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Executive Summary

This deliverable consists of an academic paper submitted to the journal Applied Economics in September 2018.

The paper introduces a theoretically consistent way of estimating a flexible infrequency of purchases model, which accounts for the actual purchase frequency of consumers – not just whether or not a consumer buys a product. Previous studies have estimated the model in log-linearized form only. The model has two stages. In the first stage, a model of purchase frequencies is estimated and in the second stage, the propabilities calculated from the first stage are used to calculate an adjusted demand system. The model was applied to consumption of salmon in France, using scanner data from 20,000 households for the years 2011-2013. In the study, French consumers are assumed to chose between three seafish categories; fresh salmon sold under the Label Rouge quality label, other fresh salmon and all other fish products. Results clearly show that consumer perception and loyalty differ substantially for fresh salmon bearing the Label Rouge label and fresh salmon that is not labelled. The framework applied also confirms that the consumers of Label Rouge salmon are more loyal than the consumers of other fresh salmon. This is consistent with results from the marketing literature and shows that Label Rouge can produce the desired effect of product differentiation. The results also provide the profile of the average Label Rouge consumer, providing retailers with enough information to target these consumers directly.

The results from this study are consistent with results from deliverable D5.4 which show the seafood consumers can be grouped into several categories. However, the output from this deliverable were not used directly in any of the tools developed in PrimeFish.

Contents

How often, how much?

Analysis of consumption of Label Rouge salmon in France

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Introduction

France is one of the most important seafood markets in Europe. In 2015, the country ranked third in the European Union (EU), with total household expenditures for farmed and wild seafood totalling about €8.5 billion (EUMOFA 2017). Fresh seafood made up about one quarter of that value, with salmon and cod being the most important species. Most of the salmon is farmed, whereas most of the cod is wild. As noted by Chen, Alfnes and Rickertsen (2015), no ecolabeling program for farmed fish has gained widespread international acceptance so far, but organic labels such as Agriculture Biologique are widely used for food in France. The quality label Label Rouge was introduced in France in 1965. It is well known there and can be used for all food products, including seafood. Initially, it was applied to agricultural products only. Scottish salmon is the first fish – and the first non-French product – to be awarded the label. Today, Norwegian and Irish salmon are also sold under this label.

The demand for fish in France has been studied extensively over the last 25 years through a variety of methods. Meghir and Robin (1992) analysed the demand for fish in France indirectly by estimating an infrequency of purchase model (IPM) using French consumer data where fish was included in the demand system as a part of the aggregated meat variable. Marette et al. (2008) studied the demand for specific types of fish. They conducted a laboratory experiment where consumers' willingness to pay was estimated before and after they received information regarding the nutritional benefits and the contamination risk. Brécard et al. (2009) estimated the demand for 'fish caught with an environmentally friendly technique, and which may carry a special label', which they referred to as green demand, using an ordered probit model. The data used for the analysis came from a European survey of seafood products, for which carried more than 5,000 consumers in Belgium, Denmark, France, Italy and the Netherlands were interviewed. Xie and Myrland (2011) applied an empirical test for the aggregation levels of French household demand for salmon.

Asche et al. (2011) analysed the demand growth for Atlantic Salmon in the EU and France. Onozaka et al. (2014) used a latent class model to study the relationship between consumer perception and frequency of salmon consumption. Gobillon and Wolff (2015) investigated spatial variations in product prices in French fish markets. Irz et al. (2015) estimated a demand system under nutritional constraints. They used French consumer panel data consisting of the purchases of all types of foods by 19,000 households. The data were collected by Kantar, and the results showed, for example, how diet changes, such as the change from beef to fish consumption, affected consumers' health and the environment. Irz et al. (2016) analysed the costs and benefits to consumers for complying with dietary recommendations. The results showed that recommendations such as lower red meat consumption in exchange for increased fish consumption imposed only moderate taste costs.

Although the literature on the demand for fish in France is extensive, Meghir and Robin (1992) conducted the only study which applied an infrequency of purchase model. Their analysis examined the demand for seafood in France only indirectly by including fish products in the aggregate variable 'meat'.

In this paper, we used an infrequency of purchase model where count data methods were used to analyse the determinants of French consumers' purchases of fresh Label Rouge salmon and other salmon, and the frequency of those purchases. The information was then used to adjust the demand system for the frequency of consumer purchases. The main motivation for using an infrequency of purchase model in this study was to be able to include

Lable Rouge salmon in our demand system which is highly infrequently purchased product with a very low budget share.

The classic econometric models by Tobin (1958), Cragg (1971), Heckman (1974), Lee and Pitt (1987), Wales and Woodland (1983) and Phaneuf et al. (2000) assume that zero purchases are the result of corner solutions from utility maximizing behaviour. This is not the only reason for the observed zero purchases in the microdata, but infrequency of purchase models (IPMs) assume that zero observations can be generated by short-term purchase fluctuations (i.e., infrequent purchases) (Deaton and Irish 1984; Kay, Keen and Morris 1984; Pudney 1985; and Pudney 1986). Blundell and Meghir (1987) introduced a two-regime IPM that assumes that all observed zeros in a data set are the result of the infrequency of purchases, i.e., there are no non-consumer households. Such a specification is reasonable in many cases, including purchases of clothes, cars, housing or other durable goods. It is also reasonable when the data set contains a subset of households that all consume a specific product group. Blundell and Meghir (1987) presented a double hurdle model, based on Cragg (1971), that nests both the Tobit and the IPM and is more general than its two alternatives. For applications of the double hurdle type models see for example Newman et al. (2003) and Mutlu and Gracia (2006). A generalization of the IPM framework was introduced by Meghir and Robin (1992) and Robin (1993). They extended the models to account for the actual purchase frequency of households over a given survey period – not just whether or not a purchase was made, as in Blundell and Meghir (1987). This approach uses more of the information in the data set and is thus able to produce more precise estimates than conventional models, as shown in Robin (1993).

The current paper extends the literature in two ways. First, it introduces a theoretically consistent way of estimating the flexible infrequency of purchase model introduced by Robin

(1993). Robin (1993) log-linearized the model and estimated it without any theoretical constraints on either the demand system or the frequency model. We estimated the model in two stages, as was done by Robin (1993). First, a count data model was developed for frequency of purchase in which we introduced homogeneity and symmetry. In the second stage, the demand system was adjusted using the probabilities calculated in the first step. We assumed a linear almost ideal demand system (LAIDS), thus introducing additivity, homogeneity and symmetry. The elaborate model introduced by Robin (1993) was therefore estimated in a microeconomic-consistent way. This has never been done before. The current study therefore connects the theoretical foundations of infrequency of purchase with a solid econometric formulation.

Our second contribution is to determine whether the results from the theory consistent infrequency of purchase demand system show that Rouge label consumers are more loyal than the average consumer, as has been shown in the marketing literature by Monfort (2006), using non-micro-founded methods. The demand for Label Rouge salmon has not been studied before in a demand system framework. If Monfort's (2006) findings hold true in this setting, they would be confirmed as being robust. This would provide price elasticities for Label Rouge salmon, which can be used in retailers' pricing strategies.

Finally, we characterised the consumer profile of Label Rouge consumers, thus providing important information for retailers to target this specific group. We applied the model to the demand for fresh salmon in France, using 2011–2013 scanner data from 20,000 households using yearly aggregation. The method used makes it possible to consider zero observations in a sophisticated manner by accounting for the actual frequency of purchases, not just whether or not a purchase was made. Therefore, the method can use more of the information contained in the data to produce more accurate estimates than the standard hurdle type models described above.

Labelling and Label Rouge

Consumers are slowly but steadily starting to place more emphasis on quality products, and they are increasingly interested in knowing where products come from and how they are produced (Dimara and Skuras 2005; Grunert 2005; Whitmarsh and Palmieri 2011). This may be partly the result of the increasing globalization of the food trade, which has created consumer concerns regarding product quality (Mariojouls and Wessells 2002). Although the emphasis on quality varies among countries, the demand for high quality has increased in France (Monfort 2006).

When forming attitudes and food quality expectations, consumers look for quality cues (Brunsø, Verbeke, Olsen and Jebbesen 2009). Quality cues in the form of informational labelling can reduce consumers' risks of buying food that might not satisfy their needs or that might negatively affect them (Dufeu, Ferrandi, Gabriel, and Gall-Ely 2014). Therefore, quality labelling can be a powerful signal that assists consumers in their purchase decisions (Dimara and Skuras 2005; Hocquette et al. 2013). Such labels provide information about food attributes that some segments of consumers find important: for example, whether the product is safe and whether it is produced in an environmentally friendly way through a socially acceptable process (Monfort 2006). Nevertheless, the efficiency of labelling as an informational source has been questioned by those who argue that such efficiency depends on the amount of importance that customers place on the information on labels (Dimara and Skuras 2005). Labels can cause confusion among consumers because of the many available signs regarding quality, origin, government certification and other attributes (Mariojouls and Wessells 2002).

Although quality labelling can be driven by consumers' concerns about quality, it is also a means for producers to compete by differentiating similar products in terms of their production process (Mariojouls and Wessells 2002). In food production, there is an increased awareness that competing on price alone is not necessarily the best strategy (Grunert 2005). Many firms are becoming more customer-focused. They are emphasising added value for customers (Grunert 2005) who, in general, have a favourable perception of products marked with official quality labels (Hocquette et al. 2012)

For a long time, France has been a world leader in food labelling programs (Mariojouls and Wessells 2002). One of its well-known food labelling trademarks is Label Rouge, created in the 1960s by the Ministry of Agriculture and managed by a national commission for labels and certifications. Foods labelled Label Rouge must meet minimum criteria and control requirements, which are updated periodically at all stages of production and development (Ministère de l'agriculture, 2007).

Among French consumers, Label Rouge is the most widely recognized product quality predictor (Hocquette et al. 2013). It has a good reputation (Dufeu et al. 2014; Monfort 2006) and is considered highly trustworthy (Dufeu et al. 2014; Hocquette et al. 2013). The label communicates to consumers that the product possesses a specific set of characteristics establishing a higher quality level than that of similar products (Hocquette et al. 2012) and incorporates safety as an important part of the overall assurance system (Caswell, 2006). The label is therefore a signal of superior quality; representing intrinsic quality, food safety and environmentally sound production practices (Dufeu et al. 2014; Westgren, 1999). When consumers buy and consume Label Rouge salmon, they know the product has met demanding production standards and complex documented protocols (Monfort 2006) and that it has a government assurance of meeting the protocols (Buhr, 2003).

Label Rouge was designed to differentiate high-quality food products from standard products (Monfort 2006). It was developed as a tool for improving the price mechanisms for products from capture fisheries (Charles and Boude 2001) and has operated successfully in this way. Products marketed with the Label Rouge label are sold at a huge premium (Mariojouls and Wessells 2002; Westgren 1999). But the potential benefits of using Label Rouge are not merely financial. Using the label conveys a positive image and engenders customer loyalty, as shown by the fact that demand for the Label Rouge products is more stable (Monfort 2006). According to Monfort (2006), the label stimulates sales, especially in specific, upper-grade niches of the consumer market.

Theoretical and statistical model

Meghir and Robin (1992) presented the following utility optimization problem for the infrequency of purchases:

$$\max_{c_1,c_2,n_1,n_2} \{U\big(u_1(c_1,n_1),u_2(c_2,n_2),T-h-L(n_1,n_2)\big): y = p_1'c_1 + p_2'c_2\}, \qquad (1)$$

where U denotes utility and u_i denotes sub utilities, $i = 1, 2$. There are four sets of choice variables, where $c_1 = (c_{11}, c_{12}, \dots, c_{1M})'$ and $n_1 = (n_{11}, n_{12}, \dots, n_{1M})'$ are the vectors of all consumption goods of interest, which in our case is fish, and their respective purchase frequencies. The vectors $c_2 = (c_{21}, c_{22}, \dots, c_{2M})'$ and $n_2 = (n_{21}, n_{22}, \dots, n_{2M})'$ represent all other consumption goods and their corresponding purchase frequency. It was assumed that u_i was quasi-concave in both c_i and n_i because of potential benefits from maintaining smaller stocks of goods. In addition, newer goods, especially fresh products, provide the consumer with higher utility. Furthermore, *y* denotes income, and the vectors $p_1 = (p_{11}, p_{12}, \dots, p_{1M})$ and $p_2(p_{21}, p_{22}, \dots, p_{2M})$ are the prices corresponding to c_1 and c_2. The time endowment is defined as $T = l + h + L(n_1, n_2)$, where *h* is time spent working, *l* represents leisure and $L(n_1, n_2)$ represents the cost of shopping in terms of time, where $\partial L(\cdot)/\partial n_i > 0$. The solution to the optimization problem involved four sets of Marshallian demand equations: $n_{1i}(p, w, R)$ and $c_{1i}(p, w, R)$, where $i = 1,2, \dots, M$.

We were interested in developing an econometric model of the consumption of and purchase behaviour for fish, i.e. the vectors c_1 and n_1. In the empirical analysis, we used purchased quantity as an approximation for consumption c_1, as is common practice (see, for example, Allais et al. (2010) and Bertail and Caillavet (2008)). A natural approach to modelling purchase behaviour would be to estimate a hurdle model where the first step would represent the binary choice between purchasing a positive amount or not and the second step would represent the quantity bought once a purchase has been completed. However, our approach used more of the information contained in the data than the infrequency of purchase model introduced by Robin (1993). We extended the previous estimation by estimating the model as a theory consistent demand system, whereas Robin (1993) used a log-linearized formulation only. The model deviates from the standard hurdle model in its first stage, in which the frequency of purchase of each good rather than the choice of whether or not to make a purchase was modelled. The second stage in the infrequency of purchase model is similar to the second stage in the hurdle model except that the expression is adjusted for purchase frequencies and not just the binary choice of whether or not to make a purchase. As was shown in Robin (1993), the model uses more of the information in the data than a standard hurdle-type model and thus produces more precise estimates.

The model employed in this paper can be represented as follows:

$$\begin{cases} if\ n_j = 0: b_j = 0 \\ if\ n_j > 0: b_j P(n_j > 0 | z_j) = f(z_j'\gamma) \left[\frac{n_j P(z_j'\beta)}{z_j'\beta}\right]^{\alpha} + u_j \end{cases}, \quad (2)$$

where n_j is the frequency of purchases of goods j, b_j is the budget shares, z_j is the exogenous variables, $P(\cdot)$ is the probability of a purchase, and β, γ and α are the parameters to be estimated. The model in (2) is derived from Robin (1993) in logarithmic form. The first line of expression (2) states that if purchase frequency n_j is equal to zero, then the budget share b_j is also zero because no purchase then takes place. The second line of expression (2) shows the case where the purchase frequency is greater than zero. In that case, the product of the budget shares and the probability of purchasing equals the product of the demand function, denoted $f(z_j'\gamma)$, and a term denoting the adjustment for the purchase frequency, $\left[\frac{n_j P(z_j'\beta)}{z_j'\beta}\right]^{\alpha}$.

The parameter α is a key parameter that determines the relationship between purchase frequency and budget shares. If $\alpha = 0$, the model reduces to a standard hurdle type model, which accounts only for whether or not a purchase is made. If, on the other hand, $\alpha > 0$, the model accounts for the actual purchase frequency. For simplicity, while still allowing for $\alpha > 0$, it is assumed here that this relationship is given by $\alpha = 1$. Thus, if α is significant, it is important to account for frequencies when adjusting a demand system using probabilities of purchase. Allowing α to take any positive value is a subject left for future research.

The data generating process of n_j is assumed to follow the truncated negative binomial distribution. The truncation makes it possible to account for the large share of zeros in the data set, and the negative binomial provides a more flexible variance specification, namely, the possibility of over- and under-dispersion.

The utility function given by equation (1) is assumed to be weakly separable, i.e., the consumer maximizes his/her utility with respect to different food groups separately, both in terms of quantity and frequency, subject to the budget share allocated to the consumption of each group. This makes it possible to estimate a complete demand system for fish, conditional on the aforementioned assumption of weak separability. The demand system consists of demand equations for three different types of fish products: fresh salmon, Label Rouge salmon (which is also fresh) and all other fish products.

The model in equation (2) is estimated in two stages. The first part of the model consists of the purchase frequencies, which are used to adjust the demand system for the consumer's frequency of purchase. As is conventional when estimating count data models, the conditional expectation is defined as a semi-logarithmic function (see, for example, Shonkwiler and Englin (2005)). Thus, these demand functions, which relate to purchase frequencies rather than quantity demanded, are given by the following expression:

$$\mathrm{E}\left(n_{ij} \middle| Z_i\right) = \exp\left(\beta_{ij} + \sum_{s=1}^{M} \beta_{is}\left(p_{sj}/CPI\right) + \theta_i\left(y_j/CPI\right)\right), \tag{3}$$

where $i = 1,2,3$ denotes the three different fish categories and $j = 1,2, \ldots, J$ denotes households. The price of fish category *i* for household *j* is denoted by p_{ij}. The total fish expenditure of household *j* is given by y_j, and *CPI* is the average French consumer price index over the three years. For the demand system to be consistent with economic theory, a number of restrictions must be imposed on the parameters. Following LaFrance and Hanemann (1989) and LaFrance (1990), the symmetry restrictions may be derived as $\beta_{is} = 0 \; \forall \; i \neq s$ and $\theta_i = \theta \; \forall \; i$. Homogeneity of degree zero is then imposed on the Marshallian demand system by dividing prices and expenditure by the *CPI*. Household heterogeneity may then be modelled by defining the constant term in (1) as:

$$\beta_{\mathrm{ij}} = \eta_{0i} + \textstyle\sum_{k=1}^{K} z_{kj}\eta_{ki}, \tag{4}$$

where z_{kj} represents household characteristics and η_{ki} are the parameters to be estimated. The frequency system described in equations (3) and (4) was then used to predict the probability of observing a positive frequency $P\left(n_j > 0 \middle| z_j\right)$ in equation (2). Furthermore, $\left[\frac{n_j P\left(z_j'\beta\right)}{z_j'\beta}\right]^{\alpha}$ was predicted using the same results. Finally, it should be noted that even though the cross-price effects were restricted to zero, i.e., $\beta_{is} = 0$, the compensated cross-price effects were not restricted in this way. The Slutsky equation yields:

$$e_{isj} = n_{ij}\frac{\partial n_{sj}}{\partial y_j} = \theta n_{ij} n_{sj}, \tag{5}$$

where e_{isj} is the compensated substitution effect between products *i* and *s* for household *j* and the *n* symbols are purchase frequencies of different product groups by household *j*.

The second part of the model specifies $f(z_j'\gamma)$ in equation (2). Here, this function consists of a system of demand equations given by the linear approximated almost ideal demand system (LA/AIDS)[4]:

$$b_{ij}P(n_j > 0|z_j) = \left(\alpha_{ij} + \sum_{s=1}^{M} \gamma_{is} \ln p_{sj} + \varphi_i(\ln y_j - \ln P_j)\right) \left[\frac{n_j P(z_j'\beta)}{z_j'\beta}\right]^{\alpha} + u_j, \quad (6)$$

where b_{ij} is the budget share of household *j* for good *i*, p_{sj} is the unit value price of household *j* for good *s*, y_j is the total expenditure on fish for household *j* and P_j is a price index, approximated by Stone's price index $\ln P_j = \sum_s^M b_{sj} \ln p_{sj}$. Household heterogeneity was obtained by specifying the constant term in equation (6) as:

$$\alpha_{ij} = \tau_{0i} + \sum_{k=1}^{K} z_{kj}\tau_{ki}, \quad (7)$$

where z_{kj} represents household characteristics and τ_{ki} are parameters to be estimated.

To be in accordance with economic theory, the parameters of the demand equations must satisfy the following restrictions:

Adding up: $\sum_i \tau_{ki} = 1$, $\sum_i \varphi_i = 0$, and $\sum_i \gamma_{is} = 0$,

Homogeneity: $\sum_s \gamma_{is} = 0$ and

Symmetry: $\gamma_{is} = \gamma_{si}, i \neq s$.

[4] See Deaton and Muellbauer for a representation and discussion of the AIDS/LAIDS model.

Data

The data used in this paper were obtained from Kantar Worldpanel and consisted of scanner data on weekly purchases of fish by 20,000 French households from 2011 to 2013. However, there is a rotation in the households that participate because some of the households drop out each year. In all, 43,127 households were included in the study. The data were collected using handheld barcode scanners and other relevant equipment that Kantar provides to all households. This method makes the data extremely detailed because the barcode contains a significant amount of information about the product. The dataset contains detailed information on sociodemographic and geographical household characteristics as well as observations on purchases. The households are selected by stratification according to a few socioeconomic variables. As is common with microdata, the fraction of zero observations is significant, as can be seen in Table 1, which shows that 73% of the observations on purchases of fresh salmon were zero, i.e., no salmon was purchased. The corresponding numbers were 98% for Label Rouge salmon and 30% for other fish products. These numbers demonstrate the importance of using the infrequency of purchase framework used in this paper. To reduce the number of zeros in the data we use yearly aggregation.

(Table 1 about here)

Descriptive statistics of all the variables used in the analysis, except for annual dummies, are given in Table 2. The mean frequency of fresh salmon purchases was 0.81. This indicates that, on average, consumers bought fresh salmon almost once during the period under observation – 2011–2013. In contrast, the mean frequency of fresh Label Rouge purchases was only 0.03.

This suggests that consumers almost never bought fresh Label Rouge salmon. Other fish products were purchased more frequently – six times on average. Thus, the difference between the purchase frequencies was quite large. This was not surprising as the category Label Rouge salmon refers to a very narrowly defined product, whereas the other product categories refer to a wide range of seafood products.

The price variables in Table 2 refer to log standardized prices, but it should be noted that these prices are unit values and not real prices. The prices were calculated from the amount of fish purchased in kilograms (kg) and expenditures in euros. This is a common practice (see, for example, Allais et al. (2010) and Bertail and Caillavet (2008))[5]. Most of the social and geographical variables used in this study have been used in other studies (see, for instance, Allais et al. 2010), except for the body mass index (BMI) variable. BMI is one of the most widely used indicators of obesity (Kim et al., 2017; Romero-Corral et al., 2008). It is also an important indicator of health status (Braha et al., 2017). Even though BMI is considered to be an indicator of health status, it is important to note that it is a rather crude approach (Nuttall, 2015; Romero-Corral et al., 2008). It does not differentiate between lean body mass and fat body mass (Nuttall, 2015; Romero-Corral et al., 2008), but for maintaining good health and reducing the risk for obesity, fat body mass is important. Other factors that are commonly ignored when BMI is used, but are important, are gender, age and ethnic group (Gallagher et al., 1996; Nuttall, 2015; Romero-Corral et al., 2008). These limitations are important to bear in mind. Given the widespread use of BMI and given its convenience and minimal cost (Shah &

[5] These constructed unit values might be endogenous because of the consumer's product quality choices.

Braverman, 2012), however, BMI is used here as an indicator of health status. Individuals with a BMI in the range of 18.5–24.9 are considered to be normal weight and are therefore considered healthy. Those with a lower BMI are regarded as underweight, and those with a higher BMI are considered overweight (BMI = 25.0–29.9) or obese (BMI ≥30.0) (World Health Organization n.d.)[6].

(Table 2 about here)

Results and discussion

The model described in equation (2) was estimated in two stages: first, using the frequency system outlined in equations (3) and (4); then using the AIDS model set out in equations (6) and (7) after adjusting for the actual purchase frequencies described in equation (2). For each equation, the frequencies were assumed to be a function of price, total expenditure, family size, number of children under the age of 16, age, education, class status,[7] geographical location, BMI, type of accommodation and dummy variables for 2012 and 2013. The model includes three education variables: primary education or less, high school and university. It also includes four class variables: lower class, lower and upper middle class and upper class. There are six geographical areas: north, south, east, west, central and Paris. The model also considers whether the consumer is a tenant, does not pay rent or owns his/her own house or

[6] Even though these BMI categories are widely used, they might need to be adjusted upward in the near future to accommodate population-based changes in height and weight (see e.g., Nuttall, 2015).

[7] Class was measured by working status, including whether the person is unemployed, has a routine occupation or is a manager. See Rose and Harrison (2010) for a detailed discussion.

flat. The base version of the model, i.e., when all dummy variables except year dummies take a value of zero, assumes an upper middle-class consumer who is of upper middle-class standing, has completed university and lives in his/her own house or flat in central France.

The estimation results are presented in Table 3. The family size parameter was significant and negative in both salmon frequency equations. This indicates that individuals from smaller families purchase fresh salmon more often. The education parameter estimates reveal two types of fresh salmon consumers in France. Those with a primary education or less are keener on regular fresh salmon, whereas those consumers with a university education prefer Label Rouge salmon. The salmon consumers are mostly upper middle class, but the purchases are not limited to a specific age group. The number of children under 16 had no effect on the demand for non-Label Rouge fresh salmon, but it was almost significant at the 5% level for the Label Rouge salmon. Those consuming salmon regularly are tenants, but the Label Rouge salmon consumers are better off and own their own houses or flats. The BMI parameter was significant and negative for those buying Label Rouge salmon. Thus, the individuals who purchase Label Rouge salmon most frequently are healthy, university-educated, upper middle-class citizens who lived in their own houses or flats in the centre of France, but not in Paris. The average buyer of other fish products is a healthy older individual in the centre of France who has a primary education and comes from a large family.

(Table 3 about here)

Table 4 shows the compensated elasticities from the truncated negative binomial model. The own-price elasticities for fresh salmon and other fish were the same; thus, a 1% increase in price would reduce the corresponding purchase frequency by 0.054%, which was quite low. It should be noted, however, that these averages are conditional on the frequencies' being positive. The own-price elasticity of Label Rouge salmon was even lower than that of the two other categories; non-labelled fresh salmon and other seafood products. When the price of Label Rouge salmon increased by 1%, the purchase frequency decreased by 0.001%. This means that changes in the price of Label Rouge salmon had little effect on purchase frequency. These differences in elasticities between fresh salmon and Label Rouge salmon create some interesting opportunities for pricing strategies. For instance, one strategy could be for stores to decrease the price of fresh salmon marginally and to raise the price of Label Rouge salmon. Such a strategy should increase purchases of fresh salmon while having a very limited effect on the frequency of Label Rouge salmon purchases, thus resulting in increases in overall store purchases.

The BMI elasticities for Label Rouge salmon and other fish were significant and negative, and their effects on Label Rouge purchases were quite small. The effect on other fish was much greater. A 1% increase in the BMI was associated with a 2.05% reduction in other fish purchases.

(Table 4 about here)

The compensated substitution effects from the truncated negative binomial model are shown in Table 5. It should be noted that the truncated negative binomial model has zero uncompensated price effects, see section 3. This is a necessary condition for the frequency system to be consistent with microeconomic theory. Thus, the compensated substitution effects from the truncated negative binomial, discussed in the following paragraph, are only income effects.

Increasing the price of fresh non-labelled salmon by $1 per kg would increase the purchase frequency of Label Rouge salmon by only 0.01, which is a very small substitution effect. In contrast, the purchase frequency of other fish would increase by 1.71 if the price of salmon increased by $1 per kg. The substitution effects from an increase in the price of Label Rouge salmon were close to zero. Thus, a marginal increase in the price of Label Rouge salmon had a very small effect on the purchase frequency of other salmon and other seafood products. These results yield a picture of a very loyal Label Rouge salmon consumer who neither reduces consumption of Label Rouge salmon nor switches products when the prices of Label Rouge increase, as is evident in Table 4. Increases in the prices of other fish had very different effects on purchases of fresh salmon and Label Rouge salmon. The compensated substitution effect was quite strong in the former case because the purchase frequency of fresh salmon rose by 1.66 when the price of other fish increased by $1 per kg. The price increase had hardly any effect on the frequency with which consumers bought Label Rouge salmon.

(Table 5 about here)

The estimation results from the purchase frequency-adjusted LA/AIDS model are presented in Table 6. The average consumer of fresh salmon is a younger, upper-class individual with higher education who comes from a small family in Paris or the North of France. Moreover, this type of consumer not only purchases fresh salmon in greater quantities but does so more frequently than other consumers. Thus, this group of customers is the ideal group to target to increase sales of fresh salmon.

The average consumer of Label Rouge salmon is a healthy, older upper middle-class individual from Paris. These consumers are similar to those who buy fresh salmon; nevertheless, there is a distinct difference between the two groups of consumers. The quality label attracts older consumers, whereas fresh salmon without any quality label is favoured by younger individuals.

(Table 6 about here)

The calculated uncompensated elasticities for fresh salmon, Label Rouge salmon and other fish are shown in Table 7. The elasticities for other fish were calculated using the adding-up condition. The price elasticities show that the three groups are substitutes. The expenditure elasticities of all groups were close to one. Thus, a 1% increase in fish expenditure was associated with a 1% increase in the budget share of each of the three groups.

(Table 7 about here)

Finally, Table 8 shows the results from the t-tests of the differences between the elasticities from the LA/AIDS model, where the null hypothesis assumes that no difference exists between parameters. The results reveal that the own-price elasticity of fresh salmon was significantly more than that for Label Rouge salmon. Thus, compared to the younger individuals who buy regular fresh salmon, the older consumers who buy Label Rouge salmon are statistically more loyal regarding their sensitivity to price changes. Furthermore, the cross-price elasticities between fresh salmon and Label Rouge were significantly different. Therefore, the effect of an increase in the salmon price on the demand for Label Rouge salmon is larger than the effect of an increase in the price of Label Rouge salmon on the demand for fresh salmon. The own-price elasticity of fresh salmon was larger than that of other fish. Thus, on average, the fresh salmon price is more elastic than that of fish products.

(Table 8 about here)

The Label Rouge label has a significant effect on consumers' perceptions of fresh salmon products. First, although younger adults purchase non-labelled fresh salmon, older individuals prefer Label Rouge salmon. Moreover, the average young fresh salmon consumer is an upper-class citizen from Paris or the north of France, whereas the average Label Rouge salmon consumer is an upper middle-class individual from Paris. Thus, the two purchasing groups are distinctly different, and marketing strategies should emphasize that they are two distinct consumer groups.

Second, the own-price elasticity of fresh salmon is greater than that of Label Rouge salmon. This suggests that older, upper middle-class consumers are more loyal to Label Rouge salmon than younger, upper-class individuals are to non-labelled fresh salmon. The label therefore makes it possible for consumers to differentiate between fresh salmon and fresh Label Rouge salmon. Label Rouge does not have such a strong foothold among younger consumers, and these consumers' willingness to pay for products bearing this label is lower than that of older consumers.

Conclusions

This paper introduces a theoretically consistent almost ideal demand system representation of Robin's (1993) model. This is an extension to Robin's (1993) model that was a simple log-linearized model without any theoretical constraints. The model involved a two-step procedure. In the first step, a truncated negative binomial model was estimated. The predictions and probabilities calculated in that step were then used to adjust the AIDS, which was estimated in the second step. This procedure makes it possible to account for actual purchase frequencies and not just the probability of positive purchases. This means that the model accounts for whether or not a purchase is made by a consumer, the frequency of the purchase and the size of the purchase This approach uses more of the elements in the data than conventional hurdle models and thus produces more accurate estimates, as was shown by Robin (1993).

The model was applied to French scanner data for fish purchases from 2011 to 2013 to analyse the demand for Label Rouge salmon in the French consumer market. This had not been done before. The results show that consumers who purchase Label Rouge salmon are more loyal than those who buy non-labelled fresh salmon, as was shown in Monfort (2006). Our analysis is based on a micro-founded demand system and is therefore more robust in economic terms. Applying a demand system provides price elasticities that can be used for retail pricing strategies. Our loyalty measure is the own price elasticity, which is around 0.8 for Label Rouge salmon and around 1.4 for other fresh salmon.

The results also show that the average consumer profile for non-labelled fresh salmon is significantly different from that for Label Rouge fresh salmon. The average non-labelled fresh salmon consumer is an upper-class, young adult from Paris or the north of France, whereas the average Label Rouge consumer is an older middle-class individual from Paris. This shows that Label Rouge customers are loyal and that the label is can generate sales among high-end consumers. Finally, the results can be summarised as showing that the Label Rouge can achieve its goal of differentiation from fresh salmon, both in terms of consumer perception and loyalty.

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Appendix

Table 1: Empirical purchase frequency

	Fresh salmon		Label Rouge salmon		Other fish	
	Freq.	%	Freq.	%	Freq.	%
0	53682	73.036	72212	98.246	22570	30.707
1	8536	11.613	863	1.174	7401	10.069
2	4007	5.452	196	0.267	5905	8.034
3	2301	3.131	91	0.124	4629	6.298
4	1452	1.975	36	0.049	4001	5.443
5	920	1.252	27	0.037	3476	4.729
6	638	0.868	19	0.026	2958	4.024
7	465	0.633	11	0.015	2674	3.638
8	372	0.506	7	0.010	2328	3.167
9	230	0.313	7	0.010	2031	2.763
10	169	0.230	9	0.012	1705	2.320
> 10	729	0.992	23	0.031	13823	18.807

Table 2: Descriptive statistics

Variable	Mean	Std. dev.	Min	Max
Fresh salmon purchase frequency	0.81	2.27	0	56
Label Rouge salmon purchase frequency	0.03	0.42	0	32
Other fish purchase frequency	6.04	9.19	0	162
Fresh salmon budget share	0.13	0.23	0	1
Label Rouge budget share*10	0.03	0.03	0	1
Other fish budget share	0.87	0.24	0	1
Log standardized price of fresh salmon	−0.03	0.24	−2.24	2.21
Log standardized price of Label Rouge salmon*10	−0.04	0.09	−1.96	1.14
Log standardized price of other fish	−0.11	0.47	−2.65	2.71
Log expenditures /Stone Price Index	3.56	1.16	−0.92	7.76
Family size	2.62	1.39	1	9
Number of children under 16	1.68	1.00	1	9
Age of head of household	46.69	15.22	17	94
BMI of head of household	24.91	4.93	11.02	59.29
Upper class	0.14	0.35	0	1
Upper middle class	0.28	0.45	0	1
Lower middle class	0.41	0.49	0	1
Lower class	0.16	0.37	0	1

Primary education or less	0.09	0.29	0	1
High school education	0.52	0.50	0	1
University education	0.39	0.49	0	1
South	0.20	0.40	0	1
Center	0.22	0.41	0	1
North	0.10	0.30	0	1
East	0.09	0.29	0	1
West	0.20	0.40	0	1
Paris metropolitan area	0.19	0.40	0	1
Housing owner	0.59	0.49	0	1
Tenant	0.37	0.48	0	1
Free accommodation	0.04	0.19	0	1

Table 3: Estimation results from the truncated negative binomial model

	Fresh salmon		Label Rouge salmon		Other fish	
	Est.	t-val.	Est.	t-val.	Est.	t-val.
Constant	−0.19	−1.95	−2.77	−3.36	1.73	71.44
Price	−0.73	−3.71	−0.08	−0.08	−0.49	−12.27
Expenditure	0.75	166.58	0.75	166.58	0.75	166.58
Family size*10	−0.63	−4.79	−3.43	−4.23	0.07	2.7
No. of children under 16	−0.01	−0.75	0.22	1.78	0.01	3.17
Age*10	−0.01	−1.48	−0.05	−0.82	0.02	7.04
Upper class	0.02	0.58	−0.72	−3.88	−0.04	−6.03
Lower middle class	−0.04	−1.52	−0.18	−1.06	0.03	5.53
Lower class	−0.07	−1.74	−0.45	−1.77	0.04	4.98
D2012*10	1.17	4.36	2.64	1.54	0.02	0.43
D2013*10	−0.02	−0.07	2.51	1.52	−0.08	−1.65
Primary ed.	0.16	4.05	0.19	0.82	0.02	2.3
Higher ed.	0.14	5.77	0.14	0.9	−0.04	−8.37
Tenant*10	−0.04	−0.13	−2.55	−1.49	0.20	4.21
Accom. for free*10	1.25	2.07	0.05	0.01	0.18	1.51
BMI*10	−0.04	−1.54	−0.38	−2.47	−0.85	−19.81
South	−0.20	−5.73	0.13	0.59	−1.32	−16.72
North	0.02	0.48	−0.95	−3.12	−1.78	−21.3

East	−0.09	−2.12	−0.59	−1.95	−1.70	−20.34
West	0.04	1.24	−0.02	−0.12	−1.47	−19.34
Paris	0.06	1.71	0.12	0.62	−1.30	−16.14
Dispersion par.	0.76	17.06	3.72	6.86	−1.21	−108.86

Table 4: Selected elasticities from the truncated negative binomial model

	Fresh salmon		Label Rouge salmon		Other fish	
	Est.	t-val.	Est.	t-val.	Est.	t-val.
Price*10	–0.54	–3.71	–0.01	–0.08	–0.54	–12.27
Expenditure	0.22	166.58	0.05	166.58	0.47	166.58
Age	–0.03	–1.48	–0.02	–0.82	0.09	7.04
BMI	–0.04	–1.54	–0.09	–2.47	–2.05	–19.81

Table 5: Compensated substitution effects from the truncated negative binomial model

	Estimate
Fresh salmon vs. Label Rouge*10	0.10
Fresh salmon vs. other	1.71
Label Rouge vs. fresh salmon*100	0.09
Label Rouge vs. other	0.02
Other vs. fresh salmon	1.66
Other vs. Label Rouge	0.01

Note: The t-values for all estimates are 166.58 as a result of equation (5).

Table 6: Estimation results from the frequency adjusted AIDS model

	Fresh salmon		Label Rouge salmon	
	Est.	t-val.	Est.	t-val.
Constant*10	2.29	19.72	−0.04	−4.81
Fresh salmon price*10	−0.45	−14.64	0.03	6.41
Label Rouge price*10	0.03	6.41	−0.05	−11.02
Other fish price*10	0.43	13.89	0.02	10.26
Expenditure*10	0.10	7.31	0.01	16.7
Family size*1000	2.04	1.11	−0.07	−0.62
No. of children under 16*100	−1.48	−5.9	0.03	1.7
Age*1000	−1.40	−11.57	0.03	3.62
Upper class*100	2.22	4.62	−0.03	−0.88
Lower middle class*100	−2.17	−5.9	−0.04	−1.73
Lower class*100	−4.96	−9.6	−0.03	−0.82
D2012*100	1.59	4.42	0.06	2.75
D2013*10	0.05	0.00357	0.02	6.55
Primary ed.*100	−0.33	−0.62	−0.03	−0.76
High school ed.*1000	27.60	8.31	−0.02	−0.11
Tenant*1000	−7.80	−2.27	0.02	0.09
Accom. for free*100	1.233	1.49	−0.06	−1.1
BMI*1000	0.19	0.63	−0.05	−2.59

South*100	–2.44	–5.45	–0.03	–1.02
North*1000	38.88	7.01	–0.07	–0.2
East*100	–1.58	–2.77	0.02	0.48
West*100	0.50	1.1	0.04	1.24
Paris*10	0.28	6.1	0.01	3.36

Table 7: Elasticities from the adjusted AIDS model

	Fresh salmon		Label Rouge salmon		Other fish	
	Est.	t-val.	Est.	t-val.	Est.	t-val.
Fresh salmon price	–1.37	–110.93	0.02	50.98	0.27	18.95
Label Rouge price	0.89	6.87	–0.84	–5.21	0.36	7.99
Other price*10	4.21	211.97	0.03	19.39	–10.40	–4593.16
Total Expenditure	1.08	141.62	1.03	62.26	0.99	554.63

Note: t-values are calculated by boot strapping.

Table 8: Price and expenditure elasticity differences

	Abs. diff.	t-value
P11– P22	0.54	−3.32
P11– P33	0.33	−26.87
P22–P33	0.20	1.26
P12–P21	0.87	−6.71
P13–P31	0.15	−10.06
P23–P32	0.35	7.93
E1–E2	0.05	2.51
E1–E3	0.09	11.67
E2–E3	0.05	2.72

Note: t-values are calculated by boot strapping.

P11 is the price of salmon in the equation for salmon.

P12 is the price of salmon in the Label Rouge salmon equation and so on.