

The role of public subsidies for efficiency and environmental adaptation of farming: a multi-layered business model based on functional foods and rural women

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ABSTRACT

This paper examines the role of public subsidies on farming efficiency for Spain by using a Data Envelopment Analysis (DEA) approach followed by a nonparametric regression of efficiency to farm specific factors (economic size, environmentally friendly behavior and regional aspects). The empirical analysis suggest that although a higher degree of direct payments negatively affects farm efficiency, these subsidies become an incentive for environmental friendly behavior by farmers in order to improve the productive efficiency. In turn, this proposition leads to a careful attention for the roots of agricultural productions in line to the EU aim of more market-oriented agriculture. Then, a conceptual framework was elaborated in order to propose a multi-layered model for supporting the design of a green business plan based on functional foods. This study also explores the process of generation-production-consumption of functional foods, involving not only the knowledge transfer of the healthy properties of these products but also the multiple role of rural women as producers, educators/advisors and buyers of these foods. The positioning of rural women in the whole process of functional foods results relevant to build their competitive advantage as local entrepreneurs. The leverage points of the strategic formulation of green business models were reinforced following the roadmapping methodology from a dynamic perspective: alliances with suppliers of knowledge (researchers), identification with their reference groups (investors, clients) and management of intellectual capital (structural, human, relational). Finally, findings reveal that rural women are better positioned than others to create businesses based on functional foods from a niche formulation.

Keywords: efficiency, bioeconomy, environmental behavior, new rurality, functional food, rural women, sustainability

1. Introduction

The future of EU rural territories are conditioned by the rapid changes in social and economic worldwide evolutions and also by the economic policies based on regional smart specialization or, in other words, in favor of the largest urbanized areas in terms of food provision, among others. As rural areas farming remains the main source of land use occupation, the development of agriculture is widely imposed nearby the city accompanied by the diffusion of new models such as short value chains or local food productions (Torre and Traversac, 2011).

Europe has the socio-economic conditions to achieve a Bioeconomy model that gets innovation through the application of agro-ecological knowledge¹. In particular, rural areas have to innovate in organizational, social and institutional fields based on specific environmental resources and renewed connectivity between local actors within localized agri-food systems (Ward and Brown, 2009). Farmers need to be part of the models of joint knowledge-production (involving academics, practitioners, businesses, land managers and consumers) in order to improve the level of co-operative production behaviors and the development of powerful local networks devoted to a better inclusion and involvement of local populations to the decision-making processes.

In this context, functional foods emerge as social responsible products since food production systems and consumption patterns are among the leading drivers of impacts on the environment (Notarnicola et al., 2017). However, the role of these products in Bioeconomy is not clear (Özkan Pir and Karaduman, 2017). There are not business designs that connect to the knowledge generators (university), producers (industry) and final consumers in order to make the businesses based on functional food viable in the market. Moreover, the potential of farmers and small companies to contribute to innovation is not fully recognized in the Bioeconomy Action Plan of the European Commission and the concept of multi-functional agriculture (Piorr and Müller, 2009) is also ignored in the Bioeconomy definition.

On the other hand, the approach of the European institutions reinforces the importance of local and tacit knowledge that come from different perspectives (suppliers, researchers, farmers, advisors, consumers). They also propose future plans to support green-care entrepreneurship and to build short food-supply chains that remunerate farmers for agro-ecological methods and thus create attractive employment for professionals in the field of agriculture (Schmid et al., 2012). The agricultural income support policy within the European Union (EU) Common Agricultural Policy (CAP) is complex and involves many policy instruments. In short, the various CAP reforms have undergone a long process from price support to the production-related direct subsidies based on greening measures (and eventually to decoupled payments²) (Zhu et al., 2012).

¹ The EU agriculture sector has roughly 11 million farms, which provide work for roughly 22 million agri-workers. But this figure doubles to 44 million if you include also the jobs created in the food processing, food retail and food services, making the EU agri-food sector the largest employment sector in the economy. It is also a sector that has performed particularly well in recent years, despite the recession and the increasing challenges to farming caused by climate change, water scarcity, soil fertility, energy costs, etc. The agri-food sector accounted for 6% of EU GDP (European Commission, 2011).

² These direct payments (DP) were originally introduced in 1992 in the McSharry CAP reform based on the set-aside area farmed and livestock kept in order to compensate farmers for an income reduction. The Single Payment System, which decoupled DPs from production, is used after 2005. The Single Payment System, which decoupled DPs from production, is used after 2005. With the 2013 reform, 30% of direct payments

Nevertheless, despite those institutional efforts, there is nothing specifically related to business models based on functional foods.

Under this approach, this study first lies on the impact of CAP subsidies on the promotion of the technical efficiency (TE) for the different type of farming since these results can potentially be translated to the reformulation of long term production planning of high value ecological farming. To study these questions at the European level, Spain is chosen as the representative country of Mediterranean farming. The analysis is developed through two step methodologies: data envelopment analysis (DEA) to model farming TE (with and without CAP subsidies) in relation to inputs management and other farm specific variables (economic size, environmental friendliness and regional aspects) under tobit regression framework. Then, this paper goes in depth in the study of environmental and socio-economic implications of agricultural land use by proposing a new conceptualization of green business model as a multi-layered process, following the approach of Anderson's (1998) findings. In particular, the model focuses on the participation of rural women in the agricultural system of functional foods, through a better understanding of their multiple role in the supply and demand of functional foods as competitive advantage.

Therefore, the objective of this study is twofold. First, we estimate the farming TE evaluating the factors affecting farm efficiency for each type of farming in Spain. Second, we propose a multi-layered model to evaluate whether rural women have competitive advantage as local entrepreneurs of businesses based on functional foods due to their positioning in the process of generation-production-consumption of these foods.

The structure of the paper is as follows. Section 2 carries out a literature review of the particularities of functional foods from a double supply-demand perspective. In this section, it is also analyzed the role of rural women in the process of generation-production-consumption of functional foods. Sections 3, 4 and 5 present the data, methods and results achieved in the farming efficiency analysis. Section 6 proposes and also evaluates a multi-layered model of generation-production-consumption of functional foods. Finally, a conclusion section summarizes the main contributions of the paper and suggests future lines of research.

2. Literature review

Functional foods are defined as those that contain naturally or processed components that contributes significantly either to enhancing health and well-being or reducing risk of diseases (Diplock et al., 1999; Siro et al., 2008). In the last years, final consumers have been appreciating those benefits and the demand of these products has risen all around the world (Ozen et al., 2012). This has led to farmers to look for business models that include the production and commercialization of these products following the Bioeconomy model of the European Commission. However, there are not enough academic tools to guide the strategic formulation of these business models and assess the competitive advantage of local entrepreneurs (Shucksmith, 2010; Dyerson and Pilkington 2005).

are linked to respecting three sustainable agricultural practices which are beneficial to environmental and climate change concerns (soil quality, biodiversity and carbon sequestration), the so-called "Greening" measures. (European Commission, 2011).

Innovative farmers and SMEs are recognized by European institutions as potential contributors of the strategic goals of the Bioeconomy model (Schmid et al., 2012). However, the implications of the Bioeconomy for agriculture are not clear either. The European Commission used a first definition of Bioeconomy for the Framework Programme 7 research agenda as “the sustainable, eco-efficient transformation of renewable biological resources into food, energy and other industrial products” (DG Research, 2006). Later on, the European Commission stated, among the objectives of the strategic plan for 2020: (1) research into safe, nutritious and affordable food and (2) improving the efficiency of agricultural, food and industrial production and distribution systems (European Commission, 2010a, 2010b).

In any case, organic food is emerging as an attractive source of rural income generation³ (Poudel et al., 2012) and, in this sense, this study intends to study functional foods from a demand-supply perspective along with the social conditions involved in their production and consumption.

2.1. Functional foods: Demand perspective

The market for functional foods has been constantly growing in spite of most European quality food labels bases on traditional products (Kaur and Das, 2011). Recent estimates for the global market of functional foods fall into the range of 30-60 million € (Stein and Rodríguez-Cerezo, 2008). The main reasons for which respondents buy functional foods are to stay healthy, “to do myself good” and “good taste”. This suggests that functional foods must have an effect on the health and well-being of consumers or, at least, consumers have to be ‘benefits believers’ to accept these products (Verbeke, 2004; Stein and Rodríguez-Cerezo, 2008). Thus, interest in nutritionally healthy eating is usually associated with the appeal of nutritionally relevant health messages such as nutrition claim. In this sense, the perceived relevance influences the willingness to buy products with health claims (Dean et al., 2012), and it is increased with the environmental education of potential consumers (Varela-Candamio et al., 2018).

On the other hand, market success depends on the holistic health image of the product or, in other words, on the trust on the effects of the ingredients of these products (Bech-Larsen and Scholderer, 2007). The factor of trust building in functional foods requires the communication of the functional value of their ingredients to the customers and distributors. However, in spite of its growing importance, there is no yet specific regulation for functional foods apart from the general food regulation in Europe (178/2002) or the European Novel Food Regulation (258/97) neither a uniform label for these products.

In the last decade, some companies have invested in product labeling that offer information about the origin and health properties of their functional foods in order to increase the relevance preference of the potential consumers (Kikuchi-Uehara et al., 2016). For this reason, the European Commission is considering a number of measures to strengthen regulations on product labeling and address misleading ecological information (European Commission, 2011). In particular, the demand of functional products (with nutritional value for end consumers) is significant in countries where ambitious studies of frequency of consumption have been conducted (Ozen et al., 2012).

³ The organic movement began in the 1930s as a campaign to minimize the overwhelmingly growing reliance on synthetic fertilizers. Nowadays, despite the uncertainty of financial viability, European Union has annual growth rate of 25% in organic crops even though their output is still lower than conventional ones.

According to these studies, the population is increasingly interested in consuming food groups that reduce fat, cholesterol or add value to their usual consumption, and women appears as the main buyer and consumer of these foods..

However, in spite of the increasing demand of final consumers of functional foods, there is a gap in the distribution chain of these products. A survey carried by Stein and Rodríguez-Cerezo (2008) analyzed attitudes and behavior of grocery shoppers regarding functional food in four European countries (Germany, the United Kingdom, Spain and Poland). The term “functional food” was not known among most of the respondents, but many of them knew specific products or brands of functional food and had already bought a functional food product at least once. Regarding the socio-demographic background of respondents, these authors found, as in other studies (Verbeke, 2004), women were more likely to buy functional food than men.

According to this empirical evidence, women are who decide the “shopping cart” that goes into every home, so they are relevant actors in the demand equation of functional foods (Bryceson, 2002; Verbeke, 2004). However, the consumer’s knowledge of the functional value of food depends on how long the foods have been in the market, and, to a lesser extent, how strongly they had been promoted. Thus, the greater the knowledge of functional food’s properties (nutritional and prebiotic, organoleptic and agronomic), the greater the positive attitude of consumers towards functional foods. However, this knowledge does not arise alone, but it depends on previous investments in communication coming from researchers, producers and distributors.

2.2. Functional foods: Supply perspective

The multiple role of rural women as producer, as decision maker of the shopping basket (advisors) and as final consumer can turn them into a relevant actor that joins the knowledge of researchers and nutritionists, product selection of farmers and buyer’s choice in the process of generation-production-consumption of functional foods (Wright and Annes, 2016).

Nowadays, most of the European producers of functional foods are concentrated in Germany, UK, Spain and Netherlands. The overview of manufacturers of functional foods has shown a dominance of established and internationally active companies that are also strong in conventional food products and have now diversified into functional foods. This situation can be identified as a barrier for the entry of entrepreneurs and SMEs in the functional food market (relatively costly because it requires investment in research, marketing and labeling, apart from the observance of legal requirements). However, from a strategic approach, the fast increasing of the market of functional foods has opened a business opportunity for entrepreneurs who can take advantage of their rural location, the knowledge of how these products cover the expectations of the group of clients (niche) that they know better and the privileged access to local suppliers (Hecht, 2006; Aldrich et al., 2006).

Under this context, what role can rural women play in the functional food market? Previous research based on rural areas of UK, USA, Europe, Australia and New Zealand showed a comprehensive analysis of the tasks carried out by women on farms and the authors conclude that the nature of both women’s domestic work and agricultural work is vital for the survival of the family farm business. Besides, some studies also reinforced

the current trend of women of adapting these tasks to the changing circumstances of agriculture and needs of the farm business (Little and Panelli, 2003, Morris and Little, 2005, Whatmore, S. 1990, 1999).

Following this approach, a work conducted in Spain by Camarero (2006) reveals that the sectors with the highest number of women in rural areas are hostelry and agriculture. Moreover, many small businesses run by rural women are inherited from their closest relatives whose survival depends on these women. This limits the risk tolerance needed for the farming innovation because they have to support economically the rest of the family. In other cases, rural women work in small business with her partner, considering their own work as an aid to her husband. Finally, there are cases where women run their own businesses and their couples perform other work, considering their economic contribution to the family merely a supplement to the main salary (Aguar Sierra et al., 2011).

With regard to this situation, there is a trend towards the association of rural women as producers. In Spain, women coming from different rural areas are associated in the National Confederation of Federations and Associations of Families and Women in Rural Areas (AFAMMER), with consulting status in the Economic and Social Council of the United Nations. Through this association, rural women are achieving the shared ownership of the land, equal consideration as rural worker as men and more resources for the training of women as rural entrepreneurs (Iglesias Osorio, 2011). This trend has been reinforced in the last years by the United Nations Conference on Environment and Development that recognizes women as “major group” of sustainable development. Table 1 shows the two types of profiles of rural women according to the criteria of the ownership of the land, risk tolerance to innovation and alliances with local suppliers.

Table 1. Current profiles of rural women as rural produces

	Land	Risk tolerance to innovation	Alliances with local suppliers
Traditional worker	In charge of the partner’s land	Low (support of the family economy)	Medium
Potential entrepreneur	Owner	High	High

On the premises.

Despite of the entry barriers of big companies in the functional food market, this is considered an emerging industry where new business opportunities also rise for small entrepreneurs. Nevertheless, these strategic options are uncharacteristic for the traditional food industry (Mark-Herbert, 2004). Producers that want to succeed in this market need to build internal skills, select new markets, establish alliances, develop packaging, build brands and find venture capital for new developments. In this context, rural women could take advantage of their profile of potential entrepreneurs of businesses by accessing to the experts’ knowledge in order to select the farming products more related to their own knowledge about the consumers’ preferences and their own investment capacities. This behavior would allow the coexistence of global strategies implemented by multinationals with niche strategies of local producers within the functional food market.

2.3. Functional foods: education, social capital and long-life learning

According to the previous analysis, the positioning of rural women in the process of generation-production-consumption of functional foods can offer them a competitive advantage in the market. In order to get the knowledge transfer in the generation stage (design of the supply of functional products) and in the consumption stage (influence in the consumer's behavior) of the process, rural women can play different roles. As producers, they are in charge of the agricultural land use in absence of men, and as head of the family, women are in charge of the education and livelihood. They are also food advisors and final consumers.

Consumer's trust is related, at last extent, with the environmental awareness of the nutritional value of functional foods. However, most individuals often evaluate environmental issues based on superficial knowledge due to they do not have access to the relevant information to take better decisions (Özkan Pir and Karaduman, 2017). In the scope of functional foods, there is also a lack of adequate channels that let the knowledge transfer from the researchers of functional products to producers, and from producers to final consumers (Stein and Rodríguez-Cerezo, 2008).

Regarding the lack of knowledge transfer from universities to industry, in the last years universities have gained increasing relevance as knowledge producers as well as sources of innovation in both business services (Villarreal and Calvo, 2015) and technology-intensive sectors (Zucker and Darby, 2007). Keeping in mind the impact of university research on the growth of individual local firms (Colombo et al. 2010), universities as a source of innovation in the industrial sector have aimed primarily at economically peripheral regions with a low capacity for adoption and production of scientific knowledge (Shapira, 2005).

Thus, the positioning of rural women in the process of generation-production-distribution of functional foods requires their connection with academic experts in functional foods. The commercial use of the ecotypes (subspecies with the same habitat) of these foods is the best tool for their conservation, according to the Food and Agriculture Organization (FAO, 2004) belonging to the United Nations. This is because it maintains the production of these subspecies in their particular set of environmental conditions. This adds the criteria of social responsibility to this production model. However, green business models require a multi-layered process that link academic experts, producers and consumers based on trust that exceeds the traditional design of agricultural business models.

According to this approach, previous research has identified new factors involved in these business models. Kahl et al. (2012) identified health and sustainability as underlying goals in organic food production. They defined a combination of process and product aspects necessary for the definition of organic food quality, also supported by results from consumer surveys. Stein and Rodríguez-Cerezo (2008) found that nutrition advisors, medical doctors, research institutions, consumer groups, health insurance, food industry, food retailers and government were the main stakeholders involved in the consumer's trust in functional food. In this study, the recommendations of an expert (doctor, nutritionist, researcher) were more influential to the extent that non-buyers will reconsider their decision by buying functional food products. On the contrary, national governments were the least trustworthy as advisors of this kind of products as consequence of a perceived lack of competence in the field of nutrition and previous food

scandals in several countries, such as the cases of mad cows or bird flu (Schmid et al., 2012).

As a result of this previous analysis, Table 2 shows the role of the main stakeholders in the process of generation-production-consumption of functional foods. In this context, women clearly become a relevant channel of communication of stakeholders' opinion about functional foods in their role as family caregiver and final consumers. This positioning also increases their competitive advantage as suppliers of these foods.

Table 2. Stakeholders' role in the process of generation-production-consumption of functional foods.

Role/Stage	Generation	Production	Consumption
Detection of functional value of farming products	Researchers Nutritionists		
Environmental education (formation of preferences)	Educators (mostly women)		
Environmental awareness (formation of values)	Advisors (nutritionists, doctors, researchers) Educators (mostly women)		
Selection of farming products		Farmers (mostly women)	
Investment in a change of production		Farmers (small business)	
Communication of functional value (Ecolabeling)	Nutritionists Researchers	Farmers Distributors	
Trust building in functional foods	Nutritionists Researchers		Women (buyers, advisors and consumers)

On the premises

3. Model and data

EU rural territories have traditionally been linked to the Common Agricultural Policy (CAP). Following the MacSharry reforms in 1994, one of the most important tools of the CAP was direct payments (DP). It was originally introduced in the EU to compensate farmers for the reduction in intervention support prices. In addition, DP pursuit other several functions such as a necessary support for EU food security, ensuring more sustainable management of natural resources, providing a safety net for farmers against unexpected market shocks and compensating for higher regulatory standards. Since its introduction, several CAP reforms have been implemented from price support to the production-related direct subsidies based on greening measures. However, there is little evidence that decoupled area-based payments are an efficient way of achieving these objectives (Matthews, 2016). On the other hand, the spatial development of rurality approaches has shifted from sectoral policies to consumption and leisure following both specific structural trends away from production per se. These trends were discussed in several policy guidelines derived from a highly influential European document, the European Spatial Development Perspective (ESDP). Besides, this new institutional approach focused on southern European rural regions (Hadjimichalis, 2003).

According to the above, as a first step, this study seeks to check the existence of technical efficiency (TE) in the agricultural sector, with and without direct payments (DP), in order to evaluate the role of the public subsidies in the primary production. The

technical efficiency model is specified by using an input-output approach. The output efficiency (TE) cannot be directly observed and must be previously calculated by Data Envelopment Analysis (DEA). The variables included in the model are described in Table 3 (see Kočiřová, 2015). Among the southern European rural regions, we chose Spain as the representative country of Mediterranean farming. This analysis is also important to analyze whether DP must potentially be oriented to the reformulation of long term production planning of high value ecological farming based on functional foods.

Table 3. Efficiency on farming: input-output and factor variables

OUTPUTS	Description
Q	Output: crop and animal output
INPUTS	
K _i	Total assets
W	Total labor input
UAA	Total utilized agricultural area
SP	Shadow price (opportunity costs for producing in a non-subsidized way)
FACTORS	
EF	Environmentally friendly degree proxy measure
ESU	European Size Unit
R	Agricultural regions

Data are obtained from the FADN under the different type of farming: PT8 Grouping. The FADN database contains mainly input expenditures and output revenues. The available FADN data did not allow us to distinguish conventional from organic farms, so both farm types are represented. All database refers to 2013, the last available year at the time of this analysis. Table 4 summarizes the number of farms that are used for all the calculations, separate by type of farming.

Table 4. Number and type of farms represented

TF8 Grouping	Farms represented
Fieldcrops	147,700
Horticulture	28,620
Wine	44,330
Other permanent crops	215,900
Milk	24,350
Other grazing livestock	87,750
Granivores	22,990
Mixed	29,610
Total	601,240

According to the FADN database, farm total output consists of two categories: on the one hand, crops and crop products and, on the other, livestock and livestock products. Regarding the inputs, we include three factor inputs (capital, labor and land)⁴. The so called “shadow prices” (SP) is calculated from the producer level of direct support (with negative sign) as a result of direct payments in farm accounts (DP). All this classification

⁴ The aggregation of the crops is made with the standard procedure used by FADN and the variables come from the individual accounting collected under FADN normalization. The detailed input-output information of each farm account is fully utilized to calculate the aggregate variables that include all production costs.

is in line with other applications in the literature⁵. In relation to the output, two types of efficiency are defined, the one using only inputs (without DP) and the other one also including DP: E_W and E_{DP} , respectively.

Beyond the aim of more market-oriented agriculture, the CAP uses TE as a key factor. Then, for the regression analysis (see Section 4.2), we select as the explanatory variables of the above TE (E_W and E_{DP}): the farming size (ESU) and crops unit equivalents per agricultural utilized area (EF) defined as a proxy for measuring how environmentally friendly the farm is, since it is intended to replicate the CAP policy makers' criteria. Besides, it is included a vector of dummy variables for agricultural regions (R) divided into North, Center, Northeast, South and East for Spain.

4. Methodology

In order to assess the impact of being environmentally friendly on being efficient and to determine the relations between public subsidies and other factors (economic size or environmentally friendliness) we apply sophisticated nonparametric methods as otherwise the chosen parametric specifications would clearly have a direct impact on the results.

4.1. Estimation of efficiency: DEA approach

The evaluation of farm performance is usually based on economic efficiency. The primary understanding is TE which allows understanding for efficient allocation of available scarce resources which has been procured within the defined farm budget constraint. This concept has been of a growing interest in methodologies and applications to efficiency measurement (Battese, 1992; Toma et al., 2015; Cherchye et al., 2017).

TE is measured using an index calculated with DEA (including DP) and a counterfactual index ignoring these CAP subsidies for each farm with all variables measured in monetary units. This allows to compare efficiency with or without included DP in the efficiency index, E_{DP} and E_W , respectively. DEA is a nonparametric approach using linear programming methods (via assigning optimal weights by solving a mathematical programming problem) to determine the envelopment of the DMUs (decision-making units) identifying "the best practice" for each productive unit. Following Coelli et al. (2005), it is formulated the input oriented DEA approach to illustrate TE via linear programming (LP). LP constructs a non-parametric piece-wise convex hull approach to frontier estimation. Efficiency measures are then calculated relative to this surface where the solving method is as follows.

Let $x \in R^p$ and $y \in R_+^q$ denote input and output vectors, respectively, with which we may define the following set of the feasible input-output combination,

$$\psi = \{(x, y) \in R^{p+q} : x \text{ can produce } y\} \quad (1)$$

For any $y \in R_+^q$ it is expressed the previous set by the input requirement set defined as

⁵ For a more detailed information about variable SP through DEA approach and also other variables used in the regression analysis, see Kleinhan et al., 2007.

$$X(y) = \{x \in R^p : (x, y) \in \psi\} \quad (2)$$

where the input efficient frontier may be determined by the following isoquant⁶:

$$\delta X(y) = \{x \in X(y) : \theta x \notin X(y), \forall \theta < 1\} \quad (3)$$

and therefore the corresponding Farrell input-oriented measure of efficiency (Farrell, 1957) is specified as the following distance function:

$$\theta(x, y) = \inf \{\theta : \theta x \in X(y)\} \quad (4)$$

So $\theta(x, y)$ defines the input efficiency (the maximum contraction) along a fixed ray away from the efficient input⁷. This DEA efficiency index defines the input efficiency and is grouped in efficient ($\theta(x, y) = 1$, meaning that the producer is input efficient) and inefficient ($\theta(x, y) < 1$, indicating that the producer is input inefficient and he may reduce inputs in that proportion while maintaining the output level). This binary censored is used to apply the regression analysis which yields relationship to produce effects on farm level efficiency.

In our counterfactual exercise, it is compared how farms do economically under the status quo allocation (and thus their present environmental friendliness) with versus without CAP subsidies. For a sample of n producers, the DEA estimate of the production set ($\hat{\psi}$) under the least restrictive returns to scale assumption (i.e., variable returns) is:

$$\hat{\psi} = \{(x, y) \in R^{p+q} : x \geq \sum_{i=1}^n \gamma_i x_i, y \leq \sum_{i=1}^n \gamma_i y_i, \sum_{i=1}^n \gamma_i = 1, \forall \gamma_i \geq 0\} \quad (5)$$

where γ_i is the intensity vector of firm i and defines its best practice or benchmark firm

by a linear combination of all the firms observed in the sample. Constraint $\sum_{i=1}^n \gamma_i = 1$

imposes variable returns to scale into the benchmark technology while the first two constraints in the Equation 5 imply that an excess of outputs or inputs can be disposed off freely.

The DEA estimates of equations 2 and 3 are then

$$\hat{X}(y) = \{x \in R^p \mid (x, y) \in \hat{\psi}\} \quad (6)$$

where the input efficient frontier may be defined by the following isoquant:

$$\delta \hat{X}(y) = \{x \in \hat{X}(y) \mid \theta x \notin \hat{X}(y), \forall \theta < 1\} \quad (7)$$

⁶ For the other option (handling CAP subsidies as output), its level could increase for a constant level on inputs which is contradictory to CAP regulations. Moreover, on one hand, the production factors considered here do not directly produce CAP subsidies (they are not part of the left-hand side of the production function) and, on the other hand, many farms in Spain have zero subsidies and would thus form a non-interpretable hyper-plane in the DEA.

⁷ Alternatively, we could formulate (5)-(7) as an output-oriented problem. In practice, the input orientated is more popular due to its easier interpretation.

while the estimate of the Farrell TE measure is computed by linear programming techniques as follows:

$$\hat{\theta}(x_j, y_j) = \min \left\{ \theta : \sum_{i=1}^n \gamma_i x_i \leq \theta x_j, y_j \leq \sum_{i=1}^n \gamma_i y_i, \sum_{i=1}^n \gamma_i = 1, \forall \gamma_i \geq 0 \right\} \quad (8)$$

Since by construction $\hat{\psi} \subseteq \psi$, the estimator $\hat{\theta}(x_j, y_j)$ constitutes a downward-biased estimator of $\theta(x_j, y_j)$. The analyzed firm j is technically efficient if and only if $\hat{\theta}(x_j, y_j) = 1$ and it is placed on the estimated frontier, while a value such that $\hat{\theta}(x_j, y_j) < 1$ means that the firm is inefficient⁸.

4.2. Analysis of efficiency: Regression analysis

In the second stage, we employ a regression model to measure farm specific factors for TE. Thus, we study the level of compatibility of the CAP, including environmental conservation and competitiveness at the farm level. As it was indicated before, the increase in consumer demand for more environmentally friendly products and the justification of the incentives paid under CAP have made “being environmentally friendly” an important issue for output efficient.

In particular, we use an application of tobit regression⁹ with limited dependent variables to estimate the factors associated to farming efficiency (Poudel et al., 2012). Since CAP uses efficiency as a key factor and under the objective of more market-oriented agriculture, we specify the following model (in euros):

$$E = \beta_0 + \beta_1 \ln(EF) + \beta_2 \ln \ln(ESU) + \beta_3 R + u_i \quad (9)$$

where:

E is the economic efficiency (E_{DP} , i.e., including DP)

EF indicates the environmentally friendly degree proxy measure

ESU represents the European Size Unit and,

R is a vector of dummy variables for agricultural Spanish regions (North, Center, Northeast, South and East) measuring possible different regional endowments.

⁸ We conclude taking into account some considerations. First, we consider the calculation of efficiency as a two-dimensional output problem (crop and animal). Second, shadow prices (SP) representing the costs paid for not producing in a subsidized manner can also be understood as including CAP subsidies (negative inputs or input subsidies). Third, since we always conduct nonparametric analysis with high-resolution level (high variance, small bias), none of our results will suffer errors due to possible misspecification.

⁹ We follow maximum likelihood approach to estimate the parameters of regression model since OLS yields inconsistency estimates. In the specification, b is a vector of unknown parameter associated with the farm specific covariates and e is an independently and identically distributed normal random variables with zero means and common variances (σ^2) as $e \sim \text{iid } N(0, \sigma^2)$.

5. Efficiency farming: Results and Discussion

First, we compare the efficiency with versus without DP under the farmer's status quo behavior, i.e., the loss/gain of economic efficiency for being environmentally friendly¹⁰. We refer to E_{DP} (including DP) as economic efficiency and to E_w as conventional efficiency under the assumption that this counterfactual exercise study how efficient the farms would be under the same allocation policy but without receiving DP. The scores are shown in Table 5.

The input-oriented model for efficient use of a given quantity of inputs, by calculating the optimal values for the input and output variables, shows that subsidies (DP) have negative impacts on TE in the Spanish agricultural sector. Thus, mean is 0.902 in economic efficient meaning that farms can potentially reduce their inputs on average by 10% and still achieve the same level of output from the existing technology. Meanwhile, mean conventional efficiency is slightly higher (9%). By type of farming, only fieldcrops, other grazing livestock and mixed animal and crops show different results for both efficiencies and except in the mixed crops all have lower E_{DP} values¹¹. This reveals that wealth and insurance effect of subsidies tend to make farmers less efficient when their motivation depend to a higher degree on subsidies as a source of income. These results for the effects of subsidies on TE are in line with those of Kleinhan et al. (2007) and Zhu et al. (2012), among others.

Table 5. Efficiency by type of farming: results

TF8 Grouping	E_{DP}	E_w
Fieldcrops	0.795	0.857
Horticulture	1	1
Wine	0.936	0.936
Other permanent crops	1	1
Milk	0.727	0.727
Other grazing livestock	0.854	1
Granivores	1	1
Mixed crops and livestock	0.905	0.834
Average	0.902	0.919

After having calculated the efficiency indexes, we focus on the “real” economic efficiency (i.e., including DP) since the calculation of conventional efficiency was a mere counterfactual exercise. Thus, we regress economic efficiency (E_{DP}) in relation to environmentally friendly behavior (EF) and economic size (ESU) both in logarithms plus a regional dummy variable (R). In the model, β is a vector of parameter associated with the farm specific covariates (Table 6).

¹⁰ Direct payments are defined as subsidies not directly linked to the output level. The possibilities of farm production include products with a DP as a monetary compensation (positive environmental externalities) whereas other have no compensation or even a cost (eg. environmental tax for a negative externalities).

¹¹ These results must be taken with caution since farms are considered at a high aggregated level (TF8). A more precise estimations are required in order to specifically identify the most efficient crops and livestock within these groups.

Table 6. Efficiency and explanatory factors: results

Efficiency	Efficiency ¹²
Ln(EF)	0.038* (0.009)
Ln(ESU)	0.026 (0.015)
R	0.002 (0.008)
Intercept	0.563 (0.087)
Obs.	89
Maximum Log-likelihood	19.44
LR X ²	23.28
Prob X ²	0.000
Sigma	(0.117, 0.01) (0.09, 0.141)

Values in parenthesis indicates standard deviation

* indicates statistical significance at 0.05 level

For the economic farming efficiency (E_{DP}) the only factor showing statistical significance is environmental friendly behavior. Thus, an increase of 1% in EF causes an improvement of 0.038 in the level of efficiency in the case of farms receiving CAP subsidies (DP). Due to the association between DP and "Greening" measures (2013 CAP reform), these results may suggest that DP become an incentive for environmental friendly behavior by farmers in order to improve the productive efficiency. As a result, some alternative rationales for continuation of DP must be proposed in terms of those greening measures. This requires to bear in mind the territorial roots of agribusiness productions, especially for the very nature of localized agri-food systems where it raises the questions of how producers related to their land, to places and to the origins of their products and to consumers' needs.

6. Proposal of a multi-layered process of generation-production-consumption of functional foods

New Rurality implies the coexistence of different uses of rural landscapes: the environmental, the socio-environmental, the agro-industrial and the peasant (Hecht, 2006). On the one hand, section 5 shows the importance of environmental friendly behavior in the agricultural production. Besides, the biotechnology advances, the expansion of global commodity markets and new production technologies have contributed both to the globalization of rural production but also to produce niche items for relatively segmented green markets (Aldrich et al., 2006). On the other hand, the literature review offered in Section 2 reveals the competitive potential of rural women as local entrepreneurs of businesses based on functional foods due to their particular positioning in the process of generation-production-consumption of functional foods, which is the main research proposition of the study.

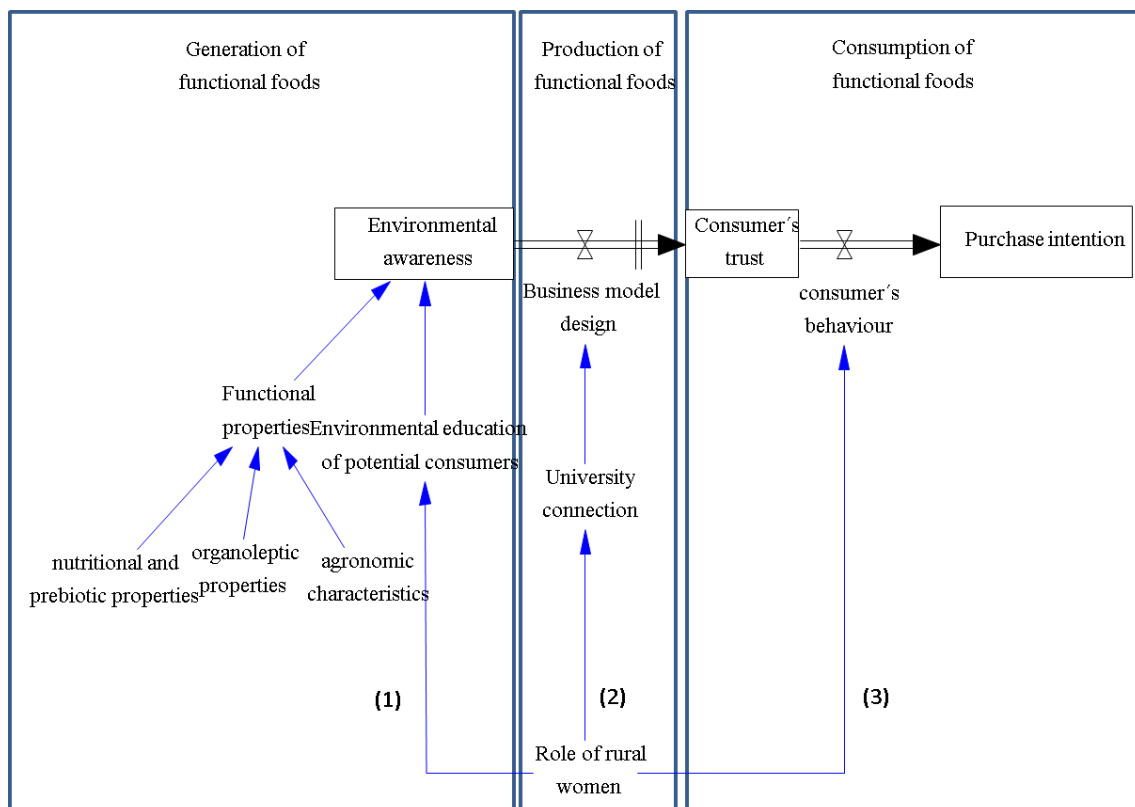
Considering both analysis, in this section we design a conceptual framework of the process of generation-production-consumption of functional foods (Figure 1). Its scheme identifies the main variables involved in each stage of the model, considering the key role of rural women. It also serves to guide the stakeholders involved in this process to build an innovative agricultural model based on the supply of functional foods. Our proposal follows the line of research of green business models initiated by Rajala et al. (2016) and uses the methodology used is the System Dynamics (Forrester, 1961;

¹² We only show the results for E_{DP} since our counterfactual exercise do not lead us to get robust estimations.

Stearman 2000). The main goal of this framework is to get a better understanding of the aspects that are not usually considered in traditional agricultural business models.

The initial aspects to bear in mind in the model, according to Kikuchi-Uehara et al. (2016), are environmental awareness and trust in environmental information since it can affect consumers' choice of environmentally conscious products. Then, business models based on functional foods should be designed to address this consumers' behavioral change in purchase intention.

Figure 1. Conceptual framework of the process of generation-production-consumption of functional foods



On the premises.

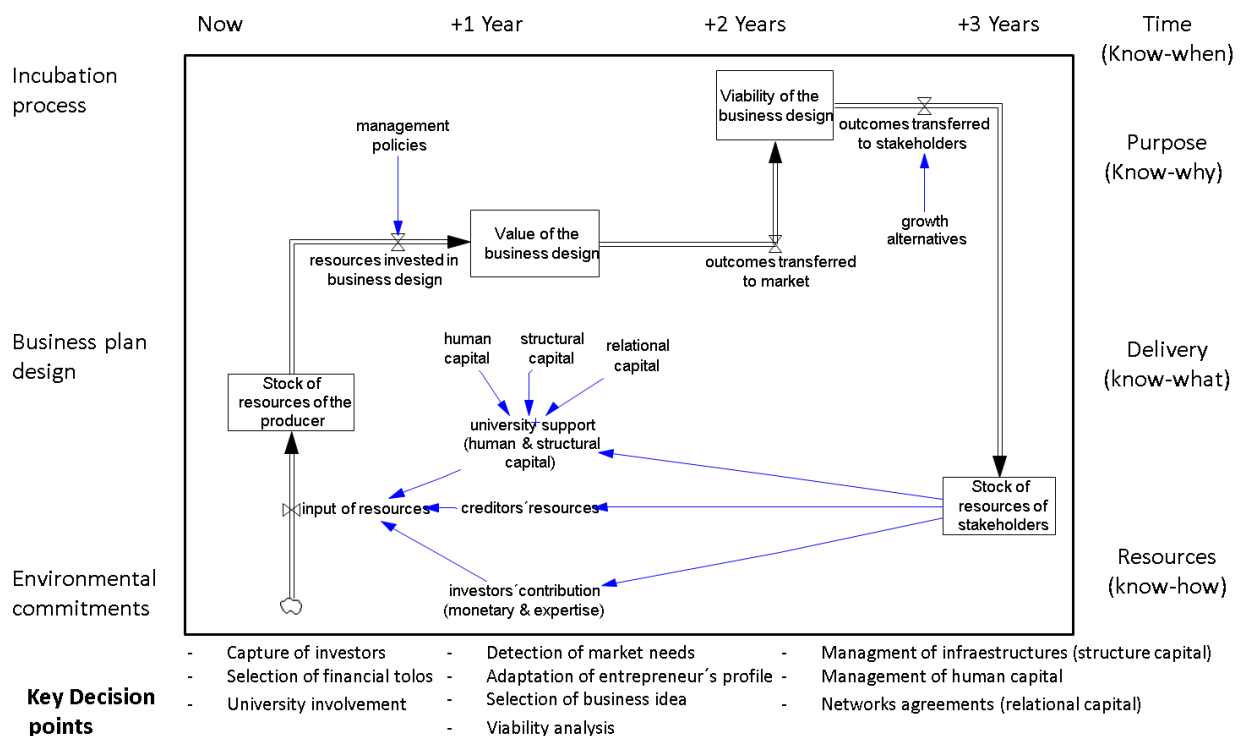
Table 7. Legend.

Variable	Legend
Environmental awareness	Consciousness of the role of environment on consumption patterns
Functional properties	Nutritional, organoleptic and agronomic properties of food
Nutritional and prebiotic properties	Food ingredients that induce the growth or activity of beneficial microorganisms and reinforce the value of nutrients for the organisms.
Organoleptic properties	Food characteristics that an organism experiences by the senses
Agronomic properties	Food characteristics induced by plant experts
Environmental education of potential consumers	Understanding and appreciation of the environment in the formation of healthier patterns of consumption
Business model design	Business plan that connect the environmental awareness with the consumer's behavior
University connection	Relations between producers and researchers of functional foods
Consumer's behavior	Consumption patterns based on targeted preferences
Purchase intention	Explicit behavior conducted to buy functional foods

In Figure 1 the role of rural women is identified as the driver of the process of generation, production and consumption of functional foods. In the generation of functional foods the role of rural women as educators in the family environment is essential in the social environmental awareness (relation 1). Advancing through the process, in the production stage, more proactive connections of rural women as agricultural producers with academic institutions will allow the knowledge transfer about new properties of functional foods through the direct access to university specialists (human capital), the use of laboratories to test the healthy benefits of these products (structural capital) and the involvement of potential investors in this production (Rodeiro et al. 2008). Although this connection (relation 2) does not look like easy because of the distance between rural women and universities, there are public incentives coming from the European Commission aimed to bring these two worlds closer. Finally, in the stage of consumption of functional foods, the role of rural women as buyers for the family consumption will increase the purchase intention of current and potential consumers of functional foods (relation 3) (Stein and Rodriguez-Cerezo,2008).

As a final result of the analysis, a model of multi-layer process of business design for producing functional foods is proposed following the previous conceptual framework (Figure 2). This model explores the interrelationship between structure and dynamic behavior of the variables (Forrester, 1961), and it aims to support the planning of tasks through the time line, identifying and assessing possible threats and opportunities in the business environment (Phaal et al., 2004). Following the approach of Phaal (2015), a flow diagram of the interrelations of the different layers through the time was built. This tool lets to use some of the layers of the roadmap from a dynamic approach.

Figure 2. Multi-layer process of the generation-production-consumption of functional foods.



On the premises.

Table 8. Legend.

Variable	Legend
Stock of resources of the producer	Accumulated supply of assets of the producers
Input of resources	Addition of university resources, creditors' resources and investor's contribution
University support	A combination of human capital (knowledge of researchers), structural capital (laboratories and procedures) and relational capital (alliances with other researchers and institutions)
Value of the business design	Economic difference between the value of the resources invested in the business design and the outcomes transferred to the market
Management policies	Criteria defined to invest resources in the business design
Viability of the business design	Economic difference between the value of the outcomes transferred to the market and the value of the outcomes transferred to the stakeholders
Stock of resources of stakeholders	Accumulated supply of assets of the stakeholders

Figure 2 shows a flow diagram that relates the initial competitive position of the company in the market of resources according to the stakeholders commitments (investors, creditors, university support), the flow of resources that supports the value of the business plan according to the internal policies (criteria that conditions the behavior of the firm) and the decision process that manages the transfer of resources through the business design towards the stakeholders. The behavior of the flow diagram will condition the viability of the green business model to survive, grow and return the investments to stakeholders through the time line. This design lets us to illustrate how the business design can link the strategic goals with the decisions involved in the transfer of resources (Phaal et al., 2004). Following the road mapping methodology, we have identified four layers: (1) Time (years), (2) Strategic process (stakeholders' commitments, business plan design, incubation process), (3) Key Decision points and (4) Strategic Formulation (resources, delivery, purpose).

Advantaged commitments with stakeholders provide competitive advantaged of the farmers of functional foods in the market of resources. If producers can get favorable agreements with investors, creditors and support institutions (they need to value the bioeconomy model), they will get a better stock of resources that will flow to increase the value of the business design. Finally, the decisions involved in the transfer of outcomes (value proposal of the functional foods) will determine the current and future viability of the green business model in the market, and the return flow of investments to stakeholders. This flow diagram allows successive iterations, following a dynamic perspective. Thus, in year 3, the transfer of resources through reinvestment (direct transfer) or through the stakeholders' behavior (indirect transfer) will activate the flow of initial resources of the producer, in a recursive structure.

Thus, rural women can use this conceptual framework to identify the key decisions that leverage their competitive advantage in the design of a business model based on functional foods. Thus, table 9 shows the relation among key decisions, strategic formulation and the competitive advantage of rural women.

Table 9. Key decisions and competitive advantage of rural women

Key decision	Strategic formulation	Competitive advantage
<i>University support:</i> To get the advice of experts in functional foods <i>Investor's support:</i> To get the financial and management resources to support the business	Competition in resources market: - Alliances with research groups (human capital, structural capital, relational capital) - Alliances with business angels and institutional financiers	<i>Easier links with researchers:</i> the collective of rural women are treated as a priority in research projects funded with public resources of the European Commission. <i>Credit facilities</i> for women entrepreneurs.
Detection of <i>market needs</i> Selection of <i>product/market</i> <i>Scenario planning</i> (viability analysis)	Business design: strategic logic (what and why) - Design of value proposals based on the differential health benefits of functional foods	<i>Personal identification</i> with client's needs (producer profile similar to client profile) <i>Previous experience</i> with farming products
Management of <i>structural capital</i> Management of <i>human capital</i> Management of <i>relational capital</i>	Growth vectors: alliances and growth alternatives - Alliances with distributors - Alliances with competitors	<i>Previous links with researchers</i> Proximity to local partners (network potential based on trust)

This analysis reinforces the leverage points of the strategic formulation in green business models: alliances with suppliers of knowledge (researchers), identification with their reference groups (investors, clients) and management of intellectual capital (structural, human, relational). From the approach of this analysis, rural women are better positioned than others in the business process of generation-production-consumption of functional foods, although the final viability of the business will depend on the design of policies that affect to the stock and flow of resources.

7. Conclusions

The impact of subsidization on farm TE are becoming a critical issue in applied policy analysis. The aim of this article is to analyze the triangular relationship between efficiency, environmental friendliness and subsidies in Spain, as a representative Mediterranean member of the EU. Economic performance can be studied by efficiency measures such as technical efficiency (TE) or economic efficiency (E_{DP}) and, in this sense, the direction of CAP subsidies affect farm performance. Our findings reveal that public subsidies (DP) have negative impacts on TE in the Spanish agricultural sector, both on average and by type of farming. This calls into question whether the farm income support of CAP is suitable to achieve its goal to increase farmer' competitiveness by improving their efficiency. However, our results also suggest that DP become an incentive for environmental friendly behavior by farmers in order to improve the productive efficiency.

Under those premises, this study contributes to the current knowledge of Bioeconomy by proposing a conceptual framework that manages the process of generation-production-consumption of functional foods, involving not only the knowledge transfer coming from academic experts in the healthy properties of new ecotypes of functional products, but also the multiple role of the rural women as producer, educator/advisor and buyer of these products. The approach used in the analysis bases on previous studies of the multiple role of rural women in the supply and demand sides. From a general

overview of the generation-production-consumption of functional foods, this work also proposes a multi-layered model for supporting strategic decisions that involves the positioning of rural women in each of these stages, considering as layers: time, strategic process, key decisions and strategic formulation.

By analyzing the value chain of functional foods, the model proposed shows a multi-layer process characterized by co-dependent dynamics and competitive cooperation strategies. It can be also harnessed to support existing product introductions or managed to preserve competitive standing against existing rivals. As a consequence, during the process there are more possibilities of territorial and sectorial concentration based on innovative activities, increasing the economic development of rural areas from a sustainable approach. In summary, this paper defines a new comprehensive framework for the design of green business models, from a dynamic perspective, that supports the competitive advantage of rural women as local entrepreneurs of businesses based on functional foods

Finally, this study encourages the participation of society from a Bioeconomic approach, through new commercial uses of farming land that increase healthy consumption and the viability of green business models. Moreover, our results can be extended to other rural products or related economic sectors such as rural tourism or renewable energies. The current fragmentation of the research of these aspects limits the extrapolation of conclusions. Future research could contribute to extend the study of the policies implemented in these business models, and also identify best practices through the analysis of multi-case studies.

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