SUPPLY RESPONSE OF MILK PRODUCTION: ANALYSIS AND IMPLICATIONS FOR BRIC COUNTRIES

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Abstract
This paper examines the supply response of milk production in BRIC countries using annual data for the period 1992 to 2010. The results derived from panel data analysis support a strong positive supply response of milk prices to the number of milking animals and total milk yield. The study also finds a strong association between price of substitutes between chicken meat and milk. The non-price factors like membership in WTO and exports have a positive impact on supply response in terms of number of milking animals. The study unfolds that export of milk have a favorable impact on the supply response both in terms of number of milking animals and milk yield. The analysis suggests that milk supply in BRIC countries is responsive to the price factors and hence price support and subsidies programmes for dairy farmers in BRIC need to more visible and effective. Such results clearly make a case for introduction of Minimum Support Price (MSP) for milk famers in BRIC countries. Milk producers in BRIC countries can take advantage of the enhanced market access provided by WTO and simultaneously increase their herd size.

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1. Introduction

Dairy sector has assumed key importance in generation of income and ensuring food security in many countries. The success of dairy sector depends on production and availability of raw milk. A large section of rural population depends on livestock as their central source of livelihood. There are approximately 600 million livestock keepers in the world whose income levels stand far below poverty line. Milk production procures two advantages over other common agricultural crops. First, milk is a highly valued livestock product and second, unlike the twice harvested annual agricultural crops in developing countries, it delivers instant income on sale. Growth of world production of milk rests on two prominent pillars- a rising demand for milk and a rising supply. As per FAO projections, by 2025 demand for dairy product in developing countries is expected to spurt by 25% as compared to the current demand (FAO, 2013). So an escalating demand for dairy products brightens the sectors future potential to grow. The OECD - Food and Agriculture Organisation outlook report (FAO, 2011) states that international dairy price has increased considerably during the last two decades. A rise in dairy price can act as a deterrent to the nutritional upliftment of the poorer sections of the society. So, an enhancement in the supply of milk

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production is important to ensure affordability of milk and milk products to the mass. Therefore it is imperative to examine the effects of price and non-price factors on milk production. Moreover, price and tax regulations in dairy sector should reckon the responsiveness of milk supply to price and non-price factors and modify their policy stances.

FAO figures reveal that the world cow milk production stands at 72.7 million tons in 2011(FAOSTAT, 2013). In terms of total milk production, BRIC nations, namely, India, Brazil, China and Russian Federation secure second, fourth, fifth and sixth positions respectively. Almost one third of the world's milk production originates from BRIC nations. [1]Over the last decade production of milk in BRIC nations exhibited a sharp increase by 50%. Production of milk can be enhanced either by multiplying the number of milking animals or by boosting yield An analysis of supply side determinants of milk production will thus indicate whether price policies and subsidies will really incentivize milk producers in BRIC countries. A number of studies have focused on effectiveness of various policy measures on milk supply. For example a study by Sckokai (2003) attempts to analyze milk supply response under quota trade in Italy. Bryantet al. (2007) estimated the impact of milk income loss contract programme on US milk production. However studies dealing with impact of WTO on milk production using cross country data are scanty. Hence the present study intends to examine two issues. First, whether price factors influence the total milk supply in BRIC countries, and second, whether opening up the economies in the post WTO context had substantially resulted in an increase in the trading opportunities in dairy sector and had any impact on milk supply in BRIC countries. The paper comprises of five sections. The following section presents a brief review of literature on determinants of milk supply. Theoretical justification of variable selection is discussed in section 3. Sections 4 and 5 delineate the methodology for estimation and data sources respectively. In section 6 empirical results and their implication are deployed and the final section outlines the concluding remarks.

2. **Review of Literature**

The literature pertaining to supply responses of the agricultural commodities is vast. Supply response of agricultural products especially for food grains have been explored by a number of scholars such as Nerlove (1979), Krishna (1995a), Krishna (1995b), Rosegrant et al. (1998), and, Bardhan (2003). Extensions of supply response analysis to the dairy industry vary in terms of techniques used, geographical areas and selection of dependent variables. Some studies are specific to the various dairy policies and their impacts on milk supply response.

A number of studies such as Levins (1982), Chavas (1986), Thraen and Hammond (1987), Blayney and Mittelhammer (1990), Tauer (1998), Mckay et al.(2000), Coleman and Harvey (2003), Chavas and Kim (2004), Wasim (2005), Bryant et al.(2007),Tauer (2008), Jezahani and Moghaddasi (2009), Rajmohan et al.(2008), Chattha et al. (2013), Bozic et al. (2012) have looked into different dimensions of milk supply- such as supply elasticity of milk production, impact of non-price and policy variables on milk supply. Though these studies differ in terms of methodology used

[1]A Brief profile of milk production of BRIC countries is provided in Appendix A

and geographical locations, a majority of them found that milk price has significant impact on the supply of milk. However, the value of supply elasticity of milk production does differ across studies. Studies by Chavas (1986), and, Thraen and Hammond (1987) reveal that elasticity coefficient is high and greater than one, whereas, Tauer (2008) using fixed effect model estimated the supply elasticity as 0.2 in the short-run and exactly 1.0 in the long-run for New York Dairy market during 1985-1993.Thraen and Hammond (1987) have analyzed the influence of price support programs and risk on milk production. Empirical results indicate that dairy farmers in US were risk sensitive. The study also suggests that termination of price support programmes will increase the risk of milk farming and result in a decline in milk supply. Applying a mixed frequency herd dynamics model Bozic et al. (2012) estimated a positive supply elasticity of milk in the USA but also reported a declining trend of supply elasticity during 2005-2010. This study votes in favour of strong price support policies for the dairy farmers. Since higher input costs were identified as a major hindrance to the dairy supply, the study advocates a substantial emphasis on expanding profit margin rather than revenue generation.

Impact of policies on dairy supply have been explored by various studies, such as Bozicet al.(2012), Sckokai (2003),Bryant et al.(2007). For one, Sckokai has found that size of quota rents affect the milk supply of the Italian dairy sector whereas Bozic et al.(2012) reveals that the impact of policies like Milk Development Programme in US dairy industry were effective only for short term. However, Bryant et al. (2007) found that the Milk Income Loss Contract (MILC) program did not have any significant impact on milk supply in US dairy sector during 2002-2007.

However, none of the aforementioned studies have attempted to analyse the determinants of milk supply in BRIC countries, despite their substantial share in world milk production. Though a few studies like Munshi and Parekh (1994) explores issues of milk supply behavior in India, country level studies using FAO data are not available in the literature. Studies addressing the impact of trade liberalization on milk production in the post WTO context are also scanty[2]. Moreover studies which have factored in the price and production substitute commodities as a determinant of addressing milk supply response [e.g,Thraen and Hammond, 1987; Bryant et al.(2007), Chattha et al (2013)], have concentrated only on price of culled cows as an indicator of competing commodities. However, over the years share of chicken meat production and consumption is ascending in these countries. Hence we have included price of

[2]The members of BRIC countries have adopted various measures to integrate their dairy sector with the rest of the world. Before 1995 Indian dairy sector was highly protected and the domestic dairy producers were protected using quotas, but in order to get a greater market access India opened up its dairy sector with a low level of average applied tariff rate (India's average applied tariff rate reduced to 34.7% in 1997 from 55.1% in 1990) and also abolished its Quota restrictions on dairy products. Similarly Brazil also opened up its trade in dairy sector by reducing the applied tariff rates though applied rates for dairy sector was at a higher level than the other products in Brazil. After 1995 China's dairy import has increased at a rate which is twice than the rate of global trade. Multinational companies entered dairy markets in China with the relaxation of constraints on foreign investment under China's WTO commitments (Fuller et al., 2006).

chicken as a variable to check the impact of substitute commodities on milk production in BRIC countries.

3. Theoretical Justification of Variable Selection

The present study tries to identify the influence of price and non- price factors on two indicators of milk supply- total milk production and total milk yield. Theoretically, milk supply is a function of milk price, price of substitute goods, quality of milking animals, cost of inputs etc. Price of milk is expected to be positively associated with the number of milking animals and milk yield. A higher price of milk, ceteris paribus will enhance the profitability of milk production and hence motivate milk producers to increase their herd size and yield of the milking animals. Milk producer's decision regarding the number of milking animals also depends on the expected price of milk which broadly can be captured by previous year's milk price. Price and production conditions of the related commodities can also influence milk producer's supply decisions. Prices of competing commodities are expected to influence milk supply negatively. For example, an increase in relative price of chicken is expected to motivate livestock producers to siphon their resources from milk production to production of chicken. The price of cattle meat might also have similar effect on the milk production. However data on producer price of cattle meat is not available for India in FAOSTAT. So, for the sake of consistency, we could not include price of cattle meat in our analysis. Nevertheless, production of cattle meat may also be negatively associated with the number of milking animals. If meat production increases and the number of cattle slaughtered for meat increases, the number of milking animals and subsequently milk production is expected to decrease. For analyzing the supply response of milk yield, we have considered lagged prices and lagged exports since effect of these variables on yield would need some time to materialize.

Costly inputs would lead to shrinking profitability and hence in theory, input prices are negatively related to the supply. In the context of an aggregate analysis of milk supply, input price could be represented by feed price. But country level data on feed prices for relevant years were not available. An alternative could be to include International Farm Comparison Network (IFCN) milk feed price ratio as a proxy to output–input price. However data on country wise milk feed price ratio were available from the year 1996 onwards which does not encompass first four years of the period under consideration. Arriving at a single index for feed prices using FAO data also was difficult because type of feed used in milk production differs across countries. For example – while in India green fodder is widely used; composed fodder is the common form of fodder in China because most of the Chinese dairy farmers are landless. Crude oil price is an important indicator of determining the corn based feed prices (Amrah, 2011). Since China is a large feed importer, cost of feed for Chinese milk producers is expected to be influenced by crude oil prices. In Brazil the farmers depend both on home grown and purchased feed(Beldman et al.,2010).In India, milk production sometimes turns out to be costly due to high transportation cost, causing a rise in milk prices in states like Gujarat(Business Standard,2013). So, considering the costs of feed and transportation, we have taken oil price as a proxy for input cost. Similar method has also been adopted in the case of agricultural crops in Asian countries byImai et al.(2011).However, this can only be the proxy for paid or cash expenditure. In the estimation, ratio of crude oil price to milk price has been taken as the variable.

Trade liberalization in dairy sector could have a twofold effect. First, trade liberalization renders an opportunity to cater to the world demand. At the same time reduction in import tariff under WTO can also pose challenge for the milk producers' in BRIC countries as majority of them are engaged in small scale farming.[3]Multilateral trade agreements under WTO has opened up an avenue for greater market access but such agreements have been criticized on the ground that they create trade barriers for free and fair trade for developing countries (Balasa, 2007).Moreover, membership in WTO might restrain domestic price supports which could be harmful for domestic primary sector producers (Brink et al., 2013). Hence impact WTO and subsequent market integration on the supply response of milk production is an important issue which requires further probing.

4. Methodology

The present study investigates the supply response of milk production in case of BRIC countries using panel data analysis. The justification for using the panel data model is to address country specific heterogeneity and to obtain more robust results by increasing the number of observations.

Algebraically the panel data model can be written as:

$$logY_{it} = \alpha + logX_{it}\beta' + \mu_i + \delta_t + \varepsilon_{it} \qquad (1)$$

Where, $logY_{it}$ is the logarithm of milking animals (Y_1) and total milk yield (Y_2)in country i and year t. $X_{it}$is a set of explanatory variables. β is the slope coefficient vector associated with explanatory variables. μ_i is an unobserved country-specific effect and δ_t is time trend;ε_{it} is the error term which independently and identically distributed among countries and years. Equation (1) is further expanded into two models:

$$logY_{1it} = \alpha + \beta_1 logP_{it}^{own} + \beta_2 logP_{it-1}^{own} + \beta_3 logP_{it}^{chicken} + \beta_4 logP_{it}^{meat} + \beta_5 log\left(\frac{P_t^{oil}}{P_{it}^{own}}\right) + \beta_6 \log EX_{it} + \beta_7 (policy)_{it} + \mu_i + \delta_t + \varepsilon_{it} \qquad (2)$$

$$logY_{2it} = \alpha + \beta_1 logP_{it}^{own} + \beta_2 logP_{it-1}^{own} + \beta_3 logP_{it-1}^{chicken} + \beta_4 logP_{it}^{meat} + \beta_5 log\left(\frac{P_{t-1}^{oil}}{P_{it-1}^{own}}\right) + \beta_6 \log EX_{it-1} + \beta_7 (policy)_{it} + \mu_i + \varepsilon \qquad (3)$$

Where, P_{it}^{own} is the milk price for country iat time t, P_{it-1}^{own} is 1-year lag of log milk price, $P_{it}^{chicken}$ is price of chicken for i country at time t, and P_{it}^{meat} is the production of cattle meat for countryi at time t. Similarly log (P_{it}^{oil} / P_{it}^{own}) is the log of ratio of oil price (common across four countries) to price of milk for each country, log EX_{it} is the export of milk products in country i at time t, and finally (policy) is defined as a dummy variable assigned value 1 and 0 after and before the country joined WTO respectively,for each of the BRIC countries (except Russian Federation which joined WTO only in 2012). There is considerable controversy regarding the treatment of the country-specific term, μ_i,and hence choosing the appropriate technique between fixed

[3]In BRIC countries dairy farming largely is conducted at small scale, In India around 90% of the dairy farmers are small scale farmers with average of 1-2 milking per farm. In China almost 75% of the dairy farmers are in small scale having 3-5 milking animals per farm(Yang et al, 2014)

effects (FE) and random effects (RE) models. However, Hausman (1978) proposes a test to choose between FE and RE models. But Baltagi (1981) and Baltagi (2006) argue that the usual Hausman test may lead to misleading inference when endogenous variables of the conventional simultaneous equation are among the regressors.

Two other econometric complications arise in estimating equations (2) and (3). First, price of milk may well be endogenous to the regression being estimated and simultaneity of milk price and milk supply might often lead to misleading results. Therefore, we use the instrumental variables (EC2SLS) to correct for the possible endogeneity of the milk price variable. Baltagi (1981) explains detail methodology of two-stage least squares in panel data model. He also argues that the fixed effects 2SLS estimates turn out to be insignificant when country specific effects are correlated with the errors terms (see, Baltagi, 2006). Secondly, the variance term of ε_{it} may well be heteroskedastic, i.e. $E\{\varepsilon_{it}\} = \sigma^2$. To overcome both problems, this study estimates equation (2) and (3) using random effects 2SLS estimator that allows for endogeneity of milking animals/milk yield and own milk price. This estimator is a matrix weighted average between 2SLS and fixed effects 2SLS and was derived by Baltagi (1981) and known as error components 2SLS or EC2SLS. Since milk price is determined by interaction of both demand and supply, we have selected per capita income and percentage of children to total population as instrumental variables for the supply equations, which are likely to affect, demand for milk and likely to be correlated with milk prices:

Before discussing the econometrics analysis, the first step is to discover the panel integral properties of our data series. We performed the panel unit root test as proposed by Im et al. (2003), which contains heterogeneous adjustment processes and pools the t-statistics from univariate independent ADF regressions. They relax the restricted assumption first order autoregressive coefficient across the region, which is constant in Levin Lin (1992) test and suggests it varies across the regions.

For a sample of N groups observed over T time periods, the Im et al.(2003) panel unit root regression of the conventional ADF test is of the following form:

$$\Delta \log(y_{i,t}) = \alpha_i + \pi_i t + \beta_i \log(y_{i,t-1}) + \sum_{j=1}^{k} \psi_{i,j} \Delta \log(y_{i,t-j}) + \varepsilon_{i,t} \qquad (4)$$

Here, y denotes the time series under consideration, Δ is the first difference operator, $\varepsilon_{i,t}$ is a white noise disturbance term with variance σ^2, $i = 1,2,...,N$ indexes countries and $t = 1,2,...,T$ indexes times. The $\Delta y_{i,t-j}$ terms on the right hand side of Equation (4) allow for serial correlation, with the aim of achieving white noise disturbance term.

5. Data

The present study uses annual data for the period from 1992 to 2010. We have used Food and Agriculture Organization (FAO) – STAT for our analysis. Accordingly, the time series data on total milk yield(Hg per animal), total number of milking animals, producer price of cow milk(USD per kg), price of chicken meat(USD per kg), production of cattle meat(tonnes), and milk exports (tonnes) are collected from FAOSTAT. We have constructed a ratio of crude oil price to producer price of milk, which is treated as a proxy for input cost, such as transportation. The crude oil price data are collected from OPEC Bulletin and Energy Information Administration (EIA) official statistics published by the U.S. government. A simple average of three spot prices; Dated Brent, West Texas Intermediate, and Dubai Fateh in US$ per barrel was considered as the crude oil price. The nominal data on producer price of milk and price of chicken were converted into real prices by deflating the Consumer Price Index (CPI) for all commodities (base 2005=100). The CPI data, per capita income (constant $ 2005 base) and population 0-14 age as percentage to total population were collected from World Development Indicators (WDI) database published by the World Bank.

Chart A: Profile of Milk Production in BRIC Countries

	Brazil	**Russia**	**India**	**China**
Total milk Production(in thousand tonnes)	32239.149	31639.510	119444.000	41847.949
Number of milking animals (million)	28.165500	8.975530	112.531000	59.805911
Yield(HG/Animal)	11446	35251	10614	6997
Dairy Farm Numbers*(in thousands	75000	3162	1209	2802

Source: FAO-STAT, * From RamanovichM,A.Ndambi and T. Hemme (2011) Status and development in the dairy sector in the BRIC, IAMO Forum 2011, No. 12

6. Empirical Results

This section details the descriptive statistics of key variables used in the study. The results are presented in Table1.

Table 1: Descriptive Statistics of Variables

Variable	**Obs.**	**Mean**	**Std. dev.**	**Min**	**Max**
$\ln(Y1)_{it}$	76	16.544	0.6956	15.02	17.57
$\ln(Y2)_{it}$	76	16.999	0.5725	15.42	17.43
$\ln(X1)_{it}$	76	5.979	1.159	5.04	12.53
$\ln(X1)_{it-1}$	75	5.979	1.166	5.04	12.53
$\ln(X2)_{it}$	76	7.731	1.260	6.39	14.17
$\ln(X3)_{it}$	76	15.458	1.679	13.47	22.73
$\ln(X4)_{it}$	76	-0.058	0.526	-0.95	2.22
$\ln(X5)_{it}$	76	6.902	3.497	0.31	10.73

Note: Y1= Total number of milking animals, Y2=Total milk yield , X1=Producer price of cow milk, X2=Price of chicken meat, X3=Production of cattle meat, X4=Input costs, X5 = Exports
Source: Author's estimates based on FAOSTAT.

Table 1 presents the mean and standard deviation of both the dependent variables and explanatory variables used in the panel data models. The mean of log total milk production is highest among all the variables and mean of log input costs is least and negative. The standard deviation column indicates that the log of exports (lnX5) is having the highest deviation from its mean. Similarly, the standard deviation of both total milking animals and total milk production are relatively low as compared to all the explanatory variables except input costs.

After detailing about the descriptive statistics, the next for us is to examine the correlation matrices of all the explanatory variables used in the model. The results are shown in Table 2. It is noticed from the Table that price of cow milk is highly correlated with price of chicken meat and price of cow milk with production of cattle meat. Similarly price of chicken meat is also highly correlated with production of cattle meat. There is no multicollinearity among any other pairs of the explanatory variables.

Table 2: Correlation Matrices of Variables

	lny1	lnx1	lnx2	lnx3	lnx4	lnx5
lny1	1.0000					
lnx1	0.1273	1.0000				
lnx2	0.1971	0.9428*	1.0000			
lnx3	-0.0634	0.8597*	0.7621*	1.0000		
lnx4	0.1739	0.0281	0.0897	0.1366	1.0000	
lnx5	-0.601	-0.3905	-0.4579	-0.2530	0.2423	1.0000

* indicates 1% level of significance

Table 3: Panel Unit Root Test

Variables	**No Trend**	**Trend**
lnY1	-3.411*** (0.000) l(0)	-2.525*** (0.005) l(0)
lnY2	-0.434 (0.332) l(1)	-3.728*** (0.000) l(0)
lnX1	-9.986*** (0.000) l(0)	-6.350*** (0.000) l(0)
lnX2	-2.643*** (0.004) l(0)	-3.920*** (0.000) l(0)
lnX3	-6.695*** (0.000) l(0)	-11.664*** (0.000) l(0)
lnX4	-2.499*** (0.006) l(0)	-5.242*** (0.000) l(0)
lnX5	-12.183*** (0.000) l(0)	-3.861*** (0.000) l(0)

Note: *** Significant at 1 percent level; Source: Author's estimates based on FAOSTAT.

A crucial first step in panel data analysis is an investigation of the integrational properties of the data series. It is important to establish that the underlying variables used in the model should be stationary in nature. Since all the variables used in this paper carry a longer time series data, the Im et al. (2003) panel unit root test was used to test the stationary property. The results are reported in Table 3. Our main finding from the panel unit root test is that all the variables are stationary at levels both in case of drift (no trend) and drift with trend. The only exception is the total milk production (lnX2), which shows non-stationary at level and stationary at first difference in case of no trend. But when we include the trend in the equation then the result clearly indicate that this variable is also stationary at level. Since all the variables are stationary at level, in the next step, we apply the panel data model. We estimate two models using equation (2) and equation (3). In the first model the total number of milking animals (lnY1) is the dependent variable, whereas, in the second model total milk yield (lnY2) is considered as the dependent variable. Further, we ran four sub-models (model I to model IV) for both supply response of milking animals as well as for total milk yield. These sub-models are chosen based on the multicollinearity that have appeared among different pairs (see Table 2). The idea for selecting different sub-models is to provide robustness results for both the supply response functions.

Table 4 presents the results of EC2SLS estimations for equation 2, which captures supply responsiveness of number of milking animals. It can be observed that milk price is positively associated with total number of milking animals. This implies that a higher milk price motivates the dairy farmers to expand their herd size and reduce the culling of animals. However the number of milking animals with respect to milk price across majority of the models ranges from 0.79 to 1.35 as shown in Table 4. This indicates that one percent increase in milk price will hike number of milking animals by about one percent. Table 4 also exhibits the influence of substitute or competing commodities on number of milking animals. It can be found that given the other factors, one percent increase in the price of chicken reduces the number of milking animals by 0.66 -0.89 percent.

Table 4: Supply Response to Price Changes in Milking Animals

Panel Simultaneous Equation Model (EC2SLS) Dependent Variable: ln(Y1 =Total number of milking animals)$_{it}$				
Variable	**Model I**	**Model II**	**Model III**	**Model IV**
$logP_{it}^{own}$	1.35***(4.05)	1.23*** (4.98)	0.79*** (4.92)	0.17 (1.01)
$logP_{it-1}^{own}$	-0.08 (-0.67)	-	-0.98 (-1.17)	-0.20* (-1.79)
$logP_{it}^{chicken}$	-0.81** (-3.18)	-0.60*** (-3.17)	-	-
$logP_{it}^{meat}$	-0.53*** (-4.47)	-0.63*** (-7.05)	-0.50*** (-6.02)	-
$log\left(\frac{P_t^{oil}}{P_{it}^{own}}\right)$	0.21(0.84)	0.27* (1.71)	-0.16 (-1.07)	-0.46*(-1.59)
$\log EX_{it}$	0.035** (1.40)	0.03* (1.19)	0.04** (1.72)	- 0.02 (-0.77)
$(policy)_{it}$	1.05*** (1.69)	1.03*** (6.63)	1.14*** (7.11)	0.84*** (4.46)
Trend	-0.10(-4.69)	-0.11***(-1.64)	-0.08***(-3.82)	-0.20(-0.78)
Constant	24.15*** (17.77)	25.85*** (20.07)	21.42*** (24.02)	17.52*** (23.23)
Wald chi2	Wald chi2(8) = 111.50 Prob > chi2 = 0.0	Wald chi2(7) = 110.73 Prob > chi2 = 0.0	Wald chi2(7) = 96.61 Prob > chi2 = 0.0	Wald chi2(6) = 39.79 Prob > chi2 = 0.0000

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively; the values in parentheses show t-statistics.

It can also be observed from Table 4 that the coefficient of variable $logP_{it}^{meat}$ is negative and statistically significant. This implies an increase in number of slaughtered animals for meat production will lead to a decrease in the number of milking animals in the case of BRIC countries. Though studies on impact of production of meat on milk production are scanty, a study by Saghaian et al.(2013) establishes this link. Using data from Turkey, the study renders that a decrease in milk price leads to liquidation of dairy herds and has positive and subsequently negative impact on beef prices stemming from initial increase and then lack of supply in beef industry. Our results also reinforce the fact that greater availability of animals for meat production will lead to a lower herd size for milk production. Hence the relative profitability of milk as compared to meat industry should be strengthened in order to ensure higher milk supply.

As evident from Table 4, oil price to milk price ratio is not significantly influencing the number of milking animals. This result indicates that automation in the dairy industry small scale diary firms prevail and hence transportation costs do not affect the number of cattle's in dairy farms. Importantly, in most of the models volume of milk exports have a positive influence on total number of milking animals. This result indicates that favourable export policies would encourage milk supply in BRIC countries. Export policies of BRIC Countries with European Union are quite strong. But BRIC-EU trade is suffering during recent years due to certain barriers imposed by BRIC countries. Though China and Russia adopted favorable export policies and imposed high import barriers, India and Brazil still retain liberal import policies for dairy sector. For example, despite being the highest milk producing country, import tariff is very low (65%) in India. Moreover, potential for increase in dairy exports from India also crunches due to the huge import tariffs on dairy products by importing countries. In order to favour exports better transport and storage facilities, better processing plants should also be facilitated by BRIC countries.

Table 5 reflects the estimation results for equation 3 using EC2SLS estimation, which captures the effects price and non-price factors on milk yield. As discussed in section 3, since the effects of price of substitutes and exports on milk yield are not expected to realize immediately we have taken lagged prices of chicken, lagged relative price of oil to milk and lagged milk export as the explanatory variables.

Table 5: Supply Response to Price Changes in Milk Yield

Panel Simultaneous Equation Model (EC2SLS) Dependent Variable: ln(Y1 =total milk yield)$_{it}$				
Variable	**Model I**	**Model II**	**Model III**	**Model IV**
$logP_{it}^{own}$	-0.56**(2.18)	0.34** (2.08)	0.58** (2.77)	0.36**(2.64)
$logP_{it-1}^{own}$	-0.15 (-1.11)	-	-0.16(-1.47)	-0.12 (-1.14)
$logP_{it-1}^{chicken}$	-0.019 (-.19)	0.082 (-.96)	-	-
$logP_{it}^{meat}$	-0.14** (-1.34)	-0.11*(-1.08)	- 0.142*** (-1.38)	-
$log\left(\frac{P_{t-1}^{oil}}{P_{it-1}^{own}}\right)$	-0.14(-0.73)	-0.14 (.75)	-0.13 (-.72)	-0.01 (0.07)
$\log EX_{it-1}$	0.12*** (3.75)	0.11*** (3.65)	0.12*** (3.87)	0.11***(3.67)
$(policy)_{it}$	-0.80*** (-3.94)	-0.80*** (-3.95)	-.0.79*** (-4.09)	-0.77***(-3.99)
Trend	0.05***(-1.96)	0.06***(2.64)	0.04***(2.21)	0.04(2.27)
Constant	7.8*** (6.35)	7.17*** (6.57)	7.93*** (7.98)	6.85*** (11.19)
Wald chi2 Prob> chi2	Wald chi2(8) = 41.61 Prob = 0.0	Wald chi2(7) = 40.24 Prob = 0.0	Wald chi2(7) = 39.35 Prob = 0.0	Wald chi2(6) = 39.77 Prob = 0.0000

Notes: ***, **, * denote statistical significance at 1%, 5% and 10% respectively; the values in parentheses show t-statistics.

Table 5 unfolds that own price has a positive impact on the milk yield. All the alternative sub-models display an inelastic milk yield with respect to own price. This corroborates with the findings of Tauer (1998),Akmal (1993)in Pakistan, Sckokai (2003), Chavas and Kraus(1990) in the context of US, Pakistan, Russia and New York respectively. It can be observed from the table that though price of competing commodities do influence herd size, but milk yield is not influenced by them. Table 5 also reveals that milk export not only has positive association with number of milking animals but also has favourable impact on milk yield. This reinforces the need for export promotion strategies for growth of milk production in BRIC countries. The estimation results also disclose that as cattle meat production increases, milk yield reduces as more number of milking cattle are slaughtered for meat.

Now let us interpret the impact of WTO on number of milking animals and milk yield for BRIC counties. Joining under WTO implies enhancing the transparency and predictability of a country in terms of its trade relations, which can help in improving the institutional environment of the country (Kiselev,2013). The transparency has to be ensured because of the existence of a notification system on trade barriers, subsidies, customs and the system of bargaining on the current and newly-prepared legislation and practiced procedures. As discussed earlier, the impact of WTO on the supply of any agricultural product can either be favorable or unfavorable. It should be noted that WTO norms act differently to different BRIC countries. For instance, Brazil, China and India as developing countries, enjoy certain relaxations under WTO in terms of the extent and type of domestic support to agriculture, while Russian Federation does not enjoy such relaxations as it is a developed country (Brink et al., 2013). However since Russia and China entered into WTO regime after 1995, they enjoy certain other flexibilities which are provisioned under Doha Round. Hence despite being a member of WTO, India, Brazil and China have been able to provide required support for agricultural sector. Brazil and India provided investment and input subsidy support mainly under the exemptions meant for development programmes under WTO(Brink et al., 2013).

As evident from Table 4, the entry into WTO has a positive impact on the milk supply in terms of increase in the herd size. However, milk yield has substantially declined after the countries joined WTO. This is a striking observation which signifies that though milk producers in BRIC countries have favourably responded to the trade liberalization and total number of milking animals has increased after the countries became a member of WTO, total milk yield has reduced. Therefore, the policy makers should note that, trade liberalization and greater market access have favoured the milk supply only in terms of increased number of milking animals and resulting increase in production, but have not encouraged increase in milk productivity. Declining productivity of milk should definitely draw the attention of the diary development authorities in order to boost milk production using the same resources.

7. Conclusions and policy implications

The present study attempts to analyze supply response of milk production using annual FAO data for BRIC countries. Applying panel data analysis, the role of price and non-price factors on milk production is identified.

The estimation results reveal a strong positive supply response of milk prices to the number of milking animals and total milk yield. However it should be noted that price responsiveness of total number of milking animals is higher than that of the milk yield. These results clearly make a case for introduction of Minimum Support Price (MSP) which is already in pipeline under Indian dairy policy, for milk famers in rest of the BRIC countries.

Our results demonstrate that one percent change in price leads to a greater than one percent increase in the number of milking animals, but less than one percent change in the milk yield. Hence, it can be stated that the price support and subsidy programmes for dairy farmers in BRIC countries will be effective in increasing the milk production and hence render higher income.

The analysis also finds a strong association between price of substitutes such as chicken meat and milk supply. This result highlights the possibility of substitution between milk and other livestock production, if the other options are more lucrative. Therefore, measures to reduce per unit cost reduction of milk production will help the milk farmers to stick to milk production instead of switching to the other alternatives.

The results of the EC2SLS model also indicate that despite various criticisms against WTO for discouraging domestic agricultural production in developing countries, market integration with the rest of the world in a post WTO context has a positive impact on milk supply in terms of number of milking animals, and hence the total milk production. However joining under WTO could not have favourable impact on milk yield. Better technological support to enhance milk yield will help milk producers to tap the benefits of an expanding herd size and can also have far reaching effects via its forward linkage to the other milk products such as skimmed milk powder, butter and cheese which occupy higher share in world trade. Hence the Milk producers in BRIC countries can take advantage of the enhanced market access provided by WTO , expand their exports and raise production of milk in their respective countries.

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