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Impacts of economic shocks on livestock in Iran: a DSGE model approach

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Abstract The objectives of this study is to investigate the responses of livestock economic variables (namely, output, consumption, prices, labor and capital) to changes in agricultural productivity, monetary, oil revenue and government spending (fiscal policy). To do so, a Dynamic Stochastic General Equilibrium (DSGE) model is constructed for Iran economy disaggregating livestock. Accordingly, the empirical results show that a rise in agricultural productivity results in rising livestock output consumption, hours worked and capital and falling price index. In response to positive monetary shock all the variables increase. Livestock consumption and prices rise following by positive oil revenue shock. However, output, employment, capital and real wages initially fall and rise 3-4 quarters after shock occurrence suggesting the symptoms of Dutch Disease in Iran's agriculture. Government spending shock leads to an increase in the output, consumption, hours and prices and a decrease in capital. To sum up with, the findings reveal agricultural productivity shock has the strongest effects on livestock subsector when compared to those of other shocks. The negative effects of oil revenue shock are more than those of other shocks and we see the weakest responses under monetary and government spending shocks.

Keywords: livestock, DSGE model, economic shocks, Iran

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Introduction

Understanding the dynamics of macroeconomic shocks is instrumental in identifying the source of economic growth and drawing the right policy conclusions for the future. Knowing the effects of macroeconomic shocks helps policymakers to formulate appropriate polices for mitigating the effects of adverse shocks on their economic and contributes to more efficient allocation of scarce resources among different economic sectors. For most developing countries, including Iran, economic growth is highly dependent on progresses of domestic agriculture and related industries. Agricultural sector in Iran is a major economic sector seen as a key strategic policy area. Livestock is a predominant subsector in Iranian agriculture that plays very important economic, social and cultural roles or functions for rural households and contributes to improve income and wellbeing of the farm family. Livestock helps on food supply, family nutrition, family income, asset savings, soil productivity, livelihoods, transport, agricultural traction, agricultural diversification and sustainable agricultural production, family and community employment, ritual purposes and social status (Moyo and Swanepoel, 2010). Moreover, livestock by-products such as hides, intestines, hair and related products constitute part of the country's exports. On average, 31.8% of the gross value of production, 22% employment and 33% capital in agriculture is attributed to livestock that, is the second largest agricultural subsector in Iran. Yet, planners and economists often underestimate the contribution of livestock to the agriculture and economy. The aim of the present paper is to evaluate the impacts of a rich range of macroeconomic shocks including those of agricultural productivity, monetary policy, oil revenue and government spending, on the livestock. The macroeconomic shocks are mostly unpredictable and come without any signal and affect almost all the macroeconomic aggregates of the economy. Propagation of shocks has inevitable consequences for agriculture including livestock. Macroeconomic shocks can cause major changes in the values of key factors linking livestock to agriculture and macro economy i.e. income, employment, interest rates and energy costs, resulting in changes in a country's prices, production, consumption, real economic growth and trade. According to the literature (Rosen et al., 1994; Aadland, 2002) these shocks cause unpredictable changes in the swings of the livestock cycles and hence induce fluctuations in livestock prices that trigger food entitlement and food security failures. Evaluating the impact of these shocks on the livestock is, also, of utmost importance, as the consequences of the shocks can push millions of people into relative poverty and deprivation. These are in this context that we have studied the impact of the shocks on the Iran's livestock. This study also contributes to the literature by developing a Dynamic Stochastic General Equilibrium (DSGE) model for Iran's economy emphasizing on livestock, which is the noble element of this work. Dividing agriculture sector into its subsectors contributes to getting more details of agricultural variables behaviors under different conditions. The literature review shows that the number of quantitative analysis on livestock dynamics is small and it is difficult to find a study investigating the responses of the livestock macro variables to economic shocks. Twine et al. (2016) analyze whether or not some of the recent market shocks can be associated with changes in the nature of the cycles. Using intervention analysis, exchange rate appreciation, feed price escalation, and bovine spongiform encephalopathy (BSE) are modeled as pure jumps. They find significant impacts of the three shocks on total inventories, but beef supply appears to have been impacted by exchange rates and BSE. Ngigi et al. (2015) employed a micro-econometric approach using two waves of a panel data set stemming from six districts in three agro ecological regions of rural Kenya. Special attention extends to the interaction of a wider range of shocks to bridge the identified gap by presenting empirical evidence on the impacts of multiple shocks on livestock portfolios. The study findings indicate that livestock is the major coping strategy against shocks, particularly for the asset-rich households. Daniel Ayalew (2015) using a stochastic dynamic programming model, characterizes the optimal savings-consumption decisions and the role of livestock inventories as a buffer stock in rural Ethiopia. The results show that relatively land-rich households use accumulation and liquidation of cattle and other animal inventories for partial consumption smoothing, while low-income households appear not to do so. The results highlight the need for improvement in livestock markets, which are often affected by high transaction costs and price risk. Mawejje and Holden (2014) examined the determinants of a household's social capital in the form of community group participation and empirically analyzed the roles that social capital plays in helping rural households rebuild productive assets after the shocks. The results show that social capital measured in form of density of participation in group activities and attendance score as well as multiplicative and additive indices of these have significant positive effects on the household ability to rebuild livestock assets. Kurosaki (2013) analyzed the dynamics of assets held by low-income households facing various types of income shocks in pre-independence and post-independence Pakistan. Results show that the population of livestock, the major asset of rural households, experienced a persistent decline after crop shocks due to droughts, but did not respond much to the Great Depression. Nkang et al. (2013) simulated the impact of a rise in the price of imported food on agriculture and household poverty in Nigeria using a computable general equilibrium (CGE) model on the 2006 social accounting matrix (SAM) of Nigeria. Results show that a rise in import price of food increased domestic output of food, but reduced the domestic supply of other agricultural commodities as well as food and other agricultural composites. McPeak (2004) investigated livestock sales behavior in an environment where both income and asset shocks occur. The nature of each type of shock is analyzed, and their respective impact on sales behavior is identified. Results indicate income and asset shocks are positively correlated, but influence sales in an offsetting fashion.

Materials and methods

The general model

Recently, the DSGE model has continued to grow into the most influential tool for analyzing macroeconomics and evaluating macroeconomic policy. The baseline model, in this study, is a small-closed economy DSGE model, with price rigidities, capital accumulation, investment adjustment cost, and habit formation, emphasizing on livestock in Iran. For more detailed description of the general model specification, the reader is referred to Allegret and Benkhodja (2015), Dib (2008), Christiano et al. (2005) and Smets and Wouters (2003).

Households

There is a representative infinitively-lived household who maximizes the expected stream of discounted instantaneous utilities by choosing the amount of consumption goods to buy, c_t and labor to supply, l_t. The intertemporal utility function is given by:

$$U(0) = E_0 \sum_{t=0}^{\infty} \beta^t \, \xi_{b,t} \left\{ \frac{(c_t - hc_{t-1})^{1-\sigma_c}}{1-\sigma_c} - \zeta \frac{l_t^{1-\sigma_l}}{1-\sigma_l} \right\}$$

where, $0 < \beta < 1$ is the subjective intertemporal discount factor, c_t is aggregate consumption and h is the parameter that controls habit persistence. $\xi_{b,t} = \rho_b \xi_{b,t-1} + \varepsilon_{b,t}$ denotes a preference shock affecting the intertemporal elasticity of substitution. The inverse elasticity of intertemporal substitution in consumption and the invers of Fritch labor supply elasticity are denoted by σ_c and σ_l respectively. ζ is a scale factor that determines hours worked in the steady state. We normalize $\zeta = 1$. The labor disutility index includes hours allocated to agricultural, $l_{ag,t}$, and non-agricultural sector, $l_{na,t}$: $l_t = l_{na,t} + l_{ag,t}$, where agricultural labor is supplied to livestock, $l_{li,t}$, and non-livestock activities, $l_{nl,t}$: $l_{ag,t} = l_{li,t} + l_{nl,t}$[1].

The aggregate consumption bundle, c_t, is a composite of non-agricultural and agricultural consumption goods that is given by the constant elasticity of substitution (CES) aggregator:

$$c_t = [(\alpha_c)^{1/\omega_c}(c_{na,t})^{(\omega_c-1)/\omega_c} + (1-\alpha_c)^{1/\omega_c}(c_{ag,t})^{(\omega_c-1)/\omega_c}]^{\frac{\omega_c}{\omega_c-1}} \quad (1)$$

where, $c_{na,t}$ is non-agricultural goods and $c_{ag,t}$ is agricultural goods. α_c is the proportion of non-agricultural goods in total consumption and ω_c is the elasticity of intertemporal substitution between agricultural and non-agricultural goods. The expenditure minimization yields the following demand functions for these goods:

$$c_{na,t} = \alpha_c(\frac{P_{na,t}}{P_t})^{-\omega_c} c_t$$

$$c_{ag,t} = (1-\alpha_c)(\frac{P_{ag,t}}{P_t})^{-\omega_c} c_t \quad (2)$$

The overall consumer price index is given as:

$$P_t = [\alpha_c(P_{na,t})^{1-\omega_c} + (1-\alpha_c)(P_{ag,t})^{1-\omega_c}]^{\frac{1}{1-\omega_c}} \quad (3)$$

The consumption of agricultural goods is determined by a CES index composed of livestock goods, $c_{li,t}$, and non-livestock goods, $c_{nl,t}$, (including: crop, forestry and fishery goods):

$$c_{ag,t} = [(\alpha_{li})^{1/\omega_{cag}}(c_{li,t})^{(\omega_{cag}-1)/\omega_{cag}} + (1-\alpha_{li})^{1/\omega_{cag}}(c_{nl,t})^{(\omega_{cag}-1)/\omega_{cag}}]^{\frac{\omega_{cag}}{\omega_{cag}-1}} \quad (4)$$

where, ω_{cag} is the elasticity of intertemporal substitution between livestock and non-livestock goods. α_{li} measures the proportions of livestock consumption goods in agricultural sector. The demand functions are:

$$c_{li,t} = \alpha_{li}(\frac{P_{li,t}}{P_{ag,t}})^{-\omega_{cag}} c_{ag,t}$$

$$c_{nl,t} = (1-\alpha_{li})(\frac{P_{nl,t}}{P_{ag,t}})^{-\omega_{cag}} c_{ag,t} \quad (5)$$

The price index of agricultural goods is expressed as:

$$P_{ag,t} = [\alpha_{li}(P_{li,t})^{1-\omega_{cag}} + (1-\alpha_{li})(P_{nl,t})^{1-\omega_{cag}}]^{\frac{1}{1-\omega_{cag}}} \quad (6)$$

where $P_{li,t}$ and $P_{nl,t}$ are price indexes for livestock and non-livestock goods respectively.

The household budget constraint is:

$$c_t + b_t\frac{B_t}{P_t} + I_t = w_t l_t + (r_t z_t - \Psi(z_t))k_{t-1} + P_{li,t}(\kappa V_{t-1}) + \frac{B_{t-1}}{p_t} + D_t \quad (7)$$

Households buy one period tax free bonds B_t at price b_t. P_t is the aggregate price index, w_t is the real wage for the household and r_t is the real rental rate households obtain from renting out capital to firms. $\Psi(z_t)$ is a function capturing the resource cost of capital utilization when the utilization rate is z_t and I_t denotes the investment. D_t is Dividends to the household from the intermediate good firms. κ is the fraction of livestock beaten down for consumption during the period and V_{t-1} is the stock of livestock:

$$V_t = (1-\kappa)V_{t-1} + (1-\frac{NB_t}{V_t})^2 NB_t \quad (8)$$

here NB_t is the number of new birthes. Households choose the capital stock, the utilization rate and investment subject to the following capital accumulation equation (law of motion for capital):

$$k_t = (1-\delta)k_{t-1} + [1 - S\left(\xi_{I,t}\frac{I_t}{I_{t-1}}\right)]I_t \quad (9)$$

here, δ is the depreciation rate of capital, $S(0)$ is the investment adjustment cost function as in Smets and Wouters (2003) and Christiano et al. (2005). $\xi_{I,t} = \rho_I \xi_{I,t-1} + \varepsilon_{I,t}$ is an adjustment cost shock. Finally, the household maximizes its utility subject to the budget constraint, the law of motion for capital and the stock of livestock. It is assumed that the aggregate capital can be either supply to non-agricultural or agricultural sector according to the following CES aggregator:

$$k_t = [{\chi_k}^{1-\omega_k}(k_{na,t})^{\omega_k} + (1-\chi_k)^{1-\omega_k}(k_{ag.t})^{\omega_k}]^{\frac{1}{\omega_k}} \quad (10)$$

where, ω_k is the elasticity of substitution between non-agricultural and agricultural capital and χ_k is the fraction of capital supply in non-agricultural sector. The household optimization problem based on capital returns, yields the following supply functions for the non-agricultural and agricultural capital:

$$k_{na.t} = \chi_k(\frac{r_{na,t}}{r_t})^{\frac{1}{\omega_k-1}} k_t$$

$$k_{ag.t} = (1-\chi_k)(\frac{r_{ag,t}}{r_t})^{\frac{1}{\omega_k-1}} k_t \quad (11)$$

[1] In this study we suppose labor supply in steady state is the same across the sectors.

where, $r_{na,t}$ and $r_{ag,t}$ are real rental rates of the capital in non-agricultural and agricultural sectors. r_t is the aggregate rental rate of capital which is defined as:

$$r_t = [\chi_k (r_{na,t})^{\frac{\omega_k - 1}{\omega_k}} + (1-\chi_k)(r_{ag,t})^{\frac{\omega_k - 1}{\omega_k}}]^{\frac{\omega_k}{\omega_k - 1}} \quad (12)$$

Finally, capital supply functions for livestock and non-livestock are as follows:

$$k_{li.t} = \chi_{li} (\frac{r_{li,t}}{r_{ag,t}})^{\frac{1}{\omega_{kag} - 1}} k_{ag.t}$$

$$k_{nl.t} = (1-\chi_{li}) (\frac{r_{nl,t}}{r_{ag,t}})^{\frac{1}{\omega_{kag} - 1}} k_{ag.t} \quad (13)$$

where, ω_{kag} is the elasticity of substitution between agricultural subsectors capital and χ_{li} is the fraction of capital supply in the livestock.

Non-agricultural production

The non-agricultural production side of the economy consists of two sectors: a retail sector operating in perfect competition to produce the final consumption good and a wholesale sector hiring labor and capital from the households to produce a continuum of differentiated intermediate goods. In the retail sector the final consumption good $y_{na,t}$ is produced out of the intermediate goods through a CRS technology: $y_{na,t} = (\int_0^1 (y_{na,t}(i))^{\frac{\theta-1}{\theta}} di)^{\frac{\theta}{\theta-1}}$ is Equilibrium in this sector yields the input demand function: $y_{na,t}(i) = (\frac{P_{na,t}(i)}{P_{na,t}})^{-\theta} y_{na,t}$ where θ is intermediate goods-elasticity. The firms in the wholesale sector produce a continuum of differentiated perishable goods out of labor and capital, according to the following production function: $y_{na,t}(i) = A_{na,t} k_{na,t}^{\alpha_{na}}(i) l_{na,t}^{1-\alpha_{na}}(i)$ in which $A_{na,t} = \rho_{na} A_{na,t-1} + \varepsilon_{na,t}$ is a stationary technology shock common for all firms and α_{na} is the share of capital in production. In choosing the optimal level of labor and capital to demand, each firm enters a competitive input market and seeks to minimize total real costs subject to production function. Accordingly, the first order conditions with respect to capital and labor are:

$$w_{na,t} = (1-\alpha_{na}) \zeta_t A_{na,t} (k_{na.t}(i))^{\alpha_{na}} (l_{na.t}(i))^{-\alpha_{na}} \quad (14)$$

$$r_{na,t} = \alpha_{na} \zeta_t A_{na,t} (k_{na.t}(i))^{\alpha_{na}-1} (l_{na.t}(i))^{1-\alpha_{na}} \quad (15)$$

where, the Lagrange multiplier, ζ_t, represent the real marginal cost. An expression for the real marginal cost obtains:

$$mc_{na,t} = (\frac{1}{1-\alpha_{na}})^{1-\alpha_{na}} (\frac{1}{\alpha_{na}})^{\alpha_{na}} \frac{(w_{na,t})^{1-\alpha_{na}} (r_{na,t})^{\alpha_{na}}}{A_{na,t}} \quad (16)$$

The price setting mechanism follows Calvo's (1983) and Yun's (1996) staggering assumption. Accordingly, during each period a *(1-φ_{na})* fraction of them, randomly chosen, is able to re-optimize its price and for those that cannot re-optimize, the price will be updated to past inflation. Finally, the optimal pricing condition yields the following real non-agricultural price index (see Benkhodja, 2011):

$$P_{na,t} = [\varphi_{na} (\pi \frac{p_{na,t-1}}{\pi_t})^{1-\theta} + (1-\varphi_{na})(\tilde{P}_{na,t})^{1-\theta}]^{\frac{1}{1-\theta}} \quad (17)$$

where $\pi_t = \frac{P_t}{P_{t-1}}$ is the CPI inflation rate, π is the long run average gross rate of inflation and $\tilde{P}_{na,t}$ is the optimal price.

Agricultural production

There is a continuum of monopolistically–competitive firms in agricultural sector. The aggregate output, $y_{ag,t}$, is described by the constant elasticity of substitution (CES) function aggregate of intermediate goods, $y_{ag,t}(i)$**.** The convexity of the CES aggregator function implies goods in this sector are differentiated that is consumers have preferences for variety:

$$y_{ag,t} = (\int_0^1 (y_{ag,t}(i))^{\frac{\theta-1}{\theta}} di)^{\frac{\theta}{\theta-1}} \quad (18)$$

Competitive intermediate good firm's production function is given as: $y_{ag,t}(i) = A_{ag,t} k_{ag,t}^{\alpha_{ag}}(i) l_{ag,t}^{1-\alpha_{ag}}(i)$ where $A_{ag,t} = \rho_{ag} A_{ag,t-1} + \varepsilon_{ag,t}$ is a stationary technology shock. Similarly, the first order conditions for the inputs, the real marginal cost and the real price index in agriculture sector are as follows:

$$w_{ag,t} = (1-\alpha_{ag}) \zeta_{ag,t} A_{ag,t} (k_{ag,t}(i))^{\alpha_{ag}} (l_{ag,t}(i))^{-\alpha_{ag}} \quad (19)$$

$$r_{ag,t} = \alpha_{ag} \zeta_{ag,t} A_{ag,t} (k_{ag.t}(i))^{\alpha_{ag}-1} (l_{ag.t}(i))^{1-\alpha_{ag}} \quad (20)$$

$$mc_{ag,t} = (\frac{1}{1-\alpha_{ag}})^{1-\alpha_{ag}} (\frac{1}{\alpha_{ag}})^{\alpha_{ag}} \frac{(w_{ag,t})^{1-\alpha_{ag}} (r_{ag,t})^{\alpha_{ag}}}{A_{ag,t}} \quad (21)$$

$$P_{ag,t} = [\varphi_{ag} (\pi \frac{p_{ag,t-1}}{\pi_t})^{1-\theta} + (1-\varphi_{ag})(\tilde{P}_{ag,t})^{1-\theta}]^{\frac{1}{1-\theta}} \quad (22)$$

In this study, based on our purpose, we disaggregate agricultural production to livestock, $Y_{li,t} = \kappa V_{t-1}$, and non-livestock, $Y_{nl,t}$, production.

Final good producer

The producer of final good, operating under perfect competition, combines non-agricultural, livestock and non-livestock outputs using the following CES technology:

$$Z_t = [\gamma_{na}^{\frac{1}{\varrho}} Y_{na,t}^{\frac{\varrho-1}{\varrho}} + \gamma_{li}^{\frac{1}{\varrho}} Y_{li,t}^{\frac{\varrho-1}{\varrho}} + \gamma_{nl}^{\frac{1}{\varrho}} Y_{nl,t}^{\frac{\varrho-1}{\varrho}}]^{\frac{\varrho}{\varrho-1}} \quad (23)$$

where ϱ is the elasticity of substitution between the outputs, γ_{na}, γ_{li} and γ_{nl}, denote the corresponding shares in the final good. Profit maximization yields the following demand functions:

$$Y_{na,t} = \gamma_{na}(\frac{P_{na,t}}{P_t})^{-\varrho} Z_t$$

$$Y_{li,t} = \gamma_{li}(\frac{P_{li,t}}{P_t})^{-\varrho} Z_t$$

$$Y_{nl,t} = \gamma_{nl}(\frac{P_{nl,t}}{P_t})^{-\varrho} Z_t \quad (24)$$

where P_{na}, P_{li}, P_{nl} and P are given. The zero profit condition leads to the price of final good:

$$P_t = [\gamma_{na}(P_{na,t})^{1-\varrho} + \gamma_{li}(P_{li,t})^{1-\varrho} + \gamma_{nl}(P_{nl,t})^{1-\varrho}]^{\frac{1}{1-\varrho}} \quad (25)$$

Finally, the final good is divided between total consumption and investment.

Fiscal and monetary authority

Iran is considered as a country which produces oil and is an OPEC member that takes the price so the quotes of production are provided. Accordingly, we assume oil revenue is exogenous and can be expressed by an AR (1) process as follows:

$$oil_t = (1-\rho_{oil})\overline{oil} + \rho_{oil} oil_{t-1} + \varepsilon_{oil,t} \quad (26)$$

Here $\overline{oil}$ is the steady state value of oil revenue. It is also assumed that the government real expenditures follow an AR (1) process:

$$g_t = (1-\rho_g)\bar{g} + \rho_g g_{t-1} + \varepsilon_{g,t} \quad (27)$$

Following, Alpanda and Aysun (2014) monetary policy is conducted via a Taylor rule for the nominal interest rate:

$$r_t = \rho r_{t-1} + (1-\rho)[r_\pi \pi_t + r_y y_t + r_{\Delta y}(y_t - y_{t-1})] + \xi_t^{\mu} \quad (28)$$

where ρ determines the extent of interest rate smoothing, the parameters r_π, r_y, and $r_{\Delta y}$ capture the relative weight of inflation, output gap and output growth in the Taylor rule. The monetary policy shock ξ_t^{μ} follows an AR (1) process: $\xi_t^{\mu} = \rho_\mu \xi_{t-1}^{\mu} + \varepsilon_{\mu.t}$.

Market clearing

To close the model, it is necessary to consider market clearing, which ensure that the economy is always in equilibrium. The constraints of aggregate resources are given by:

$$c_t = c_{na,t} + c_{ag,t}, \text{ where } c_{ag,t} = c_{li,t} + c_{nl,t} \quad (29)$$

$$k_t = k_{na,t} + k_{ag,t}, \text{ where } k_{ag,t} = k_{li,t} + k_{nl,t} \quad (30)$$

$$y_t = y_{na,t} + y_{ag,t} \text{ where } y_{ag,t} = y_{li,t} + y_{nl,t} \quad (31)$$

$$y_t = c_t + I_t + g_t + oil_t \quad (32)$$

Calibration

After the log linearization of the necessary equilibrium conditions around the steady state, the parameters of the model are calibrated. Table 1 presents the calibrated parameters. The discount factor, β, is set to 0.966, gives an annual steady-state real interest rate around 3.5%. Some parameters are calibrated according to Manzour and Taghipour (2015): the inverse elasticity of consumption, σ_c, and labor supply, σ_l, are calibrated as 1.57 and 2.92, the consumption habit, h, as 0.31 and capital depreciation rate, δ, as 0.04. The fraction of livestock beaten down for consumption, $\kappa = 0.66$, is calibrated according to the average ratio of the slaughtered livestock to their population. The elasticity of intermediate goods, θ, and capital adjustment parameter, ψ, are calibrated at 5 and 4.5 following Allegret and Benkhodja (2015). Also, inspired by the same source, the elasticity of substitution between the final good components, ϱ, is calibrated at 1 and the calibration of Calvo price parameters for non-agricultural and agricultural firms ($\varphi_{na}, \varphi_{ag}$) are set to 0.55 and 0.40, suggesting agricultural prices are re-optimized slightly more frequently than non-agricultural prices. The calibration of elasticity parameters comes from authors' regression estimation. Accordingly, agriculture and non-agriculture goods-elasticity, ω_c, and livestock and non-livestock goods-elasticity, ω_{cag}, are respectively set to 1.88 and 2.21 based on household income and expenditure statistics included in Statistical Center of Iran (SCI) website. The elasticity of substitution between non-agricultural and agricultural capital, ω_k, and the elasticity of substitution between agricultural subsectors capital, ω_{kag}, are set to 1.43 and 3.15 based on Safari et al.'s (2010) statistics. The proportions of non-agricultural goods in consumption, α_c, and livestock goods in agricultural consumption, α_{li}, are set to 0.69 and 0.24, match their corresponding average shares in household expenditure. The proportion of capital in non-agricultural sector, χ_k, and the proportion of livestock capital in agriculture, χ_{li}, are calibrated as 0.86 and 0.29 according to the GDP accounting for the period 1994-2014. The share of capital in non-agricultural and agricultural production (α_{na}, α_{ag}), are set to 0.55 and 0.41 to match the average ratios observed in the Iran data for the 1994-2014 period. The share of non-agricultural, γ_{na}, livestock, γ_{li}, and non-livestock, γ_{nl}, goods in the production of final goods are set equal to 0.87, 0.044 and 0.086 respectively. These values are

Table 1. Calibrated parameters

Symbol	Parameter explanation	Value
Β	Discount factor	0.966
Η	Habit persistence in consumption	0.31
σ_l	Inverse of Frisch elasticity of labor supply	2.92
σ_c	Inverse elasticity of substitution in consumption	1.57
Δ	Capital depreciation rate	0.04
Κ	Fraction of livestock beaten down for consumption	0.66
Θ	Intermediate goods-elasticity	5
ψ	Capital adjustment parameter	4.5
φ_{na}	Calvo parameter - non-agricultural firms	0.55
φ_{ag}	Calvo parameter - agricultural firms	0.40
ω_c	Agriculture and non-agriculture goods-elasticity	1.88
ω_{cag}	Livestock and non-livestock goods-elasticity	2.21
ω_k	Elasticity of substitution between non-agricultural and agricultural capital	1.43
ω_{kag}	Elasticity of substitution between agricultural subsectors capital	3.15
α_c	Proportion of non-agricultural goods in consumption	0.69
α_{li}	Proportion of livestock goods in agricultural consumption goods	0.24
χ_k	Proportion of capital in non-agricultural sector	0.86
χ_{li}	Proportion of livestock capital in agriculture	0.29
α_{na}	Share of capital in non-agricultural production	0.55
α_{ag}	Share of capital in agricultural production	0.41
ϱ	Elasticity of substitution between the final good components	1
γ_{na}	Non-agricultural production share in the final good	0.87
γ_{li}	Livestock production share in the final good	0.044
γ_{nl}	Non-livestock production share in the final good	0.086
ρ	Monetary policy - interest rate smoothing parameter	0.835
r_π	Monetary policy - inflation reaction coefficient	1.44
r_y	Monetary policy - output reaction coefficient	0.045
$r_{\Delta y}$	Monetary policy - output growth reaction coefficient	0.37

chosen given that the value of the average ratio of them to GDP of Iran economy. Regarding the Taylor rule parameters, as in Alpanda and Aysun (2014), inflation reaction coefficient, r_π, the reaction coefficients on output, r_y, and output growth, $r_{\Delta y}$, and the interest rate smoothing parameter, ρ, are calibrated as 1.44, 0.045, 0.37 and 0.835 respectively. Finally, Table 2 shows persistence of shocks estimated through constructing AR (1) processes except ρ_b and ρ_I which are extracted from Manzour and Taghipour (2015).

Results and discussion

Second order moments of variables

In order to complete the quantitative analysis, we compare the second moments from the observed date (the HP filtered data) and the results for the calibrated model (the simulated data). Matching second moments of the data and the calibrated model is considered crucial for the evaluation of model's empirical fit. Table 3 reports this natural robustness check for observable variables.

Table 2. Autoregressive parameters

Symbol	Parameter explanation	Value	Resource
$\boldsymbol{\rho_b}$	Preference	0.77	Manzour and Taghipour (2015)
$\boldsymbol{\rho_I}$	Investment adjustment cost	0.35	Manzour and Taghipour (2015)
$\boldsymbol{\rho_{na}}$	Non-agricultural technology	0.72	AR (1) estimation
$\boldsymbol{\rho_{ag}}$	Agricultural technology	0.88	AR (1) estimation
$\boldsymbol{\rho_g}$	Government spending	0.64	AR (1) estimation
$\boldsymbol{\rho_{oil}}$	Oil revenue	0.42	AR (1) estimation
$\boldsymbol{\rho_\mu}$	Monetary policy	0.38	AR (1) estimation

Table 3. Second moments

Variable	Standard deviation		Corr.[a] with output (GDP)	
	Observed	Simulated	Observed	Simulated
GDP	1.771	1.692	-	-
Agricultural GDP	2.628	2.564	0.451	0.396
Oil revenue	2.371	2.255	0.731	0.701
Government spending	1.618	1.558	0.935	0.911
Agricultural Employment	0.642	0.637	0.431	0.417
Inflation rate	0.137	0.124	0.383	0.339

[a]Corr: correlation.

The values show that the simulated moments match the observed ones quite well. So the model replicates well the volatility and cyclicality of the variables. In other words, the model simulates economy of Iran appropriately.

Impulse responses

Having calibrated the DSGE model, analyzing the impulse responses of livestock economic variables to agricultural productivity shock and some macroeconomic shocks including: monetary, oil revenue and government spending shocks is the main goal. Impulse response functions are obtained from a one-standard deviation positive shock in the calibrated model. Responses are plotted in figures 1 to 4, explaining behavior of the variables of interest when the economy is in its steady state and hit by a positive shock. In this way, responses are expressed as the percentage deviation of a variable from its steady-state level.

Agricultural productivity shock

Figure 1 plots the impulse response functions of the livestock to a positive agricultural technology shock. A positive technology shock increases the productivity of the inputs into the production process. This gives firms an incentive to their labor and capital. Accordingly, hours worked (0.012%) and capital (0.63%) rise. Following the shock output increases (1.97%), as firms can produce more for a given amount of production inputs, leading to a decrease in prices (0.77%) and an increase in consumption (1.38%). Findings also show that this shock, in magnitude, has the greatest effect on livestock output and consumption while, livestock labor market variable implies the weakest reaction. Output, consumption and hours worked responses are extremely persistent where the effects of the shock disappear after 40 quarters.

Monetary policy shock

Monetary shocks are proposed as a mean of economic control in the world's economic system. Proper understanding of how these shocks affect the economic system is a good guidance to determine the appropriate policies to influence other macroeconomic variables. As shown in figure 2, expansionary monetary policy, generates a slight expansion in livestock output (0.12%). A possible explanation for such weak reaction is that the agricultural sector benefits less from the liquidity arisen, where a considerable part of the liquidity allocated to the sector goes to other economic activities. Following the shock consumption rises (0.59%). Hours worked, also, increase (0.019%) and the capital rises (0.21%) in face of higher aggregate demand. The expansion in firms' costs of production is passed on to production and final prices increase (1.97%). Based on the results, the shock has the greatest effect on the livestock price index and the weakest one on the hours worked. The responses peak between 3-4 quarters after the shock hits the economy and the they return to the steady state level after 25-30 quarters.

Oil revenue shock

In oil-producing developing countries, including Iran, oil revenue plays an important role in political economy and its fluctuations are a major source of disturbance for their economies. A positive oil revenue shock, as shown in figure 3, leads to a drop in livestock output (0.39%), capital (0.48%) and hours worked (0.38%). This finding can be explained by a phenomena called Dutch Disease (DD) in economic literature. Many works have confirmed the symptoms of DD in Iran's agriculture and showed that DD in Iran' economy has been appeared as anti-agriculture phenomena (Ghasabi Kohne Ghouchan et al., 2014; Piri et al., 2011; Bakhtiari and Haghi, 2001). In fact, growing oil revenue raises the agricultural import and bring forth de-agriculture phenomenon. Following the shock, the government expenditure rises and results in an expansion in consumption (1.23%) and prices (1.25%). Following the shock, livestock prices and consumption, respectively, are more affected than other variables. As the dynamics of the monetary shock,

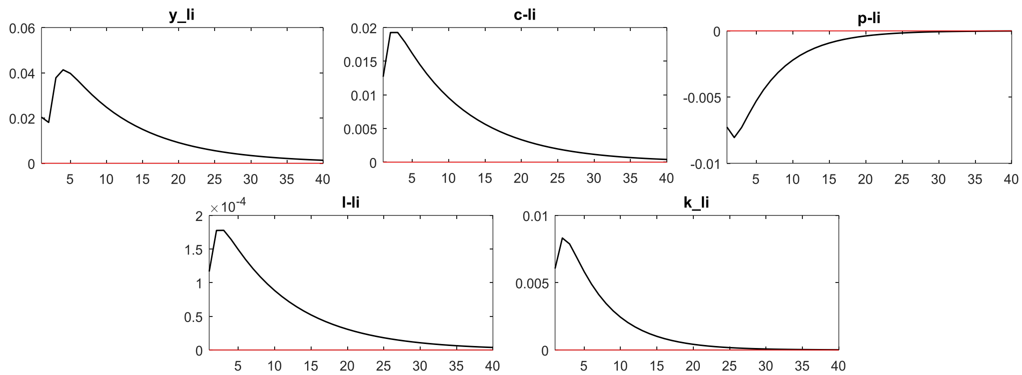

Figure 1. Livestock impulse responses to a positive agricultural productivity shock

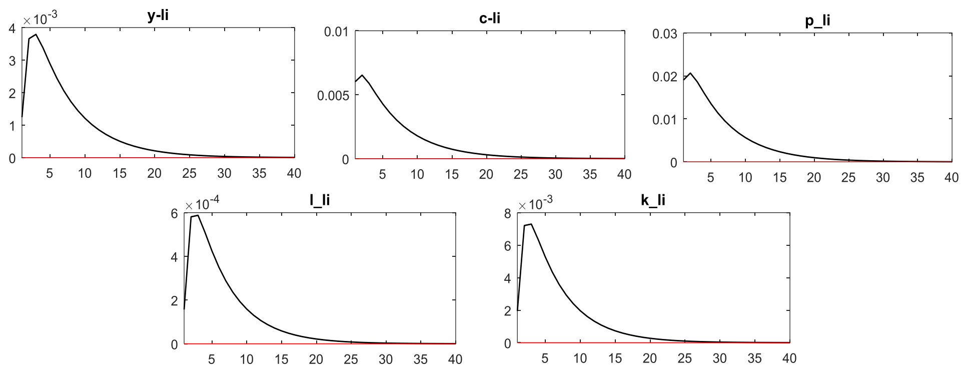

Figure 2. Livestock impulse responses to a positive monetary shock

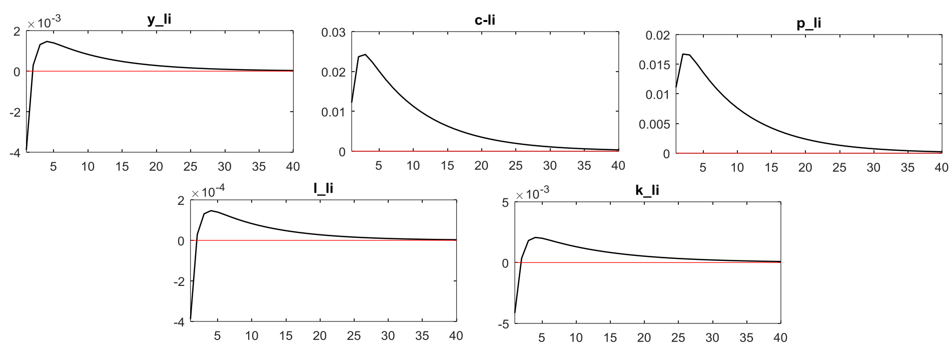

Figure 3. Livestock impulse responses to a positive oil revenue shock

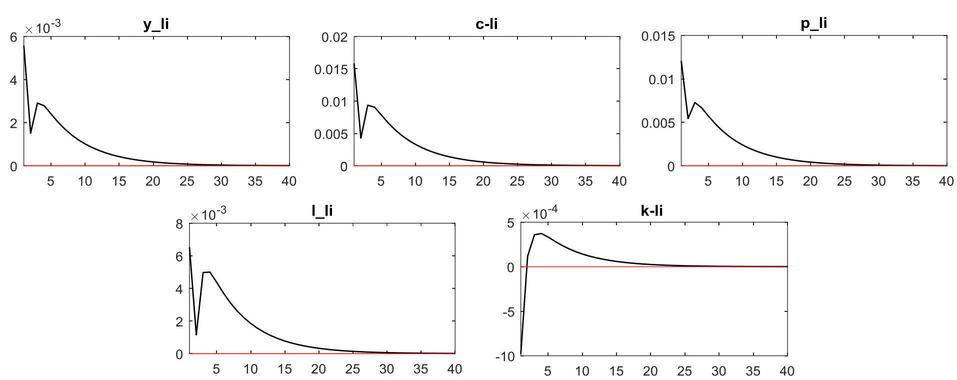

Figure 4. Livestock impulse responses to a positive government spending shock

the responses peak between 3-4 quarters after the shock has occurred and returning to the base line in long run.

Government spending shock (Fiscal policy)

Analyzing the effects of changes in government spending on economic variables is important for understanding the effects of fiscal policy on people's welfare. Livestock output arises (0.58%) in response to a positive government spending shock (figure 4). In developing countries, governments help through provision of better infrastructure, education, improvement in agricultural productivity, granting loans and credits significantly in promoting agricultural growth in different terms. Consumption (1.64%) and price index (1.22%) rise following the shock, as the expansion in public spending provides extra aggregate demand in the economy. The expansion in demand drives up output and marginal costs, and firms increase prices. The shock leads to an increase in hours worked (0.64%). In response to the shock livestock capital initially falls (0.08%) implying the possibility of crowding-out of private investment. The impulse response functions show that the shock have the highest effect on consumption and price index and the lowest on hours. In persistence, the effects of the shock disappear after 25 quarters.

Conclusions

The aim of this research was to study the impulse response functions of the livestock to a number of selected shocks, namely, agricultural productivity, monetary, oil revenue and government spending shock. Accordingly, a DSGE model for Iran economy emphasizing on livestock subsector was constructed. The results indicate that following a rise in agricultural productivity, livestock output, consumption, hours worked and capital rise while livestock price index fall. A positive monetary shock leads to an increase in the livestock macro variables, namely, output, consumption, hours worked, capital and price index. In response to a positive oil revenue shock, livestock output, capital and hours worked fall initially and rise after 3-4 quarters that the shock has occurred suggesting the symptoms of Dutch Disease in Iran’s agriculture. However, consumption and prices rise. Lastly, following a positive government spending shock output, consumption, hours and prices increase while capital fall initially. Comparing the results indicate that productivity shock is of the most desirable results and, in general, has the strongest effects on livestock subsector when compared to those of other shocks. The negative effects of oil revenue shock are more than those of other. In persistence, the effects of productivity shock are more long-lived generally. Among the variables of interest, the labor market variable exhibits the weakest responses to all the shocks while the strongest responses are for output, prices and consumption. Regarding the desirable and lasting effects of positive agricultural productivity shock on the subsector on one hand, and the importance of livestock in agriculture, society and economy, on other hand, it is imperative to take effective steps to improve the productivity level in the industry. Modernization and industrialization of livestock brought about by the effective agricultural research and supporting services along with allocating required credits are proposed as two effective practical measures to achieve this purpose.

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بررسی تأثیر شوک‌های اقتصادی بر زیر بخش دام و طیور در ایران: رویکرد مدل DSGE

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چکیده هدف از مطالعه حاضر بررسی عکس‌العمل متغیرهای اقتصادی زیر بخش دام و طیور (شامل: تولید، مصرف، شاخص قیمت، نیروی کار (ساعات کار) و سرمایه) به شوک‌های بهره‌وری کشاورزی، پولی، درآمدهای نفتی و مخارج دولت (سیاست مالی) می‌باشد. به این منظور یک مدل تعادل عمومی پویای تصادفی (DSGE) برای اقتصاد ایران با تأکید بر زیر بخش دام و طیور طراحی گردید. نتایج حاصله نشان می‌دهد که به‌دنبال افزایش بهره‌وری کشاورزی، تولید، مصرف، اشتغال و موجودی سرمایه افزایش در حالی که سطح قیمت‌ها در این زیر بخش کاهش می‌یابد. شوک مثبت پولی واکنش مثبت تمامی متغیرهای مورد مطالعه را به دنبال دارد. بر اثر شوک مثبت نفتی، مصرف و شاخص قیمت افزایش می‌یابد هرچند که تولید، ساعات کار و موجودی سرمایه ابتدا کاهش می‌یابند که این امر می‌تواند نشانی از وجود بیماری هلندی در بخش کشاورزی ایران باشد. در نهایت به دنبال یک شوک مثبت در مخارج دولت، تولید، مصرف، ساعات کار و قیمت‌ها افزایش و موجودی سرمایه کاهش می‌یابد. مقایسه نتایج، همچنین، نشان می‌دهد شوک بهره‌وری، مطلوب‌ترین نتایج را در پی داشته و بطورکلی در مقایسه با اثرات سایر شوک‌ها بیشترین تأثیر را بر متغیرهای مورد مطالعه گذاشته است. بیشترین اثرات منفی مربوط به شوک مثبت نفتی است و در مجموع، ضعیف ترین واکنش‌ها درپی وقوع شوک‌های پولی و مالی مشاهده می‌گردد.