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THE ROLE OF INTERNALIZATION OF DISCOUNT FACTOR ON HOUSEHOLDS' BEHAVIOR USING DSGE MODEL

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Abstract: This study attempts to examine the behavior of households in the Iranian economy within the framework of a dynamic stochastic general equilibrium model with the changes made in the endogenous discount factor. To this end, this study will review the existing economic literature to introduce two dynamic stochastic general equilibrium models for the economy and define two scenarios: The first model is: the endogenous discount factor. The second model: the endogenous discount factor without internalization. Considering the second-order unconditional moments observed in the two models, we can say that the calculation of the equilibrium dynamics by solving the log-linear approximation associated with a set of equilibrium conditions provides obvious and defensible results. The predictions of both models indicate upward fluctuations in the consumption, output and investment variables. The model also predicts that the components of aggregate demand are in the direction of the trade cycle, and there is a correlation between the variables and GDP. Predicting the correlation of the model's variables can be justified by the assumption of clear preferences and technologies. On the other hand, the main finding of this study is that in the second model, by changing the endogenous discount factor during the intermittent business cycles, the dynamic paths are almost the same. Still, the fluctuations and correlations of some components of aggregate demand will be different from the first model.

Keywords: Discount Factor; DSGE Model; Internalization; Behavior of Households.

JEL codes: B22, E61, F41, C11.

1. Introduction

Today, economics is usually known as a branch of social sciences with an empirical approach. In this regard, using purely rational analysis and a non-empirical method

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to understand economic phenomena is questionable. However, the study of economic theories and their development over the last two centuries shows the philosophical influence and the basis of the resulting knowledge on economic thought.

One of the most influential areas of economics from a philosophical perspective is the fundamental concept of economic value. Subjective values and objective values are two categories of economic valuation of the social environment by human beings that were dealt with by economists of the nineteenth and twentieth centuries whom the philosophical school influenced. In economics, mental values rely on consumer preferences and utility-oriented perspectives. Objective values focus on production conditions and the theory of labor value. The dynamics and movement of variables related to subjective and objective values are among the most important issues and controversies in economic theories. This value dynamics, represented as a rate of time changes, requires attention to mathematical and philosophical backgrounds.

Dynamic stochastic general equilibrium modeling (DSGE, or DGE for short), or SDGE for short, is a macroeconomic approach often used by monetary and financial authorities to analyze policy, explain historical time series data, and predict future goals. DSGE econometric modeling applies general equilibrium theory and microeconomic principles in a workable way to hypothesize economic phenomena, such as economic growth and business cycles, as well as policy effects and market shocks. Researchers often use "DSGE models" to refer to a specific class of econometric models, a few business cycles or economic growth called real business cycle models (RBC). The DSGE models form the dominant framework for macroeconomic analysis through a coherent combination of micro-fundamentals and the optimization of the economic behavior of rational agents. DSGE models are multifaceted, enabling a more comprehensive analysis of macro-effects, and their defining characteristics, as indicated by their names, are as follows: 1) Dynamic: The effect of current choices on future uncertainty makes models dynamic and assigns a special relationship to the expectations of factors in shaping macroeconomic outcomes. 2) Stochastic: Models consider the transfer of stochastic shocks to the economy and subsequent economic fluctuations. 3) General: Refers to the whole economy as a whole. 4) Equilibrium: By subscribing to general competitive equilibrium theory, this model demonstrates the interaction between policy actions and the subsequent behavior of agents. RBC theory is based on the neoclassical growth model, assuming flexible prices, to examine how real economic shocks may cause business cycle fluctuations. The "representative consumer" assumption can be taken literally or reflects a gourmet mass of heterogeneous consumers facing specific income shocks and full markets in all assets. "Efficient response" of the economy to external shocks.

There are many advantages to using Bayesian methods for model estimation. Some of these are important and general enough to be mentioned here. The problem of identification often arises when estimating a model. by different values of structural parameters, it can be summarized that lead to the same common distribution for observability. More technically, the problem arises when the posterior distribution is under a space of parameter values. But probability weighting with previous densities often adds enough curvature to the posterior distribution to facilitate numerical maximization.

The Bayesian estimate corresponds to the complete and solved DSGE model instead of the GMM estimate based on specific equilibrium relations such as the Euler equation in consumption. Likewise, Bayesian estimates are based on the probability created by the DSGE system rather than the more indirect difference between the DSGE and VAR impact response functions. Of course, if your model is completely misdefined, estimating it using Bayesian techniques can be a drawback. Bayesian techniques make it possible to consider backgrounds that act as weights in the estimation process so that the posterior distribution prevents peaks at odd points where the probability peaks. In fact, due to the stylized and often inaccurate nature of DSGE models, this probability often peaks in areas of the parameter space that contradict common observations, leading to the problem of null parameter estimates. Bayesian estimation naturally leads to the comparison of models based on fit. The DSGE models used by governments and central banks for policy analysis are relatively simple. They have structured around three interrelated parts: 1) demand, 2) supply and 3) the monetary policy equation. These sections are formally defined by micro-foundations and make explicit assumptions about the main economic behavior of actors: households, firms, and government.

Given the importance of the role of consumer preferences and Objective values on production conditions, the theory of labor value and the intertemporal household problem and also, the dynamics and movement of variables related to subjective and objective values are among the most important issues, and controversies in economic theories; this research examines This value dynamics represented as a rate of time changes, using mathematical and philosophical backgrounds.

In general, the main focus of this study is to evaluate this issue to examine the extent to which the change in the discount factor and its Internalization will affect the behavior of households, macroeconomic variables, the equilibrium dynamics, and the movement of variables during business cycles. Therefore, considering the different effects of factor differences in the behaviors of households on economic models, this study aims to investigate the business cycles in the Iranian economy resulting from this issue and their effects on the behavior of macroeconomic variables with interest rates. For this aim, quarterly data from 1997 to 2020 are used, obtained from the Statistical Center of Iran, the Central Bank and, as needed,

domestic, international and World Bank financial statistics. Finally, the paper uses data and examines the behavior of households in the Iranian economy within the framework of a dynamic stochastic general equilibrium model with the changes made in the endogenous discount factor.

This article is divided into four sections. In the continuation of the introduction and the second part, the model and the values of the models are presented, and in the third part, the calibration, the quantitative results, the discussion and the verification of the experimental results are presented. In the fourth part, the final result of the experimental results is presented.

2. Literature review

The time preference rate and its changes are variables that affect the behavior of agents and households. Obstfeld (1982) applied Uzawa preferences to study an open economy's response to permanent, unanticipated terms of trade shock. Further applications include Nairay's (1984) proof that an individual optimum exists and Bergman's (1985) study of capital-asset pricing in a stochastic environment.

The time preference rate is one of the variables that affect inflation expectations. It is derived from the degree of society's patience in using the available resources, whether now or in the future (Uzawa, 1968). However, in this context, there are ethical views about not considering the social discount rate in solving the optimization problem and the concavity of the utility function as one of the discounting factors can be considered as an intermediate utility analyzer. Also, the assumption that all members of the society have the same time preference rate seems to be unrealistic, but considering the significant share of inflation expectations and current consumption of the private and public sectors in inflation models, not including this variable in the model is considered a shortcoming.

Uzawa-Epstein preferences fall into the broader category of general recursive preferences, as defined by Koopmans (1986). Lucas and Stokey (1984) and Epstein (1987) study the stability of steady states under quite general recursive preferences. Epstein and Hynes (1983) examine some well-known dynamic economic models using a particular specification of recursive utility. Judd (1985) uses a preference specification that includes Epstein's (1987) as a special case, but his focus is on steady-state results. Becker, Boyd, and Sung (1989) provide a general existence theorem for recursive preference problems of the type explored below.

Subjective and objective values result from the economic human being valuing the surrounding social environment. Dynamic mental values rely on consumption and liquidity preferences, patience rewards, and reduced utility and money commitment. Dynamic mental values focus on production conditions, labor value theory, and population. Dynamic mental and objective values are at the root of the emergence of timed phenomena in the economy.

Time inconsistency or dynamic inconsistency expresses a situation in which the preferences of the economic decision maker change over time. The index of this change is reflected in the time preference rate and the interest rate. In this direction, the equilibrium of the time preference and interest rates is considered an indicator of equilibrium and time compatibility. Their imbalance is considered a criterion for time incompatibility and, consequently, avoidance of the optimal situation and turmoil in different sectors of the economy.

Since the method of calculating time preference rates as a subjective concept and interest rates in the field of applicability has been debated by economists, the question arises as to what is the role, effect, and method of calculating time preference rates empirically in the Iranian economy? Researchers have used the changes and modifications to the standard model to solve this problem to create the equilibrium dynamics resulting from these changes. The main focus is to evaluate the extent to which this new model and technique affect the equilibrium dynamics and behavior of households in the Iranian economy by introducing the endogenous mental discount factor.

Due to the importance of the discount factor and the nature of the utility function in this study, the economic sectors were included in the model separately and with a variety of details to investigate households' behavior by applying two different scenarios. In growth economics, the dynamics of growth and the determination of the optimal direction of movement require the dynamics and growth of subjective and objective values. The emphasis on reasoning in the growth literature instead of the rational and philosophical perspective and the dynamics of subjective and objective values with a mathematical approach open up new areas of the humanities. One of the aspects of this issue can be the household's subjective discount factor, which in some kinds of literature on economic growth has created a great deal of discussion about the dynamics of mental and objective value in the economy.

The study assumes a model with an endogenous discount factor according to the type of preferences of Uzawa. Several papers using this kind of preferences contain Obstfeld (1990), Mendoza (1991), Kollmann (1996), Schmitt-Grohe (1998), and Uribe (1997). In this study and model, β, the discount factor, is supposed to be decreasing in consumption. Households become more impatient; thus, they consume more. Kim and kose (2001) compare the implications of the business cycle of this model to those implied via a model with a constant discount factor. They discover that both models feature similar Macroeconomic aggregates movements. The discount factor is assumed to be a function of aggregate per capita consumption rather than individual consumption which is a simplified specification of the preferences of Uzawa. This specification has several advantages. Firstly, it induces stationarity. Secondly, the modified Uzawa preferences eventuate a computationally much simpler model than the standard Uzawa model.

3. Model Specification and Methodology

3.1. Endogenous Discount Factor Model

Assume an open economy with two different sections in the model: 1) Endogenous discount factor and 2) Endogenous discount factor without internalization. It is considered this economy populated by a large number of identical households with preferences that are described by the underneath utility function:

$$E_0 \sum_{t=0}^{\infty} \theta_t U_t(C_t, H_t) \quad (1)$$

$$\theta_0 = 1 \quad (2)$$

$$\theta_{t+1} = \beta(C_t, H_t)\theta_t \qquad t \geq 0 \quad (3)$$

wherein $\beta_C < 0, \beta_H > 0$. The equation of foreign debt, D_t, is determined by

$$D_t = (1 + R_{t-1})D_{t-1} - Y_t + C_t + I_t + \Phi(K_{t+1} - K_t) \quad (4)$$

Where R_t explains the interest rate that households can borrow in international markets, Y_t denotes domestic output, C_t explains consumption and H_t denotes hours, I_t denotes gross investment, and K_t denotes physical capital. Also, $\varphi(.)$ Is the function of capital adjustment costs and is granted to satisfy $\varphi(0) = \acute{\Phi}(0) = 0$. The role of capital adjustment costs in an open economy model typically is to avoid excessive investment volatility in response to variations in the domestic foreign interest rate differential. A production function defines output that capital and labor are its inputs. In fact, a linear function that catches capital and labor services as inputs. The production function and the stock of capital, respectively are given by

$$Y_t = A_t F(K_t, H_t) \quad (5)$$

$$K_{t+1} = (1 - \delta)K_t + I_t \quad , \quad \delta \in (0,1) \quad (6)$$

Where δ denotes the depreciation rate of physical capital and A_t is an exogenous stochastic productivity shock. In the following, households select processes $\{C_t, H_t, Y_t, I_t, K_{t+1}, D_t, \theta_{t+1}\}_{t=0}^{\infty}$ to maximize the utility function. As well as

The Non-Ponzi game condition is established. Putting θ_t, μ_t and λ_{t_t} define the lagrange multipliers, the household's maximization problem and the first-order conditions, finally, we will have:

$$\lambda_t = \beta(C_t, H_t)(1 + R_t)E_t\lambda_{t+1} \quad (7)$$

$$\lambda_t = U_c(C_t, H_t) - \mu_t\beta_c(C_t, H_t) \quad (8)$$

$$\mu_t = -E_t U(C_{t+1}, H_{t+1}) + E_t\mu_{t+1}\beta(C_{t+1}, H_{t+1}) \quad (9)$$

$$-U_H(C_t, H_t) + \mu_t\beta_H(C_t, H_t) = \lambda_t A_t F_H(K_t, H_t) \quad (10)$$

$$\lambda_t\left[1 + \acute{\Phi}(K_{t+1} - K_t)\right] = \beta(C_t, H_t)E_t\lambda_{t+1}\left[A_{t+1}F_K(K_{t+1}, H_{t+1}) + 1 - \delta + \acute{\Phi}(K_{t+2} - K_{t+1})\right] \quad (11)$$

the productivity shock and the its law of progress is given by:

$$\ln(A_t) = \rho_A \ln\left(A_t(-1)\right) + \epsilon_{At} \quad (12)$$

beside a set of processes $\{D_t, C_t, Y_t, I_t, K_{t+1}, \mu_t, \lambda_t\}_{t=0}^{\infty}$, the study uses the following functional forms for technology and preferences:

$$U(C,H) = \frac{(C - \frac{H^{\omega}}{\omega})^{1-\gamma} - 1}{1-\gamma}$$
$$\beta(C,H) = (1 + C - \omega^{-1}H^{\omega})^{\psi}$$
$$F(K_t, H_t) = K^{\alpha}H^{1-\alpha}$$
$$\Phi(x) = x^2 \qquad \Phi > 0$$

Using the specific functional form for the current account and the trade balance are given by:

$$TB_t = Y_t - C_t - I_t - \Phi(K_{t+1} - K_t) \quad (13)$$
$$CA_t = D_{t-1} - D_t \quad (14)$$

3.2. Endogenous Discount Factor Model Without Internalization

When households do not internalize their discount factor depending on their levels of effort and consumption, we Consider an alternative formulation model of the endogenous discount factor. Hereon, the model assumes that the discount factor depends not on the household's effort and consumption. Preferences described by the underneath function:

$$E_0 \sum_{t=0}^{\infty} \theta_t U_t(C_t, H_t) \quad , \quad \theta_0 = 1$$
$$\theta_{t+1} = \beta\left(\widetilde{C_t}, \widetilde{H_t}\right)\theta_t \quad t \geq 0 \quad (15)$$

Where $\widetilde{C_t}$ and $\widetilde{H_t}$, which the individual households take as given, explain consumption and hours, respectively. With the household's maximization problem and followed by the first-order conditions, we will have:

$$\lambda_t = \beta(\widetilde{C_t}, \widetilde{H_t})(1 + R_t)E_t\lambda_{t+1} \quad (16)$$
$$\lambda_t = U_c(C_t, H_t) \quad (17)$$
$$U_c(C_t, H_t) = \lambda_t A_t F_H(K_t, H_t) \quad (18)$$
$$\lambda_t\left[1 + \acute{\Phi}(K_{t+1} - K_t)\right] = \beta\left(\widetilde{C_t}, \widetilde{H_t}\right)E_t\lambda_{t+1}\left[A_{t+1}F_K(K_{t+1}, H_{t+1}) + 1 - \delta + \acute{\Phi}(K_{t+2} - K_{t+1})\right] \quad (19)$$

As well as, In the following, Households select processes $\{C_t, H_t, Y_t, I_t, K_{t+1}, D_t, \theta_{t+1}\}_{t=0}^{\infty}$ So as to maximize the utility function.

4. Calibration, Empirical Results and Discussion

Based on the literature on models for economies, to solve the model, The choice of parameter values is exhibited in table 1. Using the parameter values and the equations extracted from the optimization and the steady-state described by the model and the specified identities of the parameters listed in Table 1, the paper will investigate and process this model by calibration method.

Table 1 Parameter of calibration

Parameter	Description	Value	Source
δ	Depreciation rate	0.0139	Izadi (2021)
γ	risk aversion	2	Marzban et al. (2016)
Φ	capital adjustment cost	7.6	Izadi and Marzban (2019)
α	Capital share	0.44	Izadi (2018)
β	Discount factor	0.9745	Marzban et al. (2018)
ω	Frisch-elasticity	2.5	Izadi and Sayareh (2019)
ρ_A	autocorrelation TFP	0.59	Izadi (2021)
ϵ_t	standard deviation TFP	0.0164	Izadi (2018)
ψ	elasticity of the discount factor	0.16	Izadi and Marzban (2016)
$\bar{D}$	the steady-state level of foreign debt	0.47	Marzban et al. (2018)

Source: author's view
Note: Data are extracted from the Reports of the Central Bank of Iran (1997 to 2020). database: https://www.cbi.ir.

The following diagrams show the two models' impulse response function of the variables. The circular diagram refers to the first model and the star diagram refers to the second model. Figure 1 shows that models 1 and 2 have almost the same instantaneous response functions to the technology shock. For all variables except the utility function variable, the impulse response functions are very similar, which are typically seen as a path. The only noticeable difference here is the response of the utility function, which is due to the changes in the consumption lag in the model. In the second model, there is a slight increase in the utility function due to the increase in household consumption due to the household's subjective discount factor. In response to the positive technology shock, the trade balance and current account variables have the same trend in both models and their impulse response functions are very similar. The only significant difference is related to the household discount factor variable, which is due to the behavior of households due to the change in consumption, as can be seen in Model 2.

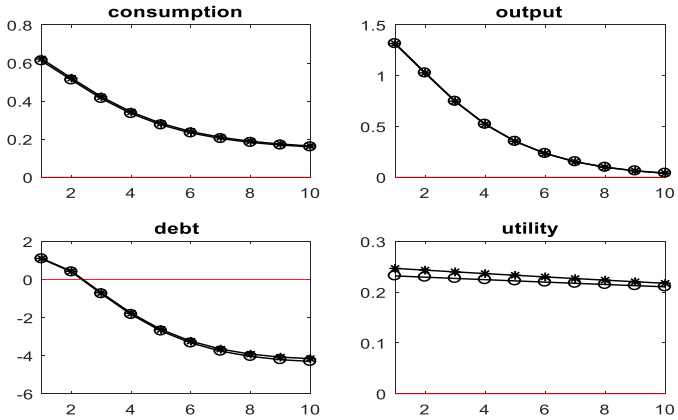

Figure 1 Impulse response to a unit technology shock in models 1 and 2. Note. Circles: Endogenous discount factor model and Stars: Endogenous discount factor model without internalization

Source: author's view

Note: Data are extracted from the Reports of the Central Bank of Iran (1997 to 2020). database: https://www.cbi.ir.

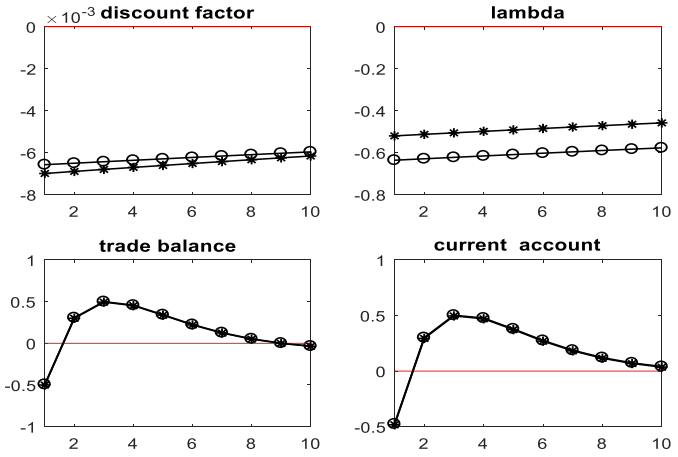

Figure 2 Impulse response to a unit technology shock in models 1 and 2. Note. Circles: Endogenous discount factor model and Stars: Endogenous discount factor model without internalization

Source: author's view

Note: Data are extracted from the Reports of the Central Bank of Iran (1997 to 2020). database: https://www.cbi.ir.

Table 2 displays implied unconditional second moments by Models 1 and 2. In all moments, we used MATLAB code to compute the unconditional second moments and impulse response functions by solving a log-linear approximation for the equilibrium dynamics to the set of equilibrium conditions[1].

Table 2 Implied unconditional second moments

	First Model	Second Model
Volatilities		
$\mathbf{std(Y_t)}$	3.2	3.2
$\mathbf{std(C_t)}$	2.4	2.3
$\mathbf{std(I_t)}$	8.3	8.3
$\mathbf{std(H_t)}$	1.3	1.3
$\mathbf{std(\frac{TB_t}{Y_t})}$	2.0	1.9
$\mathbf{std(\frac{CA_t}{Y_t})}$	1.7	1.7
Serial Correlations		
$\mathbf{corr(Y_t, Y_{t-1})}$	0.74	0.74
$\mathbf{corr(C_t, C_{t-1})}$	0.91	0.90
$\mathbf{corr(I_t, I_{t-1})}$	0.270	0.270
$\mathbf{corr(H_t, H_{t-1})}$	0.74	0.74
$\mathbf{corr(\frac{TB_t}{Y_t}, \frac{TB_{t-1}}{Y_{t-1}})}$	0.66	0.64
$\mathbf{corr(\frac{CA_t}{y_t}, \frac{CA_{t-1}}{Y_{t-1}})}$	0.59	0.57
Correlations with Output		
$\mathbf{corr(C_t, Y_t)}$	0.71	0.75
$\mathbf{corr(I_t, Y_t)}$	0.66	0.66
$\mathbf{corr(H_t, Y_t)}$	1.0	1.0
$\mathbf{corr(\frac{TB_t}{Y_t}, Y_t)}$	0.201	0.196
$\mathbf{corr(\frac{CA_t}{Y_t}, Y_t)}$	0.270	0.258

Source: author's view
Note: Data are extracted from the Reports of the Central Bank of Iran (1997 to 2020). database: https://www.cbi.ir.

Table 2 shows the second-order unconditional torques of models 1 and 2. Here, we show that both models having well-defined second-order unconditional torques compute the equilibrium dynamics by solving a linear log approximation created from a set of equilibrium conditions. The prediction results of both models indicate

a range of fluctuations in consumption, production and investment. The model also shows that the components of aggregate demand are in the direction of the trade cycle, and there is a correlation between the variables and GDP. Indeed, the models provide accurate predictions of the direction of the trade balance. The prediction of the correlation of the variables of both models with the product implies that the full correlation between these variables can be justified, assuming that preferences and technology are obvious.

On the other hand, the results suggest that the dynamic paths are almost the same in the second model by changing the endogenous discount factor during trade cycles. Still, the fluctuations and correlations of some components of aggregate demand will be different from the first model. When the discount rate leaves the endogenous state, consumption fluctuations will decrease because the tendency to procrastinate between household consumption periods will decrease and consumption fluctuations will decrease. Reduced deferral between consumption periods will reduce the business balance as household consumption increases. This increase in household consumption will increase the economy's production, so the correlation between consumption and production will be higher in the second model. Moreover, the increase in household consumption has led to increased current liabilities, so the trade and current account variables will decrease in the current period. Therefore, the impact of changes in consumption on these two variables will be negative.

Under the new preference applied by the two models and the comparison of impulse responses, it can be said, impulse response functions of all variables are very alike. However, the noticeable difference is due to the household's subjective discount factor changes.

Overall, these Models behave quite similarly in line with results obtained by Kollmann (1996), Obstfeld (1990), Mendoza (1991) and Uribe (1997) models. Also, the government can use incentive policies and encourage households to change their preferences and, as a result, change their consumption at the lowest cost.

5. Conclusions

The main focus of this study is to evaluate this issue to examine the extent to which the change in the discount factor and its Internalization will affect the behavior of households and macroeconomic variables, the equilibrium dynamics, and the movement of variables during business cycles. In economics, mental values rely on consumer preferences and utility-oriented perspectives. Objective values focus on production conditions and the theory of labor value. The dynamics and movement of variables related to subjective and objective values are among the most important issues and controversies in economic theories. This value dynamics, represented as a rate of time changes, requires attention to mathematical and philosophical backgrounds.

For all variables except the function variable, the impulse response functions are very, which are typically seen as a path. The only noticeable difference here is the response of the utility function, which is due to the changes in the consumption lag in the model. In the second model, there is a slight increase in the utility function due to the increase in household consumption due to the household's subjective discount factor. The only significant difference is related to the household discount factor variable, which is due to the behavior of households due to the change in consumption, as can be seen in Model 2. the results suggest that in the second model, by changing the endogenous discount factor during trade cycles, the dynamic paths are almost the same. Still, the fluctuations and correlations of some components of aggregate demand will be different from the first model. When the discount rate leaves the endogenous state, consumption fluctuations will decrease because the tendency to procrastinate between household consumption periods will decrease and consumption fluctuations will decrease. Reduced deferral between consumption periods will reduce the business balance as household consumption increases. This increase in household consumption will increase the economy's production, so the correlation between consumption and production will be higher in the second model. Moreover, the increase in household consumption has led to increased current liabilities, so the trade and current account variables will decrease in the current period. Therefore, the impact of changes in consumption on these two variables will be negative.

Finally, the comparison of impulse responses applied by the two models under the new preference states the impulse response functions of all variables are very alike, and the noticeable difference is the response of the utility function, which is due to the changes in the household's subjective discount factor. In general, according to the results, it can be said that these Models behave quite similarly in line with results obtained by Kollmann (1996), Obstfeld (1990), Mendoza (1991) and Uribe (1997) models. In addition, the results of these models show that the government can use incentive policies and encourage households to change their preferences and, consequently, change their consumption in the direction of government policies at the lowest cost.

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Author Contributions

Hamid Reza Izadi conceived the study and was responsible for the literature review, the design and data collection and data interpretation.

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Notes:

[1] Upon request, a full description of the model and the MATLAB computer code used to compute the unconditional second moments and impulse response functions are available.