Journal of Economics and Sustainable Development www.iiste.org
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.3, No.2, 2012

# Innovation a modern model for estimating volume of money laundering

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**Abstract**

Money laundering or dirty money laundering refers to a process which attempts to demonstrate as legal the source of money obtained through illegal or illegitimate activities. Inflation and recession are among unavoidable consequences of money laundering and will eventually lead to spread of poverty in society. Therefore, recent years have witnessed a great tendency towards the assessment of this phenomenon and the application of different methods to estimate its quantity and volume alongside other similar variables in the socio-economic context. The aim of this article is to explain the ways of modeling of economic relations in addition to introducing a new method for assessment of the quantity of dirty money based on mathematical methods, without any particular presumption. This is while other methods, due to their nature, have a variety of different premises and this has indeed created many problems, including the likelihood of having remarkable errors. The present study applies a combination of Bhatta charya method and arithmetic methods which are based on Tikhonov's regularization strategy and inverse problem in order to introduce a new equation for assessment of the quantity of dirty money.

**Keywords:** Corruption, Poverty, Money Laundering, Tikhonov Regularization Strategy, Inverse Problem

## 1. Introduction

Corruption encompasses a wide and multi-dimensional concept in such a way that a phenomenon might be regarded as corruption in one society while being a social norm in another (De Saran, 1999). People have different viewpoints towards the corruption which is taking place in different economic sectors. For instance, people usually believe that corruption in judicial systems and courts is of more significance than financial corruption (Transparency International, 2002). The occurrence of corruption as an undesirable social phenomenon has a variety of different social and economic motives. Due to the importance of the issue of corruption in different countries, extensive studies have been conducted into this issue in order to identify and analyze its causes. It should be reiterated that economic factors are the fundamental factors for all social structures and they leave significant effects on individual and group activities with regard to corruption. Reduction of bureaucracy as well as increase in transparency should be regarded as the main elements of a successful economic approach, which is free of corruption (Jain, 2001; Martinez-Vazquez, and McNab, 2003). However, corruption has many definitions. According to Chugh and Uppal (1986), different researchers consider different terminologies based on their own objectives. However, the present study puts the main emphasis on financial corruption and thus it is necessary to provide a definition of financial corruption and its different forms in order to establish an exact understanding of this type of corruption.

## 2. The Concept of Corruption

Financial corruption is a phenomenon that is usually the result of mutual interaction between the government and market economy. In addition, financial corruption, as defined by the World Bank, Transparency International and other related organizations is the exploitation of public power in order to obtain private interests (World Bank, 2004). On this basis, different forms of financial corruption can be enumerated as follows: bribe and bribery, embezzlement, cronyism, hush money, blackmail, etc.

Lho, K. and Cabuay, J. (2005) regard financial corruption as the profit-seeking measures taken by politician, businessmen, and governmental employees who misuse their governmental or private positions illegally. Some officials might even been appointed to positions based on different forms of corruption such as bribery, embezzlement, blackmailing or cronyism (Amundsen, 2000). In general, financial corruption occurs on the income part or expenditure part of budget or in such quasi-financial transactions that are not related to budget as in enactment of rules and regulations (Martinez and Vazquez et al, 2004).

However, the significance of conducting studies on financial corruption is due to the fact that in developing countries, unlike Western countries, this not only phenomenon has not led to fake economic boom, but has also resulted in destruction of added value as many productive job opportunities are either lost or the growth of which are stopped, disturbing the process of distribution of income. As the result of the recession of production, the

governmental tax income will be deprived of the necessary growth that is in accordance with the potential tax capability of GDP and this will eventually pose problems to fair distribution of facilities by government due to limitations in resources. The improper performance of this group of chain-like and disturbing factors will reduce the public purchasing power. On the other hand, the inflation resulting from the financial flow of goods trafficking will be imposed on the fixed income of people, disturbing the balance between family income and expenditure. This is due to the fact that the overall increase in prices will leave different impacts on the price of goods and services. In other words, the price of all goods and services will not increase equally. Inflation mainly causes an increase in the price of basic goods and services, which allocate a major part of the expenditures in low-income families and thus have a more prominent role in their pattern of consumption. Therefore, it can be stated that inflation will more negatively affect low-income families compared with others, and will close them to poverty line (Blank and Blinder, 1986; Blank, 1993; Powers, 1995). Thus, the number of those living below the poverty line will grow day by day. Hence, this issue is of great significance for developing countries as all their hopes and dreams are to achieve development. Consequently, in long-term development plans, the fight against this type of corruption is always highlighted, as there is a reverse correlation between the level of development and level of corruption (Kaufmann et al., 2009). As Frisch (1994) states, financial corruption will destroy development because people's motivation for honest effort and constructive jobs will be reduced. In addition, reduction of corruption is regarded as one of the indices of good governance (Kaufman and Kraay, 2002). In fact, the annual reports of Transparency International (2011) indicate that financial corruption can be found in all countries all over the world. Different studies conducted by different researchers also confirm this issue. For instance, Schneider and Enste studied 69 countries and concluded that underground economy is growing in the world. This growth is reported both relatively and absolutely (per GNP) (Schneider and Enste, 1999). In another study, Schneider et al. (2010) assessed the shadow economy as a percentage of GDP and reached the same conclusion. For this issue, they gathered the data belonging to 136 developed and developing countries during 1999-2007 and concluded that the most important consequence of issue is the people's mistrust to government. It also seriously threatens social moralities (Heymans and Lipietz, 1999).

The corruption perception index, which is being published by Transparency International, measures corruption by using reliable international world reports and questionnaires which are conducted by 9 international institutions. It gives a sore of 0 to 10 to different countries. The scores below 5 indicate the minimum transparency (Transparency International, 2010). As it was stated earlier, financial corruption can be found all over the world. This has resulted in conducting a bulk of studies in different countries and different theories are accordingly proposed by different scholars of the field, among which the followings can be considered:

- The results of the study by Pillay (2004) in South Africa indicate that financial corruption has spread as the result of organizational weakness.
- Koontz et al. (1997) believe that moralities are the main obstacle against corruption.
- Racial Theory: the countries divided based on ethnicity or race show greater tendency towards corruption (Mauro, 1995).
- Theory of Rare Resources: Based on this theory, corruption is in correlation with access to rare resources. If a government has power over such resources, then corruption will be in correlation with the size of government's activities (Rose-Ackerman, 1999). The natural resources which are exclusively under the control of certain groups provide conditions in which the owners do not feel obliged to act upon the rules (La Porta et al., 1999).
- Theory of Democracy: There is a reverse correlation between democracy and corruption (Hill, 2003; Bohara et al., 2004).

In general, financial corruption is rooted in the activities of government, particularly in its exclusive power, influence and authorities. According to Gary Becker (1974), in case government is ousted, financial corruption will be eliminated as well. In addition, Rajeev and Nelson (1998) state that the size of government has direct impact on corruption in such a way that with the increase in government size, corruption will increase as well.

In recent years, the size of underground sector in different economies has been investigated in different studies. There is an obvious mutual relationship between financial corruption and underground economic activities. In fact, any illegal economic activity requires some administrative and executive actions as well as political support that can only be provided through illegal measures and through corrupt relations. Therefore, one could claim that underground economic activities will lead to financial corruption. De Soto (1989) has investigated this issue for a number of institutions and has proved that the size of underground economy is bigger in poorer nations, concluding that illegal institutions have to pay a large portion of their gross income as bribe to legal institution.

Some scholars suppose that the cumbersome rules and regulations in government sector are the result of an intentional strategy by administration to increase the tendency of clients for paying bribes. Myrdal (1968), Tanzi

(1998), Rose-Ackerman (1978), and Kaufmann et al. (2006) believe that if something cannot be measured, no decision with regard to its improvement or enhancement would be possible. Therefore, the assumption that corruption is not measurable is wrong. With regard to the significance of measuring corruption, Feige (1990) and Feinstein (1999) state that considering this issue is an undeniable necessity in the process of recognition and policy-making.

## 3. Corruption Measurement Methods

The methods of corruption measurement and assessment are divided into micro- and macro- methods with regard to the type of approach and are divided into direct and indirect methods with regard to the means of collecting data (Frey and Weck-Hanneman, 1983). Direct methods are designed based on direct referring, using questionnaires, or sampling, such as surveying the points of view and perspectives of corporations, governmental officials, people, experts, foreign observers, and private sector, but it has numerous problems.

The following disadvantages are proposed for the survey method: surveys include people's opinions about corruption, and do not assess the corruption itself. Some people may not have enough knowledge and they may only state the common opinion in the society. Since such indices are based on mentality, they are influenced by social streams. Thus, the type of reports that are published in the media about corruption at the time of the survey, affects people's mentality about corruption. In addition, publishing the results of these reports in the next stages of the study might encourage people to base their opinion on the results gained in the previous periods. Some of the most significant indices that are being prepared and presented using this method are the result of merging the data of other surveys and researches. For instance, the corruption perception index, which is published by Transparency International, is the result of merging and standardization of the data of different surveys. Scholars believe that these types of measurement overrate the opinions of advisors and businessmen and are initially created to provide some data to help this group. Publishing such indices has also led to objections by some countries, as announcing the high rate of corruption in one country will affect the amount of investment and risk of investment in that country. Moreover, most surveys have only considered bribery. However, corruption in governmental contracts, corruption in foreign trades, corruption through cronyism, and the like are not equal to bribery. In addition, the emphasis has always been placed on macro-corruption, and different kinds of minor corruptions have been ignored. On the other hand, organized corruption is not distinguished from unorganized corruption. Another method is counting the appeals, although it has many problems. For instance, the referral to police for lodging appeals against the agents of corruption depends on many factors among which the level of corruption in the society can be mentioned. The number of appeals depends on people's trust to the police, their belief in the seriousness of the fight against corruption, the spread of corruption, benefits of reporting the corruption compared with the benefits of enjoying the advantages associated with corruption as well as the observation of people's rights and their political freedom in the society. The results of different investigations indicate that the possibility of reporting corruption in countries with highest level of corruption is less than the others in such a way that the most corrupted countries have the least number of corruption reports.

However, due to the secret nature of corruption, there are certain difficulties associated with it. Therefore, corruption assessment has to be done using indirect methods. In indirect method, both the micro-approach which investigates corruption at the organization's level based on their institutional features, and the macro-approach which is based on the ideas, in spite of the fact that secret activities cannot be observed, the factors explaining the process of changes in this phenomenon as well as its effects on different areas are not necessarily hidden, and thus can be observed. This approach attempts to rely on the observations related to the causes and effects of corruption in order to discover its size and process. Such methods can be divided into three generic categories: cause-based methods, effect-based methods, and cause and effect-based methods. The cause-based methods can be divided into cause tracing (approximate modeling) and Fuzzy. However, certain criticisms have been leveled against these two methods. In the cause tracing method, optional selection of parameters and rank-based results are criticized. However, in the application of Fuzzy logic, which was first used by Draeseke and Glies, the data hidden in the variables which reflect the black economy are not used and this is an important shortcoming, leading to little application of this method.

The effect-based methods are based on the notion that corruption will leave certain observable effects. This method has been more used compared with the other methods in such a way that it has wider categories, among which the followings can be mentioned: virtual variable methods, correlation of cash in fiscal transactions, volume of large bills in flow, discrepancy in national accounts, public expenditure tracking, discrepancy between arithmetic statistics and national income, discrepancy between family income and expenditure, discrepancy in statistics of foreign trade, controlled detection, tax audit, physical institutions and statistics of manpower.

Each of these issues have been investigated in the studies by Thomas (1999), Feige (1989), Porter and Bayer (1989), McDonald (1985), Schneider and Enste (2000) as well as Tenzi (1999).

Pillownight cites the four-categories stated by Leslie Holmes: Perception-Based Approach, Experience-Based Approach ,Tracking Approach, and Legal Statistics.

Hungarian Gallup Institute, which conducts periodic corruption assessments in different countries, enumerates three methods: measuring target groups and individual's perception on the spread of corruption, measuring behavioral indices of emergence of corruption, assessing the viewpoints of experts about the level of spread of corruption. It seems that the methods of measuring corruption are placed in this category, although there are some differences in certain details (Treisman, 2006; Reinikka & Svensson, 2006).

The most prominent and tangible form of financial corruption are bribery and embezzlement, which usually cannot be identified directly as they happen secretly and those who pay or receive the bribe are not willing to disclose it.

However, there has been a high tendency to measure this phenomenon in recent years and there has been an attempt to use different methods to assess the quantity and volume of financial corruption along with other similar variables in the socio-economic context. Some others have used indirect methods that are mainly based on the assessment of opinions and perceptions of people and experts. However, this article aims at explaining the modeling of economic relationships as well as introducing a new algorithm for assessment of financial corruption in Iran that is totally based on mathematical techniques and is free of any particular premise. This is while other methods, due to their very nature, enjoy a variety of different premises and this has indeed created many problems, including the likelihood of having momentous errors.

Thomas (1992) believes that in experimental studies, corruption generally refers to all activities that are for any reason not included in national accounts. In supplementary studies, different terminologies are used to define this type of economy, including: black (Pyle, 1989), underground (Tanzi, 1982), unobserved or invisible (Feige, 1981), hidden (Giles, 1998), nonmarket (Raw, 1993), Shadow (Cassell, 1984), irregular (Feige, 1979), informal (Thomas, 1985), illegal (Lacko, 1992), second (Contini, 1982), unrecorded or unreported (Feige and Magee, 1989), and so forth. Due to the opinion of the researchers and their focus on certain features of the economy, the meaning of each of these terms has been unusual. In addition, the studies conducted by certain researchers including Stavrps (2006), Marcel Thum et al. (2004), Johnson (1998), Rauch (1991), and Tanzi indicate a positive correlation between the volume of black economy as well as underground activities with financial corruption and money laundering.

**4. Definition of a money laundering**

In his article titled "Private Banking and Money Laundering", Carl Levin writes: "money laundering occurs when criminals try to present the incomes gained from criminal activities as legal income" (Levin, 1999). According to this definition, it can be noted that money laundering is a series of operations taken place to pretend that some illicit or illegal incomes are gained from legitimate or legal sources, However their origin is smuggling, bribery, extortion, kidnapping, fraud, forged invoices in the commercial sector, corruption, embezzlement and bribery in government organizations, financial fraud, wealth and income achieved from tax evasion, Internet fraud and other data tools and to-be-confiscated wealth.

Accordingly, the European Community investigated money demands in five countries of Bolivia, Colombia, Ecuador, Peru and Venezuela from 1989 to 1999 to fight money laundering. To do so, two approaches of Bhattacharya (1990) and A. M. Khalid (1999) were used.

In his own paper, Schneider (2002) studied the size of the black economy in Italy, France, Germany and Britain, and concluded that financial flows of criminal terrorist organizations by government officials are the main cause of the growth of underground economy in these countries. In this article, the author measured the dynamic multiple causes of black economy in the four countries using multiple variables method.

In an article titled "Major Economic Effects of Money Laundering", and according to Bhattacharya strategy, Quirk has considered the data on various types of crimes, the recommendations of the FATF to nineteen industrial countries on money demand function as a substitution variable to the illegal income, and investigated the effects of these criminal activities on monetary behavior in these countries.

Quirk's method (1996) has also been used in this article to identify the volume of dirty money and the effect of informal activities on money demand. Based on Bhattacharya strategy (1990), Quirk studies the effects of illegal activities on monetary behavior in the nineteen industrial countries. Bhattacharya divided money demands into two parts of money demand of formal sector and money demand of informal sector of economy:

$$M_t = M_{Rt} + M_{URt} \qquad (1)$$

Where $M_t$ is the total money demand in the times t, $M_{Rt}$ and $M_{URt}$ are respectively formal and informal money demands. Based on the theory of money demand, formal money demand equation is as follows:

$$M_{R_t} = \alpha_0 y_{R_t}^{\beta_1} R_{R_t}^{\beta_2} P_{R_t}^{\beta_3} e^{F(L)u_t} \qquad (2)$$

Where $y_{R_t}$ is the formal income, $R_t$ is the rate of short term interest, $P_t$ is the retail price index, and demand money of informal economy is as follows:

$$M_{UR_t}=y_{UR_t}^{\beta_4}+\omega_t \qquad (3)$$

Where, $y_{UR_t}$ is an estimation of informal economy.

Considering the fact that none of the above functions can be calculated separately, and estimating the total demand function indirectly, he measured the value of informal economy.

Inspired by Bhattacharya, Quirk considers money a function of formal GDP, price, interest rate and income from illegal activities of $y_{UR_t}$ and estimated money demand function in nineteen industrial countries and explained the effects of illegal income on money demand.

**5. Model Introduction**

The model used in the study is as follows:

$$LM_t=a+bLy_t+cR_t+dLEXR_t+LM_{UR_t}+\varepsilon_t \Rightarrow LM_{UR}(y_{UR})=LM_t-a-bLy_t-cR_t-dLEXR_t-\varepsilon_t \qquad (4)$$

Where all variables are functions of $P_t(cpi)$

Then:

$$LM_{UR}(y_{UR})=Z_t-\varepsilon_t \qquad (5)$$

Where

$$Z_t=LM_t-a-bLy_t-cR_t-dLEXR_t \qquad (6)$$

The value of $y_{UR}$should be obtained so that the value of $\varepsilon_t$ would be inclined towards zero. Equation (5) is mathematically a linear inverse problem (Kirsch, (1996)). A classic proposal to minimize the problem (5) is the least squares method where the function $G(y_{UR})$ will be minimized to $y_{UR}$ (Chiarella, Craddock and EL-Hassan, (2007):

$$G(y_{UR})=\int\sum_{t=1}^{i}(LM_{UR_t}(y_{UR})-Z_t)^2dP_t \qquad (7)$$

Unfortunately, market data are not accessible enough to obtain the unique value of $y_{UR}$ from equation (7). Therefore, determination of $y_{UR}$through this method is a ill-posed problem. On the other hand, as mentioned above, it is an inverse problem and inverse problems are often ill-posed. It means that the problem is likely to have no answer or more than one answer or the answer is not stable, i.e. in small changes in $Z_t$ can make big changes. To overcome this problem, regularization methods are used for the stability of the answer. In regularization methods, the main problem is replaced by another problem which is close to the main problem, but does not have the awkward condition of being solvable and this is the nature of all regulation methods. There are many methods to organize regularization strategies. We use Tikhonov regularization strategy in this article.

Now to minimize problem (7), we minimize Tikhonov function to $y_{UR}$:

$$T_\lambda(y_{UR})=\lambda\|y_{UR}\|_1+G(y_{UR}) \qquad (8)$$

Where,

$$\|y_{UR}\|_1=\|y_{UR}'\|_2^2+\|y_{UR}\|_2^2 \ , \|f\|_2=(\int f(x)^2dx)^{\frac{1}{2}}$$

and $\lambda$ are Tikhonov regularization parameters.

If we rewrite the equation (8), we will have:

$$T_\lambda(y_{UR})=\lambda[\int(\frac{\partial y_{UR}}{\partial P_t})^2dP_t+\int(y_{UR})^2dP_t]+\int\sum_{t=1}^{i}(LM_{UR_t}(y_{UR})-Z_t)^2 \ dP_t$$

$$\Rightarrow T_\lambda(y_{UR})=\int\left[\lambda[(\frac{\partial y_{UR}}{\partial P_t})^2+(y_{UR})^2]+\sum_{t=1}^{i}(LM_{UR_t}(y_{UR})-Z_t)^2\right]dP_t \qquad (9)$$

Now, the intended problem is to minimize equation (9). To do this, Euler-Lagrange equations will be applied to the following integrant variable ( Ewing, ( 1985)):

$$\xi=\lambda[(\frac{\partial y_{UR}}{\partial P_t})^2+(y_{UR})^2]+\sum_{t=1}^{i}(LM_{UR_t}(y_{UR})-Z_t)^2 \qquad (10)$$

Euler-Lagrange equations are as follows:

$$\frac{d}{dP_t}\frac{\partial \xi}{\partial\left(\frac{\partial y_{UR}}{\partial P_t}\right)}-\frac{\partial \xi}{\partial y_{UR}}=0 \qquad (11)$$

So, we have:

$$\frac{\partial \xi}{\partial\left(\frac{\partial y_{UR}}{\partial P_t}\right)}=2\lambda\frac{\partial y_{UR}}{\partial P_t}\Rightarrow \frac{d}{dP_t}\frac{\partial \xi}{\partial\left(\frac{\partial y_{UR}}{\partial P_t}\right)}=\frac{d}{dP_t}\left(2\lambda\frac{\partial y_{UR}}{\partial P_t}\right)=2\lambda\frac{\partial^2 y_{UR}}{\partial P_t^2}\Rightarrow \frac{d}{dP_t}\frac{\partial \xi}{\partial\left(\frac{\partial y_{UR}}{\partial P_t}\right)}=2\lambda\frac{\partial^2 y_{UR}}{\partial P_t^2} \qquad (12)$$

And

$$\frac{\partial \xi}{\partial y_{UR}}=2\lambda y_{UR}+2\sum_{t=1}^{i}\left(\frac{\partial LM_{UR_t}}{\partial y_{UR}}-\frac{\partial Z_t}{\partial y_{UR}}\right)(LM_{UR_t}-Z_t) \qquad (13)$$

Where

$$\frac{\partial Z_t}{\partial y_{UR}}=\frac{\partial LM_t}{\partial y_{UR}}$$

Putting the above values in equation (11) we have:

$$\lambda(\frac{\partial^2 y_{UR}}{\partial P_t^2}-y_{UR})-\sum_{t=1}^{i}\left(\frac{\partial LM_{UR_t}}{\partial y_{UR}}-\frac{\partial LM_t}{\partial y_{UR}}\right)(LM_{UR_t}-Z_t)=0$$

Or

$$\lambda(\frac{\partial^2 y_{UR}}{\partial P_t^2}-y_{UR})=\sum_{t=1}^{i}\left(\frac{\partial LM_{UR_t}}{\partial y_{UR}}-\frac{\partial LM_t}{\partial y_{UR}}\right)(LM_{UR_t}-Z_t) \qquad (14)$$

This is a differential equation to solve which and obtain $y_{UR}$ , we use numerical methods. However, the numerical method we use depends on that country's data according to which we can apply the best numerical method. For example, numerical methods of Crank-Nicolson, and Euler's implicit and explicit methods can be used. The advantage of this method to many other methods is that this method does not have the limitations they have.

## 5. Conclusion

What was presented as this study and its results was an exclusive attempt relying on numerical methods to estimate the volume of dirty money. Considering the increasing trend of this phenomenon throughout the world, its related data should be included in the modeling of macroeconomic economic activities. This is very important to the economic researchers. In addition, as mentioned earlier, fighting this phenomenon is essential to achieve the development. Unfortunately, the harmful effects of this ominous phenomenon are clearly seen in all cultural, social, economic, political, security, disciplinary and legal areas.

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