

## A Fuzzy Logic Approach to Estimate the Import of Smuggling in Iran

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### Abstract

The consequences of illegal import as part of underground economy indicate that why it is important to study smuggling. In this paper, fuzzy logic approach is applied to compute import smuggling in Iran from 1978 to 2010 through three explanatory variables including import tariffs, exchange gap and trade openness. According to the results, relative volume of import smuggling to official import during the years of war and revolution, and the years of first, second, third and fourth development plan was approximately estimated 18.2, 17.6, 29, 32.2 and 30.8 percent, respectively. While during the entire period it has been 24 percent, on average. Finally, the results indicate an increasing trend for import smuggling as it has increased from 19.3 percent in 1978 to 27.6 percent of official import in 2010.

**Keywords:** Import Smuggling, Tariffs, Trade Restrictions, Fuzzy Logic, Exchange Rate, Underground Economy.

### 1- Introduction

Phenomenon of illegal trade has long been regarded by politicians and scientists, including economists. The economic, social, and political consequences of smuggling in all countries, especially developing countries, make officials and politicians' ignorance inconvincible. According to Iran Customs statistics of smuggling constituent cases, the total value of these cases based on constant prices of 2004 increased from 1707.14 billion rials in 2003 to 2485.54 billion rials in 2010. Since the discoveries are only, part

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of the illegal trade volume, the widespread phenomenon of smuggling in the country is not far-fetched.

Due to the different instances of smuggling, several definitions of this phenomenon are faced in economic literature. From Kubo and Lwin's (2010) point of view, smuggling is regarded as trade without permit and contrary to the provisions of law, and trade of illegal products such as opium, etc. are not included. However, Ferrier (2009) defines smuggling as illegal import of prohibited goods (Ferrier, 2009, p.1). Regarding the Lithuanian free-market institute (2004), smuggling is the activity done to obtain income by transiting goods through the state border, contrary to existing laws. Smugglers seek to make earning, while avoiding government controls, regulations and related costs.

In this study, smuggling refers to illegal import of legal products which aims to avoid paying some costs (such as custom duties), as well as escaping some red tape. Hence import of goods such as alcohol is not desired. Dominguez (1975) writes about the consequences of illegal trade: 'Smuggling causes problems for the domestic production system and acts as an illegal activity detrimental to the community legal order and besides, due to non-payment of customs duty, leads to the loss of government revenue and by creating illegal and powerful institutions changes the internal structure of society' (Farzanegan, 2008, p.2). In fact, due to lack of competitiveness between domestic products and contrabands, domestic producers suffer losses and this may even lead to closure and semi-closure of manufacturing enterprises. Besides, reduction in productive investment and hence, reduction in production and employment, would be followed by poverty and social crisis.

Moreover, due to the covert nature of the illegal activities, country's Data Network may be impaired and the effectiveness of policies and decisions made based on these statistics may be influenced. Given the growing importance of the phenomenon of smuggling, extensive studies in this field have been made. The present study estimates the volume of smuggled import during years 1978-2010 using fuzzy logic. For this purpose, the variables used are, ratio of import tax to official imports, ratio of official exchange rate to the informal exchange rate and an index for trade openness as the ratio of non-oil exports plus official imports to production. While increase in the first

two variables and decrease in the later one are assumed to increase smuggling.

The paper is organized as follows. In Section 2, I present review of previous studies on smuggling. The Theoretical basics are described in Section 3. The methodology of present research is presented in Section 4. The estimation of Import smuggling in present study and main conclusions are set out in Sections 5 and 6, respectively.

## **2- Review of Previous Studies**

Alano (1984) carried out an econometric analysis of import smuggling in Philippines during 1965-1978. The dependent variable in his study is import smuggling that was calculated based on partner-country trade data discrepancies. This information was generated by comparing export figures of major trade partners of the Philippines with import figures of this country from them. His estimation of smuggling for the Philippines ranged from 28.95% to 53.81% of the reported exports to this country from the partner countries.

Bagheri Garmaroudi (1998) has estimated the size of the underground economy of Iran in ingredients including illegal imports and exports during the period 1971-95, using the monetary method (regression models), in which average of import tax burden was used to estimate import smuggling and subtraction of the export dollar rate from the black market dollar rate used to estimate the export smuggling volume. Based on the results, the volume of import and export smuggling during the period has been respectively 7 and 4.2 per cent of the official production, on average.

Yavari (1999) presents estimation for the import smuggling and its over invoicing by comparing the official import statistics of Iran Customs and the export statistics of the country's trading partners during years 1977-97. The results show sudden capital flight in 1977 and based on estimates made, the over invoicing has reached its peak to 3.2 billion dollars in 1991 and 2.5 billion dollars in 1993, which forms 13 percent of the total value of import in these years.

Ashrafzadeh and Mehregan (1999) provided an estimate of Iran's underground production and its components, domestic activities, import and export smuggling for the years 1969-95 by using the currency in circulation demand function. Based on the results, the average ratio of import smuggling

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to total official import is 18.5 percent and the export smuggling in the period has been equal to the formal export on average.

Holzner and Gligorov (2004) used partner-country trade data discrepancies method to estimate the illegal trade in South East Europe countries in 2003 and then cigarette smuggling were reviewed during the years 1995 and 2000. According to the results, over invoicing of domestic export was estimated about 11 percent of these countries' export in 2003 and simultaneously the under invoicing of domestic exports was calculated about 4 percent. Regarding figures on import, under invoicing was estimated about 12 percent of these countries' import and over invoicing of about 10 percent. Based on the results of cigarette smuggling over the two remarked years above, all countries studied were net illegal exporters of cigarettes except Albania (in both years) and Bosnia and Herzegovina (in 1995).

Maddah (2005) conducted an economic survey on smuggling in Iran during years 1970-2002 with multiple indicators multiple causes method. Therefore variables including fine indicator in constant prices of 1990 (in order to regard smuggling risk), tariff rate and the ratio of official exchange rate to informal exchange rate as explanatory variables, as well as variables including wholesale price index for import goods and general government revenue as indicator variables were used. Based on the results, fine indicator and tariff rate were identified the most important factors affecting smuggling respectively.

Farzanegan (2008) used multiple indicators multiple causes method to estimate the smuggling volume in Iran during years 1970-2002. Variables including black market premium for foreign exchange, penalty for smuggling, tariff burden, production per capita, trade openness and education are the explanatory variables in the model, and real governmental revenue, import price index and consumption of petroleum products are the indicators. According to the results, the absolute size of smuggling during the period was estimated on average of \$ 3 billion and its relative size on average of 13 percent.

Akhbari et al. (2010) model illegal trade in Iran using fuzzy logic for the period 1971-2006. In this study, variables import tax burden, unemployment rate and exchange rate gaps are inputs of the fuzzy model. Based on the results, the decreasing trend of smuggling initiated with a number of 6.15 units in the year 2000, which reached its least amount of 3.5 units with the

continuation of this trend in the year 2005, but the said index peaked in 2006 and reached 6 units.

Kubo and Lewin (2010) studied the impact of customs duties on import smuggling in Myanmar during the period 2000-2009, while the estimate was made from the trade discrepancies method. According to the results, Myanmar's official import for the fiscal year 2008-2009, were only 68 percent of the trading partners' corresponding figures and the ratio of import data to the trade partners' corresponding data reduced from 69.7 percent in previous years of increase in customs duties to 55 percent in the years following the increase in customs duties in June 2004. This could indicate the significance of tax evasion incentive for smuggling in Myanmar.

Buehn and Farzanegan (2011) surveyed smuggling in 54 countries during the years 1991-1999 through multiple indicators multiple causes method. In this study, tariffs, trade restrictions index, an index of corruption, black market premium for foreign exchange and an index for inhibitor laws are the explanatory variables, and variables including GDP per capita, reporting trade discrepancies in the partner country trade statistics, and tax revenues are indicators of the model. According to the results, Cameron, Pakistan and Kenya, have the largest volume of smuggling, while Switzerland, Finland and Sweden have the lowest. The analysis reveals that higher corruption and a lower rule of law encourage smuggling. Tariffs and trade restrictions are important push factors, while a higher black market premium discouraged smugglers.

### **3- Theoretical basics**

#### **3-1- Main Methods to Estimate Smuggling**

In the economic literature there are various methods to estimate the amount of smuggling. In the following the most important and most common methods are discussed. However, discussing the fuzzy approach is considered in research methodology.

##### **3-1-1- Partner- Country Trade Data Discrepancy Method**

In this approach, without recourse to econometric methods for estimating and just by comparing the foreign trade statistics registered in the goal country and its major trading partners, the amount of smuggling (exports and

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imports) is estimated. While using this method, it must be noted that differences do not always mean smuggling. Generally, it is assumed that the import figures should be somewhat higher than the export figures. The reason for this assumption could be that exports and import pricing is respectively as *FOB* (Free on Board) and *CIF* (Cost, Insurance and Freight). Usually by IMF's suggestion in 1993, about 10 percent of the differences between figures are considered for other reasons rather than illegal trade and the rest differences are attributed to illegal activities. It is clear that selecting what part of the difference can be attributed to other reasons, is a place of hesitation.

### **3-1-2- Demand Gap Method**

This approach is based on the production and consumption stream of goods within the country. As the major items having aptitude for being smuggled are considered and then demand values for these goods in the country (consumer and intermediate) are estimated. In terms of no access to information in this context, the consumer items could be estimated based on the share of these goods in the household budget. After estimating the consumer demand of each commodity selected, the intermediate demand values are calculated based on the input-output table and from the sum of intermediate and consumer demand, the total domestic demand for goods is obtained, which by adding the official export gives the total official demand. Next, the total official supply of each selected good will also be obtained from the sum of total domestic production and official import of goods and finally, the difference between total demand and supply of goods, provides smuggled quantities of each of them. Pioneering studies using this method on smuggling certain goods are the studies by Simkin (1970) and Richter (1970) on the illicit trade of rubber in Indonesia (Holzner & Gligorov, 2004, p.22).

### **3-1-3- Currency Demand Method**

The fundamental core of this approach is based on the assumption that the currency in circulation is the main means to finance transactions in the underground economy. So if the formal economy's share could somehow be removed from this variable, the remaining residual is the funds used in underground activities, including import and export smuggling (Akhbari et al., 2010). In this approach multiple independent variables could be used to

explain changes in currency demand as a regression equation, in a way that specific variables are also used to obtain the currency demanded by underground parts meanwhile. After estimating the regression equation by equating the underground variables to zero, the currency demand of the formal sector of the economy will be achieved. After calculating the velocity of money in the formal sector (regarding the quantity theory of money) and also the currency held by the underground (by deducting currency demand in the formal sector from the total currency demand) and assuming equal velocity of money in two parts, the volume of underground will be calculated based on the quantity theory of money. In particular, to estimate the smuggling volume, the stimuli and incentives of country's export and import smuggling are used in the said regression equation as explanatory variables.

#### 3-1-4- Multiple Indicators Multiple Causes Method

Due to the fact that the size of smuggling cannot be seen, this approach which is based on statistical theory of latent variable tries to determine the volume of smuggling by considering its causes and effects. In this method, statistical relationships between latent variable (smuggling) and observable variables are regarded. So that in addition to variables affecting volume of smuggling, variables influenced by it are also considered in illegal trade estimation. So we face a system of equations as follows:

$$Y = \lambda\eta + \varepsilon$$
$$\eta = \gamma'X + \xi$$

Where  $\eta$  is latent variable of the relative size of smuggling and is a scalar,  $Y$  is  $(p \times 1)$  vector of indicators or indexes representing smuggling impact on the different areas,  $X$  is  $(q \times 1)$  vector of smuggling causes and  $\gamma$  and  $\lambda$ , are respectively  $(p \times 1)$  and  $(q \times 1)$  vectors of factors,  $\varepsilon$  and  $\xi$  are random error, respectively  $(p \times 1)$  and scalar and are assumed to be normal and not having correlation. Replacing the second equation in the first equation, the model becomes a system of regression equations in the following form:

$$Y = \Pi X + Z$$
$$\Pi = \lambda\gamma'$$
$$Z = \lambda\xi + \varepsilon$$

This equation system is faced with identification problem, but if one of the elements of  $\lambda$  is bounded to a pre-designed value, the relative amounts of factors will be estimable. Then, by estimating the  $\gamma$  vector and the second equation above, a time series of numbers in ordinal form for volume of smuggling ( $\eta$ ) is obtained that can be converted to the cardinal numbers through calibration procedure (Arabmazar Yazdi, 2001, pp.13-14). Of criticisms against this approach, is not considering variables excluding smuggling, influencing indicators ( $Y$ ) reflecting changes in illegal trade, but not entered into the model.

### **3-2- Determinants of Smuggling**

According to the presented experimental and theoretical points of view in the context of smuggling, all the factors affecting smuggling can be categorized as following: A) economic factors: the smuggling occurs in pursuit of profitability and financial gain. A smuggler turns to smuggling in order not to pay legal government duties and to escape administrative and costly barriers or to use market opportunities and more economic gains. Taxes on foreign trade, black market premium for foreign exchange, price difference between official and unofficial import and various tariffs rates, are some economic factors limiting or expanding smuggling and depends on the function of government economic policies in each item. B) Non-economic factors are divided into two categories as follows: 1) Judiciary system function: the quality of law enforcement is effective in the formation, persistence and limiting criminal and underground activities. For instance, the variety of inferences from laws that are against smuggling, due to legal uncertainties can introduce escape routes of legislation for criminals. Furthermore, the inability of law enforcement agencies in the correct implementation of regulations could have a great effect on smuggling growth. 2) Environmental and geographical factors: the specific circumstances of some areas create a potential base for tendency to smuggling. The existence of illegal entry and transit places, unemployment, poverty, education level, and other cultural, social and political factors are influential in individuals' motivation to smuggle (Maddah, 2005). In the following some of the most important variables affecting smuggling which are used in domestic and foreign studies, are discussed:



1) The ratio of import taxes to total imports and tariffs: It could be claimed that, this variable has been considered as one of the important factors for business agencies turning to smuggling in all studies. Pitt (1981) suggested that tariffs lead to price difference in domestic and international markets and create or boost the incentive to illegal import and evade tariffs. In other words, by existence of tariff, the profit of the smuggling agencies is higher than legal business agencies which are imposed to additional costs. This would strengthen their motivation to do the smuggling (Farzanegan, 2008, p.16). This variable is also used among variables affecting smuggling in domestic studies (e.g., Garmaroudi, 1998; Arabmazar, 2001; Maddah, 2005; Farzanegan, 2008; Akhbari et al., 2010). Therefore in this study, the ratio of import tax to official import is used as an input variable of fuzzy system and it is assumed that increase in this ratio would be accompanied by increase in the volume of smuggled imports.

2) Risk of smuggling: as the smuggling is counted an illegal activity, the smuggler is always faced with the risk of detection, confiscation or punishment of perpetrators of smuggling by legal entities. Low Risk compared with tax evasion stemming from smuggling, enhances the motivation for illegal act of smuggling. Norton (1988), in an article titled "economic theory of smuggling", expresses smuggling causes, while surveying the relationship between smuggling and risk. By defining an expected profit function for smuggler after maximizing a bound function, he concludes that increasing the tax rate, the amount of smuggling increases and with increasing fines through a reduction in the expected profit, contraband being smuggled decreases.

Maddah (2005) in his doctoral dissertation, calculated fine rate-as the expected amount of penalty in rials in case of detection (average fine) per \$1 smuggling- based on penal codes for smuggling and governmental discretionary punishments rule, for the years 1970-2002. After that, Farzanegan (2008) has benefited from the corresponding figures for the study of the risk factor in smuggling. In the present study, due to lack of data in the period under study, this variable is not used.

3) Exchange gap: since the contraband is financed by the black market exchange, thus the importers choice between smuggling and legal trade does not only depend on tariffs and the possibility of detection, but also black market premium for foreign exchange (Farzanegan, 2008, p.14). But

regarding the direction of these variables' impact on the volume of smuggling, there is ambiguity: Barnett (2003) suggests that the unofficial exchange rate is the cost of illegal importing and therefore by increasing the official and unofficial exchange gap, the amount of smuggling is reduced. On the other hand, according to Pitt (1981), by increasing exchange gap, the official importers use over invoicing to gain profit by selling the extra currencies obtained. This means an increase in smuggling (Farzanegan, 2008, pp.14-15). In domestic studies this factor has also been considered as another explanatory variable for smuggling (e.g., Garmaroudi, 1998; Maddah, 2005; Farzanegan, 2008; Akhbari et al., 2010). Therefore, in the present study the ratio of official exchange to unofficial exchange is used to consider this variable. Moreover, since this ratio represents the cost of official import relative to the cost of smuggled import, it is assumed that by its increase- which means increase in official import costs relative to smuggled import- incentive of unofficial import and consequently the volume of smuggling is increased.<sup>1</sup>

4) Trade restrictions: often in policy prescriptions the way to fight the spread of illegal trade is to reduce legal restrictions. According to Helleiner (1990) trade openness and lower limits, facilitate integration to global markets and reduce the incentive to smuggle. Thus by reducing trade restrictions the smuggling volume is expected to decline. In domestic studies also, an index of trade openness as one of the explanatory variables in illicit trade is used (e.g., Arabmazar, 2001; Heibati, 2005; Farzanegan, 2008). In this study, the ratio of the total trade volume (Imports + non-oil exports) to GDP will be used as an index of trade openness and another input variable in fuzzy system. It is assumed that the increase in this ratio- which means reduction in trade restrictions- is accompanied by reduction in the smuggling volume.

#### **4- Research Methodology**

In many empirical analyses in economic and financial fields, the theory of fuzzy sets and fuzzy logic are used. Fuzzy theory which was established as a branch of mathematics in order to overcome the uncertainty dimensions,

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1- Refer to Maddah, 2005

is today one of the fastest branches of artificial intelligence. Fuzzy logic was first entered into econometrics by Shepherd and Shi (1998) and Lindstorm (1998) and was first used in the field of underground economy by Deraeseke and Giles (2002). The methodology of fuzzy approach consists of three stages of fuzzification, fuzzy inference and defuzzification, which will be discussed in the following.

#### 4-1- Fuzzification

In Fuzzy system we are faced with input variables with known values and a output variable (smuggling) with unknown quantity. The first step is to fuzzificate the input variables by using fuzzy membership functions and data breakpoints, where it is specified that each of the input variables in each year belongs to which fuzzy set (VH, H, N, L, VL) or (very high, high, normal, low, very low) and how much is the intensity of the attachment (membership degree). Triangular membership functions are shown in figure (1), where on the vertical axis we have membership degrees and on the horizontal axis we have input variable values:

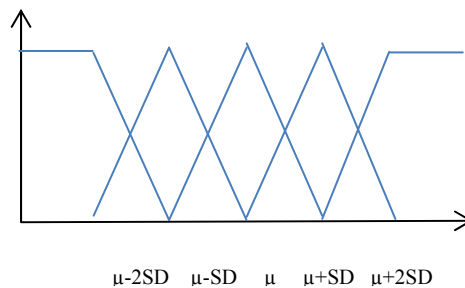


Figure 1: Triangular Membership Functions Presentation

By using moving average ( $\mu$ ) and standard deviation (SD), data breakpoints are formed into ( $\mu-2SD$ ,  $\mu-SD$ ,  $\mu$ ,  $\mu + SD$ ,  $\mu +2 SD$ ) in figure (1). Explanation goes as, for year  $t$ , the average of input variable is achieved by the average of all previous years and the year itself, and minimum number of years is considered 6 years. So if the period being studied begins from the year 1978, the input variable average in the beginning year would include values for the years 1973-78.

It is determined by table (1) that input variable belongs to which set and with what membership degree. It is noted that each value of the input variable, belongs to a maximum of two fuzzy sets and thus two membership degrees are calculated for it.

**Table 1: Fuzzy Membership Functions**

Membership Function	Intervals
$M_{VL}(x)=1.0$	$x \leq \mu - 2SD$
$M_{VL}(x) = (\mu - SD - x) / SD$	$\mu - 2SD \leq x \leq \mu - SD$
$M_L(x) = (x - \mu + 2SD) / SD$	$\mu - 2SD \leq x \leq \mu - SD$
$M_L(x) = (\mu - x) / SD$	$\mu - SD \leq x \leq \mu$
$M_N(x) = (x - \mu + SD) / SD$	$\mu - SD \leq x \leq \mu$
$M_N(x) = (\mu + SD - x) / SD$	$\mu \leq x \leq \mu + SD$
$M_H(x) = (x - \mu) / SD$	$\mu \leq x \leq \mu + SD$
$M_{HH}(x) = (\mu + 2SD - x) / SD$	$\mu + SD \leq x \leq \mu + 2SD$
$M_{VH}(x) = (x - \mu - SD) / SD$	$\mu + SD \leq x \leq \mu + 2SD$
$M_{VH}(x) = 1.0$	$x \geq \mu + 2SD$

Source: Yu et al. (2005)

**4-2- Fuzzy inference**

In this stage, constructing fuzzy rules, based on the number of input variables (NI) and the number of fuzzy sets (NS) and the relationship direction between input variables and output variable is done first. The number of existing rules (NR) in fuzzy rules base is obtained from the following equation:

$$NR = (NS)^{NI}$$

So according to the three input variables and five fuzzy sets (VH, H, N, L, VL) fuzzy rules base would consist of 125 rules. Based on the relationship direction between input variables and output variable it is specified that the output variable (smuggling) belongs to which output fuzzy set (VB, B, A, S, VS) or (very big, big, average, small, very small). Fuzzy rules would be deductible by if-then logic.

For example, according to the positive effect of foreign exchange gap, the import tax ratio and the negative effect of trade openness index on smuggling, the following formula is extracted:

If the foreign exchange gap is very high (VH), the import tax ratio is very high (VH) and trade openness index is very low (VL), then the volume of smuggled imports would be very big (VB).

As we shall see, the rule extraction is based on reasonable expert derivation of these variables impact on smuggling volume. So based on all possible states for input variables, the fuzzy rules are made of this logic. It should be expressed that, an adjustment or confidence coefficient ( $d_i$ ) is attributed to each of the rules, which shows that with what probability the output variable smuggling belongs to that particular set (VS, S, A, B, VB). For instance, in the extracted rule above, adjustment coefficient equals 1, while if the foreign exchange gap belongs to H set instead of VH, smuggling will belong to VB set with the adjustment coefficient 0.8. Noting that for each year, each input variable belongs to a maximum of two fuzzy sets, consequently 8 rules are activated in each year.

After constructing fuzzy rules base<sup>1</sup>, the fuzzification operation of the output variable (smuggling) is done. Therefore, attachment intensity of the output variable to output fuzzy sets must be determined. For this purpose, the subscription (or the minimum operator) of input variables membership degrees multiplied by the corresponding rule adjustment coefficient is used as the following:

$$M_i(S) = \text{Min}(M_i(\text{EX}), M_i(\text{FI}), M_i(\text{IMT})) * d_i$$

Where  $i$  index shows the activated rule number,  $M$  membership degree,  $S$  smuggling variable,  $\text{EX}$  exchange gap,  $\text{FI}$  trade openness index,  $\text{IMT}$  import tax ratio and  $d$  shows the corresponding rule adjustment coefficient. If in the year under review, based on a number of rules, output variable belongs to a specific set which as a result a number of membership degrees would be calculated, in order to attribute it to a single membership degree, we operate through summation (or the maximum operator) of membership degrees. For example, suppose in year  $t$ , according to rules  $i, j, k$  smuggling belongs to  $B$  set. Based on each of these rules, a membership degree is computed for  $B$

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1- It should be stated that here, the fuzzy principles base of Akhbari et al. (2010) is used, in a way that it is adjusted according to input variables of present study.

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set. Then to obtain a specific membership degree, we use the following equation:

$$M_t^B(S) = \text{Max} (M_i^B(S), M_j^B(S), M_k^B(S))$$

So in this stage, the output variable fuzzification is done as explained. It is determined that the output variable belongs to which fuzzy set and with what intensity of the attachment in each year.

### **4-3- Defuzzification**

With regard to the argument that we need a certain amount as inference output, it is required to turn the fuzzy set of output variable back to a certain number. Function of returning a fuzzy set to a certain value, is called defuzzification. For this purpose, in the present study, center of gravity method is used as the following:

$$\text{Output} = \Sigma (M_i(S) * w_i) / \Sigma M_i(S)$$

Subscript i is used to represent different sets and w represents their weights, so that it attributes weight 1 to set VB, weight 0.75 to set B, weight 0.25 to set S and weight zero to set VS. The output of this stage, gives an index of smuggled imports as a percentage of official imports which is an ordinal. However there are different methods to obtain the cardinal index of the relative size of smuggling, which makes it possible to compare the results of this study with the results of other studies, we applied the calibration method introduced by Giles and Tedds (2002) in imitation of some previous studies including Arabmazar (2001) and Khandan (2009) as below:

$$(\eta / \text{IM})_t^{\text{final}} = (\eta / \text{IM})_t^{\text{ordinal}} * \mu$$

$$\text{Where: } \mu = (\eta / \text{IM})_T^* / (\eta / \text{IM})_T^{\text{ordinal}}$$

$\eta$  is smuggling volume of import, IM official import volume,  $(\eta / \text{IM})_t^{\text{final}}$  cardinal index of the relative size of smuggling in year t,  $(\eta / \text{IM})_t^{\text{ordinal}}$  ordinal index of the relative size of smuggling in year t,  $(\eta / \text{IM})_T^*$  cardinal

index of the relative volume of smuggling that its figure is available from the data out of this survey (result of the research of others, for example) for the year T, and  $(\eta / IM)_T^{\text{ordinal}}$  ordinal index of the relative volume of smuggling in year T from the present study (Khandan, 2009, p.112 ). Here, Farzanegan's study (2008) is used to calibrate, as the relative volume of smuggled imports to official imports for the year 1992 is calculated equal to 25.23 percent.<sup>1</sup> So we have:

$$(\eta / IM)_T^* = (\eta / IM)_{1992}^* = 25.23$$

Finally, the time series of the import smuggling index is obtained as a percentage of the official import for the time period being studied which by multiplying the official IM, absolute values of smuggled imports are achieved.

## 5- Estimations

The results of estimation are given in table (2). Smuggled and official imports figures are real figures (with fixed prices of year 1997) and in billion rials scale. Figures in the fourth and eighth columns titled as the relative volume of smuggling are obtained from smuggled imports divided by official imports and are expressed as percentage. As it can be seen, for data obtained providing a better picture of how smuggling has moved during the 33-year period, we divided the time period into shorter periods: so that the years 1978-88 are correspondent to the period of the revolution and war, years 1989-94 corresponding with the first economic development program, years 1995-99 corresponding with the second program, years 2000-2004 corresponding with the third program and years 2005-2010 corresponding with the fourth economic development program.

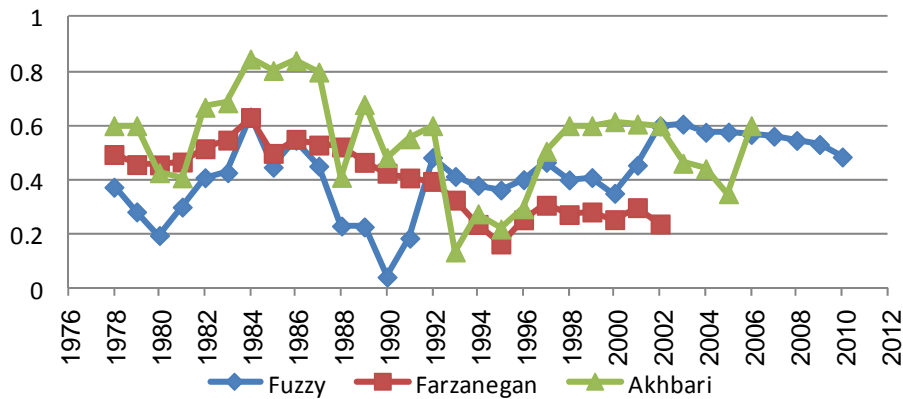
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1- It should be stated that Farzanegan has calculated the relative volume of smuggling to total trade, which we transformed to a ratio of official import and then used it for calibration.

**Table 2: Estimation of Import Smuggling**

Year	IM Smuggling	Official IM	Relative volume	Year	IM Smuggling	Official IM	Relative volume
1978	18069.14	93402	19.3455	1995	10816.78	40953	26.4126
1979	10451.33	70413	14.8429	1996	12989.28	47816	27.1651
1980	5463.61	71825	7.606	1997	14216.14	44728	31.7835
1981	7850.35	68068	11.533	1998	12948.83	44887	28.8476
1982	11377.07	60733	18.7329	1999	13072.75	42521	30.7442
1983	15891.92	84265	18.8594	Average	12808.76	44181	28.9906
1984	16849.52	57908	29.097	2000	11722.1	46047	25.4568
1985	11004.42	53889	20.4205	2001	16163.51	54006	29.9291
1986	11566.61	46920	24.6517	2002	24623.31	66566	36.9908
1987	11514.7	51612	22.3101	2003	29040.91	80262	36.1826
1988	5624.83	43924	12.805	2004	29510.06	90636	32.5588
Average	11423.95	63905.36	18.2005	Average	22211.98	67503.4	32.2236
1989	6392.23	52991	12.0628	2005	30602.76	92645	33.0323
1990	1591.44	69743	2.281	2006	32417.16	99241	32.6651
1991	8609.59	92826	9.274	2007	32359.65	102336	31.621
1992	21291.99	84378	25.234	2008	32814.95	110318	29.7458
1993	17128.94	67809	25.2605	2009	32468.22	108553	29.91
1994	13040.68	41337	31.5472	2010	32493.99	117484	27.6582
Average	11342.483	68180.66	17.6102	Average	32192.791	105096.17	30.772

The ordinal index values of the fuzzy smuggling are compared with those obtained from the MIMIC model in Farzanegan (2008) and the fuzzy model in Akhbari (2010) plotted in Fig. 2. Although these three approaches yield quite different results for the Iran smuggling, they exhibit some similar trends over this period, as it shown in Fig. 2.



**Figure 2: Comparison of Ordinal Index Values of the Smuggling**



## 6- Conclusions

In this study, the volume of smuggled imports for the years 1978 to 2010 is estimated, using three variables, the official to unofficial foreign exchange ratio, the taxes on imports to official import ratio and trade openness index. Now we survey the estimated values trend:

### 1) Years corresponding with war and revolution (1978-88)

In this period, the average relative volume of smuggling is estimated 18.2 percent. In the early and late years a downward trend in smuggling volume is observed, which stems from decreasing import tax ratio and the official to unofficial exchange ratio. However, due to the upward trend of import tax ratio, and also the downward trend of trade openness index, smuggling started to increase by the year 1981 and this trend continued till year 1986.

### 2) Years corresponding with the first development program (1989-1994)

In this period, the average of relative import smuggling has been 17.6 percent and we are faced with an increasing trend of smuggling, mainly due to increasing import tax, but it decreased in years 1993 and 1994 by decrease in exchange ratio. It should be stated that the relative and absolute volume of smuggling during the first program of economic development has been accompanied by a slight decrease compared to the revolution and war years.

### 3) Years corresponding with the second development program (1995-99)

In these years, the relative volume of import smuggling is obtained 29 percent on average. We observe that by increasing import tax ratio, smuggling starts an upward trend. However, in year 1995, due to the fall in exchange ratio and import tax ratio, and in year 1998, as a result of increase in trade openness index and decrease in exchange ratio and import tax ratio, we faced with a decline in volume of import smuggling. During the second program, compared to the first program, the relative volume of smuggled imports has increased, mainly due to decrease in the volume of official imports, while this increase in the absolute volume of contraband is negligible.

### 4) Years corresponding to the third development program (2000-2004)

According to the results the relative volume of smuggled imports is 32.2 percent and the relative and absolute import smuggling has increased, compared to the second program years. During these years, despite the increase in trade openness index, we are faced with an increasing trend of

import smuggling, due to increasing taxes on imports and mutation of the official foreign exchange to unofficial exchange (close to one).

5) Years corresponding with the fourth development program (2005-2010)

In these years, the relative volume of import smuggling is estimated 30.8 percent on average and we are mainly faced with a slight increase in contraband volume which is due to the fluctuating trend of import tax ratio. During the fourth compared with the third program of economic development, we are facing an increase in the absolute volume of smuggling, but because of official imports increase, the relative volume of smuggling is reduced.

Finally, according to the estimates made for import smuggling during years 1978-2010, it is observed that the absolute and relative smuggling volume has enjoyed an upward trend during the studied period, as the volume of import smuggling has increased from 18069.14 billion rials in year 1978 (19.3 percent of official imports) to 32493.99 billion rials in year 2010 (27.6 percent of official imports) in constant prices of year 1997. Also, the relative volume of smuggled imports for the period being studied is estimated about 24 percent of official on average.

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**Appendix**

**Fuzzy Rules**

Rules	Exchange Gap	Triffs	Openness	Smuggling	di
1	VH	VH	VL	VB	1
2	H	VH	VL	VB	0.8
3	N	VH	VL	VB	0.6
4	L	VH	VL	B	1
5	VL	VH	VL	B	0.8
6	VH	H	VL	VB	0.6
7	H	H	VL	B	1
8	N	H	VL	B	1
9	L	H	VL	A	0.8
10	VL	H	VL	A	1
11	VH	N	VL	B	1
12	H	N	VL	B	0.8
13	N	N	VL	A	1
14	L	N	VL	A	1
15	VL	N	VL	A	0.8
16	VH	L	VL	A	0.8
17	H	L	VL	A	1
18	N	L	VL	A	1
19	L	L	VL	S	0.8
20	VL	L	VL	S	1
21	VH	VL	VL	A	1
22	H	VL	VL	A	0.8
23	N	VL	VL	S	1
24	L	VL	VL	S	1
25	VL	VL	VL	VS	0.6
26	VH	VH	L	VB	1
27	H	VH	L	VB	0.8
28	N	VH	L	B	1
29	L	VH	L	B	1
30	VL	VH	L	B	0.8
31	VH	H	L	VB	0.6
32	H	H	L	B	1
33	N	H	L	B	0.8
34	L	H	L	A	0.8
35	VL	H	L	A	1
36	VH	N	L	B	1
37	H	N	L	A	0.8
38	N	N	L	A	1
39	L	N	L	A	1
40	VL	N	L	S	0.8
41	VH	L	L	A	1
42	H	L	L	A	1

43	N	L	L	A	0.8
44	L	L	L	S	1
45	VL	L	L	S	1
46	VH	VL	L	A	1
47	H	VL	L	S	0.8
48	N	VL	L	S	1
49	L	VL	L	S	1
50	VL	VL	L	VS	0.8
51	VH	VH	N	VB	1
52	H	VH	N	VB	0.6
53	N	VH	N	B	1
54	L	VH	N	B	1
55	VL	VH	N	A	0.8
56	VH	H	N	B	1
57	H	H	N	B	1
58	N	H	N	B	0.8
59	L	H	N	A	1
60	VL	H	N	A	1
61	VH	N	N	B	0.8
62	H	N	N	A	0.8
63	N	N	N	A	1
64	L	N	N	A	0.8
65	VL	N	N	S	0.8
66	VH	L	N	A	1
67	H	L	N	A	1
68	N	L	N	S	0.8
69	L	L	N	S	1
70	VL	L	N	S	1
71	VH	VL	N	A	0.8
72	H	VL	N	S	1
73	N	VL	N	S	1
74	L	VL	N	VS	0.6
75	VL	VL	N	VS	1
76	VH	VH	H	VB	0.8
77	H	VH	H	B	1
78	N	VH	H	B	1
79	L	VH	H	B	0.8
80	VL	VH	H	A	1
81	VH	H	H	B	1
82	H	H	H	B	1
83	N	H	H	A	0.8
84	L	H	H	A	1
85	VL	H	H	A	1
86	VH	N	H	B	0.8
87	H	N	H	A	1
88	N	N	H	A	1

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89	L	N	H	A	0.8
90	VL	N	H	S	1
91	VH	L	H	A	1
92	H	L	H	A	0.8
93	N	L	H	S	0.8
94	L	L	H	S	1
95	VL	L	H	VS	0.6
96	VH	VL	H	S	0.8
97	H	VL	H	S	1
98	N	VL	H	S	1
99	L	VL	H	VS	0.8
100	VL	VL	H	VS	1
101	VH	VH	VH	VB	0.6
102	H	VH	VH	B	1
103	N	VH	VH	B	1
104	L	VH	VH	A	0.8
105	VL	VH	VH	A	1
106	VH	H	VH	B	1
107	H	H	VH	B	0.8
108	N	H	VH	A	1
109	L	H	VH	A	1
110	VL	H	VH	A	0.8
111	VH	N	VH	A	0.8
112	H	N	VH	A	1
113	N	N	VH	A	1
114	L	N	VH	S	0.8
115	VL	N	VH	S	1
116	VH	L	VH	A	1
117	H	L	VH	A	0.8
118	N	L	VH	S	1
119	L	L	VH	S	1
120	VL	L	VH	VS	0.6
121	VH	VL	VH	S	0.8
122	H	VL	VH	S	1
123	N	VL	VH	VS	0.6
124	L	VL	VH	VS	0.8
125	VL	VL	VH	VS	1

## Output of Fuzzy Method

Year	Active Rules	VS	S	A	B	VB	Index
1978	85,60,90,65		0.448	0.44			0.3739
1979	64,39,69,44,65,40,70,45		0.655	0.101			0.2833
1980	89,64,94,69,90,65,95,70	0.408	0.32	0.208			0.1965
1981	64,39,69,44,65,40,70,45		0.527	0.135			0.3009
1982	39,14,44,19,40,15,45,20		0.334	0.582			0.4089
1983	59,34,64,39,60,35,65,40		0.271	0.662			0.4274
1984	29,4,34,9,30,5,35,10			0.421	0.474		0.6323
1985	34,9,39,14,35,10,40,15		0.144	0.541			0.4474
1986	29,4,34,9,30,5,35,10			0.645	0.147		0.5465
1987	34,9,39,14,35,10,40,15		0.123	0.512			0.4514
1988	74,49,75,50	0.072	0.883				0.2313
1989	69,44,74,49,70,45,75,50	0.053	0.547				0.228
1990	94,69,99,74,95,70,100,75	2.528	0.536				0.0437
1991	118,93,123,98,119,94,124,99	0.216	0.633				0.1865
1992	116,91,121,96,117,92,122,97		0.04	0.551			0.4832
1993	91,66,96,71,92,67,97,72		0.346	0.654			0.4135
1994	62,37,67,42,63,38,68,43		0.426	0.467			0.3807
1995	68,43,73,48,69,44,74,49	0.067	0.38	0.496			0.3637
1996	63,38,68,43,64,39,69,44		0.298	0.459			0.4015
1997	63,38,68,43,64,39,69,44		0.081	0.506			0.4654
1998	63,38,68,43,64,39,69,44		0.316	0.481			0.4009
1999	63,38,68,43,64,39,69,44		0.206	0.364			0.4095
2000	63,38,68,43,64,39,69,44		0.539	0.368			0.3515
2001	88,63,93,68,89,64,94,69		0.107	0.484			0.4547
2002	86,61,91,66,87,62,92,67			0.49	0.323		0.5993
2003	86,61,91,66,87,62,92,67			0.452	0.331		0.6056
2004	86,61,91,66,87,62,92,67			0.647	0.282		0.576
2005	86,61,91,66,87,62,92,67			0.541	0.239		0.5767
2006	86,61,91,66,87,62,92,67			0.525	0.197		0.5681
2007	86,61,91,66,87,62,92,67			0.469	0.153		0.5614
2008	86,61,91,66,87,62,92,67			0.523	0.118		0.5459
2009	86,61,91,66,87,62,92,67			0.53	0.075		0.531
2010	87,62,92,67,88,63,93,68		0.03	0.47			0.4851