The Empirical Factors Determining Vertical Integration in Algerian Food Manufacturing Sector

Amine M. Benmehaia
Fatima Brabez
Department of Rural Economics,
National Higher School of Agronomy, Algeria

Abstract
This paper examines the empirical factors determining vertical integration in the food manufacturing industry in Algeria. In this research, we focus on the effects of food industry structure, transaction costs, and several market conditions. We use data for the period of 16 years (2000-2015) to estimate a linear regression model. Through an econometric analysis, three vertical integration measures are utilized to examine the determinants of vertical integration in food manufacturing industry. Empirical results support that there are variations in terms of the effects of industry structure and market conditions, whereas the transaction costs involved in the food industry coordination seems to have a significant effect on vertical integration trends.

Introduction

Our study aims to present a sophisticated modeling of an aspect of one of food safety issues. Regarding the quasi-absence of studies dealing food industry linkages in Algeria, especially at the macroeconomic level, our study presents an attempt in this research direction. The purpose of this study was to assess vertical integration in the food manufacturing industry using three known measures for the modeling. Attempts were made to systematically collect and interpret available data to provide a framework for understanding the vertical integration determinants in the food manufacturing industry in Algeria.

The vertical integration is defined through the transaction costs theory (developed initially by Williamson, 1971, 1973, 1979; Coase, 1937, 1992) as the ownership and complete control over neighboring stages of

production or distribution (Perry, 1989). However, as Maddigan (1981) stated "the essence of vertical integration as discussed by Coase (1937) is the application of management control rather than market forces to coordinate the use of inputs and outputs". The main variables of interest to transaction costs economics –asset specificity, uncertainty, and frequency– are difficult to measure across firms and industries (Shelanski and Klein, 1995). Besides, vertical coordination is defined as "all ways of harmonizing the vertical stages of production and distribution" (Mighell and Hones, 1963). Campell and Clenvenger (1978) explained that this involves "collective action in control of individual action" which is accomplished through institutions.

Koch (1980) stated that vertical integration enables a firm to reduce costs and increase efficiency, and may also reduce and restrict competition in the market in which the firm operates. It also can, in some cases, create market power and increase the barriers to the entry of new competitors. According to Carlton and Perloff (2005) vertical integration is beneficial to the economy and increases the welfare of consumers if firms were allowed to vertically integrated to reduce the cost of production. Moreover, economic theory has shown that vertical integration may be induced by transaction costs, demand variability, market power motives, and other factors (Bhuyan, 2005).

The full implications of vertical integration in the food industry in developing countries are not yet completely understood. This study examines vertical integration in the food manufacturing industry using a simple econometric analysis on single-industry model. Particular attention is paid to a number of important determinants of vertical integration: structure of the food manufacturing industry, transaction costs effects with special focus on uncertainty, and several market conditions, and the changes that they have brought that affect the evolution of vertical integration. Specifically, this study focuses on how these variables impact vertical integration in the food manufacturing industry.

The paper is organized as follows. Section 2 describes research methodology. Section 3 presents and discusses our main empirical results. Section 5 concludes.

Research methodology

The model presented in this study examines the quantitative relationship of industry structure, market conditions, and transaction costs on vertical integration in the food manufacturing industry. The econometric model has ten exogenous variables in order to reflect these three determinants. The ordinary least squares (OLS) model was developed on time series between 2000 and 2015 so as to quantify the effect of the

exogenous variables on vertical integration. The general model can be written as:

$$VI_t = f(S_t, TC_t, M_t)$$

where VI_t is the level of vertical integration in the food manufacturing industry at time t, S represents the industry structure measures, TC reflects the transaction costs proxies, and M reflects some market conditions of domestic industrial production.

Data

In this study, we have used the available input-output tables officially published by the National Office of Statistics (2016) in Algeria between 2000-2015. Data before this date is not available.

Dependent variable

Food Industry Value Added on Sales Ratio (VAS): Vertical integration is measured first by the ratio of value added to sales. Although used in previous studies, this measure is susceptible to bias since it treats backward and forward integration asymmetrically (Adelman, 1955; Levy, 1985, Eckard, 1979; Martin, 1986; Perry, 1989; Bresnahan and Levin, 2012; Helfat, 2015). It is computed through the ratio of food industry's value added on the gross sales of food manufacturing sector obtained from input-output data.

Vertical Industry Connections (VIC): The VIC index is a viable starting point for measuring vertical coordination (Frank and Henderson, 1992). It is developed by Maddigan (1981), and it is largely used in previous empirical studies (Huang and Liu, 2014; Guzzini and Palestrini, 2014; Bhuyan, 2002). It is computed as following: by using the input-output matrix, the VIC index is constructed within the formula:

$$VIC_i = 1 - 1 / (\prod C_i \, D_i)$$

where $i = 1,…, t$; C_i and D_i represent matrices computed on the matrix of relative net inputs and the matrix of relative net outputs respectively (See Maddigan, 1981; Davies and Morris, 1995).

Backward Vertical Integration on Food Imports Dependency (VIFI): The VIFI index is a ratio reflecting the food importation dependency, i.e., the backward vertical integration in food production. It represents the fraction of imported food relative to the domestically consumed food production obtained from input-output data.

Explanatory variables

The explanatory variables in our model include ten exogenous variables. They can be regrouped as follows.

Industry Structure: In order to capture the food industry structure, we have used the concentration ratio (CR) and industry size through food manufacturing gross sales (FIS) obtained from input-output data.

Transaction Costs: In this study, transaction costs estimation is obtained through the uncertainty and the administration costs proxies.

On the uncertainty side, we use first the food demand fluctuation measure (DEMFLUC). In order to capture the food demand fluctuation, a coefficient of variation was computed for food industry output data. Second, to measure the uncertainty of food manufacturing input supply, we use the percentage change in farm output supply (PCFS) obtained from input-output data. Third, to measure the unanticipated food demand uncertainty (UFDUN), we compute the variance of the residual of logarithm of food industry sales regressed on the time trend, i.e.:

$$LFIS = \beta T + \alpha + \epsilon$$

where LFIS is the logarithm of food industry sales obtained from input-output data, and T is the time trend (2000-2015). Hence, the UFDUN values are obtained as residuals of the linear regression. On the other hand, the costs of administered vertical coordination are captured by two variables. First, the administration expenditure for coordination (ADEXPC) obtained from input-output data. Second, the food production price dispersion index (FPD), by computing a coefficient of variation for the dispersion of overall food production prices obtained from Fao Statistics.

Main Domestic Market Conditions: In order to capture several market conditions in Algeria, we select the major variables in Algerian economic settings for the food industry. Three variables are chosen, changes in household food consumption (HOUSFC) obtained from input-output data, the food production price index (FPPRICE) and the farm gross production value (FGPV) obtained from FAO Statistics (2016).

Empirical results and discussions

The main characteristics of the database used in this study are presented in Table 1. At the first, the descriptive statistics show the tendencies of the three dependent variables. It seems that the VAS ratio and the VIC index show decreased tendencies in the time interval (as shown in Figures 1 and 2). The VAS ratio began from 15,23% in 2000 but it has diminished until the value of 12,53% in 2015 (with a relative low standard deviation of 1,13), where the VIC index began by 0,65 in 2000 to decline at the value of 0.004 in the last five years and shows a high standard deviation (0,22). On the other hand, the VIFI ratio shows a clear increasing tendency (Figure 3). The beginning was about 30%, and the last year was about 70% (with standard deviation of 15,32).
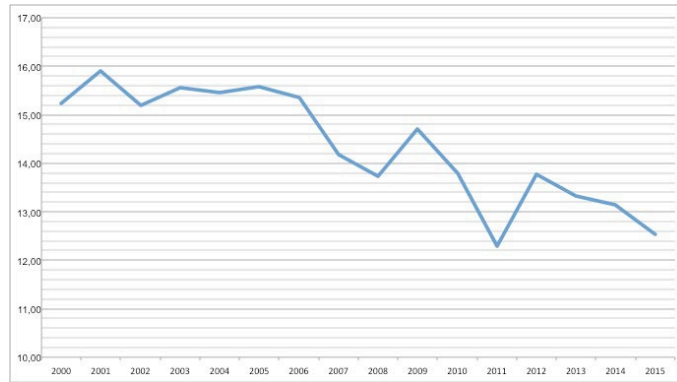
Figure 1. The evolution of value-added to sales ratio for food manufacturing industry in Algeria (2000-2015)
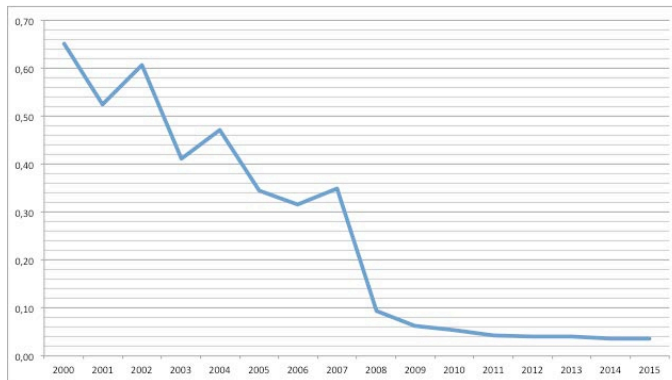
Figure 2. The evolution of VIC index for food manufacturing industry in Algeria (2000-2015)
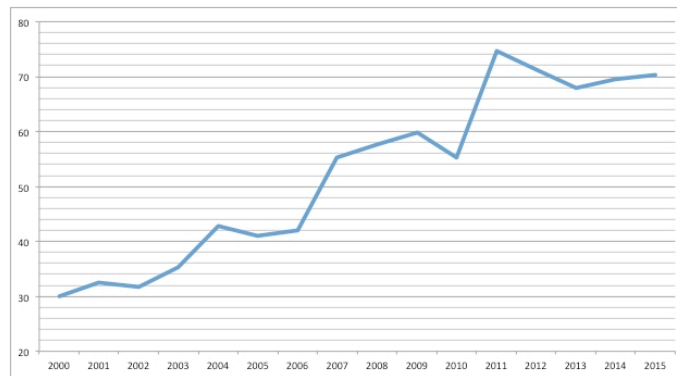
Figure 3. The evolution of VIFI ratio for food manufacturing industry in Algeria (2000-2015)

The interpretation of these tendencies for the dependent variables, which reflect somehow the vertical integration in the food manufacturing industry, deals with the critical situation of the food industry in terms of food security issues. The diminished share of the value added of food

manufacturing industry relative to the rest of sectors signals the continuous distortions in the global food chain and lower performances in this sector. Where the increased trend of the FIVI ratio could be interpreted as an increasing in the food bill for the country, in other words, a great dependency for importations indicating low levels in food security.

Despite the difficulties in interpreting the VIC index, we highlight the interpretation that the food sector suffers from lower levels of profitability, and a decreasing trend until a value of 0.04 indicates that there is a relative failure in coordinating the food industries by the government programs.

Furthermore, the descriptive statistics of explanatory variables show the main characteristics of food manufacturing industry in Algerian settings (Table 1). Concerning the industry structure, it seems that the food-manufacturing sector is marked by a relative stability in terms of the two main variables (concentration and size). The CR variable shows low level in the standard deviation with a mean of 0.12, as for the FIS measure of industry size (between 15-13% in total sales value).

Table 1. Descriptive Statistics for Variables Used in Regression Analysis

Variables	MEAN	S.D.	MIN	MAX
VAS	14,36	1,13	12,29	15,90
VIC	0,26	0,22	0,04	0,65
VIFI	52,31	15,32	30,03	74,67
CR	0,12	0,04	0,07	0,22
FIS	14,01	0,44	13,44	14,75
DEMFLUC	0,34	0,18	0,10	0,73
PCFS	45,80	41,31	-6,34	130,08
UFDUN	0,00	0,09	-0,13	0,13
ADEXPC	84,81	53,71	11,34	196,04
FPD	4,96	0,11	4,82	5,14
HOUSFC	13,46	12,35	13,06	13,90
FPPRICE	124,07	38,67	65,26	182,35
FGPV	146,07	40,57	94,25	228,01

The three last variables are those of market conditions in the food sector. The measure that reflects the changes in household food consumption (HOUSFC) shows a relative stability (with a mean of 13,4%). On the other hand, changes in the food production price index (FPPRICE) and farm gross production value (FGPV) show a clear increasing trend (where 2004=100). Both measures have tripled from 2000 to 2015.

The results of the regression that analyzed the determinants of vertical integration are summarized and presented in Table 2 in the form of three estimated models: for the VAS, VIC and VIFI. Before the modeling procedures, the multicollinearity was checked using variance inflation factor

for the ten variables. The calculated variance inflation factor values are all less than 10 (the cutoff point), which indicated that multicollinearity is not a serious problem. The Adjusted R-squared coefficient value is acceptably high. The regression's F-statistics test specified via p-value, which tests the overall significance of the models, is significant at the 0.1% level. Because our data is a time series trend on 2000-2015, the Spearman rho coefficient and Durbin-Watson statistics are used for testing the fitness of the models. It seems that they have significant values indicating the robustness of the three models.

In terms of the estimated results, the measure used to depict industry concentration (CR) is highly significant for the three independent variables, while the measure of industry size is statistically not significant, except for the VIC index. From the estimates that aim to depict transaction costs effects, it seems that all the measures have relative significant effects on the three independent variables, especially for the food demand fluctuation measure (DEMFLUC), the unanticipated food demand uncertainty (UFDUN) and the administration expenditure for coordination (ADEXPC). They represent higher statistical significance. They have commonly positive effects on the VAS ratio and VIC index. While the percentage change in farm output supply (PCFS) has a statistically significant effect on the VIC index. On the other hand, it seems that the selected market conditions measures do not have a clear significant effects on the vertical integration measures except for the food production price index (FPPRICE) on the VIC index and VIFI ratio through positive effects, and for the farm gross production value (FGPV) only on the VIC index by having a negative effect.

Table 2. Regression Results for Determinants of Vertical Integration in Algerian Food Manufacturing Industries (2000-2015)

Explanatory variables	Dependent variable					
	VAS		VIC		VIFI	
Const.	34.358 (1.492)		5.883 (2.239)	**	31.388 (1.814)	*
Industry Structure						
CR	−5.832 (−2.234)	**	−2.644 (−2.228)	**	17.841 (2.878)	**
FIS	−0.019 (−0.694)		−0.009 (−2.955)	**	0.013 (0.640)	
Transaction Costs						
DEMFLUC	4.203 (1.947)	*	0.507 (2.787)	**	−6.165 (−4.189)	***
PCFS	−0.151 (−1.085)		−0.040 (−2.550)	**	1.586 (1.052)	
UFDUN	5.017 (1.974)	**	2.423 (4.191)	***	−1.011 (−2.326)	**
ADEXPC	0.008 (3.309)	***	0.005 (4.35)	***	−0.003 (−3.221)	***

FPD	−0.007 (−0.204)	−0.526 (−1.122)		4.434 (0.374)	
Market Conditions					
HOUSFC	−0.004 (−1.226)	−0.645 (−0.980)		0.006 (1.275)	
FPPRICE	0.007 (0.204)	0.009 (3.283)	***	0.226 (2.782)	**
FGPV	−0.004 (−1.424)	−0.007 (−1.981)	*	0.004 (0.804)	
Log Likelihood	−7.172	27.559		−29.254	
Adjusted R-squared	0.887	0.856		0.873	
Spearman Rho	−0.248	−0.254		−0.371	
D.W.	2.68	2.74		2.71	
F-statistics (p-value)	2.864 (0.060)	9.139 (0.023)		10.417 (0.018)	

We turn now to the discussion of these empirical results. The significant negative influence of concentration ratio (CR) on value-added to sales ratio and on the VIC index (as well as the positive sign on VIFI ratio), used to capture the fewness of sellers, runs counter to the a priori reasoning presented previous studies in different contexts (for instance, MacDonald, 2000; Caves and Bradburd, 1988; Lieberman, 1991; Frank and Henderson, 1992). This outcome would imply that the fewness of sellers in the Algerian food manufacturing industry did not cause vertical integration, and firms in the successive stages of food manufacturing were able to overcome the potential adverse effects of the transaction costs. Furthermore, the negative sign may be reflecting the countervailing market power motive for integration. The food industry share, in contrast, does not present a relevant effect on vertical integration measures because of its relative stability.

The transaction costs in the food manufacturing industry seem to have relevant effects in the three cases. The significant positive influence of both the food demand fluctuation measure (DEMFLUC) and the unanticipated food demand uncertainty (UFDUN) on value-added to sales ratio and on the VIC index (as well as the negative sign on VIFI ratio) supports the hypothesis that food manufacturers are motivated to use vertical integration as a business strategy to rectify demand uncertainty in their output markets. This result is in accordance with some previous studies (Lieberman, 1991; Frank and Henderson, 1992; Bhuyan, 2005).

The percentage change in farm output supply (PCFS) and the food production price dispersion (FPD) index in contrast do not present relevant effects. Whereas, the signs are in the direction compared with Frank and Henderson (1992). On the other hand, the administration expenditure for vertical coordination (ADEXPC) seems to have a relevant effect. The positive highly significant effects on the vertical integration suggest that the

expenditures on the coordination issues in Algerian food industry should have more attention for the policymakers.

The effects of the food production price index and the farm gross production value indicate that the vertical coordination is strongly affected by input prices in the global chain. As stated by Alfaro et al. (2010), higher prices imply more vertical integration.

The analysis in this study, which is framed in an empirical framework, suffers of some shortcomings. The main one came from the computation of the three measures of vertical integration, where they were computed for the whole food industry (especially for the VIC index). It would be more consistent to extend each measure on the sub-sector (filière) in the food industry or for food companies. By doing so, the final conclusions should have more regularity and consistency regarding recent empirical literature. Another limitation should be highlighted. It is about the time trend of 16 years (2000-2015), which is insufficient, and the analysis would be more relevant for a long interval. This is due to the absence of official data before 2000. Moreover, the explanatory variables are imperfect measures, which may bias the results. It is also possible that the findings are specific to the food-manufacturing sector, and care should be taken in generalizing the results.

Concluding remarks

Understanding the factors that determine vertical integration in food industries has been an important subject of theoretical and empirical literature in agricultural economics. Despite the considerable research, this paper tests the determinants of vertical integration that contributes to the literature by an empirical analysis. The main results indicate that food industry structure, transaction costs, and market conditions independently and significantly influence the level of vertical integration in Algeria.

The analysis presented here leaves unanswered some interesting questions about the determinants of vertical integration. Our study focused on the vertical integration issue in the food industry. Thus, conclusions and inferences about the results may be limited to this setting and may not address vertical integration in other industries. However, we believe many of the factors can be found in other settings. Our paper is the first attempt to analyze the determinants of vertical integration in Algerian food industry using official data. But our model remains relatively modest and a more general elaboration is anticipated.

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