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PHD SUMMARIES

COMPARATIVE YIELD RISK CALCULATIONS OF SOUR CHERRY AND PEAR VARIETIES REGARDING RISK AVERSION

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Abstract: Fruit production in the world is increasing continuously. Though in the past few years China and some South-American countries have extended their fruit producing areas, Europe remains to be one of the greatest fruit producers in the world. In the middle of Europe Hungary has to face several challenges as competing for market. Since yield risk has an important role in Hungarian fruit production we investigate the yield risk of two of the most important sour cherry varieties (*'Újfehértói fürtös'* and *'Oblacsinszka'*) grown in Újfehértó (1984-2005), moreover, two of the most important pear varieties (*'Bosc Beurre'* and *'Williams'*) grown in Bánfa and Zalasárszeg (1984-2009). In the examined periods we analyse yield risk with different comparative methods such as E,V-efficiency, first and second degree as well as generalized stochastic dominance methods. We conclude that the production of sour cherry variety *'Oblacsinszka'* in Újfehértó is more preferable compared to the other sour cherry varieties and pear variety *'Bosc Beurre'* in Bánfa is more advantageous than the other pear varieties and sites.

Keywords: sour cherry, pear, yield risk, mean-variance efficiency, stochastic dominance

1. Introduction

Sour cherry production has traditionally developed on the Northern Hemisphere, in the cold temperate zone, however, it has appeared in the Southern Hemisphere, too, during the last few years (*Szabó* 2008). Yearly sour cherry production of the world is about one million tons. Sour cherry is regarded as specially East-European, since Poland, the East province of Germany, Belarus, Moldavia and the Balkan Peninsula, together with Hungary are significant sour cherry producers.

In 2003, 41.8% of the Hungarian sour cherry production had its origin of the North-Great Plain, 34.7% of Szabolcs-Szatmár-Bereg county while in 2002 the role of the North-Great Plain was determining (51.2%). The role of production is relevant on the South Great Plain (17.2%) region with Bács-Kiskun county (13%). The production in Central-Hungary, in Central-Transdanubia and in North Hungary runs up similarly to about 5 thousand tons, while it is approximately 4 thousand tons in Pest county and 3.2 thousand tons on Veszprém county.

In Hungary there are sour cherry plantations on 18750 hectares (KSH 2007). Szabolcs-Szatmár-Bereg country has ascendant position considering the area and yield. 60% of the total yield account for four counties (Bács-Kiskun, Heves, Pest and Budapest, as well as Szabolcs-Szatmár-Bereg county). The quarter of the yield of the country is produced in Szabolcs-Szatmár-Bereg county on 5500 hectares. Amongst the East-Hungarian sour cherry growing sites Debrecen, Újfehértó, Nyíregyháza, Mátészalka, Kisvárda and their neighbourhood are remarkable.

After apple sour cherry is the second most important fruit in Hungary with yearly 40-55 thousand tons yearly yield (FAO 2010). National sour cherry production has been fluctuating in the past ten years because of unbalanced economic policy and market conditions. It resulted a yield decrease to about its 50% compared to the yield of the eighties (*Soltész* 2004). In Hungarian sour cherry plantations the most favourite varieties are *'Újferhértói fürtös', 'Érdi bőtermő'* and *'Kántorjánosi 3'*. The main problem is that 28 % of Hungarian sour cherry plantations are over 15 years and only the third of them are in productive age. The average yield is usually 3-4 tons per hectare, but in 2005 it did not achieve even 3 tons because of phytopathologic problems.

Pear production has been changed considerably in recent years. While 40 percent (some 3.7 million tons) of the world production had European origin till 2000, this ratio has been decreased by half (about 3 million tons) in the past ten years.

As pear producer countries China (55-60%), Italy (5-6%) and the USA (4-5%) are super powers together with Argentina, Chile, South-Africa and Spain which also have dominant roles in the market. Considering Europe, Italy has the most significant impact both on production and sales with about 1 million tons per year production and 15-18 kg yearly consumption per capita. Italy is followed by Spain (700 thousand tons/year), Germany (400 thousand tons/year), France (250 thousand tons/year), Portugal (150 thousand tons/year) and Greece (75 thousand tons/year). The greatest exporters are Argentina (18%), China (17%) and Belgium (13%).

Though Hungary has excellent climate for good quality fruit production, it is not belonging to the greatest European pear production counties. The area of pear plantations is only 8-10% the size of the total area of the apple orchards. Moreover, Hungary has relevant shortfall regarding the level of the production. The most plantations are located in the Great Plain and North region (32% and 33%). Pear was grown on 2252 hectares in 2001 and on 2878 hectares in 2007 (KSH 2007).

Since *Drimba* and *Nagy* (1997; 1998; 2000) as well as *Drimba* (1997; 1998) have pointed out, that yield risk has remarkable role in Hungarian fruit production, we analyse the yield risk of two sour cherry varieties (*'Újfehértói fürtös'* and *'Oblacsinszka'*) in Újfehértó and two pear varieties (*'Bosc Beurre'* and '*Williams*') in Bánfa and in Zalasárszeg considering also the risk aversion of the decision maker.

2. Material and methods

Sour cherry yield data from 1984 to 2005 were taken from the Institute of Research and Extension Service for Fruit Growing at Újfehértó. The experimental site Újfehértó is one of the most important areas of cherry production of Hungary. Pear yield data (1987-2009) were taken from Gyümölcskert Zrt., Nagykanizsa.

2.1 The examined sour cherry varieties

'Újfehértói fürtös'

'*Újfehértói fürtös'* is officially recognized by the state since 1970. Its fruit is not susceptible to falling down, grows ripe late, in July which extends a long time. It is good for fresh consumption, industrial processing and deep-freezing, too. Its slightly flat-rounded fruit's size is middle big or big (5.3 g). According to the fruit amount the fruit's diameter is between 18-23 mm. The colour of the skin is shiny claret-red. The flesh is hard, blood-red, moderately colouring and its flavour is harmonious sweet-sour. The tree has strong growth, growing upwards but the top is smaller than the '*Pándy*' sour cherry variety. The buds are middle big, slicking to the rods. The leaves have middle size. The tree that yields well turns into productive early. Its drought resistance is good and its ecological resistance is excellent. '*Újfehértói fürtös'* can also be cultivated on humus-sand soil with good results. Flowers have middle size and the petals are white. Its blooming is late, bursts into bloom at the same time as the other late blooming variety. It is susceptible to monilia and medium susceptible to blumeriella *(Szabó* et al. 2008).

'Oblacsinszka'

This is a variety of unknown origin which got to Hungary from Yugoslavian area. In the last few years this unknown variety has played a big part in the cultivation of sour cherry in Europe. Its ripening is in the second part of June. Fruits are small (2.5 g), average diameter is between 16-17 mm. Its shape is rounded the ventral suture can hardly be recognized. The deep, thick, red coloured peel is not susceptible to cracking. Its flesh is succulent, juicy, red, the flavour is sweet-sour. The seed can easily be removed from the red flesh. The stalk which has middle length and thickness can be separated at the time of ripening. The tree has middle vigorous growth, the top is small, its shape is rounded and thick. The tendency of ramifaction is good. This variety yields very well and turns into productive early. Flowers are mostly self-fertilizer and bloom late.

Owing to the small top, '*Oblacsinszka*' can be planted close (5 × 2-3m) (*Takács* and *Szabó* 2006). It's mostly good for industrial processing, excellent raw material for sweets but also good for bottled fruit and juice.

2.2 The examined pear varieties

'Bosc Beurre'

'*Bosc Beurre'* is the most widely cultivated variety in Hungary. It is well-known worldwide, with its distinctive characteristics being its brown skin, which holds a delicious, sweet-spicy flavoured and slightly firmer flesh, which while a bit crunchy, remains tender. It has a long, curved stem with a neck that widens gradually into a round shape (*Göndörné* 2000). Russetting may cover the entire surface of the pear (*Soltész* 1998). Harvest is usually in mid September. The tree is medium sized or slightly weak. The size of the fruit is large or extra large (180-280 g), showing little colour change as it ripens.

'Williams'

In Hungary, this is the second most important variety after the '*Bosc Beurre'*. It has a classical "pear shape": a rounded bell on the bottom half of the fruit, with a definitive shoulder and a smaller neck or stem end (*Göndörné* 2000; 2001). This pear is extremely aromatic. The size of the fruit is large or extra large (160-220 g) (*Soltész* 2004). It is harvested from late August to early September. This pear is unique, in that its skin colour brightens as it ripens, unlike other varieties. Its flavour is sweet delicious when it reaches a golden yellow ripening stage. In addition to eating it fresh for its smooth texture, '*Williams*' is also traditionally known as a canning pear variety.

2.3 Efficiency criteria

The first breakthrough in modern risk analysis is due to *Friedman* and *Savage* (1948) with introducing the concept of utility function. *Pratt* (1964) and *Arrow* (1965) used earliest the notions of absolute and relative risk aversion. *Anderson* and *Dijjon* were pioneers in application of risk analysis in agriculture and the first monograph in this topic was published by *Hardaker* et al. (2004). They have proved that growers are mostly risk averse and suggested the forms of utility functions regarding the degree of risk aversion.

E-V efficiency criterion is used for helping to decide which alternative has its higher or equal expected value with less or equal variance, namely which is preferable regarding risk. The rule can well be illustrated in a two-dimensional E-V space. The efficient set contains the alternatives having no alternative in its north-west quadrant. Alternatives of efficient set dominate the alternatives not contained by the efficient set. However, there is no ordering of preference between alternatives within the efficiency set (*Ladányi* 2008; *Drimba* and *Ertsey* 2003).

First and second degree stochastic dominance criteria are useful in ordering alternatives which cannot be ordered by the simple E-V efficiency criterion. For case studies in crop production studies see *Ladányi* and *Erdélyi* (2005), for fertilization alternatives *Drimba* (1997) for soil cultivation problems *Drimba* and *Nagy* (1998) and for setting the number of plants *Drimba* (1998). Alternative *A* dominates alternative *B* (that is to say *A* is more preferable than *B*) in first order stochastic sense if for the distributions functions of *A* and *B* inequality $F_A(x) \leq F_B(x)$ holds for all $x \in \mathbf{R}$ (*Ladányi* 2006; 2008). The second degree stochastic dominance holds for these alternatives if the integral functions of their distribution functions have an ordering of the same direction ($Int\_F_A(x) \leq F_B(x)$ for all $x \in \mathbf{R}$).

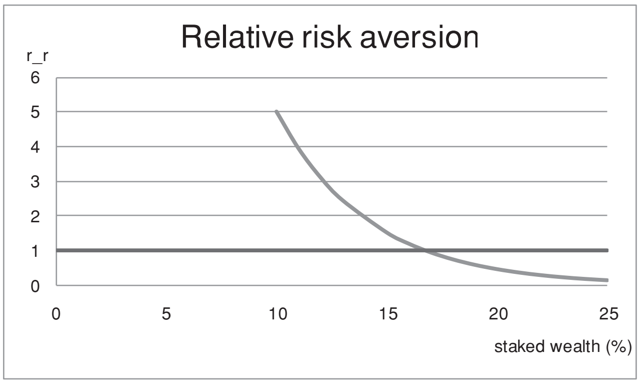

Figure 1: Relative risk aversion as the function of wealth (%) the decision maker is ready to stake

Generalized stochastic dominance is a criterion with an assumption about risk aversion. As can regard the risk attitude of the decision maker, it has a stronger discriminatory power than the criteria above (*Goh* et al. 1989; *Hardaker* et al. 2004). For this we used the most widely applied utility function, the so-called negative exponential utility function ($U{:}w \rightarrow U{:}(w) = 1 - \exp(-cw)$, $c \in \mathbf{R}^+$). The utility function can be set to the decision maker's attitude to risk with the help of constant . For a fixed wealth the greater the ratio of the second and first derivative of the (concave) utility function is, the greater the risk aversion of the decision maker is. In case of the negative exponential utility function this ratio is equal to the constant which is called absolute risk aversion (r_a). Relative risk aversion is defined as the function of wealth: r_r: $\mathbf{R} \rightarrow \mathbf{R}$ $w \rightarrow wr_a(w)$.

In Figure 1 we can observe relative risk aversion as the function of the rate of current wealth the decision maker is ready to stake for a 0.5 chance of 20% increase in wealth where $r_r(w)$ means a somewhat normal risk averse (*Anderson* and *Dillon* 1992).

Negative exponential utility function has its advantage that it contains the information on the constant absolute risk aversion due to the decision maker and also on the relative risk aversion which is an increasing function as increases; the speed of increase is characteristic.

According to *Bernoulli* theorem two-parameter ($c = r_a$ and w) utility function can be formulated with the help of density function (f_A) of alternative *A* as

$$U(x, r_a) = \int_0^x U(t, r_a) f(t) dt \text{, so (for a fixed } x \in \mathbf{R})$$

we can calculate the *certainty equivalent* CE as $CE(x, r_a) = = \frac{-\ln[1 - U(x, r_a)]}{r_a}$. *Generalized stochastic dominance* criterion says that if (for a fixed $x \in \mathbf{R}$) we plot the function $CE(ra)$ then the higher curve assigns the more preferable alternative.

3. Results and discussion

3.1. Comparisons of production of sour cherry varieties regarding risk aversion

According to the E-V efficiency diagram, the efficient set contains both the alternatives as their north-west quadrant is empty. For an ordering we go on with the calculation of the

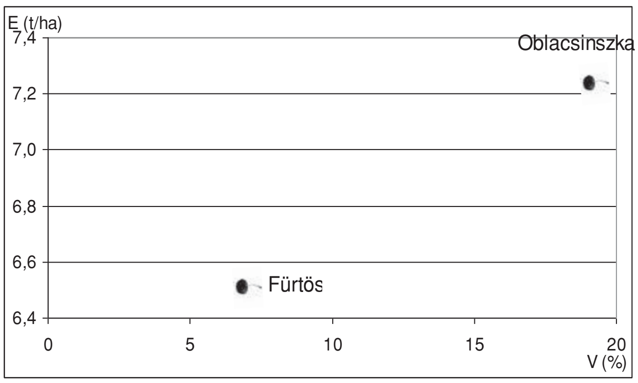

Figure 2: E-V efficiency of the yield of sour cherry varieties *'Újfehértói fürtös' and 'Oblacsinszka'* produced in Újfehértó (1984-2005)

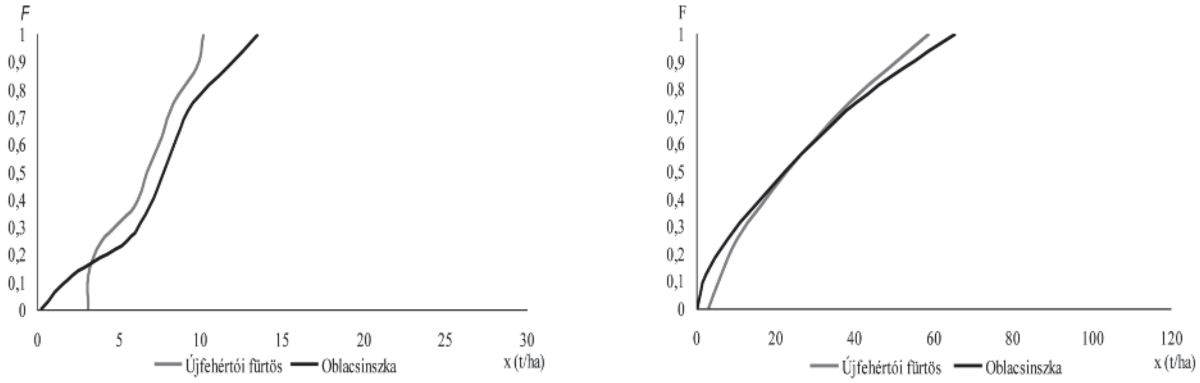

Figure 3: First (left panel) and second (right panel) degree stochastic dominance of the yield of sour cherry varieties *'Újfehértói fürtös'* and *'Oblacsinszka'* produced in Újfehértó (1984–2005)

first and second degree stochastic dominance (*Persely* et al. 2010).

In Figure 3 we can see the results of the first (left panel) and the second (right panel) stochastic dominance. Both the distribution functions and their integral functions cross each other, so we cannot define the most preferable alternative. We call for the general stochastic dominance method (*Persely* et al. 2010).

The curves of certainty equivalents () are represented in Figure 4 according to the general stochastic dominance method. With this method the two sour cherry varieties of Újfehértó became to be comparable, regarding their yield risk (Figure 4). We can see that variety '*Oblacsinszka*' is more preferable than '*Újfehértói fürtös'* as the curve of '*Oblacsinszka*' lies higher than the one of '*Újfehértói fürtös'* which indicates less risk of yield.

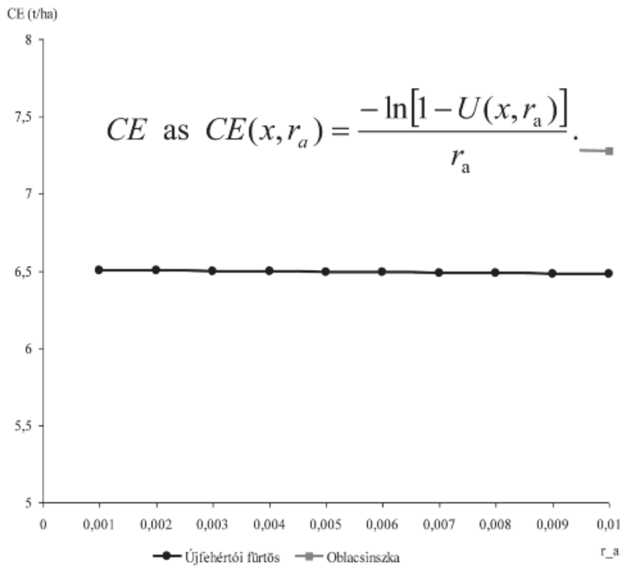

Figure 4: Certainty equivalent curves as functions of the absolute risk aversion () for the yield of sour cherry varieties *'Újfehértói fürtös'* and *'Oblacsinszka'* produced in Újfehértó (1984–2005)

Note that '*Oblacsinszka*' is a young plantation (1996) while *'Újfehértói fürtös'* was planted in 1978.

3.2. Comparisons of production of pear varieties regarding risk aversion

Again, we used the E-V efficiency criterion to compare the yield risk of two different plantations (Zalasárszeg and Bánfa) and two pear varieties ('*Bosc Beurre*' and '*Williams*', Figure 5).

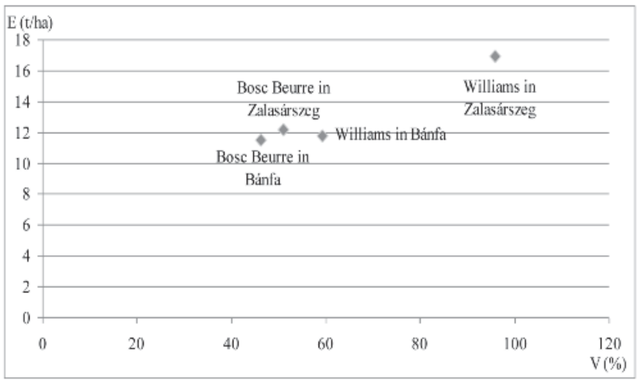

Figure 5: E-V efficiency of the yield of pear varieties *'Bosc Beurre'* and *'Williams'* produced in Bánfa and Zalasárszeg (1987–2009)

We can find out that variety '*Williams*' cultivated in Bánfa does not belong to the efficient set as it has a more efficient variety ('*Bosc Beurre'* of Zalasárszeg) in its north-west quadrant. For a more accurate ordering we calculated the first and second degree stochastic dominances (Figure 6).

Variety '*Bosc Beurre*' of Zalasárszeg is more preferable compared to variety '*Williams*' in Zalasárszeg whereas its distribution function as well as the integral function of its distribution function lies right to the one of '*Williams*' of Zalasárszeg.

Variety '*Bosc Beurre'* of Bánfa seems to be the most preferable alternative since its distribution function as well as the integral of its distribution function lie everywhere below and to the right of the other curves. Both the distribution functions and the integral functions of the distribution functions of the other three alternatives, however, cross each other, so again only partial dominance can be proved between the alternatives with this method.

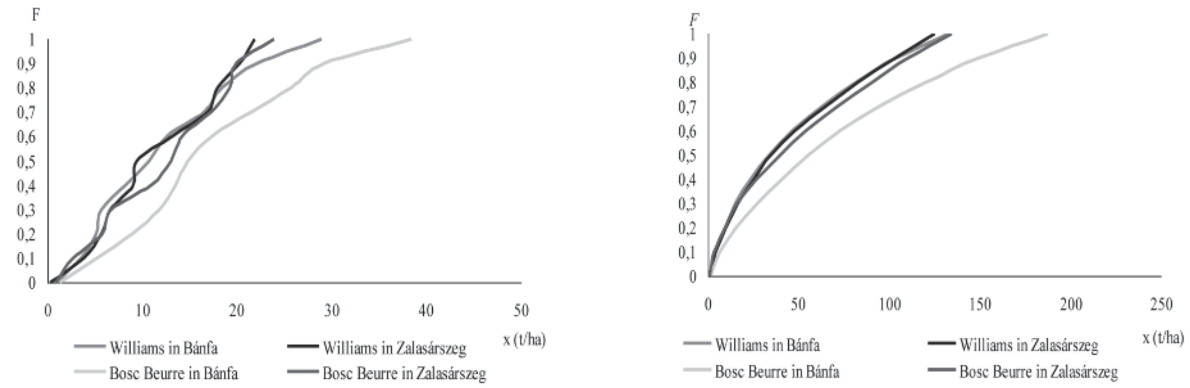

Figure 6: First (left panel) and second (right panel) degree stochastic dominance of the yield of pear varieties *'Bosc Beurre'* and *'Williams'* produced in Bánfa and Zalasárszeg (1987–2009)

General stochastic dominance method should be applied not only for the total ordering but also for considering the risk aversion of the decision maker.

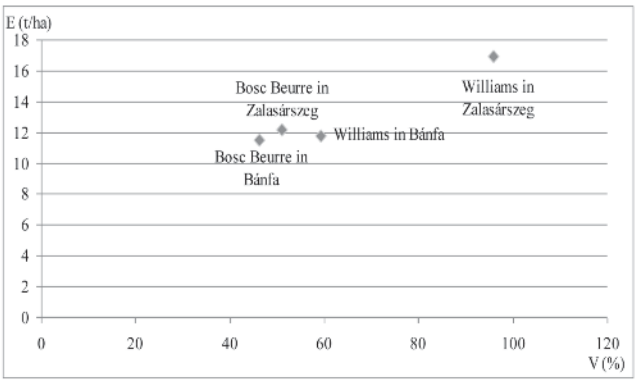

Figure 7: Certainty equivalent curves as functions of the absolute risk aversion () for the yield of pear varieties *'Bosc Beurre'* and *'Williams'* produced in Bánfa and Zalasárszeg (1987–2009)

If we represent the certainty equivalent () curves with the help of the general stochastic dominance method, we can compare the two different plantations and the two pear varieties according to their yield risk (*Persely* et al. 2010).

As it can be seen in Figure 7 the curve of variety '*Bosc Beurre'* from Bánfa lies the highest, so this alternative has the lowest yield risk. This alternative is followed by '*Bosc Beurre*' from Zalasárszeg, '*Williams*' from Bánfa and finally, as the less preferable alternative '*Williams*' from Zalasárszeg.

Thus, comparing the varieties '*Bosc Beurre'* is less risky while comparing the plantations Zalasárszeg is more risky regarding the yield with considering absolute risk aversion.

In agro economy, year by year more and more decision problems arise in which the decision maker has to consider, besides profitability and sustainability, also the risk of the issue (Ladányi 2006).

In our study we ascertained that, regarding yield risk with considering the risk aversion of the decision maker, in Újfehértó sour cherry variety '*Oblacsinszka*' (planted in 1996) is more favourable to grow, compared to the variety '*Újfehértói fürtös*' (planted in 1978).

Moreover, growing of pear variety '*Bosc Beurré'* is the most advantageous in Bánfa which may be explained by the following:

- The plantation in Zalasárszeg is extensive; most of the trees were planted in 1958 with planting design 9 × 5 m. The other orchard on that site (planted in 1977) has its planting design 6 × 4 m. The orchard in Bánfa is younger, it was planted in 1978, and the planting design is 6 × 4 m.
- Calculating risk it is also important how successful the installation was and how the trees could use their growth energy in the first years. The trees in Bánfa are more vigorous and that is why the '*Bosc Beurre'* has the lowest yield risk.

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