Trade, Factor Mobility and the Extent of Economic Integration: Evidence from the Middle East

Irena Mikolajun* Jean-Marie Viaene†

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Abstract

The Middle East was once seen as a medieval great globalized force. However, a geopolitical fragmentation of the region contributed to the sunset of the Golden Age and eroded its contribution to science and trade. Nowadays it shows one of the lowest intra-regional trade in the world and therefore it is claimed that the region is poorly integrated. Yet, with the steady flow of workers across the national borders of the Middle East is this conjecture correct? To answer this question, the paper develops an integration benchmark which consists of the steady state production equilibrium characterized by free trade and perfect factor mobility. Metrics are then used to measure the distance between the benchmark and the data. We show that economic integration in the Middle East is high, higher than expected based on intra-regional trade statistics.

JEL Classification: E13, F15, F21, F4, O11, O53, O54
Keywords: economic integration, Euclidean distance, factor shares, international migration

1 Introduction

The literature has demonstrated the benefits of international trade for the growth experience of open economies (Harrison and Rodríguez-Clare, 2009). Particularly, integration among economies plays an important role in that it increases the long-run rate of growth. For example, the essential idea of Rivera-Batiz and Romer (1991) is that integration stimulates the worldwide exploitation of increasing returns to scale in research and development.

* **Corresponding Author:** Tinbergen Institute Rotterdam, H8-20, Burg. Oudlaan 50, 3062 PA Rotterdam, The Netherlands; Tel.: +31-10-4081321; E-mail: mikolajun@ese.eur.nl.

† Department of Economics, H9-37, Erasmus School of Economics, Erasmus University, P.O. Box 1738, 3000 DR Rotterdam, The Netherlands; Tel.: +31-10-4081397; Fax: +31-10-4089161; E-mail: viaene@ese.eur.nl.

Factor mobility is also a powerful instrument in the allocation of resources and some regions of the world have fewer barriers to labour mobility than to goods trade. But it should not matter as Mundell (1957) shows in his formal analysis of the interaction between the international flow of goods and factors. In the extreme form, his result implies that if factors are internationally mobile the trade in goods will cease. More generally, the result states that goods and factor flows are substitutes as they lead to the same consumption point for host country citizens. The important assumptions are those that ensure factor price equalization, including incomplete specialization. However, Hanson (2009) addresses this conjecture and also shows cases of complementarity instead. Hence, the way international factors directly influence the allocation of resources is an empirical question. Taken together these strands of the literature point to the need to construct a comprehensive measure of economic integration among a specific group of countries that goes beyond trade statistics and includes both goods and factor flows. This paper develops such a measure and proposes ways to apply it to different regions of the world.

Let us consider the Middle East, for example. The region comprises a wide and heterogeneous group of countries. Significant variations in per capita incomes, different current account positions influenced largely by the possession of natural resources, highly unequal endowments of production factors contribute to this heterogeneity. On the other hand, common religion and common language in most economies introduce a solid common ground. The region was once seen as a series of urban islands linked by trade routes. In their discussion of the Golden Age of Islam (8th - 13th centuries), Findlay and O'Rourke (2007) mention that the exchange in goods, techniques, ideas as well as movement of people was flourishing. Arab trade routes stretched from West Africa to China and India and long distance travel of final goods and raw materials took place. However, a geopolitical fragmentation of the Middle East contributed to the sunset of the Golden Age of Islam and eroded its contribution to science and trade. It is claimed that the region has never achieved the same nor even close degree of economic integration. Nowadays, it shows by far the lowest intra-regional trade levels in the world and a low involvement in the world trading system. For these reasons, the region is claimed to be a large underachiever in trade and poorly integrated (World Bank, 2004). However, the steady flow of people across national borders have significantly contributed to migrants' remittances and to output growth thanks to their size and stability (Bugamelli and Paterno, 2011). Since the effects of increased factor mobility are not universal, the following questions are often raised: (*i*) With barriers to trade but labor mobile across countries how valid is the conjecture that the Middle East is poorly integrated? (*ii*) How are integration measures evolving over time and how do they compare to other parts of the world? The objective of this paper is to address these issues both formally and empirically.

Research institutes like the KOF Swiss Economic Institute compile indicators of globalization for countries and the world. Recognizing that the process of globilization is a complex matter, the KOF index gives weight to economic, social and political variables (see their website). Though useful these indicators assess the extent by which economies are part of the globalized world at a particular moment in time. However, they do not indicate how far these economies are in their integration process because the limits to integration are not specified. Given this, a challenge of this paper is to develop an integration benchmark which consists of a steady state equilibrium characterized by (1) free trade and (2) perfect mobility of both physical and human capital. Metrics are developed to measure the distance between this benchmark and the observed equilibrium that is characterized by barriers to international trade and to factor mobility. Measurements allow then for the comparison of integration over time and across regions.

There is a vast literature that has contributed to our understanding of the various dimensions of international labour migration. For example, recent topics include interest groups and immigration (Facchini *et al.*, 2012), policy interactions between host and source countries facing skilled-worker migration (Djajić *et al.*, 2012) and temporary low-skilled migration and welfare (Djajić, 2014). Closer to our work, Borjas (2001) tests the hypothesis of immigration being "the grease on the wheels" of the labour market. Likewise, in our model migration leads to greater labour market efficiency in that the geographic sorting of migrants ensures that the values of marginal products of labour are equalized across countries. Labour migration can also alter the market for physical capital and aggregate production. Galor and Stark (1990) show that the probability of return migration results in migrants saving more than comparable local residents. Kugler and Rapoport (2007), Javorcik *et al.* (2011) find that the presence of migrants in the US causes US foreign direct investment in the migrants' countries of origin. In contrast, calibrating a dynamic general equilibrium model to match Canadian data over 1861 - 1913 Wilson (2003) shows that labour force growth through immigration is responsible for up to three quarters of the rise in the foreign capital inflows. Similarly, the driving force behind international capital flows in our framework is the impact of international labour migration on the value of marginal products of physical capital.

Our analysis focuses on the distribution of output and the stocks of productive factors within a particular region. Particularly, the variables of interest are country output shares of regional output and country factor shares of regional factor supplies which have been shown to be important both theoretically and empirically (see for example, Helpman and Krugman, 1985; Bowen *et al.*, 1987; Viaene and Zilcha, 2002). In this paper, shares are assumed to behave randomly and their path to be described by a reflected geometric Brownian motion with a lower and upper bound. A random process modeled as Brownian motion is but one approach out of many, but it has the property of being parsimonious in terms of number of parameters. A lower bound is justified since nowadays countries are unlikely to disappear; an upper bound matters as the sum of shares must be one. Given this, starting from some initial conditions, we derive the steady state distribution of shares across member countries of a particular region.

Some features of our model have been analyzed before in other frameworks. Particularly, there has been a rapidly growing literature on the empirical measurement of economic integration. These studies have the common goal of measuring the distance between a fully integrated equilibrium and the observed state of economies operating under less than full integration. Using gravity models, Cheptea (2013) introduces a new method for measuring the trade potential from border effects and concludes that countries in Central and Eastern Europe have a much larger trade potential than previously estimated. Riezman *et al.* (2011) assess how far the world economy is between autarky and free trade and develop methodologies to answer the question using a global general equilibrium model. Riezman *et al.* (2013) discuss metrics of globalization for individual economies as distance measures between fully integrated and trade restricted equilibria. Bowen *et al.* (2010, 2011) test empirically the properties of the distribution of outputs and stocks of productive factors expected to arise between members of a fully integrated economic area.

An objective of our empirical section is to use and compare the various metrics available in this literature.[1] This section also includes other robustness checks to further assess the reliability of our integration results. Particularly, the Middle East is compared and contrasted with the 15 original countries of the European Union (EU-15)[2] as a benchmark of "complete" integration and with the Latin American Integration Association (ALADI) as a control group of countries at about the same stage of economic development. Empirical tests performed by Bowen *et al.* (2011) show that EU integration rose from the 1960s to equal that of U.S. states by 2000. A comparison to EU integration is preferred due to limitations on sourcing human capital data for the states of the U.S. A control group, ALADI, is the largest Latin American trading bloc established in 1980 that consists of 14 countries and includes most of the sovereign states of Latin America.[3] All ALADI countries are WTO members and participate on average to more than 8 regional trade agreements. Their income per capita is similar to the Middle East (on average if weighted by population) but the degree of integration as suggested by intra-regional trade measures is higher.

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[1] The evolution of integration over time can also be assessed by focussing on prices of homogeneous goods and homogeneous assets assuming that price differentials reflect market frictions and/or lack of arbitrage. For example, Volosovych (2011) looks at patterns of nominal and real long-term bonds; Uebele (2013) analyzes wheat prices in Europe and the USA.

[2] EU-15 includes all the members of the European Union as of January 1st, 1995. Namely, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden and United Kingdom.

[3] ALADI is a Spanish acronym for the Latin American Integration Association (Asociación Latinoamericana de Integración). It includes Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

Assuming fully integrated goods and factor markets and comparing dynamic equilibrium paths, we obtain the following results: (*i*) Using variable elasticity production functions, we obtain an equality between output and factor shares of a given economy. Particularly, each member's share of an area's total output will equal its share of the area's total stock of physical capital and of human capital; (*ii*) We derive the steady state distribution of shares when a lower and an upper bound are imposed on their evolution. This extends Gabaix's (1999) result for the expected distribution of city shares of a nation's population; (*iii*) Using the properties of this distribution, we derive theoretical shares of each country's output and factors in the grand total. This solution is uniquely determined as a function of the number of countries in the area and of the parameters of the reflected geometric Brownian motion; (*iv*) Using the metrics available in the literature, we show that economic integration in the Middle East is incomplete but its degree is higher than expected based on trade data.

The paper is organized as follows. In Section 2 we discuss trade and factor mobility patterns in the Middle East. Further in Section 3 we outline the model and establish main theoretical propositions. In Section 4 we present the data and discuss empirical methods used. This is followed by empirical estimates of the model. In Section 5 we compute integration measures and proceed with robustness checks in Section 6. We conclude in Section 7. The Appendix contains a detailed description of the data sources and methods.

2 Patterns of Trade and Factor Mobility

The Middle East is not a uniquely defined economic region. Although as a rule religion and geographical borders serve as a guideline for classification, definitions range from one study to another and are often adopted to meet study specific goals. There are no standards either available in the definitions used by different organizations. Table 1 provides a summary of countries classified as the Middle East and North Africa (MENA) for the three international organizations that are also the main data sources. Among the three columns we select the definition of the International Monetary Fund (IMF) as it gives a better data coverage for the purpose of our analysis. The definition includes most of the Arab World countries as the World Bank defines but augmented to the east by Iran. We exclude Djibouti due to the scarce availability of data. Our definition of the Middle East that we call MENA in shorthand notation comprises therefore 19 economies in the region and covers the geographic area that extends from Iran to the east and Morocco to the west.

The Middle East is characterized by a high labour mobility within its borders. The importance of international migration for the region is substantiated by the bilateral stocks and flows of migrants compiled by Özden *et al.* (2011) for the period 1960 - 2000. However,

Table 1: The definitions of the Middle East.

Country	IMF (Middle East and North Africa)	World Bank (Middle East and North Africa)	World Bank (Arab World)	WTO (Middle East)
Algeria	✓	✓	✓	
Bahrain	✓	✓	✓	✓
Comoros			✓	
Djibouti	✓	✓	✓	
Egypt	✓	✓	✓	
Iran	✓	✓		✓
Iraq	✓	✓	✓	✓
Israel		✓		✓
Jordan	✓	✓	✓	✓
Kuwait	✓	✓	✓	✓
Lebanon	✓	✓	✓	✓
Libya	✓	✓	✓	
Malta		✓		
Mauritania	✓		✓	
Morocco	✓	✓	✓	
Oman	✓	✓	✓	✓
Qatar	✓	✓	✓	✓
Saudi Arabia	✓	✓	✓	✓
Somalia			✓	
Sudan	✓		✓	
Syria	✓	✓	✓	✓
Tunisia	✓	✓	✓	
United Arab Emirates	✓	✓	✓	✓
West Bank and Gaza		✓	✓	
Yemen	✓	✓	✓	✓

Notes: (*i*) World Bank definition of the Arab World coincides with the list of member states of the League of Arab States, a regional organization consisting mainly of Arabic speaking countries; (*ii*) A number of subregions exist within the Middle East and North Africa: Arab Maghreb Union (Algeria, Libya, Mauritania, Morocco, Tunisia), Mashreq (Iraq, Israel, Jordan, Kuwait, Lebanon, Syria), Gulf Countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates). Several studies (Ekanayake and Ledgerwood, 2009; Al-Atrash and Yousef, 2000) documented significant difference with respect to intra-subregional trade.

the systematic publication of the migration matrix has been discontinued till 2010. In that year, Egypt is the top source country in the Middle East with 3.7 million nationals or 13.7% of its labour force living abroad. Percentagewise Qatar is the top host country in the region (and in the world) with the ratio of foreign to local labour force being 111.8%. The top migration corridor into the region includes India having 2.2 million persons being in the United Arab Emirates. The top migration corridor within the region is Egypt having 1 million nationals living in Saudi Arabia (World Bank, 2011).

Other indicators also describe the international dimensions of the Middle East: *(i)* the remittances from abroad; *(ii)* the ratio of the Gross National Income (GNI) to Gross Domestic Product (GDP) and *(iii)* intra-regional trade. Remittances cover current transfers by migrants who are employed in a host country for a year or more and are residents there.[4] Remittances paid from the countries of Gulf Cooperation Council make the Gulf region one of the most remitting regions in the world (Naufal, 2011). High per capita income MENA countries such as Oman and Kuwait are major payers of remittances in the region (see Figure 1). Remittances paid from Oman and Kuwait net of remittances received by those countries accounted for about 11% of each country's GDP in 2009. On the other hand, Jordan, Yemen, Morocco, Egypt and other lower income and labour abundant MENA economies have been repeated receivers of remittances throughout the last decade. Importantly, the outflow and the inflow of remittances in MENA has been very close in value till the Gulf war in 1990, suggesting that remittances in MENA were mostly intra-regional. As Naufal (2011) points out, however, after the Gulf war a systematic replacement of Arab workers by workers from Indian subcontinent, took place, which resulted in a large share of remittances flowing to Asian countries. Though the inflow of remittances to MENA economies diminished since then, yet it remains substantial and illustrates the mutual benefits of labour mobility in the region.

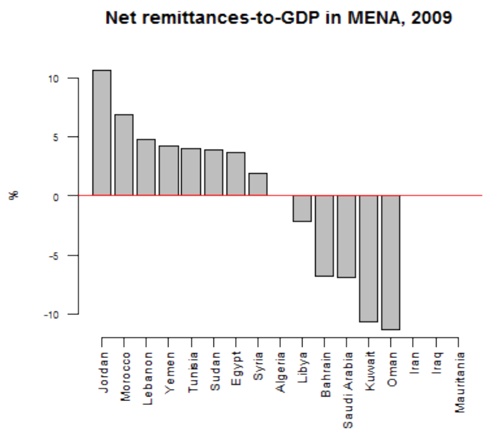
Another indicator of factor mobility is the ratio of nominal GNI to GDP. This ratio in 2009 fluctuates between 87.53 for Bahrain and 110.38 for Kuwait (see Table 2). As data suggest almost half of the countries in the Middle East are net receivers of factor income from abroad with a GNI to GDP ratio being above 100. Kuwait and Saudi Arabia are also countries receiving high flows of investment income from abroad (see Table 3). GNI exceeds GDP also for a number of labour abundant countries like Jordan and Lebanon. The difference here, however, stems not from investment income but from sizeable income of nationals employed abroad (see also Figure 1).

Not only factor mobility, but also trade patterns in the Middle East are distinct. Standard trade openness indicators remain considerably high even if fuel exports are excluded (see Table 4).[5] However, this is due to high imports in the Middle East that are largely

[4] See the IMF Balance of Payments Manual for a precise definition of the concept.

[5] 74.9% of total MENA exports in 2009 were fuel exports. 2009 fuel exports data was unavailable for Iran, Mauritania and United Arab Emirates. We used a 2010 figure for Iran and Mauritania and a 2008

Figure 1: Net workers' remittances to GDP in MENA.



Note: 2009 data for Iran, Iraq and Mauritania is missing in IMF BOPS. Data for Qatar and United Arab Emirates is unavailable for the entire time range considered .
Source: Own calculations based on IMF BOPS and World Bank.

Table 2: Ratio of GNI to GDP in MENA.

Country	GNI-to-GDP
Bahrain	87.53
Sudan	90.08
Iraq	93.93
Tunisia	94.36
Yemen	94.42
Oman	96.42
Syria	97.57
Morocco	97.94
Iran	99.27
Algeria	99.29
Libya	99.40
Egypt	100.09
Mauritania	100.56
United Arab Emirates	100.58
Jordan	102.43
Lebanon	102.54
Saudi Arabia	102.93
Qatar	105.36
Kuwait	110.38

Note: Year 2009. Ascending.
Source: Penn World Tables 7.0.

Table 3: Net Investment Income (% of GDP) in MENA.

Country	Net Investment Income
Kuwait	7.345
Iraq	2.759
Saudi Arabia	2.146
Libya	0.839
Jordan	0.369
Syria	-0.546
Algeria	-1.013
Lebanon	-1.052
Egypt	-1.104
Morocco	-1.645
Yemen	-2.950
Sudan	-4.818
Tunisia	-5.142
Oman	-6.336
Qatar$^{(2011)}$	-7.573
Bahrain	-10.462

Note: Year 2009. Descending.
Source: Own calculations based on IMF BOPS and World Bank.

Table 4: Merchandise trade in MENA.

Country	Imports (% GDP)	Exports (% GDP)	Openness	Non-fuel exports (% GDP)	Openness (excl. fuel exports)
	(1)	(2)	(1)+(2)	(3)	(1)+(3)
Algeria	27.95	32.15	60.10	0.74	28.69
Bahrain	36.42	57.65	94.07	18.01	54.43
Egypt	23.78	12.20	35.99	8.67	32.46
Iran$^{(2006)}$	18.29	34.55	52.85	5.95	24.24
Iraq	56.75	64.31	121.07	0.89	57.64
Jordan	56.74	25.41	82.14	25.26	82.00
Kuwait	18.58	47.45	66.03	3.22	21.81
Lebanon	47.46	11.99	59.45	11.93	59.39
Libya$^{(1998)}$	20.06	24.44	44.49	1.81	21.86
Mauritania$^{(2010)}$	50.11	55.90	106.01	55.90	106.01
Morocco	36.17	15.46	51.63	15.10	51.27
Oman	38.27	59.00	97.27	12.37	50.64
Qatar	25.35	41.70	67.05	11.34	36.69
Saudi Arabia	25.64	51.61	77.25	6.41	32.05
Sudan	17.74	14.92	32.66	1.18	18.92
Syria$^{(2008)}$	34.43	29.31	63.74	18.00	52.43
Tunisia	43.88	33.19	77.07	28.66	72.54
United Arab Emirates$^{(2008)}$	56.22	75.99	132.20	26.73	82.95
Yemen	34.84	23.74	58.58	1.85	36.69
MENA	32.61	42.72	75.33	11.00	43.61

Notes: (*i*) The data corresponds to year 2009 if not mentioned otherwise in the superscript of a country name; (*ii*) Fuel export comprises a third section of a Standard International Trade Classification (SITC 3). Thus, fuel export data include not only crude oil, but also coal, natural gas, non-crude oil and other mineral fuels as SITC 3 defines.
Source: Own calculations based on World Bank World Developments Indicators.

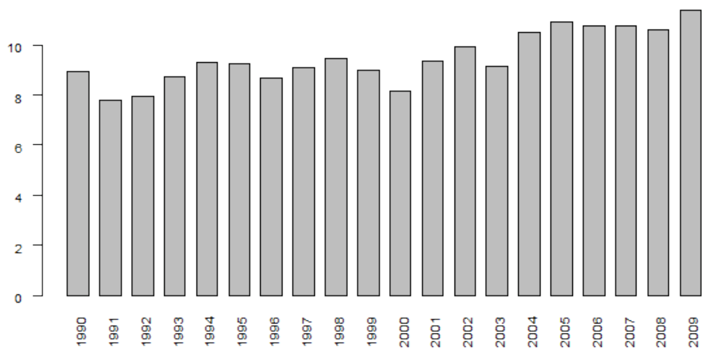
financed by high oil revenues. While total trade in MENA is considerable, intra-MENA trade accounted for only 12.4%[6] the rest being traded mainly with China, India, Japan, Korea and the United States. It is worth adding that this percentage includes oil exports. Figure 2 shows the intra-regional trade dynamics as a percent of total trade in MENA. Although a persistent upward trend is present throughout the period 1990-2009, intra-MENA trade is considerably lower than in the regions where trade barriers are low and a number of initiatives towards economic integration have been taken. For example, intra-regional trade in the European Union in 2009 was 64.9%, intra-regional trade in the IMF defined group of Emerging and Developing countries was 38.8%. For ALADI, this percentage in 2009 is 18.82%. Ethnic conflicts, protectionism, similar comparative advantages and better product quality outside the region are reasons frequently encountered in the literature (see, for example, Romagnoli and Mengoni, 2009).

figure for United Arab Emirates to estimate fuel exports of the entire region.

[6]Source: Own calculations based on IMF DOTS, 2009 data.

The Middle East is also the region with a low participation in WTO and regional trade agreements (RTAs). Only 12 MENA economies are WTO members while the remaining 8 are observers.[7] A limited number of multilateral RTAs exist within the region. Intra-regional trade is being promoted through the Gulf Cooperation Council (a customs union comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE), the Pan-Arab Free Trade Area (a free trade area including all the MENA countries except Iran and Mauritania) and trade partnerships with Europe (Euro-Mediterranean trade agreements). A significant subset of countries also takes part in the Global System of Trade Preferences among Developing Countries. Altogether, the average participation in trade agreements per country remains only 3.0 in contrast to the world average of 8.6.[8] No new negotiations between MENA countries have been currently announced to the WTO.

Figure 2: Intra-regional trade in MENA.



Note: Data in % of total trade.
Source: Own calculations based on merchandise imports and exports from MENA countries to the Arab World as available in the World Bank World Development Indicators.

3 The Economic Framework

Given this background the analysis of this section now focuses attention on what the distribution of output and stocks of productive factors should look like if an economic area were characterized by fully integrated goods and factor markets. Particularly, we show the importance of each member's share of an area's total output and its share of the area's total stock of physical capital and of human capital, concepts which have been shown to be important both theoretically and empirically. Also we show how these shares compare

[7] Observers are Algeria, Iran, Iraq, Lebanon, Libya, Syria, Sudan and Yemen.
[8] Source: Own calculations based on the WTO RTA data, list of all RTAs in force. Data downloaded in January 2014.

across countries and how they evolve over time. Ultimately, we derive the steady state distribution of shares across member countries of a particular region.

3.1 Equality of Output and Factor Shares

We consider an economic area consisting of N countries. Each member is assumed to produce a single homogenous good by means of a constant return to scale, but variable elasticity of substitution (VES) production function, proposed by Revankar (1971). The function, which is a generalized Cobb-Douglas production function, reads:

$$Y_{nt} = \gamma K_{nt}^{1-\delta\rho} \left(H_{nt} + (\rho - 1)K_{nt}\right)^{\delta\rho}, \tag{1}$$

where Y_{nt}, K_{nt}, H_{nt} denote output, physical capital and human capital respectively, $n = 1, ..., N$ is a country, $t = 1, ..., T$ is a time index. Here, parameter values must satisfy $\gamma > 0$, $0 < \delta < 1$, $0 < \delta\rho < 1$. The corresponding elasticity of substitution σ depends linearly on the physical-to-human capital ratio:

$$\sigma = 1 + \frac{\rho - 1}{1 - \delta\rho} \frac{K_{nt}}{H_{nt}}.$$

When $\rho = 1$ the VES function reduces to the Cobb-Douglas function with a unitary elasticity of substitution ($\sigma = 1$). We assume $\sigma > 0$ which implies that the human-to-physical capital ratio is such that $\frac{H_{nt}}{K_{nt}} > \frac{1-\rho}{1-\delta\rho}$. The function spelled out in (1) is different from the constant elasticity of substitution production function in that the elasticity of substitution implied by the VES production function varies along the isoquant. Under these assumptions regarding the technology and assuming free trade and perfect factor mobility within an economic area, an equality between shares arises.

Proposition 1 *Given the production function* (1)*, if no barriers to the free movement of goods, physical and human capital exist then*

$$\frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}} = \frac{K_{nt}}{\sum_{k=1}^{N} K_{kt}} = \frac{H_{nt}}{\sum_{k=1}^{N} H_{kt}}. \tag{2}$$

The shares of output, physical and human capital fully equalize for every country $n = 1, ..., N$*.Particularly, each member's share of an area's total output will equal its share of the area's total stock of physical capital and of human capital.*

Proof: Perfect mobility of labor brings about the equalization of marginal products of human capital across member countries as human capital from the low-return country flows to the high-return country until efficiency wages fully equalize. Marginal products of human capital implied by (1) can be expressed as a function f of human-to-physical capital and as a function g of output-to-physical capital. In particular, at any date t

$$\frac{\partial Y_n}{\partial H_n} = f\left(\frac{H_n}{K_n}\right) = g\left(\frac{Y_n}{K_n}\right),$$

where

$$f(x) = \gamma\delta\rho\,(x+\rho-1)^{\delta\rho-1}$$

and

$$g(x) = \gamma^{\frac{1}{\delta}}\delta\rho x^{1-\frac{1}{\delta\rho}}.$$

Functions f and g are strictly decreasing. In particular,

$$\frac{\partial f}{\partial x} = \gamma\delta\rho\,(\delta\rho-1)\,(x+\rho-1)^{\delta\rho-2} < 0$$

as the first two terms of the product have opposite signs while the last term is always positive. Namely, $\gamma\delta\rho > 0$ and $\delta\rho - 1 < 0$, which follows directly from the domain over which parameters γ, δ, ρ are defined, and

$$x+\rho-1 > \frac{1-\rho}{1-\delta\rho}\delta\rho > 0,$$

which follows from the fact that $x > 0$ and $x > \frac{1-\rho}{1-\delta\rho}$. Similarly,

$$\frac{\partial g}{\partial x} = \gamma^{\frac{1}{\delta\rho}}\delta\rho\left(1-\frac{1}{\delta\rho}\right)x^{\frac{1}{\delta\rho}} < 0,$$

which follows again from the definition of the domain of parameters γ, δ, ρ.

Given strict monotonicity of f and g, equality of marginal products implies equality of human-to-physical capital ratios and output-to-capital ratios between any two members of the economic area. Namely, for any pair of countries j and n we obtain the following equality:

$$\frac{H_n}{K_n} = \frac{H_j}{K_j} \text{ and } \frac{Y_n}{K_n} = \frac{Y_j}{K_j}, \tag{3}$$

which is sufficient to conclude that for any country n within a fully integrated economic area the human capital share coincides with that of physical capital and the physical capital share coincides with that of output. Specifically, employing (3) gives

$$\frac{H_n}{\sum_{k=1}^{N} H_k} = \frac{1}{\sum_{k=1}^{N}\frac{H_k}{H_n}} = \frac{1}{\sum_{k=1}^{N}\frac{K_k}{K_n}} = \frac{K_n}{\sum_{k=1}^{N} K_k}$$

and

$$\frac{K_n}{\sum_{k=1}^{N} K_k} = \frac{1}{\sum_{k=1}^{N}\frac{K_k}{K_n}} = \frac{1}{\sum_{k=1}^{N}\frac{Y_k}{Y_n}} = \frac{Y_n}{\sum_{k=1}^{N} Y_k},$$

from where the equal-share-relationship (2) follows.□

This proposition is the result of firms' profit maximization, the equalization of value marginal products across countries and the properties of equal ratios. It has also a number of implications. First, capital mobility is redundant to establish the result. With the final good being freely traded a single commodity price will prevail among member countries. With labor being the mobile factor of production, we expect it to flow from the low-wage to the high-wage economy until its marginal product is equalized across countries. With similar goods prices and equal wages, the returns to physical capital must equal among countries as long as production technologies are similar. Also, part of the equality of shares in (2) breaks down when the parameter space includes $\delta\rho = 0$. With $\rho = 0$ the VES function degenerates to the fixed-coefficient function as a special case: $Y_{nt} = \gamma K_{nt}$. This specification implies some redundancy of human capital in the nth economy as the employment of human capital is lower than its endowment H_{nt}. In this case, the human capital share in (2) no longer equals the other two.[9]

Proposition 1 has a number of policy implications as well. Consider for a moment the relative position of a country within a region by looking at foreign flows of productive factors, mainly human capital, as a contributor to the growth of a selected country. This aspect can be illustrated in our framework by considering immigration, an exogenous inflow $\Delta H > 0$ of human capital into the nth economic unit that originates from either outside or inside the region. An inflow of human capital from outside the integrated area (for example, from India) will, at impact, affect relationship (2) for the nth country as follows:

$$\frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}} = \frac{K_{nt}}{\sum_{k=1}^{N} K_{kt}} < \frac{H_{nt} + \Delta H}{\sum_{k=1}^{N} H_{kt} + \Delta H} \tag{4}$$

If migration instead originates from another partner country then:

$$\frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}} = \frac{K_{nt}}{\sum_{k=1}^{N} K_{kt}} < \frac{H_{nt} + \Delta H}{\sum_{k=1}^{N} H_{kt}}. \tag{5}$$

In either case, migration into country n increases its share of the total stock of human capital, with the share increase being smaller if migration originates from outside the area. Since the increase in the stock of human capital raises the marginal return to physical capital in country n, incentives arise to increase investment in physical capital. Given the increase in both stocks of productive factors, country n's output and share of total area output increase. These adjustments in output and factor stocks continue until the equality of shares in (2) is restored, but now with country n achieving a relatively higher level of economic activity than originally.

[9] In some other economies, human capital might be instead the constraining factor. It is a simple matter to obtain this outcome by interchanging the role of K_{nt} and H_{nt} in (2).

In contrast, consider the scenario where all N countries in the integrated area put in place an immigration quota system with respect to the outside world such that the human capital of each nation increases by a factor λ ($\lambda > 1$). Then:

$$\frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}} = \frac{K_{nt}}{\sum_{k=1}^{N} K_{kt}} = \frac{\lambda H_{nt}}{\sum_{k=1}^{N} \lambda H_{kt}} = \frac{H_{nt}}{\sum_{k=1}^{N} H_{kt}}. \tag{6}$$

In this situation shares are not modified and the relative position of each country in the total remains unchanged. Summarizing:

Corollary 1 *Policy coordination within an integrated area that is expressed in growth factors does not modify the distribution of shares of member countries.*

Hence, if one abstracts from random shocks then the volatility of shares would be zero according to the above corollary. This is a useful benchmark for our empirical analysis. Also, with both goods arbitrage and factor price equalization within an integrated area the aggregate effects of policy coordination affecting factor flows should not be different from those that have been explored in single economies where constituent regions are not considered explicitly. Finally, the independence of the distribution of shares with respect to specific policy coordination implies no direct link between the extent of economic integration and the level of economic development.

3.2 Steady State Equilibrium Distribution of Shares

Let us denote a share of a variable $j \in \{Y, K, H\}$ by S_{jnt}. Thus, to compute output shares S_{Ynt} we use:

$$S_{Ynt} = \frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}}$$

Factor shares S_{Knt} and S_{Hnt} are computed analogously. It is clear from (6) that complete policy harmonization among member states of an integrated area makes these shares deterministic. Any changes that do arise can be the realization of some particular states of nature. There are numerous reasons why shares could be random. Innovation and discoveries of natural resources are usually believed to follow a random process once investments in those activities have been made. Also, upheavals, military conflicts and natural disasters hit output, stock of human capital and stock of physical capital at random. To characterize such randomness we assume that both output and factor shares evolve according to a reflected geometric Brownian motion (RGBM) with a drift parameter μ, volatility σ, lower bound $b = \min S_{njt}$ and upper bound $d = \max S_{njt}$. That is, we assume:

$$\frac{dS_{jnt}}{S_{jnt}} = \mu dt + \sigma dB_t + dL_t - dU_t, \tag{7}$$

where B_t is a Wiener process, while L_t and U_t denote non-negative, non-decreasing, right-continuous processes, guaranteeing reflections every time S_{jnt} goes below the lower or above the upper bound (Harrison, 1985). We further impose a normalization constraint at every time point to ensure share summation to one:

$$\sum_{n=1}^{N} S_{jnt} = 1, \qquad t = 1, ..., T. \tag{8}$$

The evolution of shares spelled out in (7) recognizes a link between output and primary factors since the process from which shocks to the shares are derived is common to all. Though the process is similar, the realization of the states of nature might differ across shares. For example, strikes, technical breakdowns and political upheavals disrupt the production of goods with minor impacts on the stocks of production factors. Given this we show:

Proposition 2 *If shares evolve according to a reflected Brownian motion given by* (7) *and its drift and volatility parameters satisfy* $\mu < \frac{\sigma^2}{2}$*, there exists a steady state cumulative distribution of these shares that has the following form:*

$$F_{jn\infty}(S) = P(S_{jn\infty} \leq S) = 1 - \frac{S^{\frac{2\mu}{\sigma^2}-1}}{b^{\frac{2\mu}{\sigma^2}-1} - d^{\frac{2\mu}{\sigma^2}-1}}, \quad S \in [b, d]. \tag{9}$$

Particularly, it is a Pareto distribution with the tail index equalling $\left(1 - \frac{2\mu}{\sigma^2}\right)$.

Proof: Itô lemma applied to $\log S_{jnt}$ yields the following expression for (7) for any initial value S_{jn0} :

$$\begin{cases} \log\ S_{jnt} & = X_{nt} + L_t - U_t \\ X_{nt} & = \log S_{jn0} + \left(\mu - \frac{\sigma^2}{2}\right) t + \sigma B_t \end{cases} \tag{10}$$

A convenient way to model reflections is to use Skorokhod maps that restrict shares to take values within a given interval. In particular, L_t and U_t are defined as

$$\begin{cases} L_t & = -\inf_{0 \leq s \leq t} \left(\{X_{ns} - \log b\} \wedge \{0\}\right) \\ U_t & = -\inf_{0 \leq s \leq t} \left(\{\log d - X_{ns}\} \wedge \{0\}\right) \end{cases}$$

where inf stands for the infimum of a set so that reflections occur now at $\log b$ and $\log d$. For μ and σ such that $\mu < \frac{\sigma^2}{2}$ there exists a steady state distribution of (10). Zhang and Du (2010) derive the steady state density function of RGBM with two barriers. The function reads:

$$f_{jn\infty}(S) = \left(1 - \frac{2\mu}{\sigma^2}\right) \frac{S^{\frac{2\mu}{\sigma^2}-2}}{b^{\frac{2\mu}{\sigma^2}-1} - d^{\frac{2\mu}{\sigma^2}-1}}.$$

The corresponding cumulative distribution is then given by (9).□

It is clear from (9) that though realizations of states of nature differ distributions of output and factor shares are similar when $\mu = 0$. Also, an important extension of the proposition is that the steady state distribution remains Pareto even when shares of country i and country j and/or output and factor shares are correlated. The shares must follow a certain pattern of correlations described by the so called skew symmetry condition: $\mathbf{R}\, diag\,\mathbf{\Sigma} + diag\,\mathbf{\Sigma}\,\mathbf{R}^{\intercal} = 2\mathbf{\Sigma}$, where $\mathbf{\Sigma}$ is a correlation matrix, $diag\,\mathbf{\Sigma}$ is a diagonal matrix whose entries are the variances of each single component of a multivariate RGBM and $\mathbf{R}$ is a reflection matrix that corrects correlations when one of the single components hits the barrier (see Harrison and Williams, 1987; Dai and Harrison, 1992).

Given Proposition 2 we are able to focus on the steady state analysis of shares S_{nj} and therefore omit the time index t. We rank shares in a descending order attributing the highest rank to the country having the largest share of variable of interest within the area. Then a country ranked the nth has the nth largest share within the area or, equivalently, n countries have their shares larger or equal to the nth largest share. This allows to deduce the following relationship between the cumulative distribution function and a rank:

$$P(S_{jk} \geq S_{jn}) = \frac{R_{jn}}{N}. \tag{11}$$

Using the cumulative distribution function of shares (9) we obtain:

$$P(S_{jk} \geq S_{jn}) = 1 - P(S_{jk} < S_{jn}) = \frac{S_{jn}^{-\beta}}{b^{-\beta} - d^{-\beta}}, \tag{12}$$

where $\beta = 1 - \frac{2\mu}{\sigma^2}$. Using expressions (11) and (12) we obtain a non-linear relationship between a rank and a share:

$$S_{jn} = \frac{\lambda^{1/\beta}}{S_{jn}^{1/\beta}}, \tag{13}$$

where $\lambda = \frac{N}{b^{-\beta} - d^{-\beta}}$.

3.3 Theoretical Shares

Assume further without loss of generality that country 1 has the largest and country N has the smallest share of variable j in the area. That is, assume the following:

$$S_{j1} \geq S_{j2} \geq ... \geq S_{jN},\ j \in \{Y, K, H\}.$$

Given the above information, we derive the shares that describe the steady state equilibrium of an integrated area:

Proposition 3 *The steady state distribution of shares is uniquely determined by the drift parameter μ, volatility σ and the number of countries N. Particularly, shares are the solution to the following set of equations*

$$\frac{S_{j1}}{S_{j2}} = 2^{\frac{1}{\beta}},\ \frac{S_{j1}}{S_{j3}} = 3^{\frac{1}{\beta}},\ ...,\ \frac{S_{j1}}{S_{jN}} = N^{\frac{1}{\beta}}. \tag{14}$$

and

$$S_{j1} = \frac{1}{\sum_{n=1}^{N} n^{-\frac{1}{\beta}}} \tag{15}$$

Proof. Using (13) and taking the ratio of the first share over the second share, the first share over the third, etc. gives the sequence of ratios in the proposition. The definition of shares implies also that the same rule holds not only for the shares, but also for the levels of the variables $j \in \{Y, K, H\}$:

$$\frac{j_1}{j_2} = 2^{\frac{1}{\beta}},\ \frac{j_1}{j_3} = 3^{\frac{1}{\beta}},\ ...,\ \frac{j_1}{j_N} = N^{\frac{1}{\beta}}.$$

This in turn together with the definition of shares uniquely determines the share of the first ranked country or the largest share as a function of the number of countries only. Namely:

$$S_{j1} = \frac{j_1}{\sum_{n=1}^{N} j_n} = \frac{1}{\sum_{n=1}^{N} \frac{j_n}{j_1}} = \frac{1}{\sum_{n=1}^{N} n^{-\frac{1}{\beta}}}.$$

Shares of remaining countries can be uniquely determined using (14).□

Proposition 3 gives rise to a number of observations. First, assuming $\mu = 0$ implies $\beta = 1$ and Zipf's law: the share of the first ranked country is twice as large as the share of the second ranked country, three times as large as the share of the third country and so on. Also, more importantly, Proposition 3 enables a direct computation of shares for any region under investigation.[10] Table 5 applies the proposition to the Middle East and gives the complete distribution of shares for the region. The assumption $\mu = 0$ seems a

[10] An implicit property of the concept of shares is share summation to one given by (8). This constraint in combination with the result of Proposition 3 can be used to express the barriers of the RGBM in terms of its drift and volatility parameters. This is useful in identifying the model parameters when estimating the model and running numerical simulations. To that end, we use the expression of the first share as

valid assumption in the steady state, and in that case the largest share is 0.282. It is worth noting that as long as the drift parameter μ is zero the steady state distribution is not affected by the volatility. This allows for heterogeneity of volatility parameters across variables and across countries. We denote the steady state distribution as $\bar{S}$.

Table 5: Steady state distribution of shares ($\mu = 0$).

Region	Number of countries	Theoretical shares (descending)
Middle East	19	0.282 0.141 0.094 0.070 0.056 0.047 0.040 0.035 0.031 0.028 0.026 0.023 0.022 0.020 0.019 0.018 0.017 0.016 0.015

4 Empirical Results

Having described the properties of our fully integrated group of economies through Propositions 1 to 3 we now assess the gap between our ideal design and the observed outcome characterized by the data. Our data set is a balanced panel of annual data ranging from 1975 till 2009. This time range is particularly chosen because it is not clear what the implications of the Arab Spring are for the data of key countries like Syria, Egypt and Lybia.

4.1 Data Sources and Methods

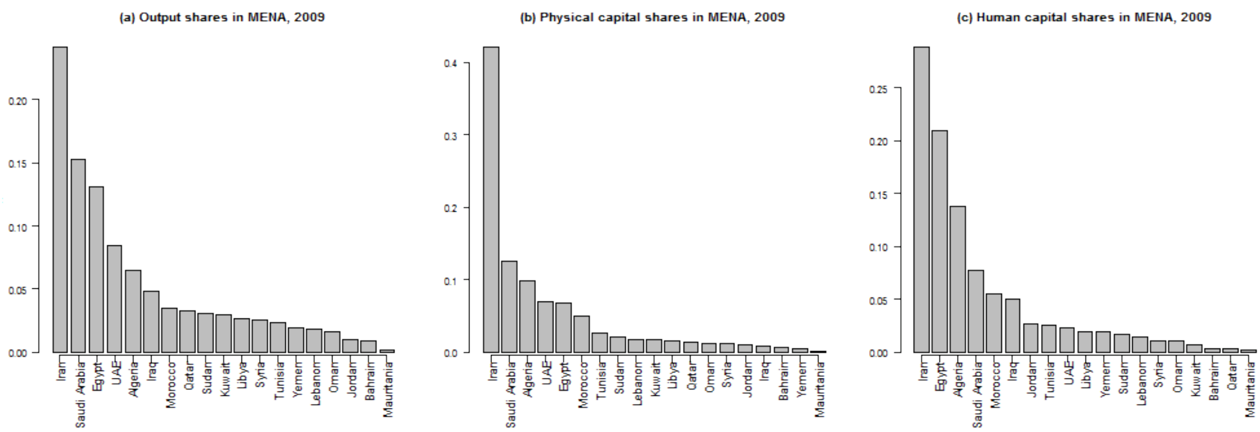
We measure output as gross domestic product (GDP) expressed in international dollars and valued at constant 2000 prices. The main source of data on output is Penn World Tables (PWT) 7.0. We use PWT 5.6, PWT 6.2 and the International Financial Statistics (IFS) database of International Monetary Fund (IMF) as additional data sources where information is unavailable in PWT 7.0. The data on the stock of physical capital till 2004 is obtained from version 6.2 of PWT. Due to the unavailability of more recent data we use the capital inventory rule on total real investment to extend the series up to year 2009. The data on investment is taken from PWT 6.2 and PWT 7.0. Depreciation rates are estimated using a five-year moving average on depreciation rates as implied by the capital

implied by (13) and set it equal to the first share found in (15) to obtain a non linear relationship between the upper and the lower barrier of RGBM. The upper barrier is then $d = \{b^{-\beta} - \frac{N}{\left(\sum_{n=1}^{N} n^{-\frac{1}{\beta}}\right)^{-\beta}}\}^{-\frac{1}{\beta}}$ and is uniquely determined by drift, volatility, the number of countries and the lower barrier of the process. Because model parameters are time invariant this expression holds also outside of the steady state and it can be used as an additional constraint when estimating the parameters of the model. When the upper barrier is infinite, the lower barrier can be determined by $b = \frac{N^{-\frac{1}{\beta}}}{\sum_{n=1}^{N} n^{-\frac{1}{\beta}}}$.

inventory rule on available capital stock and investment data. Just as output, investment and physical capital are expressed in international dollars and valued at constant 2000 prices. Human capital in our analysis is measured as total population aged 15 and over that has at least completed secondary education and is obtained from Barro and Lee's data set on educational attainment. Because the data is only available on a five-year interval basis and because it exhibits a clear exponential growth we use cubic splines to interpolate missing observations. The data on human capital for Lebanon and Oman is estimated using information on population with secondary and tertiary schooling obtained from their national statistical offices. A more detailed description of the data and the methods employed for interpolation and forecasting is contained in the Appendix.

For the purpose of our empirical analysis we further compute the shares of output, physical and human capital separately for the countries of the Middle East. Figure 3 illustrates the distribution of all three sets of shares in 2009 where it is clear that Iran takes the highest intra-regional share of all the variables. Likewise, sets of shares are also computed for EU-15 and ALADI and are reproduced in Figures 4 and 5.

Figure 3: Distribution of output and factor shares in MENA.

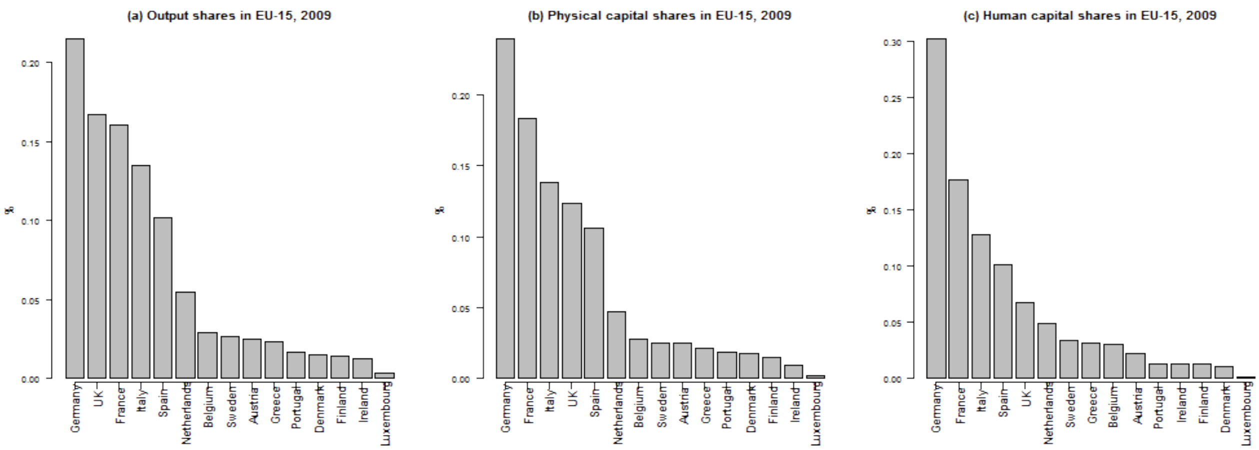


Note: Year 2009.
Source: Own calculations based on Penn World Tables 7.0, 6.2, 5.6, IMF IFS and Barro and Lee (2013).

4.2 Power Law

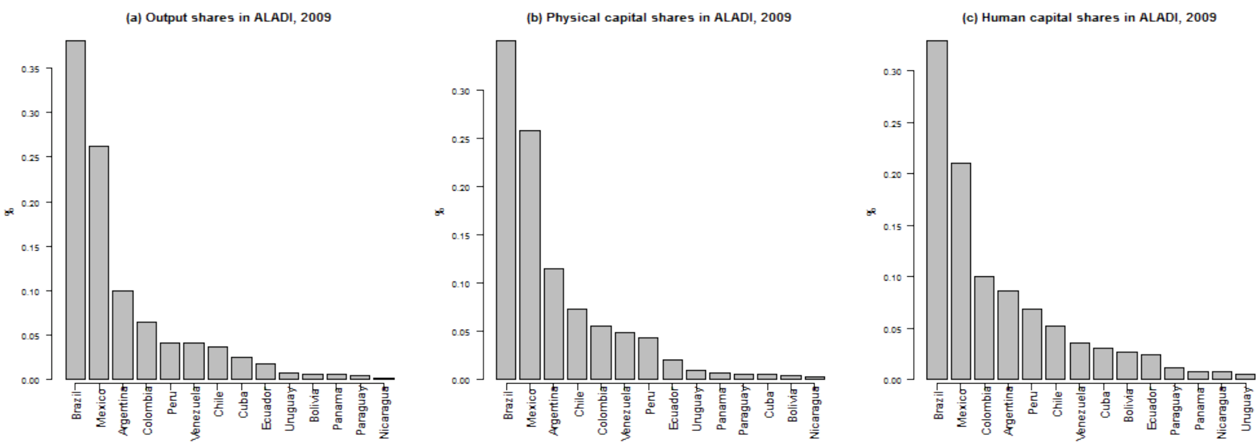
When for sufficiently large values the size of an n ranked variable is inversely proportional to a power of its rank the distribution of the variable is said to follow a power law. In our framework it is represented by (16), which is a long-term relationship derived from the

Figure 4: Distribution of output and factor shares in EU-15.



Note: Year 2009.
Source: Own calculations based on Penn World Tables 7.0, 6.2, 5.6 and Barro and Lee (2013).

Figure 5: Distribution of output and factor shares in ALADI.



Note: Year 2009.
Source: Own calculations based on Penn World Tables 7.0, 6.2, 5.6 and Barro and Lee (2013).

steady state distribution of shares. Taking the natural logarithm of (13) yields

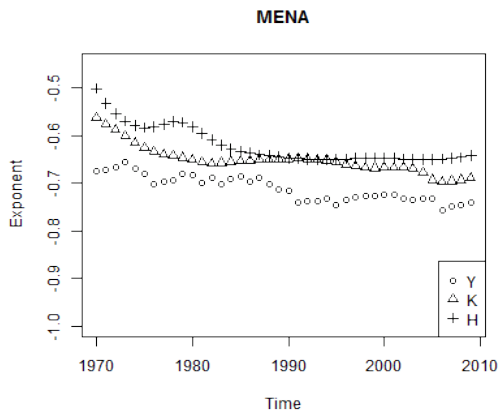
$$\log R_{jn} = \log \lambda - \beta \log S_{jn}, \quad j \in \{Y, K, H\}. \tag{16}$$

To test whether the power law holds in our sample and whether the exponent of the power law is close to unity we run simple OLS regressions on a cross-section at every time point using the log specification above. However, we follow Gabaix and Ibragimov (2011) and correct for small sample bias by using adjusted ranks:

$$\log\left(R_{jn} - 1/2\right) = \log \lambda - \beta \log S_{jn}, \quad j \in \{Y, K, H\}. \tag{17}$$

Figure 6 shows the estimated slopes of regression (17) for our three sets of shares in the Middle East. Estimated exponents are all significantly different from zero at the 5% significance level suggesting that our data is indeed characterized by power laws. However, estimated exponents are all significantly different from one, suggesting significant deviations of share distributions from Zipf's law. Estimates however do follow a slight decreasing trend which is a sign that, although slowly, convergence to Zipf's law is taking place.

Figure 6: Estimated power law exponents $-\beta$ in MENA.



Notes: *(i)* The exponents are significantly different from zero and one at the 5% level; *(ii)* The coefficient of determination R^2 varies between 0.71 and 0.92.

4.3 Maximum Likelihood Estimation of RGBM Parameters

We now use our historical series to estimate a descrete version of the reflected geometric Brownian motion. The goal is to find out whether our parsimonious model captures the essential features of the data. Particularly, we follow Aït-Sahalia (2002) and apply Maximum Likelihood (ML) on available data for output and factor shares to estimate model parameters μ and σ. Let $\theta = (\mu, \sigma)'$ denote a vector of RGBM parameters. A critical step is the derivation of the conditional density function of normalized RGBM. No such density in its analytical form exists in the literature. To obtain approximate estimates we use the density of RGBM with a sole lower barrier as derived in Veestraeten (2008). In this case the density reads:

$$\begin{aligned} P(S_{jnt}|S_{jn,t-\Delta};\theta) &= \frac{1}{\sigma S_{jnt}\sqrt{2\pi\Delta}} \exp\left[-\frac{\left(\ln S_{jnt} - \ln S_{jn,t-\Delta} - \gamma_1\Delta\right)^2}{2\sigma^2\Delta}\right] \\ &+ \frac{1}{\sigma S_{jnt}\sqrt{2\pi\Delta}} \exp[\gamma_2\ (\ln b - \ln S_{jn,t-\Delta})] \exp\left[-\frac{\left(\ln S_{jnt} + \ln S_{jn,t-\Delta} - 2\ln b - \gamma_1\Delta\right)^2}{2\sigma^2\Delta}\right] \\ &- \gamma_2 \frac{1}{S_{jnt}} \exp[\gamma_2\,(\ln S_{jnt} - \ln b)] \left(1 - \Phi\left[\frac{\ln S_{jnt} + \ln S_{jn,t-\Delta} - 2\ln b + \gamma_1\Delta}{\sigma\sqrt{\Delta}}\right]\right) \end{aligned}$$

where

$$\begin{aligned} \gamma_1 &= \mu - \frac{\sigma^2}{2} \\ \gamma_2 &= \frac{2}{\sigma^2}\gamma_1. \end{aligned}$$

S_{jnt} denotes as before country's n share of variable j at time point t and Δ is a time step equalling 1 for annual data. ML therefore solves:

$$\hat{\theta} = \arg\max_{\theta} \ell(\theta) \tag{18}$$

with the log-likelihood function ℓ having its regular form:

$$\ell(\theta) = \sum_{t=\Delta}^{T}\sum_{n=1}^{N} \ln[P(S_{jnt}|S_{jn,t-\Delta};\theta)].$$

Solution to (18) can be obtained using standard numerical optimization algorithms such as the algorithm of Broyden-Fletcher-Goldfarb-Shanno (BFGS).[11]

Table 6: Estimates of drift and volatility parameters.

	Full sample (1970 - 2009)		1982 - 2009	
Variable	Drift μ	Volatility σ	Drift μ	Volatility σ
Output shares S_Y	0.013*	0.123*	0.008	0.105*
Physical capital shares S_K	0.007*	0.051*	0.003*	0.028*
Human capital shares S_H	0.005*	0.045*	0.001	0.030*
Shares pooled	0.009*	0.081*	0.004*	0.065*

Note: * denotes statistical significance at the 5% level.

Estimation results of model parameters μ and σ are presented in Table 6. They are shown for each set of shares separately and for a sample that pools all shares. From Table 6 it is clear that the volatility of output shares is the largest. This is partly due to the fact

[11] R code for the estimation of RGBM is available upon request.

that output is a flow variable and is therefore more volatile than the more steady stocks of physical and human capital. In addition, output volatility in MENA is high though expected since MENA countries have experienced numerous armed conflicts.

For the sake of comparison, the same volatilities for ALADI for the full sample turn out to be twice as low as in MENA: 0.053 (S_Y), 0.025 (S_K), 0.037 (S_H) and 0.038 (pooled). For EU-15 the estimates are even lower: 0.020(S_Y), 0.012 (S_K), 0.023(S_H) and 0.020 (pooled). EU-15 estimates are obtained using the sample period of 1975 - 2009.

5 Measurement of Integration

To measure the degree of economic integration we use the integration index $I_E(\bar{S}, S_t)$ which is a transformed Euclidean distance. It is defined as

$$I_E(\bar{S}, S_t) = e^{-E(\bar{S}, S_t)}, \tag{19}$$

where $E(\bar{S}, S_t)$ is the Euclidean distance, measuring the deviation of observed shares S_{jnt} from their theoretical counterparts $\bar{S}_{jn}$ found by applying Proposition 3:

$$E(\bar{S}, S_t) = \frac{1}{3} \sum_{j=Y,K,H} \sqrt{\sum_{n=1}^{N} (\bar{S}_{jn} - S_{jnt})^2}.$$

The Euclidean metric is always non-negative and takes the value zero when for each variable j and for each n ranked country, $S_{jnt} = \bar{S}_{jn}$: this is the property that arises under full integration. The lower is the degree of economic integration the greater is the deviation of the measure from zero, the lower is the value of $I_E(\bar{S}, S_t)$. Due to share summation to one in (8) there exists a strictly positive lower bound of the integration index. We estimate this value to be equal to 0.55. This estimate is the minimum value of (19) obtained by taking 10000 bootstrap samples with replications from the data on various regions.[12] The integration index therefore takes values within the $(0.55, 1]$ interval, with 1 arising under full integration.[13]

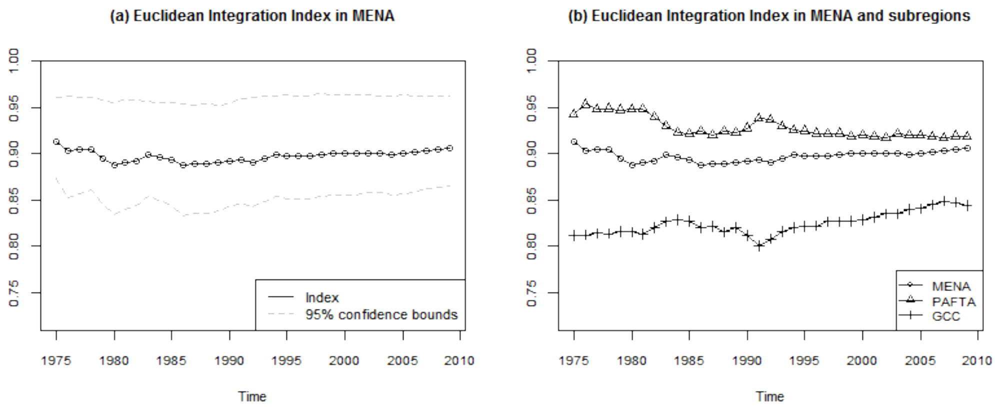
Computation of $I_E(\bar{S}, S_t)$ for the Middle East makes use of the following information. Theoretical shares are found in Table 5. Observed shares in our dataset are ranked in descending order such that rank 1 ($n = 1$) is attributed to the country having the largest share in the area; rank 2 ($n = 2$) to the second largest share; etc. In first instance

[12] The regions we considered were the Middle East, the Pan-Arab Arab Free Trade Area, Latin American Integration Association, EU-15, Gulf Cooperation Council, Mercosur, Andean Community and EU-12 (EU-15 excluding non euro countries).

[13] Our results are also robust with respect to the transformation we choose to apply to Euclidean distance. In particular, applying the linear transformation $I_T(\bar{S}, S_t) = 1 - E(\bar{S}, S_t)$ does not change the results. This is due to highly concentrated values that the Euclidean measure takes. Given those values both linear and exponential transformations produce almost identical results.

index (19) is computed without imposing any conformity of ranks among the three types of shares, something that is done later. Figure 7 displays the computed index values. The results suggest that the degree of economic integration in the Middle East is high throughout the entire time period analyzed. However, the index is significantly lower than one suggesting that although high, integration in the Middle East is incomplete.[14] The index is also increasing over time in the second half of the sample. Slope estimate of the integration index regression on time is significant at a 5% level for the period 1980 - 2009 when shares tend to get closer to their theoretical distribution. Our results also indicate

Figure 7: Integration measure for various regions in the Middle East.



Note: Dashed lines in panel (a) denote a 95% confidence interval obtained by taking 10000 bootstrap samples with replications.

that the degree of integration in MENA is lower than that in the countries that constitute the Pan-Arab Free Trade Area (abbr. PAFTA, also known as the Greater Arab Free Trade Area). The region has a long history of trying to promote trade and economic cooperation between its members with the first initiatives been taken as early as 1950s. While most of the earlier agreements were poorly implemented and hardly effective, panel (b) of Figure 7 indicates that the creation of PAFTA did show a positive effect.[15] In contrast to PAFTA, the degree of integration suggested by our index is lower in the countries of the Gulf Cooperation Council. However, because most of the GCC economies are major world oil exporters, the largest share of GCC trade occurs with non-GCC countries such as Japan, United States and European Union. Intra-regional trade is therefore likely to be even

[14] In Figure 7 we also provide with 95% bootstrap confidence intervals for our integration measure. We note, however, that our data is non sampled so that the sampling error is zero and our computed integration index is a true population value for which no confidence intervals can be defined. We only present bootstrap results as an approximate indication of statistical significance in case sampling methods were used while constructing physical or human capital data in Penn World Tables or Barro and Lee (2013).

[15] Péridy and Abedini (2008) find a 20% increase in intra-regional trade since the implementation of the agreement.

smaller than that in MENA or PAFTA. Moreover, Saudi Arabia being the only large GCC state, clearly dominates the total output of the region as well as its physical and human capital. Because its gains from trade are unlikely to be substantial so are the gains of the entire region suggesting that there indeed exists a limit to the degree of integration in GCC.[16]

Table 7: Steady state distribution of shares ($\mu = 0$).

Region	Number of countries	Theoretical shares (descending)
Latin American Integration Association	14	0.308 0.154 0.103 0.077 0.062 0.051 0.044 0.038 0.034 0.031 0.028 0.026 0.024 0.022
EU-15	15	0.301 0.151 0.100 0.075 0.060 0.050 0.043 0.038 0.034 0.030 0.027 0.025 0.023 0.022 0.020

As a benchmark of high integration in our analysis we consider the 15 countries of the European Union (EU-15) that were EU members since 1995. Visual inspection of the distribution of output and factor shares in EU-15 in Figure 4 suggests that observed human capital share distribution in 2009 meets Zipf's law the closest. The largest share is close to its theoretical value of 30.1% (see Table 7) and the remaining shares tend to follow closely a Zipf's law implied harmonic series. In contrast to human capital, output and physical capital shares seem to be more concentrated across dominating countries signalling that possible large deviations from the theoretical distribution may arise. The results, illustrated in Figure 8, reveal the extent of economic integration in the EU-15 has been higher throughout the past 25 years, but it was comparable or even lower to that in MENA before the mid 80s. Surprisingly, MENA shows a higher value in 2009, at the height of the financial crisis and just before the Arab Spring.

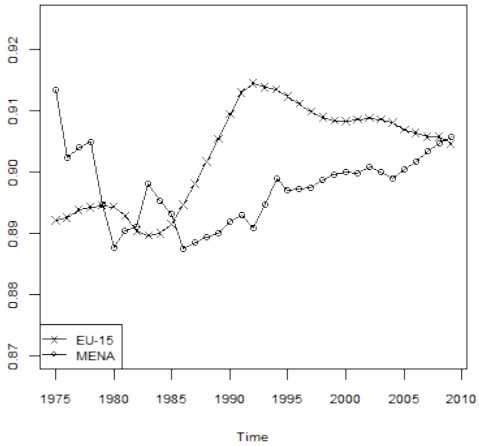
Panel (a) of Figure 9 compares the integration between the Middle East and Latin America. In addition to ALADI panel (b) also considers the two existent customs unions in Latin America, namely, the Southern Common Market (Mercosur) and the Andean Community (Andean).[17] The latter agreement is in force since 1988 as notified to WTO[18] while the former took effect in 1991 for trade in goods and was extended in 2005 to include trade in services. According to the results the extent of economic integration

[16] To test robustness of our findings to different measures of distance between observed and theoretical shares we compute the Theil entropy index. The index is given by $T(\bar{S}, S_t) = \frac{1}{3}\sum_{j=Y,K,H}\left(\sum_{n=1}^{N}\bar{S}_{jn}\ln\left(\frac{\bar{S}_{jn}}{S_{jnt}}\right)\right)$ and respectively the integration measure $I_T(\bar{S}, S_t) = e^{-T(\bar{S},S_t)}$. Like the Euclidean integration index the Theil index takes the maximum value of unity when observed shares coincide with their theoretical counterparts and there exists a positive minimum value due to share summation to one. The results on the degree of integration in the Middle East lead to the same conclusions as before. Namely, integration in MENA is higher than that of GCC and lower than that of PAFTA.

[17] Mercosur currently comprises Argentina, Brazil, Paraguay, Uruguay and Venezuela while Andean consists of Bolivia, Colombia, Ecuador and Peru.

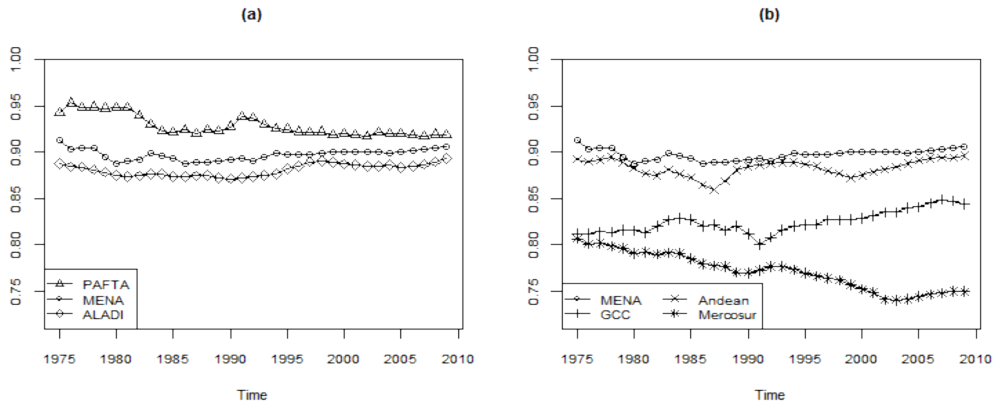
[18] The Community itself was set up in 1969 although a free trade area was formed much later.

Figure 8: Integration measure for MENA and EU-15.



Note: Computation of the index is based on the difference between the nth largest observed share and the nth largest theoretical share.

Figure 9: Integration measure for various regions in the Middle East and Latin America.



Note: Computation of the index is based on the difference between the nth largest observed share and the nth largest theoretical share.

in MENA is higher than in ALADI and the difference is even larger when ALADI is contrasted with PAFTA. Given substantial differences in factor flows and institutional arrangements between MENA and ALADI this result accentuates the role of intra-regional factor mobility in integration analysis. The index takes its lowest values for Mercosur and suggests that Mercosur is even less integrated than the countries of GCC. As in GCC there is also a clear dominant member in Mercosur, particularly, Brazil that takes the largest share in regional output, physical and human capital. This result is well in line with empirical research on the effectiveness of trade agreements in Latin America.[19]

6 Robustness Checks

Our results so far indicate that economic integration in MENA is seemingly comparable to that of EU-15 in 2009. Is it due to economic factors or to any bias in our measurement? These questions raise the issue of robustness of our results.

A conclusion of our estimation results in Table 6 is that the volatility of output shares for the Middle East was five times higher than in EU-15. This larger variation of shares must imply that ranks of these shares are more volatile as well. In our computation of the integration index so far we have not taken into consideration deviations from the equal-share result of Proposition 1. This is important because every country in a fully integrated economic area has to satisfy the equal-share relationship formulated in the proposition. To illustrate the issue take the case of the Iranian Revolution in 1979. A glance at the data reveals that it caused a severe decline in the output share of Iran. The share dropped to 17.6% in 1980 making Iran the second ranked country after Saudi Arabia. The Iran-Iraq war furthered the decline. Nevertheless, Iran still ranked first in its factor shares with the physical capital share equalling 44.6% and the human capital share equalling 29.8%. The equal-share relationship is clearly violated in this case and it is the objective of this section to impose penalties for such violations. To that end we first test the conformity of ranks implied by Proposition 1 and then re-compute our indices. To limit the number of cases we only compare the Middle East to EU-15.

6.1 Tests of Proposition 1

To test whether there is conformity between the ranks of the output and factor shares we compute Spearman rank correlation coefficients at every time point and compare them across regions and in time. Contrary to a Pearson correlation a rank correlation not

[19] For example, in their gravity analysis of bilateral trade flows between Mercosur countries García *et al.* (2013) find positive but very moderate effects of the agreement on intra-Mercosur trade. In a similar framework Carrillo-Tudela and A Li (2004) investigate the impact of both Mercosur and Andean agreements on intra-regional trade in several product classifications and find positive effects in only very few product classifications with more significant results for Andean than for Mercosur.

only allows for non linearities to be present in a relationship but also considerably lowers the influence of large observations that are typical to our data. Table 8 presents the pairwise Spearman rank correlations computed for the year 2009 and suggests that there is a significant positive relationship between any pair of shares in 2009. Statistically significant coefficients allow to conclude that a country with a higher ranked output share tends to also have higher ranked factor shares. However, correlations tend to decrease over time.

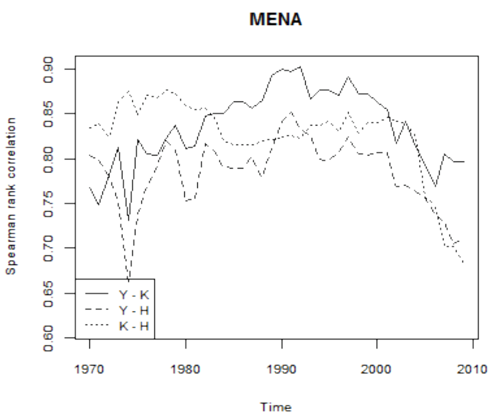
Table 8: Spearman rank correlations in MENA (year 2009).

Output-physical capital	Output-human capital	Physical capital-human capital
0.80	0.71	0.68

Notes: All coefficients are significant at a 1% level. Bootstrap confidence intervals are as follows: Y-K shares [0.41, 0.96], Y-H shares [0.26, 0.93], K-H shares [0.26, 0.90].

Figure 10 shows the changes in correlation coefficients over time. It can be observed that rank correlations for the Middle East display a negative trend that gets accentuated after the mid 90s, indicating that conformity between ranks has decreased relative to preceding years. Countries in the Middle East change their ranks more often in the second half of our sample. A look at the data reveals that shares of smaller countries become more volatile due to either shocks to these economies and/or due to changing policies of their local governments.[20]

Figure 10: Spearman rank correlations in MENA.



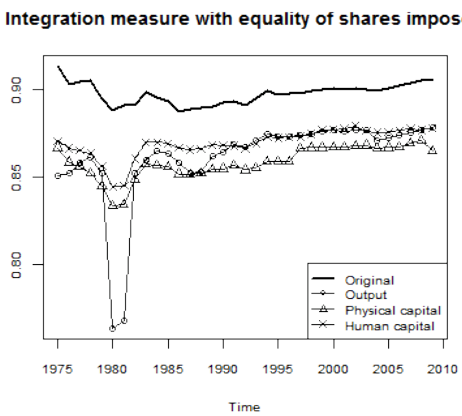
[20] The discussion of Proposition 1 already indicates that the equality in (2) breaks down when $\rho = 0$, that is when economies show unused labour resources and are constrained by the limited supply of physical capital. Also, the equality in (2) is no longer obtained when barriers to trade or to human capital mobility are present. Similarly, any impediments to trade such as import quotas or tariffs would create differences in commodity prices across member countries. Given similar technologies this would also create differences in marginal products of physical capital across countries. Again, as a result deviations from the equal-share would arise. Moreover, in the presence of barriers the relationship between output and factor shares might well be nonlinear as implied by the adding-up constraint.

In contrast, for EU-15 the 2009 Spearman rank correlation for output-physical capital shares was 0.99, for output-human capital shares it was 0.95 and 0.96 for physical-human capital shares. The correlations remain as high for the entire time range considered.

6.2 Integration Measure Re-Computed

As rank conformity is not perfect we now test the robustness of our conclusions by explicitly imposing the equal-share relationship (2) in the computation of our integration index. There are three ways to re-compute index (19). Namely, the computation can be based on the observed ranking of countries at a given year by: *(i)* output shares; *(ii)* physical capital shares; *(iii)* human capital shares. For example, let us focus on the assignment of countries to theoretical shares based on the observed human capital share distribution. In this case, the nth largest theoretical share at a given year is attributed to a country having the nth largest observed human capital share in that given year. If the equal share relationship holds this would imply that the country to which the nth largest theoretical share is attributed to should also rank the nth in its output and physical capital shares. Thus, deviations and the value of the index (19) can be computed. Similarly, the computation of the integration index can be performed based on observed output and physical capital shares. The more significant country's violations of the equal share relationship are the larger the deviations are and the smaller is the value of the integration index. Figure 11 shows the dynamics of the integration index (19) for MENA computed in all the three possible ways described above. After introducing the penalties it is clear that the values of

Figure 11: Euclidean integration measure: equal share relationship imposed.



Notes: The solid line corresponds to the integration measure displayed in Figure 7. The other three lines correspond to integration measures computed after correction for deviations from the equal-share relationship.

the index are lower than those obtained in Figure 7. Thus, countries do change ranks and this has a negative effect on the integration measure. Interestingly, computations reveal a large drop in the degree of integration in 1980. The drop is particularly large under the output share based computation and gets smoothened under the physical and human capital based computations. This occurs because only the output share of Iran dropped significantly as a result of Iranian Revolution. Its factor shares changed only marginally with no influence on the rank position of the country. Figure 11 also suggests that after 1980 the degree of integration increases over time.[21]

We now run a similar robustness check for EU-15 and test whether indeed EU-15 was less integrated than the Middle East before mid 80s. The outcome of the human capital based computation is illustrated in Figure 12. Output and physical capital based computations yield analogous results.[22] As Figure 12 suggests, when equality of shares is taken into account integration index takes higher values for EU-15 throughout the entire time period analyzed. This outcome is in line with the fact that conformity of ranks is higher in EU-15 and thus the equal-share relationship is met closer. Nevertheless, the corrected index value for MENA in 2009 is only 2.35 percent lower than that of EU-15 implying that the extent of integration in the Middle East is effectively larger than commonly believed.

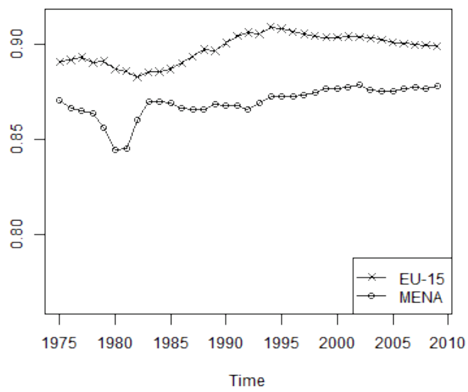
7 Concluding Remarks

The first objective of the paper was to develop a theory that would enable the measurement of the degree of economic integration among a set of countries. To that end, we constructed an integration benchmark that consists of a steady state equilibrium characterized by free trade and perfect factor mobility. Metrics were then used to measure the distance between the benchmark and the data. Measurement was another objective of the analysis because it allowed a comparison of our integration indices over time and across regions. It is a commonly held view that trade is the instrument of choice to achieve greater integration. Regions that demonstrate low intra-regional trade are often concluded to be poorly integrated. What we have shown in this paper is that international labour

[21] Estimated slopes of index regressions on time are positive and significantly different from zero at a 1% level even if the time range is limited to 1985-2009.

[22] The output based computation suggests an abrupt drop in the the degree of integration in EU-15 after 2001. A look at the data reveals that an abrupt decline in the measure occurs because the two large EU-15 economies, UK and France, interchange their positions in output share ranking. The output share of UK increased from 16.00% in 2000 to 16.06% in 2001 and turned out to be higher than 16.05%, the 2001 output share of France. This must have had a significant impact on the index as now the observed UK shares were compared to the second largest theoretical share. Particularly large deviations would become for observed human capital shares, in which the UK appears to be the fifth ranked country (see also Figure 4). Further inspection of the human capital data in Barro and Lee (2013) reveals that the number of adults with at least completed secondary education is unusually low in the UK (see the Appendix). Because of possible data inaccuracy we do not interpret this drop as an actual drop in the extent of integration and conclude that the degree of integration has been persistently higher in EU-15.

Figure 12: Euclidean integration measure: equal share relationship imposed (EU-15 and MENA).



Notes: The computation of the integration measure is performed attributing the nth largest theoretical share to the country with the nth largest human capital share at a given year. The results are similar when computation is performed based on physical capital and output shares.

and capital mobility among a group of countries can be powerful instruments to achieve integration even in the absence of such trade and of institutional arrangements like free trade agreements and WTO membership. To support our views we considered the Middle East and North Africa, a region with low intra-regional trade and limited membership in free trade agreements. We have shown that although its degree of integration has been lower than in the 15 countries of the European Union, a benchmark of "complete" integration, it has been higher than expected based on its low intra-regional trade data.

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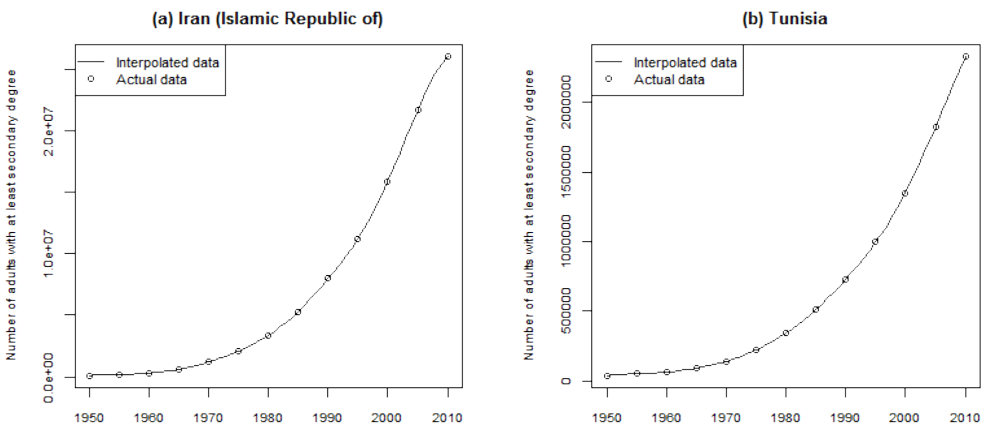
A Online Appendix: Data Sources and Methods

Human Capital

For the three groups of countries (MENA, ALADI and EU-15), human capital is measured as a total population aged 15 and over with at least completed secondary education[23] and is obtained from Barro and Lee's data set on educational attainment. The data is on the 5-year interval basis covering the period 1950 - 2010 and is available for all the countries under analysis with the exception of Lebanon and Oman. As expected the data shows a clear exponential growth with no outliers. We therefore use cubic spline interpolation as an appropriate and simple method to obtain annual data. The method is illustrated in Figure A.1 with points representing original figures before interpolation.

Figure A.1: Human capital data interpolation. The example of Iran and Tunisia.



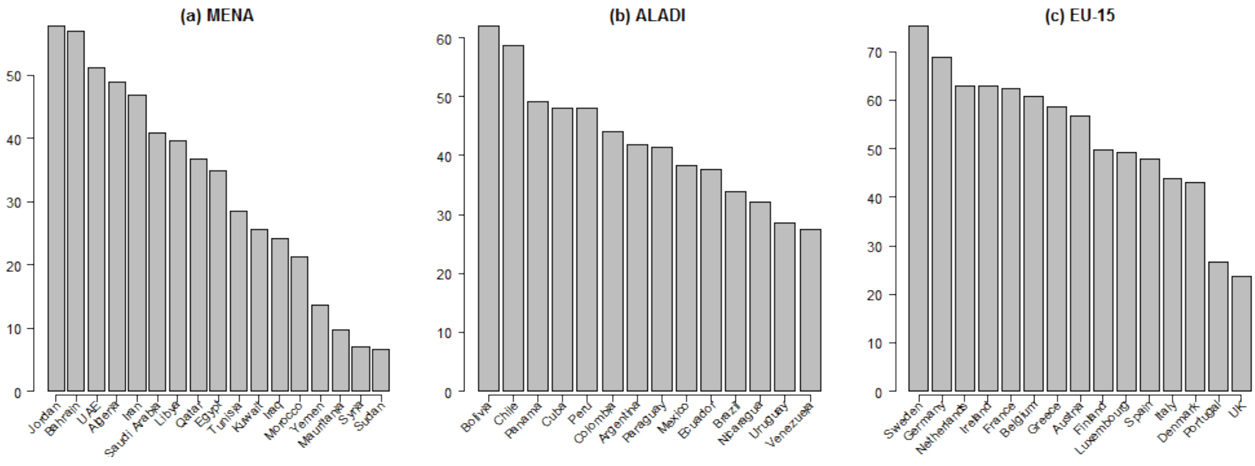
The data for Lebanon were obtained from the household surveys run by its national statistical office. The data were available for years 2004, 2007 and 2009 as a ratio of population with at least secondary schooling to total population. We extended the series by taking the growth rates of the average ratios of human capital to total population over 15 in Jordan and Turkey. To obtain the data for Oman its ratio of population with a complete secondary education to total population over 15 was approximated with the average ratio of Jordan and Saudi Arabia that were taken as its partner countries. The data on population aged 15 and over was obtained from the United Nations UNSD Demographic Statistics database. Obtained estimates are comparable to the data on the percentage of expatriate workers in Oman with at least secondary degree averaged with the percentage of Omani nationals with at least secondary degree who are employed in public sector. The

[23] We consider the sum of the population aged 15 and over with *(i)* completed secondary education as the highest obtained education level and *(ii)* completed or incomplete tertiary education as the highest obtained education level.

data on the latter two indicators is obtained from the national statistical office in Oman[24]. Immigrants make up 28.4% of Omani population[25].

Human capital demonstrates a clear exponential growth. In 2010 human capital in the Middle East and North Africa (MENA) constituted 32.5% (32.3% Lebanon and Oman excluded) of total MENA population aged 15 and over. This ratio is slightly higher when the region encompassing the countries of ALADI is concerned (38.7%) and it is even higher in the case of the 15 old members of the European Union (52.04%). As Figure A.2 suggests around 60% of adult population in Jordan, Bahrain, Bolivia, Chile have completed at least secondary education. The ratio is lower than 10% in Sudan, Syria and Mauritania.

Figure A.2: Human capital as a share in total population aged 15 and over (year 2010).



Source: Own calculations based on Barro and Lee (2013).

Regarding EU-15 an element of concern in our research is the fact that the percentage of adults with at least completed secondary education is unrealistically low in the UK (see panel (c) in Figure A.2). This might well be the cause of a large drop in our integration measure when output based computation for EU-15 is performed.

Physical Capital

Data for physical capital in all regions come from PWT 6.2 and cover the period of 1950 - 2004. The data is in constant prices with the base year of 2000. Measurement units are international dollars. Given that this is the most recent capital stock data available, year 2000 became a benchmark reference year for all the real variables included into analysis.

[24] In 1997 21.3% of expatriate workers in Oman had at least secondary education. The percentage is 17.5% in 2000 and 24.3% in 2005. Source: Own calculations based on the data from Oman National Statistics.

[25] Source: World Bank Migration and Remittances Factbook 2011.

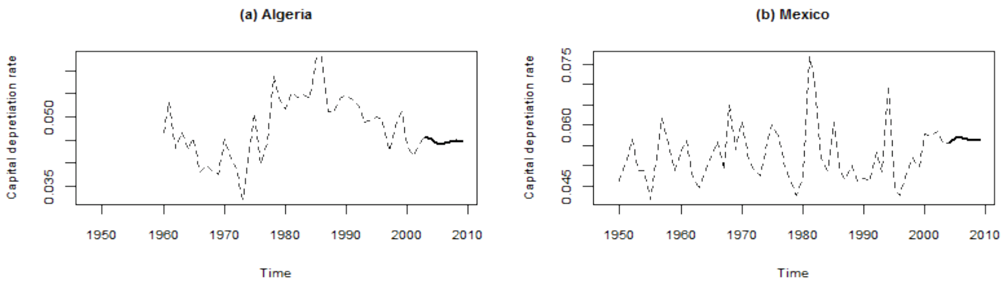
There were two problems associated with the capital stock data in hand. First, the data was available until the year 2004 only or even until 2003 for most of MENA countries. Second, no data was available for Lebanon, Libya and Yemen.

The first above mentioned problem was solved as follows. We computed the total investment I_{it} in constant 2000 prices at time period t for country i using the real investment-to-GDP ratios available in PWT 6.2. Furthermore, from the inventory rule

$$K_{it} = (1 - \delta_{it})K_{it-1} + I_{it}$$

we computed depreciation rates δ_{it} and by applying a 5-year moving average we extended them until 2009 (see Figure A.3).

Figure A.3: Depreciation rates: the example of Algeria and Mexico.

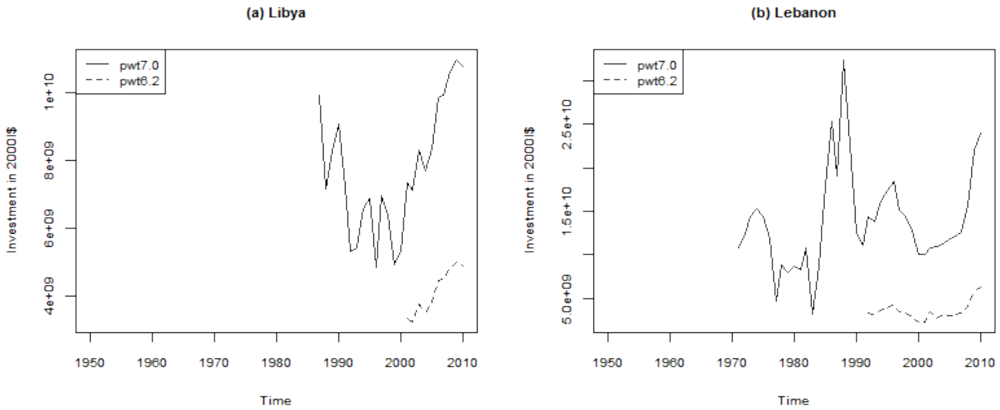


Notes: PWT6.2 data.

Capital depreciation rates vary between 3% for Sudan and 11% for United Arab Emirates in 2003. The same range of variation remained for estimated depreciation rates in 2009.

PWT 7.0 contains investment-to-GDP ratios in constant 2005 prices until 2009. This allows to compute total investment in constant 2000 prices and extend total real investment I_{it} from PWT 6.2 to missing years 2004(2005)-2009. Together with the estimated depreciation rates it becomes feasible to obtain an estimate of K_{it} for $t = 2004(2005), ..., 2009$ using inventory rule. It is to mention here that total real investment in 2000 prices differs between the two versions of PWT by almost a scalar. Growth rates, however, remain almost unchanged (see examples in Figure A.4).

Figure A.4: Difference in total real investment as available in PWT 6.2 and PWT 7.0: the example of Libya and Lebanon.



To estimate unavailable capital data for Lebanon, Libya and Yemen we employed real investment-to-GDP ratios as given in PWT 7.0. We computed total investment in constant 2000 prices and we extended the series backwards using for Libya the growth rates of gross capital formation in constant prices taken from IMF IFS database and for Yemen using real investment taken from PWT 5.6. As a result total real investment for the whole period 1970-2009 was obtained. Given total real investment initial real capital stock K_{i0} and depreciation rates δ_{it} are sufficient to compute the whole series of capital using the inventory rule. For Lebanon and Yemen δ_{it} was estimated as the average depreciation rate of Syria and Jordan and for Libya the average depreciation rate of Tunisia, Morocco, Algeria and Egypt was taken. Initial capital stock was then estimated as

$$K_{i0} = Y_{i0} \left(\frac{1}{n_i} \sum_{j=1}^{n_i} \frac{K_{j0}}{Y_{j0}} \right),$$

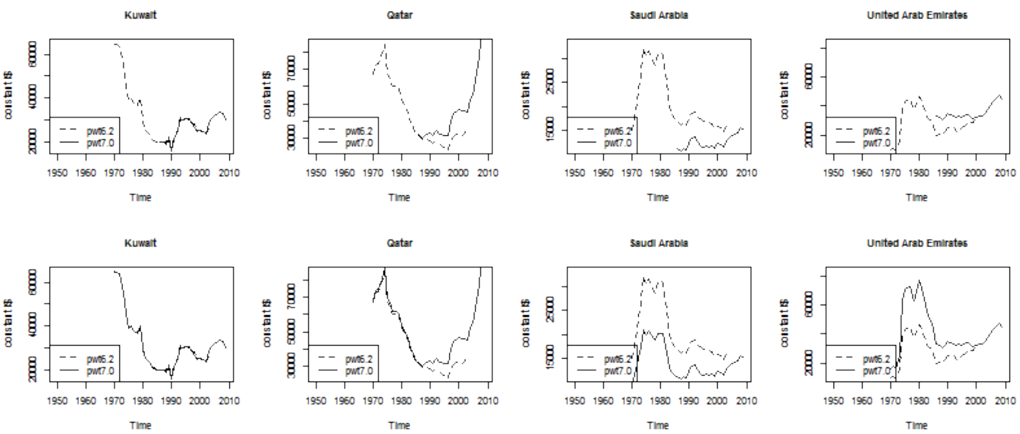
where $t = 0$ is the earliest year for which real capital-to-GDP of partner countries is available, n_i is the number of partner countries for the country in question and Y_{i0} is a real output of country i at the initial time period. As in case of δ_{it} estimation, Syria and Jordan were taken as partner countries for Lebanon and Tunisia, Morocco, Algeria and Egypt were taken as partner countries for Libya.

Output

Output in all country groupings, traditionally measured as real GDP, is obtained from version PWT 7.0. The data ranges from 1950 to 2009 and is expressed in international dollars to equalize the purchasing power of different currencies and allow for cross-country level data comparison. PWT 7.0 uses the year 2005 as a base year for all constant price variables. We use 2000 as the base year in our study. Hence, to convert the base year of real output to 2000 we find the implicit deflator in 2000 for each of the countries and rescale 2005 constant price series accordingly.

Most ALADI countries, except Cuba, have output data available as of 1950. Output of Cuba is available as of 1970. The situation differs for MENA. Only few countries, namely, Egypt, Iran, Jordan and Morocco have data starting prior to 1955. In 1970, however, 13 (out of 19) MENA countries do have observations leaving out Kuwait, Qatar, Saudi Arabia, United Arab Emirates, Libya and Yemen, series for which start in late 80-ties. The older version of PWT (6.2), however, contains real GDP data for Kuwait, Qatar, Saudi Arabia and UAE as of 1970. We used the growth rates of constant price series taken from PWT 6.2 to extend existing data backwards. Although some degree of discrepancy is present between data published in the two versions of PWT, especially for level data of Saudi Arabia and Qatar (see Figure A.5), the growth rates in overlapping years remain very similar, maintaining the plausibility of estimated data.

Figure A.5: Output data extension for Kuwait, Qatar, Saudi Arabia and UAE.



Note: PWT6.2 (7.0) is an abbreviation for Penn World Tables, version 6.2 (7.0).

Because Yemen Arab Republic and People's Democratic Republic of Yemen were united in 1990 to form the current Republic of Yemen, most of the international data sources do not publish data prior to 1990 for the two former republics separately. The data is neither publicly available on the website of the national statistical authority of Yemen. The oldest version of PWT (5.6), however, contains a joint 1969 - 1989 GDP per capita for Yemen both in current and constant 1985 prices. It therefore becomes possible, similarly as described above, to extend available real output data for Yemen by applying PWT 5.6 growth rates backwards. Although there is a substantial 48% difference in the level of real

GDP as published in PWT 5.6 and PWT 7.0 respectively in the common year 1989, it is yet the best estimate we could obtain for Yemen in the period of 1970 - 1989 prior to its unification.

To obtain real output data for Libya in the years 1970 - 1985 we used its GDP in constant prices expressed in local currency units as available in the International Financial Statistics database (IFS) of IMF. Analogously to the case of Yemen we applied the growth rates backwards to compute the data for missing years.

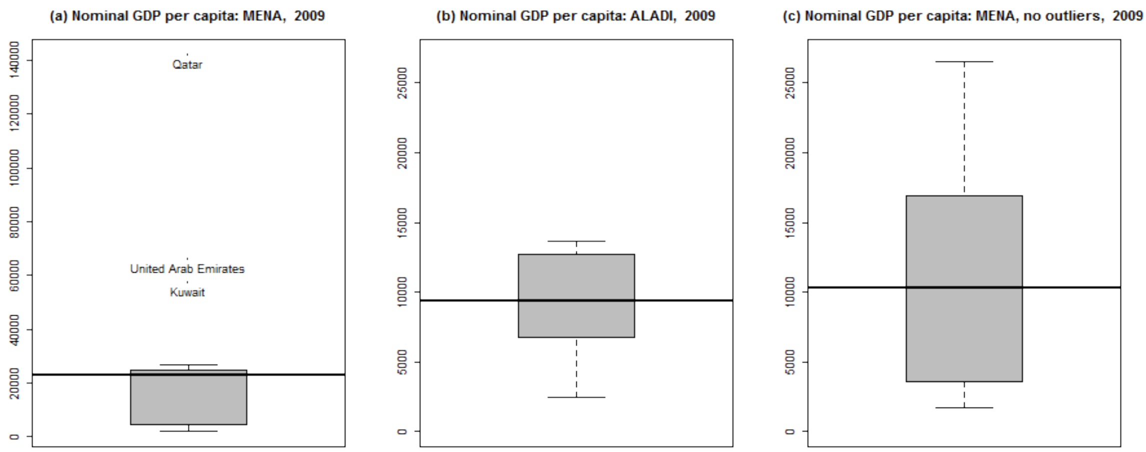
Average income per capita: MENA and ALADI

Average income per capita measured as GDP per capita in ALADI countries was 9405.8 international dollars in 2009. Average income per capita in the Middle East on the other hand was more than twice as high amounting to 21637.5 international dollars.[26] This difference, however, is mainly driven by few rich and small oil-exporting countries, like Qatar, Kuwait and United Arab Emirates. The boxplot in Figure A.6 shows that GDP per capita in Qatar, United Arab Emirates and Kuwait is more than 1.5 interquartile ranges above the third quartile of the GDP per capita distribution in MENA. These countries are therefore pointed out as outliers.[27] The distribution in ALADI is clearly more homogeneous in the sense that no extreme observations are present. After the exclusion of Qatar, United Arab Emirates and Kuwait MENA and ALADI show indeed very similar average income per capita (10283.3 international dollars in MENA vs. 9405.8 in ALADI, see also the two rightmost graphs in Figure A.6). Analogous conclusions are drawn also from the computation of the population weighted average. In MENA the population weighted average is 8952.7 international dollars and that in ALADI is 10724.8

[26] Source: Penn World Tables (PWT) 7.0.

[27] We use the simple interquartile rule to detect outliers. A data point is identified as an outlier if it is above $Q_3 + 1.5IQR$, where Q_3 is the third quartile of the data distribution and IQR is the measure of the spread of the data around the median defined as the difference between the third and the first quartiles.

Figure A.6: Nominal GDP per capita in ALADI and MENA.



Notes: The leftmost boxplot includes nominal GDP per capita for all the MENA countries. The rightmost boxplot excludes Qatar, United Arab Emirates and Kuwait and displays the distribution of nominal GDP per capita for the remaining 16 MENA countries. Horizontal lines denote sample averages. Year 2009. International dollars.

Source: Penn World Tables 7.0.

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