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Elasticity of Intertemporal Substitution: An Investigation in Iran

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We present estimates of the Elasticity of Intertemporal Substitution (EIS) for Iranian households using synthetic cohort panels based on household micro-data. Results show significant difference with the common values used in Dynamic Stochastic General Equilibrium (DSGE) models which are originally based on estimated values for developed countries. We show that this difference has important theoretical and practical implications. In a simple Real Business Cylce (RBC) setting using the estimated values rather than the common values will help explain 33% more of consumption volatility. We also study the role of EIS in the consumption response to a monetary shock in a Smets & Wouters (2003) model as a benchmark for New-Keynesian monetary models. Results indicate that the monetary policy shock has less impact on consumption in a country with lower elasticity of intertemporal substitution.

Keywords: Elasticity of Intertemporal Substitution, Euler Equation, Synthetic Panel
JEL Classification*:* D91, E21

1 Introduction

The elasticity of intertemporal substitution (EIS) in consumption reflects households' willingness to substitute consumption between time periods in response to changes in the expected real interest rate. Thus, it represents a parameter of central importance for a wide range of models in macroeconomics and finance involving intertemporal choice, from modeling the behavior of aggregate savings and the impact of fiscal policy to computing the social cost of carbon emissions, and has been estimated by hundreds of researchers. Almost all DSGE models incorporate a parameter in their household sector which directly is related to EIS. DSGE studies for United

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States and United Kingdom have used estimated values of EIS for those economies which have become the de facto standard in DSGE modeling. Most of the DSGE models that were developed for Iran have also used the standard parameters for household which reflects the EIS estimations of United States.

The empirical research on the estimation of EIS report varying results. Végh (2013) reports a few famous studies on estimation of EIS which shows this great variation. We reproduce their reporting in Table 1.

Havránek et. al. (2015) collect 2735 estimates of elasticity of intertemporal substitution in consumption from 169 published studies that cover 104 countries during different time periods. They also show a great diversity in this parameter. Mean EIS for countries differs in range from -0*:*171 for Argentina to 3*:*149 for Austria. Mean estimates for US and UK are 0.594 and 0.487 respectively. Table 2 lists the mean EIS for selected countries. Based on same dataset as Havránek et. al. (2015), Havránek (2015) reports an upward bias in published estimates of EIS due to strong selective reporting.

To the knowledge of authors of this paper, there are a few estimates of EIS in Iran and those are all based on aggregate data. Rossi (1988) estimates EIS for Iran, Jordan, Morocco, Syria, and Tunisia using macro panel data from 1973 to 1983 and give EIS estimates varying from 0.23 to 1.17, depending on the model specification. Though these estimates are often statistically insignificant. Ogaki et al. (1996) uses macro data for Iran from 1968 to 1992 and estimates EIS equal to 0.584. Attanasio & Weber (1995) point out that aggregation of macroeconomic data can cause a bias in the estimation of EIS.

We estimate Elasticity of Intertemporal Substitution for Iran in this paper using synthetic panel data of household cohorts. Our estimates show that the EIS is much lower for Iran than US and UK which is in line with literature on estimation of EIS (Havránek et. al., 2015). We show the important implications of using these values in standard DSGE models.

We will discuss the method and data used in estimating EIS in Iran in following section. The next section will discuss the significance of difference in EIS in modeling the economy using a simple RBC model and also reviewing the importance of this change in more complicated models. In the last section we will present the concluding remarks and suggestions for further research.

Table 1

Some Empirical Estimates of the Elasticity of Intertemporal Substitution

Countries	Point estimates	Dataset	Type of model	Author(s)
Chile	1.59 (na)	Quarterly 1971:3-1981:4	Money in the utility function model	Arrau (1990)
	0.46 to 0.56 (0.15) (0.26)	Quarterly 1986:1-2002:4	Pure consumption two-good model	Duncan (2003)
	0.19 (0.10)	Quarterly 1976:2-1989:2	Transactions costs model	Reinhart & Végh (1995)
Uruguay	0.53 (0.22)	Quarterly 1977:2-1989:3		
Argentina	0.21 (0.03)	Quarterly 1978:1-1989:2		
	0.15 to 0.19 (0.16) (0.11)	Annual 1967-79	Hall's one good, pure consumption model	Giovannini (1985)
Brazil	-0.17 to 0.01 (0.13) (0.14)	Annual 1960-77		
Mexico	0.07 to 0.12 (0.10) (0.12)	Annual 1965-79		
	2.87 (na)	Quarterly 1980:1-1987:4	Money in the utility function model	Arrau (1990)
Israel	0.15 to 1.32 (na) (na)	Quarterly 1970:1-1988:3	Money in the utility function model	Eckstein & Leiderman (1992)
Panel of countries: Latin America (4)	0.37 to 0.43 (0.11) (0.14)	Annual 1968-87	Pure consumption two-good model	Ostry & Reinhart (1992)
Panel of countries: Asia (5)	0.80 to 0.80 (0.20) (0.24)			
Panel of countries: Africa (4)	0.44 to 0.45 (0.18) (0.16)			
Panel of countries: Low income (31)	0.34 (na)	Annual 1968-92	Pure consumption two-good model. Stone-Geary utility function.	Ogaki, Ostry. & Reinhart (1996)
Panel of countries: Lower middle income (21)	0.58 (na)			
Panel of countries: Upper middle income (15)	0.61 (na)			
Panel of 9 South American countries	0.09 (0.07)	Annual 1973-83	Hall's one good, pure consumption model with liquidity constraints	Rossi (1988)
	0.09 (0.04)	Annual 1973-81		

Note. The number in the parentheses after names of country groups represent the number of countries in that group. Source: Végh (2013).

Table 2
Mean EIS Estimates of Several Studies for Selected Countries

Country	No. of Studies	Mean EIS	Std. Dev.
Argentina	12	-0.171	0.221
Australia	32	0.362	0.16
Belgium	10	0.677	0.39
Brazil	19	0.107	0.093
Canada	91	0.389	0.11
Finland	46	0.185	0.32
France	44	-0.034	0.153
Germany	39	0.080	0.163
Greece	18	0.561	0.291
Hong Kong	33	0.099	0.017
Israel	65	0.235	0.033
Italy	33	0.290	0.162
Japan	109	0.893	0.243
Korea	32	0.423	0.219
Malaysia	11	0.173	0.161
Mexico	12	0.158	0.053
Netherlands	31	0.027	0.221
Spain	44	0.504	0.107
Sweden	63	0.065	0.126
Switzerland	31	-0.434	0.201
Turkey	12	0.314	0.133
UK	251	0.487	0.07
US	1429	0.594	0.036

Source: Havránek et. al. (2015).

2 Estimating EIS

2.1 Model

To estimate the EIS, we follow Hall (1988) as other research do, and use the log-linearized consumption Euler equation i.e. we regress consumption growth on the intertemporal price of consumption, the real rate of return:

$$\Delta c_{t+1} = \alpha + EIS \cdot r_{t+1} + \epsilon_{t+1} \quad (1)$$

where Δc_{t+1} represents consumption growth at time $t+1$, r_{t+1} denotes the real interest rate at time $t+1$. Various measures of interest rate can be used for this equation and the variables used in literature vary from stock market or Treasury bill return to real return on deposit accounts. ϵ_{t+1} denotes the error term. It is shown that the error term is correlated with r_{t+1}, and researchers thus use instruments for r_{t+1}, typically including the values of asset returns and consumption growth known at time t. There are many potential modifications to Eq. (1), many ways in which it can be estimated and different data that can be used in the estimation.

2.2 Data

The consumption data used in the estimation of the Euler equation is calculated for a synthetic panel as described in the following section. The interest rates are calculated using reports from the Central Bank of the Islamic Republic of Iran. Due to authorities' controls on the interest rates, these rates in Iran do not reflect equilibrium status of an economy. This can be a huge issue in equilibrium studies, yet the equilibrium does not matter in our research. The household faces the question of saving or consuming and compares these options using the interest rate available for them, either equilibrium or disequilibrium rates. The official rates for different types of deposits differ but they are often constant for a few years. This makes economic agents to respond in the composition of deposits. A weighted average of deposits considering the share of each type of deposit (calculated by the CBI) can be viewed as an appropriate measure. Another possible rate is the unofficial money market rate which is gathered by the CBI (but not published publicly). We tested this variable and as it's times series was limited, the results were not significant, and thus they are not presented in the paper. Another measure would the interest rate for loans. CBI calculates the weighted average for trade loans and thus the measure they offer does not consider collaborative loans. Rates for collaborative loans are not controlled, thus banks do have incentives to diverge their resources into this kind of loans when the real interest rate for trade loans are kept negative. The overall quality of data for interest rates of loans is not high and thus not used in the estimations (if used, these rates often result in insignificant coefficients due to lack of enough variation of the rates).

2.2.1 Household Expenditure and Income Surveys

The main data source used in this paper is the "Iranian Urban and Rural Households' Expenditures and Income Surveys", (HEIS), also known as "Household Budget Surveys", conducted and published yearly by the Statistics Center of Iran (SCI). These surveys gather extensive data on expenditures of households.

Iran is one of the countries with a long history of household expenditure surveys. The first expenditure survey in Iran was conducted in 1935 by Bank

Melli Iran[1] to obtain the coefficients used for the cost of living indexes. Once again in 1959the "Economic Research Department" of Bank Melli Iran surveyed households in 23 cities to update the price index coefficients. Since the establishment of Central Bank of Iran (known as Central Bank of Islamic Republic of Iran now) in 1960, all central banking duties of Bank Melli were moved to Central Bank, along with all national-level data gatherings. Central Bank of Iran has conducted annual household budget surveys on urban households every year since1965. The first rural household expenditure survey was conducted by former Department of Public Statistics (later Statistical Center of Iran (SCI)). Since 1965Statistical Center of Iran has been running this survey annually and has added urban households since 1968. This survey is bigger than that of Central Bank, both in sample and population (covering both rural and urban households) and number of expenditure items surveyed. Thus in fact there are two separate annual household expenditure and income surveys in Iran, the one by CBI (which is often called the Household Budget Survey (HBS)) and the one by SCI. We use the SCI's data as its micro-data is published publicly.

2.2.2 Building Cohort Panels

We use the data during years 1991 to 2015 (1370 to 1394 in Persian Calendar). The data is in fact a time series of cross-sections and is not a real panel. SCI has started to sample as a rolling panel with only one fifth of new households in each year since 2009, and thus this rolling panel property of HEIS data cannot be used. We use these data to build synthetic panel of cohorts. Cohorts of 5 and 10 years are used and regional groupings are used to build different panels described in Table 3. A cohort of 5 years means all the households with their heads born in a 5 year time span, i.e. the 1960-1964 cohort consists of the households headed exclusively by the people born on 1960 to 1964. A cohort of 10 years has a similar meaning.

[1] Bank Melli Iran (meaning Iranian National Bank) is a commercial bank that until the establishment of the Central Bank of Iran (CBI) at 1965 did the central banking jobs too.

Table 3
Synthetic Panels

Synthetic Panel	Grouping Criteria	# obs	Coverage (%)
1	Cohort	206	83.1
2	Cohort+Region	385	78.1
3	Cohort+Province	2922	53.7
4	Cohort+Region+Province	3356	32.4
5	Cohort+Clusters	1473	53.5
6a	As 5 for Gov. Emp.	503	24.6
6b	As 5 for Non-Gov. Emp	1321	48.0
7a	As 5 for 1991-2000	504	46.5
7b	As 5 for 2000-2015	1027	57.8

Source: authors' calculations.

The first panel is country-wide and we average over all households of a cohort in all geographical regions of the country. In the second panel we group households in cohorts of rural and urban areas. The third panel is based on provinces and the forth is based on urban/rural areas of provinces. The fifth panel is based on a clustering of provinces of Iran based on household socio-economic characteristics as in Einian & Souri (2018). Rural and urban areas of provinces of Iran are clustered into 13 groups. Table 4 enlists these clusters. Households in rural and urban regions of provinces in each cluster share similar average characteristics such as the level of education of household members, their living place, etc.

As obvious in Table 3, the number of observations increase as the grouping goes into more geographical details. The problem with detailed geographical or any kind of grouping is that number of households to be grouped for each group decreases, and thus cannot be representative of the group. We drop any observation that is based on less than 69 households. Last column of Table 3, the coverage, shows the coverage of households used in the synthetic panel relative to the full sample. Take for example the synthetic panel 4 which has the highest number of observations but is actually representing only one third of the population.

We also build two similar cluster cohort panels for households with income from government sector and for households without that kind of income. We call these panels 6a and 6b. The differences between these two panels are about the level of financial access. Einian & Nili (2016) report that the government employees have better access to financial services in Iran and thus can set their consumption and saving profile to better match the permanent income hypothesis. For sensitivity analysis of the results, the Euler equation (1) is also estimated on cohort panels of subsets of the years called 7a and 7b.

We believe that pre-2000 can be considered the era of limited financial system in Iran and the 2000s and 2010s are the financial development years (Einian, Najafi, & Mahmoodzadeh, 2016). We check the sensitivity of our results to this change in structure of banking sector in Iran which had vast effects on all financial development indicators.

Table 4
Clusters of Rural/Urban Areas of Provinces in Iran Used to Build the Synthetic Panels 6a and 6b

Cluster	Includes
1	Urban areas of Sistan & Baluchistan
2	Urban areas of Markazi, Guilan, Mazandaran, East Azerbaijan, West Azerbaijan, Kermanshah, Fars, Razavi Khorasan, Isfahan, Kurdistan, Hamedan, Chaharmahal & Bakhtiari, Zanjan, Ardebil, North Khorasan
3	Urban areas of Khouzestan, Lorestan, Ilam, Kohgiluye & Boyerahmad
4	Urban areas of Tehran county (not including other counties of Tehran province)
5	Urban areas of Kerman, Yazd, South Khorasan
6	Urban areas of Boushehr, Hormozgan
7	Urban areas of other counties of Tehran province, Semnan, Qom, Qazvin, Alborz
8	Rural areas of Khouzestan, Chaharmahal & Bakhtiari, Ilam, Kohgiluye & Boyerahmad, Boushehr, Hormozgan
9	Rural areas of Fars, Kerman, Razavi Khorasan, Zanjan, Golestan, North Khorasan, South Khorasan
10	Rural areas of Sistan & Baluchistan
11	Rural areas of Tehran, Alborz
12	Rural areas of East Azerbaijan, West Azerbaijani, Kermanshah, Kurdistan, Hamedan, Lorestan, Ardebil
13	Rural areas of Markazi, Guilan, Mazandaran, Isfahan, Semnan, Yazd, Qom, Qazvin

Source: Einian & Souri (2018).

2.3 Estimation Results

We estimate the Equation (1) using several synthetic panels of cohorts. Table 5 presents the results for the first five cohort panels. As mentioned before the panels differ in the variables used for grouping. All panels have the cohort as major indicator for grouping.

Table 5
Euler Equation Estimation Results: Different Synthetic Panels

Panel	**1**	**2**	**3**	**4**	**5**
Grouping	Cohort	Cohort +Region	Cohort +Province	Cohort +Region +Province	Cohort +Cluster
Constant	0.10 *** (0.01)	0.06 *** (0.01)	0.08 *** (0.01)	0.05 *** (0.01)	0.06 *** (0.01)
r	0.12 *** (0.09)	0.20 *** (0.08)	0.15 *** (0.08)	-0.45 (0.42)	0.15 *** (0.07)
# obs	154	288	1796	1189	989
R^2	0.24	0.17	0.10	0.04	0.06
***F*-stat**	32.35	43.49	190.21	3.57	28.66
***p*-value**	0.00	0.00	0.00	0.03	0.00

Source: authors' estimations.

As mentioned before Havránek et. al. (2015) collect 2735 estimates of elasticity of intertemporal substitution in consumption from 169 published studies that cover 104 countries during different time periods. They show a great diversity in this parameter. Mean EIS for countries differs in range from -0:171 for Argentina to 3:149 for Austria. Mean estimates for US and UK are 0.594 and 0.487 respectively. Their study shows that EIS is dependent on properties of the country such as GDP per capita, credit availability, real interest and rule of law[1]. Mean estimates of EIS for Brazil, Chile, Colombia, Finland, Hong Kong, Indonesia, Malaysia, Mexico, Pakistan, Portugal, Singapore, Uruguay and Venezuela are in range [0:09; 0:24]. Thus it seems that our estimates of EIS for Iran are compatible with those of developing countries.

[1] Havránek et. al. (2015) explain the differences in the estimates of EIS by other explanatory variables such as form of utility function used in deriving Euler Equation (e.g. habits and non-separabilities), data used (e.g. no. of households and years, micro-data dummy, frequency), Design of estimation model (e.g. instrument lags and taste shifters), the variable definitions used for consumption (total consumption, nondurable consumption and food), interest rate (money interest rate, stock return and capital return), and the method of estimation (e.g. ML, 2SLS, OLS).

Table 6
Euler Equation Estimation Results: Synthetic Panels of Government-Employees vs. Non-Government-Employees

Panel	**6a**	**6b**
Grouping	Cohort+Cluster	Cohort+Cluster
Household Subset	Government-employees	Non-government-employees
Constant	0.05 ***	0.06 ***
	(0.01)	(0.01)
r	-0.45	0.16 ***
	(0.42)	(0.07)
# obs	232	850
R^2	0.04	0.06
***F*-stat**	3.57	28.66
***p*-value**	0.03	0.00

Source: authors' estimations.

Table 6 reports the same estimation results on subset of government-employees panel and non-government-employees panel. Einian & Nili (2016) report that the government employees have better access to financial services in Iran and thus can set their consumption and saving profile to better match the permanent income hypothesis. We would anticipate a higher estimate on EIS for government-employees synthetic panel. But as presented in Table 6 the estimation of EIS is not statistically significant, probably because of number of observations or the coverage percentage.

Table 7 presents estimates on synthetic panels of pre-2000 and post-2000 data. Consistent with the results of Havránek et. al. (2015), estimates of EIS are higher in the more financially-developed era.

Table 7
Euler Equation Estimation Results: Synthetic Panels of Pre-2000 and Post-2000

Panel	7a	7b
Grouping	Cohort+Cluster	Cohort+Cluster
Years Subset	1991-2000	2000-2015
Constant	0.07 ***	0.06 ***
	(0.01)	(0.01)
r	0.07 ***	0.18 ***
	(0.04)	(0.07)
# obs	236	488
R^2	0.13	0.09
***F*-stat**	27.88	19.20
***p*-value**	0.00	0.00

Source: authors' estimations.

3 Significance of Differences in EIS

Hall (1998) concludes that the EIS is not likely to be larger than 0.1, but some studies use larger values. Chari et al. (2002), House and Shapiro (2006), Piazzesi et al. (2007) use a value of 0.2. Jin (2012), Trabandt and Uhlig (2011), Rudebusch and Swanson (2012) use the mostly used value of EIS for the economy of United States and the economy of United Kingdom which in DSGE studies equal to 0.5. Ai (2010), Barro (2009), and Colacito and Croce (2011) use a value of 2 for EIS. The reason for the different calibrations is differences in the results of the estimates reported by empirical studies. As Ai (2010) notes: "the empirical evidence on the magnitude of the EIS parameter is mixed".

Havránek et. al. (2015) collect 2735 estimates of elasticity of intertemporal substitution in consumption from 169 published papers that cover 104 countries and conclude that a large part of the heterogeneity in EIS is explained by the level of income (per capita GDP) and asset market participation as an indicator of financial development.

EIS represents a crucial parameter for a wide range of economic models. The differences in EIS lead to different theoretical and practical differences. In the following parts we first present a very basic Real Business Cycle model to show the effect of EIS on the magnitude of consumption volatility explained by technology shocks. This shows the importance of variation in the value of EIS from the theoretical perspective. Then we analyze the effect of different values of EIS on the impulse response of consumption to a monetary shock in a New Keynesian Dynamic Stochastic General Equilibrium model to show the policy implications and significance of value of EIS. We acknowledge the fact that these benchmark models are not the best models to describe the economy of Iran. The goal in this part is to show the significance of differences in the value of EIS in different general equilibrium models and we have studied basic RBC model and the Smets-Wouters model because these models are accepted as benchmark models in the literature of general equilibrium models.

3.1 A Basic RBC model

We present here the results of a very basic RBC model that is a modified version of Kydland and Prescott (1982) model[1]. We analyze the effect of changing the calibrating parameter η that is the inverse of elasticity of intertemporal substitution. The model is prepared in the modelling language of gEcon software package (Klima, Podemski & Retkiewicz-Wijtiwiak 2015; Klima & Retkiewicz-Wijtiwiak 2014) for R statistical language (R Core Team 2016).

3.2 Volatility of Consumption and EIS

As it is illustrated in Figure 1, lower values of EIS correspond to higher consumption volatility in a simple RBC model. That general equilibrium result is intuitive. The higher the level of substitution between today's consumption and that of tomorrow, the lower the effect of income shocks on consumption. Using a value of around 0.1 for EIS rather than 0.5 can explain 33 percent more of consumption volatility.

[1] The modifications include simplifying the dependence of intratemporal utility on only current period's leisure (in Kydland and Prescott (1982) a polynomial lag operator on leisure is entered in the utility function) and simplifying the structure of investment turning into capital stock.

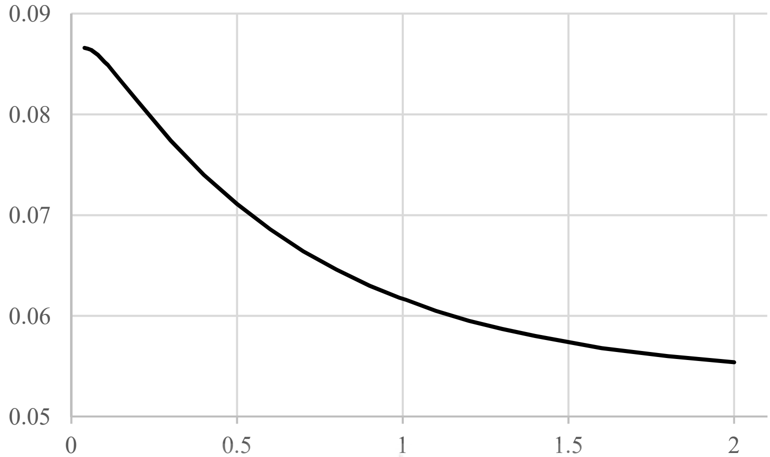

Figure 1. Standard deviation of consumption in a Basic RBC model for corresponding elasticity of intertemporal substitution.

3.3 A Smets-Wouters Model

The significance of differences in the value of EIS is not just of theoretical purposes. Not only does the difference make a huge impact on the altitude of consumption volatility explained by a basic RBC model, it also has policy related concerns. The New Keynesian Dynamic Stochastic General Equilibrium model for the Euro area presented by Smets and Wouters (2003) known as the Smets-Wouters model is often used as a benchmark model for monetary policy analysis. The model features monopolistic competition in product and labor markets as well and nominal rigidities in prices and wages that allow for backward inflation indexation. Various features such as habit formation, costs of adjustment in capital accumulation and variable capacity utilization are modeled in order to match the data. The main channel through which it influences the economy is the interest rate channel. Price and wage rigidities imply that changes in the nominal interest rate affect the real interest rate on which are based the decisions on the intertemporal allocation of consumption of the agents.

3.3.1 Monetary Shock, Consumption Response, and EIS

The propagation mechanism of monetary shock to consumption is through the real interest rate, while its effect is directly affected by the level of EIS parameter in Euler equation.

Figure 3 shows the effects of monetary policy on consumption and shows how the elasticity of intertemporal substitution matters for the modeled economy. The calibrated value of the EIS is varied over a range of values used in the literature. Figure 3 illustrates the impulse response of consumption to a one-percentage-point monetary policy shock. As the figure shows, the modeled response of consumption depends heavily on the value of EIS used for calibration.

The figure shows impulse response for the elasticity of intertemporal substitution between 0.5 and 1.1. As illustrated in this graph the monetary policy shock has less impact on consumption in a country with lower elasticity of intertemporal substitution. Havránek et. al. (2015) report that the effect of a monetary policy shock will last longer in a country with lower elasticity of intertemporal substitution.

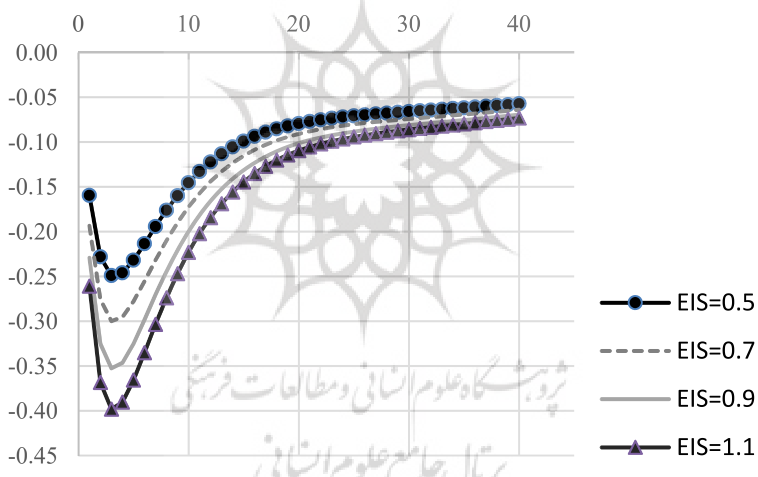

Figure 2. The simulated impulse response to a one-percentage-point increase in the monetary policy rate in a Smets-Wouters model. *Source*: author's calculations.

4 Conclusion

The elasticity of intertemporal substitution (EIS) in consumption represents a parameter of central importance for a wide range of models in macroeconomics and finance. Most of the DSGE models that were developed for Iran have used the standard parameters of about 0.5 for EIS which reflects the EIS estimations of United States and United Kingdom. In contrast we estimate Elasticity of Intertemporal Substitution for Iran using synthetic panel data of household cohorts. Our estimates show that the EIS is much lower for Iran than US and UK which is in line with literature on estimation of EIS (Havránek et al 2015). We show the important implications of using these values in standard DSGE models.

The differences in EIS lead to different theoretical and practical differences. We present these differences in two benchmark models. The theoretical difference is presented in a simple RBC model. We show that the higher the level of substitution between today's consumption and that of tomorrow, the lower the effect of income shocks on consumption. Using a value of around 0.1 for EIS rather than 0.5 can explain 33% percent more of consumption volatility. We also study the role of EIS in the consumption response to a monetary shock in a Smets-Wouters model as a benchmark model for New-Keynesian monetary models. Results indicate that the monetary policy shock has less impact on consumption in a country with lower elasticity of intertemporal substitution.

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