Limits to growth in organic sales

Price elasticity of consumer demand for organic food in Dutch supermarkets

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This report determines how sensitive consumer demand for organic products is to changes in the prices of organic products. The report is based on the analysis of scanner data for supermarkets in ten Dutch communities. In the framework of the analysis, an experiment has been performed in which the prices of organic products have been reduced below current price levels. The report shows that consumer demand for organic food is sensitive to changes in consumer prices. However, for five out of eight products the sensitivity of consumer demand with respect to price declines when the price gap between organic and conventional food falls.

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Contents

Preface

Sustainability of food production and consumption is a major social concern. Consequently, companies throughout the food supply chain, the Ministry of Agriculture, Nature and Food Quality (LNV) and other stakeholders undertake major efforts to enhance the sustainability of food production and consumption. Accordingly, the stakeholders try to promote, among other things, the production and consumption of organic food. In the end, the growth of organic production and consumption depends on consumer demand. However, in the Netherlands consumer demand for organic food is weak and growing slowly. Consumer prices are considered to be a major bottleneck. In order to find out whether this is so, an experiment has been conducted in which consumer prices of organic products have been reduced in retail outlets in ten Dutch communities. This report presents the results of this experiment.

The experiment has been made possible by the Ministry of Agriculture, Nature and Food Quality, the retailers and communities involved in the experiment and Information Resources Incorporated (IRI). The research performed has been guided by a Steering Committee. The researchers want to thank the following experts for their comments and suggestions:

Dennis Fok	Erasmus University Rotterdam
Kitty Koelemeijer	Nyenrode Business University
Laurens Sloot	Erasmus Food Management Institute
Marc Jansen	Centraal Bureau Levensmiddelenhandel
Yigael van der Hoeven	Wessanen

On behalf of the Ministry of LNV, Irene Mouthaan and Arjen Vroegop guided the research as successive project leaders. Other participants of the Steering Committee are Monica de Heide (Task Force Market Development Organic Farming) and Sabine Pronk, Jenneke Leferink and Jacques Urselmann (LNV).

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Director General LEI B.V.

Summary

Sustainability of food production and consumption is one of the major concerns of the Dutch Ministry of Agriculture, Nature and Food Quality. For this reason, the ministry undertakes major efforts in co-operation with private and public organisations throughout the food supply chain to enhance the sustainability of food production and consumption. Part of these efforts focuses on the promotion of organic production and consumption. The Ministry of Agriculture is convinced that, in the end, the growth of organic production and consumption depends on consumer demand. Despite the efforts undertaken so far, organic production and consumption in the Netherlands is still low when compared with Denmark, Germany and the UK. Consumer prices of organic food are considered to be a major bottleneck. So far, this hypothesis has not been tested for the Netherlands.

In order to find out whether consumer prices are a bottleneck for organic food demand, an experiment has been set up in which consumer prices of selected organic products have been reduced in retail outlets in ten Dutch communities. The experiment is unique because prices of organic products have been reduced to levels below current market prices. Prices were reduced for a dour month period in order to simulate a permanent price reduction. As a result, we have observations of consumer demand at prices which are not observable without the experiment. This report presents the results of this experiment. The experiment has been complemented by a consumer survey undertaken in some of the retail outlets which were part of the experiment. The survey gives insight into consumer knowledge of prices, consumer perceptions with respect to the value added of organic products and consumer buying motives. The results of the survey can be found in Tacken et al. (2007).

The experiment has been conducted in ten Dutch communities. The communities selected are small and medium-sized communities the population of which corresponds with the Dutch average in terms of population and household composition. The experiment applies to eight products: eggs, milk, minced beef, muesli, mushrooms, pork, potatoes and rice. The selection of communities and products is based among other things on factors facilitating the implementation of the experiment, such as the ability to collect data, co-operation by retailers, presence of specialty outlets, etcetera. The price reductions applied differ between communities *and* products. In Houten, for instance, pork prices have been reduced by 8% and mushroom prices by 40%. In Maassluis, pork prices have been reduced by 32% and mushroom prices by 16%. Prices have been reduced by 5 up to 25% for eggs, milk, muesli, pork and potatoes. Prices have been reduced by 8 up to 40% for minced beef, mushrooms and pork.

The sensitivity of consumer demand with respect to price has been determined on the basis of the Almost Ideal Demand specification. This specification is widely used in applied demand theory, among other things to estimate price elasticities of demand for organic food in Denmark and the US. These studies find that consumer demand for organic food is price elastic. If prices of organic products are reduced by 10%, consumer demand rises by 10-25% with outliers downwards and upwards.

This research comes to similar findings for the Netherlands. The absolute value of the price elasticity of demand for organic products at current prices lies between 1 and 2. This implies that if the prices of organic products fall by 10%, consumer demand goes up by 10-20%. The cross price elasticity of demand for organic products lies between 0.15 and 0.90. This implies that if prices of non-organic products go up by 10%, demand for organic products rise by 1.5-9.0%.

The report analyses in depth whether consumer demand for organic food becomes increasingly large when the price gap between organic and conventional products falls. This only happens for three products: organic eggs, minced beef and muesli. This does not happen for organic milk, mushrooms, pork, potatoes and rice. On the contrary, for these products, we establish a bound to the growth in total sales in euros. When the price gap becomes sufficiently small, consumers hardly react to price changes and total sales revenue actually decline. This implies that there is a bound to the budget share organic products may obtain.

The difference between eggs, minced beef and muesli on the one hand and all the other products on the other hand, may be explained by current market prices for organic food. Consumer prices for organic eggs, minced beef and muesli are relatively high compared with prices for conventional food; consumer prices for organic milk, mushrooms, pork and rice are relatively low. Probably consumer demand for organic food is sensitive to price changes when the price gap is high and not sensitive when the price gap is low.

Other arguments from the marketing mix may also be used to promote consumer demand for organic food. The report finds that folder activities and an increase in the number of organic varieties enhance long run consumer demand.

We want to conclude with one caveat. This report demonstrates that consumer demand for organic food is responsive to price changes. However, this does not imply that one should conclude that current consumer prices of organic products are too high and that consumer prices should be reduced. The report contributes to our knowledge about consumer behaviour. The analysis is descriptive. In order to assess whether consumer prices are too high, a normative analysis would be necessary. The current price gap between organic and conventional food may very well be due to differences in costs, quality or scarcity. The latter differences may justify the price differences currently observed.

1. Introduction

In order to enhance the sustainability of Dutch agriculture, the Dutch Ministry of Agriculture, Nature and Food Quality laid down goals with respect to organic production and consumption (*Beleidsnota Biologische Landbouw* 2001-2004 and 2005-2007). Currently, production and consumption of organic food in the Netherlands is low compared with, for instance, Denmark, Germany and the UK (Hamm and Gronefeld, 2004). Several reasons have been brought forward in policy, business and social sciences to explain why the rate of organic consumption is low and why organic consumption is growing slowly, in particular in supermarkets. This discussion focuses on two elements: the promotion of organic food's value added and, in particular, the high relative price of organic food in comparison with non-organic food. Both arguments are supported to some extent by results from questionnaires. However, there is little empirical evidence on the sensitivity of Dutch consumers' demand for organic products with respect to promotional activities and price based on actual buying behaviour. This research aims to fill this gap with respect to prices in order to clarify the discussion on consumers' buying behaviour with respect to organic food.

In order to determine the sensitivity of Dutch consumers' demand for organic products with respect to price, this research estimates the consumer price elasticity of demand on the basis of scanner data collected from Dutch supermarkets. The price elasticity of demand is a measure of the sensitivity of consumer buying behaviour with respect to prices. In order to improve our knowledge with respect to the price sensitivity measured, this research is accompanied by qualitative research addressing consumer knowledge of prices and consumer motivation with respect to the choice between organic and non-organic food.

In principle, one may determine the price elasticity of demand on the basis of available scanner data, provided prices and sales exhibit sufficient variation. This research would give insight into the sensitivity of consumer prices with respect to current price levels. However, these results do not necessarily hold for substantially reduced price levels. Part of the literature on organic consumption suggests that organic food consumption would increase substantially if the prices of organic food would fall substantially. The literature suggests there is a turning point in consumer demand for organic food. Beyond a certain price level, the demand for organic food would gain substantial market share and possibly crowd out non-organic food. In order to gain insight into the effects of a substantial permanent reduction of consumer prices of organic food, a unique experiment has been conducted. In ten local communities in the Netherlands, the prices of selected organic products were reduced by up to forty percent below their regular level for a 17 week period.

This report presents the results of the analysis performed to determine the price elasticity of demand. This report is constructed as follows. Chapter 2 discusses the context of this report. Chapter 3 presents the set up and the implementation of the experiment. Chapter 4 discusses the literature on consumer demand for organic food. Chapter 5 elaborates the methodology employed. Chapter 6 discusses the data collection process as well as the data. Chapter 7 presents the results of the analysis. Chapter 8 extends the analysis to promotional activities and the interaction between prices and promotional activities. Chapter 9 interprets the results. Finally, chapter 10 concludes.

2. Context

In this chapter, we elaborate the problem statement put forward in the introduction by sketching this report's context. In section 2.1, we discuss the policy framework which gave rise to this research. In section 2.2, we elaborate the problem statement put forward in the introduction. In section 2.3, we present the stakeholders involved. In section 2.4, we discuss the relation between this report and the complementary report on consumer knowledge and motivation regarding prices and value added of organic food. Finally, in section 2.5 we sketch the limits of the research discussed in the report.

2.1 Policy framework

In 2004, the Ministry of Agriculture, Nature and food Quality published its last *Beleidsnota Biologische Landbouw: 2005-2007* (MLNV, 2004). In this memorandum the Ministry defined the objectives underlying this research.

The Ministry stimulates organic farming in order to enhance the sustainability of Dutch agriculture. For 2005-2007, government policy with respect to organic farming is directed towards demand promotion. The Ministry is convinced that in the end the growth of organic farming depends on the growth in consumer demand. The memorandum ascertains that the current price gap between organic and non-organic products may be an important bottleneck impeding further demand growth for organic products (MLNV 2004: 8). The price gap is caused by, among other things, to the small scale of the organic supply chain and the fact that the negative externalities in traditional farming are only partially translated into farm and consumer prices (Bunte, 2004). To find out whether a reduction of the price gap between organic and non-organic products indeed contributes to demand growth for organic products, the Ministry decided to conduct a price experiment regarding organic consumption. The Ministry commissioned LEI to set up the price experiment in co-operation with the other stakeholders involved (see section 2.3) and to analyse the results of the experiment. If a reduction of the price gap indeed leads to demand growth for organic products, policies directed to lowering the price gap may be envisaged (MLNV, 2004). However, the note already indicates that the possibilities to define government policy may be quite limited (op. cit.: 16). Apart from the price issue, the Ministry is also interested in promoting the value added of organic products (op. cit.: 17).

2.2 Problem statement

The central problem statement in this report is what the impact is of a permanent reduction in the prices of organic food on the consumption of organic food. This problem statement will be answered by estimating the consumer price elasticities of demand for organic food and their non-organic counterparts. This problem statement will be refined as follows:

- first, we will differentiate the answer according to respective products and product varieties;

- second, we will differentiate this answer on the basis of the size of the price reductions implemented. This way, we test whether there is a turning point in consumer buying behaviour beyond which consumers switch massively from non-organic to organic food (Van der Eerden et al., 2003).

The problem statement presumes that consumers react to changes in consumer prices by adapting their buying behaviour. The literature suggests that consumers only change their buying behaviour if three conditions are met (Van Heerde et al., 2005):

1. consumers are aware of the price change;
2. consumers are able to react to the price change;
3. consumers are willing to change their buying behaviour.

With respect to these three conditions, we may formulate the following *a priori* expectations:

1. one may expect that consumers are aware of the price changes. The price reductions have been communicated through publicity and price labels and were implemented for a four-month period;[1]
2. consumers are able to switch from one product variety to another, because we are dealing with products which are bought daily (or at least weekly). For durable products consumers may face large switching costs such as contractual obligations (a telephone contract e.g.) or recent purchases (a couch e.g.);
3. if the above expectations hold, changes in consumer buying behaviour depend to a large extent on consumer motivation. If consumers perceive that organic products have value added over non-organic products, then some consumers may be expected to switch to organic products or to buy more organic products when organic food prices are reduced. If consumers perceive the price change but do not switch from non-organic to organic food, then there may be a bottleneck with respect to the value added organic products are supposed to have. The number of organic varieties may be too low or may not meet the preferences of the Dutch consumer.

Condition 1 is crucial for the results of the analysis. Consumers were not constantly informed about the price reductions during the experiment. Consumers had search costs during the experiment as they do in regular settings. Information provided was limited (see section 3.3). In the first two weeks of the experiment the price changes were communicated using promotion labels and folders. In the other weeks this information was confined to regular price labels. Consumers had to take time to read the price information available and to process it.

[1] A counter argument is the fact that the budget share of most products in total consumer expenses is low. The consumer may very well be unwilling to compare prices in a product group such as muesli. However, research shows that even for a product group such as ketchup some consumers make use of price information (Van Heerde et al., 2005).

2.3 The stakeholders involved

The experiment has been organised by four stakeholders: (1) the Ministry of Agriculture, Nature and Food Quality, (2) food retailers, (3) LEI and (4) IRI. The stakeholders performed the following roles:

(1) the Ministry formulated the research question and financed the experiment;
(2) LEI elaborated the research question into the research proposal and the experiment set-up in co-ordination with the other stakeholders involved. Furthermore, LEI performed the analysis on the basis of the data collected;
(3) IRI collected the scanner data and also interviewed consumers through the questionnaires used for the qualitative analysis;
(4) food retailers reduced the prices of the selected organic products in 2006 from week 17 until week 33. Food retailers agreed to do their utmost to prevent the participating outlets from running out of stock.

The research and experimental set-up were guided by a Steering Committee and followed by the Task Force Market Development Organic Farming. The Steering Committee was composed of representatives of the Ministry of Agriculture, Nature and Food Quality, the Task Force Market Development Organic Farming, LEI, Centraal Bureau Levensmiddelenhandel (CBL) and scientific experts: Dennis Fok (Erasmus University Rotterdam (EUR)), Laurens Sloot (Erasmus Food Management Institute (EFMI)) and Kitty Koelemeijer (Nijenrode Business University).

2.4 Relationship with the consumer research

This report is part of a research project analysing the relation between consumer demand and consumer prices. In addition to this report, complementary research has been undertaken on consumer knowledge with respect to prices and consumer perception of the value added of organic food over non-organic food relative to price differences (Tacken et al., 2007). The reports are complementary. The current report measures the consumer reaction to changes in the price of organic food. The consumer research studies whether the preconditions necessary for the change in consumer behaviour are met. In particular, the consumer research investigates what knowledge consumers have with respect to food prices and what the value added is of organic food over non-organic food relative to price differences. This may explain the size of the price elasticities found in this report.

2.5 Limits to this research

This report analyses the long-run effects[1] of permanent price changes. The report does not analyse the effects of price promotions. Because the data analysed apply to supermarkets, the results only refer to supermarkets. The results do not refer to specialty outlets, markets,

[1] The analysis focuses on the first order effects of permanent price changes. Possible effects of the permanent price changes on other variables such as the number of varieties and the resulting second-order effects on prices and demand are not taken into account.

etcetera. The report gives a glance at the effects of promotional activities by analysing the impact of folder activities and product assortment on the sales of organic products. This implies that this research will not give an answer to the question how effective marketing measures other than pricing are and how effective price measures are relative to other instruments. These questions may be addressed in future research.

3. The experiment

This chapter presents the experiment implemented in order to determine the sensitivity of consumer buying behaviour with respect to prices of organic food. The experiment was conducted to determine the effect of a permanent reduction of consumer prices of organic products below current prices. In other words, what do consumers buy if the current price gap between organic and non-organic products is permanently reduced. For this reason, a real-life experiment has been conducted in which food retailers reduced the prices of selected organic products by up to forty percent in ten selected communities. The price reduction has been subsidised by the Dutch Ministry of Agriculture, Nature and Food Quality.

3.1 The communities selected

In the experiment, prices of selected organic products were reduced in ten selected communities. The communities were selected using the following criteria:

- *Socio-economic characteristics*
  Both low and medium-income communities were selected. The sample was intended to represent average Dutch communities. High-income communities were excluded.[1] Household composition and age have been accounted for by investigating the number of households with children and the number of elderly persons. Extreme deviations were excluded.[1] Houten was included in the sample, although it is a young community and the household with children criterion deviates more than one standard deviation from the Dutch average;
- *Size*
  The experiment was carried out in small and medium-sized communities. Large communities were excluded in order to keep the organisation relatively simple, to exclude specialty stores (see criterion 5) and because the experiment might have become too expensive. Very small communities were excluded in order to guarantee the presence of several retailers in each community as well as the presence of relatively large outlets with large (organic) product assortments;
- *Retailers located in the communities*
  The experiment should not discriminate between food retailers and include all major retail chains, in particular those with a large assortment of organic products. In some communities, major discounter chains are active: Aldi (Zaltbommel, Coevorden, Uden and Uithuizen) and Lidl ('s Heerenberg, Coevorden, Uden and Maassluis). The discounters were not willing to participate in the experiment. In any case, they have a limited assortment of organic products;
- *Presence of organic specialty outlets*
  Because the analysis envisaged is applied to retail scanner data, communities with organic specialty outlets were excluded. In the end, there was one exception. In the

[1] Criterion: one standard deviation from the average in the Netherlands.

community of Houten one specialty store took part in the experiment. However, this outlet is not considered in the analysis of this report;

- *Data availability*
  In order to simplify the data collection process, we only selected communities with retail chains which are part of the IRI data set.

In the end, the following communities were selected (table 3.1). The communities chosen represent urban versus rural areas as well culturally different areas such as the South (Brabant and Limburg), the West (Holland), the Centre (Utrecht and Gelderland) and the North (Overijssel, Drente, Friesland and Groningen). Table 3.1 also indicates which retailers are present in the communities selected. Albert Heijn, Super de Boer, Jumbo and Plus have a relatively large product assortment of organic food. Albert Heijn and Super de Boer are present in all communities selected. Albert Heijn and Super de Boer belong to the two main food retail conglomerates which were active in the Netherlands when the experiment was set up: Ahold (Albert Heijn and C1000) and Laurus (Super de Boer, Konmar and Edah). Due to financial problems, Laurus sold its Edah and Konmar outlets in 2006, among other buyers to Ahold. Figure 3.1 presents the market share distribution in the Dutch food retail sector in 2004.

The dataset made available to LEI does not only contain scanner data for the 42 outlets in the communities selected, but also for 42 control outlets in other communities. For each test outlet, IRI selected one control outlet which was comparable in terms of size, neighbourhood and number of organic varieties.

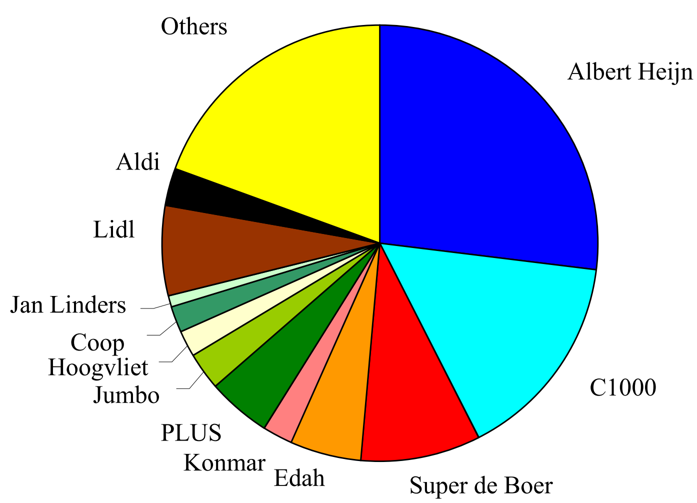

Figure 3.1 Market shares of food retailers in the Netherlands (2004)

Table 3.1 Communities selected

Community	Inhabitants (2006)	Households with children % (2005)	Aged persons (65+, %) (2005)	Region	Income per earner (2004)	Retailers present
's Heerenberg	8,150	40	16.0	Centre	15,400	AH, Coop, Edah, Super de Boer
Houten	44,499	49	8.7	Centre	19,900	AH, C1000, PLUS, Super de Boer, Groene Winkel a)
Huissen	14,820	44	12.6	Centre	17,300	AH, Coop CA, Super de Boer
Zaltbommel	26,191	46	12.7	Centre	18,100	AH, Konmar, Super de Boer
Coevorden	36,135	38	17.0	North	16,000	AH, Coop CA, Super de Boer
Uithuizen	5,310	38	15.5	North	14,800	AH, Jumbo, Super de Boer
Berkel-Enschot	10,720	44	15.0	South	19,800	AH, PLUS, Super de Boer
Uden	40,201	40	13.4	South	18,100	AH, Edah, Jan Linders, Jumbo, PLUS, Super de Boer
Brielle	15,990	38	14.2	West	19,500	AH, Jumbo, PLUS, Super de Boer, Zomermarkt a)
Maassluis	31,956	38	14.4	West	17,800	AH, C1000, Hoogvliet, Konmar, Super de Boer
Netherlands		40	14.4		17,700	

a) Specialty outlet not included in the analysis.
Source: CBS: StatLine.

3.2 The products selected

In the experiment, prices of selected organic products were reduced. The products were selected using the following criteria:

- *The availability of scanner data*
  Criterion 1 presents problems for products which are not pre-packed. This limits the possibility to include fruits and vegetables. Not all fruits and vegetables are pre-packed in all retail chains. For this reason, mushrooms and potatoes have been selected and apples have been left out of the experiment. Criterion 1 also presents problems for products with variable weights, notably meat. Not all retailers provide data on volumes and prices to IRI. Consequently, some retailers were omitted from the analysis for meat products;
- *The availability of organic varieties*
  For all products selected, organic varieties are available in the major retail chains involved in the experiment;
- the representation of major food categories such as meat, dairy, fruit and vegetables and groceries.

In the end, eight products were selected: pork, minced beef, milk, eggs, potatoes, mushrooms, rice and muesli. Table 3.2 indicates how many organic varieties (ean-codes)[1] were available per retail chains. In some retail chains, organic muesli, and mushrooms were not available.

3.3 Conduct of the experiment

The price experiment was carried out in 2006 from week 17 until week 33. The price changes were communicated with consumers in a low-key way. In week 17 and 18, the price changes were communicated to consumers using regular promotion labels in the supermarkets. For meat, the price changes were indicated using regular promotion labels in all weeks of the experiment. The price changes were announced (in the first week of the experiment) in leaflets in the communities where the experiment was carried out. In the other weeks, no special attention was paid to the price reductions.

The prices of organic food were reduced with different percentages. The prices of eggs, milk, muesli, potatoes and rice were reduced by 5, 10, 15, 20 and 25%. The prices of mushrooms and meat were reduced by 8, 16, 24, 32 and 40% (see table 3.3). The price reductions for eggs, milk, muesli, potatoes and rice were lower than the price reductions for mushrooms and meat because the price gap between organic and non-organic products is lower for the former products.

In each community, the same percentage price reductions were carries through to avoid disturbing the competitive relations between retailers. However, in each community, the price reductions differed per product. So, for instance, in Maassluis the price of organic pork was reduced by 24% while the price of organic potatoes was reduced by 10%.

In the beginning of the experiment, the following problems arose which influenced the experiment and which may have consequences for the results obtained:

[1] Ean codes are an imperfect measure for varieties because they also express differences in supplier, weights, etcetera.

- *The availability of organic varieties*
  Retailers agreed to offer organic varieties at reduced prices for all products selected in the experiment period. However, in the first weeks of the experiment, some organic varieties were withdrawn from the product assortment because they were hardly sold at all and had to be withdrawn from the outlets on a large scale because of expiry dates. This held in particular for meat. For pork, Albert Heijn decided to reduce the price of organic schnitzels only. Note that Albert Heijn also sells other organic varieties of pork (see table 3.2);
- *Out of stock*
  In the framework agreement between the Ministry of Agriculture, Nature and Food Quality and CBL which represents Dutch supermarket chains, retailers agreed to do the utmost to keep out-of-stock occurrences to normal levels. The store checks indicate that out-of-stock levels for some products may have been relatively high in the beginning of the experiment;
- *Communication*
  Some retailers did not advertise the price reductions at all and others advertised them vigorously. In some cases the price reduction was not visible in the store. Customers got the price reduction when they paid the total bill.

In order to address these issues which arose in the beginning of the experiment, the following was done. IRI, LEI and the Ministry of Agriculture undertook store checks in the outlets concerned. If one of the issues was observed, the store-manager was contacted in order to solve the above problems immediately. Although we do not know exactly to what extent these issues occurred, we believe that most of the abovementioned problems must be seen as incidents and not as structural problems.

Table 3.2 Number of organic product varieties (ean-codes) per retail chain (test and control outlets)

Product	Albert Heijn	C1000	COOP	COOP compact	Edah lekker en laag	Hoog-vliet	Jan Linders	Jumbo	Konmar	Plus	Super de Boer
Eggs	1	1	2	2	1	1	2	1	2	5	3
Milk	4	3	4	6	2	2	1	5	8	6	5
Minced beef	1	2	1	3	1	1	1	3	1	2	1
Muesli	1	1	-	-	-	-	-	2	1	2	1
Mushrooms	2	2	3	3	1	-	1	6	7	6	4
Pork	6	10	7	8	4	10	5	9	18	11	17
Potatoes	4	6	1	1	4	2	3	8	5	8	6
Rice	4	2	1	2	-	-	-	3	2	-	-
Total	23	27	19	25	13	16	13	37	44	40	37

Table 3.3 Price reductions for organic products per community (in %)

Product	Berkel Enschot	Brielle	Coevorden	's Heerenberg	Houten	Huissen	Maassluis	Uden	Uithuizen	Zaltbommel
Eggs	10	15	20	25	5	10	15	20	25	5
Milk	15	20	25	5	10	15	20	25	5	10
Minced beef	40	32	8	16	24	32	40	24	8	16
Muesli	20	25	5	10	15	20	25	5	10	15
Mushrooms	8	16	24	32	40	8	16	24	32	40
Pork	16	24	32	40	8	16	24	32	40	8
Potatoes	5	10	15	20	25	5	10	15	20	25
Rice	25	5	10	15	20	25	5	10	15	20

4. Literature review

There is extensive literature on the relationship between consumer demand and prices, both in economics and in marketing. With the growth of organic food consumption, there is also a growing literature on the relation between organic food demand and prices. This has served two purposes in the current study: To elaborate the methodology which will be discussed in chapter 5 and to provide a reference point for discussing the results of the analysis discussed in chapter 7. This Chapter provides two overviews of the same literature: one of the methodologies employed and one of the results obtained.

4.1 Methodology

Table 4.1 gives an overview of the methodologies employed to study the relation between consumer demand for organic food and prices. The table shows the predominance of classic demand models[1] and in particular the Almost Ideal Demand (AID) System. The AID System is one of the most widely employed models used to estimate consumer demand empirically (Deaton and Muelbauer, 1980). AID Systems belong to the most developed systems used in empirical demand analysis (op. cit.). Major advantages of AID specification are that the functions are general[2] and that the theoretical restrictions from demand theory are easily imposed[3] on the parameters and easily tested. The AID-specification is common and well-accepted in the literature (Thompson, 2005).

From a theoretical perspective, AID systems have various advantages, but also disadvantages. In the 1990s, the disadvantages have been addressed by generalising the AID system to more generalised systems, notably the quadratic AID system (Banks, Blundell and Lewbel, 1997; Dhar and Foltz, 2003). From an econometric perspective, the AID system also offers various advantages, but again may run into some problems. Econometric theory has addressed some of the problems put forward in the literature. We list the most important analytical and econometric issues below. We also address to what extent these issues matter for our problem statement.

Theoretical issues

1. *Constant income elasticity*
   The linear AID system generates constant income elasticities. The system does not allow products to be luxuries at some range of the demand system and necessities at other ranges. Quadratic versions of the AID System allow expenditure elasticities to vary: a good may turn from a luxury into a necessity

[1] Examples of 'classic' demand models are the logaritmic demand model (Stone, 1954a), the linear expenditure system (Stone 1954b), the Rotterdam model (Theil 1965; Barten, 1966), translog models (Diewert, 1971, Christensen, Jorgenson and Lau, 1975) and the AID system (Deaton en Muellbauer, 1980).

[2] The specifications as such do not impose any restrictions on the parameters.

[3] Economic theory derives three restrictions. (1) The budget shares sum to 1. (2) If budget and prices all rise by X%, consumer demand remains unchanged (homogeneity). Demand depends on relative rather than nominal prices. (3) There is symmetry between the coefficients of substitutable and complementary products. For the so-called pure substitution-effects between product x and product y, it does not matter whether the price of product x rises by 10% or the price of product y falls by 10%.

and vice versa. Note that - for the problem statement at hand - expenditure elasticities are not the most important result of the analysis. However, expenditure elasticities influence the price elasticities of demand. Since we applied the linear AID system (see chapter 5), organic food can only be either a luxury or a necessity and not a luxury over some range of the budget and a necessity over another range;

2. *Price Index*
   Early versions of the AID system made use of Stone's linear approximations of the price index. Linear versions of the price index are convenient from an analytical and an empirical perspective, among other things because it is easier for econometric methods to find parameter estimates. Linear approximations may generate estimation biases. For this reason, we revert to the non-linear version of the price index. However, the non-linear version of the price index may generate problems in finding solutions (Glaser and Thompson, 2000). Fortunately, theoretical restrictions with respect to the demand parameters may overcome this problem (see below);
3. *Substitutes and complements*
   In theory, everything is related to everything else. In theory, one may want to relate the demand for organic semi-skimmed milk in 0.5 liter packages to the prices of all sorts of milk in all kinds of packages. However, from a practical point of view, one may restrict the model in such a way that the most important substitutes (and complements) are considered only. A distinction can be make- between close and distant substitutes and complements by nesting demand.[1] There is one caveat when restricting attention to the most important substitutes: The identification of substitutes and complements on a priori grounds should be possible. In this respect Hansen (2003, 2004) points to a possible problem related to nesting. Does a consumer choose to buy organic first and then choose a particular vegetable? Or does a consumer choose to buy carrots first and then choose either regular or organic carrots? Most applications typically make the second assumption. However, the first assumption may be more appropriate for heavy users of organic food. Hansen (2003, 2004) finds evidence for the first assumption when testing for separability using household panel data (see below). For the current application, given the predominance of light users in the scanner data made available, the second assumption may very well be appropriate.

Econometric issues

4. *Endogeneity*
   The AID specification has one major problem. The explanatory variable is a deterministic function of the dependent variables: Budget shares - the left hand side of the equation - are a function of prices and budgets - the right hand side of the equation. This may cause a bias in the parameters to be estimated. One may overcome this problem by (i) incorporating the budget in the demand system; (ii) by imposing the restrictions from demand theory on the system of demand equations and (iii) by testing for endogeneity. This issue is elaborated in chapter 5;

[1] Demand nests identify substitution at different product levels. Food competes with e.g. travel, clothing and transport. Within food, meat competes with dairy, cereals, fruits and vegetables. Within fruits, apples compete with e.g. pears, grapes and citrus.

5. *Overidentification*
Demand systems are overidentified due to the adding up constraint. For this reason, one of the demand equations is dropped when estimating the system. The parameters found may depend on the equation dropped from the system. This issue is addressedby investigating whether it matters which equation is dropped from the system;
6. *Separability*
The estimations do not take account of the fact that demand for the products concerned also depends on the demand for and expenditure on other products. We model a part of a system. Solutions to this problem are discussed in LaFrance (1991).

To conclude, the AID is a well-developed and accepted model to estimate consumer demand. There are various theoretical and econometric issues to be addressed, but economic and econometric theory offer various tools to handle these issues.

4.2 Findings

Table 4.2 presents the results of the estimates of the price elasticities of demand for organic food. The results refer to the US and Denmark. The table presents the own-price elasticities of demand, the cross price elasticities of demand and the expenditure elasticities of demand.

- The own price elasticity of demand for organic food indicates with what percentage the demand for organic food changes if the price of organic food rises with 1%. Of course, we expect this reaction *to be negative*: if the price of organic food rises, consumers are likely to switch to a substitute product and thus to buy non-organic food rather than organic food. The demand for organic food falls.
- The cross price elasticity of demand for organic food indicates with what percentage the demand for organic food changes if the price of a substitute product - in this case non-organic food - rises by 1%. We expect this reaction *to be positive*: if the price of non-organic food rises, consumers are likely to switch to organic food which is a substitute of non-organic food. So, the demand for organic food rises.
- The expenditure elasticity of demand for organic food indicates with what percentage the demand for organic food rises if the food budget rises with 1%. We expect this reaction *to be positive*. If consumers spend more on food in general, they are likely to consume larger quantities of both organic and non-organic food. They are also likely to switch to more luxury (expensive) products, in this case organic food. For this reason, we expect the expenditure elasticity for organic food to be higher than the one for conventional food.

Table 4.2 responds in most cases to our expectations.

- First, the own price elasticities of demand are negative for both organic and non-organic food. Moreover, the price elasticities of demand for organic food tend to be higher than for non-organic food. This is primarily due to the fact that changes in buying behaviour are large in percentages of organic food sales -

column 4 in table 4.2 - and small in percentages of conventional food sales - column 5 in table 4.2.

- Second, the cross price elasticities of demand are positive for both organic and non-organic food with the exception of 1% milk. The cross price elasticity for organic food is higher than the cross price elasticity for non-organic food, because the budget share of organic food is lower than the budget share of conventional food. Substitution between organic and non-organic food is larger in percentages of organic sales - cross price elasticity of demand for organic food with respect to the price of non-organic food - than in percentages of non-organic sales - cross price elasticity of non-organic food with respect to price of organic food. This explains the difference between column 6 and 7 in table 4.2.
- Third, the budget elasticities of demand are positive with the exception of the ones for organic products reported by Glaser and Thompson (2000). The latter result is an artefact of the fact that organic milk has a very small market share in the US. What is striking with respect to the budget elasticities is the fact that the budget elasticity for organic food is not higher than the one for non-organic food. Apparently, non-organic food is not really considered as a luxury the demand for which rises with income.

There are two more remarks to be made with respect to table 4.2. First, the expenditure elasticities for organic food tend to be low when the estimations take account of the separability issue addressed in section 4.1 (see Hanssen 2003, 2004). Expenditure elasticities become lower when a larger system, i.e. more products, is taken into account. Second, Thompson and Kidwell (2000) illustrate that the demand for organic food becomes less price sensitive through time because the budget share of organic food rises. The absolute value of the price elasticity of demand falls with an increase in the market share of organic food. Consumers are sensitive for price differences when demand is low and the price gap is high and vice versa.

To conclude, the estimation of consumer demand with the AID System or a comparable system, generates plausible results in terms of own and cross price elasticities of demand and in terms of budget elasticities.

Table 4.1 Literature review I: methodology

Paper	Country/ Period	Products	Method	Data	Comments on methodology
Balcombe (2004)	Greece: 1965-1999	Meat	AIDS	National Accounts	Bootstrapping and finite sample adjustments improve estimations Unwise to abandon parameter restrictions without the above corrections
Dhar and Foltz (2003)	US: 1997-2002	Milk	Q-AIDS	Scanning	The quadratic version of the AIDS model allows for non-linear relation between demand, price and expenditure
Glaser-Thompson (1999)	US: 1990-1996	Frozen vegetables	AIDS	Scanning	Price Index is non-linear Number of substitutes reduced on a priori grounds The model accounts for seasonality
Glaser-Thompson (2000)	US: 1996-1999	Milk	AIDS	Scanning	Price Index is non-linear Number of substitutes reduced on a priori grounds Sensitivity of the results to budget shares
Hansen (2003, 2004)	Denmark: 1997-2000	Food	AIDS	Household	When separability is accounted for, the budget elasticities are lower than in normal AIDS system
Matsuda (2006)	Japan: 1965-1999	Food	Q-AIDS	National Accounts	Linear approximation to the quadratic AIDS model Approach is useful in case of non-stationary times series
Thompson-Kidwell (1998)	US: 1994	Vegetables	Discrete choice	Survey	
Torrisi, Stefani, Seghieri (2006)	Italy: 2002-2004	Wine	AIDS	Scanning	Price Index is linear The model includes demand shifters
Wier-Smed (2000, 2001)	Denmark: 1997-1998	Food	AIDS	Household	

Table 4.2 Literature review II: results for organic food

Paper	Country Period	Products	Price elasticities: Own price, Organic	Price elasticities: Own price, Non-organic	Price elasticities: Cross price, Demand organic Price non-organic	Price elasticities: Cross price, Demand non-organic Price organic	Expenditure elasticity: Organic	Expenditure elasticity: Non-organic
Dhar and Foltz (2003)	US: 1997-2002	Milk	-1.4	-1.1	3.2	0.0	0.5	1.0
Glaser-Thompson (1999)	US: 1990-1996	Frozen beans	-2.2	-0.6	0.8	0.0	1.1	1.1
		Frozen broccoli	-2.3	-1.0	0.6	0.5	1.1	0.9
		Frozen corn	-1.6	-0.1	2.4	0.0	0.8	1.2
		Frozen peas	-1.9	-0.3	0.4	0.0	1.5	0.9
Glaser-Thompson (2000)	US: 1996-1999	Whole milk	-3.6	-0.7	8.2	0.2	-5.7	1.1
		Milk, 1% fat	-9.7	-0.9	-5.5	-0.4	-8.6	0.6
		Milk, 2% fat	-7.4	-1.3	13.5	0.3	-2.8	1.1
		Nonfat milk	-3.7	-0.8	7.1	0.2	-2.8	0.9
Hansen (2003, 2004)	Denmark: 1997-2000	Dairy	-0.5	-0.7	0.5	0.1	-0.0	0.8
		Cereals	-0.6	-0.6	0.6	0.1	0.2	0.7
		Other food	-0.8	-0.1	0.3	0.0	0.8	1.1
Wier and Smed (2000, 2001)	Denmark: 1997-1998	Dairy	-2.3	-1.1	1.3	0.1	n.a.	n.a.
		Cereals	-1.9	-1.1	0.9	0.1	n.a.	n.a
		Meat	-2.3	-1.0	1.3	0.0	n.a.	n.a
		Other Food	-1.6	-1.0	0.6	0.0	n.a.	n.a

5. Methodology

This chapter describes the methodology chosen to estimate the sensitivity of consumer buying behaviour with respect to price, more specifically the price elasticity of demand. Section 5.1 justifies the method chosen and section 5.2 describes the research approach chosen to reach the results to be obtained. In the presentation of the approach, we take account of the technical issues which need to be addressed in the method chosen (see chapter 4).

5.1 Method

In chapter 2, we argued that consumers are likely to adapt their buying behaviour if consumer prices are changed for a relatively long period. For this reason, we propose to estimate consumer buying behaviour using a model which explicitly takes into account behavioural changes. Human behaviour is modelled explicitly in so-called structural models. Structural models derive consumer behaviour - or the behaviour of any other actor - under the assumption that consumers rationally optimise a certain objective function. An important advantage of structural models is that - in theory - one may relate consumer buying behaviour to any possible change in the environment (Van Heerde et al., 2005). In this report, we are particularly interested in permanent price changes.

Micro-economic theory of consumer behaviour develops a long-run relation between buying behaviour, budgets and prices under the assumption that consumers optimise their preferences (Deaton en Muellbauer, 1988). Within the micro-economic theory of consumer behaviour, several models have been developed in order to estimate empirically the relationship between consumer buying behaviour, prices and budgets. Examples are the logaritmic demand model (Stone, 1954a), the linear expenditure system (Stone, 1954b), the Rotterdam model (Theil, 1965; Barten, 1966), the translog model (Diewert, 1971, Christensen, Jorgenson and Lau, 1975) and the AID system (Deaton and Muellbauer, 1980). In chapter 4, we already argued that the AID specification is one of the most advanced and most widely used specifications. The specification is also used in studies determining the price elasticity of demand for organic food in the US and Denmark (see table 4.2).

The AID specification estimates the relationship between consumer buying behaviour and prices on the basis of the observations in the experiment. This relation applies to the area in which one may observe the prices before and after the introduction of the agreed upon price reductions (figure 5.1). The parameter values to be estimated (see Appendix 2) apply to this area. This makes the experiment performed unique exactly because one may observe prices for organic food far below current prices of organic food. The price elasticities to be measured are a function of the budget shares of the product varieties identified. The price elasticities are different on each point of the demand function. Conclusions outside the range of observed prices are not supported by the data, and therefore they have to be drawn with care. Under the assumption that the model adequately describes human behaviour, the results are valid outside the range of observed prices (Van Heerde et al., 2005). This is why we use structural models.

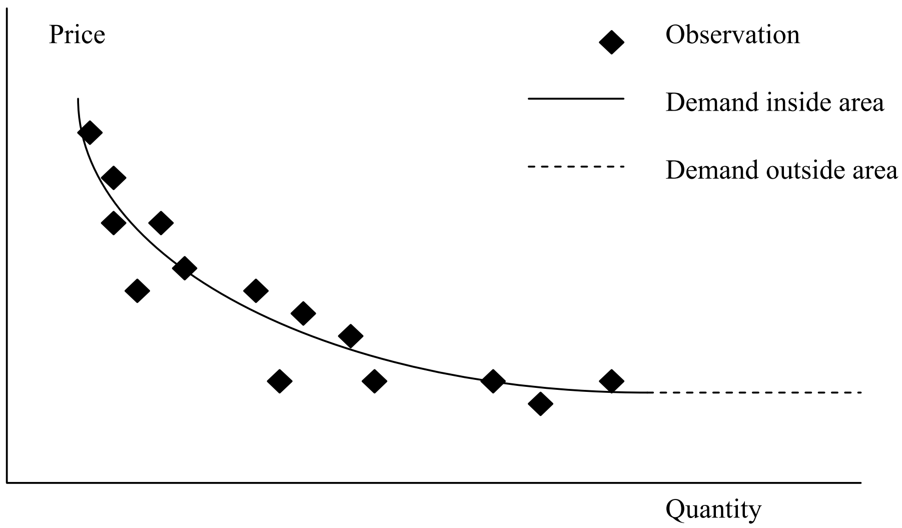

Figure 5.1 Estimating demand

In general terms, the system of demand equations to be estimated equals:

$$S_{organic} = F(P_{organic}, P_{non\text{-}organic}, B, O)$$
$$S_{non\text{-}organic} = F(P_{organic}, P_{non\text{-}organic}, B, O)$$

Where
S = Budget share
P = Price
B = Budget
O = Other variables such as the size of the organic assortment, community, retail chain, season, etcetera.

Demand for organic products and their non-organic counterparts is estimated as a function of the prices of the two product varieties and the budget for the product group concerned. Since consumer demand is derived from and linked to consumer expenditure behaviour (Deaton and Muellbauer, 1980), we do not estimate demand in terms of volumes, but in terms of budget (euro) shares. Consumer demand and budget shares depend, among other things, on the expenditure budget (B). To take account of the resulting endogeneity and separability problems (see section 5.2), the budget is replaced by a time trend in the estimations. The other variables included in the estimations are dummies for Christmas, Eastern, Whitsun, the experiment and seasonal peaks and troughs. In chapter 8, folder activities and the product assortment are included as well. On the basis of the parameters estimated the own and cross price elasticities can be derived. Appendix 2 elaborates the AID-specification.

When determining the long-run price elasticities for organic food and their direct substitutes, one should take into account that prices of the products concerned change frequently for long and short periods. Promotional price activities occur with a high frequency in the food retail sector. For this reason, we make a distinction between short-run promotional price changes and permanent price changes. One should take into account that both promotional and permanent price changes may lead to short and long run changes in consumer buying behaviour. If consumers hoard, a price promotion in week X may lead to an increase in demand in week X, but a fall in demand in future weeks. Frequent price promotions may increase the sensitivity of consumers with respect to price: the consumer is trained to check prices. If a permanent price decrease is accompanied by promotional activities, this may lead to a temporary overreaction.

5.2 Research approach

The econometric analysis underlying this report determines the own and cross price elasticities of demand on the basis of the AID specification (see Appendix 2). The estimations take account of both short-run and long-run adaptation processes by embedding the AID system in a Vector Error Correction Model (VECM) and to test the model as has been done in Pesaran and Shin (2002). The research is made up of the following subsequent phases:

1. times series are tested for stationarity using unit-root tests such as the Durbin-Watson statistic or the GLS Dickey-Fuller test (Elliott et al., 1996). In this phase we test whether or not one is able to identify a stochastic trend in the variables. Short-run price changes may have a permanent effect on demand *if* the variables themselves have a 'long-run memory' (i.e. a stochastic trend). Short-run changes in prices do not have a permanent effect on demand if the variables do not have a stochastic trend. Both stationary and non-stationary variables may have long-run equilibrium relations. We expect to find evidence of stationarity;
2. if we have established that the variables exhibit a stochastic trend, we determine whether there is a co-integrating relation between the explanatory and the independent variables. There is a co-integrating relation between variables, if there is a long-run equilibrium relation between these variables (i.e. a common stochastic trend);
3. we may or we may not establish co-integration. Of course, we would like to establish co-integration and thus long-run equilibrium relations. Depending on the question whether we find co-integration yes or no, we estimate the system of demand equations as follows:
    a. if we do not establish a co-integrating relation, but the series are integrated of order 1 (i.e. they exhibit a stochastic trend), then we estimate the AID system in a Vector AutoRegression (VAR) composed of the AID-system variables in first differences;
    b. if we do establish co-integration, then we will estimate the AID system as a VECM;

c. if the series are stationary, then the AID system will be estimated in the context of a VAR made up of AID-system variables in levels. We expect to estimate the AID system in this context.

Restrictions from the AID system will be imposed on the short-run parameters in order to establish a structural VAR. If the restrictions are rejected, then we will make use of generalised impulse responses (Pesaran en Shin, 1998). In that case there is too little information to construct a structural VAR model.

The following methodological problems may arise during the estimation process:

1. *Endogeneity*
   A major issue for AID and related specifications is that the explanatory variable is a deterministic function of the dependent variables. The budget share - the left hand side of the equation - is a deterministic function of prices and budget - the right hand side of the equation. This may give rise to a bias in the parameter estimates;
2. *Overidentification*
   Demand systems are overidentified due to the adding up constraint. For this reason, we have to drop one of the demand equations from the system of demand equations. The parameters estimated may differ depending on which demand equation is dropped from the system;
3. *Linearising the price index*
   For reasons of simplicity the empirical literature sometimes uses the linearised version of the price index. This may influence the results to some extent;
4. *Separability*
   The estimations do not take account of the fact that the demand for and the expenses on the product concerned also depends on the demand for and the expenses on all other products. We estimate a small part of the system.

We will solve these potential problems as follows:

1. *Endogeneity*
   (i) One may solve the endogeneity problem by incorporating the budget as an equation into the system of demand equations. In this way, one would substitute the budget with an instrumental variable. Instead, we replace the budget spent on one specific product by the time trend as a proxy.[1] (ii) Moreover, one may test for exogeneity.[2] The estimation of the parameter values can also be improved by using the restrictions from demand theory. If these solutions do not work, we may use quantities as explanatory variable. Note that the exogeneity problem may also arise for quantities;

[1] We also used the total budget spent on all the products in the dataset as a proxy for the budget spent on one specific product. The results are similar.

[2] Attention should be paid to the following issues: testing for weak exogeneity with respect to long-run parameters (investigating which variables show error correction), strong exogeneity (non-causality in the sense of Granger) and super-exogeneity (in order to find our whether dummies have to incorporated into the budget equations to take account of the price changes) (see for example Ericsson et al., 1998).

2. *Overidentification*
   We may test for overidentification by investigating whether it matters which demand equation is dropped from the system;
3. *Price index*
   We will employ the non-linear price index, unless non-linearity generates large problems in finding parameter estimates at all;
4. *Separability*
   In the estimations, one may take account of the fact that one is estimating part of the overall system. This implies that additional assumptions have to be made with respect to the error term (LaFrance, 1991). We have not been able to tackle this problem in the estimations. In our estimations, demand systems are confined to the products concerned.

To summarise, the estimations in this report are based on standard demand theory. As noted in chapter 4, actual estimations warrant particular assumptions. At the end of this section, we briefly summarise these assumptions:

1. demand is measured in terms of budget shares. The budget shares are derived from sales in euros;
2. the demand system is considered at the level of all the eight products analysed. In the analysis, budget refers to expenses on the product concerned. So, the budget for milk refers to milk expenses. Budget does not refer to consumer income. Demand for and prices of all other possible substitutes and complements are neglected as well. In the estimations, budget is replaced by a time trend.

6. Data

This chapter describes the data used in the estimations of the demand systems and the price elasticities of demand (chapter 7). Section 6.1 describes the data sources, the variables and the product classification used in the analysis. In section 6.2, we report the descriptive statistics at an aggregate level. In section 6.3, we show the development of average prices and sales before and after the start of the experiment.

6.1 Data collection

6.1.1 Data

Data are provided by Information Resources Incorporated (IRI). The data are made up of supermarket sales in 84 outlets for 77 weeks. The weeks refer to the period before the experiment: week 9 in 2005 till week 16 in 2006; and the period in which the experiment is carried out: week 17 in 2006 till week 33 in 2006. The data refer to the outlets and products mentioned in chapter 3. Beside the outlets mentioned in chapter 3, the dataset also contains data for 42 control outlets. For each outlet participating in the experiment a comparable outlet not participating in the experiment was selected from the IRI database.

The data provided refer to scanner data containing information on sales, volumes and national folder activities. Volumes are reported in kilograms, litres (milk) and units (eggs). Prices are determined as the quotient of sales and volume. The dataset makes a distinction between fixed and variable weight products. Beef and pork are variable weight products; all other products are fixed weight products. For beef and pork, volume data are only available for Albert Heijn, Jumbo and PLUS. The results for meat in chapter 7 refer to these supermarket chains only.

The main advantage of scanner data as provided by IRI is the fact that scanner data apply to more consumers. The data refer to all consumers who buy at specific supermarkets. Panel data as provided by GfK only apply to a limited number of consumers. For organic food, panel data would be particularly troublesome because only a limited number of consumers buy organic products.

6.1.2 Variables

Data have been provided on the lowest aggregation level possible: the ean code. Data refer to specific varieties of individual suppliers. At the highest aggregation level, each ean code refers to one of the eight product categories used in the analysis: eggs, milk, minced beef, muesli, mushrooms, pork, potatoes and rice. IRI makes a distinction between organic (EKO label) and non-organic products. In order to take account of differences in product varieties, a further subdivision has been made in major product categories whenever possible (table 6.1). Mushrooms, for instance, are subdivided into - organic and non-organic - white and other mushrooms. This gives us four mushroom varieties: organic white, non-organic white, organic other and non-organic other. Potatoes refer to unpeeled potatoes only and not to cooled and frozen potatoes. For eggs, we identify three product categories: organic, barn and other eggs. For pork, we consulted an expert. The subdivision for pork is made on the basis of price and type of meat. We identified (1) ham and other lean (high-priced) pork, (2) cutlets and ribs, (3) bacon and (4) other types of pork.

Table 6.1 Product classification

Product group	Aggregation 2	Aggregation 4	Number of varieties
Eggs	Organic/Non-organic	Organic/Barn/Other	3
Milk	Organic/Non-organic	Full-cream/Semi-Skimmed/Skimmed	6
Minced beef	Organic/Non-organic	-	2
Muesli	Organic/Non-organic	-	2
Mushrooms	Organic/Non-organic	White/Other	4
Pork	Organic/Non-organic	Ham and other lean meat/Cutlets and ribs/Bacon/Other pork	8
Potatoes	Organic/Non-organic	-	2
Rice	Organic/Non-organic	White/Other	4

6.2 Descriptive analysis

Table 6.2 gives the budget shares of organic varieties for the test and the control outlets for week 1 till 16 in 2006. The table shows that the average budget share of organic food in the test and control outlets is more or less the same for all products except muesli. Sales of organic varieties are relatively low for pork, rice and minced beef and to a lesser extent for eggs and milk. Sales of organic varieties are very high for muesli. The sales shares differ per outlet. In some outlets the sales shares of organic varieties are substantially above the 'national' average. This is indicated by the columns showing the maximum observations in the dataset. Table 6.3 presents the means and standard deviations of product volumes, sales and prices.

Table 6.2 Market share of organic products in euros (week 1-16 2006) in %

	Test outlets			Control outlets		
Product group	Mean	Standard deviation	Maximum	Mean	Standard deviation	Maximum
Potatoes	9.7	5.6	26.6	8.9	4.0	16.0
Mushrooms	8.2	4.1	17.5	7.4	5.5	21.8
Eggs	5.1	6.2	34.5	4.4	3.1	12.0
Milk	4.8	6.3	35.2	4.1	4.0	17.5
Muesli	30.3	15.1	62.9	25.7	11.3	55.4
Rice	2.3	1.9	10.4	2.2	1.1	5.6
Minced beef	5.0	2.7	9.5	5.8	3.2	12.0
Pork	2.1	1.8	5.3	2.1	2.0	7.2

Source: IRI, all outlets. The data for minced beef and pork apply to Albert Heijn, Jumbo and Plus only.

6.3 Price, volume and sales developments

Figure 6.1 shows the development of the average price of organic and non-organic products at the aggregate level. By comparing prices in test and control outlets, we get some insight in the price gap between organic and non-organic products as well as in the price reductions realised in the experiment. Note that prices are unweighted averages of weekly data: they are not based on a price index. This implies that weekly changes in consumer buying behaviour may influence the prices derived from the data. We also want to stress that price refers to all possible brands and package sizes. Organic products typically are not available in bulk discount packages. The price differences between non-organic A-labels and organic varieties are smaller than figure 6.1 suggests.

Figure 6.1 clearly shows that the experiment led to a substantial price decrease for organic products in the outlets selected and that this decrease reduced the price gap between organic and non-organic varieties substantially. For rice, the average price of organic products even fell below the average price of non-organic rice. Note, however, that non-organic rice also refers to more expensive product varieties such as pandan or basmati rice.

Figure 6.1 shows that - apart from the structural break caused by the experiment - most prices fluctuate around a given average. In technical terms, the price data are mean stationary. Pork prices fluctuate around an upward trend in this period; rice prices fluctuate around a downward trend. In technical terms, the price data are trend stationary. Potato prices fluctuate more wildly. In technical terms, potato prices may be non-stationary. We address stationarity in section 7.1.

Figure 6.2 and 6.3 present volume and sales developments for organic products for the control and the test outlets. The impact of the experiment on the volume sold is not clear from mere observation. For pork and minced beef, for instance, volumes develop more favourably in the test outlets in the experiment period, but the overall picture is not clear. In general, volume sold does not develop around a mean average or a trend. There are cyclical patterns and seasonal peaks (potatoes) or troughs (milk). In technical terms, this may point to non-stationarity. However, this may also point to the need to incorporate seasonal patterns in the demand system.

Sales of organic eggs, milk and muesli develop less favourably in the test outlets rather than the control outlets during the experiment (figure 6.3). This result is probably due to the difference in price developments in both groups of outlets and may point to a low own price elasticity of demand. Of course, the latter needs to be determined in the next chapter. For the other products, the impact of the experiment is less clear. Again, for some products, sales develop around a mean average or a mean price (rice), but for other products (eggs, milk and potatoes) sales fluctuate more wildly. For these products, sales may be non-stationary.

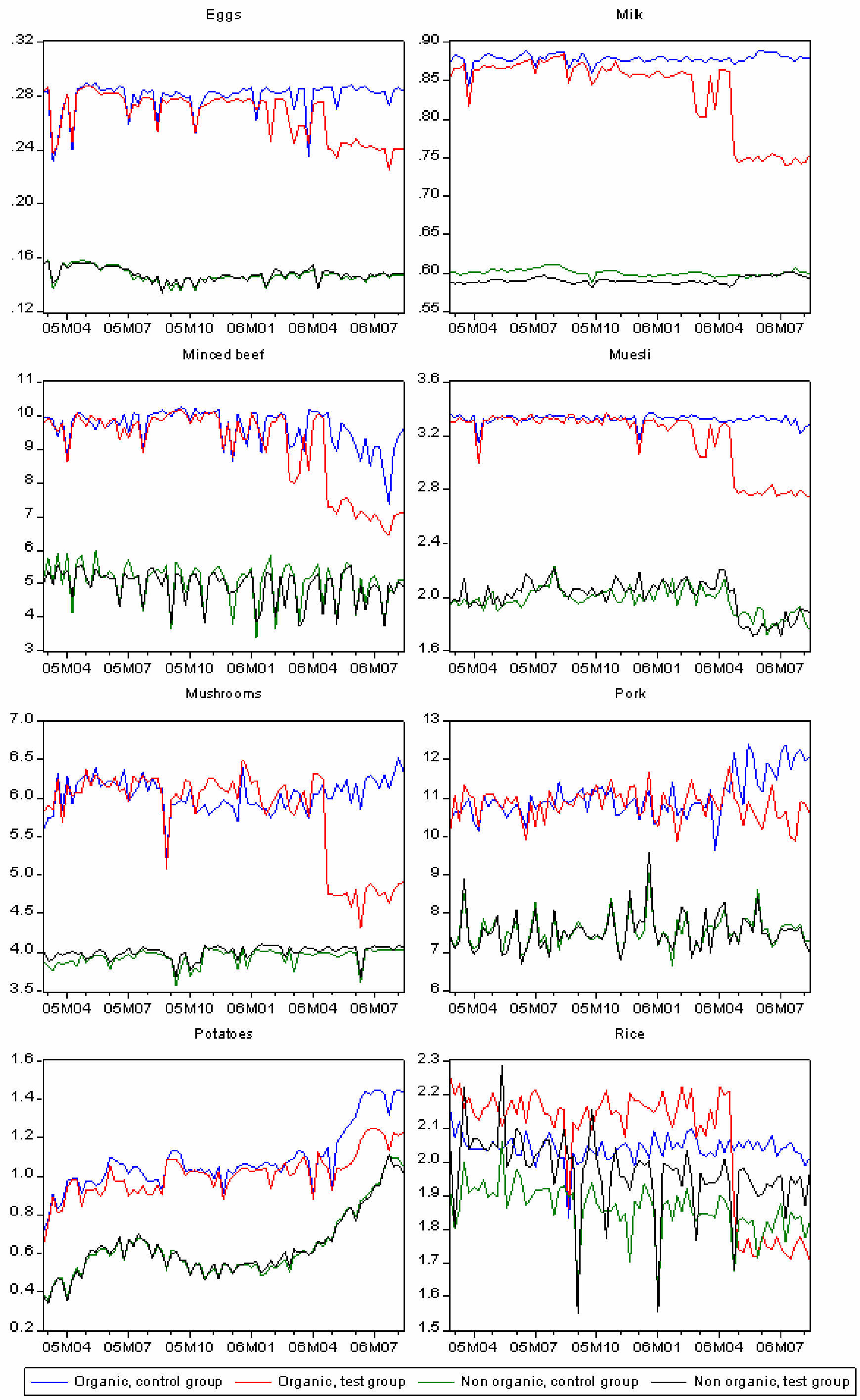

Figure 6.1 Price development for organic and non-organic products (€ kilo, week 9 2005 - week 33 2006)

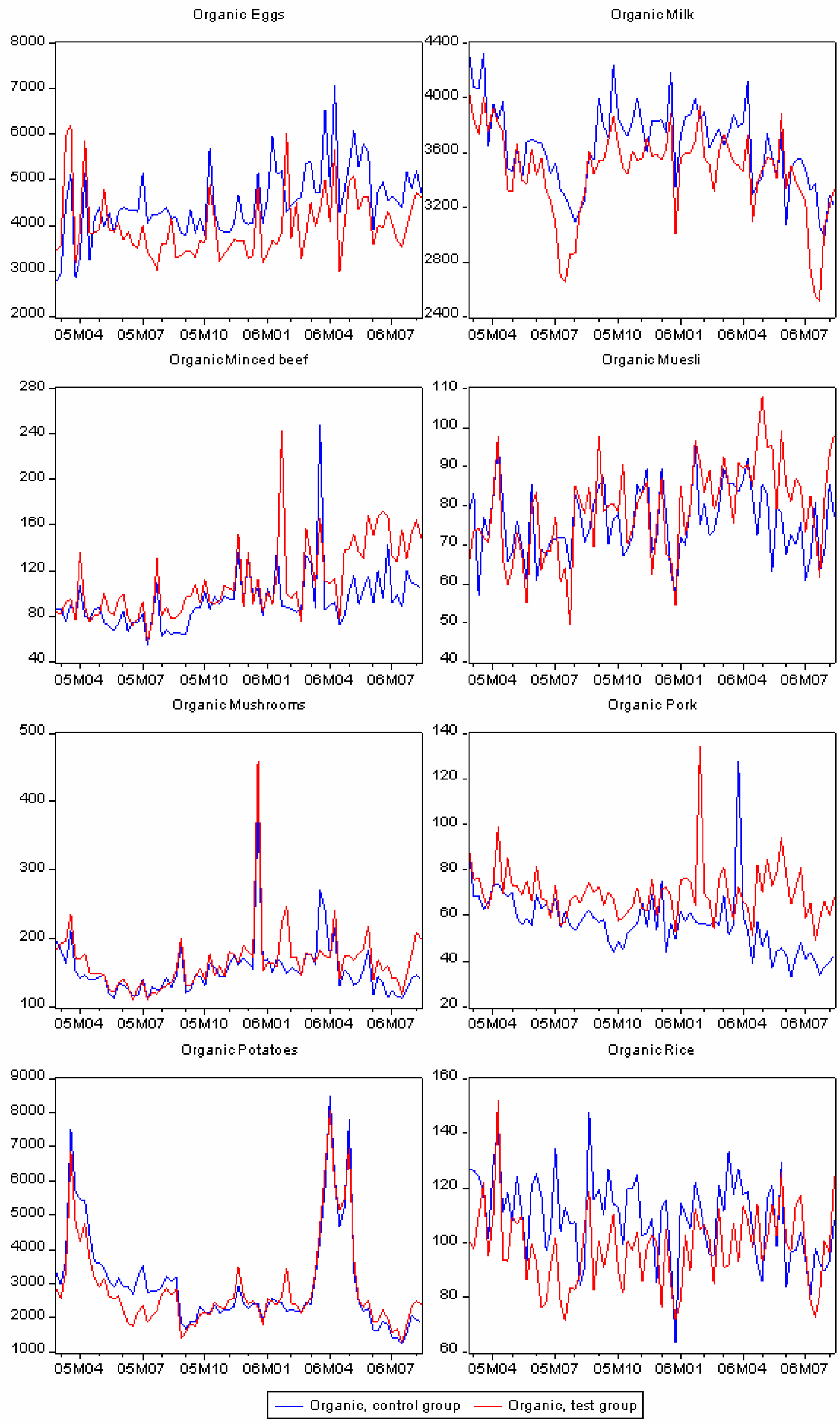

Figure 6.2 Volume development for organic products: control and test group (kilo's, week 9 2005 - week 33 2006)

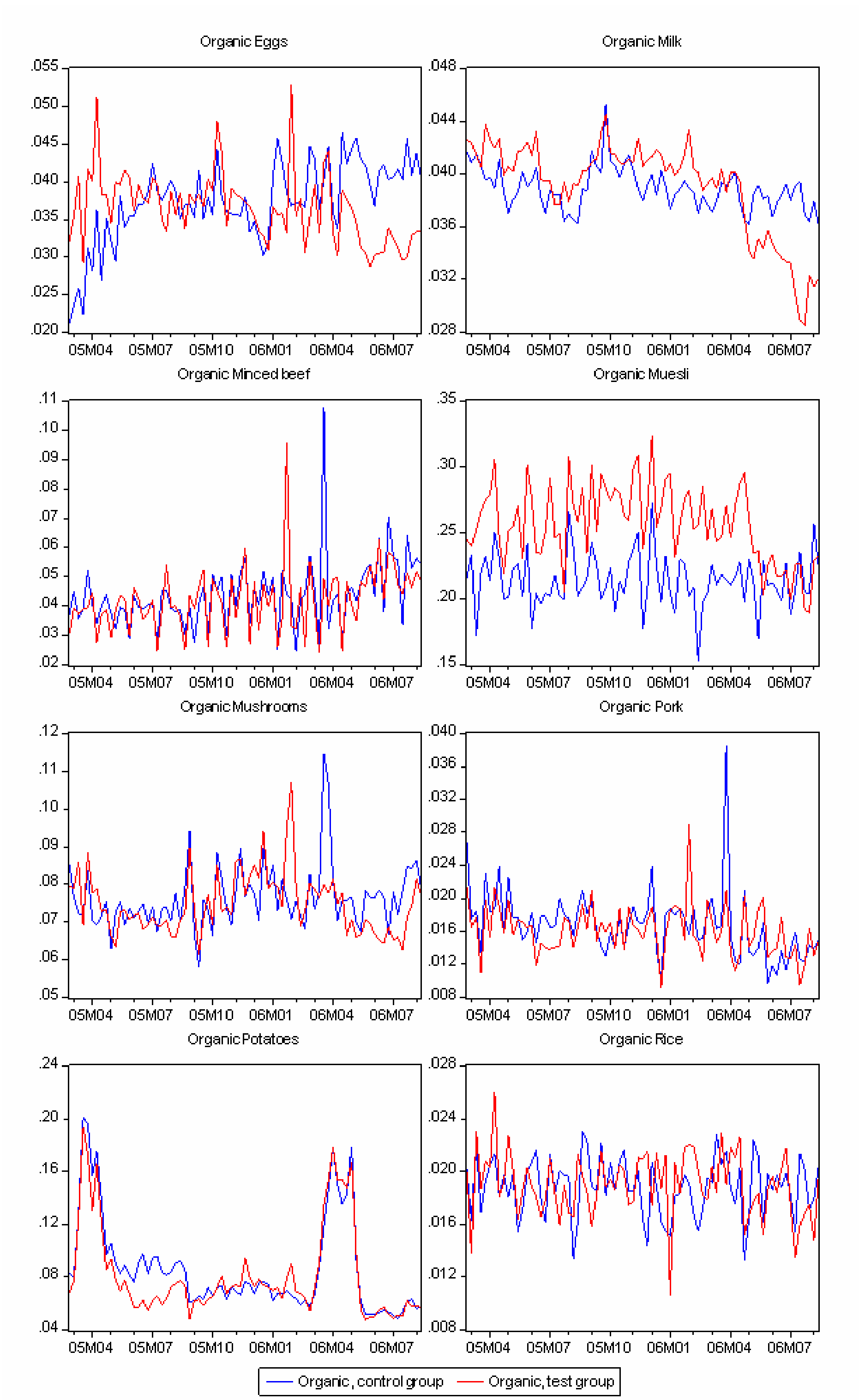

Figure 6.3 Budget share of organic products: control and test group (%, week 9 2005 - week 33 2006)

Table 6.3 Descriptive statistics of sales, volumes and prices (all outlets, meat Albert Heijn, Jumbo and Plus only)

	Sales				Volume				Price			
	Mean		Standard deviation		Mean		Standard deviation		Mean		Standard deviation	
	Organic	Non organic	Organic	Non organic	Organic	Non organic	Organic	Non organic	Organic	Non organic	Organic	Non organic
Eggs	2,317	60,990	298	10,005	8,524	415,326	1,309	72,795	0.27	0.147	0.01	0.005
- barn	n.a.	59,176	n.a	9,183	n.a.	407,293	n.a.	69,600	n.a.	0.146	n.a.	0.005
- other	n.a.	1,814	n.a	1,197	n.a.	8,033	n.a.	4,880	n.a.	0.226	n.a.	0.023
Milk	6,102	150,252	576	8,229	7,111	252,279	593	14,595	0.86	0.596	0.02	0.003
- semi skimmed	4,519	127,057	444	7,099	5,368	223,116	469	13,111	0.84	0.570	0.02	0.003
- skimmed	213	7,068	104	603	227	9,179	113	811	0.94	0.770	0.03	0.008
- full cream	1,369	16,126	121	756	1,516	19,984	129	964	0.90	0.807	0.02	0.006
Minced Beef	1,871	43,072	384	8,574	204	8,883	53	2,808	9.30	4.988	0.87	0.540
Muesli	501	1,653	56	165	155	834	18	98	3.24	1.988	0.13	0.103
Mushrooms	1,887	22,954	519	4,788	320	5,787	81	1,197	5.90	3.969	0.33	0.095
- white	668	18,713	154	3,844	127	5,111	28	1,050	5.25	3.663	0.35	0.089
- other	1,219	4,241	392	1,070	192	675	62	186	6.37	6.334	0.44	0.449
Pork	1,381	84,384	193	14,161	127	11,185	20	1,585	10.90	7.537	0.34	0.450
- lean meat	762	45,112	119	13,890	58	4,892	10	1,356	13.25	9.230	0.54	0.780
- cutlets	341	24,315	85	6,633	37	3,854	10	1,146	9.16	6.352	0.27	0.320
- bacon	235	9,112	54	1,911	27	1,491	6	282	8.60	6.098	0.44	0.261
- other	43	5,845	31	932	5	949	4	230	9.67	6.255	0.74	0.457
Potatoes	6,017	66,775	2,516	12,822	5,889	109,510	2,765	20,077	1.05	0.630	0.13	0.170
Rice	426	22,184	55	2,744	208	11,655	25	1,750	2.05	1.910	0.09	0.090

7. Results for prices

This chapter presents the results of our analysis into the price sensitivity of consumer demand for organic products. In the next chapter, we briefly address the sensitivity with respect to other arguments from the marketing mix, in particular folder activities and assortment width. This chapter is constructed as follows. Section 7.1 analyses the times series available. On the basis of this analysis we decided how to incorporate the times series into the demand system. Do we use a VAR or a VECM? Do we use the data in first differences or in levels (see section 5.2)? In section 7.2 and 7.3, we present the results at the most aggregate level. In this section, we make a distinction between organic and conventional food. In section 7.2, we present the price elasticities of demand. In section 7.3, we investigate the existence of a turning point in consumer demand. In section 7.4, we disaggregate the products analysed into more homogeneous product segments, e.g. into (organic and conventional) white and other mushrooms. Section 7.5 concludes.

7.1 Time series analysis

In this section, we justify how we incorporate time series analysis into the demand system. For this reason, we test the times series employed more formally. The tests are necessary to determine how we want to incorporate the time series analysis into the demand system. Do we use Vector Auto Regression (VAR) or a Vector Error Correction Model (VECM) (see section 5.2)?

Table 7.1A presents the Durbin-Watson statistics of the regression of all variables on a constant. As a rule of thumb, a Durbin-Watson statistic which is lower than 0.6 clearly indicates the existence of a unit root (non-stationarity). Given this rule, a rough look at the results in table 7.1A reveals that only in the case of milk and potatoes should we be worried about non-stationarity.[1] The specification that we use to estimate the parameters allows for both stationary and non-stationary variables (see equation (7') in Appendix 2). Of course, if the variables exhibit non-stationarity, the long-run parameters that are used to compute the elasticities should constitute a co-integrating vector. Co-integration exists if the adjustment parameter is quite significant. In all our estimations we find highly significant adjustment parameters. This result is confirmed by the fact that all trace statistics reject the absence of one co-integrating relation (table 7.1B). Consequently, the VECM specification is always valid. On the basis of the results, we decided to estimate the demand system in a VECM framework. Appendix 2 describes the technical specifications of the VECM.

[1] In contrast, the Dickey-Fuller statistics presented in Appendix 1 indicate that most series contain a unit root.

Table 7.1A Durbin Watson statistics for aggregate series

	Budget share	Price organic food	Price non organic food	Budget
Eggs	1.67	1.77	0.97	1.54
Milk	0.69	1.28	0.57	1.18
Minced beef	2.55	1.36	2.28	1.82
Muesli	2.07	1.68	1.29	1.04
Mushrooms	1.30	1.57	1.43	1.76
Pork	1.96	0.68	0.98	2.49
Potatoes	0.29	0.59	0.49	0.94
Rice	1.99	1.55	1.72	2.31

Table 7.1B Test on Absence of Co-integration

	Trace statistic
Eggs	99.3
Milk	58.69 a)
Minced beef	130.8
Muesli	102.9
Mushrooms	83.34
Pork	148.8
Potatoes	72.8
Rice	132.1

a) Indicates significance at 5% level.

7.2 Price elasticities of demand

In this section, we present the main results of the estimations carried out to determine the sensitivity of consumer buying behaviour with respect to prices. What are the price elasticities of demand for organic versus non-organic food? In the following sections of this chapter, we refine these results. The price elasticities of demand are derived on the basis of the parameters estimated. The parameters are estimated on the basis of times series analysis using aggregate sales, volumes and prices in all outlets. The price elasticities are determined for each observation, *id est* each week. The price elasticities shown in this report are the averages of the elasticities calculated for all weeks.

Table 7.2 presents the price elasticities of demand at the aggregate level: for all outlets included in the analysis and without making a distinction between product varieties. So, in table 7.2 milk is milk and not semi-skimmed or full-cream milk. Table 7.2 refers to the entire period investigated: from week 9 in 2005 till week 33 in 2006. Below, we make a distinction between the pre-experiment versus the experiment period.

The estimates in table 7.2 are to be interpreted as follows:

- the second column in table 7.2 gives the own price elasticity of demand for organic products. This column indicates with what percentage the demand for organic products changes if the price of organic products increases by 1%. So, if the price of organic milk increases by 1%, the demand for organic milk falls by 1.78%. Likewise, if the price of organic milk falls by 1%, the demand for organic milk rises by 1.78%;

- the third column in table 7.2 gives the cross price elasticity of demand for organic products. This column indicates with what percentage the demand for organic products changes if the price of non-organic products increases by 1%. So, if the price of non-organic milk increases by 1%, the demand for organic milk rises by 0.44%;
- the fourth column in table 7.2 gives the cross price elasticity of demand for non-organic products. This column indicates with what percentage the demand for non-organic products changes if the price of organic products increases by 1%. So, if the price of organic milk increases by 1%, the demand for non-organic milk rises by 0.03%;
- the fifth column in table 7.2 gives the own price elasticity of demand for non-organic products. This column indicates with what percentage the demand for non-organic products changes if the price of non-organic products increases by 1%. So, if the price of non-organic milk increases by 1%, the demand for non-organic milk falls by 1.02%. Likewise, if the price of non-organic milk falls by 1%, the demand for non-organic milk rises by 1.02%.

All signs in table 7.2 correspond with theoretical expectations except for the cross price elasticity of the demand for organic eggs and pork. Almost all own price elasticities are significant at the 5% level. Some of the cross price elasticities are significant at the 5% level, but the majority is not.

- First, all own-price elasticities have the correct sign (negative) and those of the organic varieties are more elastic than those of the non-organic varieties. This result shows that consumers of organic food are price sensitive on the basis of which we may expect that the demand for organic food rises when the price of organic food falls. Demand for organic food is more sensitive to price changes than demand for conventional food, because the budget share of organic food is lower. The percentage increase of one extra unit sold of organic food is higher than the percentage increase of one extra unit of conventional food, because the budget share of organic food is substantially lower than the budget share of conventional food. The budget share of organic food is the denominator of the price elasticity of organic food, while the budget share of non-organic food is the denominator of non-organic food.
- Second, the absolute value of the own-price elasticity is larger than 1 for all organic varieties except for eggs. This implies that for all organic varieties, sales rise with a price decrease, though only slightly. The volume increase more than compensates the price fall. For instance, if the price of organic milk decreases by *10%* and the volume bought rises by *17.8%*, sales of organic milk rise by (100%-*10%*)*(100%+*17.8%*)/10,000 = *6.02%*.
- Third, the cross-price elasticities of the demand for organic food have the correct sign except for eggs and pork. This implies that if the price of non-organic food rises, this has a positive impact on the demand for organic food. If the price of non-organic food rises by 1%, demand for organic food rises by 0.15-0.90%. The cross price elasticity of the demand for organic food is higher than the cross price elasticity of the demand for non-organic food, because of the differences in the budget shares (see the argument in the first bullet point above). Eggs and pork are the exceptions.

Table 7.2 Estimated price elasticities of consumer demand: all outlets, all weeks

	Demand for organics		Demand for non-organics	
	price organics	price non-organics	price organics	price non-organics
Eggs	-0.99	-0.18	0.00	-0.99 a)
Milk	-1.78 a)	0.44 a)	0.03 a)	-1.02 a)
Minced beef	-2.02 a)	0.92 a)	0.05 a)	-1.04 a)
Muesli	-1.19	0.16	0.06	-1.05 a)
Mushrooms	-2.03 a)	0.91	0.08 a)	-1.07 a)
Pork	-1.01 a)	-0.02	0.00	-1.00 a)
Potatoes	-1.31 a)	0.18	0.03	-1.01 a)
Rice	-1.65 a)	0.58	0.01	-1.01 a)

a) Significant at the 95% level.

In section 2.2, we indicate that changes in consumer buying behaviour depend on consumer knowledge with respect to price information. Tacken et al. (2007) argue that there is a group of consumers who know prices very well, but also a group of consumers who do not know prices very well. This holds in general, but also for the experiment (Tacken et al., 2007). Unfortunately, we do not know the size of both groups during the experiment. The results presented in this chapter apply to situations in which consumers are imperfectly informed. In the experiment, consumers had a limited amount of information on the price changes (see section 3.3). In order to be perfectly informed, consumers had to search for and process the price information. The experiment was constructed as a real world setting in which consumers have search costs. The results in this chapter apply to this setting and not to a full information setting. The results underestimate what would happen in a world where consumers are perfectly or better informed.

7.3 The turning point

In the literature on organic products, some papers suggest that there is a turning point in consumer buying behaviour (Van der Eerden et al., 2003). If the price gap between organic and non-organic products falls below a certain threshold, consumers are expected to switch massively from non-organic food to organic food. In this section, we assess whether there is evidence for the existence of a turning point in the demand for organic food. The parameters estimated in this section again are based on times series analysis using aggregate sales, volumes and prices for all outlets and for the test outlets.

We examine the possibility of a turning point in consumer demand in three ways. First, when estimating the demand system, we test whether the experiment causes a change in consumer buying behaviour. In particular, we test whether consumer demand jumps to a higher level. Second, we compare the price elasticity of demand during the price experiment with the price elasticity of demand in the period before the price experiment. Third, we investigate the relationship between the price gap between organic and conventional food and the price elasticity of demand.

In order to test whether the experiment caused a jump in consumer demand to a higher level, we incorporated a dummy for the experiment period in the long-run demand model.[1] The dummy measures a possible vertical shift of the demand curve: a jump to a higher or lower level. The dummy was significant for some of the products (table 7.3). The table expresses the increase in the intercept (constant) in the budget share equation for organic food as a percentage of the average share of organic food in the period before the experiment. Consequently, for mushrooms, muesli, rice and pork the experiment has led to a significant positive jump in the budget share of organic food.

Table 7.3 Existence of a structural break in consumer demand (all outlets)

	Level effect			Level effect	
	impact	significance		impact	significance
Eggs	8.6	No	Mushrooms	20.8	Yes
Milk	4.2	No	Pork	13.8	Yes
Minced beef	7.3	No	Potatoes	8.6	No
Muesli	9.2	Yes	Rice	12.4	Yes

Table 7.4 compares the own price elasticity of demand in the period before the price experiment (second column) with the price elasticity of demand during the experiment (third and fourth column). Table 7.4 extends the analysis in table 7.2. The second column in table 7.2 gives the own price elasticity of demand for the entire period investigated. The second column in table 7.4 gives the own price elasticity of demand for the pre-experiment period. The third column in table 7.4 presents the own price elasticity of demand for the experiment period. The parameters of the demand system which are used to determine the price elasticities of demand, are the same for these three columns. Note that there is a difference in the number of observations available to determine the own price elasticity. The entire period includes 77 observations (table 7.2), the pre-experiment period includes 60 observations (second column in table 7.4) and the experiment period, 17 observations (third and fourth column in table 7.4). The fourth column in table 7.4 is based on parameters for all test outlets.

If one assumes the existence of a turning point, the absolute value of the price elasticity of demand for organic food should be larger in the experiment period and - due to the price fall in the test outlets - even higher in the test outlets. Table 7.4 shows that the demand for organic food has become *less* price elastic during the experiment except for eggs and minced beef. The absolute value of the price elasticities has become smaller rather than larger. For milk, we even observe a positive price elasticity of demand for the test outlets in the experiment period. This result contradicts the turning point hypothesis except for eggs, minced beef and pork. The smaller the price gap between organic and non-organic food is, the less price elastic demand becomes. With the notable exceptions of eggs and minced beef, this points to an upper bound in the demand for organic food rather than a turning point.

[1] We allowed the other long-run parameters to be different during the experiment as well. None of these parameters were significantly different during the experiment.

Table 7.4 Own price elasticity of demand for organic food before and during the experiment

	Pre-experiment All outlets	Experiment All outlets	Experiment Test outlets
Eggs	-0.84	-1.41	-3.30
Milk	-1.95	-1.17	0.76
Minced beef	-1.97	-2.19	-1.89
Muesli	-1.25	-0.96	-1.06
Mushrooms	-2.24	-1.29	-1.12
Pork	-0.99	-1.05	-0.11
Potatoes	-1.43	-0.88	-0.69
Rice	-1.74	-1.31	-0.07

We elaborated this result by exploring how the own price elasticity of demand for organics develops as a function of the price gap between organic and non-organic food. If a turning point exists, we expect the price elasticity of demand to go up when the price gap between organic and non-organic food falls. We estimated the own price elasticity of demand for each observation we have in the sample and depicted the relation between the price elasticity of demand and the price gap in figure 7.1 to 7.16. The figures are based on estimations made for all outlets and for test outlets applying high price reduction rates (20-25% or 32-40%). Each dot in figure 7.1 to 7.16 refers to one week. The data refer to aggregate sales, volumes and prices for all outlets and the test outlets applying high reduction rates respectively. The figures show the following patterns:

- the price elasticity of demand for organic food goes down when the price gap falls for milk, mushrooms, pork, potatoes and rice. This implies that organic food demand will not accelerate when the price gap falls. On the contrary, if the price gap is small, the price elasticity of demand for organic food has a value between -1 and 0 implying that sales fall when the price of organic products decreases any further. At a certain price gap, there is a limit to the growth in sales of organic milk, mushrooms, pork, potatoes and rice;
- the price elasticity of demand for organic food goes up when the price gap falls for eggs, minced beef and muesli. This suggests that demand for these organic products accelerates when the price gap falls. Note, however, that the picture for minced beef and muesli is much less clear than the picture for eggs (and milk, mushrooms, pork, potatoes and rice).

The bound for milk, mushrooms, pork, potatoes and rice can be further illustrated by depicting the demand for organic food as a function of the price of organic food - given the parameter values estimated. Figure 7.17 and 7.18 show that the demand (volume) for organic mushrooms and rice increases and keeps increasing as long as the price of the organic product falls. Sales and market share, however, do not rise indefinitely, because at a certain stage the volume increases no longer compensate the price decreases. At this point, the absolute value of the price elasticity of demand becomes smaller than 1. Figure 7.19 and 7.20 show that both demand (volume) and sales of organic eggs and minced beef rise exponentially when the price of organic food falls. The price elasticity of demand increases when the price of organic eggs and minced beef falls.

This result is further illustrated by table 7.5. The table shows the market share of organic food as a function of the price reductions pursued in the experiment. In order to construct table 7.5, demand is simulated on the basis of the demand parameters found above. Average sales, volumes and prices in the pre-experiment period are taken as benchmark. In the simulations prices are reduced at the rates actually applied during the experiment. The numbers in italics give the maximum budget share, at least for the price reductions investigated. For eggs, minced beef and muesli, the budget share increases with the size of the price reduction. For milk, rice, mushrooms, pork and potatoes, price reductions have little impact on the budget share of organic food. Moreover, substantial price reductions actually decrease the market share of organic food in terms of euros due to the low price elasticity of demand.

Table 7.5 Impact of price reductions on market share of organic food

	Current market share	Price reductions (%) 5	10	15	20	25
Eggs	3.7	3.7	3.9	4.2	4.6	*5.1*
Milk	3.9	*4.0*	4.0	3.8	3.4	2.8
Muesli	23.7	24.5	26.5	30.0	35.2	*42.5*
Potatoes	9.0	9.2	9.3	9.4	*9.4*	9.4
Rice	1.9	2.0	*2.0*	2.0	1.9	1.8

	Current market share	Price reductions (%) 8	16	24	32	40
Minced beef	4.0	4.3	4.8	5.4	6.1	*7.2*
Mushrooms	7.6	8.2	*8.4*	8.1	7.1	5.3
Pork	*1.7*	1.6	1.5	1.4	1.1	0.7

An important explanation of the difference observed between both groups of products - organic eggs, minced beef and muesli on the one hand and organic milk, mushrooms, pork, potatoes and rice on the other hand - may be found in current price differences between organic and non-organic food. The price of organic eggs, minced beef and muesli are relatively high. The price of organic milk, mushrooms, pork and rice are relatively low. This is illustrated by table 7.6.

Table 7.6 Average price difference (%) between organic and non-organic food in test outlets before the price experiment

	Price difference
Eggs	85
Milk	46
Minced beef	94
Muesli	60
Mushrooms	53
Pork	44
Potatoes	75
Rice	9

On the basis of economic theory, one may posit that revenues from product sales are low when prices are either very high or very low. Figure 7.21 illustrates this using a simple linear demand function. P denotes price and Q quantity. Sales revenue is represented by the shaded areas in the figure. Revenue rises when the price drops from P^1 to P^3 and then fall when the price drops from P^3 to P^5. For the linear case, one may show that revenue reaches a maximum exactly in the middle of the demand line. As an aside, the absolute value of the price elasticity of demand falls along the line from infinity at the price-axis to 1 in the middle and subsequently to zero at the quantity-axis. The economic argument is the following. One does not generate high sales when prices are very high, because one hardly sells anything. One does not generate high sales revenue when prices are very low, simply because prices are low.

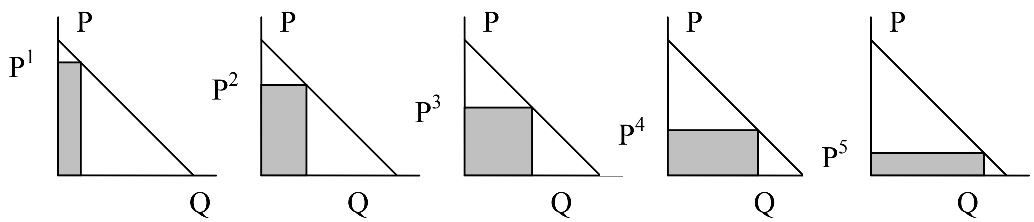

Figure 7.21 The relation between price and sales

Table 7.6 shows that the prices of organic eggs, minced beef, muesli and potatoes are relatively high and that the price of organic milk, mushrooms, pork and rice are relatively low. One may expect organic eggs, minced beef, muesli (and potatoes) to be in the P^1-P^2 range of figure 7.21 and organic milk, mushrooms, pork and rice to be in the P^2-P^3 range of figure 7.21 This suggests that there is scope for enhancing sales of organic eggs, minced beef and muesli. But the scope to promote sales of organic milk, mushrooms, pork, rice (and potatoes) may be quite limited. A non-economic argument explaining why demand for organic eggs and minced beef is highly sensitive for price changes and demand for organic milk, mushrooms, potatoes and rice is less sensitive for price changes may be due to the fact that animal welfare may be an issue for eggs and minced beef, but not for mushrooms, potatoes, rice and possibly milk. This last argument would not explain the low level of price sensitivity for pork.

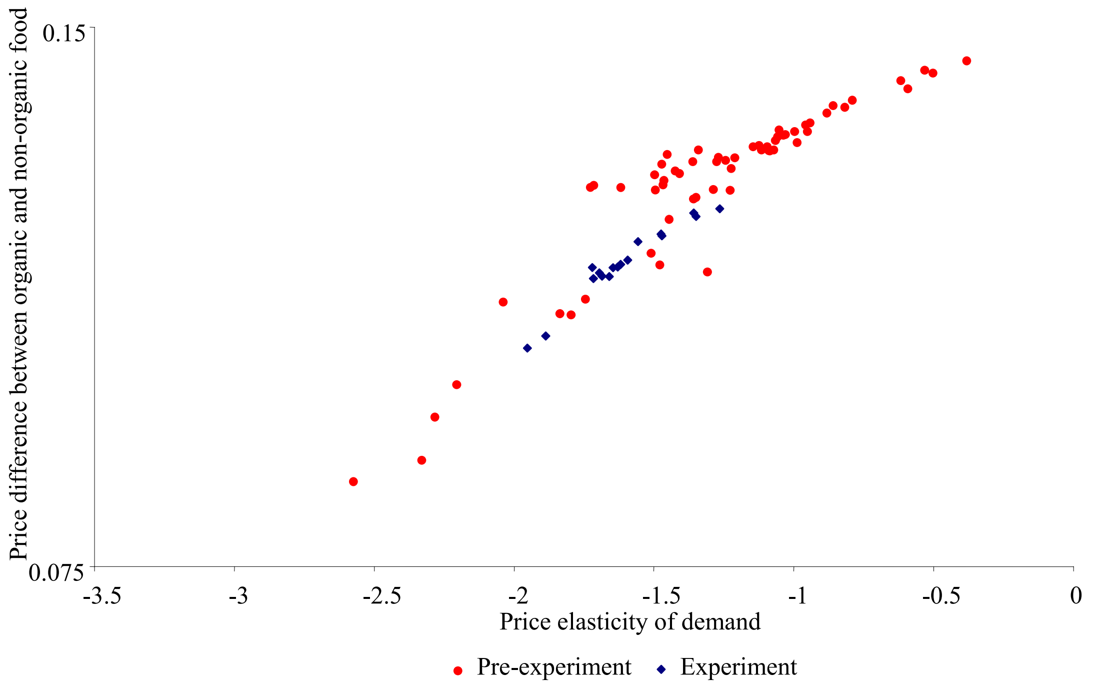

Figure 7.1 Price sensitivity of demand for eggs (based on all outlets)

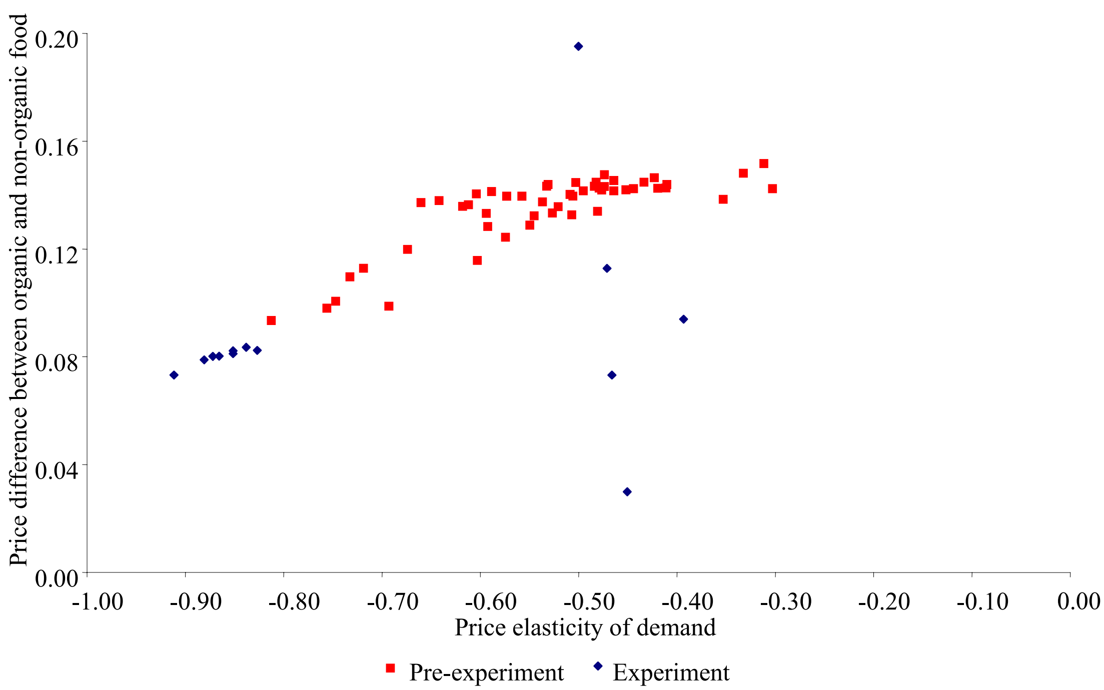

Figure 7.2 Price sensitivity of demand for eggs (based on test outlets with high reduction rates)

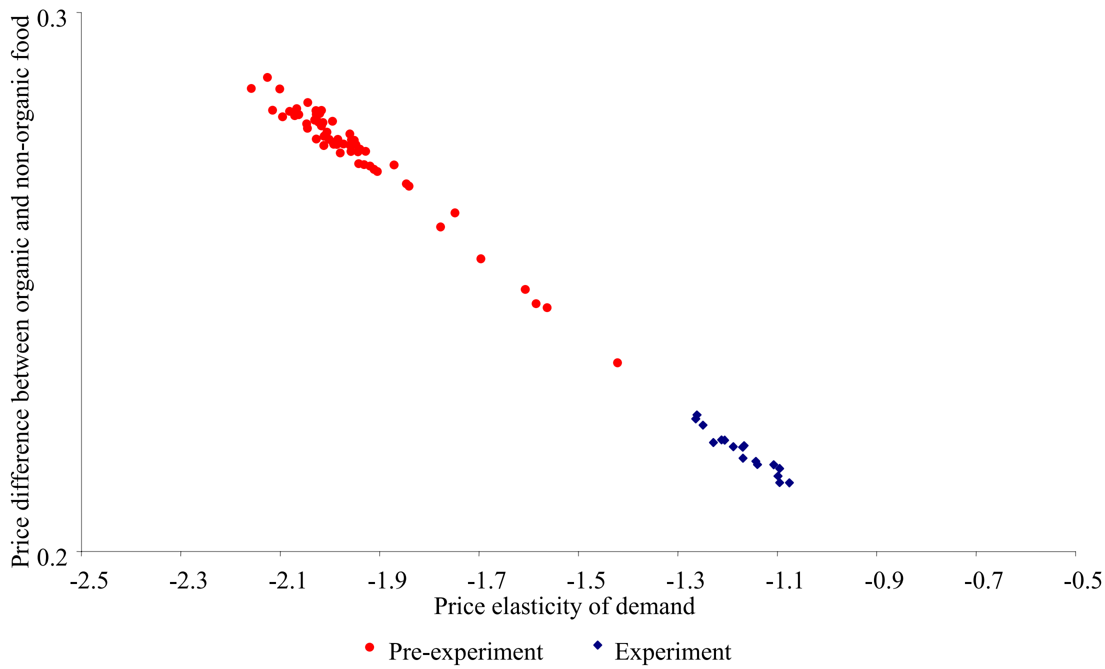

Figure 7.3 Price sensitivity of demand for milk (based on all outlets)

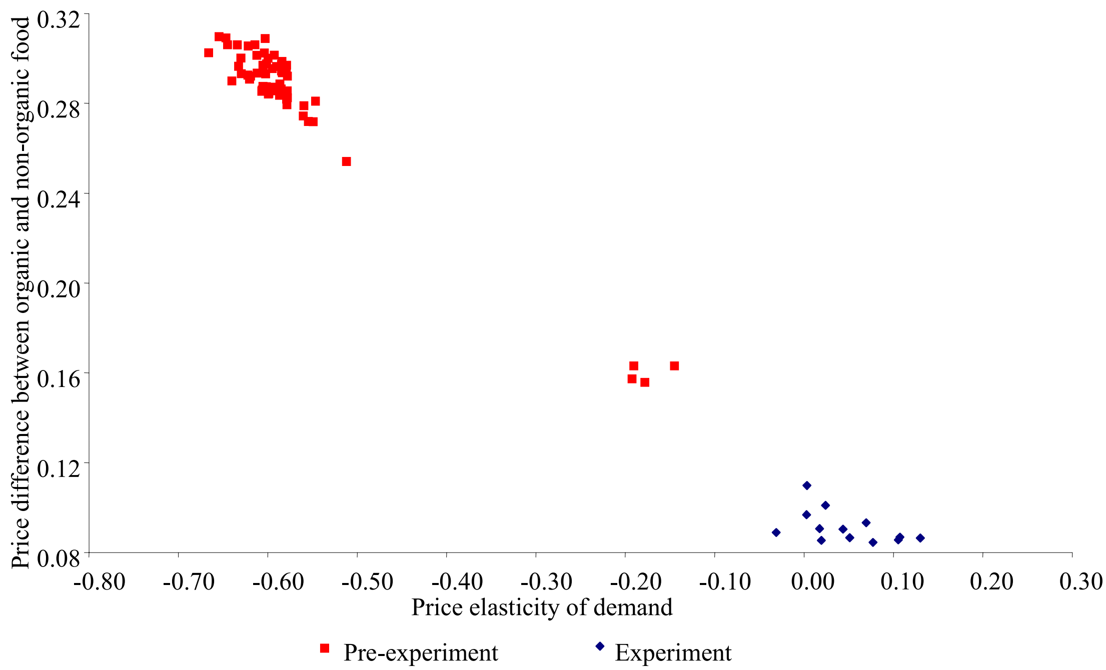

Figure 7.4 Price sensitivity of demand for milk (based on test outlets with high reduction rates)

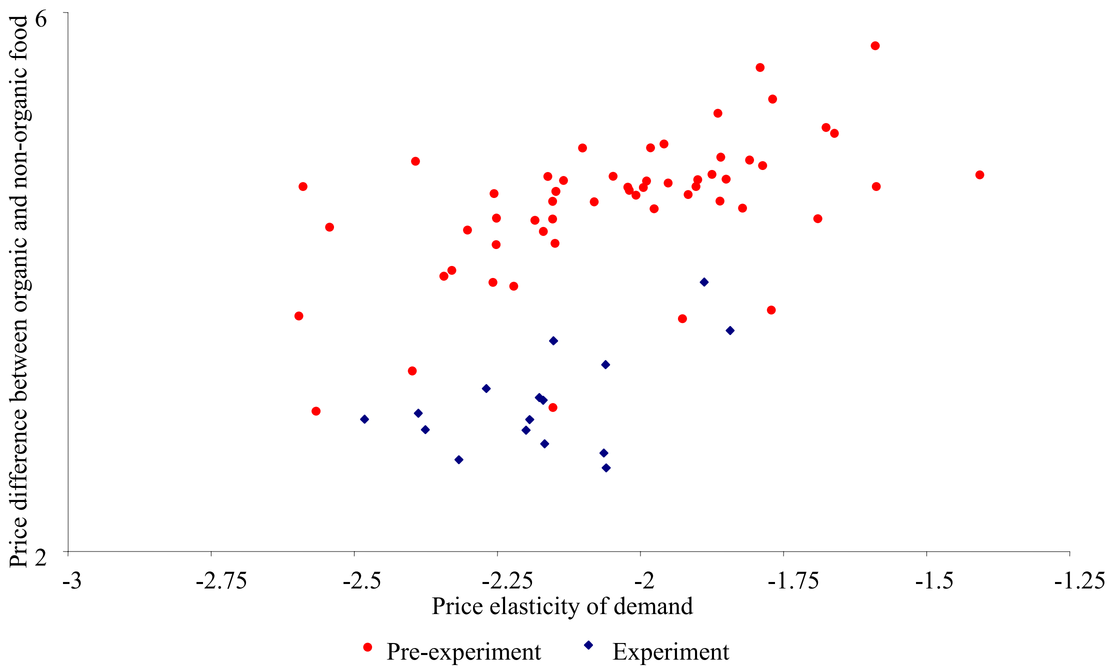

Figure 7.5 Price sensitivity of demand for minced beef (based on all outlets)

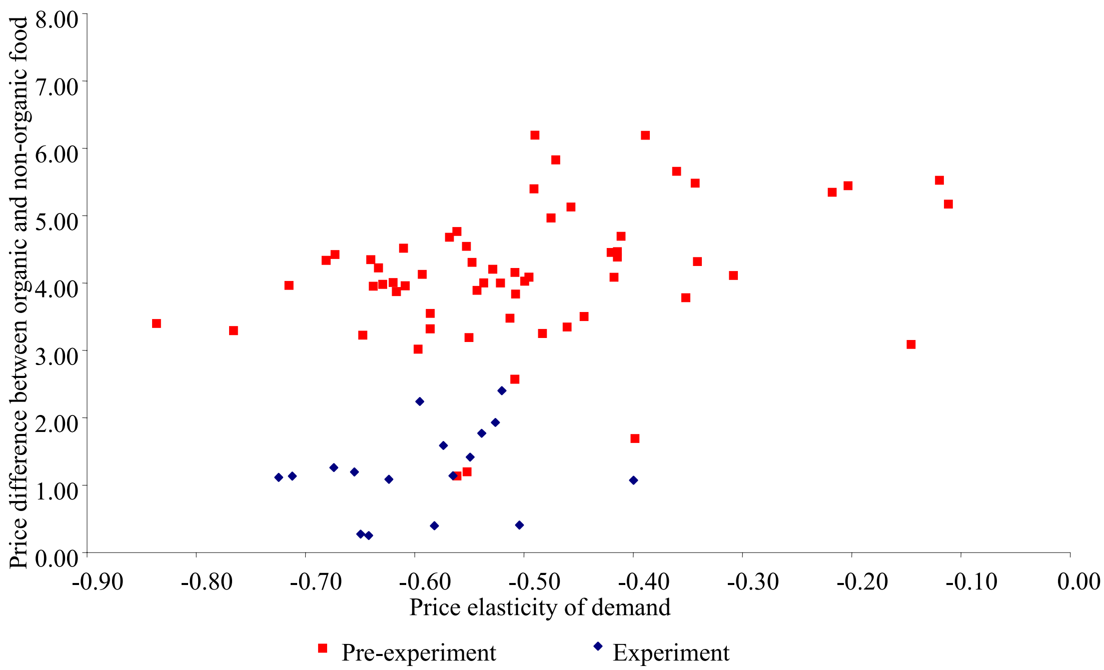

Figure 7.6 Price sensitivity of demand for minced beef (based on test outlets with high reduction rates)

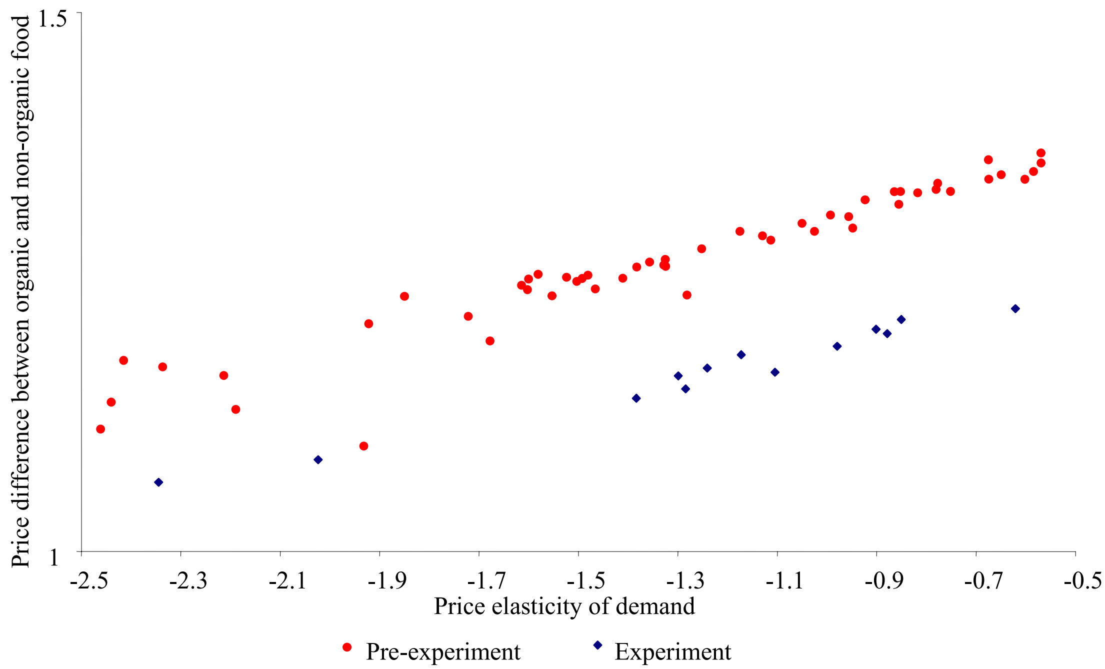

Figure 7.7 Price sensitivity of demand for muesli (based on all outlets)

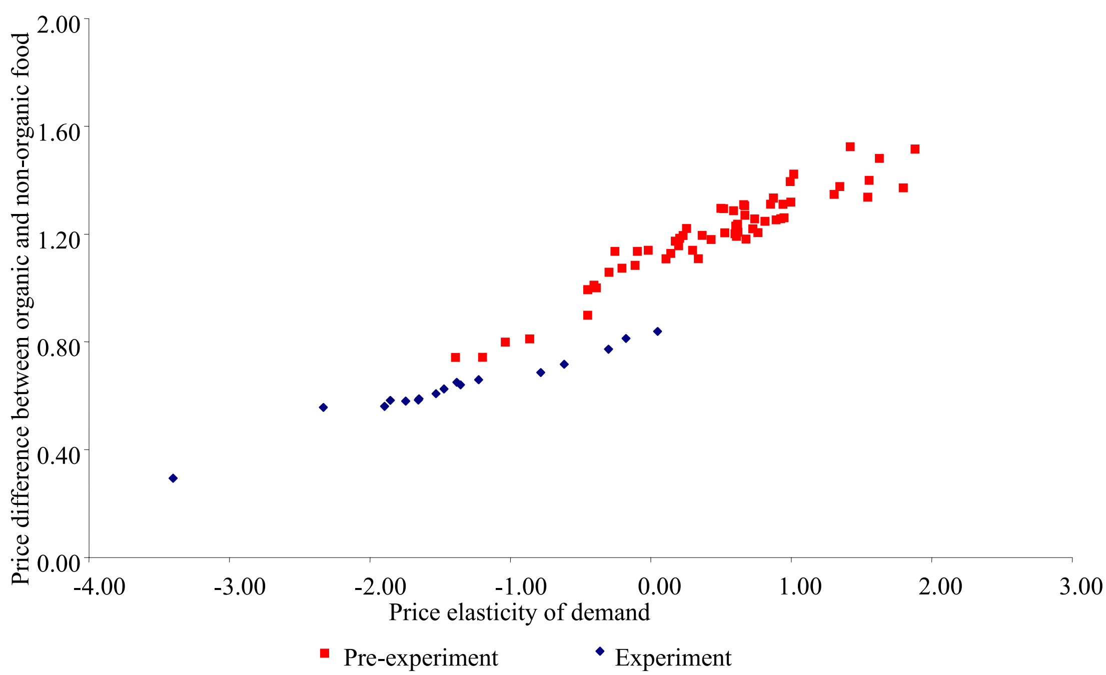

Figure 7.8 Price sensitivity of demand for muesli (based on test outlets with high reduction rates)

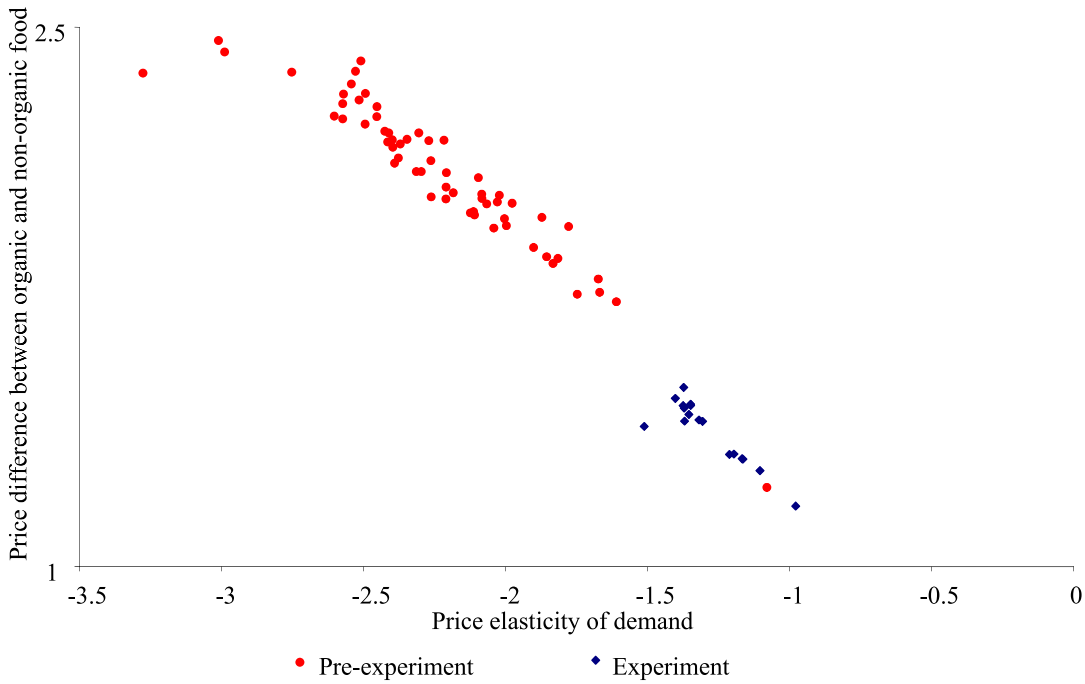

Figure 7.9 Price sensitivity of demand for mushrooms (based on all outlets)

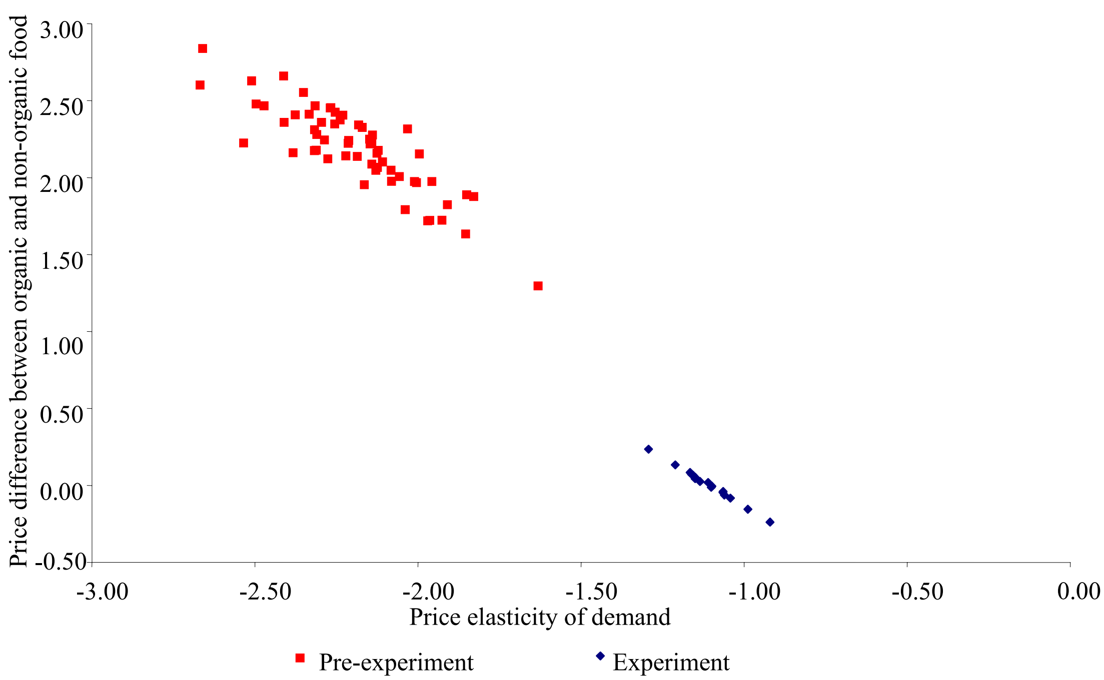

Figure 7.10 Price sensitivity of demand for mushrooms (based on test outlets with high reduction rates)

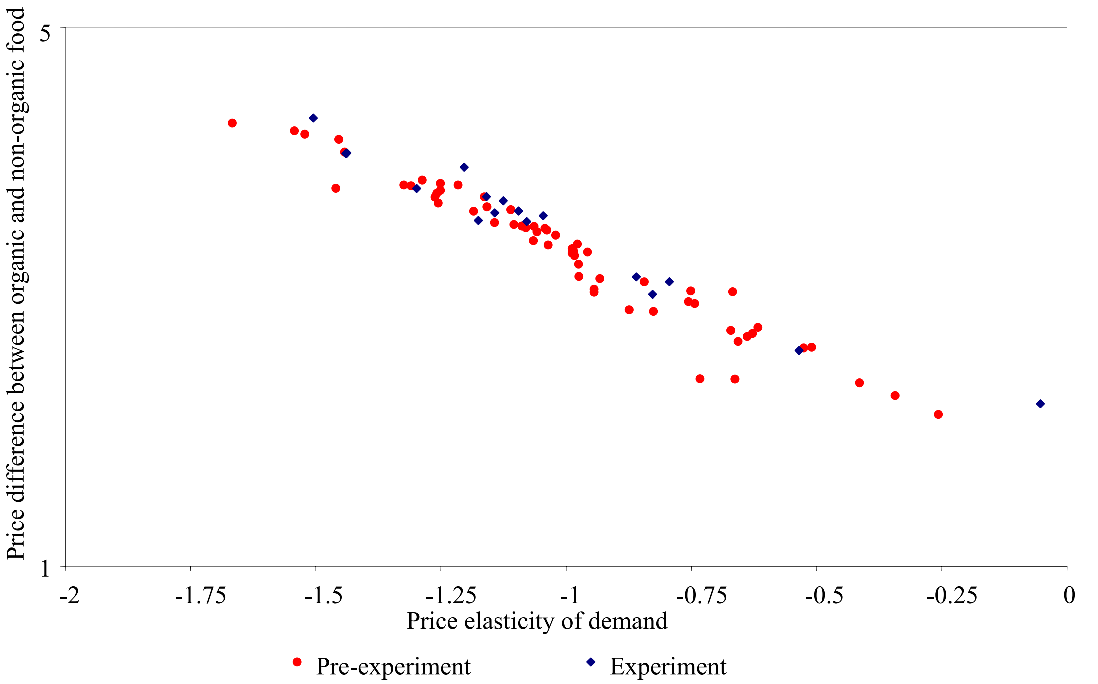

Figure 7.11 Price sensitivity of demand for pork (based on all outlets)

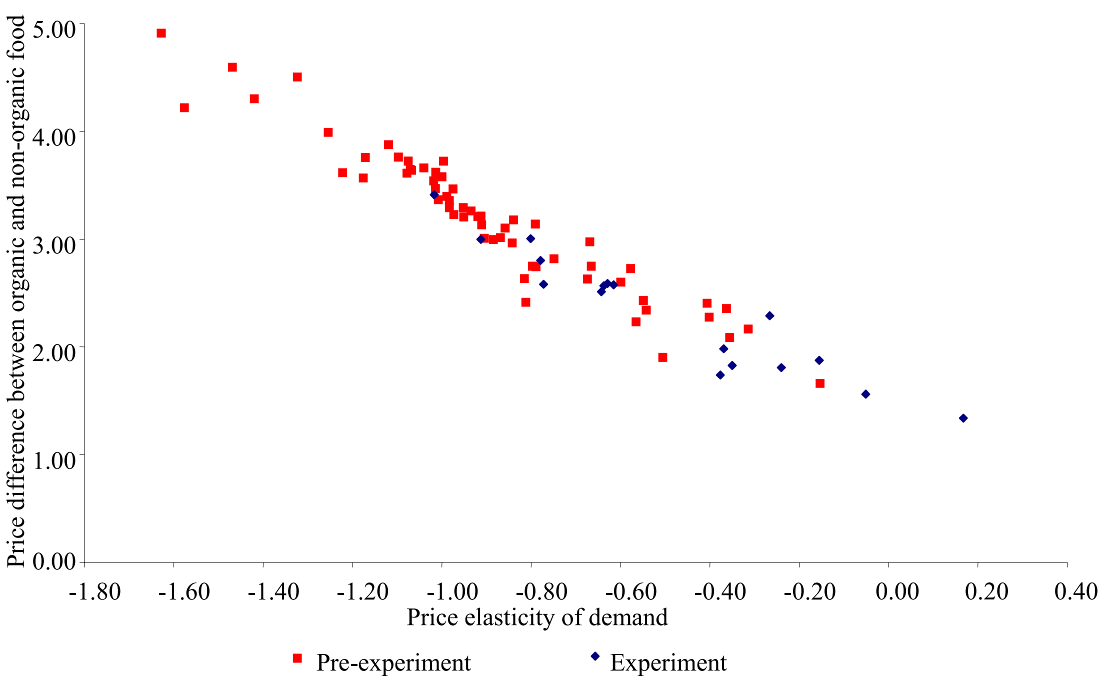

Figure 7.12 Price sensitivity of demand for pork (based on test outlets with high reduction rates)

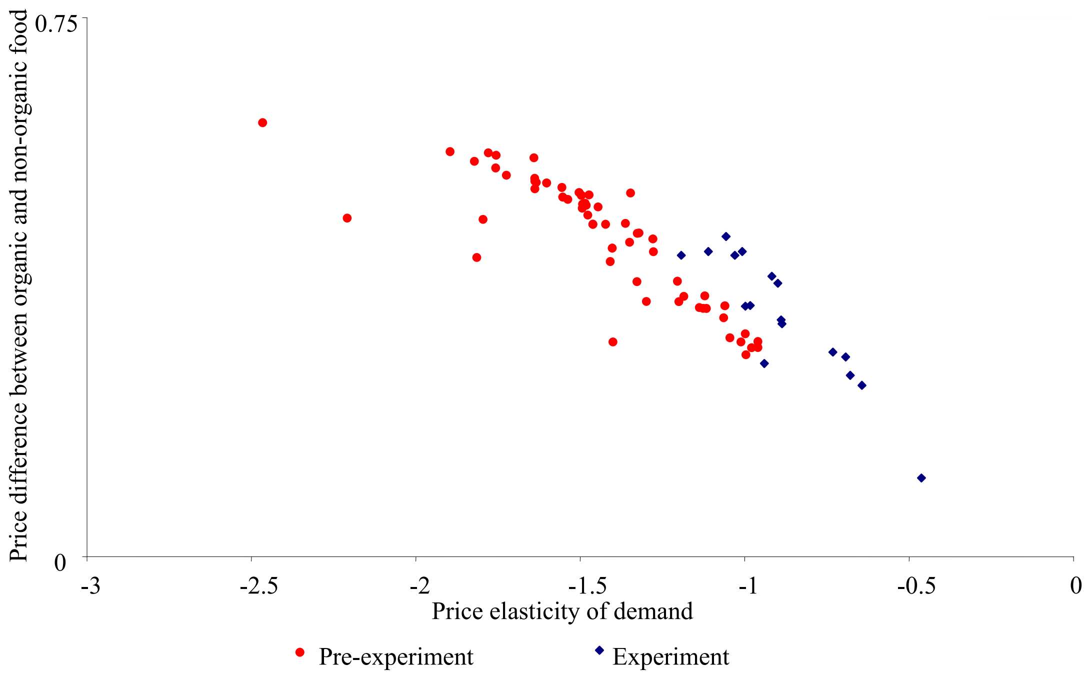

Figure 7.13 Price sensitivity of demand for potatoes (based on all outlets)

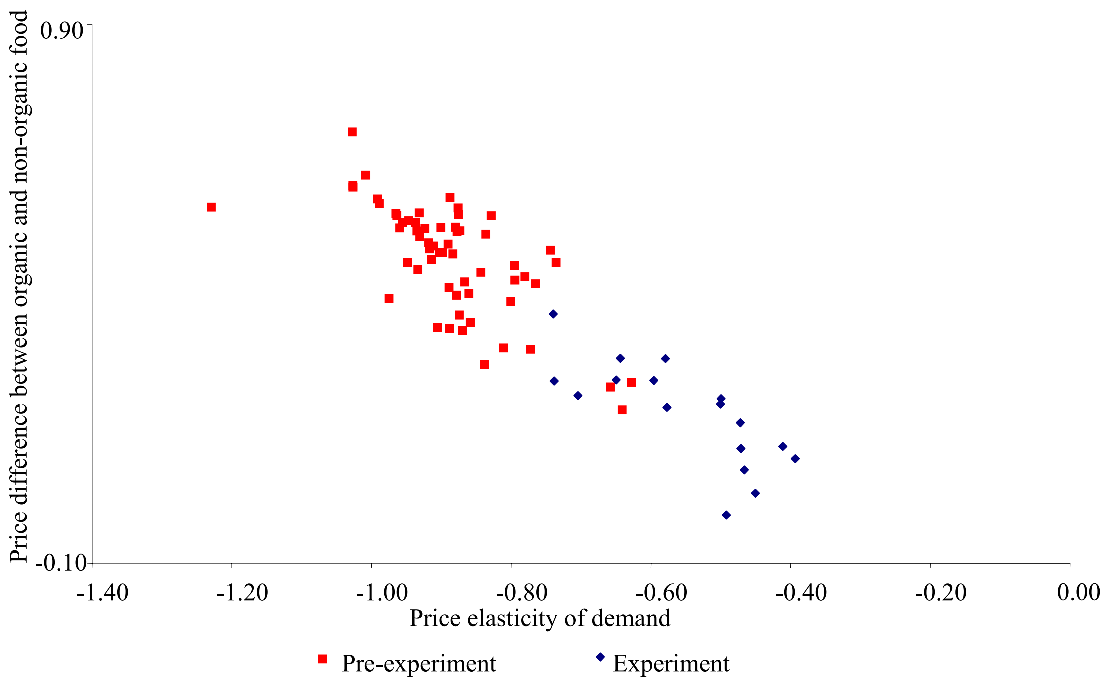

Figure 7.14 Price sensitivity of demand for potatoes (based on test outlets with high reduction rates)

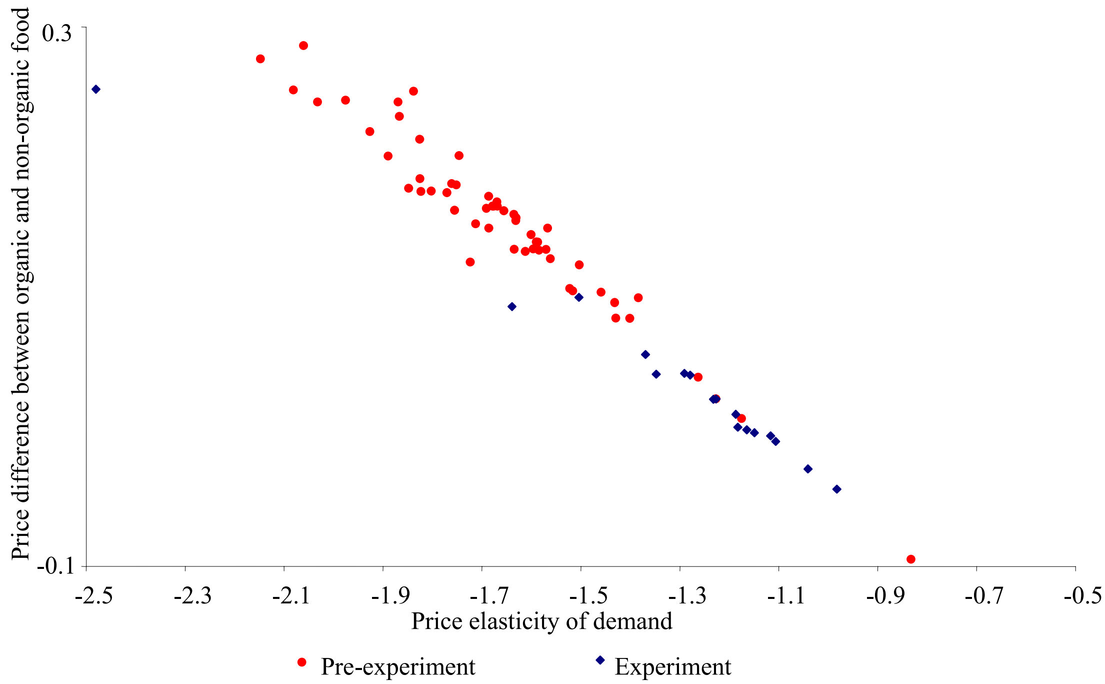

Figure 7.15   Price sensitivity of demand for rice (based on all outlets)

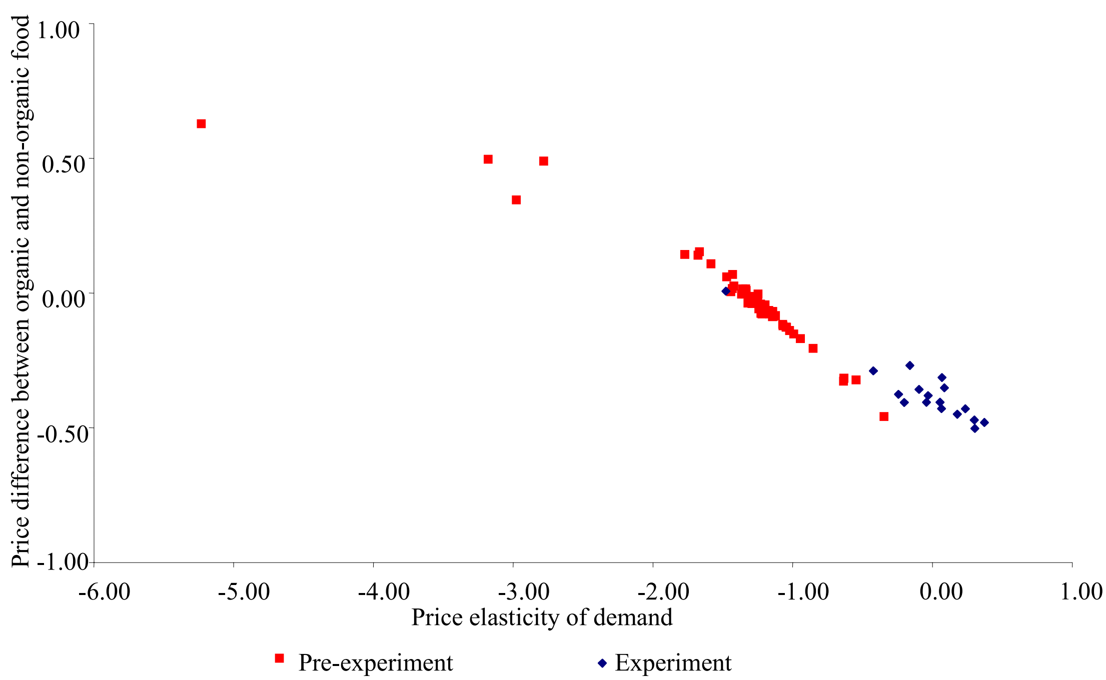

Figure 7.16   Price sensitivity of demand for rice (based on test outlets with high reduction rates)

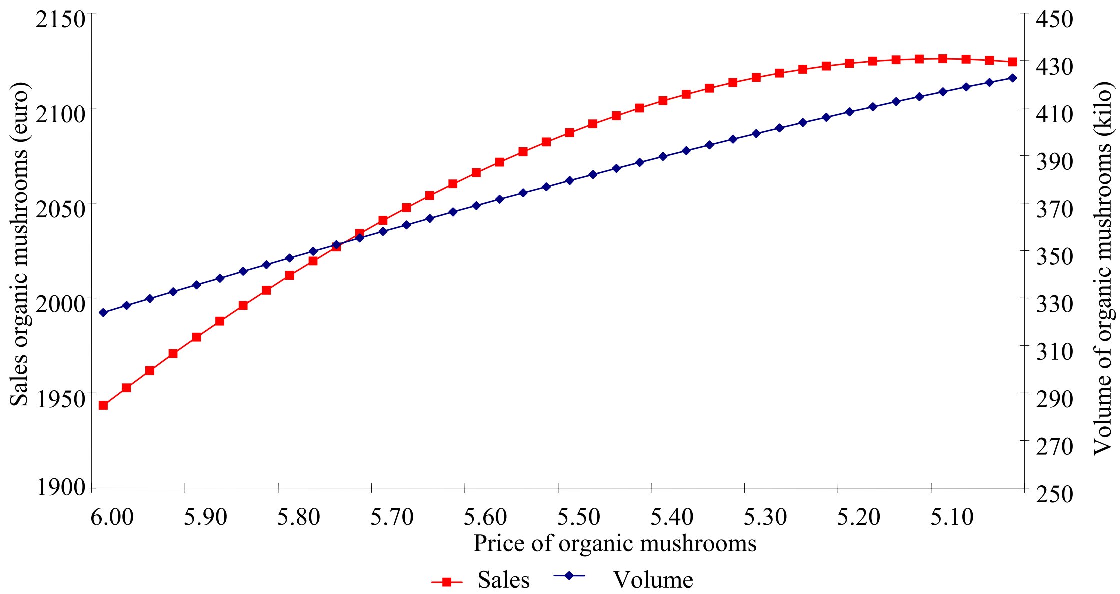

Figure 7.17 Sales of organic mushrooms as a function of the price of organic mushrooms

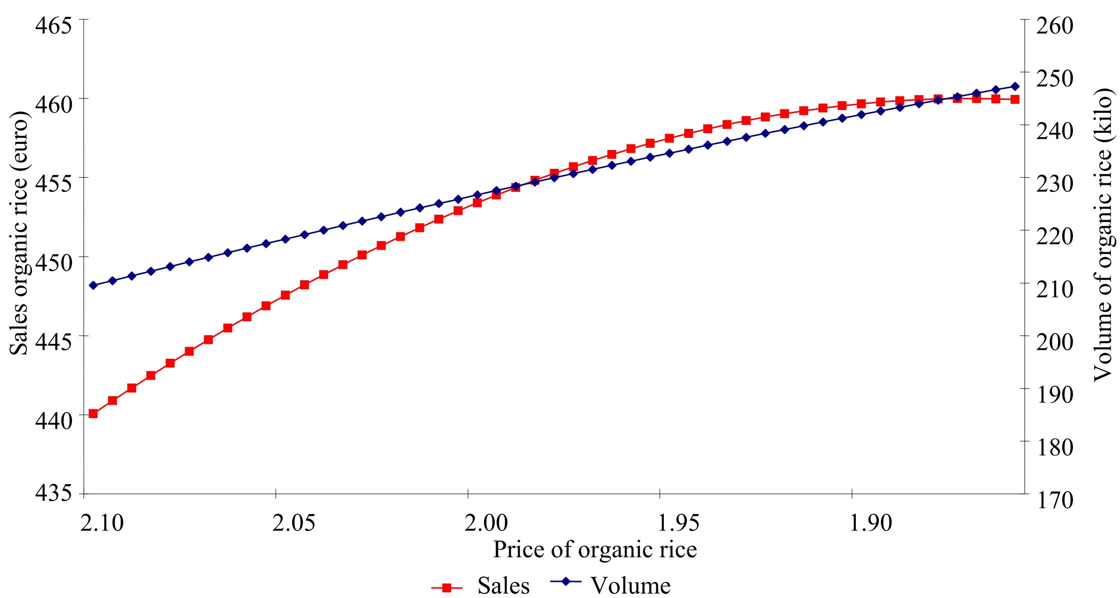

Figure 7.18 Sales of organic rice as a function of the price of organic rice

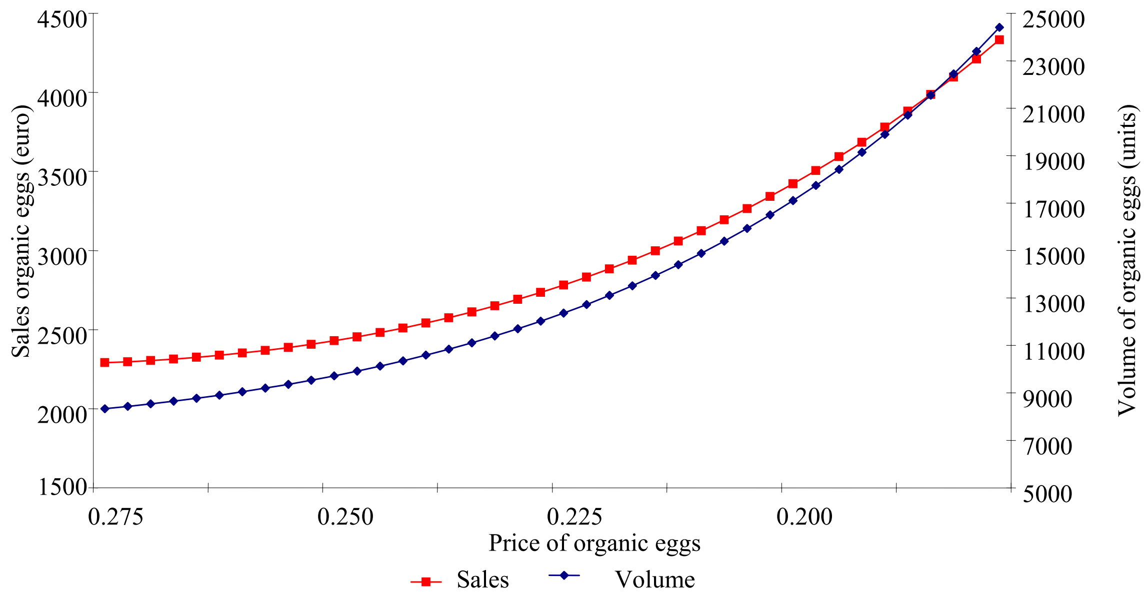

Figure 7.19 Sales of organic eggs as a function of the price of organic eggs

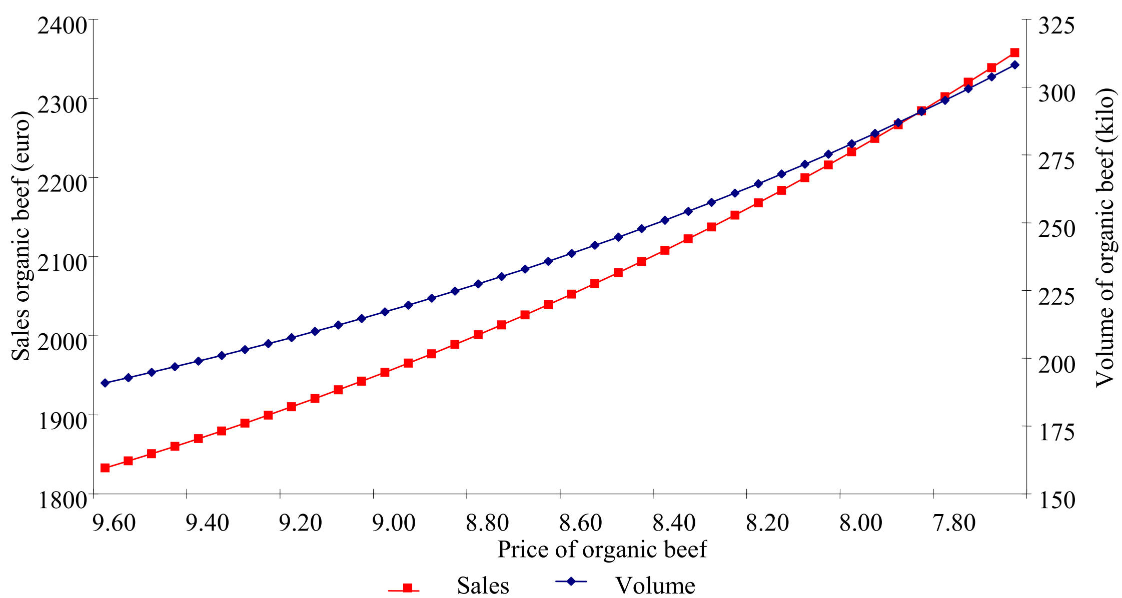

Figure 7.20 Sales of organic minced beef as a function of the price of minced beef

7.4 Product disaggregation

In this section, we differentiate the results from the previous section for eggs, mushrooms and pork by disaggregating these products into different product varieties. We do not present the results for milk and rice because it is difficult to get plausible estimates for milk due to the summer trough in milk consumption and for rice because the demand for both organic varieties of rice is very low (see table 6.3).

7.4.1 Eggs

The data allow us to differentiate eggs into three varieties: barn, organic and other eggs. Unfortunately, other eggs comprise two varieties: free land and cage eggs. We did not split other eggs into both varieties, because splitting requires extensive analysis of the ean-codes provided. Barn eggs are the most important variety with a share of 93.5% of total sales. Organic eggs refer to 3.7% of total sales and other eggs to 2.8%.

The price elasticities for the three egg varieties are given in table 7.7. The own price elasticities of demand on the cross diagonal are negative. The price elasticities for barn and other eggs are smaller in absolute value than the price elasticities recorded in table 7.2. The first result is as expected. In section 4.2, we indicated that the expected sign of the own price elasticity of demand is negative. We also expect that demand becomes more price elastic the more specific a product variety is. For instance, the demand for eggs may be inelastic with respect to price, because one does not want to adapt ones consumption behaviour, but one can always switch from one egg to the other. The results suggest the opposite.

Positive cross price elasticities point to substitutability. Negative cross price elasticities point to complementarity. *A priori*, we expect to find substitutes only. However, table 7.7 suggests that e.g. organic and other eggs are complements. Maybe, this result is a statistical artefact due to the fact that other eggs are comprised of free land and cage eggs.

Table 7.7 Long run price elasticities for eggs (test outlets)

Demand for	Price of		
	barn	organic	other
Barn	-0.98	0.00	-0.01
Organic	0.17	-0.81	-0.23
Other	-0.87	-0.33	-0.39

7.4.2 Mushrooms

In this section, we identify four varieties: organic and conventional white mushrooms and organic and conventional other mushrooms. Conventional white mushrooms are the most widely sold variety with a 75.4% market share, followed by conventional other mushrooms (17.0%). The market share of both organic varieties is relatively high: 2.7% for organic white mushrooms and 4.9% for organic other mushrooms.

Table 7.8 indicates that the own price elasticities of demand on the cross diagonal are higher in absolute value than in table 7.2. Conventional white mushrooms are substitutes for all other varieties. The organic varieties are complements. When a price reduction induces a consumer to buy one organic variety, the consumer may very well buy the other organic variety as well. For mushrooms, this is a reasonable result given the fact that different types of mushrooms are often combined into one meal. Organic white and conventional other mushrooms are complements as well.

Table 7.8 Long run price elasticities for mushrooms (test outlets)

Demand for	Price of			
	conventional, other	conventional, white	organic, other	organic, white
Conventional, other	-1.25	-0.03	0.10	-0.10
Conventional, white	0.06	-1.18	0.14	0.07
Organic, other	0.33	1.79	-3.34	-0.15
Organic, white	-0.73	2.21	-0.30	-2.26

7.4.3 Pork

Supermarkets hardly sell any organic pork. Of total pork sales, 1.6% refers to organic products, 0.9% to lean (high priced) pork and 0.7% to other (low priced) pork. Of conventional pork, 53% of total sales refer to lean meat and 45% to other meat. On the basis of table 7.9 one major conclusion may be drawn. Demand for organic pork is insensitive to changes in the prices of organic and conventional pork. In particular, the own price elasticities of demand are extremely low. A rise in the price of conventional other pork has a negative impact on the demand for all four varieties, primarily because of the budget effect.

Table 7.9 Long run price elasticities for pork (test outlets)

Demand for	Price of			
	conventional, lean	conventional, other	organic, lean	organic, other
Conventional, lean	-0.74	-0.27	0.01	0.00
Conventional, other	-0.32	-0.66	-0.02	-0.02
Organic, lean	0.17	-0.32	-0.04	0.25
Organic, other	0.28	-0.88	0.33	0.01

7.5 Conclusion

Demand for organic products is sensitive to changes in the prices of organic products. One may enhance sales of organic products somewhat by reducing the prices of organic products. However, there is a ceiling to the possibility to enhance sales of organic products. When prices of organic products drop too far, sales revenue actually falls because demand becomes price inelastic, insensitive to price changes. These price levels have been reached in the price experiment. This holds in particular for organic milk, mushrooms, pork, potatoes and rice. This does not hold for organic eggs, mined beef and muesli. There is scope to promote sales of organic eggs, minced beef and muesli by reducing prices of organic products substantially. Sales of organic products may also be enhanced, be it slightly, by raising the prices of conventional products.

8. Results for promotion

In this chapter, we investigate the impact of promotional activities on sales and market share of organic products. Due to data limitations, we focus on folder activities and assortment width. Section 8.1 studies the impact of folder activities. Section 8.2 studies the impact of assortment width.

8.1 Folder activities

Distributing folders is an important means of conveying information about promotional activities in supermarkets. Most promotional activities refer to temporary price reductions in one way or the other. Supermarkets may reduce per unit prices, grant quantity discounts, give products away free-of-charge if a minimum quantity is bought, etcetera. Promotional activities are targeted to products with a high turnover. Promotional activities with respect to organic products may be expected to be infrequent. Table 8.1 indicates the number of weeks in which at least one organic product was promoted in at least one outlet of a supermarket chain. Retail chain PLUS promoted organic eggs for nine weeks in at least one outlet. All other retail chains promoted eggs 13 times in at least one of their outlets: Albert Heijn for six weeks, Coop Compact for two weeks, Coop for two weeks and Super de Boer for three weeks. In total, we have 103 observations if we aggregate data to the retail chain level. The PLUS retail chain promotes organic products frequently. The other retail chains do not, at least not in the outlets in our sample. Most folder activities refer to potatoes, eggs and to a lesser extent mushrooms, milk and pork. Given the number of observations, we limit our attention to eggs, potatoes, mushrooms and milk.

Table 8.1 Number of weeks organic products appear in folders (week 9 2005 week 33 2006)

	PLUS	Other retail chains	Total
Eggs	9	13	22
Milk	3	11	14
Minced beef	7	1	8
Muesli	2	1	3
Mushrooms	9	7	16
Pork	11	1	12
Potatoes	3	20	23
Rice	3	2	5
Total	47	56	103

Source: IRI.

Table 8.2 shows that folder activities generate long term effects on the demand for organic products. In the long run, folder activities in 10 outlets boost the budget share of organic products by 0.25-0.30%. The table shows that folder activities for organic products have long run effects on consumer demand for organic food. Taking into account that folder activities with respect to organic products are infrequent (table 8.1), one may want to stimulate such activities. The long run effects of folder activities for conventional food are negligible.

Table 8.2 Long term effect of folder activities in 10 outlets on demand for organic products (%)

	Organic	Non-organic
Eggs	0.03 a)	0.00
Milk	0.27 a)	0.00
Mushrooms	0.24 a)	0.00 a)
Potatoes	0.28 a)	0.04 a)

a) Significance at the 5% level.

8.2 Assortment width

The number of organic varieties sold in Dutch supermarket chains is limited. In chapter 3, we saw that the number of organic varieties (ean codes) per supermarket chain ranges from 0-5 for eggs, minced beef, muesli and rice to 1-8 for milk and potatoes and even to 5-18 for pork. The latter is primarily due to differences in packages (weights).

We expect the budget share of organic products to be higher when the number of organic varieties of the product under consideration or the number of organic varieties in general increases. An increase in the number of organic varieties available makes it more likely that the organic varieties offered meet consumer demand in other respects than the characteristic 'organically produced'. An increase in the number of varieties in general is likely to increase the visibility of organic products in supermarkets and consumer awareness in this respect.

Table 8.3 shows that adding one additional organic variety to the current product assortment leads to an increase of the budget share of organic varieties. Rice and eggs are the exceptions. The effect of adding non-organic varieties to the product assortment is negligible.

Table 8.3 Long-term effect of adding one variety to the product assortment on budget share of organic food

	Organic varieties	Non-organic varieties
Eggs	-0.16 a)	-0.02
Milk	0.28 a)	-0.04
Muesli	0.54 a)	-0.07
Mushrooms	0.03 a)	0.00
Potatoes	0.75 a)	0.03 a)
Rice	-0.45 a)	0.01 a)

a) Significance at the 5% level.

9. Evaluation

Chapter 7 determined to what extent consumer demand for organic food is sensitive to changes in food prices, notably the prices of organic food itself. In particular, chapter 7 concluded that consumer demand for organic food is sensitive to changes in the prices of organic food, but also to changes in the prices of conventional food. More importantly, the results show that there is a limit to the growth in sales for five of the eight organic products analysed. Now what? Researchers typically have problems with this question. Do the conclusions drawn in the report have direct policy implications for government, business or any party involved? In this chapter, we spend some time on what conclusions may and may not be drawn on the basis of the report.

First, in order to draw conclusions with respect to the demand for organic food in the Netherlands, one should pay attention to the following traditional caveat. Do the results obtained in this report for selected organic products in ten selected communities also hold for the Netherlands as a whole? Of course, the answer is 'No' or at least 'Not necessarily'. The products selected represent major product categories such as dairy, meat, vegetables and groceries and refer to products with a low and a high turnover (e.g. muesli versus milk or potatoes). The communities selected represent average Dutch communities according to some *a priori* criterions (see chapter 3). However, the sample is not based on a random sample selection process and the sample is not large in terms of number of products, communities and outlets. The sample is constructed on the basis of practical arguments which were necessary to come to a real-world experiment. Moreover, the results apply to supermarkets only and not to other distribution channels. Finally, the results are likely to depend to some extent on the model specifications chosen (see chapter 4 and 5).

Second, in the organic supply chain, there is an intense debate on the effectiveness of various marketing strategies which may promote the demand for organic food. This report contributes to this debate (see section 2.5). This report focuses on the sensitivity of consumer demand with respect to permanent price changes. However, the report does not say much about the sensitivity of consumer demand with respect to any other element in the marketing strategy, such as short-run price changes or any other type of promotional activities. So, on the basis of this report, one is not able to draw many conclusions with respect to the effectiveness of promotional activities other than permanent price changes or on the effectiveness of permanent price changes versus other marketing strategies.

Third, and more importantly, the results in this report fall in the realm of descriptive (or positive) economics. The results refer to the question: *What is*? They do not refer to prescriptive (or normative) economics. The results do not have any direct implications with respect to the question: *What should be*? The results indicate to what extent volume and sales of organic food rise in the long run if prices of organic food fall by X% permanently. These results are useful in assessing the effectiveness of lowering long-run organic food prices. If the price elasticity of organic food demand is low, policies directed to lowering organic food prices are not likely to be effective in terms of promoting organic food's market share (Bunte, 2004). Information with respect to the price elasticity of demand may be used to set realistic targets in terms of volume, sales or market share (Thompson, 2000).

The results of this report do not imply that organic food prices are too high, that the price gap between organic and non-organic food is too large, or even less so that the price gap should be reduced. In competitive markets, price differences are primarily based on differences in costs, quality and scarcity. Products are more expensive because they cost more, because they have a better perceived quality or simply because they are scarcer, for instance due to natural restrictions. This explains why a G-class Mercedes is more expensive than a Smart and white truffles are more expensive than white bulk mushrooms. A price gap only becomes too large if the price gap is not based on differences in costs, perceived quality or availability or to put it differently if markets are not sufficiently competitive (Bunte, 2005). The report does not say whether the price gap between organic and non-organic food is based on differences in costs, perceived quality or scarcity or not.

Now what? If the results of the analysis are accepted (see point 1 above), this means that a reduction of the price gap between organic and conventional food will only have a limited effect on the demand for organic food. This has implications for policies directed to reducing the price gap. Moreover, the report indicates that organic products are likely to remain a niche product. The budget share of organic products reaches a ceiling when the price gap becomes sufficiently low, for at least five out of eight products. This contradicts the turning point hypothesis for these products. This report focuses on price effects. However, the WRR points out that if human behaviour is unresponsive with respect to one factor (price), it is likely to be unresponsive with respect to other factors as well (WRR, 1992).

10. Conclusion

This report presents the results of a price experiment in ten Dutch communities in which the prices of eight organic products were substantially reduced in supermarket outlets. The experiment took place from week 17 until week 33 in 2006. The experiment has made possible by cooperation between the Ministry of Agriculture, Nature and Food Quality, the supermarkets concerned, IRI and LEI. In the experiment, the prices of eggs, milk, minced beef, muesli, mushrooms, pork, potatoes and rice were reduced. This report measures how sensitive consumer demand is to price changes by estimating the price elasticity of demand.

The price elasticities have been estimated using the AID specification. This specification is widely applied in applied demand theory, also with respect to the demand for organic food. Empirical applications typically find that the demand for organic food is sensitive to changes in the price of organic food and to a lesser extent to changes in the price of their conventional substitutes.

The basic conclusion of this report is that demand for *some* organic products is responsive to price changes. Demand for and sales revenue of organic eggs, minced beef and muesli increase exponentially when their prices are reduced. Demand for the other products analysed is unresponsive to price changes. Demand for and sales revenue of organic milk, mushrooms, pork, potatoes and rice hardly grow when their prices are reduced. Moreover, if prices of these products are reduced to the levels set during the price experiment, sales revenue may actually reach a ceiling. Further price reductions have no or even a detrimental impact on sales revenue. Because the impact of price changes on the demand for organic products is substantial for a limited number of products, it may be wise to focus price reducing policies on these products. Examples of price reducing policies are consumer subsidies and cost reduction strategies.

More specifically, the report reaches the following conclusions:

1. demand for organic food is elastic. At current prices, the absolute value of the own price elasticity of demand is larger than one except for eggs. This implies that at current price levels there is some scope to increase both demand for and sales of organic food slightly;
2. however, if prices of organic products are reduced, we find two types of consumer responses:
    a. demand for milk, mushrooms, pork, potatoes and rice becomes less sensitive to price changes when the price gap between organic and conventional food falls. There is a bound in the sales and budget share of organic milk, mushrooms, pork, potatoes and rice, because the absolute value of the price elasticity of demand becomes smaller than one when the price gap falls below a certain level. This level has been reached for some products during the experiment;
    b. demand for eggs, minced beef and muesli on the other hand becomes more sensitive to price changes when the price gap between organic and conventional food falls. Sales and budget share accelerate when the price gap between organic and

non-organic food falls. The absolute value of the price elasticity of demand increases when the price gap falls;

3. the contrast between milk, mushrooms, pork, potatoes and rice on the one hand and eggs, minced beef and muesli on the other hand may be explained by the difference in the price gap for these products. The price gap between organic and non-organic food is relatively low for milk, mushrooms, pork and rice and relatively high for eggs, minced beef and muesli. The price elasticity of demand may very well increase when the price gap falls provided the price gap is relatively high, but decrease when the price gap is relatively low;
4. demand for organic food is also responsive to changes in the price of conventional food. Policies aimed at raising the price of conventional food, increase demand for organic food slightly;
5. folder activities increase demand for organic products both in the short and the long run. The long-run effect on sales of conventional products over all outlets is small;
6. an increase in the assortment width also increases demand for organic products in the long run. The long run effect on sales of conventional products is small.

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Appendix 1Dickey Fuller Test

Table A1.1 Elliot-Rothenberg-Stock Dickey-Fuller GLS Test Statistics

	Budget share	ln Price organic food	ln Price non organic food	ln Budget
Eggs	-1.75	-3.85 a)	-1.80	-1.38
	(-3.12)	(-3.13)	(-3.12)	(-3.13)
Milk	-2.50	-1.04	-2.60	-1.40
	(-3.11)	(-3.13)	(-3.11)	(-3.13)
Minced beef	-11.88 a)	-1.42	-10.50 a)	-1.39
	(-3.11)	(-3.12)	(-3.11)	(-3.12)
Muesli	-1.68	-2.30	-1.67	-2.90
	(-3.13)	(-3.11)	(-3.11)	(-3.11)
Mushrooms	-1.81	-1.37	-4.92 a)	-2.20
	(-3.13)	(-3.12)	(-3.11)	(-3.12)
Pork	-1.28	-1.62	-1.98	-3.97 b)
	(-3.13)	(-3.12)	(-3.13)	(-2.82)
Potatoes	-2.15	-1.36	-0.87	-1.53
	(-3.11)	(-3.12)	(-3.11)	(-3.14)
Rice	-8.69 a)	-2.26	-1.49	-1.62
	(-3.11) a)	(-3.11)	(-3.14)	(-3.13)

a) 5% level in parentheses.
b) Indicates significance at 5% level, lag-length selection based on modified HQ criterion.

Appendix 2 The AID specification

Demand is modelled on the basis of the AID (Almost Ideal Demand) specification (Deaton and Muelbauer 1980). The system of demand equations is made up of J budget share equations. Product i's budget share equals $w_i = p_i q_i / X$ where p_i and q_i represent the consumer price and the quantity sold of product i respectively and X all expenses on all products considered. The demand equations are:

$$w_i = \alpha_i + \sum_{j=1}^{J} \gamma_{ij} \ln p_j + \beta_i \ln(X/P) \qquad (1)$$

where α_i, β_i and γ_{ij} are parameters and P is a price index defined as:

$$\ln P = \alpha_0 + \sum_{i=1}^{J} \alpha_i \ln p_i + \frac{1}{2} \sum_{i=1}^{J} \sum_{j=1}^{J} \gamma_{ij} \ln p_i \ln p_j \qquad (2a)$$

This price index may be approached by Stone's geometric approximation:

$$\ln P = \sum_{i=1}^{J} w_i \ln p_i \qquad (2b)$$

The system of demand equations is submitted to the adding up, the homogeneity and the symmetry conditions:

$$\sum_{j=1}^{J} \gamma_{ij} = \sum_{i=1}^{J} \gamma_{ij} = \sum_{i=1}^{J} \beta_i = 0 \qquad (3a)$$

$$\sum_{i=1}^{J} \alpha_i = 1 \qquad (3b)$$

$$\gamma_{ij} = \gamma_{ji} \qquad (3c)$$

The logic behind these three conditions is the following:

- condition (3a) implies that the budget shares sum to 1. This condition is based on the assumption that the consumer spends his entire budget;
- condition (3b) implies that if budget and prices fall or rise by X%, demand for all products will remain constant. This condition is known as the homogeneity restrictions. Demand depends on relative rather than nominal prices;
- condition (3c) presumes symmetry between the coefficients of two different and potentially substitutable or complementary products. This condition refers to the cross price elasticity of demand. For the so-called 'pure' substitution-effects between product X and product Y it does not matter whether the price of product X rises by 10%

or the product Y's price fall by 10%. Again, demand depends on relative rather than nominal prices.

The price elasticity of demand is defined as:

$$\varepsilon_{ij} = \frac{\partial q_i}{\partial p_j}\frac{p_j}{q_i} = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \beta_i \frac{s_j}{s_i}$$

Where δ_{ij} represents the Kronecker delta δ.[1]

For our purposes the AID-specification has the following advantages:

- in the AID-specification, budget shares are the explanatory variables. The budget share of organic food is the key variable in our problem statement;
- the results of the estimations may be improved - in terms of plausible outcomes - by imposing restriction (3a)-(3c) on the basis of economic theory. Economic theory offers a basis for these restrictions in the form of the presumed rationality of consumer behaviour. The marketing literature offers less justification for restrictions except common sense (with respect to the signs of the parameters to be estimated).

The AID-specification also has some technical drawbacks:

- the price elasticities have to be determined on the basis of the parameter values estimated. This also holds for the corresponding confidence intervals;
- when applying structural models such as the AID specification, some econometric requirements need to be addressed (see chapter 5).

For the two goods case in section 7.2, we have to consider only one expenditure share equation:

$$w_1 = \alpha_1 + \gamma_{11}\ln p_1 + \gamma_{21}\ln p_2 + \beta_1 \ln Y - \beta_1 \ln P \qquad (1')$$

because, by definition, $w_2 = 1 - w_1$. Furthermore, the price index in (3) can be written out as

$$\ln P = a_0 + \alpha_1 \ln p_1 + \alpha_2 \ln p_2 + ½(\gamma_{11}\ln p_1 \ln p_1 + \gamma_{21}\ln p_2 \ln p_1 + \gamma_{12}\ln p_1 \ln p_2 + \gamma_{22}\ln p_2 \ln p_2) \qquad (2a')$$

From the restrictions $\sum_{i=1}^{n}\alpha_i = 1$ it follows that $\alpha_2 = 1 - \alpha_1$ and from $\gamma_{ij} = \gamma_{ji}$ and $\sum_{j=1}^{n}\gamma_{ij} = 0$ we obtain $\gamma_{21} = \gamma_{12} = -\gamma_{11} = -\gamma_{22}$. As a consequence, (1') and (2a') reduces to

$$w_1 = \alpha_1 + \gamma_{11}(\ln p_1 - \ln p_2) + \beta_1 \ln Y - \beta_1 \ln P \qquad (1'')$$

[1] De Kronecker delta is 1 voor i = j en anders 0 (i ≠ j).

and

$$\ln P = a_0 + \alpha_1(\ln p_1 - \ln p_2) + \ln p_2 + ½\gamma_{11}[\ln p_1 \ln p_1 - 2\ln p_1 \ln p_2 + \ln p_2 \ln p_2] \qquad (2a'')$$

respectively. Substituting (7) in (6) and collecting terms gives

$$w_1 = \alpha_1 - \beta_1 a_0 + (\gamma_{11} - \beta_1\alpha_1)(\ln p_1 - \ln p_2) + \beta_1(\ln Y - \ln p_2) - ½\beta_1\gamma_{11}[\ln p_1 \ln p_1 - 2\ln p_1 \ln p_2 + \ln p_2 \ln p_2] \qquad (1''')$$

By estimating model (1'''), we are able to identify all parameters. To see this, consider the linear model for w_1 with a constant and explanatory variables $(\ln p_1 - \ln p_2)$, $(\ln Y - \ln p_2)$ and $[\ln p_1 \ln p_1 - 2\ln p_1 \ln p_2 + \ln p_2 \ln p_2]$. Let the coefficients attached to the regressors be b_0, b_1, b_2 and b_3, respectively. Then, $b_0 = \alpha_1 - \beta_1 a_0$; $b_1 = \gamma_{11} - \beta_1\alpha_1$; $b_2 = \beta_1$; and $b_3 = -½\beta_1\gamma_{11}$, from which it follows that $\beta_1 = b_2$; $\gamma_{11} = -2b_3/b_2$; $\alpha_1 = -(b_1 + 2b_3/b_2)/b_2$; and $a_0 = -[b_0 + (b_1 + 2b_3/b_2)/b_2]/b_2$.

On the basis of equation (1'''), we are able to derive the price and budget elasticities of demand. By definition,

$$\ln w_1 = \ln (p_1q_1/Y) = \ln p_1 + \ln q_1 - \ln Y \Leftrightarrow \qquad (1'''')$$
$$\ln q_1 = \ln w_1 - \ln p_1 + \ln Y \qquad (4)$$

Using this, we obtain the following own-price elasticity:

$$e_{11} = (dq_1/q_1)/(dp_1/p_1) = d \ln q_1/d \ln p_1 = d \ln w_1/d \ln p_1 - 1 = (1/w_1)\, dw_1/d \ln p_1 - 1 \qquad (5a)$$
$$= (\gamma_{11} - \beta_1\alpha_1 - \beta_1\gamma_{11}\ln p_1 + \beta_1\gamma_{11}\ln p_2)/w_1 - 1$$
$$= [\gamma_{11} - \beta_1\alpha_1 - \beta_1\gamma_{11}(\ln p_1 - \ln p_2)]/w_1 - 1$$

Notice that $\gamma_{11} - \beta_1\alpha_1 - \beta_1\gamma_{11}\ln p_1 + \beta_1\gamma_{11}\ln p_2 = \gamma_{11} - \beta_1(\alpha_1 + \gamma_{11}\ln p_1 + \gamma_{21}\ln p_2) = \gamma_{11} - \beta_1[w_1 - \beta_1\ln(Y/P)]$, see (1'), so that we can also write (5a) as

$$e_{11} = \{\gamma_{11} - \beta_1[w_1 - \beta_1\ln(Y/P)]\}/w_1 - 1 \qquad (5a')$$

at least, if (1') is exact, i.e., does not contain an error term. The other price elasticities are

$$e_{21} = [\beta_1(\alpha_1 - 1) - \gamma_{11} + \beta_1\gamma_{11}(\ln p_1 - \ln p_2)]/w_1 \qquad (5b)$$
or
$$e_{21} = \{\gamma_{21} - \beta_1[w_2 - \beta_2\ln(Y/P)]\}/w_1) \qquad (5b')$$

$$e_{12} = [\beta_2(\alpha_2 - 1) - \gamma_{22} + \beta_2\gamma_{22}(\ln p_2 - \ln p_1)]/w_2 \qquad (5c)$$
or
$$e_{21} = \{\gamma_{12} - \beta_2[w_1 - \beta_1\ln(Y/P)]\}/w_2) \qquad (5c')$$

$$e_{22} = [\gamma_{22} - \beta_2\alpha_2 - \beta_2\gamma_{22}(\ln p_2 - \ln p_1)]/w_2 - 1 \qquad (5d)$$

or

$$e_{22} = \{\gamma_{22} - \beta_2[w_2 - \beta_2 \ln(Y/P)]\}/w_2 - 1) \tag{5d'}$$

In vector and time-series notation, the budget share equation equals: (6)

$$w_{1t} = \mathbf{b}'\mathbf{x}_t + u_t$$

with $u_t = \sum_{i=1}^{p} \rho_i u_{t-i} + \varepsilon_t$, i.e., $\{u_t\}$ is a pth order AR process. Define $\rho(L) = \sum_{i=1}^{p} \rho_i L^i$, called a 'lag-polynomial', where L is the lag-operator defined as $L^i z_t = z_{t-i} \ \forall \ i \in Z$. Then we can write $[1 - \rho(L)]u_t = \varepsilon_t$ from which it follows that $u_t = \varepsilon_t/[1 - \rho(L)]$. Consequently, (6) becomes:

$$[1 - \rho(L)]w_{1t} = [1 - \rho(L)]\mathbf{b}'\mathbf{x}_t + \varepsilon_t \tag{6'}$$

In case of an AR(1) model we have $\rho(L) = \rho_1 L$ in which case (6') reduces to

$$w_{1t} = \rho_1 w_{1,t-1} + \mathbf{b}'\mathbf{x}_t - \rho_1 \mathbf{b}'\mathbf{x}_{t-1} + \varepsilon_t \tag{6''}$$

Rewriting (6'') into error-correction form gives:

$$\begin{aligned} \Delta w_{1t} &= -(1 - \rho_1)w_{1,t-1} + \mathbf{b}'\Delta\mathbf{x}_t + (1 - \rho_1)\mathbf{b}'\mathbf{x}_{t-1} + \varepsilon_t \\ &= \mathbf{b}'\Delta\mathbf{x}_t - (1 - \rho_1)[w_{1,t-1} - \mathbf{b}'\mathbf{x}_{t-1}] + \varepsilon_t \end{aligned} \tag{6'''}$$

This model is nested in the general ADL(1,1) model:

$$w_{1t} = \rho_1 w_{1,t-1} + \mathbf{b}_0'\mathbf{x}_t + \mathbf{b}_1'\mathbf{x}_{t-1} + \varepsilon_t \tag{7}$$

of which the error-correction form is obtained by rewriting the model as follows:

$$\Delta w_{1t} = \mathbf{b}_0'\Delta\mathbf{x}_t - (1 - \rho_1)[w_{1,t-1} - \mathbf{b}_*'\mathbf{x}_{t-1}] + \varepsilon_t \tag{7'}$$

where $\mathbf{b}_* = (\mathbf{b}_0 + \mathbf{b}_1)/(1 - \rho_1)$ are the long-run coefficients.