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Deep habits in an Iranian Markov-switching DSGE Model

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Abstract:
This paper attempts to compare a Markov-Switching Dynamic Stochastic General Equilibrium (MS-DSGE) model by including deep habits consumption to a MS-DSGE model without deep habits. It is concluded that the deep habit adjusted model with regime switching is able to fit the Iranian data better. The results of estimating parameters indicate that deep habit formation, together with the persistence of habit stock, are significant parameters. The results also confirm that current and future consumption demand, expected marginal cost and stock of habits are effective driving forces in extracted New Keynesian Philips Curve considering deep habits. However, in contrast with Ravn et al (2006, 2010) findings, it is shown that presence of deep habit consumption in the model for Iranian economy, cannot lead to reduce inflation in response to monetary shock while the amount of increase in inflation in response to monetary shock in the model with deep habit is less than inflation increase in model without deep habits. Furthermore, in response to fiscal shock in the model considering deep habits, the negative effect of wealth could not be compensated in Iranian economy. Therefore, consumption begins to decrease in response to fiscal shock, although these reduction in the model without deep habits takes more longer than in the model with deep habits.

1. Introduction

This paper seeks to empirically investigate the ability of deep habits consumption in Markov-Switching Dynamic Stochastic General Equilibrium (MS-DSGE) to fit the Iranian data by comparing it to a MS-DSGE model without deep habits.

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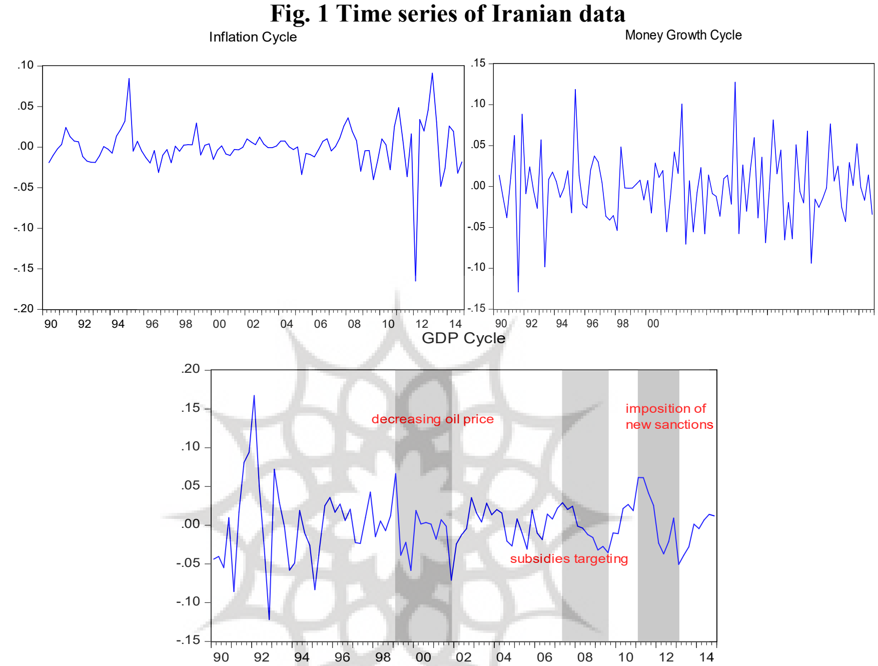
Deep habits were first introduced by Ravn et al. (2006) in a DSGE model and flexible price environment. They demonstrate that households do not simply form their habits from overall consumption level –i.e., superficial habit- and the habit formation is based on the consumption of individual goods. In this way, supply side is affected. That means, deep habit-adjusted demand function is added to the firm's optimal pricing problem as a constraint. Therefore, future demand for each variety of goods faced by firms, depends on the current sale of that specific goods and firms' current pricing of goods affects its future sale through its future demand. This effect, named inter-temporal effect of deep habits, leads to countercyclical behavior of mark-up. When firms face high demand of goods, they reduce prices in order to create habit and be able to guarantee raising future demand and profits. Moreover, as Ravn et al (2010) indicate, the NKPC changes fundamentally, and some new driving forces such as expected marginal value of future demand and current and expected consumption growth are added to inflation dynamics.

By including deep habits in the model, various empirical studies have been conducted to investigate the effect of monetary and fiscal shocks on the dynamics of key macroeconomic variables. Ravn et al. (2010) implies that, consumption increases as a result of monetary shock, however, due to deep habits, firms have a tendency to keep the price low. Ravn et al (2010) using sticky price/sticky wages model augmented with deep habit, estimate key parameters by limited information approach. They demonstrate that the role of deep habit and nominal rigidities are the same in dynamic effects of monetary shock. Counter-cyclicality of firms' markups in response to a fiscal shock is also derived in Ravn et al. (2010). They demonstrate that increasing aggregate demand due to a fiscal shock leads to a raise in labor demand and, consequently, a raise in wages. Including deep habits in demand function causes a decline in markups; therefore, negative wealth effect of fiscal shock may be compensated and thereby, consumption increases. Zubairy (2010) also confirms counter- cyclicality of markups by introduction of deep habits in new Keynesian model; however, he indicates that for very high degree of deep habits, determinacy is not guaranteed under interest rate rule and Taylor principal is a very weak condition to guarantee stability of the model. Laith et al (2015), in line with Ravn et al (2006), find out government spending crowding-in of household consumption, by including deep habit in the model as well as discriminating between the price of public and household sector. Jacob et al (2013) declare that considering simultaneously deep habit and price stickiness in the model, can weaken government spending crowding-in of consumption. Moreover, consumption may be crowded out of government spending, depending on how large is the degree of price stickiness. Contore et al (2014) using Bayesian estimation technique, compare deep and superficial habit in a DSGE model and evaluate their ability to fit the US data in the model. They show that in comparison with superficial habit, the persistence in the stock of deep habit makes the model fit the data better. Following Ravn et al (2010), Lubik & Teo (2011) derive deep habits NKPC without considering the stock of deep habit and estimate parameters using general method of moment (GMM) in a partial equilibrium model. They confirm that the degree of indexation in obtained NKPC is much lower than standard NKPC. Jacob & Uskula (2019), using the Bayesian method with both limited and complete information approach and also a two-country situation model where data of US is considered as a country of import destination and the whole world as the country of origin, have shown that deep habits by entering the import demand function cause the import price mark up to be adjusted independently of the nominal price friction. The results also confirm that the model with deep habit has far better performance than the model without deep habit in data compatibility.

Two main features of Iranian economy namely, the reliance of economy on oil revenues and the dependency of monetary policy on fiscal policy motivate us to try to find out whether in Iranian economy, deep habits act the same way in controlling inflation resulted from monetary shocks and compensating negative wealth effect resulted from fiscal shock as in above mentioned literatures. Furthermore, we use an extended NKPC including the persistence in the stock of deep habits both in household and public consumption as well as deep habit formation derived by Davoudi & Heidari (2021) which introduces new driving forces in previous NKPC such as the stock of deep habits in household and public consumption as well as the expected marginal value of the persistency of the stock of deep habits, current and future consumption demand, expected marginal cost and stock of habits.

Few studies consider superficial habits in DSGE models for Iranian economy (e.g., Fakhr Hosseini, 2011, 2017; Marzban et al ,2017; Hematy et al, 2019). Furthermore, Simultaneous effect of price stickiness and deep habits consumption on monetary and fiscal shock transmission was investigated by Davoudi and Heidari (2021) to determine the domination of these two forces in transmission mechanism of shocks. In addition, Iranian economy has experienced various economic events over the last few decades such as GDP growth in 1991 to 1993 resulted from first five- years economic development plan which started after end of the Iran-Iraq war; a sharp drop in oil prices in 1998 and consequently, the decline in GDP growth due to the dependency on oil revenues; a significant jump in oil export in 2005 and its considerable effect on liquidity growth; the beginning of realization of energy prices (eliminating subsidies on energy) in 2008 which led to a further increase in liquidity and intensified inflation; augmentation of international sanctions in 2010 and the considerable reduction in oil export; a great uncertainty which was created because of the sanctions; and finally, the experience of the most negative economic growth in 2012 theretofore. These structural changes are shown in fig.1 for some macroeconomic time series from 1990 Q1 to 2015 Q1. In such an environment with changing variances and structural parameters, some parameters of macroeconomic variables such as inflation and output in monetary reaction function may fluctuate over time. As Maih (2014) suggests, regime switching DSGE models are better frameworks for analyzing the dynamics of macroeconomic variables in such economies.

Fig. 1 Time series of Iranian data



The rest of the paper is organized as follows: section 2 introduces our model, section 3 contains MS-DSGE solution and estimation method, section 4 analyzes the results, and section 5 concludes.

2.The model

As mentioned before, the deep habits model used in this paper is based on Davoudi and Heidari (2021) considering regime switching in the parameters related to the monetary reaction function and based on the algorithm introduced by Farmer et al (2011). We also attempt to remove deep habits in the model to compare the estimating results of two models. The model is based on two main features of Iranian economy, the reliance of economy on oil revenues and the dependency of monetary policy on fiscal policy. Households gain utility from habit-adjusted composite of various consumption goods. Catching up with the

Joneses, goods by goods, in the composite of consumption along with habit formation in the previous consumption is a feature of these preferences. Deep habits also enter government spending in the same way. Firms behave under monopolistic competition, renting labor and capital from households and using them in the production process.

The economy consists of a continuum of identical households with an infinite lifetime, so each household j, has not only preferences over the consumption of different goods, but also deep habits on their consumption. Following Ravn et al. (2006), deep habit- adjusted consumption of household j is defined as follows:

$$X^{cj}{}_t = [\int_0^1 (c^j_{i,t} - \theta^c s^c_{i,t-1})^{1-\frac{1}{e^p_t \eta}} di]^{\frac{1}{1-\frac{1}{e^p_t \eta}}} \quad (1),$$

where $(X^c{}_t)^j$ is habit-adjusted composite of consumption of various goods, $\theta \epsilon$ (0.1) is the degree of deep habit formation, η is the intertemporal elasticity of substitution, and $s^c_{i,t-1}$ is the stock of habit in the consumption of goods i. The expression $s^c_{i,t-1}$ evolves over time according to the following equation:

$$s^c_{i,t} = \varrho^c s^c_{i,t-1} + (1 - \varrho^c) c_{i,t} \quad (2),$$

where $\varrho^c \epsilon$ (0, 1) indicates the persistence of the stock of habit. e^p_t is also a markup shock and follows a AR (1) process as follows:

$$\log e^p_t = \rho_{e^p} \log e^p_{t-1} + \varepsilon^{e^p}_t$$

The optimal level of consumption demand of goods i for household j, i.e., $c^j{}_{it}$ is obtained from the expenditure minimization problem according to constraint (1):

$$\min_{c^j{}_{it}} (\int_0^1 P_{i,t}\, c^j{}_{i,t}\, di)$$

$$st: (X^c{}_t)^j = [\int_0^1 (c^j_{i,t} - \theta^c s^c_{i,t-1})^{1-\frac{1}{e^p_t \eta}} di]^{\frac{1}{1-\frac{1}{e^p_t \eta}}}$$

$$\Rightarrow c^j_{i,t} = (\frac{P_{i,t}}{P_t})^{-e^p_t \eta} (X^c_t)^j + \theta^c s^c{}_{i,t-1} \quad (3)$$

where, P_{it} is the price of goods i and P_t is the price index. According to Leith et al. (2015), habit formation feature is not considered in investment, and therefore, private investment demand function for goods i will be as follows:

$$I_{it} = (\frac{P_{it}}{P_t})^{-e^p_t \eta}\, I_t \quad (4)$$

e^B_t is preference shock which follows a AR (1) process:

$$\log e^B_t = \rho_{e^B} \log e^B_{t-1} + \varepsilon^{e^B}_t \quad (5)$$

Capital accumulation equation will be also as follows:

$$k_{t+1} = (1 - \delta) k_t + i_t \quad (6)$$

where δ is the depreciation rate. Maximizing lifetime utility function subject to budget constraints and capital accumulation equation as in eq. (6) gives the first order conditions with definitions as follows:

$$L_t^j = (X_t^{cj})^{-\frac{\sigma_c}{\sigma_L}} (\frac{W_t}{P_t})^{\frac{1}{\sigma_L}} \quad (7)$$

$$(\frac{M_t}{P_t})^{-\sigma_M} = (X_t^{cj})^{-\sigma_c}(1 - \frac{1}{R_t^b}) \quad (8)$$

$$\beta E_t \left[\frac{\varepsilon_{t+1}^{\beta}}{\varepsilon_t^{\beta}} (\frac{X_{t+1}^{cj}}{X_t^{cj}})^{(-\sigma_c)} R_t^b \frac{1}{\pi_{t+1}}\right] = 1 \quad (9)$$

$$E_t R_{t+1}^K = \frac{R_t^b}{E_t \pi_{t+1}} - 1 + \delta \quad (10)$$

The equations given above demonstrate labor supply, real money demand, standard Euler equation, and the relationship between rental rate on capital and the return on nominal private bond holdings respectively.

The demand function of public consumption is:

$$G_{i,t} = (\frac{P_{it}}{P_t})^{-\varepsilon_t^p \eta} X_t^g + \theta S_{i,t-1}^g \quad (11),$$

On the other hand, total government expenditure G_t, is exogenously determined based on the budgeting process and follows the exogenous autoregressive process as:

$$log\, G_t = \rho_g \log G_{t-1} + (1 - \rho_g) log\, \bar{G} + \varepsilon_t^g \quad (12).$$

The real budget constraint faced by the government is as follows:

$$g_t + \frac{R_t^b}{\pi_t} b_{t-1} = \tau_t + m_t - \frac{1}{\pi_t} m_{t-1} + b_t \quad (13).$$

It is assumed that the tax is a function of gross domestic product (GDP) as follows:

$$log\, \tau_t = \rho_t\, log\, y_t + e_t^t \quad (14),$$

where (y_t) is aggregate income from oil-free GDP (y_t^p) and oil income oil_t).

$$y_t = y_t^p + oil_t \quad (15).$$

Considering the dependency of Iranian economy on oil revenue, it is essential to take it into account in the model as it makes the results to be more real. Furthermore, according to global oil pricing, oil income follows an exogenous AR (1) process as follows:

$$log\,(oil_t) = (1 - \rho_{oil}) \log(oli_t) + \rho_{oil} \log(oil_{t-1}) + e^{oil}{}_t \quad (16),$$

where e_t^{oil} is oil shock and will affect oil sales and consequently, macroeconomic variables.

Minimizing firm's cost subject to production function, and obtaining the first-order conditions from Lagrangian function, gives marginal cost and labor demand functions as follows:

$$mc_t = \frac{1}{A_t} \left(\frac{1}{1-\alpha}\right)^{1-\alpha} \left(\frac{1}{\alpha}\right)^{\alpha} (w_t)^{1-\alpha} (R_t^k)^{\alpha} \quad (17)$$

$$l_t = \frac{\alpha}{1-\alpha} w_t^{-1} R_t^k k_{t-1} \quad (18).$$

Technology shock follows a AR (1) process as follows:

$log\, A_t = \log \bar{A} + \rho_A \, log\, A_{t-1} + \varepsilon_t^A$ (19).

Maximizing the profit subject to constraints such as consumption demand function, investment demand function, demand function of public consumption and stock of habit in the private and public consumption, gives NKPC is rewritten as follows (See Davoudi and Heidari (2021) for details):

$$\hat{\pi}_t = \chi_1 \hat{\pi}_{t-1} + \chi_2 \hat{\pi}_{t+1} + \chi_3 \hat{x}_t^c + \chi_4 \hat{x}_t^g + \chi_5 \hat{I}_t + \chi_6 \hat{S}_{t-1}^c + \chi_7 \hat{S}_{t-1}^g + \chi_8 \hat{x}_{t+1}^c + \chi_9 \widehat{mc}_t + \chi_{10} \widehat{mc}_{t+1} + \chi_{11} \hat{\lambda}_{t+1}^c + \chi_{12} \hat{\lambda}_{t+1}^g + \chi_{13} \hat{x}_{t+1}^g + +\chi_{14} \hat{I}_{t+1} + \chi_{15} \widehat{xS}_t^c + \chi_{16} \hat{S}_t^g + \chi_{17} \hat{e}_t^p + \chi_{18} \hat{e}_t^B + \chi_{19} \hat{e}_{t+1}^B \quad (20).$$

It can be simply shown that in the absence of deep habits and their persistence, when $\theta^c = \theta^g = \varrho^c = \varrho^g = 0$, the extracted equation in eq. (20) reduces to the standard NKPC as follows:

Based on derivation process in Davoudi and Heidari (2021), in long- run equilibrium and in absence of deep habits, we reach NKPC equation in Christiano et al (2005) as follows:

$$\hat{\pi}_t = \frac{1}{1+\beta} \hat{\pi}_{t-1} + \frac{\beta}{1+\beta} \hat{\pi}_{t+1} + \frac{(1-\omega\beta)(1-\omega)}{\omega(1+\beta)} \widehat{mc}_t \quad (21)$$

In comparison with standard NKPC in equation (21), It is clear that by including deep habits, the NKPC is affected by various variables. Variables such as the current and expected composite of consumption in private and public, the stuck of habit consumption, expected marginal cost, the marginal value of demand and the marginal value of the stock of habit both in private and public sectors are driving forces for inflation dynamics. The question that arises is whether all additional terms in obtained NKPC can be effective in controlling inflation in response to monetary and fiscal shocks in Iranian economy.

The monetary policy reaction function in log-linear form will be:

$$\hat{\tilde{m}}_t = \rho_m \hat{\tilde{m}}_{t-1} + \rho_\pi \hat{\pi}_t + \rho_y \hat{y}_t + v_t \quad (22)$$

which reflects the central bank's behavior in response to increasing or decreasing in output and inflation. In the above equation, $\tilde{m}_t$ is the money growth rate and is expressed in log-linear form as follows:

$$\hat{\tilde{m}}_t = \hat{m}_t - \hat{m}_{t-1} + \pi_t \quad (23)$$

ρ_π and ρ_y are also parameters related to the response of the money growth rate to inflation gap and output gap respectively, and v_t is monetary policy shock and is defined as $AR(1)$ process:

$$\hat{v}_t = \rho_v \hat{v}_{t-1} + \sigma_v e_t^v \quad (24)$$

The model will be completed by the resource constraint:

$$y_t = c_t + I_t + g_t \quad (25)$$

By including deep habits in household and public consumption in MS-DSGE model, we estimate the parameters of the model and examine the effectiveness of existing of deep habits in reducing inflation in response to monetary shock and also increasing in consumption in response to fiscal shock. We also shut off deep habit parameters and re-estimate the model to compare the estimation results and impulse- response functions. However, according to Foerster (2013), the reason for choosing Markov Switching DSGE model is that the parameters of variables such as output and inflation in the monetary policy reaction function face regime switching fluctuations. Moreover, according to Tavakolian and Komijani (2012), in Iranian economy, the parameters of the monetary reaction function such as output and inflation face regime changes. They note that in such economies DSGE models with regime changes in the parameters can give better results comparing to models with constant parameters. Based on findings of Komijani and Tavakolian (2012), regarding asymmetry in the Iranian central bank monetary policy, the preferences of central bank for inflation and the output gap change according to business cycles. They point out that the asymmetric rule of monetary policy indicates that during the economic boom, the central bank reacts more to the inflation rate. Moreover, by entering to economic recession, the central bank becomes more concerned about the output gap.

3.Model Estimation and Results

This section presents the results of the Bayesian estimation of two models, one with consideration of deep habit in household and public consumption and the other in the absence of deep habit consumption. We begin with specifying data set, calibrated parameters and prior distributions for estimating parameters. We then describe the posterior estimates of the models with considering two different regimes. Finally, we analyze the impulse responses of macroeconomic variables such as consumption and inflation to monetary and fiscal shocks.

3.1 Data

We use 6 observable variables including the consumption of private sector, government spending, CPI inflation, real GDP, and monetary base growth rate from 1991Q1 to 2015Q4. Seasonality of all-time series was removed by the X12-ARIMA technique, and the HP filter was used for de-trending of the data. All the data have been provided by the official website of *Central bank of Iran*[1]. All variables in the model are expressed as a percentage of deviation from the steady state. Before estimating the parameters, it is essential to calibrate some parameters which can be calibrated based on the data and also calculate some economic ratios in their steady-states which are used in solving model. The average seasonal gross inflation in the period under review is 1.04069; therefore, the annual average is 16%. Consequently, according to Iranian previous studies see inter alia (Tavakolian, 2015; Hemmaty et al, 2019), if we have the steady-state of equation (9) as $\beta = \frac{\bar{\pi}}{\bar{R}}$ and consider β as 0.97, then $\bar{R}$ will be equal to 1.07287, and as a result, the annual interest rate will be 29%. Due to the existence of an unorganized money market in the Iranian economy and the significant gap between this market and the official money market, the interest rate applied in

[1] website address for data: www.cbi.ir

this study conforms to the interest rate in the rental housing market. The calibrated parameters based on Iranian time series data and some steady- state economic ratios are presented in Table (1):

Table 1. Calibrated parameters

$\frac{\overline{oil}}{\overline{y^p}}$	$\frac{\bar{g}}{\overline{y^p}}$	$\frac{\bar{\imath}}{\overline{y^p}}$	$\frac{\bar{c}}{\overline{y^p}}$	$\bar{\pi}$	β	δ
Ratio of oil income to oil-free GDP	Ratio of government expenditure to oil-free GDP	Ratio of investment of private sector to oil-free GDP	Ratio of consumption of private sector to oil-free GDP	Average seasonal of gross inflation	discount factor	Depreciation rate
0.25	0.23	0.45	0.57	1.04069	0.97	0.024

Source: Iranian time series data & steady- state economic ratios

3.2 Prior distribution

The prior distribution, mean and bounds for all estimated parameters are shown in Table (2). The prior distributions for estimated parameters are largely drawn from Komijani & Tavakolian (2012) and Tavkolian (2015). Prior distributions for parameters of the inverse of the intertemporal elasticity of substitution σ_c, the inverse of Frisch elasticity of labor supply σ_l, the inverse of elasticity of money demand σ_m are drawn from Tavakolian (2015) so that they follow Gamma distribution of means 1.166, 2.893, and 1.072 respectively. Other parameters defined according to Tavakolian (2015) were: labor share of income α, and AR parameter of technology ρ_a. In line with Tavakolian (2015) we assume inverse Gamma distribution with mean of 0.01 for the standard deviation of the technology shock, markup shock, oil shock and monetary shock. AR parameter of Monetary Policy ρ_v is assumed to follow Beta distribution with a mean of 0.554 (Tavakolian, 2015). The autoregressive parameters of government spending ρ_g, and oil income ρ_{oil} are obtained from associated time series regression. According to Hemmaty et al (2019), it is assumed that AR parameter of money growth rate ρ_m, and AR parameter of preference ρ_{eB}, follow a Beta distribution with a mean of 0.44 and 0.27. The parameter of the standard deviation of preference shock σ_{ee5} is also drawn from Hemmaty et al (2019). Due to lack of priori knowledge of degree of habit formation in both private and government consumption, θ^c and θ^g, persistent of habit stock ϱ_c and ϱ_g parameters and also the probabilities of the transition matrices, a diffuse prior is imposed on them. The parameters that govern the probability of the transition matrices P_{11} and P_{22} are assumed to follow a Beta distribution with a mean of 0.96. As mentioned in Tavakolian & Komijani (2012), when money growth rate is considered as a monetary policy instrument, coefficients of both inflation and output in monetary reaction function will be negative in order to increase money growth rate in response to output reduction as well as decrease it in response to inflation growth. Consistent with Tavakolian (2012), we choose a normal distribution for coefficient of inflation $\rho^{m}{}_{\pi}$ and coefficient of output in monetary reaction function $\rho^{m}{}_{y}$ with means -0.703 and -2.702 respectively.

Table 2 Prior distribution of parameters

parameter		**Distribution**	**Mean**	**Lower& upper bound**
σ_c	Inverse of the intertemporal elasticity of substitution	Gamma	1.166	[0.10, 5.5]
σ_l	Inverse of Frisch elasticity of labor supply	Gamma	2.893	[0.10, 3.0]
σ_m	Inverse of elasticity of money demand	Gamma	1.072	[0.10, 3.0]
θ^c	Degree of habit formation	Beta	0.6	[0.10, 0.9]
α	Labor share of income	Beta	0.557	[0.10, 0.9]
ρ_a	AR parameter of technology	Beta	0.85	[0.50, 0.99]
θ^g	Degree of habit in G	Beta	0.5	[0.10, 0.9]
ϱ_g	Persistence of habit stock in G	Beta	0.6	[0.10, 0.9]
ϱ_c	Persistence of habit stock in C	Beta	0.8	
ρ_{oil}	AR parameter of oil	Beta	0.339	[0.10, 0.9]
ρ_m	AR parameter of money growth rate	Beta	0.8	[0.10, 0.9]
ρ_v	AR parameter of Monetary Policy	Beta	0.554	[0.50, 0.9]
ρ_{eB}	AR parameter of preference	Beta	0.85	[0.50, 0.9]
ρ_{ep}	AR parameter of Price Mark-up	Beta	0.5	[0.10, 0.9]
ρ_{gov}	AR parameter of government spending	Beta	0.7486	[0.10, 0.9]
σ_{eA}	technology shock std.	Inverse gamma	0.01	[0. 005, 1]
σ_{eep}	Mark-up shock std.	Inverse gamma	0.01	[0. 005, 1]
σ_{eeB}	preference shock std.	Inverse gamma	0.01	[0. 005, 1]
σ_{eG}	Government spending shock std.	Inverse gamma	0.05	[0. 005, 1]
σ_{eoil}	Oil shock std.	Inverse gamma	0.01	[0. 005, 1]
σ_{eev}	Monetary shock std.	Inverse gamma	0.03	[0. 005, 1]
ρ^{m}_{π}	Inflation coef. In monetary reaction function	normal	-0.703	[-2, -0.1]
ρ^{m}_{y}	Output coef. In monetary reaction function	normal	-2.702	[-3, -0.1]
P_{12}	Prob of coefficient regime 1	Beta	0.04	[0.01, 0.9]
P_{21}	Prob of coefficient regime 2	Beta	0.04	[0.01, 0.9]

3.3. Estimation procedure

The RISE package is used for solving the model and estimating the parameters. Results presented in Table (3) are based on an MCMC algorithm with 2 chains with 400,000 draws each and where the last 240,000 draws are used to find posterior distributions of the models. We report estimating results for two models, one by including deep habit in private and public consumption, and the other in the absence of deep habits in Iranian economy. The posteriors of formation of deep habits in both sectors are almost the same, but estimated posteriors of the persistence of deep habits indicate that, persistence of deep habit in the public consumption is larger compared to the same parameter in the household consumption. The posteriors of most of the parameters are close in two models. However, Inverse of the intertemporal elasticity of substitution, σ_c, in the model included deep habit parameters was estimated 1.4955 (elasticity 0.6686) which is greater than the value estimated by Tavakolian (2012), but lower than value estimated in model without deep habit parameters (elasticity 0.3494) which illustrates higher intertemporal elasticity of substitution in the deep habit adjusted model. As shown in Table 3, the immediate impact of deep habit captured by parameters θ^c and θ^g is similar for household and public consumption, but the persistence of habit stock is higher for public consumption, suggesting that the stock of habits in public consumption is much stronger than household. Totally, the estimated parameters mentioned above confirm the significance of deep habit consumption based on Iranian data. The estimated AR parameters of preference and markup shocks in the deep habit adjusted model are lower than the same parameters in the model without deep habit. The probabilities of monetary policy regimes 1 and 2, P_{12}, and P_{21}, estimated for both models suggest that regime 2 is more persistent than regime 1. In line with the Tavakolian (2012) findings, in both models the sign of inflation coefficient in monetary reaction function in both regime and the sign of output gap in regime 1 are negative. Estimated parameter of inflation and output deviations in deep habit adjusted model implies that in regime 1 the central bank of Iran places a heavier weight on output compared to inflation control. However, in the model without deep habits, the weight of both inflation and output deviations variables is almost the same in regime 1. We claim that magnitude of inflation coefficient in regime 2 in both models indicate that in regime 2, central bank of Iran concerns more with controlling inflation than output stabilization.

Table 3 posterior statistics across the models (modes)

Parameters	Model without deep habit	model with deep habit
σ_c	2.8616	1.4955
σ_l	0.3758	0.3745
σ_m	1.4318	0.0524
θ^c	0	0.2368
α	0.00092	0.0012
ρ_a	0.403	0.4723
θ^g	0	0.2354
ϱ_g	0	0.5608
ϱ_c	0	0.2664
ρ_{oil}	0.2388	0.2547
ρ_m	0.022	0.0123
ρ_v	0.2565	0.2688
$\rho_{e\pi}$	0.4985	0.2945
ρ_{ep}	0.6698	0.5395
ρ_{guv}	0.1253	0.1236
σ_{eA}	0.0122	0.01252
σ_{eep}	0.1362	0.2591
$\sigma_{ee\pi}$	0.049	0.06709
σ_{eG}	0.1145	0.1144
σ_{eoil}	0.0813	0.1139
σ_{eev}	0.1141	0.06564
ρ_π^m(regime1)	-0.9326	-0.7434
ρ_π^m(regime2)	-3.3953	-2.4086
ρ_y^m (regime1)	-0.9498	-2.2198
ρ_y^m (regime2)	0.57	0.3364
P_{12}	0.94	0.9726
P_{21}	0.065	0.1574

We use the results of estimated parameters to compute coefficients in NKPC in equation 34. The extended form of each coefficient has been presented in Davoudi and Heidari (2021). Table (4) shows ammount of coefficients of variables in eq. (20). As shown in Table (4), in comparison with NKPC without deep habits, some other variables effects on inflation. Based on estimation results, some of these variables are more effective than the others. Beside common variable in both NKPC like past period inflation, expected inflation and current marginal cost, it can be seen that the coefficient of composite consumption ($\hat{x}_t^c$) and expected marginal cost ($\widehat{mc}_{t+1}$) are considerable rather than others.

As it is clear from the table (4), the coefficient of expected inflation in NKPC without deep habits is much stronger than same coefficient in NKPC considering deep habits. This indicates that by taking deep habits into account, the effect of expected inflation on inflation is reduced, and in this case, inflation of the past period has a greater impact on inflation in comparison with the model without deep habits. In addition, in the NKPC with considering deep habits, the impact of the marginal cost is also less than the same coefficient in model without deep habit. The results of computing coefficients of expanded NKPC demonstrate that current and future consumption demand, expected marginal cost and stock of habits are also taken as driving forces of inflation. The effect of other variables is not so considerable based on Iranian data. However, in presence of all these variables in NKPC, when a policy shock occurs, the increase in inflation may be postponed for a short period or maybe less affected rather than in the absence of deep habits.

Table 4. coefficients of NKPC

coef	NKPC including deep habit equation. (20)	NKPC without deep habit equation. (21)
χ_1	0.9176	0.507
χ_2	0.0747	0.492
χ_3	0.1236	0
χ_4	-0.0067	0
χ_5	-0.00027	0
χ_6	0.01	0
χ_7	0.004	0
χ_8	0.071	0
χ_9	0.275	0.4847
χ_{10}	0.112	0
χ_{11}	-0.0047	0
χ_{12}	-0.001	0
χ_{13}	-0.0025	0
χ_{14}	-0.00011	0
χ_{15}	0.0037	0
χ_{16}	0.0015	0
χ_{17}	-0.515	0
χ_{18}	0.2144	0
χ_{19}	0.066	0

Source: Computing each coefficient of equation (20) using estimated parameters and expanded form of the models

Table 5 illustrates the results of comparing two estimated models: deep habits adjusted model with regime switching in monetary reaction function and model without deep habit with regime switching in monetary reaction function. As shown in Table 5, the deep habits adjusted model with regime switching (with high log marginal data density) among others fit the data better. Totally, based on the results of log-MDD, MS-DSGE models match Iranian data better than DSGE models.

Table 5. Model comparison (logarithm of marginal data density)

Model	log-MDD (Laplace)
Deep habits adjusted model with Regime switching in monetary reaction function	-898.2823
Model without deep habits with Regime switching in monetary reaction function	-904.1199

Source: Estimation of the models

3.4. Comparing Impulse responses in two models

In this section the response of consumption and inflation as some key variables to monetary and fiscal shocks in both models is compared. In addition, results are compared with Ravn et al (2006, 2010) findings.

Monetary shock

Figure 3 shows the impact of monetary shock on consumption and inflation in both models. As a Result of a positive monetary shock, consumption increases. In line with Ravn et al (2010), this countercyclical movement in markup is due to the presence of deep habits, hence a tendency to keep the price low to guarantee raising future demand and profits. However, in contrast with Ravn et al (2010), inflation starts to increase but not immediately. As mentioned before, given that the source of monetary shocks in Iran is often a response to fiscal policies and to compensate budget deficit, the inflationary effect of the monetary shock and consequently, the effect of expected inflation is strong. In general, the dynamism of the effect of monetary policy shock on selected variables is the same in both regimes.

Comparing the effect of monetary shock on inflation in model with deep habits and without it, it can be seen that inflation increases as a result of monetary shock in both models. This could be due to the fact that in Iranian economy, existence of deep habits is not strong enough to reduce inflation. However, they help to prevent a sudden increase of inflation. However, figure (4) shows that the increase in inflation in the model with deep habits is higher than the model without deep habits. In other words, without deep habits, increasing of inflation in response to monetary shock is 0.02 higher.

Fig. 2 Impulse-responses to monetary shock

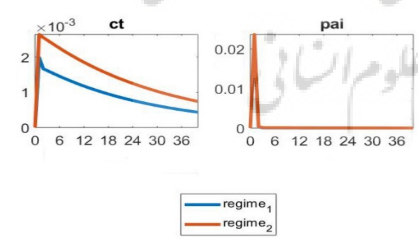


fig 2.1 model with deep habits

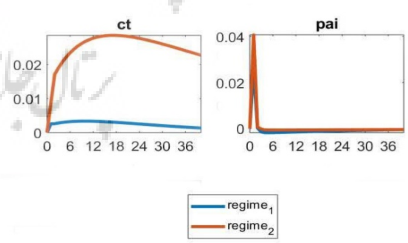


fig 1.2 model without deep habits

Fiscal Shock

Figure (3) shows that contrary to Ravn et al (2006), despite the considering of deep habits consumption, negative wealth effect of fiscal shock cannot be compensated in Iranian economy, so consumption decreased due to the financial shock. But it is clear from the figure (3) that in the model without deep habits, the compensation of the negative wealth effect and consequently increase in consumption happens more later than the model with deep habits. That is, in the model without deep habits, fiscal shock leads to decrease in consumption and after more than ten periods starts to intensify, while in model considering deep habits, negative wealth effect is compensated in the next three periods and after that consumption began to increase.

Fig. 3 Impulse-responses to fiscal shock

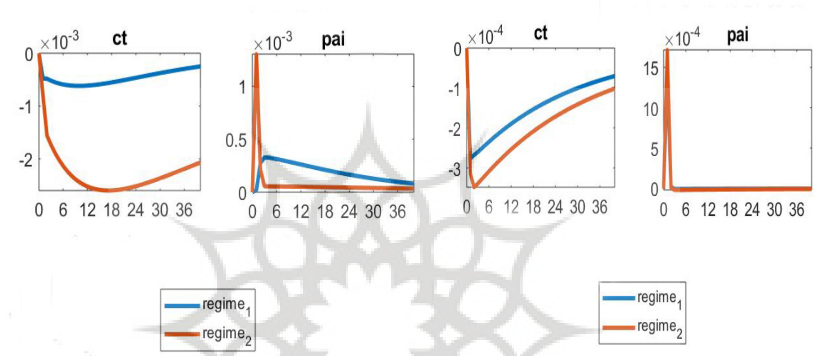


fig 3.1 model with deep habits **fig 3.2 model without deep habits**

4. Conclusion and Recommendation

This paper compared two MS-DSGE models, one including deep habits consumption in both household and government sectors and another one without deep habits. Iranian data was used for estimating these two models. Some Iranian economic features were taken into account such as oil sector and monetary growth rate in monetary reaction function which is used as monetary tool. An expanded NKPC based on Davoudi and Heidari (2021) finding was used in model considering deep habits. Both models were solved using method suggested by Farmer et al. (2011) and estimated by Bayesian approach with two regime shifts in the parameters of inflation and output in monetary reaction function. MS-DSGE model was chosen because Iranian economy has experienced a lot of fluctuations and regime switching during the last decades.

The results of estimating parameters indicate that the parameter of the degree of habit formation and the persistence of habit stock are significant values. It was also proven that current and future consumption demand, expected marginal cost and stock of habits are effective driving forces in NKPC considering deep habits. Furthermore, it was confirmed that the model with presence of deep habits and regime switching in monetary reaction function fit Iranian data better and it is better to be taken into account in studying DSGE models for Iran. However, the results reveal that, contrary to Ravn et al (2006, 2010) findings, including deep habits for Iranian economy in MS-DSGE model cannot make decreasing in inflation in response to both fiscal and monetary policy. Another difference between our findings and other literatures about deep habits is that, in contrary to the said literatures, presence of deep habits in the model is not strong enough to make crowding in effect in consumption as a result of fiscal shock, although these reduction in the model without deep habits takes more longer than in the model with deep habits.

According to authors, the way fiscal policy is financed in Iranian economy, is highly inflationary and it makes the variables associated with deep habits not to be strong enough to reduce inflation in Iranian economy. however, comparison of two models has shown that the amount of inflation in response to fiscal and monetary policy in the model with deep habits is much less than that amount in the model without deep habits, implying that although presence of deep habit could not reduce inflation, it could control the amount of its increasing which is essential for policy makers.

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عادات عمیق در مدل DSGE سوئیچ مارکوف ایرانی

چکیده:

در این مطالعه یک مدل تعادل عمومی پویای تصادفی با رویکرد تغییر رژیمی (MS-DSGE) با لحاظ عادات عمیق مصرفی با مدل MS-DSGE بدون عادات عمیق مقایسه می‌شود. نتیجه مقایسه آن است که مدل با لحاظ عادت عمیق، بهتر می‌تواند با داده‌های ایرانی مطابقت داشته باشد. نتایج تخمین پارامترها نشان می‌دهد که متغیرهای شکل‌گیری عادت و ماندگاری این عادات، در مدل حائز اهمیت هستند. همچنین مطابق نتایج به دست آمده، تقاضای مصرف حال و آینده، هزینه نهایی مورد انتظار و عادات انباشته، نیرو محرکه‌های مؤثر در منحنی فیلیپس نیوکینزی استخراج‌شده از مدل با لحاظ عادات عمیق هستند. با این حال، برخلاف یافته‌های راون و همکاران (۲۰۰۶، ۲۰۱۰)، نتایج نشان داده است که وجود عادت عمیق مصرفی در مدل با داده‌های ایران، نمی‌تواند منجر به کاهش تورم در واکنش به شوک پولی شود، هرچند میزان افزایش تورم در پاسخ به شوک پولی در مدل با عادت عمیق، کمتر از افزایش تورم در مدل بدون عادت عمیق است. همچنین در پاسخ به شوک مالی، اثر منفی ثروت در اقتصاد ایران در مدل با لحاظ عادات عمیق قابل جبران نبود. بنابراین، مصرف در پاسخ به شوک مالی شروع به کاهش می‌کند، اگرچه این کاهش در مدل بدون عادات عمیق بیشتر از مدل با عادات عمیق طول می‌کشد.