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The analysis of 85 years of food purchases at the rich, market-oriented Saint-Cyr convent school in the 18th century probes the determinants of consumption, its short-term variations and long-term shifts. Using time-series econometrics, we show that there is no equilibrium relationship between series of consumed quantities, prices and income that would be specific to the long term. Regarding short-term variations in consumption, the estimation of a demand system and the derivation of the corresponding elasticities allow us to show that market prices and budgetary constraints do play an important role, but also that this role remains limited, essentially because economic variables do not make it possible to account for the long-term evolutions. These unexplained long-run shifts suggest an interpretation in terms of structural changes in preferences, confirmed nonparametrically using revealed preference tests, which can be related – but not always – to the main subsistence crises that occurred throughout the century.*

I. Introduction

Historical data carry three notable benefits for inquiries into consumption shifts: they chronicle behavior in the long run; they allow for comparison with different temporal or spatial contexts; and, as records, they offer the possibility to test the pertinence and power of competing explanations. Here we propose to take advantage of a French boarding school's meticulously kept ledgers that contain information on the price and quantity of annual food purchases in the 18th century.[1] Why bother with such dusty files? First, because recent data confine contemporary studies to narrow time slices. Such series, hardly ever exceeding thirty years in length and often much shorter, make it virtually impossible to examine dynamic factors influencing consumption. Furthermore, many such studies focus on a single group of products, often meat (see, for example, BRYANT and DAVIS [2008]), to the exclusion of all other perishables, the operational presumption being that interactions between the studied and the excluded commodities do not mar results. The Saint-Cyr accounts present the advantage of capturing an entire system

1. All accounting sources on the Maison Royale de Saint-Cyr are located in the Archives Départementales des Yvelines (henceforth AD Yvelines), D246-D263, D446-449, D474.

*JEL: A12, D12, N33 / KEY WORDS: Consumer behaviour, Price variations, Preference evolution, Short/long run, Historical data

of provisioning. Then there is the amplitude of variations in prices. Contemporary runs show some spatial and temporal heterogeneity but, when all things are considered, their stability largely outweighs their volatility. Not so historical long-term data: the 18th century saw major subsistence crises with consequential price jumps that exceeded the secular upward trend in prices. Even quieter periods registered significant price changes. It is their effect on provisioning that we examine.

Our investigation receives a boost from the relative simplicity of historical markets. Wheat, meat, dairy, vegetables, fruit and groceries, all show up, and their identification is all the easier as their form varies little. Milk, for one, was a unique, identifiable bulk product, a far cry from today's beverage whose marketing heightens the effects of branding and product differenciation. Meat purchases concerned bovine carcasses and some mutton; only very occasionally did a *rôtisseur* deliver grilled chicken. Trifling modifications of the goods' attributes, minor product innovations even over the long haul, and all but inexistent advertising help the modelling of prices. They reduce problems of aggregation and increase confidence in the measure of price effects. Not only are the series long and complete, but they emanate from a single consumer. There was no room for idiosyncrasy: the rules for running the establishment's provisioning obtained throughout the century and so steadied the behavior of the managing office (the *économe*).

But does the historical context warrant the application of modern econometric know-how? In other words, how about the danger of anachronism, the subreptitious attribution of familiar, taken-for-granted contemporary motives and values to an 18th-century consumer? Literary documentation discards such worries. Administrative rules at Saint-Cyr stipulated, "the person who will be in charge of food provisioning must be reliable, intelligent and disinterested; she must not stop at one sole merchant of each sort as he may possibly abuse her trust but must go to all stalls and shops to locate the best merchandise and to find merchants who will provide goods at a lower price".[2] An outside but well-connected observer emphasized the institution's insistance on the selfsame qualities. The bursar "must keep expenses low, must not waste anything but buy only prime goods, be well informed about markets and provisioning (...) keep up with prices of everything and avoid being cheated".[3] The search for the best price at times turned into sprees that required sanctions: catching the opportunity to venture beyond the school walls, the sisters loitered and returned with some delay to turn in their vegetables (Mme de Maintenon to Mme de Fontaines, Dec. 1696, in LANGLOIS [1935-1939], 5: 157). Indeed, it was in the buzzing town of Versailles, not quite three miles away from the village of Saint-Cyr, where the School did most of its business. There its envoys took advantage of a rich supply, compared quality, and looked for the best price: they were price takers. Only the immense quantities of fresh meat consumed at Saint-Cyr warranted an exception to the rule of daily price comparisons: over the century, the institution signed contracts with a single butcher for several years, imposing its conditions with respect to quantity, quality and price of the meat delivered every day. Here, too, the market was regional as the institution pitted

2. Mémoire de Monsieur Mauduyt sur l'administration de l'intérieur de la Maison de Saint-Cyr, fol. 4, no date (1710-1745), Archives d'Ormesson, 144 AP 145, Archives Nationales.
3. Mémoire de ce qui s'observe dans la royale Maison de Saint-Louis établie à Saint-Cyr, fol. 25-26, no date (mid-18th century), Ms. Nlle. Acq. Fr 10677, Bibliothèque Nationale de France.

master butchers from Saint-Cyr against competitors from Versailles (AD Yvelines, D 446). Meat represented the largest food expense at Saint-Cyr. Administrators surely wielded some market power when negotiating contracts. That power eventually found a formal expression in 1786. The renewed agreement with master butcher Le Moine now – and for the first time – specified that the convent-school "pay the meat delivered by the said Sieur Le Moine at one sol six deniers below the price per pound stipulated on the market at Versailles" (Marché fait avec le sieur Le Moine pour la fourniture de viande, Oct. 25, 1786, AD Yvelines, D 446).

Everything had a price. Flour coming from the institution's endowment in farms entered the books as an expense, whereas total rental payments were recorded on the income side. Game from the foundation's forests had a price tag attached, too. Garden produce eventually formed an exception. The original resolve to avoid indoor production weakened in the face of the prestige value of a pleasure park that also sported a few vegetable and herbal patches. Their produce ended up in the infirmary, of course ("let food by thy first medicine"), and next to other, bought greens in the kitchen.[4] Other sources of distorsion exerted minimal effect. The classic charity of religious institutions mattered at Saint-Cyr, but prohibition struck the distribution of leftover foods to the area's poor. Such almsgiving seemed to have occurred; however its instances were "few and far between", and from the institution's early days it was clear that its mission was, in the words of its founder, Mme de Maintenon, "to educate the Demoiselles, not to feed the poor" (Mme de Maintenon to Mme du Pérou, May 30, 1696, in LANGLOIS [1935-1939], 5:65).[5] Thus, parcimony determined consumer conduct at Saint-Cyr. Its accounting data afford a reliable record of the foods provided to the school's inmates and pedagogical staff.

Having ascertained the legitimacy of using these purchasing data as a laboratory to examine the determinants of provisioning, it is the evolving composition of Saint-Cyr's 18th-century food basket which we wish to explain. Using time-series econometrics, we show that there is no equilibrium relationship between series of consumed quantities, prices and income, that would be specific to the long term. Regarding short-term variations in consumption, the estimation of a demand system and the derivation of the corresponding elasticities allow us to show that market prices and budgetary constraints do play an important role, but also that this role remains limited, essentially because economic variables do not account for the long-term evolutions. These long-run shifts suggest an interpretation in terms of structural changes in preferences, which is confirmed nonparametrically using revealed preference tests, with turning points falling into two of the century's major subsistence crises (1709-1710, 1770-1774) and the 1730s.

The paper is organized as follows. SECTION II starts out with a presentation of the community at Saint-Cyr; we then briefly review the accomplishments of recent research that has attempted to tell apart taste, preferences and prices in describing consumption dynamics in historically removed as well as more recent contexts. Our own model benefits from the limits pointed out by our predecessors, and its logic appears in SECTIONS III and IV. The final section summarizes our results and their implications for future research.

4. On the original intent to buy everything and forgo kitchen garden and henhouse, see TAPHANEL [1902], pp. 69-70. Prestige came with a cost, and the chief gardener at Saint-Cyr received a very good salary, see Contrats, D446, AD Yvelines; a renewal of the contract in 1779 justified a salary hike from 3500 to 3650 livres tournois because "two squares of the garden, formerly used to produce hay, are now laid down in vegetables, which increases the gardeners' work load".

5. On the absence of almsgiving, see Mémoire de ce qui s'observe, fol. 26; CHOUET [1912], pp. 207, 238-239).

II. The Convent School: Assets, Diet and Food Purchases

Hers was quite a success story. Born into the noble but destitute D'Aubigné family, Françoise (1635-1719) caught Louis XIV's eye, became his favorite mistress and received the title of Marquise de Maintenon before eventually marrying the sun king in 1683. The splendor of the court did not blind Mme de Maintenon to the fate of aristocratic girls in need. She persuaded Louis XIV to endow a religious institution to raise and educate the orphaned daughters of the impecunious nobility. Hence the foundation of the convent school of Saint-Cyr in 1685. Its boarding capacity of 250 pupils was constantly filled between 1695 and 1792. Girls aged seven to twelve entered the establishment and left it as women on their twentieth birthday at the latest. Throughout the school's existence, the pupils' average age was between 14 and 15.[6] Sixty nuns were responsible for the boarders' intellectual and spiritual instruction, and they ate with their pupils.[7] The number of mouths to feed oscillated around 310, visitors and changing personnel included. The stability of the pupils' average age encourages the assumption that eaters' demographics did not vary significantly over the 18th century.

The account books covering the period 1703 to 1789 form the archival stock on which we construct our analyses of Saint-Cyr's food purchases, although they also contain information on other expenses, such as clothing, heating, lighting and schooling. Large volumes register yearly expenses whose detailed components figure, for the last few years of the era, in bills and receipts. Information on prices and quantities concern major or regularly purchased food items: grain, wine, meat, milk, butter and eggs. Lesser buys like olive oil, cheese, fish and sugar only show the expended amount, but invoices sometimes allow the calculation of volume and cost per unit. The accounting system distinguished exterior concerns from interior expenses while keeping track of the expected and realized revenues (FIGURE 1a). Although food expenditure rose from a yearly average of 43,610 livres during the first decade of the 18th century to 80,311 livres before the Revolution (FIGURE 1c), their share in the overall outlays shrank from about one quarter to one fifth over the century (FIGURE 1d). The need to repair farms and buildings and to maintain lands put pressure on the food budget. However, borrowing money to run the place never constituted a threat to the Saint-Cyr budget.

TABLE I provides some descriptive statistics for the raw data. The ledger at Saint-Cyr listed expected revenue and actual income. Sources that yielded earnings consisted most importantly in land rents, but also wood sales and seigniorial rights bestowed by King Louis XIV. Most of these revenues were predictable but payments at times lagged, which explains the discrepancy between anticipations and intakes (for more details, see PETER [1975]). A per capita food outlay increasing from 140 to 250 livres between the beginning and the end of the century bought a rich and varied diet throughout the 18th century. Even without including edible oils, fish, fruit, honey, legumes, sugar, and vegetables, for which only expense data are complete, the average number of available calories per person and per day never fell far below 2180, a total that contemporary medicine considers sufficient for 14-year-old women. Our data suggest a diet at Saint-Cyr that falls above the eighth decile of the probable distribution of daily consumption of calories in France toward the end of the 18th century, built by Fogel on the series of foodstuff

6. Our estimation; data available on request. Our thanks to David Delobel for help with these genealogical records.
7. Personnel (cooks, bakers, garderners, etc.) saw their sustenance financed through separate budgets.

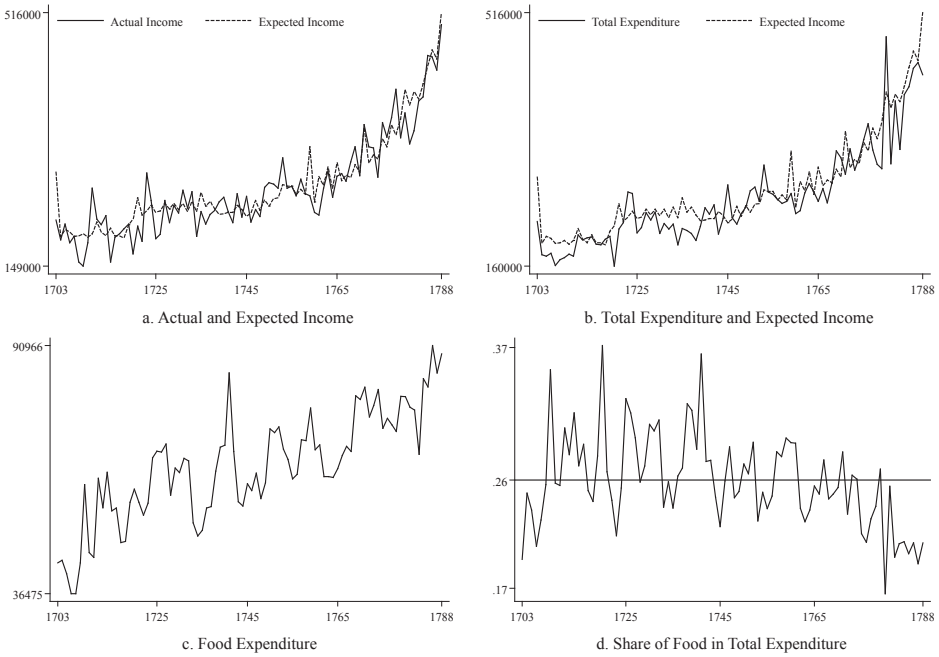

FIGURE 1. – Expenditures and Income Series

TABLE I. – Descriptive Statistics: Mean (Standard Deviation)

Expenditures (livres tournois)					
Wheat	15558.5	(5112.97)	Wine	5163.9	(2305.61)
Butch. meats	22516.6	(3328.03)	Milk	1804.4	(668.275)
Eggs	4166.4	(1343.45)	Butter	2098.5	(860.381)
Poultry	2108.1	(671.403)	Edible oil	1050.3	(1272.69)
Fish	2680.3	(952.835)	Vinegar	169.0	(120.892)
Game	571.0	(550.405)	Rice	152.9	(113.967)
Fat bacon	541.9	(366.421)	Sugar	2326.5	(1466.51)
Cheese	147.7	(93.3385)	Pastry	267.6	(255.158)
Fruits	1976.9	(1041.35)	Groceries	350.9	(265.827)
Vegetables	777.1	(298.200)	Beer	68.0	(135.945)
Food	64496.6	(12048.5)	Interior	151627.9	(27501.9)
Total	254848.8	(68821.1)			
Quantities					
Wheat (muids)	62.7	(12.9062)	Wine (muids)	61.5	(23.7406)
Butch. meats (lbs)	70343.3	(9002.80)	Milk (pints)	13497.7	(4224.22)
Eggs (units)	117295.6	(18406.2)	Butter (lbs)	3241.0	(624.164)
Incomes (livres tournois)					
Actual	261941.9	(71568.0)	Expected	266686.0	(69888.7)

availability established by Toutain (TOUTAIN [1971]; FOGEL [1992], p. 269). The role of the school was to train noblewomen, the table carried markers of that distinction.

Cornucopia notwithstanding, the diet at Saint-Cyr displayed unexpected features. Bread furnished about 60% of the available calories. Butchery meat, the other staple, provided 25% on average. However, it varied surprisingly. Its contribution rose first, then declined, only to rise again. The presence of these heavyweights limited the caloric contributions of other products. Eggs and butter remained essentially stable over the century. Milk's contribution grew, an increase whose effect on the health of the demoiselles warrants further exploration. The importance of meat marked Saint-Cyr's diet as aristocratic. The reduced place of dairy products – the total amount grew from 5% of calorie availability at the dawn of the century to 9% during its last decade – was in line with the lactose-poor diets at other French boarding schools but distinguished Saint-Cyr's fare from the rations distributed in the Amsterdam Burgerweeshuis where orphans received 25% of their calories from milk, butter and cheese (meat provided 7.5%) (FRIJHOFF and JULIA [1975], pp. 495-496; MCCANTS [1992], p. 87, MCCANTS [1993], p. 138; FLANDRIN and MONTANARI [1996], pp. 23-24, 602-603).

How can the inertia and modification in the Saint-Cyr diet be explained? The data invite an analysis in economic terms. With the help of a demand model we test whether market prices and budget constraints guided the convent school's consumer behavior. Of course, the overall pattern of expenditures and its transformations captures our attention, but another question also motivates our inquiry. We would like to uncover whether changes in relative prices might unravel the relative nutritional improvement at Saint-Cyr over the course of the 18th century. Comparison helps. The analysis of provisioning at Saint-Cyr benefits from the insights and suggestions of earlier historical and contemporary studies, many of which struggled with lacunary data sets because self-produced goods (dairy, eggs, fruit, legumes, vegetables) were often not included in the accounts. McCants's inquiry into the well-run Amsterdam Municipal Orphanage from 1639 to 1812 offers the opportunity to refine and contrast both methods and findings. The riddle pertains to the long-term modifications in the make-up of alimentary purchases (MCCANTS [1992; 1993; 1995]). The conundrum of price and taste in the shaping of consumer behavior did not escape McCants' attention. Yet her sensitive construction of the Burgerweeshuis records and her effort to root their generation in a specific social context do not quite deal with the problem. With the adoption of SCHOKKAERT and WEE [1988] pioneer demand system to estimate the Amsterdam data, McCants imports its frailty to furnish significant long-term parameters. The imposition of chronological discontinuity offers some insights but it really only creates two periods in which to measure elasticities. This decision does not furnish the wherewithal to assess dietery modifications in the long run. The extent to which evolving tastes affect the composition of the orphans' monotonous but not meager burgerlijke diet remains obscured. The Saint-Cyr data expand the empirical basis and indeed present the possibility of estimating an entire food demand system over almost a century, all the while keeping track of other budgetary constraints.

III. The Demand Model

In this section, we develop a simple demand model in order to explain the relation between series of consumptions, on the one side, and series of prices, incomes and expenditures, on

the other. Can we explain, and if so to what extent, the somewhat erratic changes in the series of quantities and budget shares, only from the information contained in the price and income series?

Basically, the idea is to consider food consumption in the form of fractions of the total budget devoted to various food items, and to regress these budget shares on the logarithm of prices and total food outlay.[8] As the dataset provides information on both expenditures and quantities, a measure of prices can be obtained as the ratio of the former to the latter. Unfortunately, quantities are missing for many goods (at least over long periods) and prices therefore cannot be calculated for them. Only the quantities of wheat, butchery meats, eggs, wine, milk and butter (the diet "heavyweights") are available over the whole century, whereas expenditures are recorded for many other goods. These are regrouped into three additional categories: one is composed of all other meats (poultry, fish, game, fat bacon) and cheese, another one is fruit and vegetables, and the last one gathers together all remaining commodities, mainly groceries (edible oil, vinegar, rice, sugar, etc.). We thus construct 9 budget shares and 6 logged-prices. In addition to food expenditure, the data contain information on the institution's interior and total expenses, and on its actual and expected incomes. All expenditure and income variables are divided by the same global food price index and expressed in logarithms. Different modelling strategies can then be considered, depending on the statistical properties of the data.

III.1. *Long-Run Evolution*

Many contributions to the empirical demand analysis assume that the time series data used are stationary. Yet there is evidence in the literature that series of prices, real income or expenditure are not. Apart from budget shares which, by construction, are bounded and thus expected to be stationary in the very long run, most economic time series trend upward over time and therefore seem to violate the stationarity assumption (as can be seen in FIGURE 1). It is well-known that the usual asymptotic results derived in standard econometric theory cannot be expected to apply if the variables in a regression model are generated by a nonstationary process, and that least squares estimation tends to be spurious (C. W. GRANGER and NEWBOLD [1974]).

Two simple ways to tackle the problem when using such series are either to detrend them when they are trend-stationary or to difference them when they have unit roots prior to use. Detrending or differencing a time series has the undesirable consequence of completely discarding the long-run information contained in the data; it thus makes it impossible to model a potential long-term equilibrium relationship between a set of economic variables. Nonetheless, it remains the best solution when the series are trend-stationary or not integrated of the same order. Another approach is possible if the variables are all integrated of the same order and if there exists some linear combination of them that is stationary. In this case, the variables are cointegrated and must therefore obey an equilibrium relationship in the long run, although they may diverge substantially from equilibrium in the short run. A very convenient way to deal with such series is to use Vector Error Correction (VEC) models, which incorporate both dynamic short-run behaviors, through differenced variables, and long-run equilibrium behaviors, through

8. An implicit assumption here is that food is weakly separable from all the other goods, which means that a change in the prices of the latter affects the demand for a food item only through its effect on the food budget.

cointegrating relationships between the variates in levels (ENGLE and C. W. J. GRANGER [1987]). These three modelling strategies – based on detrended, differenced or cointegrated series – are quite different from one another and the main technique for choosing between them consists in testing for unit roots.

An important issue in testing for unit roots in a series is trend specification. If the trend is misspecified, then unit root tests can be inconsistent – they are inconsistent when the trend is underspecified, while their power is reduced when the trend is overspecified. This case obtains when a series containing a linear trend is tested without being detrended. It extends to other types of trends as well, in particular to misspecification of a piecewise-linear (or broken) trend as a single linear trend (see STOCK [1994], p. 2783, and references therein). PERRON [1989] and RAPPOPORT and REICHLIN [1989] suggest that the broken-trend model provides a useful description of a wide variety of economic time series, and that if the break date is known a priori, then detrending can be done by correctly specifying it. However, most of our series show a rather nonlinear pattern, and assuming a piecewise linear trend may not be appropriate.[9] Instead, trends are approximated by smoothing each series with a moving-average filter. Basically, we construct new series in which each observation is the average of nearby observations in the original series. The interval width is chosen small enough to allow a good approximation of the long-run trend, but not too small so as to capture as few as possible short-run variations that could be economically explained.[10] This way of approximating trends works well for most series (see budget shares in FIGURE 2), but not for butchery meats and milk prices because of the stair shape they take in some portions. For these two series, we specify a parametric trend. Detrended series are then obtained substracting the estimated trends from the original series.

TABLE II reports, for all the detrended variables that we could use in the estimation, the results obtained using two versions of the Dickey-Fuller test for unit roots: one is the standard Augmented Dickey-Fuller (ADF) test (DICKEY and FULLER [1979]), the other is the Dickey-Fuller GLS (DF-GLS) test, which is a modified ADF test where the time series is transformed via a Generalized Least Squares (GLS) regression before performing the test, and which is known to have significantly greater power than the ADF test (see ELLIOTT, ROTHENBERG, and STOCK [1996]). The number of lags of the first-differenced variable to include in the tests in order to account for serial correlation is chosen so as to minimize the Schwarz Information Criterion. In both tests, the null hypothesis is that the variable has a unit root, and the alternative is that it is stationary around zero. From a qualitative point of view, the two tests give identical results: out of 21 series, the null hypothesis is rejected in 17 cases at the 1% level, 18 case at the 5% level and 19 cases at the 10% level by the DF-GLS tests; it is rejected in all cases by the ADF tests. At the loosest confidence level, both tests thus indicate that all our variables are stationary, except two: the logarithm of total outlay and the difference between the logarithm of expected and actual incomes, all in real terms. These results suggest that there is no long-run equilibrium relationship between our variables, in so far as the annual observation unit does not already pertain to the long term, and that detrending is the most appropriate operation to apply before

9. In fact, no common parametric specification for trends was found appropriate (for instance, a second-order polynomial trend led to strong colinearity issues in the estimation).

10. The first 5 lagged values, the current value and the first 5 forward terms of the series are averaged, with each term receiving a weight of one. Results are mainly unaffected when using an interval twice as large.

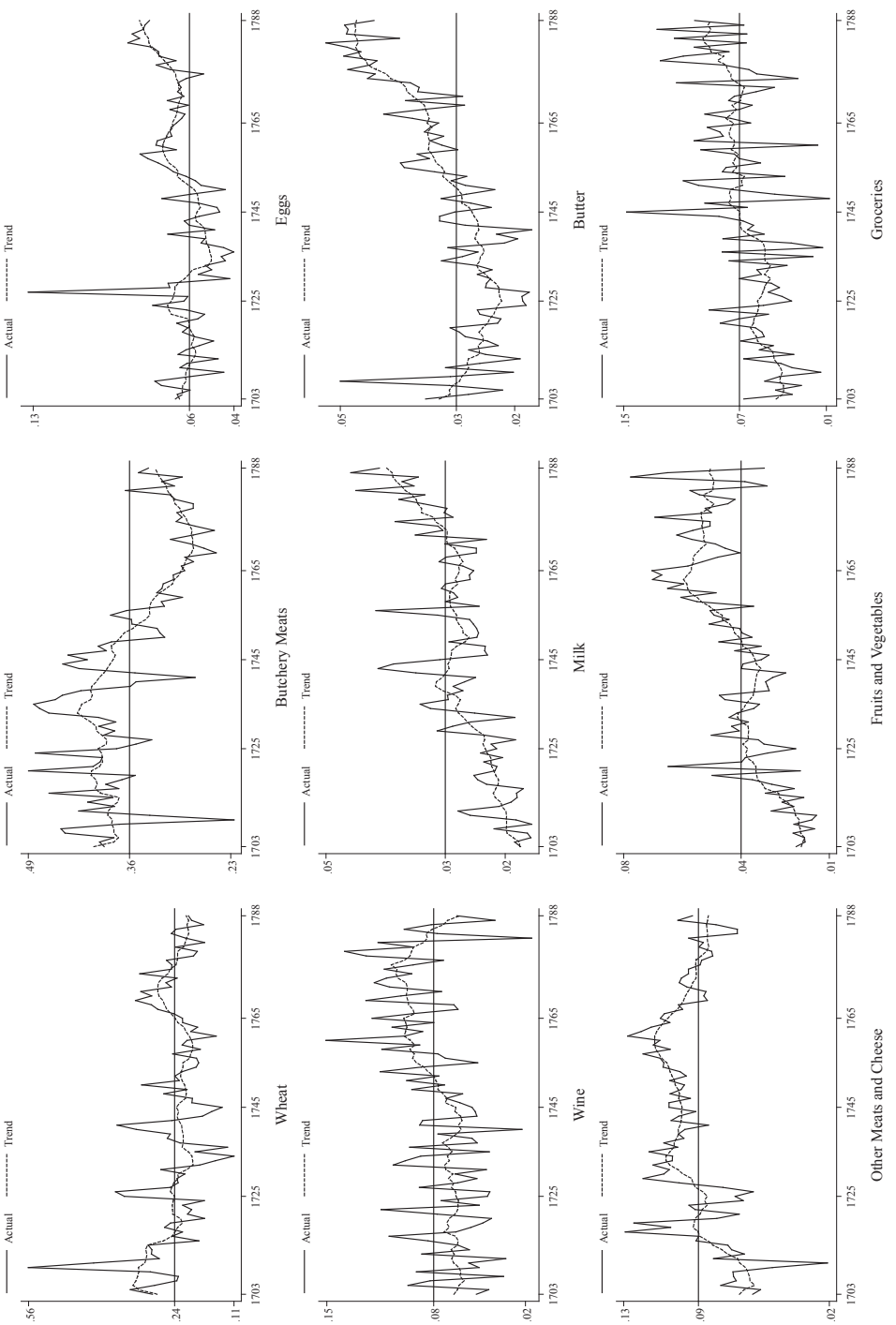

FIGURE 2. – Budget Shares, Actual Series and Trends

TABLE II. – Unit Root Tests

	Lag	DF-GLS	ADF		Lag	DF-GLS	ADF
Shares				Log prices			
Wheat	4	-6.396^{***}	-6.672^{***}	Wheat	1	-5.858^{***}	-6.736^{***}
Butch. meats	2	-5.756^{***}	-6.710^{***}	Butch. meats	2	-2.308^{**}	-5.594^{***}
Eggs	1	-6.007^{***}	-6.813^{***}	Eggs	1	-6.576^{***}	-7.083^{***}
Wine	1	-5.975^{***}	-8.115^{***}	Wine	2	-6.760^{***}	-7.771^{***}
Milk	3	-7.378^{***}	-7.661^{***}	Milk	1	-3.839^{***}	-6.422^{***}
Butter	1	-5.266^{***}	-7.948^{***}	Butter	1	-6.171^{***}	-7.194^{***}
Other meats	1	-4.502^{***}	-5.902^{***}				
Fruits, veg.	1	-6.996^{***}	-7.443^{***}				
Groceries	1	-4.296^{***}	-7.001^{***}				
Log expenses				Log incomes			
Food	1	-5.148^{***}	-5.859^{***}	Actual	2	-4.819^{***}	-8.273^{***}
Interior	2	-6.330^{***}	-7.829^{***}	Expected	1	-2.031^{*}	-5.382^{***}
Total	10	-1.012	-4.340^{***}	Exp.-Act.	5	-1.348	-5.048^{***}

using our series in a parametric setting. Doing so means that we will focus on the influence that short-term variations in prices may have had on the institution's consumption pattern. This does not preclude the possible existence of some long-term effects, but acknowledges that if such effects could be accounted for in a parametric demand system (adding properly specified trend variables), they would remain unexplained. It does not mean either that nothing more can be said about long-run developments. They will be investigated in SECTION IV using nonparametric approaches.

III.2. *Short-Run Variations*

The model that we estimate is a simple version of the Almost Ideal Demand System (AIDS) of DEATON and MUELLBAUER [1980]. This specification is convenient since it is both as general as the class of flexible functional form models, i.e. models whose functional form has enough parameters to be regarded as a reasonable approximation to whatever the true unknown function may be, and much simpler to use (see DEATON and MUELLBAUER [1980b], p. 75). Formally, let n_1 and n_0 be the sets of commodities whose quantities are respectively observed and unobserved in the data, and $n = n_0 + n_1$. Denote w_{it} the (detrended) budget share of good $i \in n$ at time $t = 1703, ..., 1788$, p_{it} the corresponding price for $i \in n_1$, and x_t total food outlay. The model can be written as

$$w_{it} = \alpha_i + \sum_{j \in n_1} \gamma_{ij} \ln(p_{jt}) + \beta_i \ln(x_t / P_t) + u_{it}, \qquad i = 1, ..., n, \tag{1}$$

where u_{it} is unobserved and reflects the effects of all unobserved explanatory variables, and P_t is the Stone price index defined as $\ln P_t = \sum_{i \in n_1} \overline{w}_i \ln(p_{it})$, where $\overline{w}_i$ denotes the average budget share of good i over time. In order to control for first-order serial correlation that we detected in the residuals of two equations (milk and groceries), we incorporate habit formation by expressing each intercept α_i as a linear function of all budget shares, lagged one period (using more lags does not improve the results), i.e. $\alpha_i = \alpha_{i0} + \sum_{j \in n} \alpha_{ij} w_{jt-1}$.

The demand system then has the form of a first-order Vector Auto-Regressive (VAR) model, where budget shares are the only endogenous variables. It could be estimated, either

equation-by-equation using Ordinary Least Squares (OLS), or all equations simultaneously, removing one from the estimation process and recovering its parameters afterwards through the adding-up restriction,[11] using Seemingly Unrelated Regressions (SUR). However, food expenditure x_t is also the result of a decision which may lead to endogeneity issues — it is clear from FIGURE 1 that after 1760 income increases more quickly than the food budget. We shall therefore characterize the decision concerning food consumption as a whole (both food with respect to other commodities and within-food budget allocation) using Instrumental Variable (IV) techniques. Note that prices may be endogenous here, too. Not only because the *économe* was surely not a price-taking consumer when negociating meat contracts, but also because quantities, and thus prices, are missing for items accounting for small fractions of the food budget. As we have no instruments for prices, there is not much we can do but admit that our results may be affected by the endogeneity of prices.[12] Traditional IVs for budget, namely income variables, are not appropriate in our context for two reasons: first, as we mentioned above, the institution's income partly came from the sale of wheat, which implies that it is probably not so disconnected from shocks on demand (at least for wheat); second, conditionally on covariates, income variables are not significantly correlated to food outlay at any conventional confidence level; the same holds with respect to any budget shares when added to (1). In fact, lagged food budget turns out to be the only variable showing the required properties.[13] The reduced form equation is then as follows

$$\ln(x_t/P_t) = a + \sum_{i\in n_1} c_i \ln(p_{it}) + b\ln(x_{t-1}/P_{t-1}) + \sum_{i\in n} d_i w_{it-1} + v_t, \tag{2}$$

where v_t is the equation error term. Lagged share for wheat is excluded from the set of regressors, in both the reduced form and the demand system, because of perfect multicolinearity with the other explanatory variables. The results (available from the authors) from the OLS estimation of (2) show a relatively poor overall fit with a $\overline{R}^2$ equal to 0.200, but Ramsey's regression specification error test fails to reject the null hypothesis that the equation has no omitted variables. There is no unexplained dynamics in the residuals $\widehat{v}_t$ either, as the Breusch-Godfrey statistic is not significant. Regarding the identifying IV, the past value of total outlay has a significant and positive impact of about one half, indicating a rather strong inertia in the series.

The simultaneous determination of budget shares w_{it} and total food outlay x_t may imply a correlation between the error terms u_{it} and v_t (say some unobserved explanatory variables condition both budget allocation and budget determination). Let us decompose u_{it} into the sum of a term reflecting this correlation plus an independent shock, $u_{it} = \rho_i v_t + \varepsilon_{it}$. In practice, v_t is replaced by its estimation $\widehat{v}_t$, and shares w_{it} are regressed on $\ln p_{jt}$, $\ln(x_t/P_t)$, w_{jt-1}, and residuals $\widehat{v}_t$. Applying OLS to each demand equation separately and SUR to the whole system then provide the same parameter estimates as Two-Stage Least Squares (2SLS) and Three-Stage Least Squares (3SLS), respectively. In addition, testing whether the estimated parameter of $\widehat{v}_t$ is

11. Identical estimates are obtained regardless of the equation chosen to be removed. This is a property of so-called singular systems of equations, where the dependent variables sum up to a constant over equations and the set of independent variables is common to all equations.

12. Regarding the endogeneity related to missing prices, however, we estimated the model on the 6 groups for which prices are observed and found comparable results (full results are available from the authors).

13. Stationary, both correlated to the current food budget and uncorrelated to residuals in all demand equations.

significant or not in these regressions is a direct test of exogeneity: if $\widehat{\rho}_i$ is significant, then it is possible to reject the null hypothesis of no correlation between perturbations u_{it} and v_t. In this case, omitting to control for this correlation would yield biased estimates.

TABLE III summarizes the SUR estimation results. As can be seen at the bottom of the table, the exogeneity of total food expenditure cannot be rejected for any food categories, whether these are considered separately (ρ estimates are all insignificant) or jointly (a joint test yields a χ^2_8 equal to 9.59 with a P-value of 0.295). Consequently, more efficient estimates can be obtained applying SUR to the system under the null hypothesis that food outlay is exogeneous, that is without $\widehat{v}_t$. All the results reported in the rest of the table come from this reestimation. The overall quality of fit differs from one equation to another, with $\overline{R}^2$s ranging from 0.046 for fruit and vegetables to 0.770 for butchery meats.[14] Other direct tests of the model's quality are provided by Breusch-Godfrey and Ramsey statistics. Breusch-Godfrey tests show that serial correlation in residuals cannot be detected any longer when lagged budget shares are added to the set of independent variables, while Ramsey statistics indicate that some specification issues may only subsist in the egg equation. Prices seem important in explaining budget shares, especially for butchery meats and wheat: out of 6 prices, 5 and 3 are significant in the butchery meats and wheat equations, respectively. Variations in food expenditure play a role as well, total outlay being significant in 6 equations. Eventually, the estimated coefficients of the lagged dependent variables suggest that habit formation is more important for milk and groceries, whose budget shares are significantly influenced by their respective past value, than for the other food items.

Budget and price elasticities provide a more straightforward device to analyse the short-run effects of total food outlay and prices on consumption. TABLE IV presents these elasticities evaluated at the sample mean point. Budget elasticities are computed by evaluating the relative effect of a small increase of food expenditure on each quantity. First note that a small and insignificantly different from zero elasticity of quantities with respect to food outlay is obtained for butter and milk. This means that when the orphanage's food expenditure increased the demoiselles did not increase (nor decrease) their consumption of the two items. This is also true, to a lower extent, of butchery meats and eggs, whose budget elasticities are significant but small: if their consumption increased with the institution's food budget, it did so less than proportionately. All these commodities come out clearly as necessary goods. Other meats as well as fruit and vegetables seem mainly unaffected by changes in food outlay; the fact that, for these commodities, food expenditure parameters are not significantly different from zero implies that their budget elasticities are not significantly different from one. The last group of commodities, the luxury goods, is made up of the goods whose shares are positively and significantly correlated with total outlay: wine, groceries and wheat. This last result is less surprising than it appears at first sight if we take into account that crises increased the share of food expenditures in the institution's total outlays while at the same time increasing the monies spent on wheat. For example, the ratio of food-to-total expenditure in 1709 is by 10% higher than in nearby years, with the share of wheat at its peak (56%) and the share of butchery meats at its lowest point (23%). And indeed, adding dummy variables to control for the 7 main

14. The absence of a permanent market most likely explains the low adjustment for fruit and vegetables since the purchased quantities may have been supplemented by the school's own garden and fruit-tree production.

TABLE III. – Demand System Estimates

	Wheat	Butch. meats	Eggs	Wine	Milk	Butter	Other meats	Fruits, veg.	Groceries
Constant	−0.001(0.004)	−0.000(0.002)	−0.000(0.001)	−0.000(0.000)	0.000(0.000)	−0.000(0.001)	0.001(0.002)	0.000(0.001)	0.000(0.002)
Log prices (t)									
Wheat	0.169(0.018)*	−0.086(0.010)*	−0.015(0.004)*	−0.013(0.010)	−0.003(0.002)	−0.007(0.002)*	−0.008(0.005)	−0.011(0.004)*	−0.026(0.010)*
Butch. meats	−0.225(0.066)*	0.214(0.035)*	−0.023(0.015)	0.022(0.038)	−0.002(0.007)	−0.011(0.007)	−0.014(0.017)	−0.031(0.016)	0.070(0.037)
Eggs	0.020(0.028)	−0.030(0.015)*	0.040(0.006)*	0.005(0.016)	−0.007(0.003)*	−0.003(0.003)	−0.006(0.007)	−0.006(0.007)	−0.014(0.016)
Wine	−0.015(0.016)	−0.027(0.008)*	−0.006(0.004)	0.026(0.009)*	−0.002(0.002)	−0.005(0.002)*	−0.006(0.004)	0.001(0.004)	0.033(0.009)*
Milk	−0.220(0.071)*	0.130(0.038)*	0.010(0.016)	0.001(0.041)	0.012(0.007)	0.001(0.007)	−0.065(0.018)*	0.037(0.017)*	0.094(0.039)*
Butter	0.028(0.025)	0.017(0.014)	0.002(0.006)	−0.043(0.015)*	0.003(0.003)	−0.000(0.003)	0.009(0.007)	−0.007(0.006)	−0.010(0.014)
Log food outlay	0.212(0.052)*	−0.301(0.028)*	−0.029(0.012)*	0.054(0.030)	−0.017(0.005)*	−0.025(0.005)*	0.016(0.014)	0.001(0.013)	0.089(0.029)*
Shares ($t-1$)									
Butch. meats	0.045(0.104)	0.043(0.055)	−0.040(0.023)	0.037(0.060)	−0.036(0.010)*	−0.011(0.010)	−0.009(0.027)	0.002(0.025)	−0.032(0.058)
Eggs	0.023(0.403)	−0.042(0.214)	0.039(0.089)	−0.047(0.232)	0.018(0.040)	−0.014(0.040)	0.087(0.104)	0.053(0.096)	−0.117(0.225)
Wine	−0.116(0.187)	−0.085(0.099)	−0.121(0.041)*	−0.107(0.107)	0.024(0.019)	0.044(0.019)*	0.142(0.048)*	0.044(0.045)	0.174(0.104)
Milk	−2.529(1.068)*	1.225(0.568)*	−0.485(0.237)*	−0.539(0.614)	0.208(0.106)*	−0.023(0.106)	0.182(0.277)	−0.129(0.255)	2.090(0.597)*
Butter	0.960(0.964)	−0.405(0.513)	−0.126(0.214)	−1.263(0.554)*	0.193(0.096)*	0.094(0.095)	0.474(0.250)	0.078(0.230)	−0.005(0.538)
Other meats	−0.070(0.349)	−0.203(0.186)	−0.033(0.078)	0.244(0.201)	−0.048(0.035)	0.014(0.035)	0.084(0.090)	−0.090(0.083)	0.102(0.195)
Fruits, veg.	−0.397(0.449)	−0.133(0.239)	−0.104(0.100)	−0.205(0.258)	0.034(0.045)	0.000(0.044)	0.322(0.116)*	−0.024(0.107)	−0.286(0.251)
Groceries	0.237(0.165)	0.054(0.088)	−0.006(0.037)	−0.057(0.095)	−0.026(0.016)	−0.014(0.016)	0.053(0.043)	0.002(0.039)	−0.243(0.092)*
Exog. test ($\hat{v}_t$)	−0.060(0.154)	0.076(0.081)	−0.063(0.033)	0.113(0.088)	0.006(0.015)	−0.019(0.015)	−0.042(0.040)	0.002(0.037)	−0.013(0.086)
AR(1) test (χ^2_1)									
Uncorrected	0.320(0.572)	3.640(0.056)	0.329(0.566)	1.305(0.253)	4.146(0.042)	0.005(0.946)	0.259(0.611)	0.436(0.509)	6.648(0.010)
Corrected	0.002(0.965)	0.877(0.349)	1.574(0.210)	1.873(0.171)	3.792(0.051)	0.478(0.489)	1.090(0.296)	0.033(0.856)	0.022(0.883)
Spec. test (F^{45}_{24})	1.23(0.295)	1.58(0.114)	2.43(0.011)	0.89(0.636)	1.03(0.484)	1.22(0.303)	1.73(0.076)	1.53(0.130)	1.17(0.348)
$\bar{R}^2$	0.573	0.770	0.351	0.211	0.285	0.405	0.397	0.046	0.229

Notes: Standard errors (P-values for specification error and AR tests) in parentheses; * Significant at the 5% level.

peaks and lows observed in the quantity of wheat consumed brings the budget elasticity down to one. Note that McCants' first estimation resulted in even higher values which she explained by the Amsterdam orphanage's capacity to store wheat and rye (McCants [1995]: 202-203). At Saint-Cyr, it was not an opportunity but a constraint that helps explain the luxury status of wheat.

Two sorts of price elasticities are calculated here. The first are the usual uncompensated price elasticities which measure the relative change in consumption induced by a relative change in prices, holding food expenditure constant. Each of these elasticities combines both a substitution effect and an income effect (since budget is maintained constant, its real value decreases when a price increases). Therefore, in order to study the substitutabilities between commodities, we also compute the compensated price elasticities, in which the decrease in real budget implied by the price increase is exactly compensated for. First, it is worth noting that the own-price elasticities for butchery meats are very small and not significantly different from zero, which means that their consumption is not affected by price changes. This result, as well as the relative budget inelasticity of butchery meats, seems consistent with instructions given to the abbess by the board of trustees and translated in contracts with the butcher: an order from 1714 advised "to offer only very good cuts, well conditioned, such as served at the best tables... and to reject pieces of the so-called low butchery" (D446, AD Yvelines). Wheat consumption is affected by price changes through an income effect only (its own-price elasticity being zero when compensated for and significantly negative when not compensated for). All other groups of commodities have significant and negative, though relatively small, own-price elasticities, butter and, to a lower extent, wine appearing more sensitive to price changes than milk, wheat and eggs.

Regarding compensated and uncompensated cross-price elasticities, few are significant. Let us focus on compensated values. All significant elasticities are located above the diagonal, which means that there is no symmetry in price effects. Consider, for instance, the relationship between butchery meats, milk and butter: an increase in the price of milk or butter has a positive and significant effect on the quantity of butchery meats consumed (which are therefore substitutes for milk and butter), but an increase in the price of butchery meats has no significant impact on milk and butter consumptions. Milk is by far the most connected among the items: an increase in the price of milk is followed by a decrease in the demand for wheat, and for other meats and cheese (which seem to act as complements to milk) and an increase in the consumption of butchery meats, fruit and vegetables, and groceries (which appear as substitutes for milk). But the main result concerns the luxury commodities: other meats and cheese are substitutes for wheat; groceries are substitutes for butchery meats. This implies not only that the consumption of these goods increases more than proportionally with food expenditure, but also that they benefit from increases in the prices of wheat and butchery meats, this effect being all the more important in that wheat is also found to be a complement to butchery meats.

In the modelling framework retained in this section, economic variations (in prices, incomes, expenditures and past budget shares) do play a role in the explanation of short-run fluctuations in food consumption patterns at Saint-Cyr. An overview can be given comparing detrended shares to the model's predictions in Figure 3. In general, the model manages to reproduce short-term variations. This is particularly true for butchery meats and wheat, which are by far the largest

TABLE IV. – Elasticities Estimates

Wheat	Butch. meats	Eggs	Wine	Milk	Butter	Other meats	Fruits, veg.	Groceries	
					Food expenditure elasticities				
Food outlay	1.879(0.218)*	0.156(0.078)*	0.543(0.182)*	1.686(0.384)*	0.364(0.190)	0.225(0.163)	1.169(0.145)*	1.034(0.301)*	2.362(0.447)*
					Uncompensated price elasticities				
Prices									
Wheat	−0.511(0.087)*	−0.039(0.031)	−0.188(0.095)	−0.329(0.153)*	0.031(0.075)	−0.017(0.064)	−0.123(0.058)*	−0.278(0.119)*	−0.724(0.178)*
Butch. meats	−1.250(0.285)*	−0.098(0.102)	−0.196(0.238)	0.040(0.501)	0.141(0.248)	−0.056(0.214)	−0.209(0.189)	−0.757(0.393)	0.574(0.583)
Eggs	0.029(0.120)	−0.032(0.043)	−0.352(0.100)*	0.021(0.211)	−0.196(0.104)	−0.030(0.091)	−0.079(0.080)	−0.137(0.166)	−0.293(0.246)
Wine	−0.133(0.064)*	−0.008(0.023)	−0.061(0.053)	−0.718(0.112)*	−0.021(0.055)	−0.087(0.046)	−0.077(0.042)	0.023(0.088)	0.400(0.130)*
Milk	−0.939(0.293)*	0.388(0.105)*	0.171(0.245)	−0.005(0.516)	−0.559(0.255)*	0.047(0.220)	−0.694(0.195)*	0.893(0.404)*	1.389(0.600)*
Butter	0.090(0.104)	0.075(0.037)*	0.053(0.087)	−0.569(0.184)*	0.126(0.091)	−0.991(0.078)*	0.094(0.069)	−0.173(0.144)	−0.192(0.214)
					Compensated price elasticities				
Prices									
Wheat	−0.059(0.075)	−0.002(0.027)	0.013(0.062)	0.076(0.131)	0.119(0.065)	0.037(0.054)	0.159(0.050)*	−0.029(0.103)	−0.155(0.153)
Butch. meats	−0.580(0.276)*	−0.043(0.099)	−0.003(0.231)	0.642(0.486)	0.271(0.241)	0.025(0.208)	0.208(0.184)	−0.388(0.381)	1.416(0.566)*
Eggs	0.149(0.117)	−0.022(0.042)	−0.317(0.098)*	0.129(0.206)	−0.173(0.102)	−0.016(0.088)	−0.005(0.078)	−0.071(0.161)	−0.142(0.239)
Wine	0.015(0.066)	0.004(0.024)	−0.019(0.055)	−0.585(0.116)*	0.008(0.057)	−0.070(0.047)	0.015(0.044)	0.105(0.091)	0.586(0.135)*
Milk	−0.887(0.293)*	0.393(0.105)*	0.186(0.245)	0.041(0.516)	−0.549(0.255)*	0.053(0.220)	−0.662(0.195)*	0.921(0.405)*	1.454(0.601)*
Butter	0.150(0.106)	0.080(0.038)*	0.070(0.089)	−0.515(0.186)*	0.138(0.092)	−0.984(0.079)*	0.131(0.070)	−0.140(0.146)	−0.117(0.217)

Notes: The elasticity of commodity i with respect to food expenditure x is computed as $e_i = 1 + \beta_i / w_i$; The uncompensated elasticity of commodity i with respect to the price of commodity j is $e^u_{ij} = -\delta_{ij} + (\gamma_{ij} - \beta_i w_j)/w_i$, where δ_{ij} is the Kronecker delta which equals one if $i = j$ and zero otherwise; The compensated elasticity is given by $e^c_{ij} = e^u_{ij} + w_j e_i$; Standard errors in parentheses; * Significant at the 5% level.

sources of expenses. This is less true of wine, however: the series of prices, quantities and shares fluctuate a lot, but fluctuations in prices do not seem to predict well those in quantities. Thus, institutional wealth did not allow the *économe* to escape the hold of the prices of the foods. The fact that the food budget reacted to crises, when prices rose and scarcity obtained, confirms the institution's insertion in the market economy. Status and market were not opposed to each other. They marched hand in hand.

But what about long-run evolutions, captured by the long-term trend of all budget shares? If the increase in the food budget over the century left the composition of the diet unchanged in many goods, how can we explain the observed shift of consumption away from butchery meats and towards milk, fruit and vegetables, and groceries, suggesting that the diet and the sources of nutrients were more and more diversified at Saint-Cyr? This we want to explore in the next section: do tests for structural changes help us identify turning dates in consumption series? If so, can we draw on historical facts to disentangle between the role played by prices, budget and tastes in unexplained long-term developments?

IV. Structural Change and Long-Term Developments

Two conclusions are usually drawn from the presence of significant unexplained trends in consumption series.[15] The first is that structural changes have occurred over time. A test for this would be to estimate our demand system, with a well-specified parametric trend, on the original series, several subperiods, and to check for parameter stability, significance of trends or serial correlation in residuals.[16] This may not be appropriate, however. Given that all the results would be conditional on the model's functional form being correct,[17] any specification error would account for a change in tastes. As argued by CHALFANT and ALSTON [1988], a definitive test for structural change would involve only the hypothesis that preferences are stable, not that they are stable and of a particular form. The other conclusion, indeed, is that the model is misspecified.

Nonparametric approaches make it possible to test the null hypothesis that there is a stable set of preferences, so that variations in observed quantities can be explained by changes in relative prices and expenditures, avoiding the specification bias likely with arbitrarily selected functional forms. They simply consist in checking for consistency of the series of prices and quantities with this hypothesis using revealed preference axioms. For instance, the Strong Axiom of Revealed Preferences (SARP) is equivalent to the existence of a well-behaved utility function, so that when it is satisfied by the data, there is a stable demand system that fully explains observed consumptions. Conversely, the axiom need not hold when structural changes occur, so a test for violations of SARP enables the identification of changes in preferences.

Before going further, let us briefly discuss the following point. SECTION III implicitly assumes that preferences are stable in the short run: conditional on the long-term evolution

15. Similar unexplained shifts are quite often reported in the literature. See, for example, the results obtained by DEATON [1974] and further discussed in DEATON and MUELLBAUER [1980b], pp. 70-72.

16. Note that this would imply defining subperiods relevant both to all groups, which from FIGURE 2 is not so obvious, and with a sufficient number of observations.

17. Such an assumption would be unlikely at least for the trend, the specification of which has to be both correct and identical in all equations (so as to preserve the singularity of the system).

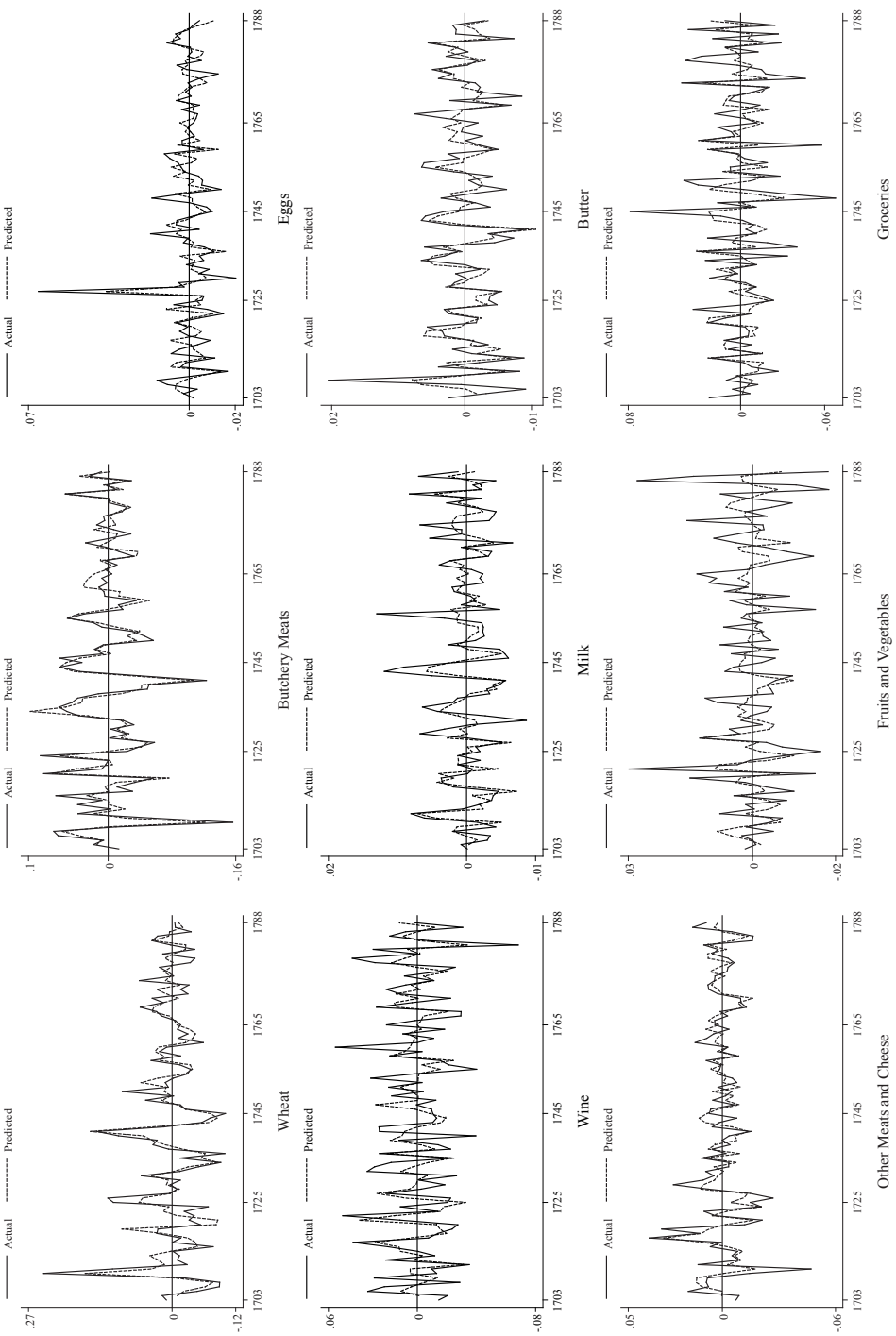

FIGURE 3. – Budget Shares, Detrended Series and Model's Predictions

of the diet (the trends), reactions to prices, budget, past consumptions – the parameters in (1) – and unexplained factors captured in the residuals are stable over time. This assumption is necessary to measure price effects, and hence to show whether and how this wealthy institution was inserted in the market. It also seems reasonable as the estimated model does predict the short-term data fairly well over the whole century, and shows relatively good diagnostic tests. Then, would a change in preferences (detected using the original, non detrended series) imply that the assumption is false and that short-run estimates, based on the detrended data, are incorrect? The possibility cannot be discarded a priori, but we argue that it is unlikely to be the case here, as most (if not all) changes in preferences are captured by trends. A formal test, which consists in applying revealed preference tests to the detrended series, and checking that they are, at least more than the original series, consistent with the axioms, is reported below.

IV.1. *Revealed Preference Tests*

Denote $p_t = (p_{1t}, ..., p_{nt})'$ and $q_t = (q_{1t}, ..., q_{nt})'$ the n-vectors of (non detrended) prices and quantities consumed in year t, and consider the following definitions (VARIAN [1982]). According to revealed preference theory,

1. a bundle of goods consumed at time t, q_t, is directly revealed preferred to a bundle of goods consumed at time t', $q_{t'}$, written $q_t R^0 q_{t'}$, if the latter was affordable at the price of time t, that is if $p_t' q_t \geq p_t' q_{t'}$;

2. q_t is indirectly revealed preferred to $q_{t'}$, written $q_t R q_{t'}$, if there exists a sequence $(q_u, q_v, ..., q_w)$ such that $p_t' q_t \geq p_t' q_u$, $p_u' q_u \geq p_u' q_v$, ..., $p_w' q_w \geq p_w' q_{t'}$; in this case, we say that the relation R is the transitive closure of R^0.

In what follows, we examine the consistency of our data with two revealed preference axioms: the weak and the strong axioms.[18] According to the Weak Axiom of Revealed Preferences (WARP), $q_t R^0 q_{t'}$ implies *not* $q_{t'} R^0 q_t$ for $t \neq t'$. This can easily be tested by forming a matrix Φ with typical element $\Phi_{tt'} = p_t' q_{t'}$, so that each element $\Phi_{tt'}$ represents the cost at time t prices of purchasing the set of goods consumed at time t'. The elements in each column therefore give the cost at various prices of a fixed bundle, and the elements in each row give the cost of various bundles at constant prices. If the actual expenditure at time t exceeds the cost of bundle $q_{t'}$ at time t prices, so that $\Phi_{tt} \geq \Phi_{tt'}$, then $q_t R^0 q_{t'}$. Violation of WARP occurs if it is also true that bundle q_t was affordable at time t', so that $\Phi_{t't'} \geq \Phi_{t't}$ and thus $q_{t'} R^0 q_t$. The absence of violation in the data is consistent with stable preferences over the period. Conversely, any violation of WARP must be interpreted as evidence of a change in preferences between time t and time t'. For example, if a bundle consumed at time t was affordable at time t' but was rejected in favor of a bundle with more wheat and less meat, it implies a preference for the bundle with more wheat. If the latter was affordable at time t but was not chosen, we would conclude that, between t and t', preferences have shifted to wheat and away from meat.

Finding no violation of the weak axiom is a necessary but not a sufficient condition for the existence of a stable set of preferences. It is also necessary to check that the strong axiom

18. All results are, as in the parametric case, conditional on food being weakly separable from other goods.

is satisfied. Similarly to WARP, SARP holds if $q_t R q_{t'}$ implies *not* $q_{t'} R q_t$ for $t \neq t'$. Basically, testing for SARP amounts to searching for intransitivities in the data, to see whether bundles q_t, $q_{t'}$ and $q_{t''}$ can be found such that $q_t R^0 q_{t'}$, $q_{t'} R^0 q_{t''}$ and $q_{t''} R^0 q_t$. The data are consistent if no such intransitivities are found in the matrix Φ. To test for SARP, we need to construct the transitive closure R of R^0. We use Warshall's algorithm described in VARIAN [1982]. When no violation is found, it can be said that the data have been generated by the maximization of a stable, well-behaved utility function by a representative consumer. Conversely, detecting a violation of SARP is, strictly speaking, enough to reject the hypothesis of stable preference maximization. In practice however, some violations might be found in most data sets not because of inconsistency with the axiom but because of measurement errors. To determine whether the data satisfy SARP (or WARP), it may therefore be more reasonable to use the violation rate, defined as the percentage of couples that violate the axiom. Then, a violation rate of 5%, a standard significant test critical value, can be used as a criterion for the rejection of the axioms (see FAMULARI [1995]). Furthermore, when a WARP or SARP violation is found, we use AFRIAT [1973] efficiency index to measure its importance. Let $e \in]0,1]$, redefine the direct revealed preference relation as $q_t R^0(e) q_{t'}$ if $e p_t' q_t \geq p_t' q_{t'}$, and define SARP$(e)$ and WARP(e) replacing R by $R(e)$ and R^0 by $R^0(e)$ in SARP and WARP definitions, respectively. Note that when $e = 1$, $R(e) = R$ and $R^0(e) = R^0$. Denote e^* the largest value of e such that a SARP, or WARP, violating couple of bundles satisfies SARP(e^*), or WARP(e^*). Then, a violation with e^* equal to 0.8 is more important than a violation with e^* equal to 0.9.

A well-known drawback of revealed preference tests applied to time series data is that they often lack power to reject the axioms. As mentioned in the previous section, most economic time series trend upward over time, with income (and budget) growth much more important than period-to-period relative price variations. As a consequence, each year is revealed preferred to the preceding years in the sense that it is typically possible in a given year to purchase the consumption bundles of each of the previous years (see VARIAN [1982]). This makes it unlikely to find a violation of revealed preference axioms. One simple solution is to select couples of bundles whose costs, at fixed prices, are not too different from each other. FAMULARI [1995] proposes to evaluate all bundles at a reference price vector, say p_0, and to retain for the tests any couple $(q_t, q_{t'})$ satisfying the rule $2(p_0' q_t - p_0' q_{t'})/(p_0' q_t + p_0' q_{t'}) \leq \kappa$, with κ an arbitrarily defined threshold. Then, only couples whose costs at p_0 differ by at most κ are kept to perform the tests. As it is precisely those couples with small differences in costs that provide the strongest tests, the lower κ the larger the power of the tests.[19]

An additional problem in our context is that the construction of the matrix Φ requires us to observe both quantities and prices for all groups of goods. In our data, however, quantities are missing for three sets of foods (only expenditures are observed). If preferences over the 6 groups with observed quantities are assumed not to be separable from the 3 others, which is probably the case, and if we do not account for the latter, then it is possible to rationalize any set of prices and quantities for the first six (VARIAN [1985]). Thus, omitting these 3 groups makes it impossible to test for WARP and SARP. To cope with our lacunary data, we choose to

19. Given that strict rules regulated the food purchases effected by the *économe* for all the people living in the institution, our data can be seen as describing the behavior of a representative consumer. No violation of revealed preference conditions on these data can therefore be attributed to an inappropriate aggregation of individual behaviors.

apply the same coefficient of augmentation as we find for the set of foods with complete figures to the set of foods for which we know only the expenditures. In other words, if at time t the actual expenditure on foods with missing quantities represents say 10% of the food budget $p_t'q_t$, the expenditure on them at time t' prices is computed so as to represent 10% of the food budget $p_{t'}'q_t$.[20]

TABLE V presents the number of couples violating WARP and/or SARP, together with the corresponding violation rate (in parentheses). For each axiom, it reports the results obtained for the set of all possible couples in the first column, and for the sets of couples remaining after deleting those whose costs at constant prices differ by more than $\kappa = 15$, 5 and 1% in the next three columns (results for $\kappa = 20$ and 10% are omitted from the table but available from the authors). Prices observed in the first year of the sample, 1703, are chosen as reference prices p_0; choosing any other year has no qualitative impact on the results. From the top to bottom rows, the number of violations is given for decreasing values of Afriat's efficiency index, e. Let us first look at the results when $e = 1.00$. Out of 3655 possible couples, 62 (1.7%) violate WARP and 214 (5.9%) violate SARP. This is few and the vast majority of couples thus fail to reject the two axioms. In both cases, however, violations do not concentrate on a particular subperiod but rather spread over the whole century. Out of 86 years, only 21 show no violation of SARP (32 for WARP), with the largest number of subsequent consistent years being four, from 1721 to 1724.

The violation rates discussed above are obtained using all couples of bundles, including those that are unlikely to violate the axioms. In the next three columns, the count of violations is restricted to couples with a difference in expenditures (at reference prices) at most equal to κ. Still focusing on rows where $e = 1.00$, the number of violating couples does not vary much until $\kappa = 1\%$, which indicates that violations are primarily found among bundles with similar costs: 96.7% of all SARP violations and 93.5% of all WARP violations still occur when $\kappa = 5\%$. Up to that threshold, almost all couples that are eliminated are those that trivially respect the axioms. Calculating violation rates using only bundles with similar expenditures therefore improves the power of the tests. As the number of couples kept for this calculation decreases with κ, the percentage of violating couples increases proportionally: from 1.7 to more than 6% for WARP and from 5.9 to more than 21.4% for SARP. Hence, although 5.9% only of all possible couples reject the hypothesis of stable preferences maximization, the fact that more than one fifth of those providing the highest power tests are inconsistent should clearly be a source of concern.

How important are these violations? Consider the results when e is lower than unity. A small diminution of Afriat's efficiency index induces a large reduction in the number of violations. When $e = 0.99$, this number is divided by more than two regardless the value of κ. In the first column, for example, only 23 (0.6%) and 91 (2.5%) couples of bundles remain inconsistent with WARP and SARP, respectively. This suggests that there are many couples in our sample that "almost" satisfy the axioms. Similarly, the number of years showing no violation of the axioms is now much larger (42 for SARP and 54 for WARP), and though violations still seem

20. This is admittedly a strong hypothesis, as the share of the 3 groups with missing quantities increased from 15 to 23% in the food budget between the beginning and the end of the century. Working on the 6 budget parts with known quantities only, based on an equally strong but less realistic assumption, yields the same qualitative results (results are available from the authors).

TABLE V. – Number of Violations (%)

		K				*K*		
e	SARP	0.15	0.05	0.01	WARP	0.15	0.05	0.01
1.00	214 (5.9)	213 (8.4)	207 (21.4)	86 (39.8)	62 (1.7)	61 (2.4)	58 (6.0)	34 (15.7)
0.99	91 (2.5)	90 (3.6)	85 (8.8)	31 (14.4)	23 (0.6)	22 (0.9)	19 (2.0)	10 (4.6)
0.98	10 (0.3)	10 (0.4)	8 (0.8)	0 (0.0)	5 (0.1)	5 (0.2)	3 (0.3)	0 (0.0)
0.97	3 (0.1)	3 (0.1)	1 (0.1)		2 (0.1)	2 (0.1)	0 (0.0)	
0.96	3 (0.1)	3 (0.1)	1 (0.1)		2 (0.1)	2 (0.1)		
0.95	1 (0.0)	1 (0.0)	0 (0.0)		1 (0.0)	1 (0.0)		
0.94	1 (0.0)	1 (0.0)			1 (0.0)	1 (0.0)		
0.93	1 (0.0)	1 (0.0)	1 (0.0)		1 (0.0)			
0.92	0 (0.0)	0 (0.0)	0 (0.0)		0 (0.0)			
Obs.	3655	2531	967	216	3655	2531	967	216

Note: Prices observed in 1703 are chosen as reference prices p_0.

fairly dispersed over the century, many of them (85%) concentrate on three subperiods about 15-years long: for SARP, 20% of violations occur between 1703 and 1717, 29% between 1731 and 1748, and 36% between 1768 and 1782. A comparable pattern emerges when $e = 0.98$. SARP is violated by 10 couples and WARP by 5 couples, with all violations taking place within the subperiods defined above and whose range can further be reduced to 1709-1711, 1734-1746, and 1770-1782. Some violations appear very robust however, as those 3 couples – (q_{1709}, q_{1711}), (q_{1709}, q_{1734}), (q_{1711}, q_{1734}) – that violate SARP, among which the first two do not satisfy WARP either, when $e = 0.97$ and 0.96, and the one (q_{1709}, q_{1734}) that still violates both axioms until $e = 0.93$. This does not change when the count is restricted to couples of bundles with similar costs if $\kappa = 20$ and 15%, but it does if $\kappa = 10$ and 5%: no couple is then found to be inconsistent with WARP and only one (q_{1711}, q_{1734}) violates SARP when $e = 0.97$ and 0.96. Note that such a result does not mean that the axioms are satisfied by the data. It simply indicates that the two additional violations found in the less restricted samples are actually related to bundles with fairly different costs, and that using too restrictive values for κ to get rid of trivially consistent couples may also eliminate violations. These results – the important violation rates found among couples with similar costs when e equals unity and the persistence of some violations as e decreases – seem therefore robust enough to suggest a change in preferences that calls for interpretation.[21]

The years detected by WARP and SARP precisely match historically well-documented subsistence crises: on the one hand, 1709 and its exceedingly cold winter that, destroying seeds and trees, drove up produce prices to levels unknown since the late 16th century (LACHIVER [1991]); on the other hand, the late 1760s and the ensuing turbulent times leading up to the so-called Flour War in 1775 (KAPLAN [1982], pp. 39-47; BOUTON [1993]). This is no mean result. Other years of abrupt price hikes and food scarcity (1725-1726, 1740-1741) tried the bursar's routine administration but did not preclude a return to the alimentary protocol that had obtained before these predicaments. 1709 and 1770 were different in that these subsistence

21. On the detrended data, violations are both fewer and much less robust, which confirms that trends (at least partly) capture changes in tastes. For instance, the SARP violation rate is 12.8% when $\kappa = 5\%$ and $e = 1$ (21.4% in TABLE V); it falls to 0.9% when $e = 0.99$ (8.8% in TABLE V); no violation is found anymore when $e = 0.97$, for all κ (3 or 1 violations remain, in TABLE V, depending on κ). Full results are available from the authors.

crises affected the structure of the establishment's food expenditures in ways that unhinge our model's capacity to predict long-term developments. However, WARP and SARP also single out 1734 (and the ensuing decade that saw a crisis) as years of a shift in tastes. No immediate, macrohistorical explanation – be it a political, economic, meteorological or agricultural shock – is at hand for this finding. The determinants of the food basket's long-term development at Saint-Cyr thus lie within its walls, and it is to their empirical examination that we turn now.

IV.2. *Historical Analysis*

Even though the structural model fails to predict long-term shifts in the food purchases at Saint-Cyr, the evolution of budget shares and food quantities provides an apt venue to explore the secular modifications of its consumption pattern. It so happens that the second half of the 1730s, one of the periods found to be notable when it comes to violations of the WARP and SARP hypotheses, emerges as a bundle of small, but altogether significant changes in the institution's consumer behavior. Note first, however, that the bursar's anticipations of income were off by more than 10% between 1734 and 1738, a series that has no equivalent in the school's century-long existence. This, then, was the context in which meat consumption, in terms of quantities and budget shares, began to slide into its downward slope, lasting for the following 25 years. As if to make up for foregone beef cuts, the consumption of game took off in 1739 after almost forty years of only sporadic appearances on the menu. Extant records indicate that feathered and ground game supplied an estimated 20 grams of meat per day between the early 1760s and 1788, not enough to fill the gap in the 80 grams decline in meat consumption per head per day after 1738 (AD Yvelines, D448 and D449). Another change concerned sweetness. The purchases of sugar became both more regular and larger. Simultaneously fruit weighed in more heavily in the school's budget, a development that escaped our structural model, which predicted a severe drop in the monies allocated to fruit and vegetables in the long run (capturing the dynamics of groceries). Hence the remarkable coalescence of invidivual developments in the late 1730s: the reversal of a trend (quantity of meat), the increased frequency of purchases (sugar) and the growing expenses (fruit), all of which happened simultaneously at the moment when the share of food expenses in the institution's total expenditures began to decline.

Let us briefly ponder the growth of milk consumption, a major, if unintended contribution to the demoiselles' health (via calcium and vitamin D). Milk did not substitute for butchery meat. Their secular trajectories appear independent from each other and provide no evidence that the cutback of meat on the menu favored the rise of milk from less than 2 to about 4% over the century. The requalification of milk as a food explained its rise. Used first and foremost against pulmonary diseases – Mme de Maintenon encouraged its use in the infirmary (Mme de Maintenon to Mme de Fontaines, Sept. 7, 1696, in LANGLOIS [1935-1939], 5: 96-97), medical prejudice against its use as a food seemed to fade (LAURIOUX [1994], pp. 30-42) to a degree that allowed it to enter the diet. With no reported increase in the number of patients at the infirmary where therapeutic uses continued during the 18th century (PICCO [2000], pp. 135-156), milk occasionally replaced the evening soup on the menu (BnF MS 10678, Mémoire de ce qui s'observe, p. 24). The novelty added to Saint-Cyr's expenses, but without affecting its consumption of meat.

Then there were culinary constraints. They curbed the influence of prices. The cost of butter more than doubled the rise in the cost of meat, while eggs outpaced it by 50%. Yet their respective quantities could not suffer trimming without compromising gastronomic standards at Saint-Cyr. Their shares therefore increased from about 2.5 to 4.5, and 6 to 8% over the century. But how did an 18th-century cooking staff whip up butter and eggs? With sugar! Indeed, sugar figured most prominently among the items whose importance increased in the budget and on the menu. While its share in food expenditures grew from 1.5 to 5%, consumption expanded from less than 1000 pounds per year in the first decade of the 18th century to roughly 5000 pounds in its last. The secular expansion, noted for English budgets (SHAMMAS [1984], pp. 266-267) and documented for the orphans in Amsterdam (MCCANTS [1992], p. 89), translated into a climb from 4 to 20 grams per person and per day. Here again – and this refines our knowledge on consumption shifts and the arbitrages they required, the 1730s appear as a turning point. Growth proceeded faster in the first half of the century than in the second half, but purchases are more regular after the first third of the 18th century. The development of a provisioning routine – the move away from opportunist purchases after the 1730s – owed much to the increased supply as overseas plantations grew and exportations to metropolitan France expanded. Increased supply stimulated the taste for sugar. Price played only a minor role in the development. It varied throughout the century between 14 and 21 sols per 1000 pounds, peaking in times of war. Then, as in the War of the Austrian Succession (1740-1748) and the French-and-Indian or Seven-Years War (1756-1763), acquired quantities got pushed down without, however, reversing the secular tendency to indulge the pensionnaires' sweet tooth. That is, purchases picked up as soon as prices came down. By the American Revolutionary War, the demand was so strongly rooted in eating habits as to prevail over a price hike. Consumed quantities grew in spite of it. And eating there was! For the ledgers at Saint-Cyr do not record a single exotic good transformed into sweet, stimulating beverages: chocolate, tea and coffee did not make it into the convent-school where pupils and nuns were ever more likely to indulge in pastry as the century went by.

Sweetness appears as the key to another modification to consumer behaviour. The expense on fruit and berries grew from 1 to almost 4% in the school's budget while the outlays for preserved fruit consumed during lent remained stable at about 1% throughout the century. Our sources remain silent on acquired quantities, and the purchases may also have supplemented produce from the school's gardens and orchards (which, as we have seen, took on a minor role in provisioning as the century advanced). But the fact remains that the *économe* at Saint-Cyr was willing to spend more money on fresh fruit in the course of the century, whether to satisfy increasing demand or to avoid depriving the demoiselles of their habitual level of fruit consumption, in cakes prepared on the premises or as fresh apples, apricots, cherries, pears, plums and peaches arriving as desserts (BnF MS 10678, Mémoire de ce qui s'observe, p. 24).

The forms different food expense indices took in the course of the century bolster the assertion that the rising taste for sweets and the corollary requirement of butter and eggs necessary to its gratification combined to bring down expenses for butchery meats. FIGURE 4 reproduces the secular evolution of outlays made on meat (butchery and game) and other food groups. When indices of butter, eggs, sugar and fruit augment the index for meat, they espouse the dynamics of the index for total food expenses even after the 1740s and the reduction in outlays for meat. All other groups responded to different economic cycles and so imparted

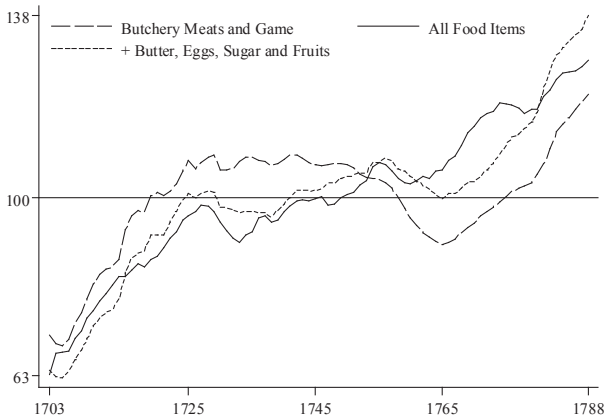

FIGURE 4. – Food Expenditure Trend Indices (Mean = 100)

various impulses to the long-term pattern of food expenditures without aligning themselves to its general form. This is additional evidence to prove the point. Meat consumption declined in order to maintain the quantities of butter and eggs required in a rich cuisine. Furthermore, the reduction favored the period shift toward a sweeter diet.

The long-term analysis demonstrates a change in taste but this modification owed much to an important innovation: the rise in sugar production and its spread in Europe. At the threshold of the 18th century, price did not compete with pleasure when it came to sugar, yet once its taste was known and liked, Caribbean sugar rapidly became an economic item. Other modifications were due to medical practices (milk), budgetary restraints (meat) and culinary necessity (butter and eggs). In the long run, then, several elements combined into a system whose configuration privileged sometimes one, sometimes the other of its constituents as the main explanatory factor. The rising taste for sweetness provides the major key to these developments. Overall, however, the long run bears out Mme de Maintenon's original injunction to "diversify foods so that the demoiselles eat better" (Mme de Maintenon to Mme du Pérou, May 30, 1696, in LANGLOIS [1935-1939], 5: 66).

V. Conclusions and Implications for Future Research

Economics mattered a great deal to the manager of the institutional purse at Saint-Cyr. Invidious waste to trumpet the convent-school's aristocratic lineage and to exhibit its symbolic proximity to the Versailles court never propelled its food purchases. Ostentation may have driven royal expenses to exhibit the king's distance from everyday material concerns and to showcase his country's riches, thereby recklessly draining resources that could have financed other projects (ELIAS [1992], pp. 98-106); it had no impact on purchasing patterns at Saint-Cyr. Throughout the century, aristocratic values and expectations determined the quantity of the available daily ration (close to, or above, 2200 kcal per inmate) and the quality of foods (white, not brown *wheaten* bread; above all muscle and little organ meat, but no lowly *charcuterie* at all; fresh rather than preserved fish, for example). Strict accounting principles governed food logistics from

buying to disposing. Efficiency was to guide food acquisition: cautious, even shrewd purchases aimed at keeping a consistently optimal relation between financial means and consumption ends. Saint-Cyr prized attunement to the market. The evidence in the accounting ledgers suggests that even while increasing their budget share from 1 to 5% in the course of the century, price considerations long determined the purchase of white or brown sugar (*cassonade*). They were substitutes: when the price of sugar went up, the ratio of sugar to the less refined cassonade declined (honey was consumed in small quantities). Economic imperatives directed provisioning at Saint-Cyr in the 18th century. At least on a day-to-day basis, because provisioning's protracted movements – and especially the shift away from meat toward a sweeter diet – escape our model's predictions.

The explanation of the long term requires different variables than the short term. To be sure, the ebb and flow of different budget shares (FIGURE 2) over the 18th century corroborates Saint-Cyr's aim to provide a varied diet. A small, often less than 5%, increase in the shares of fruit and vegetables, groceries (mostly sugar), milk and butter, offset the roughly 15% drop in the budget share of butchery meats. As a matter of fact, much indicates that preferences revealed in budget shares and consumed quantities shifted over time and, moreover, that the *économe* struggled to keep the budget in good shape, since change implied costs. For instance, the forty-year period between 1727 and 1767 quite consistently registered additional expenses when checked against the institution's original food basket (see FIGURE 5). In other words, had that mix of goods persisted over time, Saint-Cyr would have saved money. It is only after the mid-1760s that modifications in purchases induced lower expenditures when compared to the cost of the original food basket at current prices. All this suggests willful change, so to speak, and Saint-Cyr's administrators understood that dietary innovation entailed a financial burden.

Consumption shifts introduce a different time scale and with it, different determinants of consumer behavior. Testing for structural change on this household's food budget between 1703 and 1788 furnishes information to bolster the case for an evolution in tastes, that is, a change in the utility assigned to the different items in the food basket in the course of the century. It is worth pointing out that all but one period during which makeovers happened according to the theory of revealed preferences coincide with years of subsistence crises. In 1709 when wheat was rare and the food budget strained, Mme de Maintenon considered the demoiselles' consumption of brown (not black) bread the last recourse to rein in expenditures at Saint-Cyr (Mme de Maintenon to Mme du Pérou, written in early 1709, in LA BEAUMELLE [1778], 9:184). This was a reversible maneuver, of course. Down-grading quality was definitely quite unlike the combination of the patterned changes in the 1730s. They expressed the turn toward a sweeter, if also more expensive diet. As an unintended result, the increase in variety improved nutritional benefits. Neither the economy, nor dietary theory, but taste accounted for that shift in food consumption.

These findings invite prudence when structural changes are investigated on aggregate data and shorter time spans with a lesser incidence of economic strain; they emphasize the necessity of the series' careful insertion in the historical contexts. Besides offering a solution to this caveat, the microanalytical focus on almost one hundred years of accounting ledgers presents another advantage: it tells contingency apart from choice. First, the Saint-Cyr records differentiate short- and long-run determination of consumer behavior; they highlight the immediate impact

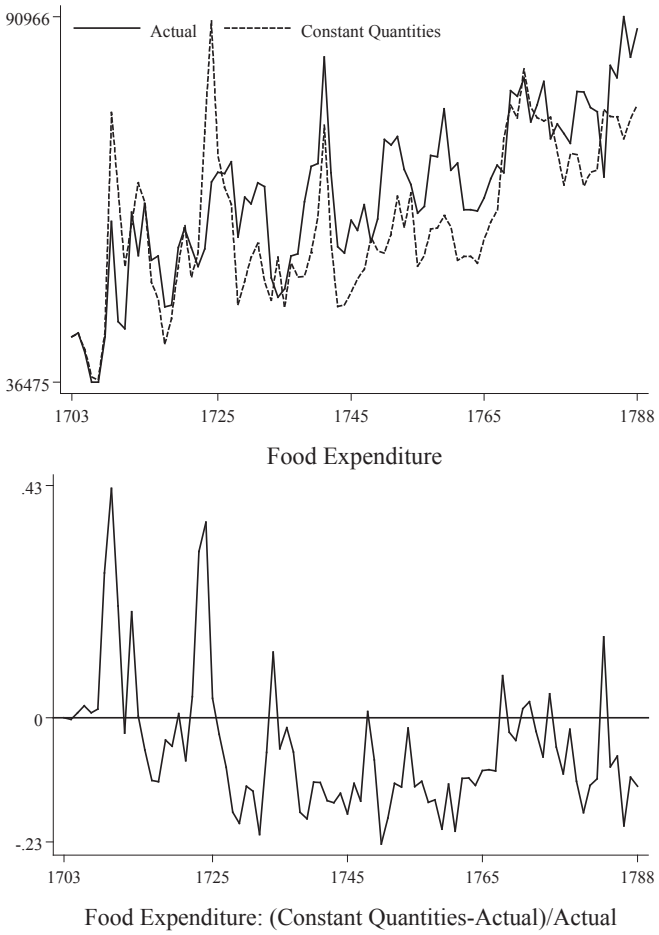

FIGURE 5. – Cost of 1703 Food Basket at Current Prices

of economic factors while demonstrating the important influence of other variables, such as the formation of new tastes, over the long haul. Second, changes in tastes not only reordered preferences that then shaped the institution's purchasing program, they imposed deliberate economic decisions. The shift toward a sweeter diet came with a cost. Butchery meat bore the brunt of the additional expenses. And yet, the rising consumption of sugar from the Caribbean owed little to its price and much to its expanding supply. Availability drove the diet's make-over. Prices and tastes, this exploration shows, evolved in different temporal dimensions, and their interactions require examination. Here we touch upon the general problem of supply in research on consumption: for instance, the industrialization of poultry production in post-World War II North America and Europe altered the progressive inclination to purchase chicken probably as much, if not more than, the role of relative prices in consumers' decisions to buy white meat (see GODLEY and WILLIAMS [2009]). It is a point which many studies on structural change lose sight of when they apply static models to dynamic configurations.

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