The Impact of Resource Intensification on the Resource Use Efficiency among Dairy Farms: Gross Margin and Production Function Approaches

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Abstract

The impact of agricultural resource intensification on the resource use efficiency is not fully understood in most of the developing countries. No enough empirical evidences are available to address this impact. This study aimed at providing an empirical evidence of the effect of resource use intensification on the resource use efficiency of dairy farms in Jordan. Both marginal analysis and production function procedures were followed in this study. The marginal procedure was based on the comparison of the Marginal Value Product of the variable inputs (MVP) with their Marginal Cost (MFC) to estimate the efficiency of the used resources in two dairy production systems; intensive and semi-intensive systems. The production function procedure conducted by developing of multiple regression models for the used inputs in the investigated production systems. A structured pre-tested questionnaire was used for data collection. Two hundred fifteen dairy producers were interviewed. The results of the study revealed that there is no need for any modifications in the rate of use of all resources in the intensive dairy production system since all resources are ideally utilized and farmers are maximizing profits. In the semi-intensive dairy production system increasing the number of dairy cows and cost of veterinary services, drugs, and vaccines and decreasing the quantity of labor and cost of feed will increase farmers profits. The overall conclusion is that resource use intensification will end in improving its use efficiency and profit maximization of dairy farms. Encouraging farmers to shift to intensive production systems by providing credit facilities, subsidized inputs and specialized extension services will aid in this regard.

Keywords: Resource intensification, resource use efficiency, dairy farms, marginal analysis, marginal physical product, marginal factor cost, over utilized, underutilized.

1. Introduction

Among livestock sectors in Jordan, in terms of enterprise investment volume, the dairy sector is ranked in the second place after the poultry sector. This sector is one of the main sectors for fresh milk (AL-Sharafat, 2013). According to the records of the Jordanian Ministry of Agriculture (MOA), the total number of dairy producers in Jordan in the year 2014 is around 6800 running 580 working dairy farms with a capacity of 120000 dairy cows and producing around 310000 metric tons of fresh milk. The country is completely self-sufficient in this product (MOA, 2014). Challenges faced by Jordanian dairy sector such as fluctuations of fresh milk price, limited financial resources, increase in feedstuffs prices, health problems and inefficient marketing channels has been largely reflected on the efficiency and productivity of this sector. In the last decade a dramatic change has occurred in dairy industry in Jordan. Large dairy farms depending on intensive production system were established.

This structural change with tendency towards the implementation of more intensive production systems in Jordanian dairy industry have significant effects on the economic and financial performance of this industry (Al-Faqeer, 2009). Cooper et., al (2004) stated that the efficient production process is when the output is improved without worsening inputs. The situation of input intensification occurs when there is an increase in the total volume of agricultural production that results from a higher productivity of inputs, or agricultural production is maintained while certain inputs are decreased (FAO, 2004). The main aim of input intensification is to increase agricultural production per unit of inputs.

World population is continuously growing and for satisfying the human needs that increase causes changes in agricultural practices to be intensive (Roman et., al, 2006). In a study aimed at estimating how rural population density affects both agricultural intensification and household well-being Jacob et. al., (2014) concluded that households in more densely populated areas increasingly rely on off-farm income to earn a living. Pingali et al., (1987(and Ruthenberg (1980) have examined the relationship of agricultural intensification under increased population and showed that as population density increases returns to agricultural labor appears to decline quite slowly indicating remarkable degree of substitutability of capital and labor for land in the long run. Additionally, more labor intensive fertilizer techniques (composting and manuring) are increasingly used as agricultural intensification increased (Pingali and Binswanger, 1988). In areas of high population density a move towards the more intensive use of agricultural inputs is needed (Turner et al., 1993). Lipton (1989) stated that as population grows, agricultural intensification practices are needed for poverty alleviation. Agricultural intensification may lead to increase either (or possibly both) the quantity and quality of livelihoods through increasing the value of output per unit of land which in turn will result in an increase livelihood sustainability (Arnold and Dewees, 1995).

Agricultural intensification can be measured by the increased inputs per unit of land, by the frequency of cultivation (reduced fallow), or by total factor productivity (Binswanger, et al., 1993). In addition to increase production, agricultural intensification could be a useful tool to handle agricultural risks. The time of intensification and the decisions related to product diversification are two issues largely related to agricultural risk management. (Schelhas 1996; Roumasset et al., 1979). In dairy farms, increasing the number of dairy cows per unit of land as well as increasing concentrates in the diet is the base of intensification of production leading to certain structural changes in the farms (Caviglia-Harris, 2005).

These structural changes in dairy farms resulting from intensification may have significant effects on the resource use efficiency of these farms (Alvarez et al., 2008). Reinhard et al. (1999) found that extensive dairy farms were technically less efficient compared to intensive dairy farms in the Netherlands in terms of resource use efficiency. Simpson and Conrad (1993) analysis of dairy cattle production in 7 countries in Central America revealed similar results of those obtained by Reinhard et al. (1999). Ledgard et al. (2004) argued that intensive production systems among dairy farms in New Zealand increased production and resource use efficiency despite the findings that these systems decreased environmental efficiency. Greater levels of resource use efficiency among intensive dairy farms in Portugal were reported by Hallam and Machado (1996). The aim of this study is to offer an empirical analysis of the effect of resource use intensification on the resource use efficiency of dairy farms in Jordan.

2. Dairy Production Systems in Jordan

2.1: Intensive production system

This system exists in farms distributed across the country with average size between 40-100 cows per farm. It is dominant in the eastern semi-arid area of Jordan were the largest amount of milk in the country is produced. The eastern semi-arid area of Jordan is characterized by high temperature in summer and very low temperature in winter. Under intensive dairy production system two categories can be classified: the large scale farms and the average-size farms. Holstein Friesian breed is dominant in these two categories. Under this system of production animals are reared in barns. Land areas used in this system are mostly less than 10 Dunums (one hectare) per farm.

In Jordan, producing nearly 50% of the total milk produced in the country, the intensive dairy production system is dominated in Ad Dulayl area. In this area dairy farmers benefit from the Dairy Breeders Association, which helps farmers in milk marketing, water support and other technical issues. On average, the production is about 6000 kg/cow/year. In this type of dairy production crop production is separated from dairy farming. Dairy farming depends on concentrate feeds (maize, barley, soybeans, wheat bran).

Under this system of production large farms are provided with mixed rations and advanced feeding programs. Feeders are used to deliver fodder and concentrates to the barns.

2.2: Semi-intensive Production System

This type of dairy production systems is dominant in the northern highlands and the Jordan Valley. Shami and Akshi (local breed) are the major breeds in this system. Farmers adopting this system are now gradually replacing the local breeds by Holstein breed. Under this system, farm size is ranging from 1 to 20 dairy cows. Cows are housed in small traditional brick barns, with no protection against solar radiation in the hot summer, or the cold weather in winter. Less management practices than in the intensive system are observed. This system is also characterized by poor feeding resources, less health management, and less sound housing facilities. Farmers use both hand milking and mobile milking machines. Only small areas of land are used to produce fodder crops. Farmers prefer to use crop by-products in this system.

3. Materials and Methods

3.1: Sample and sampling procedure:

Two hundred fifteen dairy producers were interviewed. The selection criterion of the sample was based on the relative importance (number of dairy cows in the region divided by the total number of dairy cows in the country) of the number of dairy cows in each part of the three main parts of the country (North, Middle and South). Following New bold (1995), the sample size was determined according to the following equation:

n = [(p. q . z2)/ e2]/ [(N . e2) + (p . q . z2)/ (N . e2)]
Where:
N = Population (580).
n = Sample size (?).
p = The proportion that the sample will occur (0.5).
q = The proportion that the sample will not occur = (1- p) = (0.5).
z = The standardized score (1.96).
e = Error term (0.05).

The sample size was determined at a confidence level of 0.95. According to the above equation was 231. For precession reasons and due to invalid data 16 questionnaires were not included in the statistical analysis. The remaining 215 questionnaires were statistically analyzed.

3.2: Data

To obtain information from the interviewed producers a structured pre-tested questionnaire was used. The questionnaire was designed to get information on factors related to input use intensification as well as the economic performance of the surveyed farms. The data were collected for both the intensive and the semi-intensive dairy production systems in the three regions of the country (North, Middle and South). The main inputs considered in data collection for the intensive and semi-intensive production systems include; number of cows, labor, veterinary services and feeds. These inputs have been included in many previous studies related to production efficiency and resource use efficiency (Mbaga et al., 2003; Binam et al. 2004 and Bravo-Ureta & Rieger, 1991). Other variables regarding the socio-economic aspects were included in the survey. The period of primary data collection was from March 1st, 2014 to July 30th, 2014. Secondary data were obtained from its original sources; Ministry of Agriculture, Department of Statistics, Agricultural Directorates, Governmental Reports, Research Institutions and Universities, ..etc.

3.3: Analytical Framework

To achieve its objectives in evaluating the impact of input use intensification on the input-use efficiency of dairy farms in Jordan, statistical analysis in this study was based on the application of both marginal analysis and production function procedures. To achieve objectives similar to the objectives of the present study several studies adopted this procedure (Taru et al., 2010). As Oladeebo and Ezekiel (2006) stated, the comparison of the Marginal Value Product of the variable inputs (MVP) with their Marginal Cost (MFC) is the core of the marginal analysis procedure in determining the efficiency of the used resources.

The MVP was computed after computing the Average Physical Product (APP) and the Marginal Physical Product (MPP). The result of dividing the Total Physical Product (TPP) by the quantity of the variable input gave us the APP, which is the output produced per unit of input used.

MPP is the change in TPP divided by the change of the variable input quantity. MPP was computed by multiplying APP with elasticity's of factor inputs obtained from a the regression model which was developed for the used inputs. The unit input price or the market price of the input (Pxi) is the Marginal Factor Cost which is usually abbreviated MFC.

Multiplication of MPP with the unit price of the output (Py) gave us the Marginal Value Product of the variable inputs (MVP). The resource use efficiency simply obtained by dividing MVP by MFC. The resource use efficiency for both the intensive and the semi-intensive dairy production systems were determined. To evaluate the impact of input use intensification the resource use efficiency for the intensive dairy production system will be compared with the resource use efficiency for the semi-intensive dairy production system.

A multiple regression model representing Cobb-Douglas production technology for the used inputs in both the intensive and the semi-intensive dairy production systems was developed to obtain elasticities of factor inputs for both the intensive and the semi-intensive dairy production systems adopted in Jordan. Multiplying APP with elasticities of factor inputs obtained from a regression model for the used inputs gave us MPP values. Cobb Douglas production function was used in several studies to measure resource use efficiency (Anene, et al., 2010, and Gani and Omonona, 2009). The implicit form of the model is as follows;

Q = f(X1, X2, X3, X4,…, Xn , U)
Where
Q = quantity of milk produced (tons).
X1 = number of dairy cows (number).
X2 = labor (hrs)
X3 = cost of veterinary services, drugs, and vaccines (JDs)
X4 = cost of feeds (JDs)
μ = stochastic error term

4. Results and Discussions

Table 1 shows the percentages of dairy farms in the three regions of the country (North, Middle and South) and table 2 shows sample distribution according to the percentages in table 1. Table 3 shows number of dairy cows in the country based on dairy groups and table 4 shows the sample distribution according to the groups presented in table 3. Table 5 shows the sample distribution according to production system. Farmers were randomly selected for interview in each of the three regions.

Table 1. Percentages of dairy farms in the country;

Region	Percentage (%)
North	55
Middle	35
South	10
Total	100

Source: MOA, 2014.

Table 2. Sample distribution according to percentages presented in table 1;

Region	No. of Interviewed Farmers
North	118
Middle	75
South	22
Total	215

Source: Field survey.

Table 3. Groups of dairy farms in the country;

Group	No. of Dairy Cows	Percentage (%)
1	0 - 10	34
2	11 - 25	47
3	26 - 50	14
4	more than 50	5
Total		100

Source: MOA, 2014.

Table 4. Sample distribution according to groups presented in table 3;

Group	No. of Interviewed Farmers
1	73
2	101
3	30
4	11
Total	215

Source: Field survey.

Table 5. Sample distribution according to production system;

System	No. of Interviewed Farmers
Intensive	154
Semi-intensive	61
Total	215

Source: Field survey.

Dairy production is found all around the country. Among other regions in the country, the Northern region is with the highest percentage of dairy farms. This is mainly due to the ease of marketing and presence of many associated facilities and services compared to the other two regions. 55% of dairy farms are located in this region. The middle and south regions contains 35% and 10% respectively. Dairy farms with 11 – 25 heads are the dominant category in the country. These farms constitute 47% of the whole dairy farms in Jordan. The lowest percentage is the dairy farms with more than 50 heads (only 5%).

4.1 Production Function Estimates

Based on goodness of fit and depending on the highest value of adjusted R² and F-value, among other fitted functional forms of the production function, the double log form was chosen. The form is presented below:

$\ln Q = \ln\beta + \beta 1\ln X1 + \beta 2\ln X2 + \beta 3\ln X3 + \beta 4\ln X4 + \ldots\ldots + \beta n\ln Xn + Ui$

Where

ln = natural logarithm

β = constant

Q, X1, X2 … X4, and Ui are as defined in the analytical framework section (3.3).

The tables below presents the estimated form of the production function for intensive and semi-intensive production systems. Table 6 presents the estimated form of the developed Cobb-Douglas production function for intensive production system and table 7 presents the estimated form of the developed Cobb-Douglas production function for semi-intensive production system;

Table 6. Estimated production function for intensive production system farms:

Factor	Coefficient	t-value
Constant	5.6012	6.1748*
X_1 (number of dairy cows)	0.9932	12.151**
X_2 (labor)	0.5547	1.9543*
X_3 (cost of veterinary services, drugs, and vaccines)	0.0966	0.6657**
X_4 (cost of feed)	- 0.4111	- 3.8751**

**Significant at 1% level; *Significant at 5% level; R^2 = 0.811 Adjusted R^2 = 0.842 F = 203.12*.

Table 7. Estimated production function for semi-intensive production system farms:

Factor	Coefficient	t-value
Constant	3.8541	8.2370*
X_1 (number of dairy cows)	1.1088	14.891**
X_2 (labor)	0.7599	1.1853*
X_3 (cost of veterinary services, drugs, and vaccines)	0.1038	0.6984**
X_4 (cost of feed)	- 0.6002	- 4.7741**

**Significant at 1% level; *Significant at 5% level; R^2 = 0.871 Adjusted R^2 = 0.892 F = 203.12*.

The estimates of the intensive system production function revealed that the included explanatory variables explained 81% of adjusted variability observed in dairy production in the sample of this system. The remaining 19% are due to residual error. In the semi-intensive production system the included explanatory variables explained 87% of adjusted variability observed in dairy production under this system. The remaining 13% are due to residual error.

The estimates also show that an increase in the quantity of milk produced will result if any of the included variables except the cost of feed was increased. Cost of feed is negatively related to the quantity of milk produced, which means that any increase in this variable will lead to a decrease in the quantity milk produced. Milk production will be decreased by 0.6% if the cost of feed increased by 1%.

4.2: Elasticities of factor inputs

The coefficients estimated in tables 6 and 7 are actually the elasticities of factor inputs of production to be used in determining the resources use efficiency as explained in section 3.3. A table 8 and 9 presents these elasticities for both the intensive and the semi-intensive production systems:

Table 8. Elasticities of factor inputs for intensive production system;

Factor	Coefficient
X_1 (number of dairy cows)	0.9932
X_2 (labor)	0.5547
X_3 (cost of veterinary services, drugs, and vaccines)	0.0966
X_4 (cost of feed)	- 0.4111

Table 9. Elasticities of factor inputs for intensive production system;

Factor	Coefficient
X_1 (number of dairy cows)	1.1088
X_2 (labor)	0.7599
X_3 (cost of veterinary services, drugs, and vaccines)	0.1038
X_4 (cost of feed)	- 0.6002.

4.3: Efficiencies of resources use

Resources use efficiencies for both the intensive and semi-intensive production systems were determined by dividing MVP by MFC. The indicators of the resources use efficiencies are presented in tables 10 and 11:

Table 10; Indicators of resource use efficiency for intensive production system;

Factor	MVP	MFC	Efficiency	Description
X_1 (number of dairy cows)	129.01	121.15	1.064	Efficiently utilized
X_2 (labor)	0.5892	0.5747	1.023	Efficiently utilized
X_3 (cost of veterinary services, drugs, and vaccines)	19.555	19.998	0.977	Efficiently utilized
X_4 (cost of feed)	- 335.05	329.	– 1.015	Efficiently utilized

Table 11; Indicators of resource use efficiency for semi-intensive production system;

Factor	MVP	MFC	Efficiency	Description
X_1 (number of dairy cows)	204.13	141.94	1.438	Under utilized
X_2 (labor)	1.0038	3.6522	0.275	Over utilized
X_3 (cost of veterinary services, drugs, and vaccines)	27.098	3.2954	8.223	Under utilized
X_4 (cost of feed)	- 239.61	371.57	– 0.645	Over utilized

An optimum amount of a variable input or resource to be used efficiently is when the value of the resource use efficiency equal to 1. If MVP is lower than MFC, the resource use efficiency is less than 1 and the resource here is over utilized or it is excessively used. If MVP lower than MFC, the resource use efficiency is more than 1 and the resource here is underutilized. The values of resource use efficiencies for both the intensive and the semi-intensive dairy production systems adopted in Jordan as shown in tables 10 and 11 indicates that the number of cows, labor, cost of veterinary services and cost of feed resources are efficiently used in the intensive production system. The same resources in the semi-intensive production system are either underutilized or over utilized used means that they are inefficiently used.

5. Conclusions

The results of the study revealed that production resources such as number of cows, labor, cost of veterinary services and cost of feed resources used in intensive dairy cows production system are utilized in an efficient and optimum way. This efficient use of these resources means that farmers are maximizing profits.

In the semi-intensive dairy production system, the same resources are either underutilized or over utilized which means that these resources are inefficiently used. If the resource is over utilized or being excessively used, decreasing the quantity used of that resource increases profits. If the resource is underutilized or being under used, increasing its rate of use will increase profit level. The results of the study showed that there is no need for any modifications in the rate of use of all resources in the intensive system of dairy production since all of these resources are ideally utilized and farmers are maximizing their profits. In the semi-intensive system dairy production system, increasing the number of dairy cows and cost of veterinary services, drugs, and vaccines and decreasing the quantity used of labor and cost of feed will increase farmer's profits. The overall conclusion is that resource use intensification will end in improving its use efficiency and maximizing profits of dairy farms. Encouraging farmers to shift to intensive production systems by providing credit facilities, subsidized inputs and specialized extension services will aid in this regard. In Jordanian dairy production under semi-intensive systems re-adjusting use of resources is needed; number of dairy cows and cost of veterinary services should be re-adjusted upwards and labor and cost of feed should be re-adjusted downwards.

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