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How Do Agricultural Subsectors Respond to Productivity Shocks? Evidence from a Bayesian DSGE Model in Iran

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Understanding the dynamics of productivity shocks is instrumental if we are to identify the sources of economic growth. This paper, investigates dynamic effects of positives productivity shocks to agricultural subsectors during the period from 1991-2015, by disaggregating agricultural sector in Iran into four key subsectors (crops, livestock, fishing and forestry) through an estimated DSGE model. Our Bayesian estimation results suggest that positive productivity shocks lead to an increase in output, consumption, capital, employment and real wages and a fall in marginal costs and price indexes in all four subsectors. Comparing the results across the subsectors shows that following the shocks, generally, crops and livestock have the strongest reactions and forestry has the weakest ones. Additionally, among the variables, output indicates the highest responses to the shocks. Variance decomposition analysis reveals that agricultural fluctuations are mainly explained by productivity, monetary, preference and government spending shocks.

Keywords: Agricultural Subsectors, Bayesian Estimation, DSGE Model, Productivity Shocks
JEL Classification: C69, N5

1 Introduction

Understanding the dynamics of productivity shocks is instrumental if we are to identify the sources of economic growth and draw the right policy conclusions for the future. Ignorance of the consequences of a productivity shock will cause policy makers to unknowingly respond to a flawed measure of economic changes. Results from the empirical studies provide strong evidence indicating that agriculture is an engine of economic growth

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especially in developing countries ((Irz & Tiffin 2006)). Agricultural sector plays a fundamental role in the development of Iran's economy by providing 85% of the food needed by the population and 90% of the raw materials needed by the industries. In 2014, agriculture contributed 13.9% to the country's GDP, 22% to employment and 25% to non-oil exports. Agriculture is a source of income to a large proportion of the rural households, and creates a market for agricultural products industry. Recently, due to the international sanctions against Iran's economy, a lot of attention has been paid to the domestic economic capacities and, in particular, to agricultural sector.

Iran's agricultural sector is intensely suffering from limitations of the factors of production as well as high potential risks and bottlenecks, suggesting the necessity of agricultural productivity improvement. Considering severe lack of essential resources and investment to promote agricultural productivity, the dynamic effects of the productivity shocks allows distributing scarce resources more optimally and making better policy decisions in agricultural sector. The aim of this paper is to investigate the responses of agricultural subsectors to a rise in the productivity of each subsector. To do so, we estimate, by using the Bayesian approach, a Dynamic Stochastic General Equilibrium (DSGE) model for Iran's economy emphasizing on agricultural subsectors. Dividing agricultural sector into subsectors contributes to getting more details of agricultural variables under different conditions. In addition, to formulate right strategies for achieving sustained production and rapid growth in agricultural sector, relevant information is absolutely necessary. This study also contributes to the literature by developing DSGE models. To the best of our knowledge this is the first paper which disaggregates agricultural sector into subsectors through an estimated DSGE model.

In this paper, based on the national accounts of Iran, agricultural sector is disaggregated into four key subsectors namely; crops, livestock, fishing and forestry. Among the agricultural subsectors, the crops dominates in terms of its contribution to agricultural sector. This subsector contributed 61.8% value added, 53% employment and 51.4% capital to the agricultural sector in the year 2014-15. The second largest is the livestock accounting for 30.11% value added, 32.6% employment and 21.4% capital of the sector. Forestry and fishing, compared to the other two, have a smaller contribution to Iran's agricultural sector. Reviewing the literature—on the determinants of productivity growth in agricultural sector, reveals that researchers focus on different factors. For instance, Easterly & Serven (2002), Schiffbauer (2009) and Sibert (2007) stress on capital to labor ratio. Suphannachart (2010), Mullen (2007) and Thorat et al., (2006) stress on R&D expenditures. Sharma et al., (2006) and Singh & Singh (1972) emphasize on mechanization. Yanikkaya (2003) and Ahmed & Emmanuel (2000) show that the degree of trade openness matters.

According to Olagunju (2000), Xi & Zi-nai, (2007) and Carter & Olinto (2003), access to credit is the most important factor in productivity growth. The literature also implies there is, almost, a consensus about the effects of technology shock on macroeconomic variables with the exception of the employment. For example, Basu et al., (2006) find that total hours worked fall after a positive TFP (Total Factor Productivity) shock.

By contrast, Chang & Hong (2006) find that total hours worked rise after a positive TFP shock. Gali (1999), Francis & Ramey (2005) and Gali & Rabanal (2004) argue that due to the presence of nominal price rigidities, habit formation and investment adjustment costs, positive productivity shocks lead to an immediate fall in hours worked. In contrast, using alternative VAR specifications and identification strategies, Christiano et al., (2004), Dedola & Neri (2004) and Peersman & Straub (2005) argue that the empirical evidence on the effect of a productivity shock on hours worked is not very robust and could be consistent with a positive impact on hours worked. The remainder of this article is organized as follows: Section 2 provides the overview of our DSGE model structure. The calibration and estimation of parameters are discussed in Section 3. The quantitative results are then presented in Section 4. Section 5 concludes the paper.

2 The Model

Recently, the DSGE model has continued to grow into the most influential tool for analyzing and evaluating macroeconomic policy. The baseline model, in this study, is a small-open economy DSGE model, with price rigidities, capital accumulation, investment adjustment cost, and habit formation, emphasizing on agricultural subsectors.

2.1 Households

There is a continuum of households in the economy indexed by i supplying differentiated labor $l_{i.t}$, consuming $c_{i.t}$ of the final output good and accumulating capital $k_{i.t}$. They maximize their utility function, which is given by:

$$U(0) = E_0 \sum_{t=0}^{\infty} \beta^t \, \xi_t^b \left\{ \frac{(c_{it-}hc_{t-1})^{1-\sigma_c}}{1-\sigma_c} - \frac{l_{it}^{1-\sigma_l}}{1-\sigma_l} \right\}$$

Where, $0 < \beta < 1$ is the subjective intertemporal discount factor, c_t is aggregate consumption and h is the parameter that controls habit persistence. $\xi_t^b = \rho_b \xi_{t-1}^b + \varepsilon_{b.t}$ denotes a preference shock affecting the intertemporal substitution elasticity. The elasticity of intertemporal substitution in consumption and the invers of Fritch labor supply elasticity are denoted by σ_c and σ_l respectively. The budget constraint of household i is:

$$c_{it} + I_{it} = w_{it} l_{it} + \left(r_t z_{it} - \Psi(z_{it})\right) K_{it-1} + D_{it} \tag{1}$$

Here $w_{i.t}$ is the real wage for household i, r_t is the real rental rate households obtain from renting out capital to firms. $\Psi(z_{i.t})$ is a function capturing the resource cost of capital utilization when the utilization rate is $z_{i.t}$ and I_{it} denotes the investment. $D_{i.t}$ are dividends to household i from the intermediate good firms. Households choose the capital stock. The utilization rate and investment subject to the following capital accumulation equation:

$$K_{it} = (1-\delta) K_{it-1} + [1 - S\left(\xi_t^i \frac{I_{it}}{I_{it-1}}\right)] I_{it} \tag{2}$$

Here, δ is the depreciation rate of capital, $S(0)$ is the investment adjustment cost function as in Smets and Wouters (2003) and Chrstiano et al. (2005). In the steady state $S(0)$ equals zero. $\xi_t^i = \rho_i \xi_{t-1}^i + \varepsilon_{i.t}$ is a shock to the investment adjustment cost function.

2.1.1 Household Consumption Decisions

The aggregate consumption bundle, c_t, for the i^{th} household is a composite of non-agricultural and agricultural consumption goods. Its consumption is given by the constant elasticity of substitution (CES) aggregator:

$$c_{it} = [(\alpha_c)^{1/\omega_c} (c_{it}^{na})^{(\omega_c - 1)/\omega_c} + (1-\alpha_c)^{1/\omega_c} (c_{it}^{ag})^{(\omega_c - 1)/\omega_c}]^{\frac{\omega_c}{\omega_c - 1}} \tag{3}$$

Where, c_t^{na} is non-agricultural goods and c_t^{ag} is agricultural goods. α_c is the proportion of non-agricultural goods in 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:

$$c_{it}^{na} = \alpha_c(\frac{P_t^{na}}{P_t})^{-\omega_c} c_{it} \quad (4)$$

$$c_{it}^{ag} = (1-\alpha_c)(\frac{P_t^{ag}}{P_t})^{-\omega_c} c_{it} \quad (5)$$

The overall consumer price index is given as:

$$P_t = [\alpha_c(P_t^{na})^{1-\omega_c} + (1-\alpha_c)(P_t^{ag})^{1-\omega_c}]^{\frac{1}{1-\omega_c}} \quad (6)$$

The consumption of agricultural goods is determined by a CES index composed of domestically produced (home) goods c_t^{dag}, and imported agricultural goods, c_t^{mag}, as follows:

$$c_{it}^{ag} = [(\alpha_{ag})^{1/\omega_{ag}}(c_{it}^{dag})^{(\omega_{ag}-1)/\omega_{ag}} + (1-\alpha_{ag})^{1/\omega_{ag}}(c_{it}^{mag})^{(\omega_{ag}-1)/\omega_{ag}}]^{\frac{\omega_{ag}}{\omega_{ag}-1}} \quad (7)$$

Where, ω_{ag} is the elasticity of intertemporal substitution between home and imported agricultural goods and α_{ag} is the proportion of home agricultural goods in the agricultural goods. The agricultural price index is given as:

$$P_t^{ag} = [\alpha_{ag}(P_t^{dag})^{1-\omega_{ag}} + (1-\alpha_{ag})(P_t^{mag})^{1-\omega_{ag}}]^{\frac{1}{1-\omega_{ag}}} \quad (8)$$

Where, P_t^{dag} is the price index of home agricultural goods and P_t^{mag} is the price index of imported agricultural goods. The consumption of home agricultural goods is determined by a CES index composed of agricultural subsectors' goods including: crops, c_t^{cr}, livestock, c_t^{li}, forestry, c_t^{fo}, and fishing , c_t^{fi}, goods as follows:

$$c_{it}^{dag} = [(\alpha_{cr})^{1/\omega_{dag}}(c_{it}^{cr})^{(\omega_{dag}-1)/\omega_{dag}} + (\alpha_{li})^{1/\omega_{dag}}(c_{it}^{li})^{(\omega_{dag}-1)/\omega_{dag}} + (\alpha_{fo})^{1/\omega_{dag}}(c_{it}^{fo})^{(\omega_{dag}-1)/\omega_{dag}} + (1-\alpha_{cr}-\alpha_{li}-\alpha_{fo})^{1/\omega_{dag}} c_{it}^{fi\,(\omega_{dag}-1)/\omega_{dag}}]^{\frac{\omega_{dag}}{\omega_{dag}-1}} \quad (9)$$

Where, ω_{dag} is the elasticity of intertemporal substitution between subsectors' goods. α_{cr}, α_{li} and α_{fo} respectively, measure the proportions of crops, livestock and forestry goods in home agricultural goods. The price index of home agricultural goods is expressed as:

$$P_t^{dag} = [\alpha_{cr}(P_t^{cr})^{1-\omega_{dag}} + \alpha_{li}(P_t^{li})^{1-\omega_{dag}} + \alpha_{fo}(P_t^{fo})^{1-\omega_{dag}} + (1-\alpha_{cr} - \alpha_{li} - \alpha_{fo})(P_t^{fi})^{1-\omega_{dag}}]^{\frac{1}{1-\omega_{dag}}} \quad (10)$$

Where, P_t^{cr}, P_t^{li}, P_t^{fo} and P_t^{fi} are the price indexes for crops, livestock, forestry and fishing respectively.

2.1.2 Household Labor Supply Decisions

In this model, a fraction Λ_l of households provide labor to non-agricultural sector and the rest of them, $(1-\Lambda_l)$, provide labor to agricultural sector. The aggregate labor is given by the following CES aggregator of non-agricultural labor, l_t^{na}, and agricultural labor, l_t^{ag}:

$$l_{it} = [(\Lambda_l)^{-\omega_l}(l_{it}^{na})^{(1+\omega_l)} + (1-\Lambda_l)^{-\omega_l}(l_{it}^{ag})^{(1+\omega_l)}]^{\frac{1}{1+\omega_l}} \quad (11)$$

Where, ω_l is the elasticity of intertemporal substitution between agricultural and non-agricultural labor. The household optimization problem based on wage earnings, yields the following supply function for the non-agricultural and agricultural labor:

$$l_{it}^{na} = (\Lambda_l)(\frac{w_t^{na}}{w_t})^{\frac{1}{\omega_l}} l_{it} \quad (12)$$

$$l_{it}^{ag} = (1-\Lambda_l)(\frac{w_t^{ag}}{w_t})^{\frac{1}{\omega_l}} l_{it} \quad (13)$$

Where w_t^{na} and w_t^{ag} are real wages in non-agricultural and agricultural sectors. w_t is the aggregate wage index which is defined as:

$$w_t = [\Lambda_l(w_t^{na})^{\frac{\omega_l}{1+\omega_l}} + (1-\Lambda_l)(w_t^{ag})^{\frac{\omega_l}{1+\omega_l}}]^{\frac{1+\omega_l}{\omega_l}} \quad (14)$$

We also assume that agricultural labor can be supplied to its subsectors to a CES aggregator:

$$l_{it}^{ag} = [(\Lambda_{cr})^{-\omega_{lag}}(l_{it}^{cr})^{1+\omega_{lag}} + (\Lambda_{li})^{-\omega_{lag}}(l_{it}^{li})^{1+\omega_{lag}} + (\Lambda_{fo})^{-\omega_{lag}}(l_{it}^{fo})^{1+\omega_{lag}} + (1-\Lambda_{cr}-\Lambda_{li}-\Lambda_{fo})^{-\omega_{lag}}(l_{it}^{fi})^{1+\omega_{lag}}]^{\frac{1}{1+\omega_{lag}}} \quad (15)$$

Where, ω_{lag} denotes the elasticity of intertemporal substitution between subsectors' labor. Λ_{cr}, Λ_{li}, and Λ_{fo} are the fractions of labor supply in the crops, livestock and fishing respectively. w_t^{ag} is defined as:

$$w_t^{ag} = [\Lambda_{cr}(w_t^{cr})^{\frac{\omega_{lag}}{1+\omega_{lag}}} + \Lambda_{li}(w_t^{li})^{\frac{\omega_{lag}}{1+\omega_{lag}}} + \Lambda_{fo}(w_t^{fo})^{\frac{\omega_{lag}}{1+\omega_{lag}}} + (1 - \Lambda_{cr} - \Lambda_{li} - \Lambda_{fo})(w_t^{fi})^{\frac{\omega_{lag}}{1+\omega_{lag}}}]^{\frac{1+\omega_{lag}}{\omega_{lag}}} \quad (16)$$

Where, $w_t^{cr}, w_t^{li}, w_t^{fo}$ and w_t^{fi} are real wages in crops, livestock, forestry and fishing respectively.

2.1.3 Household Capital Supply Decisions

It is assumed that the aggregate capital can be either supply to non-agricultural or agricultural sector according to the following CES aggregator:

$$k_{it} = [\chi_k{}^{1-\omega_k}(k_{it}^{na})^{\omega_k} + (1-\chi_k)^{1-\omega_k}(k_{it}^{ag})^{\omega_k}]^{\frac{1}{\omega_k}} \quad (17)$$

Where, ω_k is the elasticity of intertemporal 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:

$$k_{it}^{na} = \chi_k(\frac{r_t^{na}}{r_t})^{\frac{1}{\omega_k - 1}}k_{it} \quad (18)$$

$$k_{it}^{ag} = (1-\chi_k)(\frac{r_t^{ag}}{r_t})^{\frac{1}{\omega_k - 1}}k_{it} \quad (19)$$

Where, r_t^{na} and r_t^{ag} are real rental rates of the capital in non-agricultural and agricultural sectors respectively. r_t is the aggregate rental rate of capital which is defined as:

$$r_t = [\chi_k(r_t^{na})^{\frac{\omega_k - 1}{\omega_k}} + (1-\chi_k)(r_t^{ag})^{\frac{\omega_k - 1}{\omega_k}}]^{\frac{\omega_k}{\omega_k - 1}} \quad (20)$$

The agricultural capital is accumulated, using a CES technology that combines subsectors' capital as follows:

$$k_{it}^{ag} = [(\chi_{cr})^{1-\omega_{kag}}(k_{it}^{cr})^{\omega_{kag}} + (\chi_{li})^{1-\omega_{kag}}(k_{it}^{li})^{\omega_{kag}} + (\chi_{fo})^{1-\omega_{kag}}(k_{it}^{fo})^{\omega_{kag}} + (1-\chi_{cr}-\chi_{li}-\chi_{fo})^{1-\omega_{kag}}(k_{it}^{fi})^{\omega_{kag}}]^{\frac{1}{\omega_{kag}}} \quad (21)$$

Where, ω_{kag} is the elasticity of intertemporal substitution between subsectors' capital. χ_{cr}, χ_{li} and χ_{fo} are the fractions of capital supply in the crops, livestock and forestry respectively. r_t^{ag} is defined as:

$$\mathrm{r}_t^{ag} = [\chi_{cr}(\mathrm{r}_t^{cr})^{\frac{\omega_{kag}-1}{\omega_{kag}}} + \chi_{li}(\mathrm{r}_t^{li})^{\frac{\omega_{kag}-1}{\omega_{kag}}} + \chi_{fo}(\mathrm{r}_t^{fo})^{\frac{\omega_{kag}-1}{\omega_{kag}}} + (1-\chi_{cr}-\chi_{li}-\chi_{fo})(\mathrm{r}_t^{fi})^{\frac{\omega_{kag}-1}{\omega_{kag}}}]^{\frac{\omega_{kag}}{\omega_{kag}-1}} \quad (22)$$

Where, r_t^{cr}, r_t^{li}, r_t^{fo} and r_t^{fi} are real rental rates of the capital in crops, livestock, forestry and fishing respectively.

2.2 Production

2.2.1 Non-agricultural firms

The final non-agricultural good is a continuum of differentiated goods, each supplied by a different firm indexed by j, using the following CES aggregation technology:

$$y_t^{na} = (\int_0^1 (y_{jt}^{na})^{\frac{1}{1+\gamma_t^p}} dj)^{1+\gamma_t^p} \quad (23)$$

Where, γ_t^p is a stochastic processes that determines the time varying markup in the non-agricultural good market and is given by: $\gamma_t^p = \rho_p \gamma_{t-1}^p + \varepsilon_{p.t}$. The demand for the differentiated product of the j[th] firm, y_{jt}^{na}, follows:

$$y_{jt}^{na} = (\frac{P_{jt}^{na}}{P_t^{na}})^{-\frac{1+\gamma_t^p}{\gamma_t^p}} y_t^{na} \quad (24)$$

Where, $P_{j.t}^{na}$ is the price of the intermediate good j and P_t^{na} is non-agricultural price index which can be written as:

$$P_t^{na} = (\int_0^1 (P_{jt}^{na})^{-\frac{1}{\gamma_t^p}} dj)^{-\gamma_t^p} \quad (25)$$

Firms producing intermediate goods operate in a monopolistically competitive market. They hire labor and capital from households, paying the salary w_t^{na}, and capital rental rate r_t^{na}. The output of an intermediate good producer is given by the following production technology:

$$y_{jt}^{na} = A_t^{na}(k_{jt}^{na})^{\alpha_{na}}(l_{jt}^{na})^{1-\alpha_{na}} \quad (26)$$

Where, α_{na} is the share of capital in production, $k_{j.t}^{na}$ is rented capital, $l_{j.t}^{na}$ is hired labor by intermediate firm j. Following Christiano et al., (2004), A_t^{na}, is a technology shock common for all firms that exhibits the following process:

$$A_t^{na} = (1 - \rho_{na}) + \rho_{na} A_{t-1}^{na} + \rho_{on} \varepsilon_{oil.t} + \varepsilon_{na.t} \tag{27}$$

Here, $\varepsilon_{oil.t}$ is an oil revenue shock and ρ_{on} measures the effect of oil revenue shock on the non-agricultural technology level. The first order conditions with respect to capital and labor are:

$$w_t^{na} = (1 - \alpha_{na}) \zeta_t A_t^{na} (k_{jt}^{na})^{\alpha_{na}} (l_{jt}^{na})^{-\alpha_{na}} \tag{28}$$

$$r_t^{na} = \alpha_{na} \zeta_t A_t^{na} (k_{jt}^{na})^{\alpha_{na}-1} (l_{jt}^{na})^{1-\alpha_{na}} \tag{29}$$

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

$$mc_t^{na} = (\frac{1}{1-\alpha_{na}})^{1-\alpha_{na}} (\frac{1}{\alpha_{na}})^{\alpha_{na}} \frac{(w_t^{na})^{1-\alpha_{na}} (r_t^{na})^{\alpha_{na}}}{A_t^{na}} \tag{30}$$

Intermediate goods producers also face another type of problem. During each period a (1-φ_{na}) fraction of them, randomly chosen, is able to re-optimize its price (see Calvo, 1983). For those that cannot re-optimize, the price will be updated to past inflation as follows:

$$P_{t+s}^{na} = (\pi_t \pi_{t+1} \dots \pi_{t+s-1})^{\tau_{na}} P_t^{na*} \tag{31}$$

Where $\pi_t^{na} = \frac{P_t^{na}}{P_{t-1}^{na}}$ is the gross rate of non-agricultural inflation, τ_{na} is the parameter governing the degree of price indexation and P_t^{na*} is optimal price. The first order condition of maximization of discounted future profits, subject to the intermediate good demand functions by the final good producers, written in terms of the optimal price, p_t^{na*}, is as following:

$$E_t \sum_0^{\infty} (\beta \varphi_{na})^k \frac{\lambda_{t+k}}{\gamma_{t+k}^p} [\prod_{s=1}^k \frac{(\pi_{t+s-1}^{na})^{\tau_{na}}}{\pi_{t+s-1}^{na}}]^{-\frac{1}{\gamma_{t+k}^p}} \frac{P_t^{na*}}{P_{na.t}} y_{t+k}^{na} =$$

$$E_t \sum_0^{\infty} (\beta \varphi_{na})^k \lambda_{t+k} \frac{1+\gamma_{t+k}^p}{\gamma_{t+k}^p} [\prod_{s=1}^k \frac{(\pi_{t+s-1}^{na})^{\tau_{na}}}{\pi_{t+s-1}^{na}}]^{-\frac{1+\gamma_{t+k}^p}{\gamma_{t+k}^p}} mc_{t+k}^{na} y_{t+k}^{na} \tag{32}$$

The aggregate price index can be expressed as:

$$(P_{t+k}^{na})^{-\frac{1}{\gamma_t^p}} = \varphi_{na}[(\pi_{t+s-1}^{na})^{\tau_{na}} p_{t-1}^{na}]^{-\frac{1}{\gamma_t^p}} + (1-\varphi_{na})(P_t^{na*})^{-\frac{1}{\gamma_t^p}} \quad (33)$$

After some manipulating, an equation describing dynamics of the non-agricultural sector inflation rate that is known as Hybrid New Keynesian Philips Curve (HNKPC) is obtained (see Smets and Wouters (2005)):

$$\pi_t^{na} = \frac{\beta}{1+\beta\tau_{na}} E_t\pi_{t+1}^{na} + \frac{\tau_{na}}{1+\beta\tau_{na}} \pi_{t-1}^{na} + \frac{1}{1+\beta\tau_{na}} \frac{(1-\beta\varphi_{na})(1-\varphi_{na})}{\varphi_{na}} mc_t^{na} + \gamma_t^p \quad (34)$$

2.2.2 Agricultural Firms

Agricultural market is a perfect competition because the market structure characterized by a large number of firms, the agriculture product is said to be standardized or homogenous, and there are freedom of entry and exit from the market. This type of market is feasible in the long run and no firm will dominate the market and evict other firm. Furthermore, each firm's products supplied to the markets are prefect substitutes for the product of others firms, so the demand for each firm's product is perfectly elastic. Therefore, the firms in the perfect competition have no power to set the price and they have to sell the product at the going market price (Geoff Riley, 2006). Accordingly, we can present each subsector by a single firm because firms are too small to influence the behavior of other firms, and they are symmetric in equilibrium. Furthermore, there is no need to introduce any pricing persistence in each sector. Competitive agricultural firm's production function for each subsector is given as:

$$y_t^j = A_t^j (k_t^j)^{\alpha_j} (\mathrm{l}_t^j)^{1-\alpha_j} \quad \text{for j = crops, livestock, forestry and fishing}$$

Where, α_j is the share of capital in production, k_t^j is rented capital and l_t^j is hired labor by intermediate good firms in each subsector. A_t^j denotes a stationary technology shock that for each subsector j exhibits the following processes:

$$A_t^{cr} = (1-\rho_{cr}) + \rho_{cr}A_{t-1}^{cr} + \rho_{oa}\varepsilon_{oil,t} + \varepsilon_{crt} \quad (35)$$

$$A_t^{li} = (1-\rho_{li}) + \rho_{li}A_{t-1}^{li} + \rho_{oa}\varepsilon_{oil,t} + \varepsilon_{lit} \quad (36)$$

$$A_t^{fi} = (1-\rho_{fi}) + \rho_{fi}A_{t-1}^{fi} + \rho_{oa}\varepsilon_{oil,t} + \varepsilon_{fit} \quad (37)$$

$$A_t^{fo} = (1-\rho_{fo}) + \rho_{fo}A_{t-1}^{fo} + \rho_{oa}\varepsilon_{oil,t} + \varepsilon_{fot} \quad (38)$$

These shocks, as is commonly in DSGE models, are interpreted as productivity shocks. The intermediate good firms maximize the expected present value of their profits that leads to the following first order conditions with respect to input factors and final price.

$$\alpha^j \tau_t^j \frac{y_t^j}{k_t^j} = r_t^j \quad (39)$$

$$(1-\alpha^j)\tau_t^j \frac{y_t^j}{l_t^j} = w_t^j \quad (40)$$

$$P_t^j = \tau_t^j \quad (41)$$

Where τ_t^j is the real marginal cost corresponding to each subsector. Equation (41) implies the usual profit-maximizing condition under perfect competition.

2.3 Foreign Sector

2.3.1 Optimal Pricing Decision in Import

In importing sector, the firms buy a homogenous good in the world market, and use a branding technology to transform it into differentiated goods, which are then sold to local household's subject to price stickiness in the local currency. There is a continuum of monopolistic domestic importers purchase the foreign good at the consumer price index of the world P_t^*, that for a small open economy (like Iran), P_t^* is taken as given. The final imported consumption good is a composite of j ϵ (0,1) differentiated imported goods supplied by different firms, which is described by the CES aggregator:

$$c_t^m = \left(\int_0^1 (c_{jt}^m)^{\frac{1}{1+\gamma_t^m}} dj\right)^{1+\gamma_t^m} \quad (42)$$

Where, $\gamma_t^m = \rho_{im}\gamma_{t-1}^m + \varepsilon_{im.t}$ is markup in importing sector. Similar to obtaining the equation describing dynamics of the non-agricultural inflation rate, a Philips Curve for importing goods firm is obtained (see Adolfson (2007) and Monacelli (2005)):

$$\pi_t^m = \frac{\beta}{1+\beta\tau_m} E_t\pi_{t+1}^m + \frac{\tau_m}{1+\beta\tau_m}\pi_{t-1}^m + \frac{1}{1+\beta\tau_m}\frac{(1-\beta\varphi_m)(1-\varphi_m)}{\varphi_m} mc_t^m + \gamma_t^m \quad (43)$$

Where, $mc_{t+k}^m = \frac{ex_{t+k}(1+trf_t^m)P_t^*}{P_t^m}$, ex_t is nominal exchange rate, P_t^m is import price index and $trf_t = \rho_{trf} trf_{t-1} + \varepsilon_{trf.t}$ is tariff rate.

2.3.2 Optimal Pricing Decision in Export

There is a continuum j ϵ (0, 1) of exporting firms that buy a homogeneous good in domestic market and transforms it into a differentiated good to be sold on foreign market. The marginal cost of an exporting firm is the price paid for domestic good. Each exporting firm faces the following demand function for its product in each time period:

$$X_{jt} = \left(\frac{P_{jt}^x}{P_t^x}\right)^{\frac{1+\gamma_t^x}{\gamma_t^x}} X_t \quad (44)$$

Where P_t^x is export price index and $\gamma_t^x = \rho_x \gamma_{t-1}^x + \varepsilon_{xt}$ is markup. Briefly, the following export price dynamics (a Philips Curve for exporting goods firm) is obtained:

$$\pi_t^x = \frac{\beta}{1+\beta\tau_x} E_t \pi_{t+1}^x + \frac{\tau_x}{1+\beta\tau_x} \pi_{t-1}^x + \frac{1}{1+\beta\tau_x} \frac{(1-\beta\varphi_x)(1-\varphi_x)}{\varphi_x} mc_t^x + \gamma_t^x \quad (45)$$

2.4 The Government and Central Bank

Due to lack of independence of the Central Bank and financial control of the government in Iran, the government and Central Bank could be considered in one framework. In the study we assume the government is trying to balance its expenditures through tax earnings from households and earnings from the sale of the oil. Hence, the government budget deficit is obtained as the following equation:

$$\mathrm{GBD_t} = \mathrm{G_t} - \frac{\mathrm{ex_t oil_t}}{\mathrm{P_t}} - \mathrm{T_t} \quad (46)$$

Where $G = \rho_g G_{t-1} + \varepsilon_{g.t}$ is total government expenditures, T_t is the government tax earnings and oil_t is oil export earnings. Considering Iran as an oil exporter country which its oil export share is determined by OPEC, hence, exchange earnings from oil export are exogenous and it is assumed it follows an AR(1) process as the following equation:

$$oil_t = \rho_{oil} oil_{t-1} + \varepsilon_{oil,t} \quad (47)$$

We, also, supposed that balance sheet merely contains high-powered money:

$$M_t = DC_t + ex_t FR_t \tag{48}$$

Where FR_t is net foreign assets of the Central Bank and $DC_t = GBD_t + DC_{t-1}$ is net public sector debt to the Central Bank. By dividing both sides of the above equation by prices' level, real high powered money is obtained:

$$m_t = dc_t + \frac{ex_t FR}{P} \tag{49}$$

A change in net foreign assets of the Central Bank (in foreign currency) has the following equation:

$$FR_t - FR_{t-1} = (oil_t + P^x X_t - \frac{1}{ex_t} P^m M_t) \tag{50}$$

Where M_t is imported consumption goods. Since the interest rate is discretionary determined in Iran's economy, the best assumption that could explain the behavior of monetary policy in Iranian economy, instead of Taylor rule, is to assume that monetary policy tool available to the Central Bank is money growth rate. Also, it is assumed that monetary policy response function is in a way that the money growth rate responds to changes in government budget deficit and real exchange rate as well as oil revenue fluctuations. Regarding the inevitable relationship between volatility of money growth rate and volatility of oil revenue in an oil producing country, when petrodollars exchanged to national currency, the monetary policy response function in log-linearized form is defined as follows:

$$\hat{\mu}_t = \rho_m \hat{\mu}_{t-1} + \rho_{gbd} \widehat{GBD}_t + \rho_{rer} \widehat{rer}_t + \rho_o \varepsilon_{oil} + \varepsilon_{\mu_t} \tag{51}$$

Here $\hat{\mu}_t = \widehat{m}_t - \widehat{m}_{t-1} + \hat{\pi}_t$ is money growth rate, $\widehat{\mathrm{GBD}}$ is the government budget deficit deviation from its steady state level in the period t, $\widehat{\mathrm{rer}}_t = \widehat{\mathrm{ex}}_t + \widehat{\mathrm{P}}^*_t - \widehat{\mathrm{P}}_t$ is real exchange rate gap in its steady state, ε_{oil} is oil revenue shock, ρ_m, ρ_{gbd}, ρ_{rer} and ρ_o are the parameters of the monetary policy rule and $\xi^{\mu}_t = \rho_\mu \xi^{\mu}_{t-1} + \varepsilon_{\mu.t}$ is the monetary policy shock.

2.5 Market Clearing

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

$$y_t = c_t + I_t + G_t + \frac{ex_t(P^x X_t + oil_t) - P^m M_t}{P_t} \quad (52)$$

$$y_t = y_t^{na} + y_t^{cr} + y_t^{li} + y_t^{fi} + y_t^{fo} \quad (53)$$

3 Calibration, Prior and Posterior Distributions

A number of are calibrated as commonly done in the DSGE literature. This is because they are either difficult to estimate or they are better identified using other information. To account for their influence on the estimation results we provide an extensive robustness analysis, using different values for these parameters. In what follows, we present the calibration of the fixed parameters.

Following Manzour & Taghipour (2015), we set the discount factor, β, to 0.975 the value of the depreciation rate, δ, to 0.035 and the inverse of Frisch elasticity,σ_l, to 2.95. We use 0.60 for the share of non-agricultural goods in consumption, α_c, and 0.78 for the share of home agricultural goods in agricultural goods, α_{ag}. The share of crops, α_{cr}, livestock, α_{li}, and forestry, α_{fo}, in home agricultural goods are set to 0.50, 0.25, and 0.13 respectively. We set the share of labor supplied to non-agricultural sector, Λ_l, to 0.81. The share of crops, Λ_{cr}, livestock, Λ_{li}, and forestry, Λ_{fo}, in agricultural labor are set to 0.51, 0.29, and 0.12 respectively. The share of non-agricultural sector in capital supply, χ_k, is set to 0.92. The fraction of crops, χ_{cr}, livestock, χ_{li}, and forestry, χ_{fi}, in agricultural capital are set to 0.54, 0.22, and 0.15 respectively. The share of capital in non-agricultural output is calibrated to 0.44.

We also set the share of capital in the subsectors' output to: 0.45 for crops, 0.47 for livestock, 0.43 for fishing and 0.41 for forestry. It is worth noting that all these proportions and shares match the data from official statistical sources in Iran. The remaining parameters are estimated by using the Bayesian method, conditional on prior information relating to the values of parameters. To estimate the model, we use 17 series of Iran's yearly data from 1991 to 2015: domestic inflation, real GDP, real oil revenues, agricultural subsectors' employment and capital, non-agricultural employment and capital, total employment and capital, government expenditures and Central Banks' foreign assets. Data used in this study originates mainly from Iran Statistical Center (ISC) and Central Bank database.

We choose priors from evidence-based studies available in the Iran, such as Manzour and Taghipour (2015), Manzour and Taghipour (2015), Tavakolian & Ebrahimi (2012). Detailed descriptions of the prior distributions for the structural DSGE parameters and the results from the maximum likelihood estimates are summarized in table 1. We use beta distribution for those parameters that must lie in the [01] interval, Gamma priors for parameters with positive support, Normal priors for parameters with negative support, and Inverse-Gamma priors for shock standard deviations. The habit formation parameter, h, is set to have a mean of 0.35 in line with referenced literature for Iran. The mean of inverse elasticity substitution of consumption, σ_c, as in Manzour and Taghipour (2015), is 1.5. The parameter related to capital adjustment costs has a mean of 3.94 following Manzour and Taghipour (2015). The mean of the parameters representing the degree of price indexation for non-agricultural, import and export sector are set to 0.51, 0.7 and 0.55 respectively, based on Manzour and Taghipour (2015). Calvo price parameters ($\varphi_{na}, \varphi_m, \varphi_x$), are assumed to follow Beta distribution centered at 0.2, as in Tavakolian & Ebrahimi (2012). The mean of parameters corresponding to monetary policy ($\rho_m = 0.32, \rho_{gbd} = 0.53, \rho_{rer} = 0.66, \rho_o = 0.73$) and that of the coefficients on oil shock in technology process ($\rho_{oa} = 0.65, \rho_{on} = 0.73$) are set based on authors' estimations.

Turning to the parameters of agricultural sector, due to lack of prior knowledge, we choose relatively diffuse priors based on realities available in Iran's agriculture. Their means are supposed to lie in [1.8-3.5] interval with a standard deviation of 0.7 except for the elasticity of substitution between agricultural and non-agricultural goods and the elasticity of substitution between agricultural and non-agricultural capital that both have a mean of 0.6. Lastly, all of the AR (1) coefficients (ρ's), reported in table 2, are assumed to have a prior of Beta distribution with standard deviation 0.05. Also, priors for the standard deviations (ε's) of all shocks have an Inverse Gamma distribution with mean 0.1 and standard deviation of infinity. As the posterior means, reflected at the last 3 columns in table 1, show the estimates of h, and φ, are slightly less than their prior means, whereas, that of σ_c is slightly higher than its initial mean. Price stickiness parameters fall from their prior means to around 0.08. The estimations of monetary policy parameters exceed from their referred priors except for ρ_{dgb} that falls to 0.5126. The posterior mean of non-agricultural price indexation exceeds from its priors while those of import and export price indexation drop. Regarding the parameters corresponding to agriculture, the estimates are nearly close to the prior means with the exception of ω_{kag} and ω_{ag} that are relatively, much greater than their prior means.

Table 1

Prior and Posterior Distribution of the Structural Parameters

Parameter		Prior distributions			Posterior modes		
		Type	Mean	SD	mean	SD	95%
H	Habit formation	Beta	0.35	0.0 2	0.3129	0.0311	[0.2901,0.3358]
Ψ	Capital adjustment cost parameter	Gama	3.94	0.05	3.8841	0.0532	[3.7241,4.0440]
σ_c	Inverse elasticity of substitution in consumption	Gama	1.5	0.05	1.6332	0.0226	[1.6175,1.6490]
ω_c	Elasticity of substitution between agricultural and non-agricultural goods	Beta	0.60	0.07	0.5328	0.0601	[0.5189,0.5467]
ω_{ag}	Elasticity of substitution between home and imported agricultural goods	Gama	2.5	0.07	3.4512	0.0233	[3.4381,3.4643]
ω_{dag}	Elasticity of substitution between subsectors' goods	Gama	3.50	0.07	3.5704	0.0425	[3.5584,3.5822]
ω_l	Invers elasticity of substitution between agricultural and non-agricultural labor	Gama	2.80	0.07	2.9443	0.0430	[2.9114,2.9772]
ω_{lag}	Elasticity of substitution between subsectors' labor	Gama	2.40	0.07	2.5456	0.0315	[2.5294,2.5617]
ω_k	Elasticity of substitution between agricultural and non-agricultural capital	Beta	0.60	0.07	0.5672	0.0132	[0.5461,0.5883]
ω_{kag}	Elasticity of substitution between subsectors' capital	Gama	1.80	0.07	2.6320	0.0361	[2.6064,2.6576]
φ_{na}	Non-agricultural price stickiness	Beta	0.20	0.05	0.0832	0.0521	[0.0811,0.0853]
φ_m	Import price stickiness	Beta	0.20	0.05	0.0761	0.0376	[0.0745,0.0777]
φ_x	Export price stickiness	Beta	0.20	0.05	0.0813	0.0351	[0.0794,0.0832]
τ_{na}	Non-agricultural price indexation	Beta	0.51	0.03	0.5411	0.0123	[0.5437,0.5375]
τ_m	Import price indexation	Beta	0.70	0.05	0.6711	0.0142	[0.6512,0.7032]
τ_x	Export price indexation	Beta	0.55	0.05	0.5302	0.0251	[0.5121,0.5483]
ρ_{oa}	Coefficient on oil shock in agricultural technology process	Beta	0.65	0.05	0.7165	0.0137	[0.7004,0.7326]
ρ_{on}	Coefficient on oil shock in non-agricultural technology process	Beta	0.73	0.05	0.7855	0.0142	[0.7611,0.8099]
ρ_m	Coefficient on lagged money growth rate in monetary Policy	Beta	0.32	0.05	0.3531	0.0212	[0.3349,0.3713]

ρ_{dgb}	Coefficient on GBD in monetary Policy	Beta	0.53	0.05	0.5126	0.0106	[0.5049,0.5203]
ρ_{rer}	Coefficient on real exchange rate in monetary Policy	Beta	0.66	0.05	0.6841	0.0311	[0.6549,0.7133]
ρ_{oil}	Coefficient on oil shock in monetary Policy	Beta	0.73	0.05	0.7627	0.0312	[0.7449,0.7805]

Source: Authors' Findings.

Table 2

AR (1) Processes Coefficients (Exogenous Processes)

Parameter	Description	Prior distributions			Posterior modes		
		Type	Mean	SD	Mean	SD	95%
Persistence							
ρ_b	Consumption preference	Beta	0.65	0.05	0.6842	0.0311	[0.6691,0.6951]
ρ_i	Investment	Beta	0.70	0.05	0.7235	0.0405	[0.7112,0.7331]
ρ_{na}	Non-agricultural technology	Beta	0.75	0.05	0.7964	0.0309	[0.7892,0.8009]
ρ_{cr}	Crops technology	Beta	0.55	0.05	0.7838	0.0403	[0.7698,0.7953]
ρ_{li}	Livestock technology	Beta	0.45	0.05	0.6332	0.0310	[0.6194,0.6428]
ρ_{fi}	Fishing technology	Beta	0.35	0.05	0.4134	0.0501	[0.4022,0.4228]
ρ_{fo}	Forestry technology	Beta	0.60	0.05	0.6841	0.0330	[0.6709,0.6951]
ρ_{μ}	Monetary policy	Beta	0.65	0.05	0.7327	0.0116	[0.7202,0.7417]
ρ_p	Non-agricultural price markup	Beta	0.70	0.05	0.7852	0.0083	[0.7686,0.7991]
ρ_x	Export price markup	Beta	0.5	0.05	0.5114	0.0322	[0.4941,0.5263]
ρ_{im}	Import price markup	Beta	0.45	0.05	0.4912	0.0887	[0.4749,0.5082]
ρ_{trf}	Tariff	Beta	0.68	0.05	0.6671	0.0417	[0.6388,0.6959]
ρ_{oil}	Oil revenue	Beta	0.40	0.05	0.4563	0.0471	[0.4361,0.4773]
Standard Deviation							
ε_b	Consumption preference	Inv. Gamma	0.1	Inf	0.9694	0.0322	[0.9412,1.0188]
ε_i	Investment	Inv. Gamma	0.1	Inf	1.7542	0.1130	[1.7303,1.7761]
ε_{na}	Non-agricultural technology	Inv. Gamma	0.1	Inf	1.6761	0.1203	[1.6503,1.6999]
ε_{cr}	Crops technology	Inv. Gamma	0.1	Inf	0.3592	0.0317	[0.3361,0.3801]
ε_{li}	Livestock technology	Inv. Gamma	0.1	Inf	0.4964	0.0612	[0.4725,0.5177]
ε_{fi}	Fishing technology	Inv. Gamma	0.1	Inf	0.4286	0.0672	[0.4172,0.4377]
ε_{fo}	Forestry technology	Inv. Gamma	0.1	Inf	1.4016	0.1334	[1.3911,1.4087]
ε_{μ}	Monetary policy	Inv. Gamma	0.1	Inf	0.5632	0.0421	[0.5472,0.5768]
ε_p	Non-agricultural price markup	Inv. Gamma	0.1	Inf	0.4363	0.0634	[0.4143,0.4572]

ε_x	Export price markup	Inv. Gamma	0.1	Inf	0.0072	0.0322	[0.0061,0.0082]
ε_{im}	Import price markup	Inv. Gamma	0.1	Inf	0.0960	0.0921	[0.0701,0.1221]
ε_{trf}	Tariff	Inv. Gamma	0.1	Inf	0.0756	0.0561	[0.0421,0.1093]
ε_{oil}	Oil revenue	Inv. Gamma	0.1	Inf	0.1231	0.0437	[0.0892,0.1568]

Source: Authors' Findings.

Table 3 compares the second moments from actual data and those generated by the model. In the analysis of business cycles, matching second moments from actual data and the model is crucial for the assessment of model performance. The results indicate that the simulated moments (standard deviations and correlations) match the actual ones quite well. So the model is well-constructed to explain Iran's economy.

Table 3
Real and Simulated Data Moments

Standard deviations	correlation with agri output		SD	
	Actual	Simulated	Actual	simulated
Real GDP	0.862	0.822	0.064	0.051
Inflation rate	0.759	0.692	0.153	0.141
Real oil revenues	0.551	0.534	0.112	0.088
Government spending	0.921	0.902	0.086	0.073
Real agricultural output	-	-	0.042	0.040
Real non-agricultural output	0.931	0.914	0.053	0.049

Source: Authors' Findings.

4 Dynamics of the model

4.1 Impulse responses

Figures 1 through 4 display impulse responses of each subsectors' variables (i.e., consumption, output, employment, real wages, capital, price indexes and marginal costs) to a rise in the productivity of same subsector. Impulse response functions (IRFs), after log-linearizing and estimating the DSGE model, are obtained from one-standard deviation shocks. Each response is expressed as the percentage deviation of a variable from its steady state level. As the results show, positive productivity shocks lead to an increase in output. Following the productivity shock firms can produce more for given amount of labor and capital. We can also see that the output of crops (1.41%), livestock (1.23%) and fishing (1.15%) have the strongest responses and, in persistence, the effects are uniform. The responses of marginal costs and price indexes are standard. Increasing production, due to a positive productivity shock, makes the marginal costs of the firms drop and this enables firms to lower producer prices. However, the drop in marginal costs is greater than the drop in price indexes. The livestock (0.44%), crops (0.39%) and fishing (0.17%) have the most drop in the marginal costs and the same happens to their price indexes. The rise in output and the fall in price lead to an increase in consumption. The strongest consumption responses are for livestock (1.18%), fishing (1.37%) and crops (0.81%). Increasing productivity, makes it profitable for firms to employ more production inputs.

Incidentally, capital rises. The greatest reactions are observed in crops (0.78%), livestock (0.26%) and fishing (0.09%). Finally, in response to positive productivity shocks, employment in all four subsectors rises. The higher productivity makes it more attractive for the firm to increase employment and allows it to do so by increasing the wage it offers to workers. This finding could be different if we considered price rigidities for agricultural firms in the model. In theory, positive productivity shocks in real business cycle models with real rigidities (Francis and Ramey (2005)) or in sticky price models (Gali (1999)) can generate negative effects on employment. When productivity increases, fixed prices imply unclenched real sales so that less labor is required to meet a given level of nominal demand. Whereas, not considering the rigidities might lead to different results as in this study. The shock has the strongest effect on livestock subsector employment. A further investigation of the IRFs shows that following the productivity shocks, in general, output shows the greatest reactions, whereas the weakest ones are observed in labor market variables specifically employment and real wages.

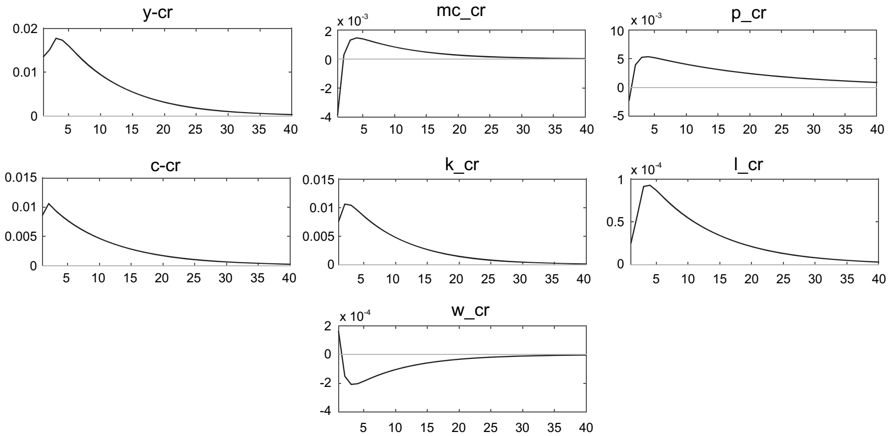

Figure 1. Impulse response functions of crops to a one standard deviation productivity shock. *Source*: Authors' Findings.

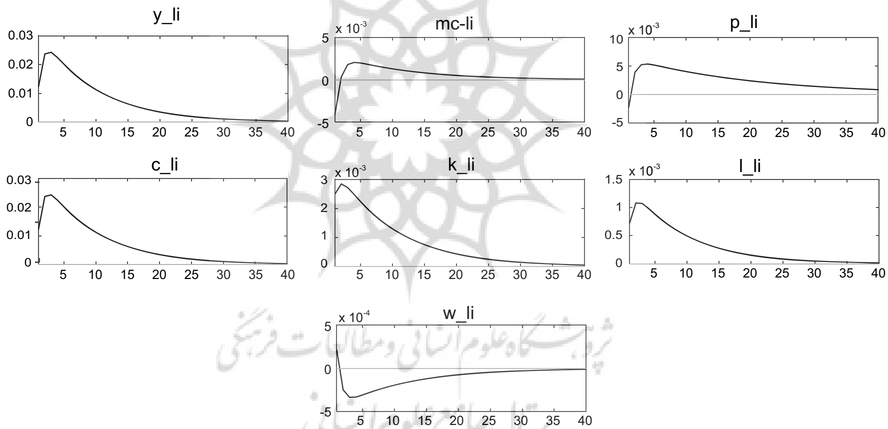

Figure 2. Impulse response functions of livestock to a one standard deviation productivity shock. *Source*: Authors' Findings.

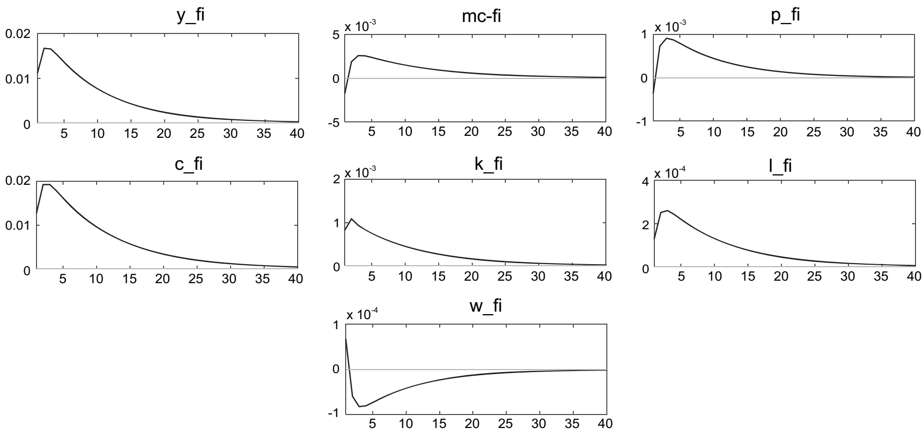

Figure 3. Impulse response functions of fishing to a one standard deviation productivity shock.
Source: Authors' Findings.

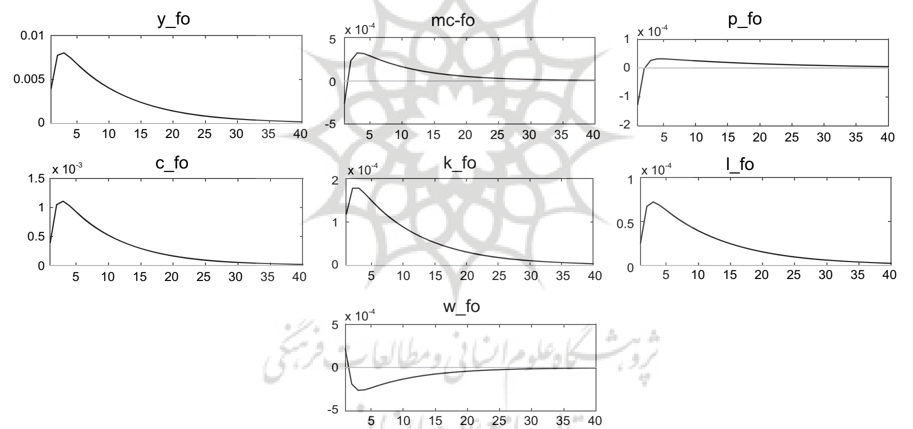

Figure 4. Impulse response functions of forestry to a one standard deviation productivity shock.
Source: Authors' Findings.

4.2 Variance Decomposition

Table 4 depicts the conditional variance decomposition of some of the agricultural subsectors' macro-variables i.e., output, consumption and price indexes. It permits the impact of different shocks to the variability of the variable of interest at different horizons be formally assessed. We only report shocks that explain at least one percent of the variance of the variables. As the results indicate productivity and monetary shocks explain most of the observed variance for output across the subsectors. The former, on average, explains 36.5-35% while the latter explains 22-19.5% at different horizons. Government spending shock (15-13.5%) also plays an important role in explaining the output movements. Regarding the drivers of consumption, a big part of the fluctuations is explained by the preference shock (30-28%). However, productivity shock (24-21.5%) and monetary shock (16-15%) also contribute significantly to the volatility of agricultural consumption. As for price indexes, its dynamics is mainly explained by monetary shock (30-27.5%) and productivity shock (26-24%). Also, government spending and preference shock, to a lesser extent, are of importance in driving the cyclical fluctuations in agricultural price indexes. The results further show oil revenue and investment shocks, relatively, have a little contribution in explaining agricultural fluctuations. However, as the time lag increases, the investment shock gains more importance (accounting for about 8% in the short run, its contribution rises to about %16 in the long run).

Table 4
Variance Decomposition

Subsector	**Variable**	**Year**	**Productivity**	**Monetary**	**Government spending**	**Oil revenue**	**Preference**	**Investment**
	Output	1	39.32	19.42	13.48	8.55	10.71	8.52
		5	38.03	18.47	13.29	7.64	10.24	12.33
		10	36.76	17.51	12.95	7.53	9.82	15.43
		20	35.81	16.97	12.54	7.31	9.42	17.95
	Consumption	1	22.55	15.86	11.76	12.65	29.76	7.42
		5	21.49	17.45	10.65	11.65	29.43	9.33
		10	20.13	19.56	8.89	11.21	28.67	11.54
		20	19.96	18.62	7.84	10.97	27.89	14.72
	Price index	1	26.53	28.74	14.33	9.63	15.33	5.44
		5	26.32	28.56	15.89	8.53	16.14	4.56
Crops		10	25.87	28.09	15.67	8.21	16.43	5.73
		20	24.98	27.78	15.22	7.53	16.53	7.96
	Output	1	38.47	20.48	14.78	8.76	9.56	7.95
		5	37.45	19.34	13.44	8.39	9.52	11.86
		10	36.56	18.66	13.76	7.82	8.66	14.54
		20	36.53	17.84	14.12	6.55	8.31	16.65
	Consumption	1	25.43	14.33	10.45	10.65	30.51	8.63
		5	24.78	13.85	10.32	10.65	29.63	10.77
		10	22.78	13.46	9.89	10.81	29.47	13.59
		20	20.96	13.22	9.54	10.37	29.59	16.32
	Price index	1	28.4	29.35	15.26	7.67	16.11	3.21
Livestock		5	28.21	29.69	14.77	7.32	15.45	4.56
		10	26.67	28.58	14.48	6.79	14.97	8.51
		20	25.74	27.93	14.16	6.03	14.75	11.39
	Output	1	35.18	22.64	15.34	8.48	11.23	7.13
Fishing		5	35.45	21.54	14.04	8.29	9.82	10.86

		10	34.72	21.21	13.69	7.98	8.86	13.54
		20	33.98	19.92	12.89	7.45	8.81	16.95
	Consumption	1	24.76	15.73	11.53	10.55	29.45	7.98
		5	24.63	14.47	10.98	10.11	29.22	10.59
		10	23.43	13.86	10.43	9.69	28.82	13.77
		20	22.66	13.41	9.35	9.42	28.15	17.01
	Price index	1	25.23	30.31	16.16	7.24	16.04	5.02
		5	25.11	30.23	15.2	7.79	15.34	6.33
		10	25.18	29.78	14.95	7.64	15.24	7.21
		20	24.23	28.85	14.76	6.83	15.36	9.97
	Output	1	33.87	24.67	16.34	7.78	10.23	7.11
		5	33.64	24.51	16.24	7.56	8.82	9.23
		10	32.92	23.91	15.79	7.03	6.86	13.49
		20	32.75	23.72	14.85	6.78	5.81	16.09
	Consumption	1	22.89	17.73	12.87	9.45	28.78	8.28
		5	22.53	17.47	11.65	10.11	28.38	9.86
		10	22.33	15.77	11.43	9.54	27.52	13.41
		20	21.86	14.91	10.85	9.22	26.75	16.41
	Price index	1	23.78	31.78	16.39	8.37	15.36	4.32
		5	22.05	31.02	16.28	8.25	13.81	8.59
		10	21.83	30.34	15.12	7.84	12.34	12.53
Forestry		20	20.36	29.41	14.95	7.53	11.82	15.93

Source: Authors' Findings.

5 Conclusion

The aim of this study is to investigate dynamics of each agricultural subsector to a positive productivity shock in the same subsector. To do so, a DSGE model for Iran economy, emphasizing on agricultural subsectors, including price rigidities, capital accumulation, investment adjustment costs, and habit formation, is constructed. Our Bayesian estimation results suggest that positive productivity shocks lead to an increase in output, consumption, employment, capital and real wages and a fall in marginal costs and price indexes in all four Iran's agricultural subsectors. Comparing the results across the subsectors shows that following the shock, generally, crops and livestock subsectors have the strongest reactions and forestry has the weakest ones. In explanation of the result we explain the following possible reasons: First, livestock and crops are the fastest growing agricultural subsectors gaining more the benefits of the technological advances in different scopes such as laboratory equipments, irrigation systems, improved seeds, chemical fertilizers, breeds and genes. Second, crops and livestock, together, contribute about 86 percent to agricultural capital, a key effective factor in enhancing productivity. Third, since most of the food needs are provided by these two sectors, they benefit significantly from the supportive government policies such as subsidies and agricultural credit. Forth, the highest share of agricultural R&D expenditures belongs to these two subsectors. And fifth, the private sector in these two sectors has the greatest presence. On the contrary, fishing and forestry are mostly stated-owned suffering from lack of capital. There are a lot of economic capacity left unused in these two subsectors. The results also reveal that in response to productivity shocks the greatest responses are observed in output, whereas, labor market variables show the weakest ones.

Variance decomposition analysis reveals that the subsectors' output movements, are mainly explained by productivity, monetary and government spending shocks. The main drivers of the price indexes are monetary and productivity shocks and, lastly, consumption dynamics are mainly explained by preference, productivity and monetary shocks.

Given that positive productivity shocks have desirable effects on agricultural sector and taking into account that the sector plays an important role in Iran' economic growth and development, it is inevitable to improve agricultural productivity level. In this regard, increasing farmers' income, developing agricultural insurance, industrializing production and operation methods in agriculture are taken as useful and effective measures that not only increase domestic supply and employment, but also, through promoting competitiveness in foreign markets, boost agricultural exports. The government should consider increasing productivity in crops and livestock subsectors that can play an important role in economy growth by helping to increase food security and reduce poverty. However, in this process, fishing and forestry should not be neglected.

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