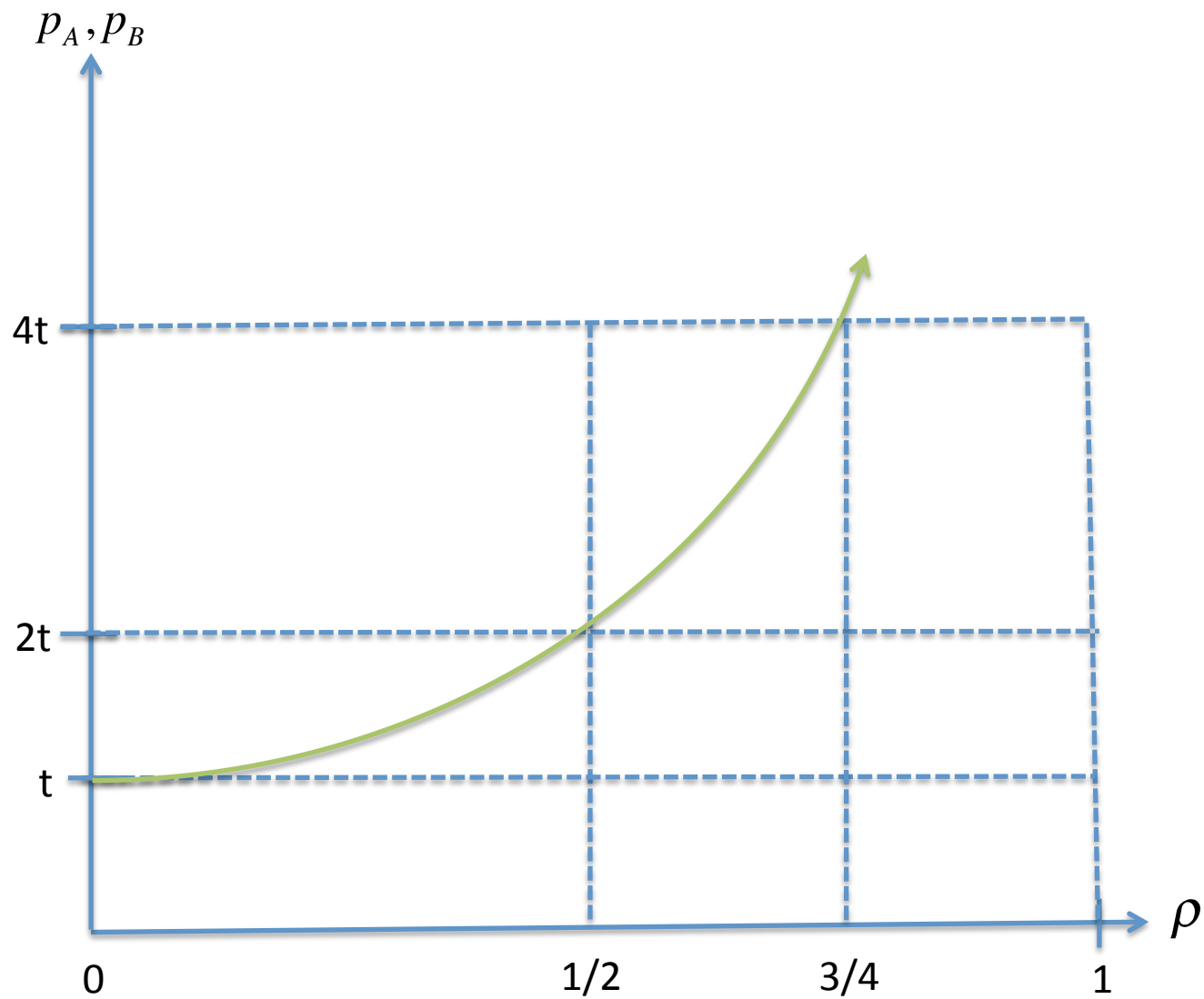


Figure 1. Prices and price-dependence of preferences with exogenous product differentiation, general case

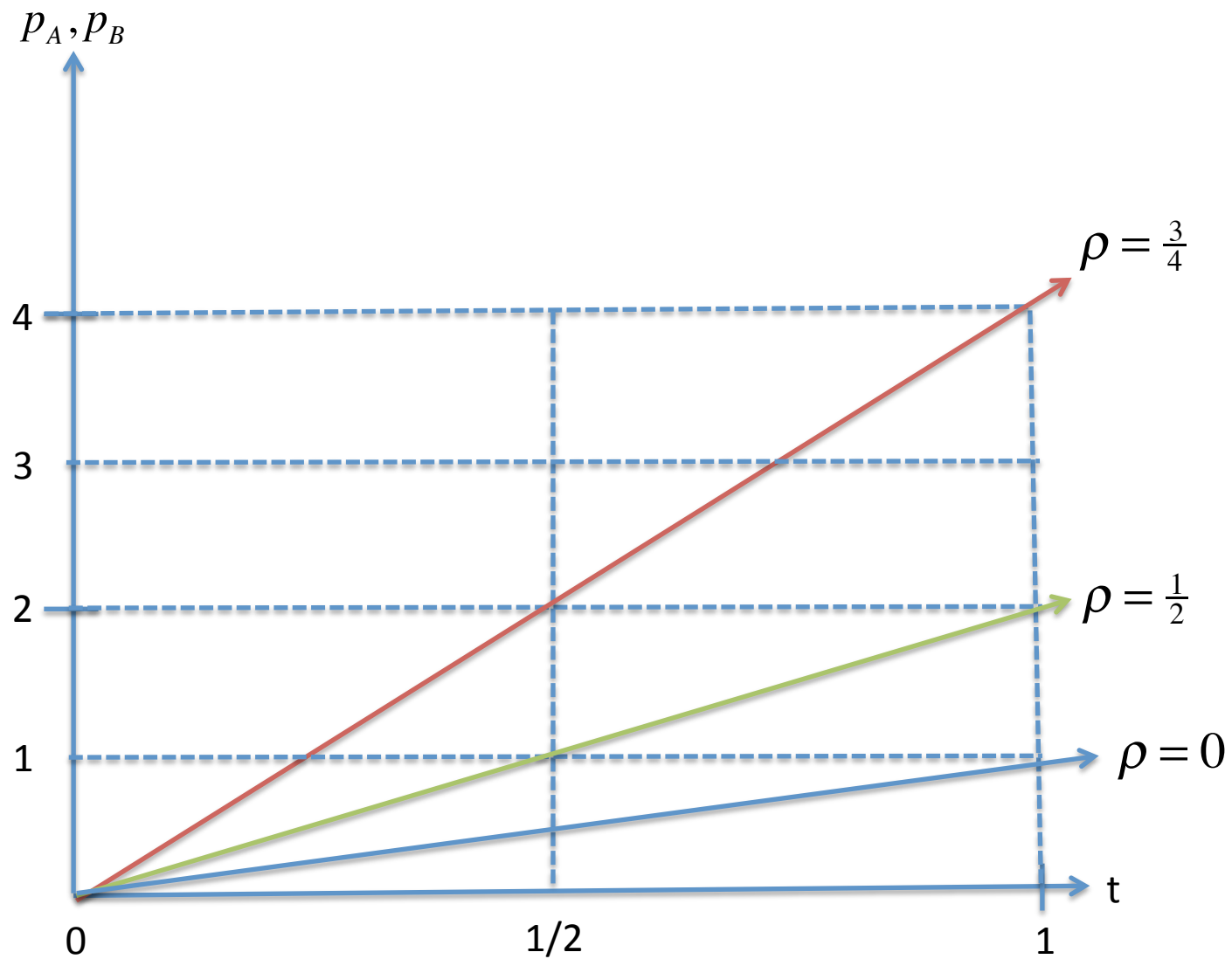


Figure 2. Prices vs. exogenous product differentiation with price-dependent preferences, general case

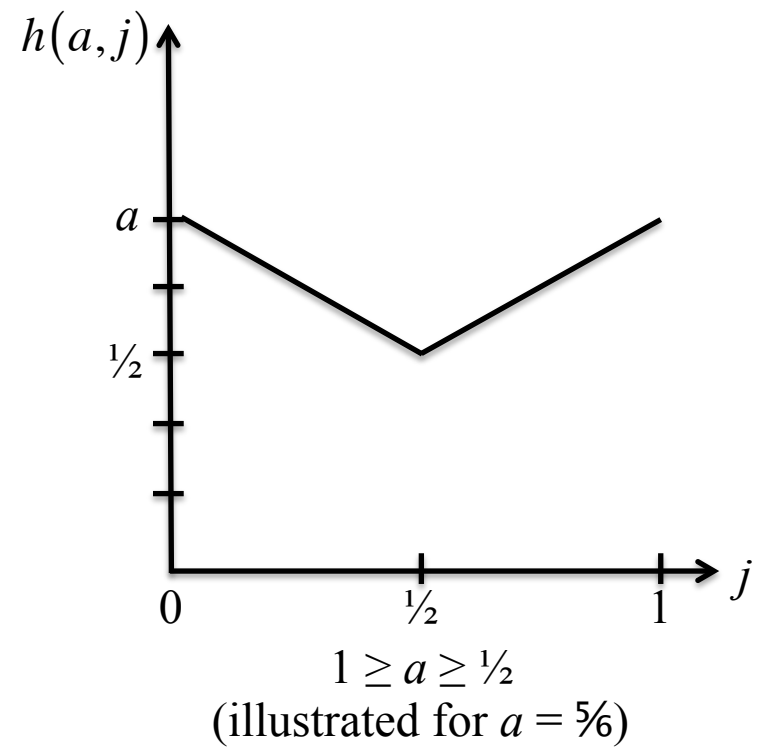
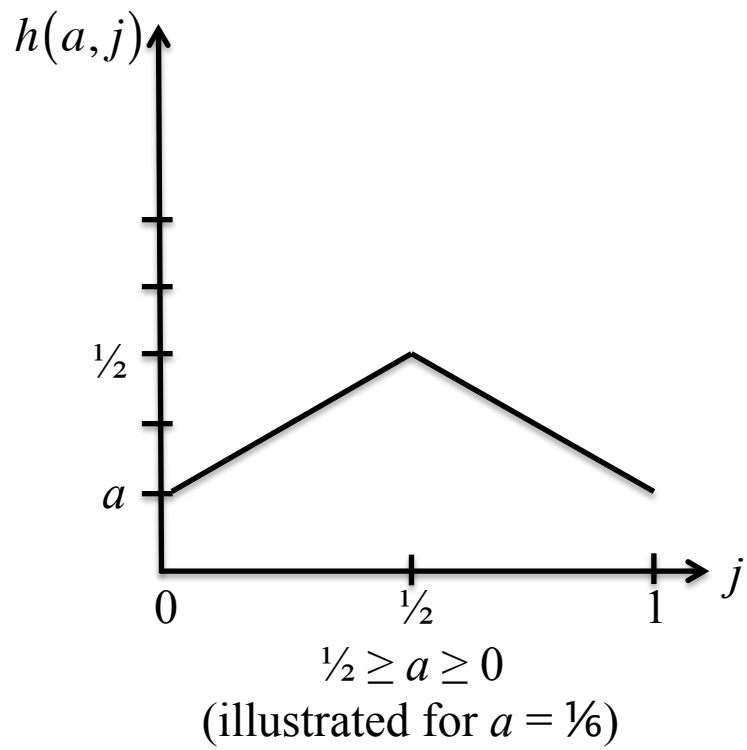


Figure 3. Values of PPD function  $h$  for  $h(a, j) = a + j - 2aj$ .



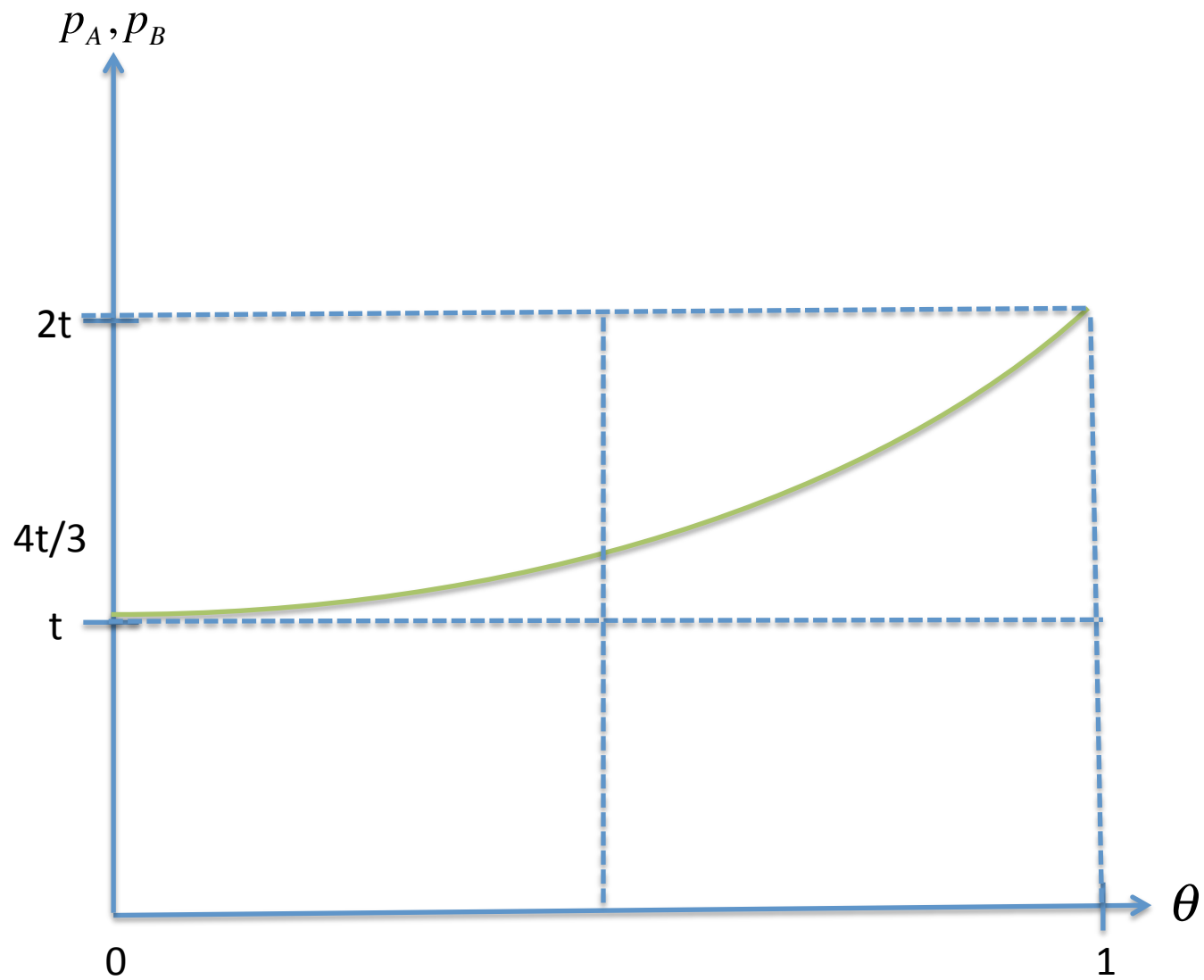


Figure 4. Prices and price-dependence of preferences with exogenous product differentiation,  $h(a,j)=a+j-2aj$  special case

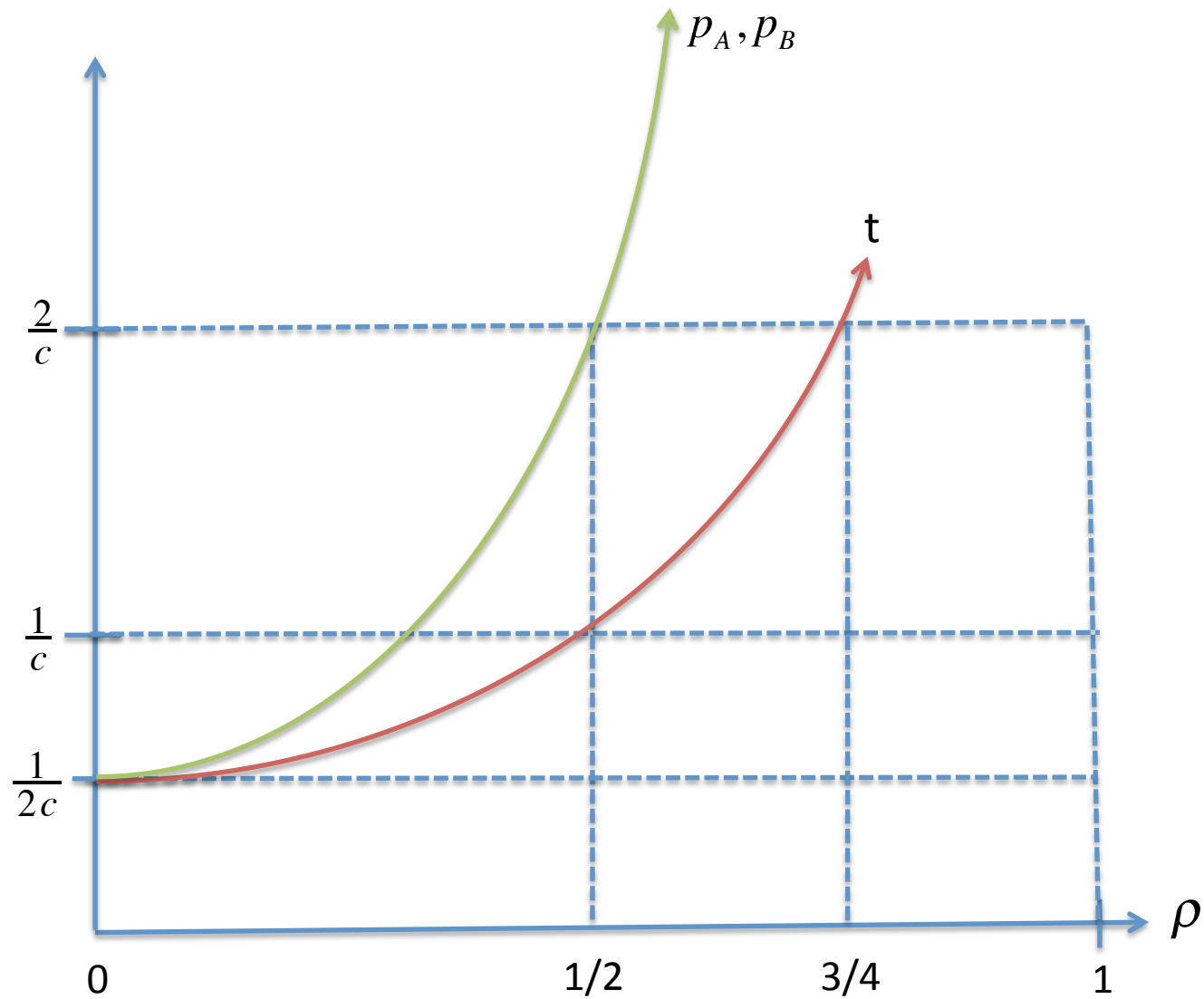


Figure 5. Product differentiation, price, and price-dependence of preferences (general case)