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Private and Public Incentive to Reduce Seasonality: A Theoretical Model

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Abstract In this article, the authors present a theoretical model to investigate the private and social incentives to reduce seasonality in a given market. They assume that consumers derive different utilities from the consumption of the same good in different seasons. The seasonal product differentiation is modelled along the lines of Gabszewicz and Thisse (*Price Competition*, *Quality and Income Disparities*, 1979) and Shaked and Sutton (*Relaxing Price Competition through Product Differentiation*, 1982). The authors assume that it is possible for a firm to invest in order to reduce the degree of the demand seasonality. They show that, for a wide set of parameter configuration, the optimal effort to reduce seasonality is higher from a social welfare perspective, as compared to the private producer perspective. The tourism market can represent an application of the present model. However, unlike most available literature in this field, their model provides a microeconomic basis for the evaluation of investments aimed at reducing seasonality, rather than taking a macroeconomic approach.

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1 Introduction

Seasonality is a major concern in several markets for different sectors (from tourism, transport, energy, agricultural and food items, movies and cultural goods to financial products). A large body of literature, in each of the different fields, deals with the causes and effects of seasonality. Even if some causes of seasonality are truly exogenous, there is no doubt that the seasonal pattern of markets can be affected largely by the institutional (or cultural) framework, and also by the choices of sellers. How strong the incentive is for firms and policy-makers to reduce the demand seasonality, if possible, is an open question.

The pros and cons for both sellers and consumers, indeed, are associated with the seasonal patterns of quantity and price. Seasonality entails private costs and benefits that, in most cases, diverge from social costs and benefits.[1] In industries with fixed capacity (in the case of the tourism sector, let us think, e.g., of beds in hotels or seats in airplanes), it is a common-place that sellers have a strong incentive to reduce the demand seasonality, while a consistent incentive also holds for policy-makers in reducing seasonality and avoiding peaks with congestion or an underutilization of capacity. In the field of tourism, for instance, a large set of interventions may be taken to reduce seasonality. Such interventions may be taken by the firms themselves (e.g., through appropriate pricing or special offers for the low season) or by policy-makers, at the national or local level – institutional measures, ranging from school time-table to holiday design, to the organization of specific events in the cultural field, in sport, and so on.

Often, private subjects complain about the lack of public initiatives aimed at reducing the seasonality of demand. Private subjects usually claim that they are unable to do business because of the lack of adequate public initiatives attracting consumers. However, on several occasions, public initiatives do not find consistent responses from private firms. Some examples can be easily given – in mountain resorts, several hotels remain closed at the beginning of December and in April, even if the ski stations are open; in minor Mediterranean islands or in specific

[1] See different contributions in Baum & Lundtorp (2001), and specifically Butler (2001); or Soo Cheong (2004), Koenig-Lewis & Bischoff (2005) and Cuccia & Rizzo (2011) for examples from the tourism sector.

seaside destinations, hotels and resorts remain closed in May or September, even if the connections are open and other public initiatives and interventions are operative.

In this article, we show that a conflict does arise between social and private incentives when investing to reduce seasonality, even if we do not consider the social costs emerging from external effects. We consider the case in which consumers derive different utility levels from the consumption of a good in high or low season; the preference for consumption in high (or low) season varies among consumers. The proposed model can be interpreted as an extension of the Gabszewicz & Thisse (1979) seminal model to the case of seasonal differentiation (see also Gabszewicz, 2009).

We assume that it is possible to use investments to reduce the demand seasonality. We find that only in some parameter regions do private and public incentives to reduce seasonality coincide; in other regions, the policy-makers find it optimal to make a greater effort to reduce seasonality when compared to private sellers. More specifically, it can happen that a policy-maker (caring for consumer utility and profits of firms) finds it optimal to have the market served over both seasons, while private suppliers find it optimal to serve the market during the high season; or, a policy-maker finds a larger amount of investment optimal, leading to complete market coverage, whereas private firms put in less effort and leave the market partially uncovered, even if they operate over both the seasons. Eventually, it can happen that both the social planner and the private firms find it optimal to serve the market in both seasons (though partially uncovered), but the optimal effort for reducing seasonality from a private perspective is smaller when compared to the social choice.

The reason for conflict between public and private incentives to reduce seasonality rests on the fact that policy-makers take into account the utility of consumers too, whereas firms are interested in their own profits only. No further considerations concerning (negative) externalities in the high season and congestion (that is, the social costs of seasonality) are taken into account. In other words, the conflict between public and private incentives to mitigate seasonality rests on the trivial fact that not only do producers benefit from a limited seasonality degree, but so do consumers, thanks to the higher utilities generated by the deseasonalization measures. In other words, we show that private and social incentives to reduce seasonality are not aligned, and the social planner desires greater effort to mitigate seasonality, even if he does not take into account the local population (other than local firms), which of course can gain benefit from the reduction of seasonality.

In this article, we take a microeconomic perspective to explain private and public incentives to reduce demand seasonality. In fact, as far as we know, a comprehensive microeconomic theory of seasonality does not exist. The available economic theory of seasonality mainly takes a macroeconomics approach, and focuses on the reasons and the pros and cons of seasonality. Closely related to this macroeconomic line of research, a large body of applied empirical research is available, which defines and measures the degree of seasonality in time. In this article, we disregard the applied literature on the statistical measurement of seasonality and focus on the microeconomic theoretical aspects of seasonality.

The structure of the article is as follows. Section 2 provides a short review of available theoretical literature on seasonality; from these contributions, we select some factors for our model. Section 3 introduces the basics of the model and explains how it can be considered as an extension of well-known models of product differentiation and their application to the case of seasonal demand. Section 4 takes into account the possibility of high investment for reducing seasonality. Section 5 takes the social welfare perspective and compares the optimal levels of effort aimed at reducing demand seasonality, from the social and private standpoints. Section 6 provides the concluding remarks and comments, and also suggests some possible extensions of the model.

2 Insights from Literature Review

In economic terms, generally speaking, seasonality consists in the systematic, although not necessarily regular, movement of a variable in a selected period of time, usually the year (Hylleberg, 1992). In statistic and econometric fields, several operative definitions are available to measure and compare the degree of seasonality in time series. However, since our present interest is mainly theoretical, we do not need to make spefic reference to this body of statistic research.[2] Economic literature mainly focuses on the determinants and consequences of seasonality,

[2] A short selection of relevant contributions for the definition and measurement of seasonality, with particular reference to tourism, includes Ghysels (1988), Hylleberg (1992), Butler (1994), Baum and

usually analysing the dynamics at the level of specific markets and or economic systems.

Following Hylleberg (1992), seasonality may have natural and/or institutional causes, beyond the so-called calendar effects.[3] Natural causes, such as climatic factors (temperature, sunlight and rainfall) are generally out of the control of the decision-makers.[4] Among the institutional aspects that influence seasonality, we can mention the schedule of school holidays, the planning and scheduling of festival or cultural events and the planning of urban public and private services supply that can influence the preference of citizens on the consumption across seasons.

The seasonality of demand for specific goods may change over time, even if seasonality changes are usually quite slowly. With reference to tourism, for instance, the patterns of seasonality of a tourism destination can change over the life cycle of the destination (see, e.g., the analysis of the Balearic Islands, in Rossellò Nadal et al., 2004). In this sense, the choice of producers about marketing the positioning of the good may have some effect on the demand seasonality (Yacoumis, 1980).

In tourism (but also in other sectors), seasonality has obvious (macro) effects on several important aspects. In their comprehensive review, Koening-Lewis & Bischoff (2005) distinguish three domains of effects – economic, ecological and social effects. We can further distinguish the individual from the aggregate effects. Consider also that seasonality entails costs, but also benefits, for different subjects,

Lundtorp (2001), and especially, the contribution of Lundtorp (2001). See also the comprehensive book by Ghysels and Osborn (2001) on the econometric modelling of seasonality.

[3] Calendar effects refer to the fact that different months have a different number of working days (and different number of weekends and holidays), with obvious effects on the aggregate level of production and various other economic variables.

[4] However, if we think of the case of tourism, at least two cautionary observations are possible: firstly, climatic changes, such as global warming, are partly due to human behaviour and may have an impact on the seasonality of tourism flows (Butler & Mao, 1997; Agnew &Viner, 2001); secondly, as noted by Cuccia & Rizzo (2011), there are many tourism destinations where the climate does not represent a strict constraint but there exists seasonality in tourism: the Mediterranean (or even tropical) sun and sea destinations, for example, have their peak seasons in the summer months, but tourism suffers during the rest of the year, even if their climate is quite mild and bathing tourism can be practised in several months of the years. Hence, the true cause of seasonality has to be found elsewhere.

so it has redistributive effects, and a positive optimal degree of seasonality can be posited under specific circumstances (Murphy, 1985; see also Butler, 1994; 2001).

As to the individual economic costs, seasonality may affect the cost of production of goods and services. The larger the demand seasonality, the more difficult the determination of the optimal dimension of the private capital to invest (e.g., for the production of accommodation, food, and so on, in the case of tourism). If the private investors consider the peak season demand to determine the dimension of the facilities, in the off-seasons, there will be a certain level of under-exploited capacity, and hence relevant fixed costs. The return on capital could be lower and more volatile due to demand seasonality. The cost of seasonality paid by the private investors can be shifted to the final consumers; in the case of tourism, the final consumers are both tourists and residents – who pay higher prices for any kind of product and service in the peak seasons – and workers who do not find easy long-term job opportunities and, in most cases, have to accept seasonal jobs without the usual protective measures.

As for individual benefit, it has been suggested that seasonality permits maintenance work with low opportunity costs during the off-season periods (Grant et al. 1997). From the labour force perspective, in some areas, such as rural regions where the labour demand in the tourism sector can be considered as a complement to agriculture, seasonality in tourism can represent a benefit, as long as the seasonal peaks in the labour markets in agriculture and tourism are different, and the income from tourism can complement the (main) income from agriculture. This point also holds for some people who choose seasonal occupations to suit their main (non-market) activities, like students or housewives (Mill & Morrison, 1998).

At the macroeconomic level, seasonality entails costs related to the management of local public utilities. If we take tourism, the dimension of the public utilities is usually based on the dimension of the residents of the destinations; therefore, if the destination is congested by tourist arrivals in the peak seasons, there can be problems in water supply, waste management and traffic ruling. There can be an over-exploitation of the capacity of the local public utilities that causes dissatisfaction both in the residents and in tourists. These problems concerning the optimal dimension of public infrastructures usually take a long time to be resolved – the investment decisions of policy-makers have procedures and times that vary from those of private investors.

The costs and benefits of seasonality from the "ecological" perspective can be easily understood – the pressure of tourism on the environment could be unsustainable for the destination if it goes beyond the carrying capacity of the site and can cause irreversible intra-generational and inter-generational damages – damages to natural heritage, litter problems and disturbance of wildlife are analysed by available studies (e.g., Manning & Powers, 1984; Grant et al. 1997); these problems can crowd out the local communities and alter the image of the destinations. However, long off-season periods may be the only chance for the local ecological system to recover (Hartmann, 1986).

From a socio-cultural standpoint, the seasonal concentration of demand may be the cause of inappropriate (or even criminal) behaviour, with a lower quality of life during peak seasons, due to a sort of "social carry capacity". Yet, off-season months give the community relief from "social stress" (Murphy, 1985).

In any case, determining the optimal degree of seasonality, which changes according to the carrying capacity of the different tourism destinations, could require a preliminary analysis of the carrying capacity of the local destinations (through Benefit-Cost-Analysis or Environmental Impact Valuation, as Candela & Castellani, 2008, suggest).

As mentioned earlier, a genuine microeconomic theory of seasonality is, to the best of our knowledge, absent. When we talk about a microeconomic theory of seasonality, we intend to refer to the optimal individual choice in the presence of seasonal dynamics. From the firm's point of view, the unique contributions we are able to mention are those related to the peak-load pricing – in this vein of literature, it is shown that when demand changes in a given time period (during the day, or during the week or during the year), in the presence of fixed capacity and varying marginal cost, the firms find it optimal to change the price, setting a higher price in correspondence to higher demand. In other words, price discrimination is profitable, if possible. Clearly, the theory of peak-load price – even if conceived for explaining public utility pricing in the event of demand peaks – is appropriate for dealing with the pricing of goods that have a seasonal demand. From the consumer standpoint, the contributions we have in mind refer to non-standard explanations of the individual preference for the peak season – bandwagon effects or forms of demand addiction or sluggishness provide a rational justification for seemingly strange individual habits, such as to go on holidays in the peak summer season when tourism destinations are really congested.

In the model we present here, we take into account several aspects of seasonality, as detailed by available literature, and we will show that an individual firm – aiming at its maximum profit – has a lower incentive to reduce seasonality as compared to a policy-maker who interested in social welfare. Some (important) details are not taken into account by our model, even though these details would lead to an obvious strengthening of our hypothesis. For instance, in our theoretical model, the marginal cost of production will be assumed to remain constant across all seasons. Available literature underlines the fact that production costs are higher in the peak season, but this detail is not considered in our model simply because we will show that the lower incentive for firms to reduce seasonality is not due to the fact that production costs are higher in the peak season.

3 The Model

Consider a market characterized by seasonality, that is, consumers get different utility levels depending on whether they consume in the high season or the low season.

Each consumer can choose between buying one unit of the good (either in high or low season) or not buying at all.

We define consumer θ's utility function as:

$$U(\theta, u_i) = \begin{cases} U_0 + \theta u_h - p_h & \text{if buys in high season} \\ U_0 + \theta u_l - p_l & \text{if buys in low season} \\ 0 & \text{does not buy at all} \end{cases} \tag{1}$$

where: U_0 is the utility derived from consuming the good, whatever the season; u_h and u_l are the (constant) levels of utility from consuming in high or low season, respectively; p_h, p_l are the set prices for each season; parameter θ measures the differential in utilities that the individual consumer gets, by consuming in high season as opposed to the low season. We assume that consumers are heterogeneous with respect to the evaluation of seasonal characteristic, so that they differ as far the parameter θ concerns; in particular, the parameter θ is assumed to be distributed on $[0, \overline{\theta}]$.

Solving for θ the equation $U_0 + \theta u_h - p_h = U_0 + \theta u_l - p_l$, we identify the consumer indifferent between h and l, that is:

$$\theta_{h,l} = \frac{p_h - p_l}{\Delta u} \tag{2}$$

where $\Delta u \equiv u_h - u_l > 0$.

In the same way, solving for θ the equation $U_0 + \theta u_l - p_l = 0$, we find the consumer who is indifferent between l and non consumption:

$$\theta_{l,0} = \frac{p_l - U_0}{u_l} \tag{3}$$

Solving for θ the equation $U_0 + \theta u_h - p_h = 0$, we find the consumer indifferent between h and non consumption:

$$\theta_{h,0} = \frac{p_h - U_0}{u_h} \tag{4}$$

It is easy to show that

$$\theta_{h,l} \geq \theta_{h,0} \Leftrightarrow \theta_{h,0} \geq \theta_{l,0}$$

while:

$$\theta_{h,l} \leq \theta_{h,0} \Leftrightarrow \theta_{h,0} \leq \theta_{l,0}$$

so that one of the following inequalities must be true:

$$\theta_{h,l} \geq \theta_{h,0} \geq \theta_{l,0} \tag{5}$$

$$\theta_{h,l} < \theta_{h,0} < \theta_{l,0} \tag{6}$$

Figure 1, in which the abscissa is the set of consumers ordered by θ and the ordinate is the utility level in high and low season, graphically shows the case of inequality (5), where consumer indifferent between h and l is at the right of the consumer indifferent between l and non consumption. Figure 2, instead, represents

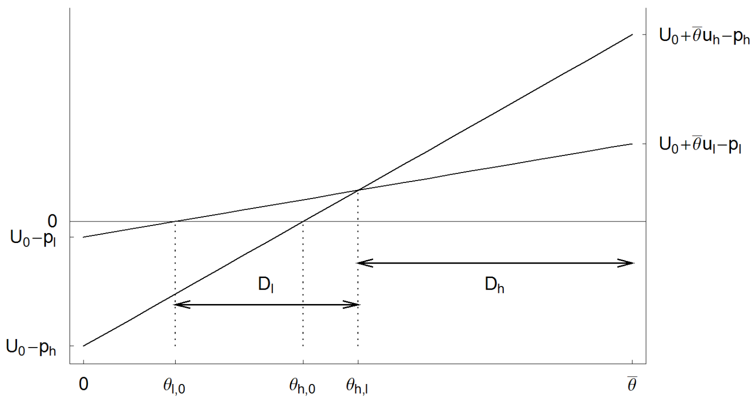

Figure 1: Utility in high and low season depending on θ (case (5)).

the case of inequality (6), where the consumer indifferent between h and l is at the left of the consumer indifferent between l and non consumption.

We assume that θ is uniformly distributed over $[0,\overline{\theta}]$,with the mass of consumers normalized to 1. While convenient for mathematical reasons, the uniform distribution assumption does not limit our analysis significantly: all consumers (apart from the consumer with $\theta = 0$) have a preference for the high season, with a differing intensities.

Under parameter configuration corresponding to (5), the demand functions in high and low seasons (both positive) are:

$$D_h = \frac{\overline{\theta} - \theta_{h,l}}{\overline{\theta}} = \frac{\overline{\theta}\Delta u - p_h + p_l}{\overline{\theta}\Delta u} \tag{7}$$

$$D_l = \frac{\theta_{h,l} - \theta_{l,0}}{\overline{\theta}} = \frac{U_0\Delta u + u_l p_h - u_h p_l}{\overline{\theta} u_l \Delta u} \tag{8}$$

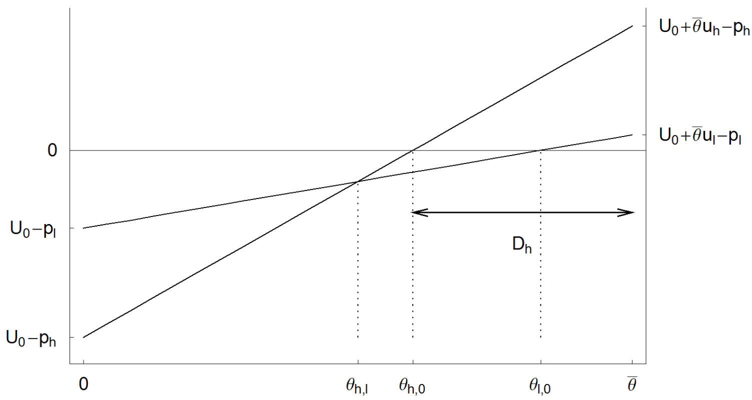

Figure 2: Utility in high and low season depending on θ (case (6)).

In the case of parameter configuration corresponding to inequality (6), the demand functions in high and low seasons are:

$$D_h = \frac{\overline{\theta} - \theta_{h,0}}{\overline{\theta}} = \frac{U_0 + \overline{\theta} u_h - p_h}{\overline{\theta} u_h} \tag{9}$$

$$D_l = 0 \tag{10}$$

The profit function of a monopolistic firm is:

$$\pi(p_h, p_l) = D_h(p_h, p_l)(p_h - c_m) + D_l(p_h, p_l)(p_l - c_m) \tag{11}$$

where $c_m > 0$ is the marginal cost of production.

Some comments are in order. First, we are going to consider a market served by a monopolistic firm. In the case of tourism, it is true that there are some specific destinations in which the hypothesis of a monopolistic provider could be justified. In most other cases, however, the market structure is closer to oligopoly or monopolistic competition (with differentiated goods). In any case, private firms usually have a degree of market power, at least at the local level. We are ready to admit that the monopoly assumption is a strong simplification, and that the model should be extended, taking into account different market structures; this is left to future research.

Second, note that we do not consider fixed costs. In fact, fixed costs are immaterial to the optimal solution of the problem of the monopolistic firm, at least as long as profit remains positive; however, it is important to recognize that concern about fixed costs is very strong in the real world for firms facing a seasonal demand. Similarly, we assume that marginal costs are equal across seasons, even if the assumption of different marginal costs across seasons could be justified, and perhaps would be more realistic.[5]

Maximizing the profit with respect to high and low season prices, we get the optimal prices:

$$p_h^* = \frac{c_m + U_0 + \overline{\theta} u_h}{2} \tag{12}$$

$$p_l^* = \frac{c_m + U_0 + \overline{\theta} u_l}{2} \tag{13}$$

Substituting the optimal prices in equations (2), (3), (4) we get:

$$\theta_{h,l} = \frac{\overline{\theta}}{2}$$

$$\theta_{h,0} = \frac{\overline{\theta}}{2} + \frac{c_m - U_0}{2u_h}$$

$$\theta_{l,0} = \frac{\overline{\theta}}{2} + \frac{c_m - U_0}{2u_l}$$

and then the following lemmata:

LEMMA 1. If the marginal cost of production is low ($c_m < U_0$), inequalities (5) are true and the firm operates in both seasons. The optimal prices are given by

[5] Asymmetry in the marginal costs across seasons is postulated in several available contributions in the literature, and it is at the basis of the peak-load price behaviour in several markets. Such an asymmetry would imply much more involved calculations in our model. However, consider that we allow for different prices across seasons, and hence for different mark-ups upon the marginal costs, even in this simple version of the model with equal marginal costs across seasons.

(12) and (13) and the profit is:

$$\pi^* = \frac{(U_0 - c_m)^2 + \overline{\theta} u_l (2U_0 + \overline{\theta} u_h - 2c_m)}{4\overline{\theta} u_l}$$

LEMMA 2. If the marginal cost of production is high ($c_m > U_0$), inequalities (6) are true and the firm operates only in high season. The high season optimal price is given by (12) and the profit is:

$$\pi_0^* = \frac{(U_0 + \overline{\theta} u_h - c_m)^2}{4\overline{\theta} u_h} \tag{14}$$

Moreover if:

$$c_m < U_0 - \overline{\theta} u_l \tag{15}$$

then the market is covered ($\theta_{l,0} \leq 0$). If

$$c_m > U_0 + \overline{\theta} u_h \tag{16}$$

then the firm does not operate, not even in high season ($\theta_{h,0} \geq \overline{\theta}$).

4 Deseasonalization Effort

Consider now the case in which the firm, before setting prices, is able to choose to make an effort e in order to deseasonalize the demand. The effort e, by part of the firm, is defined in a way such that consumer θ's utility function is:

$$U(\theta, u_i) = \begin{cases} U_0 + \theta u_h - p_h & \text{if in high season} \\ U_0 + \theta u_l - p_l + e & \text{if in low season} \\ 0 & \text{if not consume} \end{cases} \tag{17}$$

Deseasonalization effort is assumed to entail a quadratic cost, $C(e) = ce^2$, $c > 0$. Just to give an example, one can imagine that e represents the supply of additional service in the general case of a good with seasonal pattern, like the organization of entertainment events, or the provision of wet weather facilities during the low season in the case of tourism markets.

We are aware that our modelling design for deseasonalizing actions is very simple – we assume that investments can be made that are effective in enhancing the low-season demand. In the real world, a wide range of actions are available, with different effectiveness. Keonig-Lewis & Bishoff (2005) list various types of counter-seasonal actions – beyond the already mentioned actions aimed at *increasing the demand outside peak season* (e.g., creation or promotion of events or festival; creation of diversified multiple attractions; bad weather facilities), they mention the actions for *reducing the demand in peak season* (e.g., through the introduction of additional fees for specific goods or services); for r*edistributing the demand* across seasons or across space (spatial redistribution of demand at peak times); for *increasing supply in the peak season* (by expanding the capacity or using external resources) or *reducing the supply off the peak season* (through the closure of structures during the dead periods, where possible) or *redistributing supply* (via the restructure of output, thanks to product differentiation or a modified market/mix of the product).[6] We omit to model all the different ways to reduce seasonality, and we do not take into account the uncertainty characterizing the outcomes of various specific measures. Moreover, we are also aware that even if private providers (or public authorities) make an effort to boost the demand in the low season, it may not imply that the consumer's perception about the season will be influenced – it depends on "what's on offer" and on the entire supplied package (Cuccia & Rizzo, 2011). However, for the sake of simplicity, we assume that effective investments are easily available to reduce seasonality, with quadratic cost. Quadratic cost – a rather usual assumption in industrial organization – is aimed at capturing the non-linearities in the investment effort, which are quite realistic in general and also in this specific case.

An additional remark is in order, as far as the difference is concerned between the deseasonalization effort considered in our model, and the policy of price reduction in the low season. From the utility function in the low season, as modelled in (17), one can easily realise that the effort e can be interpreted as a

[6] On specific actions to mitigate seasonality in selected tourism destinations, see also Bar-On (1999), Baum & Lundtorp (2001) and Capò Parrilla et al. (2007), among others.

linear price reduction with respect to p_l, the effective price for consumers becoming $(p_l - e)$. On the one hand, it is correct to state that the net utility of consumers is given by the difference between the gross utility from consumption and price –and hence, there is a similarity between increasing the gross utility and reducing the price; on the other hand, the two strategies are substantially different. Indeed, in the case of price reduction, the firm does not intervene on the characteristics of the good,[7] while in the case of the deseasonalization effort, the firm tries to affect the characteristics of the good, as much as possible. Clearly, price reduction policies do not require explicit non-linear effort, while our model explicitly considers the non-linearities in the investment effort.[8]

Finally, it must be noticed that the cost of effort is fixed for the produced quantity; this assumption is debatable and a different assumption could be appropriate as well. Nevertheless, we prefer to assume such a simple hypothesis because we have in mind a situation in which deseasonalization efforts are made prior to production, and hence the cost of deseasonalization is not affected by the (subsequent) amount of production.

The effort e, as modelled in (17), shifts up the low season utility, moving $\theta_{h,l}$ rightward and $\theta_{l,0}$ leftward, with reference to figures 1 and 2. In this case, the equations (2) and (3) are substituted, respectively, by the following:

$$\theta_{h,l} = \frac{p_h - p_l + e}{u_h - u_l} \tag{18}$$

$$\theta_{l,0} = \frac{p_l - e - U_0}{u_l} \tag{19}$$

[7] On the policy of price reduction in low season, in tourism markets, see specifically Baum & Mudambi (1995).

[8] Admittedly, the deseasonaliztion effort would have been more properly captured by assuming consumer net utility in low season of the form $U_0 + \theta(u_l + e) - p_l$, instead of the formulation considered in (17): with such an alternative formualation, it is clear that the deseasonalization effort affect the characteristics of the good, and hence the gross utility of consumers. However, under such a formulation it is not possible to arrive at analytical close results, and one is forced to resort to numerical simulations to find the optimal choices. Following such a route, we found that under plausible parameter configuration substantial results remain unchanged, with respect to the analytical results from our formulation. For this reason we prefer to develop the model under the simpler form corresponding to eq. (17).

while $\theta_{h,0}$, as defined by (4), does not change, since it is independent of e. As before, we can show that one between (5) and (6) must be true.

In case of (5), where the demand is positive in both seasons, this implies a reduction of D_h to the good of D_l ($\theta_{h,l}$ moves rightward), and an higher market coverage, still to the good of D_l ($\theta_{l,0}$ moves leftward). Therefore, the demand functions become:

$$D_h = \frac{\overline{\theta}\Delta u - p_h + p_l - e}{\overline{\theta}\Delta u} \tag{20}$$

$$D_l = \frac{U_0\Delta u + u_l p_h - u_h p_l + u_h e}{\overline{\theta} u_l \Delta u} \tag{21}$$

In case of (6), where the demand is positive only in the high season, if the deseasonalization effort is sufficiently high, the firm starts operating in the low season; otherwise, the investment does not affect demand and prices, and the demand functions remain (9) and (10).

4.1 The Firm's Optimal Choice

The firm profit function is:

$$\pi(p_h, p_l) = D_h(p_h, p_l)(p_h - c_m) + D_l(p_h, p_l)(p_l - c_m) - ce^2 \tag{22}$$

Substituting the demand functions in the profit function and maximizing wrt the prices, we get the following optimal prices:

$$p_H^* = \frac{c_m + U_0 + \overline{\theta} u_h}{2} \tag{23}$$

$$p_L^* = \frac{c_m + U_0 + \overline{\theta} u_l + e}{2} \tag{24}$$

Lemmata 1 and 2 are still valid for $e = 0$. As e increases, we have some particular cases:

1. If $e \geq e_c \equiv \overline{\theta} u_l + c_m - U_0$, then the market is fully covered.

2. If $e \geq e_i \equiv \overline{\theta}\Delta u$ then $D_h = 0$, that is, the firm operates only in the low season.

Clearly, e_c and e_i represent the threshold level of effort under which the market is, respectively, full covered or covered only in the low season. In what follows we assume that $e_c < e_i$ (i.e. $c_m < U_0 + \overline{\theta}(\Delta u - u_l)$), which means that investing in deseasonalization, first the firm covers the market, and then the high season will possibly be erased.

This implies that the firm has an incentive to invest in e only in order to increase D_l by an increase of the market coverage and not by a reduction of D_h, since this would imply a reduction of profits, because the high season price is always higher than the low season price ($e < e_i$); therefore the firm will never invest $e > e_c$.

4.2 Case 1: Low Production Costs

PROPOSITION 1. If the marginal cost of production is low ($c_m < U_0$), and hence Lemma 1 holds, then:

(i) if $c > u_h/(4\overline{\theta}u_l\Delta u)$ then there are two cases:

$$\begin{aligned} c_m &> \psi_\pi(c) \Rightarrow e^* = e_m \equiv \frac{(U_0 - c_m)\Delta u}{4\overline{\theta}cu_l\Delta u - u_h} \\ c_m &< \psi_\pi(c) \Rightarrow e^* = e_c \end{aligned}$$

where $\psi_\pi(c)$ is the decreasing convex function

$$\psi_\pi(c) \equiv U_0 - \overline{\theta}u_l + \frac{\overline{\theta}\Delta u}{4\overline{\theta}c\Delta u - 1}$$

(ii) if $c < u_h/(4\overline{\theta}u_l\Delta u)$ then the firm finds it optimal to invest in desasonalization up to the complete coverage of the market, $e^* = e_c$.

Proof: In appendix.

By lemma 1, if the marginal cost is low, the firm tends to operate in both the seasons, but in general, without completely covering the market.

If the investment cost is lower than a certain threshold, the profit function is convex and divergent in e. Hence, the firm has an incentive to invest up to the complete coverage of the market.

If, on the contrary, the investment cost is high then the profit function has a maximum in e_m: therefore the firm will invest in deseasonalization, but not necessarily completely covering the market. In particular, only if $c_m < \psi_\pi(c)$ and then $e_m > e_c$, then the firm will cover the market completely.

4.3 Case 2: High Production Costs

PROPOSITION 2. If the marginal cost of production is high ($c_m > U_0$), and hence Lemma 2 holds, then:

(i) if $c > u_h/(4\overline{\theta}u_l\Delta u)$, the firm finds it optimal not to invest in deseasonalization, that is, $e^* = 0$

(ii) if $c < u_h/(4\overline{\theta}u_l\Delta u)$, there are two cases:

$$\begin{aligned} c_m &> \phi_\pi(c) \Rightarrow e^* = 0 \\ c_m &< \phi_\pi(c) \Rightarrow e^* = e_c \end{aligned}$$

where $\phi_\pi(c)$ is the decreasing convex function

$$\phi_\pi(c) \equiv \frac{\sqrt{4\overline{\theta}cu_h\Delta u}(U_0 - \overline{\theta}u_l) - u_l(U_0 - \overline{\theta}u_h)}{\sqrt{4\overline{\theta}cu_h\Delta u} - u_l}$$

Proof: In appendix.

By lemma 2, if the production cost is high, the firm will tend to operate only in the high season.

However, if the investment cost is lower than a certain threshold, the profit function is convex and divergent in e, with a firstly decreasing part. Therefore if the marginal cost is not excessively high with respect to the investment cost ($c_m < \phi_\pi(c)$), the firm finds it convenient to invest in deseasonalization up to the complete coverage of the market.

In particular, if the firm can invest in deseasonalization at least till the threshold level:

$$e_\sigma \equiv \frac{\Delta u(c_m - U_0)}{u_h - \sqrt{4c\overline{\theta}u_h u_l\Delta u}} \tag{25}$$

it will reach profits at least equal to those obtainable without deseasonalization (π_0^*).

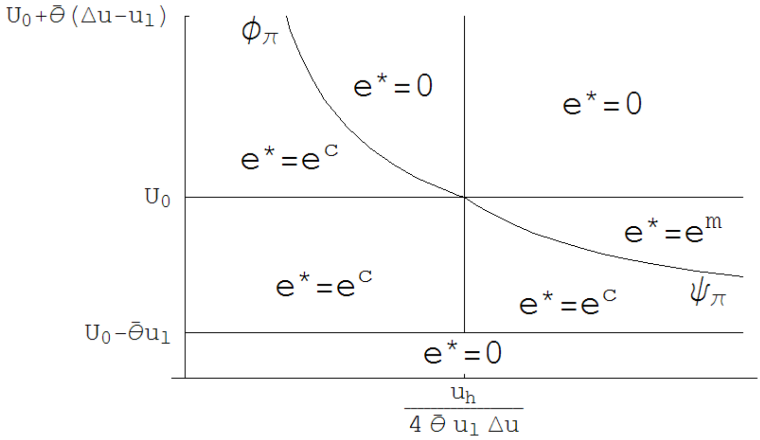

Figure 3: Deseasonalization effort e in the space (c, c_m)

If, on the contrary, the deseasonalization cost is high, the firm will not be able to recover such costs through the low season activity, and hence it is operative only in the high season.

Figure 3 illustrates the optimal behaviour of the firm, depending on the levels of the production cost c_m and the deseasonalization cost c. In the region under the curve defined by functions ϕ_π and ψ_π, the firm will completely cover the market with deseasonalization investments (if the market was not already covered from the beginning); above such curve, however, the market will remain partially uncovered and, if the production cost is high ($c_m > U_0$), the firm will continue to operate only in the high season, without deseasonalization investment.

5 Welfare

Here, we aim at evaluating the optimal amount of deseasonalization effort from a social welfare perspective. Social welfare is defined as the sum of firm profit and consumer surplus minus the investment cost in deseasonalization:

$$w(e) \equiv \frac{1}{\overline{\theta}}\left[\int_{\theta_{l,0}}^{\theta_{h,l}}(U_0+\theta u_l+e)d\theta+\int_{\theta_{h,l}}^{\overline{\theta}}(U_0+\theta u_h)d\theta\right]-c_m(D_h+D_l)-ce^2 \tag{26}$$

It is worth stressing that social welfare does not consider the welfare of any third party outside the market, like the local population in a tourist destination. A policy-maker who assumes the social welfare function under consideration can be interpreted as extremely altruistic, as far as he cares about the non-domestic, but not about the domestic, household welfare. Our assumption also entails that we overlook, at the moment, the large body of literature focusing on the interest of local communities in reducing the seasonality of incoming tourism (see, e.g., Butler, 2001; Capò Parrilla et al., 2007). We fully agree with the observation that our assumption can be questioned; however, it is at the core of an important aspect of our present model – we are going to show that the optimal effort for reducing seasonality is higher from the social welfare perspective as compared to the private firm standpoint. Thanks to our assumption, it is clear that this conclusion does not depend on the trivial fact that the local population welfare enters social welfare, while it is not considered by a profit-oriented firm.

Furthermore, it is worth stating openly that the cost for reducing seasonality, from the social welfare standpoint, is the same as for the private firm. In the real world, one can argue that the kind of deseasonalization efforts made by the policy-makers (taking a social welfare perspective) are different when compared to the private interventions aimed at deseasonalization, so that it would be appropriate to assume different cost functions. However, the assumption of different cost functions for private and public subjects would make it impossible for a sensible straightforward comparison between the optimal levels of effort from the private and social perspectives. The fact that the policy-maker, in the real world, can make *different* interventions to mitigate seasonality, is an additional point that we leave for future research. At the present moment, we are simply evaluating whether the private effort to deseasonalize is efficient from a social welfare perspective. With an almost identical analysis to the previous one, we get what follows:

PROPOSITION 3. If the marginal cost of production is low ($c_m < U_0$), and hence Lemma 1 holds, then:

(i) if $c > 3u_h/(8\overline{\theta}u_l\Delta u)$ then there are two cases:

$$\begin{aligned} c_m &> \psi_w(c) \Rightarrow e^* = e_{pm} \equiv \frac{3(U_0 - c_m)\Delta u}{8\overline{\theta}cu_l\Delta u - 3u_h} \\ c_m &< \psi_w(c) \Rightarrow e^* = e_c \end{aligned}$$

where $\psi_w(c)$ is the decreasing convex function

$$\psi_w(c) \equiv U_0 - \overline{\theta}u_l + \frac{\overline{\theta}\Delta u}{(8/3)\overline{\theta}c\Delta u - 1}$$

(ii) if $c < 3u_h/(8\overline{\theta}u_l\Delta u)$ then, under the social welfare perspective, it optimal to invest in desasonalization up to the complete coverage of the market, $e^* = e_c$.

Proof: In appendix.

Verbally, e_{pm} and e_c are the optimal effort levels from the social welfare perspective, under specific parameter conditions, so that it is important to realize that only under specific parameter conditions does the optimal deseasonalization effort coincide, under the social welfare or private perspectives; basically, this coincidence occurs if both the production costs and the costs of reducing seasonality are low.

PROPOSITION 4. If the marginal cost of production is high ($c_m > U_0$), and hence Lemma 2 holds, then:

(i) if $c > 3u_h/(8\overline{\theta}u_l\Delta u)$, then it is optimal not to invest in de-sasonalization, $e^* = 0$, under the social welfare perspective.

(ii) if $c < 3u_h/(8\overline{\theta}u_l\Delta u)$, then there are two cases:

$$\begin{aligned} c_m &> \phi_w(c) \Rightarrow e^* = 0 \\ c_m &< \phi_w(c) \Rightarrow e^* = e_c \end{aligned}$$

where $\phi_\pi(c)$ is the decreasing convex function

$$\phi_w(c) \equiv \frac{\sqrt{(8/3)\overline{\theta}cu_hu_l\Delta u}(U_0 - \overline{\theta}u_l) - u_l(U_0 - \overline{\theta}u_h)}{\sqrt{(8/3)\overline{\theta}cu_hu_l\Delta u} - u_l}$$

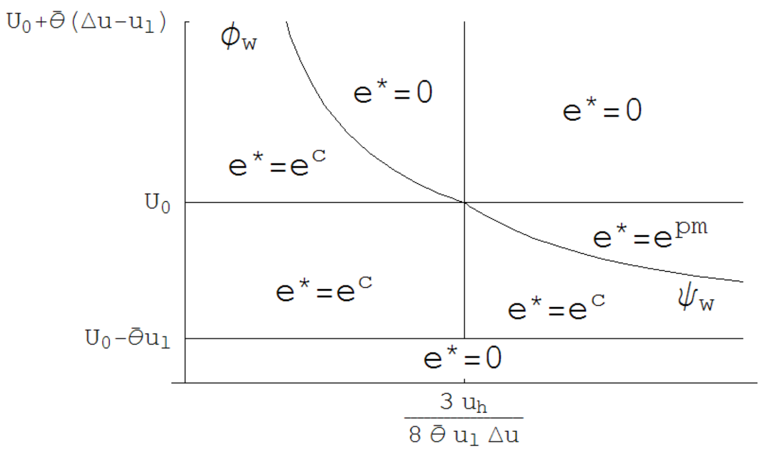

Figure 4: Deseasonalization effort e by the policy-maker in the space (c, c_m)

(ii) if $c < 3u_h/(8\overline{\theta}u_l\Delta u)$ then the policy-maker finds it optimal to invest in desasonalization up to the complete coverage of the market, $e^* = e_c$.

Proof: In appendix.

Basically, the coincidence between the socially optimal effort for reducing seasonality and the private optimum occurs also in the case in which both the production costs and the cost of deseasonalization are high.

Figure 3 (analogous to Figure 4) illustrates the optimal choices by the policy-maker, depending on the cost levels (c, c_m). It can be shown that the following inequalities hold: $\phi_\pi(c) > \phi_w(c)$ and $\psi_\pi(c) > \psi_w(c)$. Thus, in the space (c, c_m) the area where the market is covered is larger under the social welfare perspective. Moreover it turns out that $e_{pm} > e_m$, hence a policy-maker taking a social welfare perspective as defined in (26), always invests at least as much as the firm, since he takes into account the increase in the consumer surplus.

Figure 5 puts together the optimal behaviour of the firm and the policy-maker. With reference to Figure 5:

- in the area included between curves ϕ_w and ϕ_π, and above U_0 (area 1), the policy-maker would invest up to the complete coverage of the market,

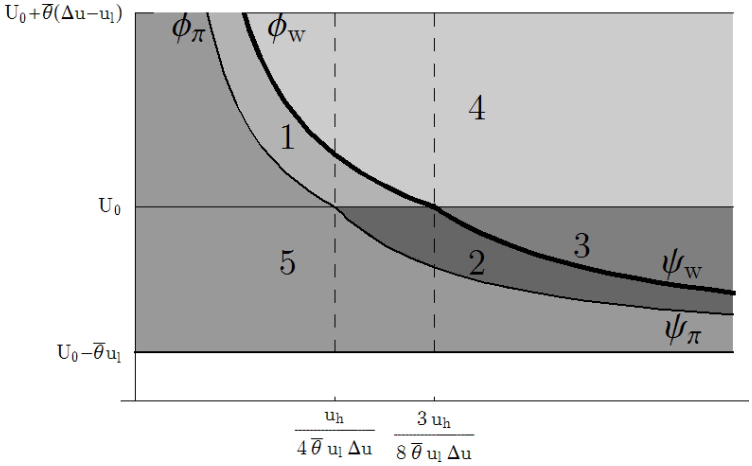

Figure 5: Public vs. private deseasonalization investment in the space (c, c_m)

whereas the firm would not invest in deseasonalization and would continue to operate only in the high season;

- in the area included between curves ψ_w and ψ_π, and below U_0 (area 2), the policy-maker would invest up to the complete coverage of the market, whereas the firm would invest in deseasonalization e_m, therefore covering the market just partially, and operating in both the seasons;
- in the area included between U_0 and ψ_w (area 3), the market would remain partially covered according to both the private and the social perspectives; however, the policy-maker would invest more than the firm ($e_{pm} > e_m$);
- in the area above ϕ_w and U_0 (area 4) no investment effort is judged optimal, from both the private and the social perspectives;
- in the area below curves ϕ_π and ψ_π (area 5) the optimal investment is e_c under both the private and the social welfare perspectives.

It is clear that private and social choices are coincident in areas 4 and 5. The intuition is simple – when both the production costs and the costs to reduce seasonality are very high (area 4), the optimal choice is the null effort, both for the private provider and from a social welfare perspective. Symmetrically, when both the production costs and the costs for reducing seasonality are low (area 5), the optimal choice is the complete coverage of the market, with the same optimal amount of effort for reducing seasonality from both the private and the social welfare perspectives. Social and private incentives to reduce seasonality are misaligned for "intermediate" levels of production costs and deseasonalization costs – the areas 1, 2 and 3 are the cases of interest, where a conflict emerges between the private and social perspectives. There are different parameter configurations where the policy-maker taking a market welfare perspective finds it optimal to make a greater effort for reducing seasonality than the private firm. In some cases, the policy-maker finds it optimal to have a complete coverage of the market over both the seasons while the private supplier prefers to serve only in the high season. In a second case, both the public and private subjects find it optimal to serve in both the seasons, but the policy-maker finds it optimal to cover the market while the private subject leaves the market partially covered. Finally, for some values of the parameters, both the policy-maker and the private firm find it optimal to leave the market partially covered, but the policy-maker's optimal effort to reduce seasonality is still larger than the private one.

Once again, our conclusions have nothing to do with negative externalities due to congestion – in the case of tourism, upon local residents – which can represent a further reason to reduce seasonality, from a social welfare perspective. Clearly, the consideration of the additional desire of the domestic population for seasonality reduction would lead to an even larger effort for reducing seasonality, on the part of a policy-maker who takes into account the welfare of all actors (firm, tourists and domestic residents).The consideration of this issue would simply strengthen our conclusion that the public incentive to mitigate seasonality is stronger than the private incentive.[9]

[9] In the social welfare function, the aversion of domestic population to the congestion in high season can be caputred by adding a term like $CS^D = [-z(D_h - D_l)], z > 0$. The computation of the social optimum under such an assumption is left to the readers. Substantial results do not change. More articulated formalization of the domestic residents is beyond the scope of the present article.

6 Concluding Remarks

In this article, we have proposed to use the Gabszewicz & Thisse (1979) – Shaked & Sutton (1982) theoretical frameworks to model market behaviours in the case of a good for which seasonality is relevant. The application to the tourism market, which we have provided in the article, is straightforward, but not unique.

Our argument has been that a planner taking a social welfare perspective finds it optimal to reduce seasonality to a larger extent as compared to a private firm supplying the item. In fact, the elaboration of the present theoretical model has been suggested by the observation that, in some cases in the field of tourism, local authorities take actions to sustain the demand in low seasons, but private firms do not follow these actions; this observation suggests that the incentive of the public sector to mitigate seasonality is higher than the incentive of private firms. An obvious reason could be that the congestion in the high season generates negative externality to the local population; this obvious explanation has not been considered in the model. We have shown that, apart from the negative externality upon residents, the social incentive to reduce seasonality is stronger than the private incentive simply because the reduction of seasonality represents a benefit not only for firms but also for consumers, whose utility is considered in the social welfare at the market level. Thus, our model makes clear that the misalignment of the public and private goals exists, even apart from the consideration of the preference of a third party – like the domestic population in a tourism destination.

The theoretical model is very simple and a more complicate – and more realistic – modelling is perhaps necessary to grasp all the relevant aspects of markets for seasonal items. However, we believe that our model, though very simple, can provide an explanation of the smaller private incentive to reduce seasonality as compared to the social welfare perspective.

Several extensions are possible to this model. First, one can take into account that the deseasonalization effort of private providers are different in kind from the effort made by public authorities. Private and public efforts to reduce seasonality can be complementary or substitute one another. In any case, a strategic interaction between public and private subjects can be present, and this point is worth analysing, in a game theory framework. Secondly, financing public efforts for reducing seasonality is an important aspect, ignored by the present model. If public financing is based on distortive taxes, contradictory considerations arise as far as the desirability of public intervention is concerned. Last but not least, the assumption of a monopolistic market, even if justified in some cases (where a dominant private firm in fact coincides with a specific tourism destination), is far from describing the situation of several other cases, where private providers compete under oligopoly or monopolistic competition with differentiated products, and offer competing off-season proposals, with possible positive externality on the competitors. Under all these perspectives, the present model is clearly a first attempt to look at the microeconomics of markets for seasonal products.

Appendix

PROOF OF PROPOSITION 1

If the production cost is low, for $e = 0$ lemma 1 is valid; therefore, the firm operates in both the seasons.

If the market is covered (eq. 15), the firm does not have an incentive to deseasonalize and $e^* = 0$; otherwise the profit function in e is:

$$\pi^*(e) = \frac{u_h - 4\overline{\theta}u_l c\Delta u}{4\overline{\theta}u_l\Delta u}e^2 + \frac{(U_0 - c_m)(U_0 + 2e - c_m) + \overline{\theta}u_l(2U_0 + \overline{\theta}u_h - 2c_m)}{4\overline{\theta}u_l} \tag{27}$$

and hence:

$$\frac{d\pi^*}{de} = \frac{u_h e + (U_0 - c_m)\Delta u}{2\overline{\theta}u_l\Delta u} - 2ce \tag{28}$$

$$\frac{d^2\pi^*}{de^2} = \frac{u_h - 4\overline{\theta}u_l c\Delta u}{2\overline{\theta}u_l\Delta u} \tag{29}$$

Setting eq. (28) equal to zero, we find a critical point in:

$$e_m = \frac{(c_m - U_0)\Delta u}{u_h - 4\overline{\theta}cu_l\Delta u} \tag{30}$$

The profit is concave (resp., convex) in e if the following inequality (resp., the opposite inequality) is valid:

$$c > \frac{u_h}{4\overline{\theta} u_l \Delta u} \tag{31}$$

If (31) is false then $e_m < 0$, and it is a minimum. In this case the profit function diverges in e and the firm will completely cover the market, investing $e^* = e_c$. This proves the second point of the proposition.

If (31) is true then $e_m > 0$, and it is a maximum. The firm tends to invest e_m, however if $e_m \geq e_c$ it will not invest more than e_c, having already completely covered the market.

So we can define a (decreasing convex) function ψ_π which solves the equation $e_m = e_c$:

$$\psi_\pi(c) \equiv U_0 - \overline{\theta} u_l + \frac{\overline{\theta}\Delta u}{4c\overline{\theta}\Delta u - 1}$$

and it is such that:

$$c_m > \psi_\pi(c) \Rightarrow e_m < e_c; e^* = e_m$$
$$c_m < \psi_\pi(c) \Rightarrow e_m > e_c; e^* = e_c. \quad \text{QED}$$

PROOF OF PROPOSITION 2

If the production cost is high, for $e = 0$ lemma 2 is true, therefore the firm operates in high season only and gets a profit π_0^*, defined by (14).

The firm can operate also in low season only if $\theta_{l,0} < \theta_{h,l}$, i.e. if $e > e^s \equiv \frac{\Delta u(c_m - U_0)}{u_h}$: under such threshold, the firm does not deseasonalize because it would not be able to take advantage of such investment. Above this threshold, the profit function is the (27), whose first and second derivatives were calculated above.

If the (31) is valid, then $e_m < 0$ and it is a maximum, therefore profits are decreasing in e and the firm does not invest in deseasonalization ($e^* = 0$). This proves the first point of the proposition.

If the (31) is not valid, then $e_m > e^s > 0$, but it is a minimum. In this case, profits are decreasing up to e_m and increasing afterwards, hence the firm has to choose between either not investing in e, getting π_0^* operating in high season only, or investing in $e > e_m > e^s$, operating in both seasons and getting $\pi^*(e)$ which diverges in e.

Clearly the firm does invest in deseasonalization only if $\pi^*(e) \geq \pi_0^*$, i.e.:

$$e > e_\sigma \equiv \frac{\Delta u(c_m - U_0)}{u_h - \sqrt{4c\overline{\theta} u_h u_l \Delta u}} > e_m \tag{32}$$

Therefore e_σ is the least necessary investment so that the firm chooses to operate in low season as well. Once e_σ is invested, profits are increasing in e.

If $e_\sigma \leq e_c$, the firm aims to completely cover the market, investing $e^* = e_c$; otherwise the complete coverage of the market implies profits lower than π_0^*, then $e^* = 0$.

So we can define a (decreasing convex) function ϕ_π which solves the equation $e_\sigma = e_c$:

$$\phi_\pi(c) \equiv \frac{\sqrt{4\overline{\theta} c u_h u_l \Delta u}(U_0 - \overline{\theta} u_l) - u_l(U_0 - \overline{\theta} u_h)}{\sqrt{4\overline{\theta} c u_h u_l \Delta u} - u_l}$$

and it is such that:

$$\begin{aligned}
&c_m > \phi_\pi(c) \Rightarrow e_\sigma > e_c; e^* = 0 \\
&c_m < \phi_\pi(c) \Rightarrow e_\sigma < e_c; e^* = e_c \quad \text{QED}
\end{aligned}$$

PROOF OF PROPOSITION 3

If the production cost is low, for $e = 0$ lemma 1 is valid, therefore the firm operates in both seasons.

If the market is covered (eq. 15), the policy-maker does not have incentive to deseasonalize and $e^* = 0$; otherwise the welfare function in e is:

$$w^*(e) = \frac{3(U_0 - c_m)[U_0 - c_m + 2(e + \overline{\theta} u_l)] + 3\overline{\theta}^2 u_h u_l}{8\overline{\theta} u_l} + \frac{e^2(3u_h - 8\overline{\theta} u_l c \Delta u)}{8\overline{\theta} u_l \Delta u} \tag{33}$$

and hence:

$$\frac{dw^*}{de} = \frac{3(U_0 - c_m)}{4\overline{\theta}u_l} + \frac{3u_h - 8\overline{\theta}u_l c\Delta u}{4\overline{\theta}u_l\Delta u}e \tag{34}$$

$$\frac{d^2w^*}{de^2} = \frac{3u_h - 8\overline{\theta}u_l c\Delta u}{4\overline{\theta}u_l\Delta u} \tag{35}$$

Setting eq. (34) equal to zero, we find the critical point:

$$e_{pm} = \frac{3(c_m - U_0)\Delta u}{3u_h - 8\overline{\theta}cu_l\Delta u} \tag{36}$$

The welfare function is concave (resp. convex) in e if the following inequality (resp. the opposite inequality) is true:

$$c > \frac{3u_h}{8\overline{\theta}u_l\Delta u} \tag{37}$$

If the (37) is false then $e_{pm} < 0$, and it is a minimum. In this case the welfare function diverges in e and the policy-maker will aim to the complete coverage of the market, investing $e^* = e_c$. This proves the second point of the proposition.

If the (37) is true then $e_{pm} > 0$, and it is a maximum. The policy-maker tends to invest e_{pm}, however if $e_{pm} \geq e_c$ it will not invest more than e_c, having already completely covered the market.

So we can define a (decreasing convex) function ψ_w which solves the equation $e_{pm} = e_c$:

$$\psi_w(c) \equiv U_0 - \overline{\theta}u_l + \frac{\overline{\theta}\Delta u}{(8/3)c\overline{\theta}\Delta u - 1}$$

and it is such that:

$$c_m > \psi_w(c) \Rightarrow e_{pm} < e_c; e^* = e_{pm}$$
$$c_m < \psi_w(c) \Rightarrow e_{pm} > e_c; e^* = e_c \quad \text{QED}$$

PROOF OF PROPOSITION 4

If the production cost is high, for $e = 0$ lemma 2 is true, therefore the firm operates in high season only, and gets profit equal to π_0^*, as defined by (14). Moreover, in this case, we define the welfare as:

$$w_0^* \equiv \frac{1}{\overline{\theta}} \int_{\theta_{h,0}}^{\overline{\theta}} (U_0 + \theta u_h) d\theta - c_m D_h = \frac{3(U_0 + \overline{\theta} u_h - c_m)^2}{8\overline{\theta} u_h} \tag{38}$$

The firm can operate also in low season only if $\theta_{l,0} < \theta_{h,l}$, i.e., $e > e^s \equiv \frac{\Delta u(c_m - U_0)}{u_h}$: under such a threshold, the policy-maker does not deseasonalize because the firm would continue to operate in high season only. Above this threshold, the welfare function is the (33), whose first and second derivatives are already computed.

If the (37) is valid, then $e_{pm} < 0$ and it is a maximum, therefore welfare is decreasing in e and the policy-maker does not invest in deseasonalization ($e^* = 0$). And this proves the first point of the proposition.

If the (37) is not valid, then $e_{pm} > e^s > 0$, but it is a minimum. In this case, welfare is decreasing up to e_{pm} and increasing afterwards, hence the policy-maker has to choose between either not investing in e, getting w_0^* with high season only, or investing in $e > e_{pm} > e^s$, with both seasons and getting $w^*(e)$ which diverges in e.

Clearly the policy-maker does invest in deseasonalization only if $w^*(e) \geq w_0^*$, i.e. if:

$$e > e^{p\sigma} \equiv \frac{\Delta u(c_m - U_0)}{u_h - \sqrt{(8/3)c\overline{\theta} u_h u_l \Delta u}} > e_{pm}$$

Therefore $e^{p\sigma}$ is the least necessary investment so that the policy-maker chooses to invest in deseasonalization, allowing the firm to operate in low season as well. Once $e^{p\sigma}$ is invested, welfare is increasing in e.

If $e^{p\sigma} \leq e_c$, the policy-maker aims to the complete coverage of the market, investing $e^* = e_c$; otherwise the complete coverage of the market implies welfare lower than w_0^*, then $e^* = 0$.

So we can define a (decreasing convex) function ϕ_w which solves the equation $e^{p\sigma} = e_c$:

$$\phi_w(c) \equiv \frac{\sqrt{(8/3)\overline{\theta} c u_h u_l \Delta u}(U_0 - \overline{\theta} u_l) - u_l(U_0 - \overline{\theta} u_h)}{\sqrt{(8/3)\overline{\theta} c u_h u_l \Delta u} - u_l}$$

and it is such that:

$$c_m > \phi_w(c) \Rightarrow e^{p\sigma} > e_c; e^* = 0$$
$$c_m < \phi_w(c) \Rightarrow e^{p\sigma} < e_c; e^* = e_c$$

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