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Application of Trend Impact Analysis for predicting future fruit consumption

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SUMMARY
Knowledge of those aspects that motivate consumers towards more fruit consumption is necessary in order to implement policies to stimulate fruit consumption. To predict future fruit consumption based on such knowledge from experts, and based on historic consumption data, the method of Trend Impact Analysis (TIA) was applied to four countries. From the historic data, a trend or baseline has been estimated. TIA combines this information with expert knowledge to forecast future consumption. A Monte Carlo simulation was used to handle uncertainty in the TIA model thus developed. Despite the disadvantages of TIA, the method is suitable to explain a trend by means of impact factors, and offers an opportunity to deal with uncertain prognoses by experts. TIA is a relatively unknown method and requires more research and experience to judge if it is widely applicable, and if it provides a good alternative to more traditional forecasting methods.

The market for fruit products in Europe is demand-driven. Knowledge of those aspects that motive consumers towards more fruit consumption is necessary in order to implement any policy to stimulate fruit consumption. Therefore, not only is a reliable prediction of fruit consumption needed, but also knowledge about the causes of changing consumption. This was one of the objectives of the ISAFRUIT Project, a European integrated research project that focussed on all aspects of fruit production and consumption by taking a total chain approach. The aim was to gain a better understanding of the forces that drive the consumption of fruit (products) in order to stimulate consumption.

To predict fruit consumption, forecasting methods could be used. In general, forecasting, or the estimation of future values for the development of scenarios, provides valuable information for managers, marketers, politicians, etc., who have to justify their decisions. Some forecasting methods are qualitative (e.g., consensus methods in which opinions from several experts are combined). However, most forecasting methods are quantitative; for example, trend extrapolation, simulation, cross-impact analysis, and decision trees. Bishop *et al*. (2007) provided an overview and a comparison of different scenarios and futures techniques, including Trend Impact Analysis (TIA). TIA is a method that combines the extrapolation of trends and the expectations of experts about the future, and was first introduced by Gordon and Stover (1976). TIA can deal with changes in trends and allows the forecaster to specify factors that might alter a trend, and to assess the probabilities of their occurrence (Makridakis and Wheelwright, 1989). Compared with the other methods mentioned, the main advantage of TIA is the opportunity to link events with a trend, the main drawback is that the method requires a judgment to estimate impacts (Bishop *et al*., 2007). These authors suggested using a group of experts and, in this way, "It utilises experts' judgements to explicitly deal with unprecedented future events with varying degrees of severity in generating different possibilities (scenarios) of how the future might unfold" (Agami *et al*., 2009).

This paper explains the TIA method, and describes the way in which it was applied in the ISAFRUIT Project. Due to the novelty and attractiveness of combining available historic data and expert knowledge, and the gathering and quantification of factors to explain consumption, it was agreed to apply TIA to this Project. Based on the advantages and drawbacks experienced with this method, it was our objective to find out if TIA could provide a sound alternative to more traditional forecasting methods.

METHOD

In the TIA method, historical data and expert information are combined to produce forecasts of future fruit consumption. For these forecasts, a Monte Carlo simulation was applied, as suggested by Gordon (1994b), Gordon and Stover (1976), and others. A Monte Carlo simulation can deal with uncertainty as a result of the probabilities given by experts. The simulation is named after Monte Carlo, Monaco, because of the casinos where games of chance can be played. In a Monte Carlo simulation, random values are generated a large number of times for all uncertain parameters in an equation predicting future values. For each uncertain parameter, a probability distribution is defined, from which random values are generated. A number of distributions exist. Generating random values, and calculating results a large number of times, permits calculation of the upper and lower confidence limits for the predicted values.

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Agami *et al*. (2009) use neural networks instead of a Monte Carlo simulation. Hack and Zimmermann (1996) used a different, qualitative approach to determine future trends regarding the consumption of flower bulbs. They scanned the environment, analysed the significance of trends, and translated trends into a corporate strategy based on interviews and panel discussions (the so-called "Delphi method").

From a literature search, we concluded that TIA is not frequently applied. In a review of CAB Abstracts, the paper by Hack and Zimmermann (1996) was the only reference from 1984 to 2009 with the term "Trend Impact Analysis" in the abstract. The *International Journal of Forecasting* contains only one reference (Huss, 1988), and the *Journal of Forecasting* has none after 1996. More references (17) were found in *Technological Forecasting and Social Change*; however, only two had the term "Trend Impact Analysis" in the title (e.g. Agami *et al*., 2009). For more information about the TIA method, see Gordon (1994a) and Gordon and Stover (1976).

The application of TIA in this study differed from Gordon (1994a) regarding the use of past impacts.

The following steps were taken:

1. Gathering of data on fruit consumption for different countries and the calculation of baselines (i.e., trends in recent years) from these data.
2. Acquiring information on potential future trends from experts (e.g., expectations of the magnitude (impact) and time-frame of certain factors underlying these trends).
3. Feeding baselines and the expectations of experts into the TIA model.

Consumption data

Data on fruit consumption in four countries were used to estimate trend lines for recent years (baseline). These data were derived from the FAO dataset (FAO, 2009) in which actual fruit consumption was approximated by apparent human fruit consumption, which was calculated indirectly:

Apparent Human Consumption = Production + (Imports – Exports) + (Changes in Stocks – Feed – Seed – Food Manufacture – Waste – Other Uses).

Before 1990, the FAO-definition of fruit consumption was different from its definition after 1990. In fact, there are two datasets, one covering the period 1961 – 2003 and the other 1990 – 2005 (Groot *et al*., 2008).

Questionaire and interviews

Six experts from the fruit sector, and six consumer experts from outside the fruit sector, were asked which events that influenced fruit consumption occurred up to 2007, and which events influencing fruit consumption are likely to happen in the coming years, up to and including 2025. For each event that an expert mentioned, he/she was asked to estimate its impact on past and future fruit consumption (i.e., an increase or decrease) and to estimate the probability that these events would occur at different moments in the future. Several experts supplied information and, for each country, the three events mentioned most were used later. Information from the experts for the years ahead was combined, giving an equal weight to each expert. To interpret the interview results, it was important that uniform definitions were used for the different Trend Impact Factors (defined in Groot *et al*., 2008). When interpreting the results, we took into account the fact that when one of the three most important impact factors was not mentioned by an expert, it was scored as if the expert had assigned zero impact to it, which made the factor, as a whole, less important.

Estimation of the baseline

To make a baseline projection for the future, by extrapolation of a trend line, the historic data should be examined. To estimate trends in fruit consumption in the past, several regression equations were applied (Groot *et al*., 2008). Regression equations that are used as baselines for the trends in the future, were estimated using the following two equations that gave the best trade-off between fit and parsimony:

1. Assuming no discontinuity in the historic trend, the equation for the regression analysis was:

$$Y_t = b_0 + b_1 t \qquad \text{Eqn. 1}$$

where b_0 is the calculated consumption (Y) in the first year ($t = 0$) of the time series (intercept), t is the number of years after the start of the time series, and b_1 is the trend (slope). So, for each year, fruit consumption was assumed to increase with a constant term, b_1.

2. In some countries, there appeared to be a discontinuity in the historical time series. The slope before a particular year appeared to be different from the slope after that year. This could be caused by a change in definition. In order to cope with this break in trend, the following equation was used:

$$Y_t = b_0 + b_1 t + b_2 D + b_3 D \times t \qquad \text{Eqn. 2}$$

where D is a dummy variable that takes the value 0 before the moment of discontinuity in the dataset, and the value 1 after that date.

Calculation of the impact

Future trend impact lines were constructed based on the baseline (historic data) and on the aggregated expert information. Deviations from the baseline and the trend impact line were caused by the difference between past and future factors, and their degree of influence on fruit consumption. A Monte Carlo simulation was used to account for the fact that the experts gave their predictions in terms of probabilities.

In mathematical terms, the impact was calculated as:

$$Incr = Y_c - Y_s \qquad \text{Eqn. 3}$$
$$Infl = \Sigma_f [\Sigma_e \{(\%Future_{ef} - \%Past_{ef}) \times Incr\}] \qquad \text{Eqn. 4}$$
$$Pred = Y_e + Infl \qquad \text{Eqn. 5}$$

where, $Incr$ is the increase in consumption from the start to the current date, Y_t is the value of the baseline in year t (s, c, or e are the first, current, or end periods

TABLE I
The most important past and future Trend Impact Factors according to 11 experts

Trend Impact Factor	Before 2007[†]		From 2007 to 2025[†]	
	Number of experts that mentioned the factor	Mean importance (% ± SD)	Number of experts that mentioned the factor	Mean importance (% ± SD)
Health	7	15.0 ± 8.7	11	30.2 ± 12.6
Convenience	6	18.4 ± 7.9	7	23.4 ± 8.9
Product variation/Product innovation	7	24.4 ± 20.4	4	29.4 ± 8.8
Sustainability	3	11.7 ± 2.9	6	21.6 ± 4.9
Country feeling	–	–	4	23.1 ± 10.3

[†]Mean importance and standard deviations are based only on the answers of those experts who mentioned the factor.

respectively), *Infl* is the total influence on the future trend (i.e., –7.5 in 2025), $\%Past_{ef}$ is the influence of factor *f* (from the set of three most important factors) in the past (%), as estimated by expert *e* (from the set of experts), $\%Future_{ef}$ is the expected influence in the future (%), as estimated by expert *e*, *Pred* is the predicted value in the end of the period. This is explained in more detail in an example in Groot *et al.* (2008).

The TIA model

The TIA model was implemented in Excel Visual Basic to calculate future trends. This model consisted of the following components:

1. Baseline data. These were supplemented with the lower and upper bounds of the 95% confidence interval of the baseline, and fitted by linear regression.
2. Expert data (human judgement). For every country an "expert sheet" was prepared with the data from all the experts including past influences and future influences (i.e., judgements of minimum and maximum effects, as percentages), probabilities of occurrence in year *t*, and the impact period.
3. Aggregate expert data. The expert data were aggregated across the individual experts. All the experts were given equal weight. When an expert did not judge (or mention) the influence of one of the three most important factors, this influence is then expected to be zero.
4. Monte Carlo simulation. Experts provided estimates of probabilities that particular factors would occur at different periods in the future. These probabilities were used as the uncertainties in the calculations for the Monte Carlo simulation. The number of iterations for the simulation could be chosen. A higher degree of uncertainty in the input data required more iterations. In this study, a total of 100 iterations appeared to yield stable results.
5. Graphical presentation of the model. The results were presented as a graph, which consisted of the historic data (these were the actual data; i.e. the line "Historic"), a baseline or trend, based on these historic data (i.e., the line "Baseline"), an expected (predicted) trend (i.e., the line "Estimation (TIA)"), and the 95% upper and lower confidence limits (i.e., the lines "2.5%" and "97.5%"). Before 2007 (the past), these confidence limits referred to the baseline, after 2007 (the future) they belonged to the estimation. The X-axis represented the year, and the Y-axis represented the fruit consumption in kg per capita per annum. It was also possible to see the results for separate factors.

RESULTS

The TIA model was developed primarily to estimate trend impacts in fruit consumption (ISAFRUIT). It is illustrated using the results for fruit consumption in the Netherlands.

Estimating the trend

The first step to estimate the trend impact was to estimate the baseline. A "dummy" was used, because the definition of fruit consumption in the FAO dataset after 1990 differed from the data before 1990. The values of the parameters b_0, b_1, b_2, and b_3 were –3,443.2, 1.79, 3,609.9, and –1.804, respectively. For more statistical information, see Groot *et al.* (2008). Referring to the baseline, the annual increase in per capita fruit consumption for the next years is expected to be 1.946 kg per capita per year (Groot *et al.*, 2008).

Expert opinion

Table I shows the results from the interviews with experts. Eleven of the 12 experts were able to give estimates for changes in the trend lines. Table I illustrates that fruit consumption is expected to increase due to "Health" and "Convenience" issues more than it will do by "Product variation/Product innovation". The last factor will have a decreasing effect on fruit consumption in future, compared to the years before 2007. "Sustainability" will become an important factor for fruit consumption in the future. Despite this, TIA was carried out for "Health", "Convenience", and "Product variation/Product innovation".

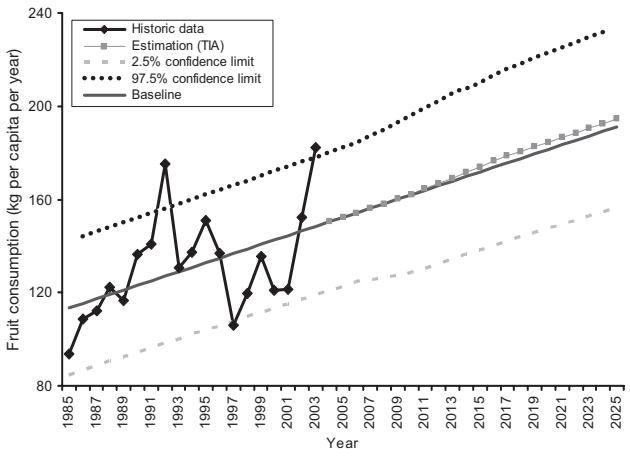

FIG. 1
Trend impact forecast lines, and the upper and lower confidence limits, for the influence of "Health" on fruit consumption (kg per capita per year) based on the responses of 11 experts for The Netherlands.

Table II
TIA estimation of fruit consumption in 2012 and 2025 compared to the baseline in 2007 (kg per capita p.a.)

Trend Impact Factor	Baseline consumption (2007)	Trend Impact Forecast (2012)	Trend Impact Forecast (2025)	Difference upper and lower limits (2012)†
Health	156.2	167.9	196.2	66.5
Convenience	156.3	168.4	195.1	66.6
Product variation/Product innovation	155.9	162.5	186.3	64.8
Combined impact	156.1	167.1	194.7	69.9

†The difference between the upper and lower limits (confidence) is an indication of uncertainty.

Estimating the impact

The results for the impact of "Health" are represented in Figure 1. Comparable Figures for the other factors are presented in Groot *et al.* (2008). The combined effect of the three trend impact factors was an addition of effects, but the effects cannot simply be summed mathematically as probabilities, and time intervals differ between factors.

The variance around the baseline was large in relation to (estimated) fruit consumption. After 2007, the variance in the trend impact line increased. This was due to increasing uncertainty (i.e., probability of impacts). Table II shows the result of the forecast by means of TIA.

Fruit consumption is expected to increase by 2.12 kg per capita per annum, until 2025, as a result of the three most important trend impact factors. This was calculated from (194.7 – 167.1) / 13 years.

DISCUSSION

The questions for the expert interviews were used to acquire the information needed for the trend impact analysis in a direct way. In spite of the fact that the experts were competent in their area, the estimation of impacts and their probability of occurrence appeared to be difficult for them. Some experts were not able to estimate the values needed, which makes the TIA less reliable and resulted in broader (95%) confidence intervals. Clear definitions of the distinguishing factors are essential for this process. Perhaps a more indirect way of questioning would make it easier for the experts to give estimates.

Accounting for past impacts is a drawback compared to the method applied by Gordon (1994a), who did not distinguish any influence of trend impact factors in the past. When a factor only plays a role in the future (in this case, after 2007) only its future influence will appear in the TIA line. That is why interview questions about impact influences on fruit consumption trends before 2007 were essential.

The difference between the upper and lower limits was large compared to the level of consumption. This was already the case regarding the baseline. Looking at the TIA lines, the difference between the limits increases a little more when the future lies further away. This seems to be realistic.

Our experience with TIA in this study revealed a number of advantages and disadvantages. TIA appeared to be a suitable method to quantify the impacts behind the trends, and to make the trends more comprehensible. With TIA, it is possible to account for events in the future, to combine statistical (historical) data with expert knowledge, to explain a trend by means of impact factors, and to make it possible to deal with uncertainty regarding the prognoses of the experts.

On the other hand, the TIA method is fairly unknown, which may be an indication that the method is difficult to use, although no published indications of that were found. The experts appeared to have trouble with the kinds of questions needed to obtain information for a TIA. This study makes it clear that experts with visions on fruit consumption in the future and the past are essential.

The estimated effects were small compared to the 95% confidence intervals. The large variations in consumption between years contributed to this.

TIA requires more research and experience to judge if this method is widely applicable and if it is a good alternative to more traditional forecasting methods.

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