Efficient Trade Matrix and Gold Reserve Requirement for Commodity Trade among Organization of Islamic Cooperation (OIC) Countries

[1]Muhammad-Bashir Owolabi Yusuf, [2]Ahamed Kameel Mydin Meera, [3]Gairuzazmi Mat Ghani,
[3]Turkhan Ali Abd Manap and [4]Mousa Larbani

[1]Department of Economics, International Islamic University Malaysia
[2]Department of Finance, International Islamic University Malaysia
[3]Department of Economic, International Islamic University Malaysia
[4]Department of Business, International Islamic University Malaysia

Abstract: The triple crises of 2008 with its enormous impact on the world trade have made many countries to start to look inward on how to prevent or curtail the future re-occurrence and impact. The Organization of Islamic Cooperation Countries should not be left out of the effort to beat future crises of this nature. To do this, they need to look inward and strengthen the intra trade among one another. To achieve this, they need a common platform in terms of trade coordination and a generally accepted international reserve currency that will be stable and will not be a potential source of crises in itself. All these require a proper strategic planning and evaluation of what is and what is supposed to be. This study is one of the earliest works in that direction. This study used a non linear mathematical programming to analyze the efficient trade matrix among OIC countries and the gold reserve requirements for every single country that participate in that trade. It was discovered that trade among these countries could be maximized based on the output of the analysis. The quantities of gold required by each of the country to participate in the multi-bilateral and multilateral trade were also found out. It was also discovered that the quantity of gold needed for such trade was least in multilateral trade arrangement. This study has a lot of implications in strengthen the cooperation among OIC countries and maximizing the trade relationship among them.

Key words: Financial crisis · Efficient trade matrix · Gold reserve requirement · Commodity trade · OIC

INTRODUCTION

This paper analyzes OIC countries' trade assuming gold is used as a medium to settle the trade. The objective is to determine the efficient trade matrix and level of gold required to support intra OIC commodity trade. The triple crises of 2008 (financial, fuel and food) had a great impact on the international trade of developed and developing countries. Specifically, the OIC countries' international trade was seriously hit by the crises. The organization members' international trades fall by more than 77 percent from 401 billion in 2008 to 89 billion US dollar in 2009. Most member countries trade mostly with non-members developed countries affected by the crises and use dollars as their trading currency and keep/invest

their foreign reserve in these developed countries. The impacts of these crises call for concerted effort by OIC in terms of promoting intra member trade and finding a more stable reserve currency.

Although what economists referred to as classical era of the gold standard ended with the breaking-out of the World War I in 1914, policy makers and scholars have never ceased interest in the issue of gold. Immediately after the end of World War I, great economies of the world experience hyper inflation and volatile exchange rate which made the world power to call for the return to prewar gold era. By 1928, majority of the countries around the world had returned to gold exchange standard. However, this was short-lived with the advent of the great depression in the early 1930s which lasted for several years [1, 2].

Corresponding Author: Yusuf Muhammad-Bashir, Department of Economics, International Islamic University Malaysia.

The issue of gold was revisited in the post-second world war international monetary order. American planers canvassed for a nominal gold standard that anchor dollar on gold and all other world currencies on the dollar. This was ratified at the Breton Wood Agreement in 1944. This, it was believed would facilitate exchange rate stability and growth in international trade. As it turns out to be, this led to asymmetry in the world monetary order with dollar taking the position of gold as an international reserve currency. Some European countries such as France who did not like this development started piling up gold. This put pressure on the thin American gold reserve [3].

In the mid-sixties, in the period some economists referred to as "Gold battle within cold war," France renewed call for return to pre-World War I classical gold standard which allowed for free movement of gold. The earlier Breton Wood agreement created imbalance gold-dollar standard. Countries now use dollar as a reserve instead of gold which give undue seigniorage advantage to America. This eventually made IMF to create paper gold inform of Standard Drawing Right (SDR) in 1968. This did not solve the problem. In August 1971, due to pressure and inability to fulfill its dollar for gold pledge, America unilaterally suspends convertibility of dollar to gold and thereby permanently severs the relationship between the paper money and gold. Ever since then, fiat currency has triggered speculative attack, persistent inflation and hundreds of financial crisis [4, 3].

As a solution to the present day search for ideal monetary rules, Bordo [2] notes two important relevance of gold in the present day monetary system. The first is commitment mechanism. This, he argues, makes the monetary authorities to pursue consistent policies, which will be an antidote to persistent rise in general price level. The second is the cooperation among the monetary authorities of different nations. This will facilitate policy coordination for a feasible international monetary system.

Previous study by Meera and Larbani [5] developed a non-linear optimization model to determine an efficient trade matrix, which need the minimum gold amount to settle the trade balances among the participating countries. Their theoretical paper developed a mathematical model and used hypothetical data in the model to determine the hypothetical minimum gold requirement for each participating country. This was done for both bilateral and multilateral trade arrangement. They found that the amount of gold reserve needed to support a volume of trade was reduced through

bilateral and multilateral netting among these countries. The amount of gold requirements to volume of trade is least in multilateral arrangement because of an increase in trade opportunities among the participating countries through netting. This paper which builds on the model used real data of international trade from selected OIC countries to determine the efficient trade matrix and the amount of gold requirements to support such trade among these countries.

The specific objectives of this study are therefore:

- To determine the efficient commodity trade matrix among OIC countries,
- To determine the gold requirement for multi-bilateral trade among OIC countries and;
- To determine the gold requirement for multilateral trade among OIC countries.

A Brief History of Organization of Islamic Cooperation (OIC): The Organization of Islamic Cooperation countries (OIC) formerly known as Organization of Islamic Conference is the second largest international organization after the United Nation with 57 member states spread over three continents. The OIC was founded in September 1969 at the first conference of Muslim leaders in Rabat, Morocco against the attempted arson of Al-Aqsa mosque in occupied Jerusalem. At the summit, the leaders of Muslim countries announce their intention to 'liberate Al-Qudus Al-Sheriff (Jerusalem) and Al-Aqsa mosque,' the third sacred mosque in Islam, from Israeli occupation they also agree on 'the need to institutionalize an effort to forge unity among Muslims, defend Muslim causes in the world politics and establish a mechanism to resolve internal differences within the Muslim world' [6-8]. The first conference of Islamic foreign ministers (ICFM) took place in Jeddah, Saudi Arabia in March 1970. At the conference, OIC permanent secretariat was established and its first Secretary General appointed. Jeddah was also selected to be the temporary head quarter of the organization until the emancipation of Jerusalem. The third session of the ICFM was held in February, 1972. There, the OIC charter was adopted, which aim to 'strengthen a) Islamic solidarity among member states; b) cooperation in the political, economic, social, cultural and scientific field; and c) the struggle of all Muslim people to safeguard their dignity, independence and national rights' [6, 7].

Geographically, the 57 member nations of OIC are located in the North and West Africa, Central Asia, Southeast Asia, The Indian Subcontinent and

Middle East. Africa has the largest number with 29 countries, followed by Asia, 27; Latin America has two and the remaining one is in Europe. There are 11 observers, which include five states and Russia. The UN, the Non-aligned Movement, the Leagues of Arab States and the economic Cooperation Organization (ECO) are important OIC observers among international organizations.

Literature Review

Regional Trade Agreement: Regional Trade Agreements (RTAs) can be defined as groupings of countries that come together with the goal of reducing trade barriers among member countries. These groupings or union may be an arrangement between countries that do belong to the same geographical region. There are five categories of RTAs, depending on the level of integration: Preferential Trade Agreement (PTAs), Free Trade Agreements (FTAs), Customs Union (CUs), Common Markets and Economic Unions. A PTA refers to a union in which member nations impose lower trade barriers on goods produced within the region, with some flexibility for each member country on the degree of reduction. A Free Trade Area (FTAs) refers to a unique case of PTA where member countries totally eradicate trade barriers (both tariff barriers and non-tariff barriers) for the products that originate from member countries. A Customs Union (CU) offers a deeper integration than FTA because member countries also apply a common external tariff (CET) on good exported from outside the region together with being free to maintain their individual level of tariff barriers for goods imported from non-member countries. Common Market refers to where member countries try to synchronize some institution arrangements and commercial and financial laws and regulations with one another. There are also free movements of factors of production in a Common Market. Economic Union is where countries apply similar economic policies and regulations and embrace a single currency [9, 10].

Regional trade agreement RTA is one of the most remarkable events in the world trade since the middle of 1990s. By the end of 2011, the number of RTAs reported to the World Trade Organization (WTO) was over 511 from mere 50 prior to 1990[1]. Regional trade agreement signifies a notable exception to the WTO's principle of fairness. In line with the rules of WTO, nations within a RTA can trade with one another using preferential tariff and easier market access condition that is different from what applies to other WTO member nations. Furthermore, trading inside the regional trade blocs is outside the coverage of WTO [9].

Reasons for Regional Trade Agreements: The economic and political reasons which make nations to adopt regionalism can be divided into four broad categories. These are: The welfare impact of RTAs, Dissatisfaction with the current multilateral trade regime, bandwagon effect of regionalism and other factors.

- The Welfare Impact of RTAs: Trade Creation and Trade Division.

The traditional theory of trade proposes that removal of trade barriers give consumer and producers opportunity to buy from the cheapest most competitive source of supply. This boosts efficiency and promotes welfare. Because of this, it was traditionally believed that regional trade blocks would engender gains from trade due to member countries' decrease in trade barriers with one another. However, this view was first challenged by Viner [11]. Viner introduced the concepts of 'trade creation' and 'trade diversion' and showed that the effects of trade liberalization may not necessarily be positive. He points out that RTA can lead to trade creation if regional agreement makes members to change from inefficient domestic producers and import more from efficient producers from other countries of RTA. This leads to production efficiency and consumption efficiency gains for the countries concerned. On the other hand, it will be trade diversion if RTA results in members changing import from low-cost production in other parts of the world and import more from higher-cost producer member countries. As such, trade diversion reduces welfare of both partner countries and the rest of the world [9].

- Dissatisfaction with the Current Multilateral trade Regime.

The emerging consensus among the economists for the proliferation of RTAs in the 1990s is the frustration with the multilateral trading system. Krugman [12] opines that 'countries find regionalism an easier alternative because a large number of participants in multilateral trade negotiations reduces the cost of non-cooperation and

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[1]http://www.wto.org/english/tratop_e/region_e.htm

creates rigidity in the system; and modern trade barriers are much more complicated to negotiate in a multilateral forum. Most countries find it easier to deal with this issue in a bilateral or regional level'. Furthermore, developing countries are not satisfied with development in WTO for most of the assurances of Uruguay Round agreement to enlarge global trade have not materialized in practice. The promised expansion in agriculture, textiles and services has not been met. In addition, initial protectionism and unwillingness on the part of developed countries to grant market access on a multilateral basis has encouraged many developing countries to seek solace in regional groupings. Thus, it is not surprising that there is a surge in the formation of regional trade agreements after the failure of Seattle Ministerial meeting of WTO [9].

- Bandwagon Effect on Regionalism.

A number of economists, Bhagwati [13], Panagariya [14] and Bergsten [15], are of the opinion that changing of USA from a supporter of multilateralism to follow regionalism is another factor behind the surge of regionalism since the 1990s. Bhagawati [13] notes that, 'the main driving force for regionalism today is the conversion of the United States, hitherto an abstaining party to Article XXIV.'.

To buttress this theory it has been shown that many big developed countries like the USA and the European Union are actively involved in Free Trade Agreements with developing nations in a bilateral or at the regional level. This has encouraged many developing nations to seek involvement in Free Trade Agreements with the developed countries in other to protect themselves against any possible exclusion from these markets.

- Other Factors

Some other vital economic factors which are encouraging regionalism today are foreign direct investment (FDI) and the gains associated with economies of scale. Trade Report (2003) list preferential access to large regional markets as one of the key determinants of inflow of FDI to developing countries. FDI is now the most important source of foreign capital access to developing countries. The World Trade Report (WTR, 2003) proposes that countries involve in RTAs to draw FDI. Ghosh [16] adds another angle to this debate when he argues that there is a difference in motivation between the RTAs initiated and pushed through by the major developed country governments and efforts within developing countries to forge trading blocs. In her opinion, developed countries, most especially USA and EU are pushing regional trade agreements to force developing countries to make deeper trade and investment commitments than is ordinarily possible in the multilateral arrangement of the WTO. Whereas, the motivating factor behind the developing countries coming together to form regional grouping among one another is to prevent the domination of large powers in world trade. Political factors are another why countries join RTAs. Trade connections among economies can reduce conflict and improve cross-border cooperation. For this reason, RTAs are employed as a strategic move to strengthen peace and increase regional security among member countries. RTAs are often used by developed countries to forge geopolitical alliances and build up diplomatic ties [9].

Regional Economic Groupings and Trade Arrangements among Oic Countries: Organization of Islamic Cooperation Countries members belong to different economic groupings and trade arrangements in the world. The regional economic grouping among OIC countries can be categorized into two: integration schemes comprising only OIC countries and other groupings composed of other developing countries and the OIC members as well. Under the first group, there are four regional groupings: the Arab Maghreb Union (AMU), the Council of Arab Economic Unity (CAEU), the Gulf Co-operation Council (GCC) and the Economic Co-operation Organization (ECO).

The second group comprises integration schemes of other developing countries and the OIC members which include nine in Africa, four in Asia and one in Europe. Those in Africa are the African Economic Community (AEC), the Central African Customs and Economic Union (UDEAC), the Common Market for Eastern and Southern Africa (COMESA), the Cross-Border Initiative (CBI), the Economic Community of West Africa (ECOWAS), the Indian Ocean Commission (IOC), the Mano River Union (MRU) and the West African Economic and Monetary Union (WAEMU). The groups in Asia include the Association of East Asia Nations (ASEAN), the Black Sea Economic Cooperation (BSEC), the East Asian Economic Caucus (EAEC) and the South Asian Association for Regional Cooperation (SAARC). The one in Europe is the Commonwealth of Independent States (CIS) (Hassan [10, 17]).

Table 1: Major Regional Integration Schemes Comprising Only OIC Countries

Name of the organization	Number of members	Form of regional integration
Arab Maghreb Union (AMU)	5	Stage 1: Customs union Stage 2: Common market
Council of Arab Economic Unity (CAEU)	12	Stage 1: Customs union Stage 2: Common market
Gulf Cooperation Council (GCC)	6	Stage 1: Customs union Stage 2: Common market
Economic Cooperation Organization	10	Preferential trade area

Culled from Guler, [10].

Table 2a: Intra-OIC exports in billion US$ (2000-2008)

OIC	2000	2001	2002	2003	2004	2005	2006	2007	2008
Intra-OIC exports	53.48	52.81	59.27	74.24	99.94	134.34	162.45	200.20	265.38

Table 2b: Intra-OIC imports in million US$ (2000-2008)

OIC	2000	2001	2002	2003	2004	2005	2006	2007	2008
Intra-OIC imports	56.73	60.50	60.19	76.58	105.13	137.11	170.91	220.40	285. 65

Source: ICDT, [8]

Major Regional Integration Schemes Comprising Only OIC Countries: Three of the four major integration schemes that comprise only OIC members are: the Arab Maghreb Union (AMU), the Council of Arab Economic Unity (CAEU) and the Gulf Cooperation Council (GCC). Their goal is the establishment of a customs union as a precursor to establish a common market among the member nation. The ECO, however, is a preferential trade arrangement within member countries for members to enjoy preferential treatment on selected goods from member countries (Table 1).

Trend of Intra and Inter International Trade in OIC Countries: The Intra OIC Trade increased progressively from 2000 and reached its highest point in 2008 before the triple crises slow it down (Table 2a & b). The main actors of the foreign trade of the OIC Member States in 2008 are: Malaysia with 288 billion US dollars, i.e.11.21 percent of the global trade of the OIC Member States, the United Arab Emirates (277.5 billion US dollars, i.e. 10.80 percent), Saudi Arabia (269.7 billion US dollars, i.e. 10.50 percent), Turkey (243.16 billion US dollars, i.e. 9.46 percent), Indonesia (213.3 billion US dollars, i.e. 8.30 percent), Iran (196.6 billion US dollars, i.e. 7.65 percent), Nigeria (84 billion US dollars; 3.27 percent), Egypt (83.1 billion US dollars; 3.23 percent), Algeria (82.9 billion US dollars; 3.23 percent) and Kazakhstan 70.3 billion US dollars; 2,74 percent). These ten countries totaled 70.40 percent of the global trade of the OIC Member States in 2008.

Theoretical Framework: This theoretical framework makes use of Meera and Larbani [5] in their conceptual paper.

The Multi-Bilateral Case: Let

- $i = \{1,2,3,.....,n\}$ be the set of countries involved in the multi-bilateral trade,

- $k = \{1,2,3,.....,m\}$ be the set of products traded between these countries,

- $x_{ij}^k =$ the quantity of product k taken from country i to country j

$$i = 1,2,...,n \qquad j = 1,2,...,n \qquad k = 1,2,...,m$$

- $p_i^k =$ the quantity of product k available in country i (or the export potential of country i of product k)

- $b_i^k =$ the minimum quantity of product k needed by country I

- $t_i^k =$ the maximum quantity of product k needed by country I

- $c_k =$ the price in gold dinar per unit of the product k

It is to be noted that if a country i wants a precise quantity of a product k, say a then in the model we take $b_i^k = a-\varepsilon$ and $t_i^k = a+\varepsilon$, were ε is a small positive number, which indicates the desired precision.

Conditions of the Model:

$$\sum_{i=1}^{n} t_i^k \leq \sum_{i=1}^{n} p_i^k \qquad k = 1,2,....,m \qquad (8)$$

Condition (8) means that the maximum quantity of a product demanded by the countries in the multi-bilateral trade arrangement must not be higher than the quantity of that product produces within the system. If this condition is not satisfied, then:

- The countries importing the product k have to decrease t_i^k (the maximum needed quantity) and may be also b_i^k,
- The countries exporting the product k have to increase their export potential p_i^k,
- Both (a) and (b)

The constraints of the Model: According to (3), (5) and (6), we have

$$b_j^k \leq \sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq t_j^k \qquad j = 1,2,...,n \qquad k = 1,2,...,m \quad (9)$$

This inequality means that the quantity of product k imported by country j from all other countries has to be between the minimum (b_j^k) and maximum quantity of product k (t_j^k) needed by country j.
According to (3) and (4) we have

$$\sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq p_i^k \qquad i = 1,2,...,n \qquad k = 1,2,...,m \qquad (10)$$

The inequality (10) means that the quantity of product k exported from a country i should not exceed its export potential of product k.

We have also the natural constraints $x_{ij}^k \geq 0$.

This means that cannot export negative quantity of product k.

The Objective Function of the Model: The amount of Gold Dinar due to country i by country j is

$$\sum_{k=1}^{m} c_k x_{ij}^k \qquad (11)$$

The net payment between countries i and j is the module of the difference between the amounts due by each country to the other:

$$\left| \sum_{k=1}^{m} c_k x_{ij}^k - \sum_{k=1}^{m} c_k x_{ji}^k \right| = N_{ij} \qquad (12)$$

N_{ij} refers to the net settlement among the participating countries.

- If $\sum_{k=1}^{m} c_k x_{ij}^k > \sum_{k=1}^{m} c_k x_{ji}^k$ then country j has to pay the amount of N_{ij} in gold dinar to country I.

- If $\sum_{k=1}^{m} c_k x_{ij}^k < \sum_{k=1}^{m} c_k x_{ji}^k$ then country i has to pay the amount of N_{ij} in gold dinar to country j.

- If $\sum_{k=1}^{m} c_k x_{ij}^k = \sum_{k=1}^{m} c_k x_{ji}^k$ then no country has to pay.

Thus by taking into account (8), we obtain the following optimizing problem for a multi-bilateral payments set-up.

$$\min \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left| \left(\sum_{k=1}^{m} c_k x_{ij}^k - \sum_{k=1}^{m} c_k x_{ji}^k \right) \right| \qquad (13)$$

This is the minimum sum of all the net settlements among the participating countries.

Subject to constraints:

$$b_j^k \leq \sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq t_j^k \quad j = 1,2,...,n \qquad k = 1,2,...,m \qquad (14)$$

$$\sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq p_i^k \qquad i = 1,2,...,n \qquad k = 1,2,...,m \qquad (15)$$

$$x_{ij}^k \geq 0 \quad i = 1,2,\dots,n \quad j = 1,2,\dots,n \quad j \neq i \quad k = 1,2,\dots,m \tag{16}$$

The problem (13) to (16) is a non linear programming problem. By solving it we get

- The minimum quantity of Gold Dinar needed for the multi-bilateral trade to take place is

$$\sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left| \left(\sum_{k=1}^{m} c_k x_{ij}^k - \sum_{k=1}^{m} c_k x_{ji}^k \right) \right|$$

- The quantity x_{ij}^k, that any country i has to export to any country j, of product k.

- $N_{ij} = \left| \sum_{k=1}^{m} c_k x_{ij}^k - \sum_{k=1}^{m} c_k x_{ji}^k \right|$, the net payment between any couple of countries i,j.

- The minimum amount of Gold Dinar holdings needed by each country i to participate for the considered trading period.

The Multilateral Case: The conditions and constraints of the model are the same; there are changes only in the objective function. We obtain the following model

$$\text{Min } \tfrac{1}{2} \sum_{i=1}^{n} \left| \sum_{k=1}^{m} \sum_{j \neq i}^{n} \left(c^k x_{ij}^k - c^k x_{ji}^k \right) \right| \tag{17}$$

Subject to constraints (14)-(16).

Remark: The term $\left| \sum_{k=1}^{m} \sum_{j \neq i}^{n} \left(c^k x_{ij}^k - c^k x_{ji}^k \right) \right|$ represents the net payment between country i and the remaining countries. The coefficient ½ is introduced in the objective function (17) because the amount of gold dinars paid (by countries which have to pay) is the same as the amount of gold dinars received (by countries which receive) in the multilateral arrangement.

Methodology

Data and Analysis: The intra-trade commodity data of 2008 for selected OIC countries was used for this study. Five OIC countries and five major primary commodities of these countries were used in our analysis to form a five-by-five matrix. The five countries were selected to reflect their contributions to the OIC economy and their regional distributions. The selected countries are: Turkey, Saudi Arabia, Malaysia, Indonesia and Nigeria. Incidentally, only Turkey, out of these countries, meets the 25 percent intra OIC trade integration benchmark of the organization [8]. Thus finding the trade efficient matrix of these nations' intra OIC trade will be a big boost for trade among the OIC countries. The five commodities were selected from the World Bank list of primary commodity based on their production potentials and their importance to these countries. The products include: crude oil, palm oil, rice, wheat and meat. These products are choosing based on their importance to OIC countries, either in terms of production and consumption.

The United Nations Commodity Trade (UNCOMTRADE) data served as the main source of data used in this study. This is the database that reports disaggregated data to six digits, which suits our analysis. Annual intra trade commodity data for the year 2008 of the five selected OIC countries based on the United Nation COMTRADE SITC Revision 3 classification was used. This is because, of all the four classification under UNCOMTRADE, this classification is the one recommended for economic analysis by the provider, recommended by World Trade Organization, World Bank and also the one in use by ICDT to compute OIC trade data. Year 2008 data was chosen for our analysis because that was the year that OIC trade reached its peak before it started to decline. Intra OIC trade, import and export, of the selected products among the chosen countries for the year 2008 were used throughout this analysis.

Efficient trade matrix based on import and export needs and potentials of these countries was computed using non-linear programming as discussed under the theoretical frame work, using MATLAB 7.5b. The 2008 price for product k was taken from the World Bank primary commodity prices and converted to the gold equivalent in ounce for 2008.

The commodities' data was obtained from UNICOMTRADE, the price per unit of each of the commodity and the price of gold per ounce in dollar were obtained from the World Bank. The data of the problem are given in 1000 tons. We assume prices are fixed for the trading period. The first column presents the serial number of the selected products; column 2, the products; column three shows their code according to UNICOMTRADE; column 4 the dollar prices and the last column show their corresponding gold prices.

Table 3: Selected commodity

Product No.	Commodity Name	Commodity Code	Price $	Price gold (toz)
1	Palm oil, crude	42221	901/mt	0.73551
2	Crude petroleum	3330	79040/1000bbl	64.52245
3	Rice,	042	555/mt	0.453061
4	Wheat	041	300.5/mt	0.245306
5	Meat, live animal	0011	4276/mt	3.490612

$= US dollar, bbl = barrel, mt = metric ton, kg = kilogram, toz = troy oz of gold. Gold 1,225$/toz,

Table 4: Potential Export

	Products (1000 ton)				
Countries Potentials (p)	Palm oil, crude (mt)	Crude petroleum(bbl)	Rice (mt)	Wheat (mt)	Meat (kg)
Turkey (1)	0.018810	-	8.034246	8.004850	-
Malaysia (2)	2402.029562	16920.003884	0.908224	1.724380	0.000987
Indonesia (3)	7904.178630	18235.030429	0.876502	39.499986	0.091995
Saudi Arabia (4)	-	365059.863000	-	-	-
Nigeria (5)	0.763465	110557.000000	-	1.472150	-

bbl = barrel, mt = metric ton, kg = kilogram

Table 5: Import (maximum quantity needed)

	Products (1000 ton)				
Countries Import max. (t)	Palm oil, crude (mt)	Crude petroleum(bbl)	Rice (mt)	Wheat (mt)	Meat (kg)
Turkey (1)	-	21833.471071	239.998220	3708.003201	0.005393
Malaysia (2)	612.346142	9228.518191	1096.927408	1000.434303	0.099571
Indonesia (3)		12749.025317	289.689411	4497.193017	0.495578
Saudi Arabia (4)	97.694000	-	1242.793000	151.006000	0.035680
Nigeria (5)	0.003500	0.031790	160.332752	2428.431043	0.001270

bbl = barrel, mt = metric ton, kg = kilogram.

Table 6: Current Trade Volume among member countries

Actual form x^k_{ij}	Form $x(1, 2, 1)$	Program form $x(1)$	Values of x
x^1_{31}	$x(3, 1, 1)$	$x(1)$	3.02
x^1_{23}	$x(2, 3, 1)$	$x(2)$	12.035910
x^2_{23}	$x(2, 3, 2)$	$x(3)$	1288.767712
x^3_{23}	$x(2, 3, 3)$	$x(4)$	0.001650
x^1_{32}	$x(3, 2, 1)$	$x(5)$	574.530009
x^2_{32}	$x(3, 2, 2)$	$x(6)$	509.099
x^3_{32}	$x(3, 2, 3)$	$x(7)$	0.129439
x^4_{32}	$x(3, 2, 4)$	$x(8)$	29.446104
x^5_{32}	$x(3, 2, 5)$	$x(9)$	0.091995
x^1_{24}	$x(2, 4, 1)$	$x(10)$	13.503000
x^1_{34}	$x(3, 4, 1)$	$x(11)$	84.191
x^3_{34}	$x(3, 4, 3)$	$x(12)$	0.00685
x^1_{35}	$x(3, 5, 1)$	$x(13)$	25.599775
x^2_{35}	$x(5, 3, 2)$	$x(14)$	337.0107906

Source: Author's computation.

Palm oil, crude	=	735.51toz/1000mt
Crude petroleum	=	64522.45toz/1000000bbl
Rice	=	453.061toz/1000mt
Wheat	=	245.306toz/1000mt
Meat	=	3490.612toz/1000mt

Table 4 shows the potential export of the selected products by the selected countries in 1000 tons of the designated weight. Palm oil, rice meat and wheat are measured in kilogram while crude petroleum is measured in barrel. The last row shows that Nigeria exports 0.763465 thousand ton of palm oil crude; 110557 thousand cubic barrels of crude petroleum and 1.472150 thousand ton of wheat.

Table 5 presents volume of imports for selected products for selected countries. Column one presents the countries with their serial numbers. The first row of the table shows that Turkey imports

21833.471071 thousand cubic barrels of crude petroleum and 239.998220 thousand ton of rice, 3708.003201 thousand ton of wheat and 0.005393 thousand ton of meat respectively.

Table 6 shows the values of trade for the bilateral trade arrangement for different commodity. Given that there are five product and five countries, 100 combinations of product- country trade are possible. However, only 14 register any value. The implication of this is that a country cannot export a product if it has no potential export on this product and a country will not import a product if it doesn't need it. Explaining the form, $x(3, 1, 1)$ means Indonesia exported palm oil to turkey.

RESULTS AND DISCUSSION

Multi-Bilateral Payment Arrangement: From the above and as shown in the appendix, the optimization problem to solve is

$$\text{Min} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \left| \left(\sum_{k=1}^{m} c_k x_{ij}^k - \sum_{k=1}^{m} c_k x_{ji}^k \right) \right|$$

This becomes (refer to the appendix):
Min (L2+L5+L6+L8+L9), where:
L 2 = abs $- (c_1 x_{31}^1)$
L 5 = abs $(c_1 x_{23}^1 + c_2 x_{23}^2 + c_3 x_{23}^3) - (c_1 x_{32}^1 + c_2 x_{32}^2 + c_3 x_{32}^3 + c_4 x_{32}^4 + c_5 x_{32}^5)$
L 6 = abs $(c_1 x_{24}^1)$
L 8 = abs $(c_1 x_{34}^1 + c_3 x_{34}^3)$
L 9 = abs $(c_1 x_{35}^1) - (c_2 x_{53}^2)$

Subject to first and second constraints:

$$\sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq p_i^k$$

$x_{32}^1 + x_{31}^1 + x_{23}^1 + x_{24}^1 + x_{34}^1 + x_{35}^1 \leq 10306.99$
$x_{32}^2 + x_{23}^2 + x_{35}^2 \leq 510771.8973$
$x_{32}^3 + x_{23}^3 + x_{34}^3 \leq 9.818972$
$x_{32}^4 \leq 50.70137$
$x_{32}^5 \leq 0.092982$

This shows the total quantity of each product exported by the selected countries for the year 2008. The superscript 1, 2, 3, 4, 5 represent palm oil, crude petroleum, rice, wheat and meat respectively.

$$b_j^k \leq \sum_{\substack{i=1 \\ i \neq j}}^{n} x_{ij}^k \leq t_j^k$$

$3.02 \leq x_{31}^1 \leq t_1^1$
$574.530009 \leq x_{32}^1 \leq 612.346142$
$509.099 \leq x_{32}^2 \leq 9228.518191$
$0.129439 \leq x_{32}^3 \leq 1096.927408$
$29.446104 \leq x_{32}^4 \leq 1000.434303$
$0.091995 \leq x_{32}^5 \leq 0.099571$
$12.03591 \leq x_{23}^1 \leq t_3^1$
$1625.779 \leq x_{23}^2 + x_{53}^2 = 12749.025317$
$0.00165 \leq x_{23}^3 \leq 289.689411$
$97.694 \leq x_{24}^1 + x_{34}^1 \leq 97.694$
$0.00685 \leq x_{34}^3 \leq 1242.793$
$25.599775 \leq x_{35}^1 \leq t_5^1$

$x_{ij}^k \geq 0 \quad i = 1,2,3,4,5 \quad j = 1,2,3,4,5 \quad j \neq 1 \quad k = 1,2,3,4,5$

$x_{ij}^k =$ The quantity of product k taken from country i to country j: This refers to the quantity of product k taking from country i to j in 2008.

$p_i^k =$ The quantity of product k available in country i (or the export potential of country i of product k): This refers to the total quantity of product k export to the world by country i in 2008.

$b_i^k =$ The minimum quantity of product k needed by country i: This refers to the quantity of product k by country j already import from participating countries in 2008.

$t_i^k =$ The maximum quantity of product k needed by country i: This refers to total quantity of product k imported from the world by country i in 2008.

c_k The price in gold dinar per unit of the product k: This refers to per unit equivalent price of product k in ounce of gold.

c_1 = Price of 1000 tons of crude palm oil an ounce of Gold
c_2 = Price of 1000 tons of crude petroleum oil an ounce of Gold
c_3 = Price of 1000 tons of rice an ounce of Gold
c_4 = Price of 1000 tons of wheat an ounce of Gold
c_5 = Price of 1000 tons of meat an ounce of Gold

Table 7: Solution to the optimization problem for the Multi-Bilateral

Actual form x^k_{ij}	Form $x(i, j, k)$	Program form $x(i,j,k)$	Minimum import $b(i,k)$	Optimization result for multi-bilateral trade (x)	Differences x and b
x^1_{31}	$x(3, 1, 1)$	$x(1)$	3.02	3.02	0
x^1_{23}	$x(2, 3, 1)$	$x(2)$	12.035910	563.2338	551.1979
x^2_{23}	$x(2, 3, 2)$	$x(3)$	1288.767712	1336.648	47.88037
x^3_{23}	$x(2, 3, 3)$	$x(4)$	0.001650	9.682683	9.681033
x^1_{32}	$x(3, 2, 1)$	$x(5)$	574.530009	574.53	0
x^2_{32}	$x(3,2, 2)$	$x(6)$	509.099	973.455	464.356
x^3_{32}	$x(3, 2, 3)$	$x(7)$	0.129439	0.129439	0
x^4_{32}	$x(3, 2, 4)$	$x(8)$	29.446104	29.4461	0
x^5_{32}	$x(3, 2, 5)$	$x(9)$	0.091995	0.091995	0
x^1_{24}	$x(2, 4, 1)$	$x(10)$	13.503000	13.503	0
x^1_{34}	$x(3, 4, 1)$	$x(11)$	84.191	84.191	0
x^3_{34}	$x(3, 4, 3)$	$x(12)$	0.00685	0.00685	0
x^1_{35}	$x(3, 5, 1)$	$x(13)$	25.599775	269.6081	244.0083
x^2_{53}	$x(5, 3, 2)$	$x(14)$	337.0107906	435.278	98.26725

Source: Author's computation.

Table 8: Results of the Multi-Bilateral Payments Arrangement in toz of gold

Country	Turkey	Malaysia	Indonesia	Saudi Arabia	Nigeria
Turkey	-	-	2221.2	-	-
Malaysia	-	-	63,240,000	-	-
Indonesia	-	86,662,000	-	-	28,085,000
Saudi Arabia	-	9,931.6	61,926	-	-
Nigeria	-	-	198,300	-	-

Source: Author's computation.

Results of the Computed Multi-Bilateral Payments Arrangement (BPAs) (in 1000 of tons): The solution to the optimization problem gives the following values as shown in Table 4.1.

Putting these in a matrix, Table 7 gives us the minimum gold needed as 51,384,000 ounce of gold for a total trade of 178,260,000 ounce of gold. This is in a multi-bilateral setup. Turkey pays Indonesia 2221.2 toz, Indonesia pays Malaysia 86,662,000 toz, Malaysia pays Indonesia 63,240,000 toz, Saudi Arabia pays Malaysia 9,931.6 toz, Saudi Arabia pays Indonesia 61,926 toz, Nigeria pays Indonesia 198,300 toz and Indonesia pays Nigeria 28,085,000 toz.

Table 8 presents the computed ounce of gold payment due from one country to another in the multi-bilateral arrangement. The payment is due from row to column. Row three shows that Indonesia will pay Malaysia and Nigeria the sum of 86,662,000 and 28,085,000 ounce of gold respectively. The net settlement due from country to country is presented below.

Bilateral Payment Arrangement

Indonesia pays Malaysia	23,422,000
Turkey pays Indonesia	2221.2
Saudi Arabia pays Malaysia	9,931.6
Saudi Arabia pays Indonesia	61,926
Indonesia pays Nigeria	27,886,700
Minimum Gold Dinar Needed	51,384,000

Multilateral Payments Arrangement (MPAs): In the case of a multilateral payments arrangement, the optimization problem to solve is

$$\text{Min } \tfrac{1}{2} \sum_{i=1}^{n} \left| \sum_{k=1}^{m} \sum_{\substack{j \neq i}}^{n} \left(c^k x^k_{ij} - c^k x^k_{ji} \right) \right|$$

For our problem after removing zero, this translates to:

$G1 = \text{abs} - (c_1\, x^1_{31})$

$G2 = \text{abs } (c_1\, x^1_{23} + c_1 x^1_{24} + c_2\, x^2_{23} + c_3\, x^3_{23}) - (c_1\, x^1_{32} + c_2\, x^2_{32} + c_3\, x^3_{32} + c_4\, x^4_{32} + c_5\, x^5_{32})$

$G3 = \text{abs } (c_1 x^1_{31} + c_1\, x^1_{32} + c_1\, x^1_{34} + c_1\, x^1_{35} + c_2\, x^2_{32} + c_3\, x^3_{32} + c_3\, x^3_{34} + c_4\, x^4_{32} + c_5\, x^5_{32}) - (c_1\, x^1_{23} + c_2\, x^2_{23} + c_2\, x^2_{53} + c_3\, x^3_{23})$

$G4 = \text{abs} - (c_1\, x^1_{24} + c_1\, x^1_{34} + c_3\, x^3_{34})$

$G5 = \text{abs } (c_2\, x^2_{53}) - (c_1\, x^1_{53})$

$g = 0.5(G1 + G2 + G3 + G4 + G5)$

As noted in the theoretical framework, the constraints remain the same as in the case of multi-bilateral arrangement:

$$b^k_j \leq \sum_{\substack{i=1 \\ i \neq j}}^{n} x^k_{ij} \leq t^k_j$$

$x^1_{32}+x^1_{31}+x^1_{23}+x^1_{24}+x^1_{34}+x^1_{35}\le 10306.99$

$x^2_{32}+x^2_{23}+x^2_{53}\le 510771.8973$

$x^3_{32}+x^3_{23}+x^3_{34}\le 9.818972$

$x^4_{32}\le 50.70137$

$x^5_{32}\le 0.092982$

$3.02\le x^1_{31}\le t^1_1 \quad 30009\le x^1_{32}\le 612.346142$

$509.099\le x^2_{32}\le 9228.518191$

$0.129439\le x^3_{32}\le 1096.927408$

$29.446104\le x^4_{32}\le 1000.434303$

$0.091995\le x^5_{32}\le 0.099571$

$12.03591\le x^1_{23}\le t^1_3$

$1625.779\le x^2_{23}+x^2_{53}\le 12749.025317$

$0.00165\le x^3_{23}\le 289.689411$

$97.694\le x^1_{24}+x^1_{34}\le 97.694$

$0.00685\le x^3_{34}\le 1242.793$

$25.599775\le x^1_{35}\le t^1_5$

$x^k_{ij}, \quad i=1,2,3,4,\ 5 \quad j=1,2,3,4,5 \quad j\neq1 \quad k=1,2,3,4,5$

Results for Multilateral Payments Arrangement (MPA) (in 1000 of tons): The minimum of the objective function is 148,160 toz. Therefore, the minimum amount of troy oz of gold needed is 148,160 toz for a total trade of 178,259,378.8 toz. Putting these results in a matrix gives

us the multilateral setup. Turkey will pay Indonesia 2221.2 toz; Malaysia will pay Indonesia 63,240,000 toz; Indonesia will pay Malaysia 86,662,000 toz and Nigeria 28,085,000 toz; Saudi Arabia will pay Malaysia 9,931.6 toz; and Indonesia 61,926 and Nigeria is to pay Indonesia 198,300 toz respectively. In line with Meera and Larbani (2004), the quantity of gold needed to settle trade balances reduces as we move from gross settlement, to multi-bilateral to multilateral trade arrangements, confirming that cooperation pays. The solution to the optimization problem also provides each country with a target gold holding (for the trading period), within the efficient multilateral trading arrangement (Table 10). The payment is due from row to column.

Table 11 presents the import and export payment, in ounce of gold, due from each country. Comparing the results reveal that the multilateral trade arrangement requires least amount of gold quantity. To perform the same volume of trade using gross settlement requires 178,259,378.8 toz; it reduces to 51,384,000 toz for multi-bilateral trade arrangement while for multilateral trade arrangement, it is only 148,160 toz, a significant difference of 178,111,218.8 toz and 51,235,840 for gross and multi-bilateral settlement respectively.

Table 9: solution to the optimization problem for the Multilateral

Actual form x^k_{ij}	Optimization result for multilateral trade
x^1_{31}	3.02
x^1_{23}	563.2338
x^2_{23}	1336.648
x^3_{23}	9.682683
x^1_{32}	574.53
x^2_{32}	973.455
x^3_{32}	0.129439
x^4_{32}	29.4461
x^5_{32}	0.091995
x^1_{24}	13.503
x^1_{34}	84.191
x^3_{34}	0.00685
x^1_{35}	269.6081
x^2_{53}	435.278

Source: Author's computation.

Table 10: Results for Multilateral Payments Arrangement for Trade in Trade in Gold

Country	Turkey	Malaysia	Indonesia	Saudi Arabia	Nigeria	Total
Turkey	-	-	2221.2	-	-	2221.2
Malaysia	-	-	63,240,000	-	-	63,240,000
Indonesia	-	86,662,000	-	-	28,085,000	114,747,000
Saudi Arabia	-	9,931.6	61,926	-	-	71,857.6
Nigeria	-	-	198,300	-	-	198,300
Total	-	86,671,931.6	63,502,447.2		28,085,000	178,259,378.8

Source: Author's computation.

Table 11: Multilateral Payment Arrangement

	Export	Import	Net
Turkey	-	2221.2	-2221.2
Malaysia	86,671,931.6	63,240,000	23,431,931.6
Indonesia	63,502,447.2	114,747,000	-51,244,552.8
Saudi Arabia	-	71,857.6	-71,857.6
Nigeria	28,085,000	198,300	27,886,700
Minimum Gold 148,160 toz			

Source: Author's computation.

For easy settlement in a larger trade matrix that involves more countries, Meera and Larbani [5] suggest intermediation by reputable banks that acts as the clearing house. They suggest that the role of the clearing house be performed by a custodian bank, such as, the Islamic Development Bank (IDB) or the Bank of England that would keep the gold holdings of the central banks of the participating countries. Their role would be to net-off the trade among countries and keep the record of their balances.

CONCLUSION

This research work studied efficient trade matrix and gold reserve requirement for multi-bilateral and multilateral trade among the Organization of Islamic Cooperation countries using non-linear optimization as employed by Meera and Larbani, [5]. Five countries with five primary products were used in the study. The data for the study was obtained from UNICOMTRADE, World Bank and other relevant sources. Intra trade data of the selected products among these countries for the year 2008 was used for our analysis. The study was designed to achieve three objectives. The three objectives were achieved through solving non-linear optimization problems. The efficient trade matrix was achieved in form of the solutions to our optimization problem. The second objective was achieved from the solution to the objective function which gives the least amount of gold in ounce required for trade in the intra trade among OIC. The last objective was achieved through the net-off which shows the quantity of gold need for each participating country to take part in the arrangement.

This study has contributed to knowledge in four different ways. The first contribution is the use of real economic data to calculate the efficient trade matrix among the countries. The second contribution is the use of gold as a unit of measurement for intra trade among OIC. The third contribution of this work is the extension of the original three-by-three matrix used by Meera and Larabani in their seminar work to five-by-five matrix in the present study. The last contribution of this study is the operationalization and the validation of the result obtained by Meera and Larbani [5] with the real world economic data.

This study has encountered a number of limitations, the major one being the availability and reliability of available data at the disaggregated level required for the study. There is also a problem of the size of data that could be handled manually. It is, therefore, suggested that further studies be conducted on how to source for reliable data and development of customized software/program that can source and handle large data size directly from the source.

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