DO INDUSTRY AND ACADEMIC EXPERTS DIFFER IN WEIGHTING CRITERIA FOR AGRICULTURAL PLANNING AND IN THEIR LOSS AVERSION?

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ABSTRACT

Agricultural planning models account for changing weather conditions and for high food price volatility. Applying the criteria of maximum farmer's profit in various years enables the use of multi-criteria techniques. This paper presents the application of the Analytical Hierarchy Process (AHP) to estimate the importance of these criteria. The study contributes to the literature by a) addressing expert opinions on the importance of the criteria of profit in normal, dry years, and in years when agricultural prices rise; b) examining differences in weighting criteria between industry and academic experts; c) taking into account the loss averse behavior for these two groups of experts. Industry and academic experts were interviewed in the agricultural region of North-Eastern Israel. Changes in profit are approximated by a linear utility function with a positive slope (for both losses and gains) which is steeper for losses (profit in dry years) than for gains (profit in years when prices rise). The AHP method allows for the identification of the importance of the criteria for all respondents as a whole and for academic experts as compared to industrial experts. The share of loss averse respondents and coefficients of loss aversion are identified for both groups of experts. These coefficients are used for explaining differences between industry and academic expert opinions in estimating the criteria importance.

Keywords: AHP; farmers profit; dry year; prices rise; consistency; loss averse

1. Introduction

Many agricultural planning models, including those for optimal crop selection, production and distribution, and water resource allocation, pertain to various aspects of weather, price and other uncertainties. The models account for marketing and agronomic risks, for changing weather conditions in normal and dry years, and for the volatility of

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food prices that have remained high since the 1970s. These factors greatly affect the profit variability in agriculture. In particular, their management requires selection of crops which allow for a diversified income for farmers and mitigation of the risks (Lehmann et al., 2013; Rădulescu et al., 2014; Tadesse et al., 2014).

As for changing weather conditions, although cropland per person in the world in the last 50 years decreased twice from 0.44 to 0.22 hectare/person, the increase in total cultivated land accounted for 12%, and in irrigated land for 117% (FAO, 2011). As a result, 70% of the global water supply (part of renewable freshwater resources removed from rivers or aquifers by installing infrastructure) is currently used by agriculture. Extreme events, such as heatwaves and droughts, will become more frequent in the coming years, negatively impacting crop yields (FAO, 2010). Climate models project increased aridity during the current century, in particular, in the Middle East (Thornton et al., 2014). For this region the maximal climate change impact on agricultural production was estimated for a potential decrease in precipitation. A 20% decrease in precipitation was projected to affect a 38% drop in crop yields (Calzadilla et al., 2013).

Regarding food price volatility, some researchers suggest that liberalizing agricultural trade maintains high prices and mitigates price volatility in the near future (Rutten et al., 2013). Other researchers have discovered that food prices have become even more volatile in recent years. This phenomenon is attributed to the use of food commodities for production of biofuel, with the biofuels link introducing an additional source of demand variability and ensuing food price volatility (Gilbert & Mugera, 2014). The output prices combined with the operational and scale efficiency continue to be major factors in explaining farm profitability (Tey & Brindal, 2015). The analysis of ten global economic models that assess plausible futures for agricultural markets revealed contradictory outcomes. Three of the ten reviewed models projected falling real prices, six – increasing, and one – a stable level of prices, while the volatility in general trends remains important (Lampe et al., 2014).

In agricultural planning models, the best solutions are often selected based on a single economic criterion of maximum farmer profit (Dury et al., 2012). The application of the criteria of maximum profit in various years - with various weather conditions and price level movements – allows for the use of additional information on weather and price uncertainties and allows for the use of multi-criteria techniques. For this purpose, the weight (importance) attached to various agricultural criteria can be calculated from the collected expert opinions (Arriaza & Gómez-Limón, 2003; Bjørndal et al., 2012).

The purpose of this study is twofold. Firstly, it aims to examine expert opinions on the importance of profit criteria in various years – normal years, dry years, and years of agricultural price rise, and the differences in criteria weighting between industry and academic experts. Secondly, the study examines loss averse behavior for these two groups of experts.

The study contributes to the literature by a) addressing expert opinions on the importance of the criteria of profit in normal years, dry years, and in years of agricultural price rise; b) examining differences in weighting criteria between industry and academic experts; and c) taking into account the loss averse behavior for these two groups of experts.

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In the present study, the expert opinions on the criteria of maximum profit in a normal year, in a dry year, and in a year of agricultural price rise were collected. The data from questionnaires answered by industry and academic experts were processed through the Analytic Hierarchy Process (AHP) method (Saaty 1977, 1980). This method is widely used for calculating the weights of the criteria as well as the differences between weights given by experts from various groups, and among others, in agricultural applications (Pelizaro, 2011; Toledo, 2011).

It is assumed in the current study that in agricultural planning models, profit changes can be approximated by a linear utility function with a positive slope (for both losses and gains) which is steeper for losses (in dry years) than for gains (in price rise years, in this study) (Loewenstein, 1988). This assumption is based on the predictions of the prospect theory regarding the shape of the value function (Tversky & Kahneman, 1992). Examination of the farmer's preferences – whether they are loss averse, gain seeking or neutral - revealed that the prospect theory was relevant in describing the farmer's behavior in risk conditions. In many published studies, most of the surveyed farmers were identified as loss averse (Coelho et al., 2012). However, further examination of farmer's loss aversion remains a research topic since this phenomenon can vary across countries and over time. Economic crises and chronic losses can further influence a farmer's loss aversion (Rivers & Arvai, 2007; Ashta & Otto, 2011). Additionally, it was revealed that the perception of losses and gains can differ for various groups of experts – novice vs. professionals, industry vs. academics, and experts of different ages and levels of education (Isin & Miran, 2005).

2. Materials and methods

2.1. Data

A sample of 32 experts was surveyed during the study of the agricultural development conducted in North-Eastern Israel from 2012-14. The surveyed experts were divided into two groups, industry and academic experts. Average work experience of the industry experts was 56% longer in duration than that of the academic experts. Women comprised 22% of the respondents and the duration of their work experience was shorter in both groups of experts (Table 1).

Table 1
Characteristics of experts

Categories	Number of respondents and average work experience in agriculture, years					
	Men		Women		Total	
	Number	Work Experience	Number	Work Experience	Number	Work Experience
Industry	13	30	2	16	15	29
Academic	12	20	5	15	17	18
Total Experts	25	25	7	15	32	23

2.2. Estimating importance rates of the criteria

In-person interviews were conducted at the respondent's workplaces. The interviews

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began with a short discussion of the study's background – the concept of optimal agricultural planning, water allocation, possible changes in farmer's profit in dry years and in years of agricultural price rise. In the surveyed agricultural region, all crops are irrigated, but in dry years the water quota for irrigation can be substantially reduced. Changes in the share of annual (mainly, vegetables) and perennial (fruit orchards, vineyards, flower greenhouses) crops, temperate (apples) and subtropical (mango, avocado) cultures in the crop structure can result in different profit losses in dry years, and in different gains in years of agricultural price rise. Then the experts were asked to compare three pairs of agricultural planning criteria, as given below, and rate each pair as "much less important", "less important", "the same importance", "more important", and "much more important".

The three pairs were (Appendix 1):

1) the importance of "normal year profit" vs. "dry year profit";
2) the importance of "normal year profit" vs. "profit in an agricultural price rise year";
3) the importance of "dry year profit" vs. "profit in an agricultural price rise year";

These pairwise comparisons make it possible to complete a Saaty's reciprocal matrix **A** for every expert:

$$\mathbf{A} = \begin{bmatrix} 1 & a_{12} & a_{13} \\ 1/a_{12} & 1 & a_{23} \\ 1/a_{13} & 1/a_{23} & 1 \end{bmatrix} \tag{1}$$

where a_{12} denotes the importance rate of "normal year profit" compared to "dry year profit", a_{13} denotes the importance rate of "normal year profit" compared to "profit in an agricultural price rise year", a_{23} denotes the importance rate of "profit in a dry year" compared to "profit in an agricultural price rise year".

Saaty suggested the scale for importance rates as follows: "much less important" corresponds to 1/9, "less important" to 1/5, "the same importance" to 1, "more important" to 5, and "much more important" to 9 (Saaty, 1977). In this study we also used the balanced which was defined as follows: "much less important" - 1/2.33, "less important" - 1/1.5, "the same importance" - 1, "more important" - 1.5, and "much more important" - 2.33 (scale (Salo & Hämäläinen, 1997; Brunelli, 2014).

The consistency index (*CI*) suggested by Saaty for measuring consistency of expert's judgements is defined as follows:

$$CI = (\lambda_{\max} - n)/(n-1) \tag{2}$$

where n is the number of criteria ($n = 3$ in this study),
$\lambda_{\max}$ is the principal eigenvalue of the matrix **A** for a given expert.

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Saaty suggested comparing the value of *CI* with the same index averaged over a large number of reciprocal matrices of the same order with random matrix entries. For $n = 3$, this averaged index equals 0.58. He recommended using data of those experts for whom the “consistency ratio” of *CI* to the value 0.58 was not greater than 10%, and for other experts to attempt to improve the consistency (Saaty, 1990).

As the alternative test for consistency, the elements of the matrix **A** (calculated now using the above described balanced scale) were used for calculating the "consistency measure" using the same formula (Equation 2). This measure can change from 0 to 1, and its value increases with inconsistencies in the answers of the expert. There are no specific recommendations on the maximum upper limit of this indicator. Researchers recommend the use of the consistency measure as an indicator of those experts whose responses can be inconsistent (Mustajoki & Hamalainen, 2000). In the current study, both consistency ratio and consistency measure were used to test the consistency of the expert answers.

The importance rates a_{ij} from Equation 1 were averaged over all experts and also separately over groups of industry and academic experts to compare the importance, or weights, of all three criteria used in the study. Individual judgements were aggregated into a single representative judgement for the entire group or for all experts using their geometric mean. The latter was calculated for every importance rate from the matrix (Equation 1). The geometric mean of judgments is the mathematical equivalent of consensus assuming all the experts to be equal in weighting their judgements (Saaty, 2008; Saaty & Vargas, 2007).

To estimate the significance of the difference in the calculated importance rates between industry and academic experts, the standard pooled-variance *t* test for differences in two means was used. It was assumed that the two groups of experts were drawn from the underlying normal populations of industry and academic experts that have the same variance.

2.3. Estimating loss aversion

The following widely used definition of the loss aversion, which is a concept of the prospect theory, has been employed:

$$-U(-x) > U(x) \tag{3}$$

where *U* is the utility function for losses (decrease in dry years profit) and gains (increase in profit in price rise years). The inequality Equation 3 expresses is one of the basic phenomena of choice under uncertainty that losses loom larger than gains (Tversky & Kahneman, 1992). The surveyed experts weighted criteria under uncertainty when outcomes were known (one criterion is less important that the other, much less important - Appendix 1), but not necessarily their probabilities (the experts were not informed about the statistics shown in Appendix 2).

It was assumed for the questionnaire used in our study that:
the additional profit in a normal year equals 0 – the reference point;
x is the additional profit (gain) in a price rise year;

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-*x* is the profit received less (loss) in a dry year.
It was assumed that $x = 20\%$ and consequently $-x = -20\%$ for the region studied. The assumption was based on the regional crop calculations approved by the Israel Ministry of Agriculture and Rural Development (received upon request from the Kiryat Shmona office of the Ministry).

The following linear utility function *U* for losses and gains was assumed:

$U(-x) = -ap_1x, a > 0$ for losses, (4)

$U(x) = bp_2x, b > 0$ for gains. (5)

where p_1 is the probability of a dry year,

p_2 is the probability of a price rise year,

a and *b* are the sought coefficients of the utility function.

Based on the collected 14-year historical data, it was assumed $p_1 = 2/14$ (Appendix 2, Fig. 1A) and $p_2 = 3/14$ (Appendix 2, Fig. 2A).

For every expert, the importance rate which is assigned to dry year profit is used as the value of the utility function $U(-x)$ ($-x = -20\%$) for losses, and the importance rate assigned to profit in a price rise year is used as the value of the utility function $U(x)$

($x = 20\%$) for gains.

Based on the data presented in the Section 2.2 matrix A:

a_{12} is interpreted as the importance rate of "profit in a normal year" compared to "profit in a dry year", or the loss ; a_{13}- as the importance rate of "profit in a normal year" compared to "profit in an agricultural price rise year", or the gain $U(x)$.

This interpretation, and the above assumptions for x, p_1, p_2 and Equations 4 and 5 for the utility function U enable the calculation of the coefficients a and b as follows:

$$a = -U(-x)/p_1x = a_{12}/p_1x = a_{12}/(2/14 \cdot 20\%) = a_{12}/2.9\%,$$

$$b = U(x)/p_2x = a_{13}/p_2x = a_{13}/(3/14 \cdot 20\%) = a_{13}/4.3\%.$$

Measuring loss aversion using the above derived coefficients a and b is important as it can explain a variety of field data, in particular, differences between opinions of agricultural and industrial experts. In this study, the expert for whom Equation 3 is valid is classified as loss averse; if the left side of Equation 3 equals its right side, the expert is

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classified as loss neutral; and if the left side of Equation 3 is less than its right side, the expert is classified as gain seeking. The individual loss aversion coefficients are calculated as the ratio

$$-U(-x)/U(x) \qquad (6)$$

They demonstrate to what degree risk preferences are exhibited more strongly for losses than for gains (Kahneman & Tversky, 1979; Abdellaoui et al., 2007).

2.4. Hypotheses of the study

Hypothesis 1: The author hypothesizes that the significance of the differences between the average importance rates for various groups of experts (industry affiliated and academic) can be at least partially due to the expert's different expertise. This is based on the revealed different opinions of industry against academic experts reported in recent empirical studies of multi-criteria decision making methods. The following examples illustrate this point: AHP applied to selecting sires in dairy industry, multiple expert elicitation for studying technological change under uncertainty, and a Delphi survey of decision-making in engineering (Stokes &Tozer, 2002; Rai, 2013; Shishank & Dekkers, 2013).

Hypothesis 2: The author also speculates that the average importance rate for the criteria pair "normal year profit" and "dry year profit" (losses) will be higher than for the pair "normal year profit" and "profit in an agricultural price rise year" (gains) due to the loss aversion effect.

3. Results

The consistency ratio was calculated for all 32 experts. For 29 of them this ratio was less than 10% and for the other three experts the ratio was slightly larger, 14-15%. The average consistency ratio was low and equaled 3.3%. Low values of the consistency measure (much closer to zero that to 1) also indicated consistency of the expert's answers. Because of the good results of the consistency testing the data of all experts were used for the following analysis.

The importance rates (weights) of the three studied maximum profit criteria for different years were calculated. The criterion "normal year profit" had the maximum weight – almost half of the overall importance of the compared criteria which is assumed to be 100% - followed by "profit in a price rise year". The criterion "dry year" had the least importance (Table 2).

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Table 2
Importance rates (weights) of the compared criteria

Compared criteria	Importance rate (weight)
Normal year profit	49%
Dry year profit	22%
Profit in a price rise year	29%

The differences in the importance rates between industry and academic experts were examined. Industry experts attached more importance to the criterion "normal year profit" than academic experts, and the difference between these groups of experts was significant at the 5% level. For two other criteria - "dry year profit" and "profit in price rise years", the differences between the groups of the experts were non-significant. This confirms hypothesis 1 that the differences between the importance rates of criteria for different groups of experts, or at least part of them, can be significant (Table 3).

Table 3
Importance rates separately for industry and academic experts

Criterion	Importance rate			*t*
	Industry experts	Academic experts	Difference in % points	Statistic
Normal year profit	58%	41%	17%	2.418
Dry year profit	19%	25%	-6%	-0.942
Profit in a price rise year	23%	34%	-11%	-1.603

We now examine hypothesis 2 of the possible loss aversion of the interviewed experts. For both groups, most of the experts were identified as loss averse persons – 87% of industry, 82% of academic experts, and 84% of all experts. But the averages of the coefficients of loss aversion, as calculated by Equation 6, were 5% significantly higher for academic experts (Table 4).

Table 4
Loss averse / gain seeking experts from different groups of experts

	Number of experts			Coefficient of loss aversion	
	Loss averse	Gain seeking	Loss neutral	Mean	Std. error
Industry	13	2	0	1.67	0.13
Academic	14	2	1	2.67	0.37
Total experts	27	4	1	2.20	0.22

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4. Discussion and conclusion

The current study identified differences between importance rates of the maximum profit criteria that the surveyed experts selected for use in agricultural planning models. The impact of climate and price factors was taken into account – expert judgements on the criterion of normal year profit were compared to those on dry year profit and profit in agricultural price rise years. Using the AHP method, maximum importance was assigned to the criterion normal year profit. The novelty of the suggested approach lies in a) the set of compared criteria that included dry year profit and profit in years of agricultural price rise, and b) the estimate of loss aversion of the interviewed industry and academic experts using their opinions collected and analyzed with the AHP method.

The results obtained for industry experts differed from those received for academic experts. Industry experts attached more importance than their academic colleagues to the criterion “normal year profit” – 58% and 41%, respectively, and this difference was significant at the 5% level. These results are consistent with those of other studies, where the AHP method gave different results for various groups of experts from the same field. Sengar et al. (2014) used the AHP method to rank the major barriers to rural markets in India. The researchers found that industry and academic experts ranked these barriers differently, although both groups of experts viewed organizational barriers as the most important barrier category. Stokes and Tozer (2002) used the multi-criteria model for the selection of sires in the dairy breeding program. For this purpose, they ranked and weighted several breeding and economic criteria using the AHP method and responses of industry and agricultural experts. Some of the criteria were ranked differently by the two groups of experts which led to different results in modelling optimal sire selection. Similar results were obtained in assessment of alternative farming activities using the AHP method in the study of Chavez et al. (2012). The authors compared criteria such as income, market feasibility and other criteria that received different weights for various groups of experts - farmers, researchers, farm advisers, and cooperative and government representatives.

The attitude of the experts towards dry year profit (losses) and profit in price rise years (gains) was used in the current study for identifying the experts as loss averse / gain seeking persons and for estimating their loss aversion coefficients. The results are compatible with the findings of other studies where experts in agricultural problems / farmers were identified as loss averse individuals. Bocquého et al. (2014) studied a sample of French farmers and found that the farmers were twice as sensitive to losses as to gains. This is compatible with the coefficients of loss aversion in the present study estimated to be 2.20 on average for all experts, and 1.67 and 2.67 for industry and academic experts, respectively (Table 4).

Measuring loss aversion can explain differences in expert opinions and farmer’s decisions. In the current study, the criteria of dry year profit and profit in price rise years are more important for academic experts who are more loss averse than for industrial

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experts (consequently, the opposite is true for the criterion profit in normal year profit). A possible explanation for this difference is that academic experts display more knowledge and interest in optimization of crop structure by favoring the crops which allow for diminishing losses in dry years or increasing gains in price rise years. Indirect support for this assertion can be found in the study of cotton farmers in China, which concluded that if farmers viewed new varieties of cotton as effective in eliminating pests (as was advertised by scientists), then more loss-averse farmers adopted these varieties sooner (Liu, 2013).

The present study arrives at the following conclusions:

a) The criterion normal year profit is more important than other studied criteria of dry year profit and profit in a price rise year, according to the expert's opinion.

b) The criterion normal year profit is less important for academic than for industrial experts.

c) Almost the same portion of both groups of experts, 82-87%, was identified as loss averse persons. However, the coefficient of loss aversion was significantly higher for academic experts.

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APPENDIX I

The AHP Questionnaire

All answers were reported on the 9-point scale as “much more important”, “more important”, “the same importance”, “less important”, and “much less important”.

Please compare the following criteria for agricultural planning:

1. What is the importance of the criterion “profit in a normal year” compared to “profit in a dry year”?

2. What is the importance of the criterion “profit in a normal year” compared to “profit in a year when agricultural commodity prices rise”?

3. What is the importance of the criterion “profit in a dry year” compared to “profit in a year when agricultural commodity prices rise”?

Please describe yourself: …

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APPENDIX II

Annual data of water supply and changes in prices of agricultural commodities in Israel

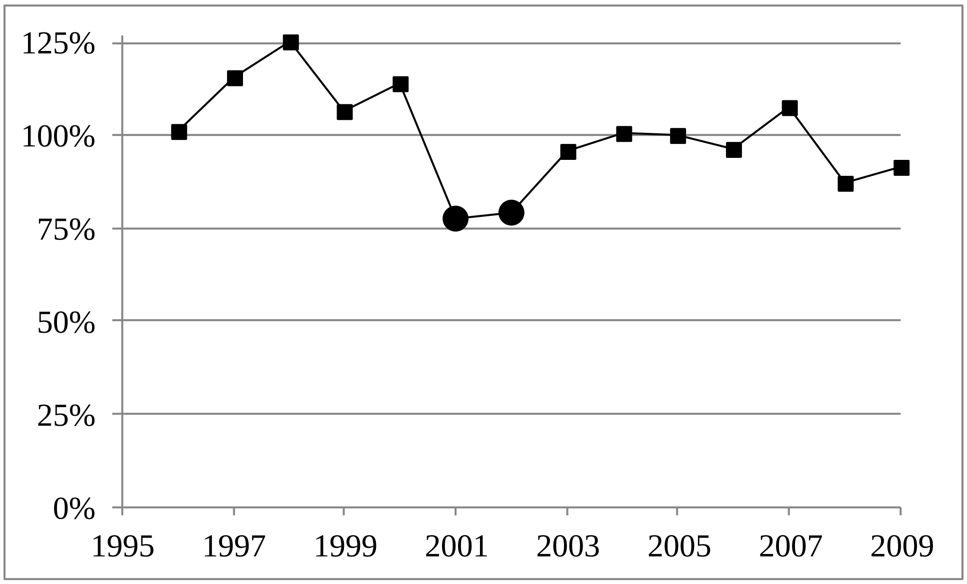

Figure 1a. Water supply to the 32 communities in North-Eastern Israel, % to the 14 years average: calculated by the author based on data collected in Mei Golan Association. The two years of this period, 2001 and 2002, marked with a circle in the figure, were assumed as dry years because the water supply in these years was less than 80% of the average annual supply.

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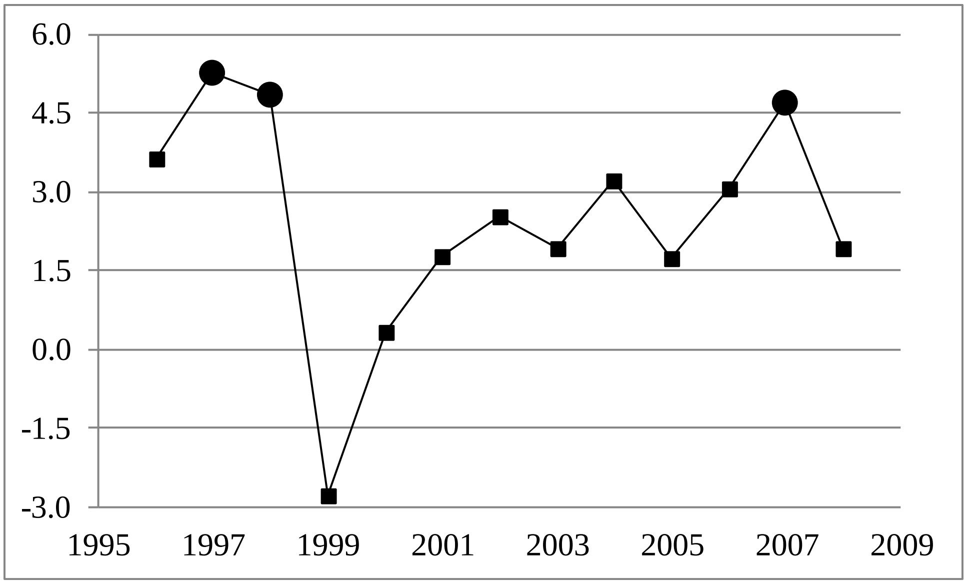

Figure 2a. Changes in price indices of fruit and vegetables as compared to a previous year calculated by the author based on data from Central Bureau of Statistics, Israel, 2015. The three years of this period, 1997, 1998, and 2007, marked with a circle in the figure, were assumed as years of price rise (more than 4.5% in this figure).

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