EMPIRICAL ESSAYS IN INTERNATIONAL ECONOMICS

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Chapter 1

Introduction

1.1 Background

Many empirical studies find that a significant part of country's economic growth can be explained by how open it is to the rest of the world (Harrison and Rodríguez-Clare, 2009). International trade, integration initiatives aimed at promoting trade, migration of people strengthen cross-country linkages and are phenomena that are increasingly taking place. The volume of the world trade has more than tripled over the past 20 years. More and more bilateral trade relationships are being established. The number of non-trading country-pairs has dropped to 18% (see Table 4.3 in Chapter 4). Along with the increasing trade, a growing number of regional and preferential trade agreements are being ratified every year in different parts of the world. A total number of regional trade agreements is currently 278 compared to twice as few (138) just a decade ago. Several regions have adjusted their migration policies to lower or eliminate barriers to human capital mobility. An example could be the expansion of the European Union that granted the right for citizens of the new entrants to freely move across regional borders. This all raises a variety of interesting questions that fall into the domain of international economics. At the same time data availability and data quality have improved greatly. Detailed sets of panel data are currently available that span a variety of topics for nearly all the world countries. A large body includes survey data such as the World Bank logistics performance index or the Consensus Economics data on inflation expectations. The growth of data availability and the advancement of statistical and econometric theory enables the application of modern econometric techniques to empirically investigate numerous research questions of interest to academics and policy makers.

The recent decade was rich of events in the international arena. The world has experienced the deepest recession since the World War II. The sluggish recovery that followed and the prolonged phase of low inflation posed challenges to governments and central banks of many world economies. The end of 2010 brought the Arab Spring to the Middle East and North Africa. The turmoil had significant geopolitical and economic consequences for the region. It strongly hit the region's tourism sector, decreased workers' remittances and created uncertainty among domestic and foreign investors. Four years later the Maidan Revolution took place in Ukraine which prompted the signing of the so called Deep and Comprehensive Free Trade Area agreement between the country and the European Union. The trade agreement came into force on January 1st, 2016. This thesis empirically assesses key aspects surrounding these events.

Methodologically, a variety of econometric methods have been adopted in this thesis. In Chapter 2 the results from the theory of stochastic processes are employed. In particular, the result on the steady state distribution of a reflected geometric Brownian motion is used to model the development of shares of output and production factors in a given economic area. Chapter 3 employs instrumental variable approach to time series while Chapter 4 deals with the self-selection models for three-dimensional panel data. Both Chapter 3 and Chapter 4 rely on well established economic relationships - Phillips curves in Chapter 3 and the gravity model of trade in Chapter 4.

The results of this thesis are policy relevant in several perspectives. First, the results suggest that governments can stimulate economic integration in the region via migration policies even if sizable intra-regional trade is absent. Second, central banks in advanced economies should focus primarily on monitoring domestic rather than global economic slack as (core) inflation remains largely a domestic phenomenon. Third, free trade area agreements can have significant indirect effects on trade flows. In formulating their trade policy stance policy makers in emerging markets may therefore consider secondary aspects that arise from the establishment of closer economic ties with advanced economies. Important relevant aspects include the improvement in the quality of institutions and the improvement in the quality of infrastructure.

1.2 Key Questions

1.2.1 Is the Middle East Poorly Integrated?

Chapter 2 develops an integration measure and analyzes the extent of economic integration in the Middle East. The region was once seen as a medieval great globalized force. 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 the region shows one of the lowest intra-regional trade in the world. Together with a low number of trade agreements present in the region, the region is often concluded to be poorly integrated. Yet, with the steady flow of workers across national borders of the Middle East is this conjecture correct? To answer this question Chapter 2 develops an integration benchmark that consists of the steady state production equilibrium characterized by free trade and perfect mobility of physical and human capital. We apply metrics to measure the distance between this benchmark and the data and compare three different regions of the world: European Union, Latin America and Middle East. We find that, despite large differences in trade patterns, measures of economic integration in 2009 are remarkably close across regions. For example, we calculate that economic integration in the Middle East is just 2.4% below that of the European Union.

1.2.2 Do Global Factors Determine Inflation in Advanced Economies?

A number of recent studies document the prominent role of global factors in domestic inflation developments (e.g. Borio and Filardo, 2007; Ciccarelli and Mojon, 2010). In Chapter 3 we investigate global dimensions of advanced economy inflation. We estimate open-economy Phillips curves for 19 advanced economies. We include backward- and forward-looking survey measures of inflation expectations and augment Phillips curves with global factors including global economic slack, global inflation and commodity prices. Our results provide little support for the existence of direct effects of global economic slack on domestic inflation. Moreover, the results suggest that the importance of global inflation in forecasting domestic inflation has its roots solely in its ability to capture slow-moving trends in inflation rates. In the Phillips curve context much the same role is performed by domestic forward-looking inflation expectations. With the exception of commodity prices, therefore, our results reveal little reason to include global factors into traditional reduced form Phillips curves.

1.2.3 What are the Implications of Ukraine's Trade Policy?

The dissolution of the Soviet Union in 1991 has led to the independence of fifteen new states. Twelve of these, including Ukraine, joined the Commonwealth of Independent States (CIS) whose goal was to form a common economic space with free movement of goods, labor and capital. Twenty five years later, CIS countries, and Ukraine in particular, still face important trade policy choices the implementation of which is conditional on the quality of governance and infrastructure. The evaluation of these policy choices gains therefore considerable importance. In Chapter 4 we estimate the gravity model of trade using alternative estimation approaches that account for zeros in trade: Heckman (Heckman, 1979), Poisson pseudo-maximum likelihood (Santos Silva and Tenreyro, 2006) and Martin-Pham tobit (Martin and Pham, 2015). We use an unbalanced panel data set of bilateral export flows among 159 economies over 1997 - 2012 and we control for free trade area and customs union agreements relevant

for Ukraine. Our empirical results show robust outcomes and advocate importance of WTO membership, governance and effective distance (corrected for infrastructure). Using scenario analyses we assess counterfactuals for Ukraine and find, for example, that improved infrastructure would on average lead to a 22% increase in Ukrainian exports while improved governance would, *ceteris paribus*, almost double its trade. Most of these changes originate from the intensive margin of trade.

Chapter 2

Trade, Factor Mobility and the Extent of Economic Integration: Theory and Evidence*

2.1 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. 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. Mundell (1957), in his formal analysis of the interaction between the international flow of goods and factors, shows that if factors are internationally mobile, in the extreme form, trade in goods will cease, which implies that goods trade and factor flows are substitutes. The important assumptions are those that ensure factor price equalization, including incomplete specialization. However, Hanson (2010) addresses this conjecture and shows cases

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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 chapter 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.[1] Nowadays, the region shows by far the lowest intra-regional trade level in the world and a low involvement in the world trading system. For these reasons, it is often 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 labour 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 chapter is to address these issues both formally and empirically.

Several research institutes compile indicators of globalization for countries and the world. Recognizing that the dynamics of globalization is a complex matter, indices give weight to economic, social and political variables (see, for example, the KOF index). Though useful these indicators assess the extent by which economies

[1] Moreover, the region was once an example of high and successful economic integration. 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.

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 chapter 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 then developed to measure the distance between this benchmark and the observed equilibrium characterized by barriers to international trade and to factor mobility. These metrics allow for 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.*, 2011), 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 value 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 chapter, shares are assumed to behave randomly and their path to be described by (possibly correlated) reflected geometric Brownian motions with a lower and upper bound. A random process modeled as a Brownian motion is 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.

Caselli and Feyer (2007) find that, despite large differences in capital-labour ratios, marginal products of capital are close across countries.[2] As Lucas (1990) originally pointed out one of the explanations for this outcome is that poor countries also have lower total factor productivity (TFP) and lower endowments of factors complementary to physical capital such as human capital. Other studies, e.g. 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.* (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.[3]

An objective of our empirical section is to apply measures of economic integration to three groups of countries. Particularly, we contrast the Middle East with the

[2]Though marginal products of capital (MPK) are generally close, differences are observed across countries of the Middle East. Implied estimates of MPK are 0.09 in Jordan and Morocco, 0.07 in Tunisia, 0.05 in Egypt and 0.03 in Algeria (their Table II, last column).

[3]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.

European Union (specifically the 15 original countries or EU-15), which we consider to be a benchmark of "complete" integration, and with Latin America (specifically the Latin American Integration Association or ALADI), 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 US states by 2000. A comparison to EU integration is also preferred due to limitations on sourcing data for US state physical capital stocks.[4] The other control group, ALADI, is the largest Latin American trading bloc that includes most of the sovereign states of Latin America. Their income per capita is similar to the Middle East (on average if weighted by population) but their degree of integration, suggested by intra-regional trade and memberships in trade agreements, is seemingly higher.

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 (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 of distance available in the literature, we show that economic integration in the Middle East is incomplete but in 2009 only 2.4% below that of the European Union; (v) More generally, we find that despite large differences in trade patterns, measures of economic integration are remarkably close across regions.

The chapter is organized as follows. Section 2.2 defines our geographic units and discusses the respective patterns of trade and factor movements. Section 2.3

[4] Annual estimates of physical capital stocks per states have to be approximated from estimates of the aggregate US physical capital stock in each of nine one-digit industrial sectors that comprise aggregate activity.

outlines the model and establishes a key theoretical result; in addition, it describes the data and discusses the empirical method used. Section 2.4 derives the steady state equilibrium distribution of shares and applies maximum likelihood on available data. Section 2.5 includes the derivation of the steady state distribution of shares and the computation of integration measures for each region. Section 2.6 explores the quantitative implications of our results by computing, for example, how large human capital flows in the Middle East should be in order to achieve complete integration. Section 2.7 concludes. Appendix 2.A contains a detailed description of the data sources and methods.

2.2 Patterns of Trade and Factor Movements

2.2.1 Defining Geographic Units

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 2.1 provides a summary of countries classified as the Middle East and North Africa for the three international organizations that are also the main data sources. Among the four 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 by Iran. We exclude Djibouti due to the scarce availability of data. Our definition of the Middle East therefore, that we also call MENA in shorthand notation, comprises 19 economies in the region and covers a geographic area that extends from Iran to the east and Morocco to the west.

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

ALADI, a Spanish acronym for the Latin American Integration Association (Asociación Latinoamericana de Integración), includes the following 14 countries:

Table 2.1: The definitions of the Middle East.

Country	IMF (MENA)	World Bank (MENA)	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*) MENA is an abbreviation for the Middle East and North Africa; (*ii*) 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; (*iii*) 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.

Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela.

2.2.2 Comparative Review of Selected Indicators

Table 2.2 reviews a number of indicators that are important for our analysis. They characterize each region's position in the world economy and give answers to questions like: In comparison to EU and Latin America does the Middle East really display a high level of labour mobility? Is it true that it is less involved in the world economy?[5]

From Table 2.2 it emerges that international migrants in the Middle East represent on average 6.9% of the population. This average is lower than in the EU (9.8%) but it hides a wider cross-country variation. Though the stock of international migrants is only 0.2% in Morocco, it is much larger in the Gulf States (86.8% in Qatar, 84.1% in Kuwait, etc.). Latin American countries have a low base of foreigners in their societies.

The importance of international migration can be further substantiated by the bilateral migration matrix compiled by Özden *et al.* (2011) for the period 1960 - 2000. The systematic publication of the latter has been discontinued till 2010. Nevertheless, in that year, what we learn from Table 2.2, is that 27.6% of inflows of international migrants into EU-15 originate from within the region against 49.1% in Latin America and 30.6% in the Middle East. In contrast, the intra-regional outflow of nationals is 57% in the EU-15, reflecting the notional free mobility of workers and persons within the region. These percentages are lower for the other two regions, mainly due to the attraction of Northern America. Exploiting bilateral mobility data even further, it turns out that Egypt is the top source country in the Middle East with 3.7 million nationals living abroad. The top migration corridor within the region is Egypt having 1 million nationals living in Saudi Arabia. The top migration corridor into the Middle East includes India having 2.2 million persons being in the United Arab Emirates. This is little compared to the world's largest corridor, the

[5] A more exhaustive description of the data can be found on the EU website (http://ec.europa.eu/trade/), the ALADI website (www.aladi.org) and World Bank (2004).

Table 2.2: Selected summary statistics.

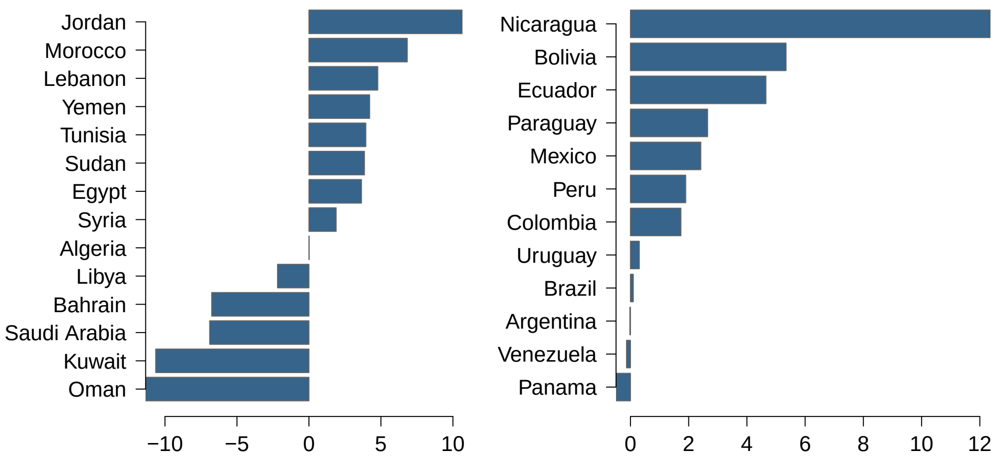
Statistics	EU-15	Latin American Integration Association	Middle East and North Africa
Stock of migrants			
(2005, % of population)			
Region$^{(i)}$	9.8	0.7	6.9
Max	33.6 (Luxembourg)	3.9 (Argentina)	86.8 (Qatar)
Min	3.3 (Finland)	0.1 (Cuba)	0.2 (Morocco)
Inflow of migrants	27.6	49.1	30.6
(2010, % coming from region)			
Outflow of nationals	57.0	23.3	32.5
(2010, % heading to region)			
Intra-regional trade	64.9	18.8	12.4
(2009, % of total trade)			
WTO participation			
Members	15	14	12
Observers	0	0	8$^{(ii)}$
Average participation in regional trade agreements$^{(iii)}$	35	8	3

Notes: (i) Euro area average is taken for EU-15, average of developing countries of Latin America and Carribean is taken for ALADI and Arab World average is taken for MENA; (ii) Observers are: Algeria, Iran, Iraq, Lebanon, Lybia, Syria, Sudan and Yemen; (iii) This corresponds to the average number of regional trade agreements notified to the GATT/WTO and in force.
Source: Own calculations based on World Bank and WTO.

12.2 million Mexicans living in the US (World Bank, 2011).

This pattern of international migration stocks is also reflected in the countries' balance of payments through remittances from abroad. Remittances paid from the Gulf Sates make the Gulf region one of the most remitting regions in the world (Naufal, 2011). High per capita income countries such as Oman and Kuwait are major payers of remittances in the region (see Figure 2.1). Their net remittances amount to about 11% of their GDP in 2009. On the other hand, Jordan, Yemen, Morocco, Egypt and other lower income and labour abundant economies have been repeated receivers of remittances throughout the last decade. Importantly, the outflow and the inflow of remittances in the Middle East has been very close in value till the Gulf war in 1990, suggesting that remittances were mostly intra-regional. As Naufal (2011) points out, however, after the Gulf war a systematic replacement of Arab workers by cheaper workers from the Indian subcontinent took place, which resulted in a large share of remittances flowing to Asian countries. Though remittances to the Middle East economies diminished since then, yet they remain substantial and illustrate the mutual benefits of labour mobility in the region. The pattern is very different in Latin America. The majority of countries are net receivers of remittances in 2009 (see Figure 2.1) and although several countries are net payers their net remittances do not even reach 1% of their GDP.[6]

Figure 2.1: Net workers' remittances to GDP in MENA (left) and ALADI (right).



Notes: (*i*) In percent; (*ii*) Year 2009; (*iii*) Current prices.
Source: Own calculations based on IMF Balance of Payments Statistics and World Bank.

It is a commonly held view that trade is a crucial instrument to achieve greater integration. Regions that demonstrate low trade performance are therefore often classified as poorly integrated. Intra-regional trade in the Middle East in 2009 is 12.4% (see Table 2.2). This is lower than intra-regional trade in the EU (64.9%)

[6]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. 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 IMF BOPS and World Bank). 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. In contrast, for all countries of Latin America GNI never exceeds GDP meaning that countries are net payers of factor income to the rest of the world: while there is a net inflow of remittances into the region there is a larger net outflow of investment income. This comes at no surprise as production of multinationals is widespread in the region while relatively few local firms have subsidiaries abroad.

and Latin America (18.8%). Ethnic conflicts, protectionism, similar comparative advantages and better product quality outside the region are reasons frequently invoked for this low percentage (see, e.g., Romagnoli and Mengoni, 2009). Standard trade openness indicators, however, remain considerably high even if fuel exports are excluded (see Table 2.3).[7] This is basically due to high imports in the Middle East that are largely financed by high oil revenues.

Table 2 reveals also that the EU and Latin America are regions that are part of the global system in that all countries are members of the WTO and are participants of several regional trade agreements (RTAs). In contrast only 12 Middle East countries are WTO members while the remaining 8 are observers. A very limited number of multilateral RTAs exist within the region. Intra-regional trade is being promoted through the Gulf Cooperation Council (GCC, a customs union comprising Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and UAE), the Pan-Arab Free Trade Area (PAFTA, 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 is 3 in contrast to the EU average of 35 and the Latin American average of 8.

2.3 Equality of Output and Factor Shares

Given this background the analysis of this section focuses on how the distribution of output and stocks of productive factors would 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. Particularly, human

[7] 74.9% of total MENA exports in 2009 were fuel exports (this percentage is computed using 2009 World Bank data on fuel exports of each MENA economy with the exeption of Iran and Mauritania, for which a 2010 figure was taken due to unavailability of 2009 data and United Arab Emirates, for which a 2008 figure was taken).

Table 2.3: 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.

capital is the factor complementary with physical capital, as it is one of Lucas' major explanations for his puzzle (Lucas, 1990).

2.3.1 The Economic Framework

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:

$$Y_{nt} = \gamma K_{nt}^{1-\delta\rho} \left(H_{nt} + (\rho - 1)K_{nt}\right)^{\delta\rho}, \tag{2.1}$$

where Y_{nt}, K_{nt}, H_{nt} denote output, physical capital and human capital respectively, $n = 1, ..., N$ is a country, $t = 1, ..., T$ a time index. Parameter values in (2.1) satisfy $\gamma > 0$, $0 < \delta < 1$, $0 < \delta\rho < 1$. The corresponding share of human capital in total output is $\delta\rho[1 + (\rho - 1)\frac{K_{nt}}{H_{nt}}]^{-1}$, decreasing in ρ and K_{nt}/H_{nt}. The 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 (2.1) is therefore 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. With $\rho > 1$, the latter is generally steeper as K_{nt}/H_{nt} increases.

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* (2.1)*, if no barriers to the free movement of goods, physical and human capital exist then*

$$\frac{Y_{nt}}{\sum_{k=1}^{N} Y_{kt}} = \frac{K_{nt}}{\sum_{k=1}^{N} K_{kt}} = \frac{H_{nt}}{\sum_{k=1}^{N} H_{kt}}. \tag{2.2}$$

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: Marginal products of human capital implied by (2.1) can be expressed as a function f of human-to-physical capital (x) and as a function g of output-to-physical capital (y). 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

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

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,

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

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

Perfect mobility of labour brings about the equalization of value 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. With free trade the price of the single good are similar across countries. Given this and the 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:

$$\frac{H_n}{K_n} = \frac{H_j}{K_j} \text{ and } \frac{Y_n}{K_n} = \frac{Y_j}{K_j}, \tag{2.3}$$

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 (2.3) 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 (2.2) follows.□

This proposition is simply the result of firms' profit maximization, the equalization of value marginal products across countries and the properties of equal ratios.[8] It has a number of implications. First, though equal-share relationship (2.2) has been derived in a frictionless environment, a similar expression obtains in the case of, for example, TFP differences across locations and barriers to international labour mobility. While the former are represented in the model by adding country subscript k to γ, the latter can be captured by a multiplicative wedge ω_k. This wedge is a shorthand for all distortions that potentially affect the marginal return to labour: income tax, migration quota, pension system, etc. As both parameters enter expressions for value marginal products directly they impact the allocation of primary factors across countries. Repeating the steps of the proof of Proposition 1, we obtain:

$$\frac{\alpha_n \overline{Y}_{nt}}{\sum_{k=1}^{N} \alpha_k \overline{Y}_{kt}} = \frac{\overline{K}_{nt}}{\sum_{k=1}^{N} \overline{K}_{kt}} = \frac{\beta_n \overline{H}_{nt}}{\sum_{k=1}^{N} \beta_k \overline{H}_{kt}}. \tag{2.4}$$

where $\alpha_k = (\gamma_k^{-\delta\rho}\omega_k)^{-\delta\rho/(1-\delta\rho)}$ and $\beta_k = (\gamma_k \omega_k)^{-1/(1-\delta\rho)}$. Importantly "$-$" represents

[8] 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 labour 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.

levels of output and factors that differ from (2.2). Thus, the introduction of TFP differences and barriers to free mobility though they rescale variables maintain the equal-share relationship.[9]

Second, 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 outside the region.[10] An inflow of human capital from outside the integrated area (for example, from India) will, at impact, affect relationship (2.2) for the nth country as follows:

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

Thus, migration into country n increases its share of the total stock of human capital. 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 (2.2) is restored, but now with country n achieving a relatively higher level of economic activity than originally.

Having established the equality of output and factor shares in integrated areas, we now verify its empirical validity. To that end we outline the construction of our data set and then perform empirical tests.

2.3.2 Data Sources and Methods

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:

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

---

[9]The last equality of relationship (2.4) requires, however, one of the following two conditions to hold: either $\rho = 1$ or $\alpha_k = \alpha_n$ in any bilateral comparison of marginal products of human capital.

[10]In contrast, an inflow of migrants from inside the region is endogenous. It responds to cross-country differences in wages and contributes to equality (2.2).

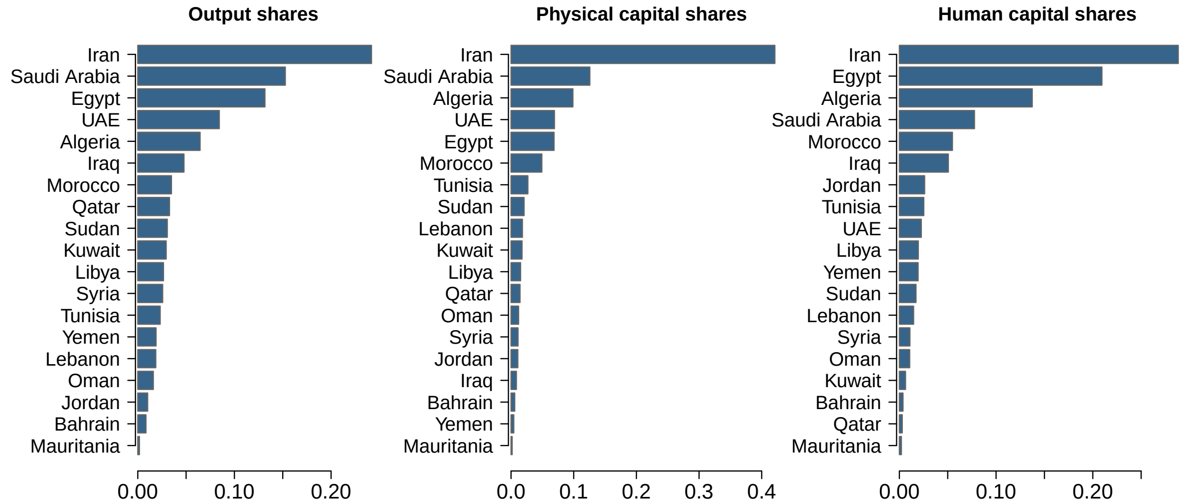
Factor shares S_{Knt} and S_{Hnt} are computed analogously. Hence, our sample includes country data on outputs and stocks of physical and human capital. Our data set is a balanced panel of annual data ranging from 1975 till 2009. This time range is particularly chosen because the Arab Spring makes the accuracy of data in key countries like Syria, Egypt and Lybia questionable.

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 the 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 implied by the capital 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 is measured as total population aged 15 and over that has at least completed secondary education. The data is obtained from version 1.3 of the 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 extrapolation is contained in Appendix 2.A.

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 2.2 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 2.3

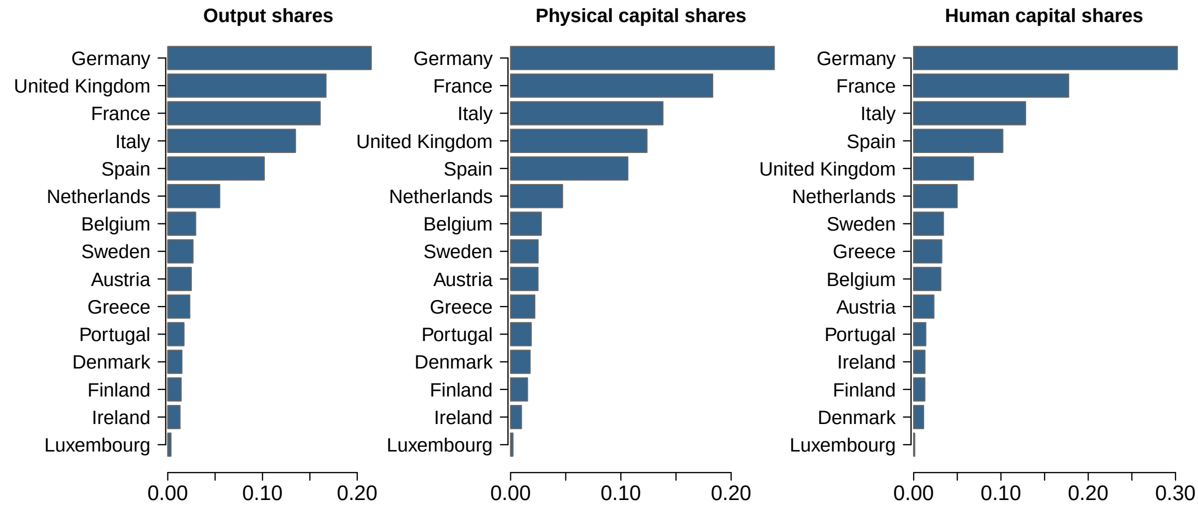
and 2.4.

Figure 2.2: Distribution of output and factor shares in MENA.



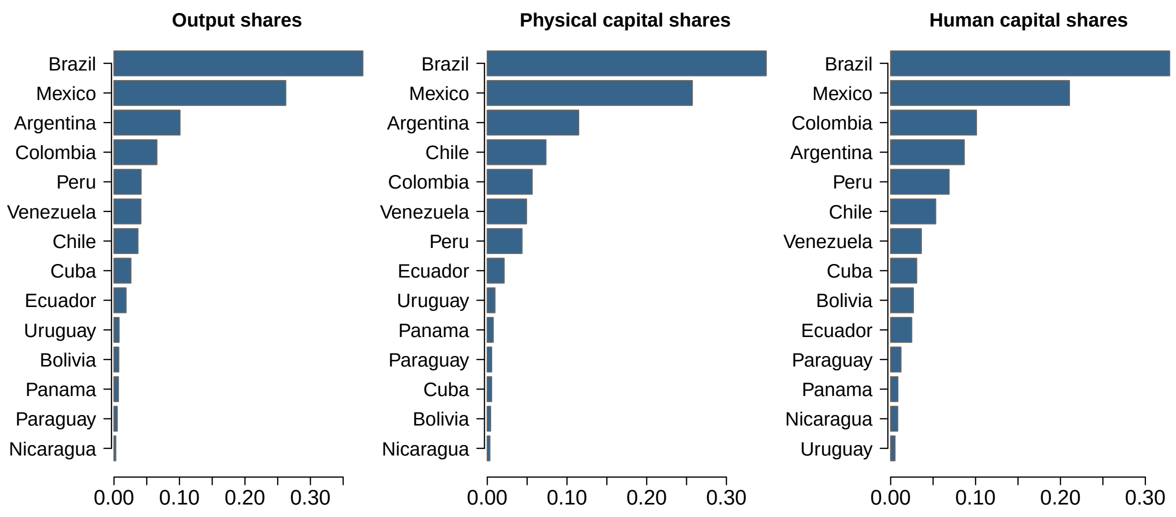
Note: Year 2009.
Source: Own calculations based on Penn World Tables 7.0, 6.2, 5.6, IMF IFS and Barro and Lee (2013).

Figure 2.3: 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 2.4: 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).

2.3.3 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 over time. Contrary to Pearson correlation, rank correlation not 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 2.4 reports pairwise Spearman rank correlations computed for the three regions at different time points. Although reported correlation coefficients are population values and as such are not subject to sampling errors we nevertheless report bootstrap confidence intervals in the brackets to take into account possible data measurement errors. The table reveals a significant positive relationship between any pair of shares. All the coefficients are close to or above 0.7. Thus, a country with a higher ranked output share tends to also have higher ranked factor shares. Particularly high, close to unity, coefficients are observed for EU-15 indicating a nearly perfect rank conformity. Correlations are also relatively stable over time with some but minor over time variation, which means that a country that takes a certain rank position is unlikely to change it quickly.

Table 2.4: Spearman rank correlations.

	Output-physical capital	Output-human capital	Physical capital-human capital
MENA			
1975	0.82 [0.51, 0.95]	0.74 [0.42, 0.89]	0.85 [0.57, 0.96]
1980	0.81 [0.47, 0.95]	0.75 [0.38, 0.90]	0.86 [0.58, 0.97]
1985	0.86 [0.59, 0.97]	0.79 [0.44, 0.94]	0.82 [0.45, 0.96]
1990	0.90 [0.68, 0.97]	0.84 [0.56, 0.96]	0.82 [0.49, 0.95]
1995	0.88 [0.63, 0.97]	0.80 [0.44, 0.96]	0.84 [0.52, 0.95]
2000	0.86 [0.61, 0.96]	0.81 [0.46, 0.96]	0.84 [0.54, 0.96]
2005	0.79 [0.42, 0.96]	0.76 [0.40, 0.93]	0.76 [0.38, 0.94]
2009	0.80 [0.45, 0.96]	0.71 [0.30, 0.92]	0.68 [0.26, 0.91]
ALADI			
1975	0.93 [0.71, 1.00]	0.92 [0.71, 0.98]	0.93 [0.69, 0.99]
1980	0.93 [0.72, 1.00]	0.92 [0.63, 1.00]	0.89 [0.58, 1.00]
1985	0.93 [0.71, 1.00]	0.94 [0.69, 1.00]	0.93 [0.69, 1.00]
1990	0.95 [0.72, 1.00]	0.94 [0.72, 1.00]	0.92 [0.66, 1.00]
1995	0.96 [0.84, 1.00]	0.94 [0.76, 1.00]	0.87 [0.57, 0.98]
2000	0.94 [0.75, 1.00]	0.93 [0.71, 1.00]	0.84 [0.49, 0.97]
2005	0.92 [0.67, 1.00]	0.91 [0.67, 0.99]	0.80 [0.39, 0.96]
2009	0.90 [0.65, 1.00]	0.93 [0.70, 1.00]	0.82 [0.42, 0.96]
EU-15			
1975	0.97 [0.86, 1.00]	0.97 [0.86, 1.00]	0.99 [0.90, 1.00]
1980	0.99 [0.91, 1.00]	0.97 [0.86, 1.00]	0.98 [0.90, 1.00]
1985	0.99 [0.94, 1.00]	0.99 [0.91, 1.00]	1.00 [0.95, 1.00]
1990	0.99 [0.90, 1.00]	0.97 [0.84, 1.00]	0.97 [0.86, 1.00]
1995	0.99 [0.92, 1.00]	0.97 [0.84, 1.00]	0.98 [0.90, 1.00]
2000	1.00 [0.95, 1.00]	0.98 [0.89, 1.00]	0.99 [0.91, 1.00]
2005	0.99 [0.91, 1.00]	0.96 [0.82, 1.00]	0.98 [0.89, 1.00]
2009	0.99 [0.91, 1.00]	0.95 [0.80, 1.00]	0.96 [0.83, 1.00]

Notes: (*i*) Although correlation coefficients are population values and not subject to sampling errors we report bootstrap confidence intervals in the brackets to account for possible data measurement errors; (*ii*) 5% significance level; (*iii*) Number of bootstrap replications is 5000.

Though Proposition 1 established the equality of shares, its underlying assumptions can be used to explain why deviations from equality might be observed in empirics. First, part of the equality of shares in (2.2) 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 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 (2.2) no longer equals the other two. Second, 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 (2.2). In this case, the physical capital share in (2.2) no longer equals the other two. Lastly, the human capital share in (2.4) differs from the other two when, as shown in footnote 9, the assumptions $\rho = 1$ or $\alpha_k = \alpha_n$ are not verified in any bilateral comparison of marginal products of labour.

2.4 Steady State Equilibrium Distribution of Shares

2.4.1 Dynamics of Shares

We assume that changes in shares 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, stocks of human and 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 $b = \min S_{jnt}$ and upper bound $d = \max S_{jnt}$. That is, we assume:

$$\frac{dS_{jnt}}{S_{jnt}} = \mu dt + \sigma dB_t + dL_t - dU_t, \tag{2.5}$$

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:

$$\sum_{n=1}^{N} S_{jnt} = 1, \qquad t = 1, ..., T. \tag{2.6}$$

The evolution of shares spelled out in (2.5) recognizes a link between output and primary factors in that 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. Later in this section, however, we discuss the case of explicitly modelled correlations. Given this we show:

Proposition 2 *If shares evolve according to a reflected Brownian motion given by* (2.5) *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:*

$$F_{jn\infty}(S) = P(S_{jn\infty} \leq S) = 1 - \frac{S^{\frac{2\mu}{\sigma^2}-1}}{b^{\frac{2\mu}{\sigma^2}-1} - d^{\frac{2\mu}{\sigma^2}-1}}, \quad S \in [b, d]. \tag{2.7}$$

Proof: Itô lemma applied to $\log S_{jnt}$ yields the following expression for (2.5) for any initial value S_{jn0} :

$$\begin{cases} \log\ S_{jnt} & = X_{nt} + L_t - U_t \\ X_{nt} & = \log S_{jn0} + \left(\mu - \frac{\sigma^2}{2}\right) t + \sigma B_t \end{cases} \tag{2.8}$$

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 (2.8). 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 (2.7).[11]□

It is clear from (2.7) that though realizations of states of nature differ distributions of output and factor shares are similar when $\mu = 0$.

An important extension of the proposition is that the steady state distribution exhibits power law behaviour even when shares of country i and country j and/or output and factor shares are correlated. The shares must follow RGBM with a sole lower barrier and 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:

$$P(S_{jk} \geq S_{jn}) = \frac{R_{jn}}{N}. \tag{2.9}$$

Using the cumulative distribution function of shares (2.7) we obtain:

$$P(S_{jk} \geq S_{jn}) = 1 - P(S_{jk} < S_{jn}) = \frac{S_{jn}^{-\beta}}{b^{-\beta} - d^{-\beta}}, \tag{2.10}$$

[11]When $d = \infty$ it is a Pareto distribution with the tail index equalling $\left(1 - \frac{2\mu}{\sigma^2}\right)$. The tail index can take any positive value. The adding-up constraint (2.6) that we impose further will prevent shares from being infinite in expectation in case the tail index is smaller than 1.

where $\beta = 1 - \frac{2\mu}{\sigma^2}$. Using expressions (2.9) and (2.10) we obtain a non-linear relationship between a rank and a share:

$$S_{jn} = \frac{\lambda^{1/\beta}}{R_{jn}^{1/\beta}}, \tag{2.11}$$

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

2.4.2 Empirical Results

Having described the properties of our fully integrated group of economies through Propositions 1 to 2 we now estimate the long-term relationship derived from the steady state distribution of shares and show ways to apply maximum likelihood on available data to estimate μ and σ.

Power Law

Equation (2.11) is a long-run relationship derived from the steady state distribution of shares, a so called power law. The distribution of ranks S_{jn} is said to follow a power law when, for sufficiently large values of the nth ranked variable S_{jn}, its size is inversely proportional to a power of its rank. Taking the natural logarithm of (2.11) yields:

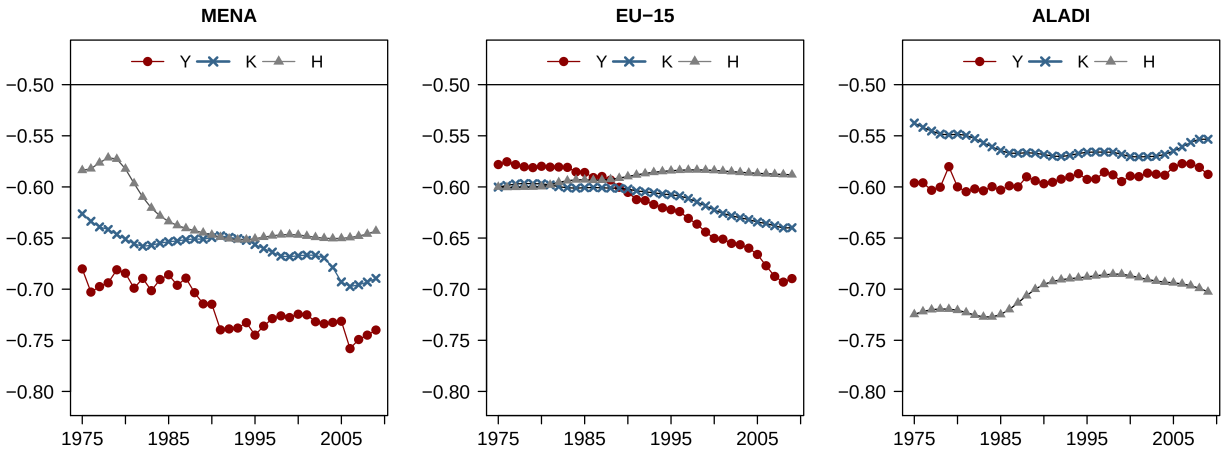
$$\log R_{jn} = \log \lambda - \beta \log S_{jn}, \quad j \in \{Y, K, H\}.$$

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. To correct for a possible small sample bias we follow Gabaix and Ibragimov (2011) and use adjusted ranks:

$$\log (R_{jn} - 1/2) = \log \lambda - \beta \log S_{jn}, \quad j \in \{Y, K, H\}. \tag{2.12}$$

Figure 2.5 shows the estimated slopes of regression (2.12) for the three sets of shares in the three regions under consideration.

Figure 2.5: Estimated power law exponents $-\beta$.



Notes: *(i)* The exponents are significantly different from zero and one at the 5% level. *(ii)* The coefficient of determination varies between 0.60 and 0.91.

Estimated exponents are all significantly different from zero at the 5% significance level. The data therefore can be indeed well described by power laws. The estimates, however, are all significantly different from one, which indicates that there are significant deviations of the share distributions from Zipf's law. A slight decreasing trend, however, can be observed for most of the exponents, which is a sign that, although slowly, convergence to Zipf's law may be taking place.

Maximum Likelihood Estimation of RGBM Parameters

The second part of our empirical analysis uses historical series to estimate the parameters of the reflected geometric Brownian motion. We follow the estimation approach outlined in Aït-Sahalia (2002) and apply maximum likelihood (ML) on available data for output and factor shares to estimate the 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 derived in Veestraeten (2008). In this case the density reads:

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

where

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

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:

$$
\hat{\theta} = \arg\max_{\theta} \ell(\theta) \tag{2.13}
$$

with the log-likelihood function ℓ being:

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

Solution to (2.13) can be obtained by various numerical optimization algorithms such as, for example, the algorithm of Broyden-Fletcher-Goldfarb-Shanno (BFGS).

Estimation results of model parameters μ and σ for each set of shares are presented in Table 2.5.[12] From the table it is clear that the volatility of output shares is the largest. This is partly due to the fact 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 the Middle East is high though expected since MENA countries have experienced numerous armed conflicts that significantly affected its output. That volatility in EU is so low can be explained by policy coordination that is a key to the region. For example, consider the scenario where all N countries in

[12] We tested this estimation procedure on numerous simulated RGBMs with different μ and σ to see how estimation using normalized data affects parameter estimates. The method delivers estimates that are consistent with true parameter values when simulated data is non-normalized. When simulated RGBM data is normalized and then used as input for estimation, the method still delivers volatility (but not drift) estimate close to its true value.

the integrated area put in place a coordinated policy such that the human capital of each member country increases by a factor λ ($\lambda > 1$). Then, using (2.2):

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

Table 2.5: Estimates of drift and volatility parameters.

		Full sample (1975 - 2009)		1982 - 2009	
Region	Variable	Drift μ	Volatility σ	Drift μ	Volatility σ
MENA	Output shares S_Y	0.013*	0.117*	0.006	0.106*
	Physical capital shares S_K	0.005*	0.041*	0.003*	0.028*
	Human capital shares S_H	0.002	0.037*	0.001	0.030*
EU-15	Output shares S_Y	0.004*	0.020*	0.003*	0.020*
	Physical capital shares S_K	0.003*	0.012*	0.002*	0.012*
	Human capital shares S_H	-0.007*	0.023*	-0.009*	0.022*
ALADI	Output shares S_Y	0.001*	0.053*	0.000	0.057*
	Physical capital shares S_K	0.000	0.024*	0.001	0.021*
	Human capital shares S_H	-0.004*	0.024*	-0.006*	0.023*

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

In this situation shares are not modified and the relative position of each country in the total remains unchanged. It is clear from the above equation that complete harmonization of policies, expressed in growth factors, makes these shares deterministic and 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 this result. This is a useful benchmark for our empirical analysis.

2.5 Assessing the Degree of Economic Integration

2.5.1 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*

$$\frac{S_{j1}}{S_{j2}} = 2^{\frac{1}{\beta}},\ \frac{S_{j1}}{S_{j3}} = 3^{\frac{1}{\beta}},\ ...,\ \frac{S_{j1}}{S_{jN}} = N^{\frac{1}{\beta}}. \tag{2.14}$$

and

$$S_{j1} = \frac{1}{\sum_{n=1}^{N} n^{-\frac{1}{\beta}}} \tag{2.15}$$

Proof. Using (2.11) 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 (2.14).□

Proposition 3 gives rise to a number of observations. First, assuming $\mu = 0$[13] 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

[13] $\mu = 0$ follows from the adding-up constraint (2.6). Let $g_{jnt} = \frac{S_{jnt}}{S_{jn,t-1}} - 1$ denote the growth rate of factor j, country n at time point t. Then (2.6) implies $\sum_{n=1}^{N} S_{jn,t-1} g_{jnt} = 0$. Taking average of this expression over time gives $E_t \sum_{n=1}^{N} S_{jn,t-1} g_{jnt} = \sum_{n=1}^{N} S_{jn,t-1} E_t g_{jnt} = 0$ and because in our model the drift parameter μ does not vary across countries, this holds only if $E_t g_{jnt} = 0$. Therefore, the average growth rate must be zero.

computation of shares for any region under investigation.[14] Table 2.6 applies the proposition to the Middle East and gives the complete distribution of shares for the region. Likewise Table 2.6 includes the theoretical distribution of shares for our two control groups, namely the EU-15 ($N = 15$) and the Latin American Integration Association ($N = 14$). It is worth noting that as long as the drift parameter μ is zero the steady state distribution is not affected by volatility. This allows for heterogeneity of volatility parameters across variables and across countries. We denote the steady state distribution as $\bar{S}$.

Table 2.6: 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
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

[14]An implicit property of the concept of shares is share summation to one given by (2.6). 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 implied by (2.11) and set it equal to the first share found in (2.15) 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 $b = \frac{N^{-\frac{1}{\beta}}}{\sum_{n=1}^{N} n^{-\frac{1}{\beta}}}$.

2.5.2 Measurement of Integration

Given the theory and the empirical analysis of the preceding sections we now assess and interpret the gap between the limiting distribution of Table 2.6 and the observed outcomes characterized by the data.

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

$$I_E(\bar{S}, S_t) = e^{-E(\bar{S}, S_t)}, \tag{2.16}$$

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:

$$E(\bar{S}, S_t) = \frac{1}{3} \sum_{j=Y,K,H} \sqrt{\sum_{n=1}^{N} (\bar{S}_{jn} - S_{jnt})^2}. \tag{2.17}$$

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 $I_E(\bar{S}, S_t)$.[15] Due to share summation to one in (2.6) there exists a strictly positive lower bound of the measure. We estimate this value to be equal to 0.55. This estimate is the minimum value of (2.16) obtained by taking 10000 bootstrap samples with replications from the data on an extended set of regions.[16] The integration index therefore takes values within the $(0.55, 1]$ interval, with 1 arising under full integration.[17]

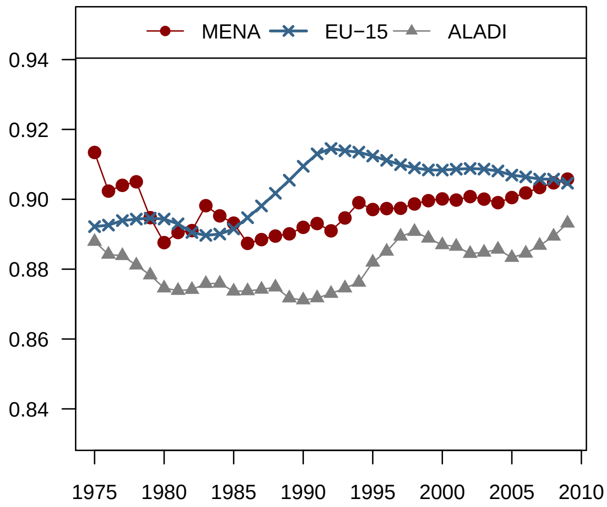
[15]To test robustness of our findings to different measures of distance between observed and theoretical shares we also compute the Theil entropy index. The index is given by $T(\bar{S}, S_t) = \frac{1}{3} \sum_{j=Y,K,H} \left(\sum_{n=1}^{N} \bar{S}_{jn} \ln \left(\frac{\bar{S}_{jn}}{S_{jnt}} \right) \right)$ and respectively the integration measure $I_T(\bar{S}, S_t) = e^{-T(\bar{S}, S_t)}$. Like 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 using this index lead to the same conclusions as the results of integration index I_E.

[16]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).

[17]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

Computation of $I_E(\bar{S}, S_t)$ makes use of the following information. Theoretical shares are found in Table 2.6 while observed shares are ranked in the descending order so that rank 1 ($n = 1$) is attributed to the country with the largest share in the area; rank 2 ($n = 2$) to the second largest share; etc. Figure 2.6 displays the computed index values.

Figure 2.6: Integration measure I_E.



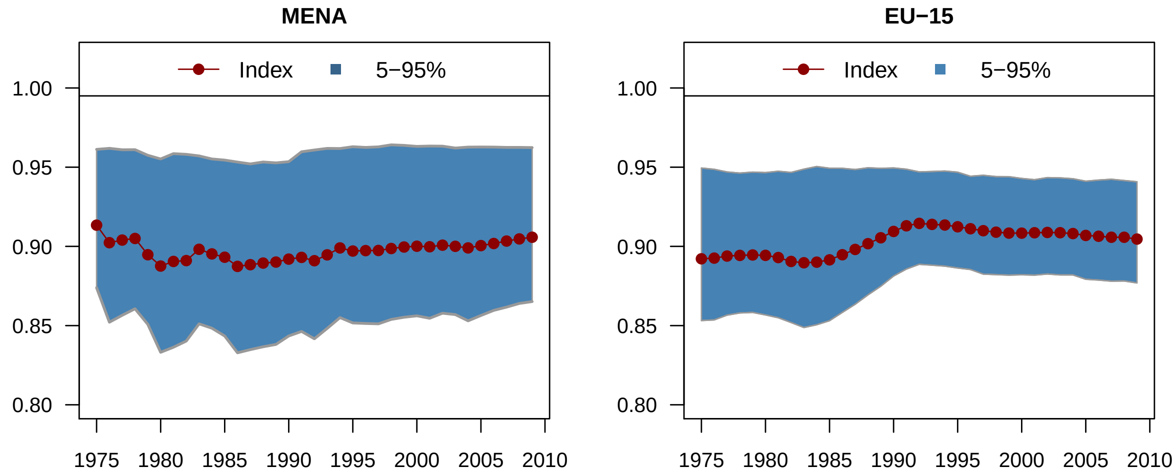
The results suggest that since mid 1980s the degree of economic integration is the highest in the EU-15. However, MENA and ALADI also show high and increasing index values.[18] Surprisingly, the value of the index in the Middle East is comparable to the EU-15 in 2009, at the height of the financial crisis and just before the Arab Spring. The values of the indices are, however, all significantly lower than unity suggesting that although high, integration in MENA and EU-15 is incomplete (see Figure 2.7).[19]

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.

[18]Slope estimate of the integration index regression on time is significant at the 5% level for the period 1980 - 2009.

[19]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 exist. Statistical significance in this case accounts rather for possible data measurement errors.

Figure 2.7: Integration measure I_E with estimated confidence bounds.



Note: Shaded area denotes a 95% confidence interval obtained by taking 10000 bootstrap samples with replications.

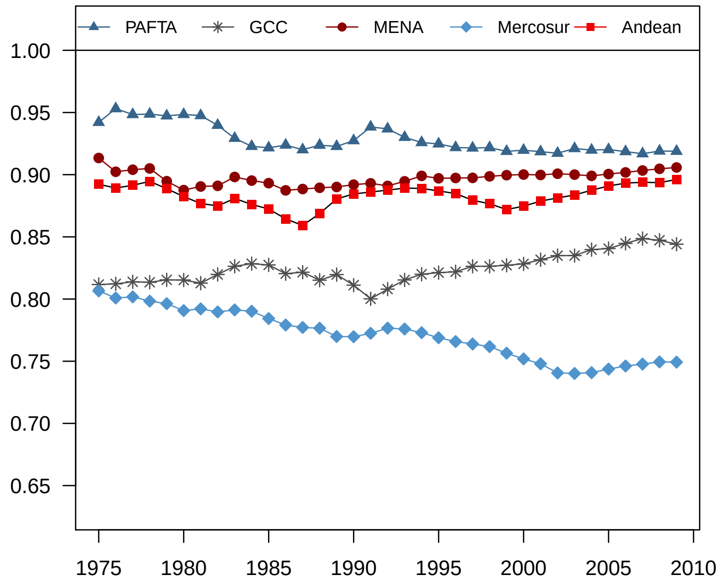
2.5.3 Regional Comparisons

The computation of the integration index also reveals considerable regional differences. For example, the results indicate that the degree of integration in MENA is lower than that in the countries that constitute PAFTA (also known as the Greater Arab Free Trade Area or GAFTA). PAFTA has a long history in trying to promote trade and economic cooperation between its members with first initiatives taken as early as 1950s. While most of the earlier agreements were poorly implemented and hardly effective, Figure 2.8 suggests that the creation of PAFTA did have a positive effect.[20] Another economic area in the Middle East - GCC - shows instead a lower integration level. It may be explained by the fact that most of the GCC economies are major world oil exporters and as such direct most of its trade to non-GCC countries. 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 intra-regional trade are unlikely to be large so would be the gains of the entire region suggesting that there indeed exists a limit to the degree of integration in the regions that consist of one large and a few smaller economies. The

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

index takes even lower values for the Southern Common Market (Mercosur).[21] Just like GCC Mercosur also includes a clear dominant member - Brazil - that takes the largest share in regional output, physical and human capital. Andean Community (Andean),[22] another economic area in the South American continent, shows instead an integration level comparable to that of MENA. These results are in line with other empirical studies on the effectiveness of trade agreements in Latin America.[23]

Figure 2.8: Integration measure in different regions of the Middle East and Latin America.



2.5.4 Re-computed Integration Measures

Our results so far indicate that economic integration in the Middle East is seemingly comparable to that of EU-15 in 2009. Is it due to economic factors or to any

[21]Mercosur is a customs union that currently comprises Argentina, Brazil, Paraguay, Uruguay and Venezuela. The agreement is in force since 1988 as notified to WTO.

[22]Andean Community is a customs union that consists of Bolivia, Colombia, Ecuador and Peru. The union took effect in 1991 for trade in goods and was extended in 2005 to include trade in services.

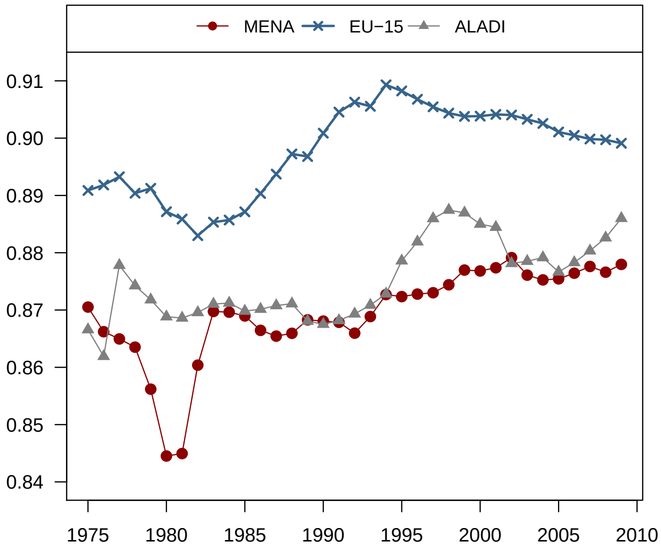
[23]For example, in their gravity analysis of bilateral trade flows between Mercosur countries García *et al.* (2013) find positive but very moderate effects of the agreement on intra-Mercosur trade. In a similar framework Carrillo-Tudela and A Li (2004) investigate the impact of both Mercosur and Andean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

distortion in our measurement? These questions raise the issue of robustness of our results. To that end we use the results on the conformity of ranks implied by Proposition 1 and then re-compute our indices.

Spearman rank correlations in Section 2.3.3 indicate that the conformity of ranks is not perfect, i.e. the equal-share relationship, that should hold in our fully integrated benchmark, does not always hold in the data. We did not take this into account while computing the deviations from the fully integrated benchmark in our index (2.17). We essentially missed to assure that the country that ranks the nth in the observed distribution of shares is the same across all types of shares. There are three ways to re-compute index (2.17) so that this distortion was accounted for and the deviations from the fully integrated benchmark were quantified more accurately. We can compute the index 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 latter and consider the case of the Iranian Revolution in 1979.

A glance at the data reveals that the Iranian Revolution 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 the 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 penalties for such violations must be introduced in (2.17) to accurately quantify deviations from the fully integrated benchmark. Thus, Iran is ranked the first in 1980 for both human (H) and physical capital (K). To preserve the equality of shares, Iranian output (Y) is positioned the first though it is not, which introduces a large gap between $\bar{S}_1$ and $S_{Y1,1980}$. $E(\bar{S}, S_t)$ increases and the integration measure decreases as a result of this correction. The more a country violates the equal share relationship the larger are the deviations and the smaller is the value of the integration index. Likewise the revision of the integration index can be performed using observed output and physical capital shares instead.

Figure 2.9: Integration measure re-computed.



Note: 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.

Figure 2.9 illustrates the re-computed integration index. Output and physical capital based computations yield analogous results.[24] As Figure 2.9 suggests, when equality of shares is taken into account, the integration index takes higher values for EU-15 throughout the entire time period analyzed including also 2009 and the period preceding 1980s. This is because conformity of ranks is higher in EU-15 and therefore 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

[24]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 2.3). 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 Appendix 2.A). 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.

that the extent of integration in the Middle East is effectively larger than commonly believed.

2.6 Counterfactuals

The analysis in Klein and Ventura (2009) leads us to conclude that regulation of labour mobility is a distortion of first-order importance. They quantify that even small differences in barriers to labour mobility can have substantial implications for the allocation of labour forces as well as the size of output and capital stocks. In Bernanke (2005), Gourinchas and Rey (2014), a powerful case is made that demographic characteristics can also explain global imbalances. This section explores the quantitative implications of our results.

A country's stock of human capital in our empirical analysis is measured by multiplying the percentage of its population aged 15 and over with at least a secondary level of education times its local population. This construct includes thus a policy variable, the rate of educational attainment, and a demographic variable, population. Policy makers can affect the former by closing gender gaps in education and changing the ending age of compulsory schooling; they can alter the latter by removing barriers to international labour mobility.

Focusing on the Middle East in year 2010, we compute the distribution of human capital that would prevail under complete integration. Specifically, given the actual distribution of human capital in 2010, our numerical exercise solves for the 19 unknown stocks of human capital such that it matches the MENA theoretical shares of Table 2.6. Our numerical results are reproduced in column (2) of Table 2.7 and are compared to actual stocks in column (3).

Results of Table 2.7 suggest that for a large number of countries in the Middle East a significant increase in human capital is needed to achieve the level compatible with full integration: the percentage change in column (3) is positive for the majority of countries. In larger countries with a low percentage of schooled population (Mauritania, Syria, Yemen)[25] most efforts should be devoted to the improvement of

[25] See also Figure 2.A.2 in Appendix 2.A.

Table 2.7: Counterfactual implications: complete integration.

Country	Stock of human capital		Difference
	Actual (2010)	Theoretical	$\frac{(2)}{(1)} - 1$, %
	(1)	(2)	(3)
Algeria	12670555	8628558	-31.9
Bahrain	341700	1522687	345.6
Egypt	19101817	12942838	-32.2
Iran	26019339	25885675	-0.5
Iraq	4778917	4314279	-9.7
Jordan	2388708	3697954	54.8
Kuwait	591043	1617855	173.7
Lebanon	1356728	1991206	46.8
Libya	1796990	2353243	31.0
Mauritania	194439	1362404	600.7
Morocco	5074259	5177135	2.0
Oman	1008028	1848977	83.4
Qatar	254767	1438093	464.5
Saudi Arabia	7389469	6471419	-12.4
Sudan	1654617	2157140	30.4
Syria	993174	1725712	73.8
Tunisia	2326392	3235709	39.1
United Arab Emirates	2043778	2876186	40.7
Yemen	1850918	2588568	39.9

educational attainment rates. In smaller economies, like Bahrain, Qatar and Kuwait, sole education policies are, however, unlikely to lead to a sufficiently large increase of human capital. In those economies education policies must be accompanied with the ones that could attract more human capital from abroad (e.g. Algeria, Egypt or Saudi Arabia). The results also indicate that Iran and Morocco do not need major education or immigration reforms as their stocks of human capital in 2010 are close to what a fully integrated benchmark implies.

2.7 Concluding Remarks

The chapter developed a framework that enables the measurement of the degree of economic integration among a group of countries. The objective was to construct 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 allowed for a comparison of integration indices over time and across regions. It was performed on the European Union, Latin America and the Middle East, the latter being characterized by low intra-regional trade and limited involvement in the global system. We have shown that degrees of integration in 2009 were very close, that of the Middle East being just 2.4% lower than in EU-15, a benchmark of "complete" integration.

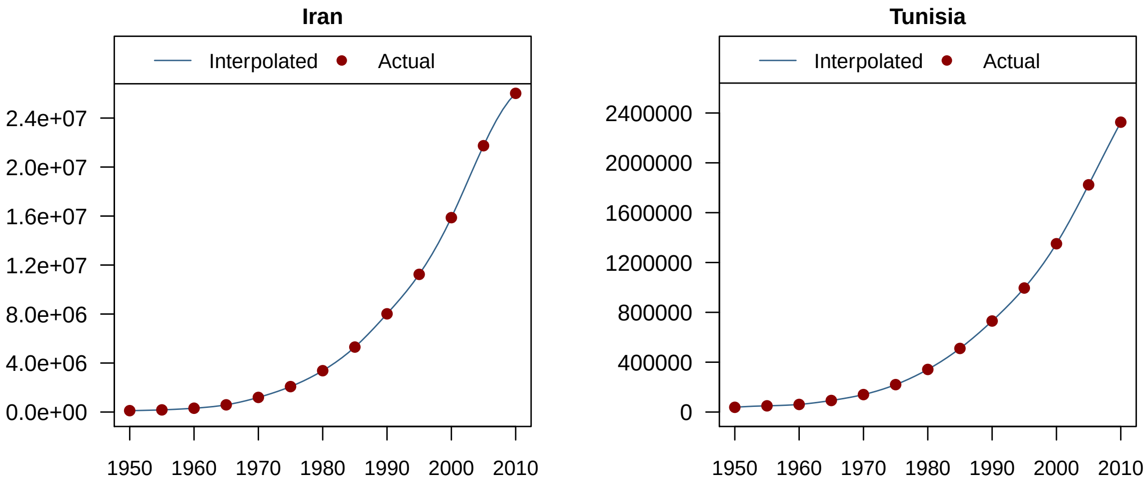
It is a commonly held view that trade is the instrument of choice to achieve greater integration. Regions that demonstrate low intra-regional trade are often concluded to be poorly integrated. The chapter casts doubt on the assertion that trade is necessary in order to achieve a high level of economic integration among a group of countries. What we have shown is that international labour and capital mobility 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.

2.A 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[26] and is obtained from Barro and Lee's data set on educational attainment (version 1.3). 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. The data shows a clear exponential growth and we use cubic spline interpolation to obtain annual data. The method is illustrated in Figure 2.A.1 with points representing original figures before interpolation.

Figure 2.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 extrapolated 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 we approximated its ratio of population with a complete secondary education

[26]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.

to total population over 15 with the average ratio of Jordan and Saudi Arabia. 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 data on the latter two indicators is obtained from the national statistical office in Oman.[27] Immigrants make up 28.4% of Omani population.[28]

Human capital demonstrates a clear exponential growth. In 2010 human capital in MENA constituted 32.5% (32.3% Lebanon and Oman excluded) of the total MENA population aged 15 and over. This ratio is higher when for ALADI (38.7%) and it is even higher for EU-15 (52.04%). As Figure 2.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.

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 2.A.2). This may explain a large drop in our integration measure when output based computation for EU-15 is performed.

Physical Capital

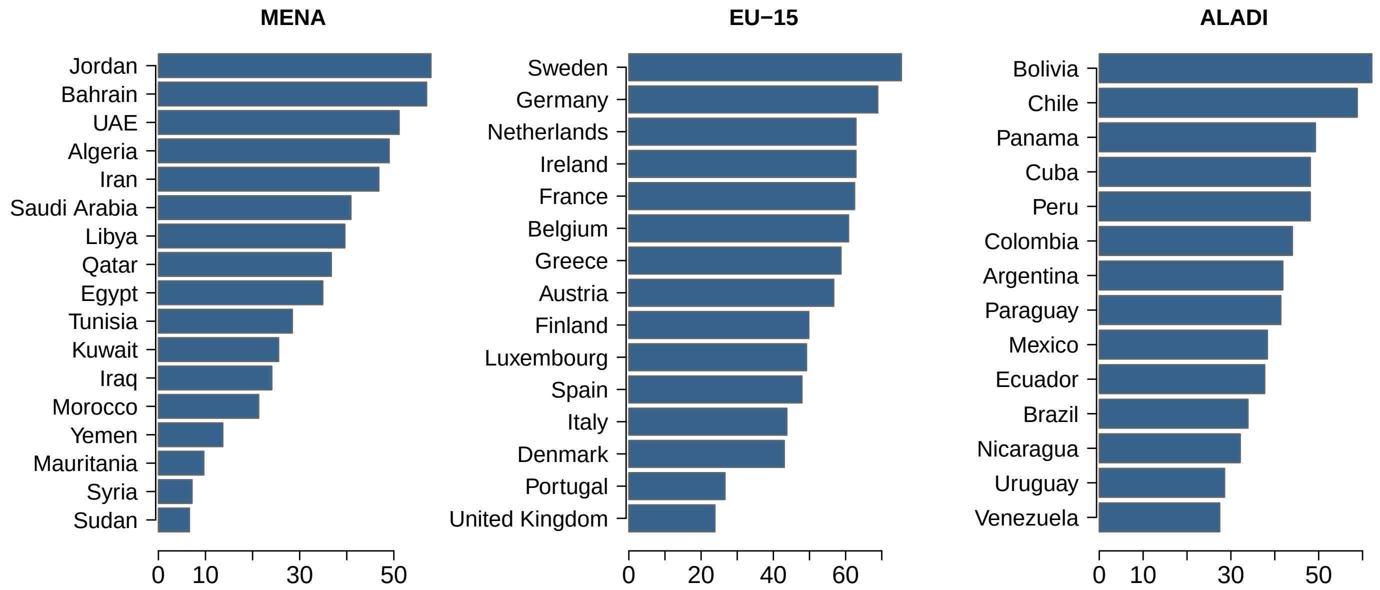
Data for physical capital in all regions come from Penn World Tables, version 6.2 (PWT 6.2) and cover the period of 1950 - 2004. The data is in constant prices with the base year of 2000. Measurement units are international dollars. Given that this is the most recent capital stock data available, year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

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.

[27] 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.

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

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



Note: Year 2010.
Source: Barro and Lee (2013).

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

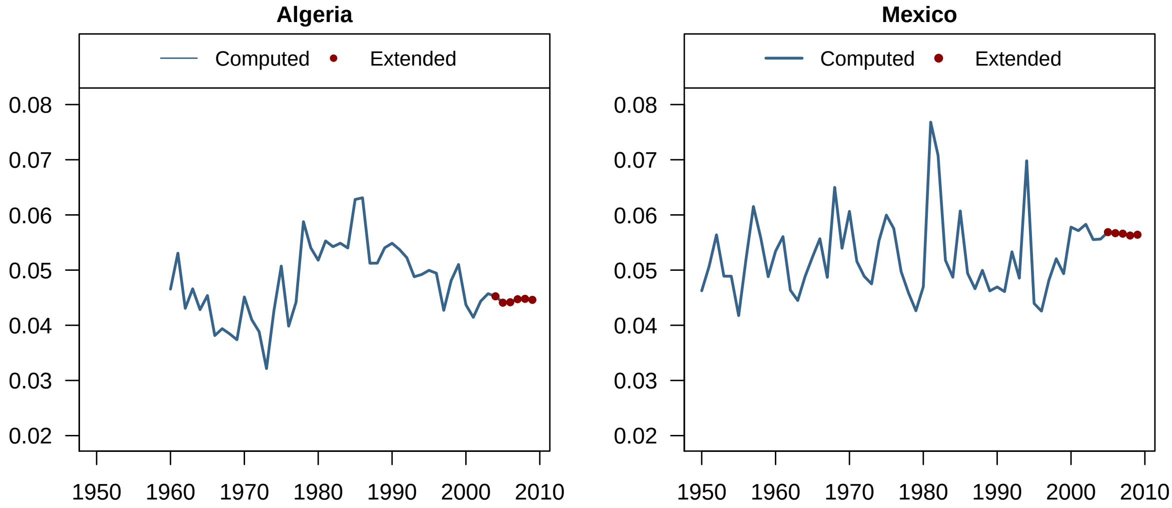
$$K_{it} = (1 - \delta_{it})K_{it-1} + I_{it}$$

we computed depreciation rates δ_{it} and by applying a 5-year moving average we extended the rates until 2009 (see Figure 2.A.3).

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}

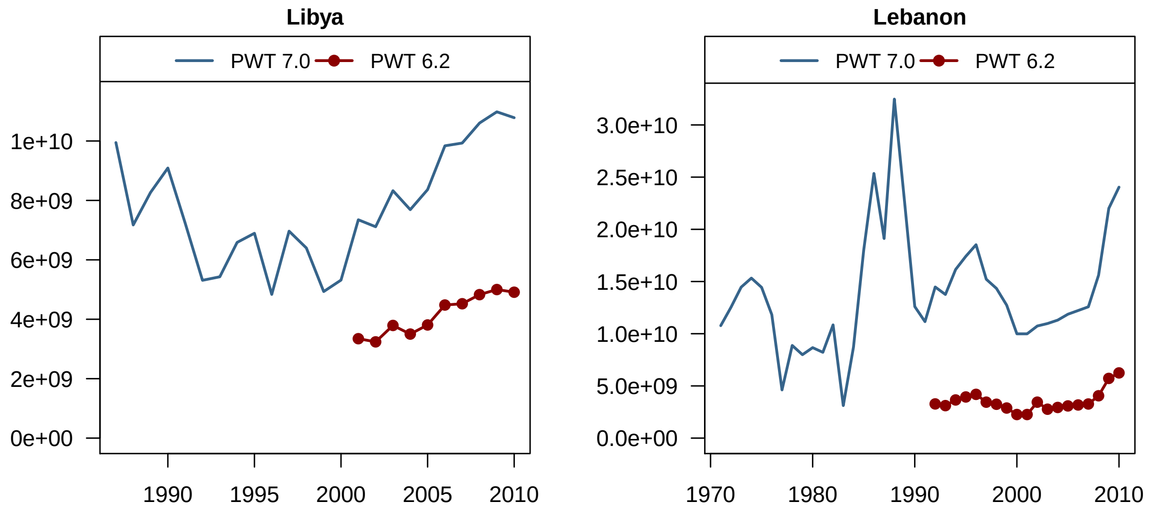
Figure 2.A.3: Depreciation rates: the example of Algeria and Mexico.



Source: Own calculations based on PWT 6.2.

for $t = 2004(2005), ..., 2009$ using inventory rule. It is to mention 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 2.A.4).

Figure 2.A.4: Difference in total real investment as available in PWT 6.2 and PWT 7.0: the example of Libya and Lebanon.



Source: PWT 6.2, PWT 7.0.

To estimate unavailable capital data for Lebanon, Libya and Yemen we employed real investment-to-GDP ratios available 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.

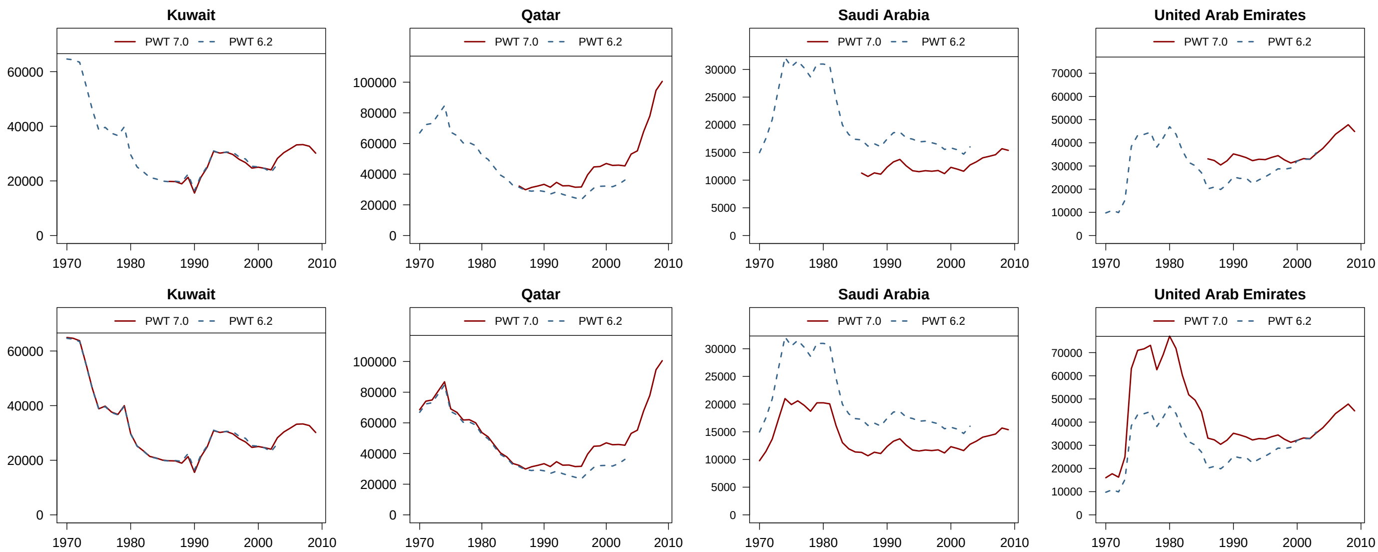
Output

Output in all country groupings, measured by real GDP, is obtained from 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 2.A.5), the growth rates in overlapping years remain very similar, maintaining the plausibility of estimated data.

Figure 2.A.5: Output data extension for Kuwait, Qatar, Saudi Arabia and UAE.



Note: PWT 6.2 (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 some 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 for the period 1970 - 1989 prior to its unification.

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

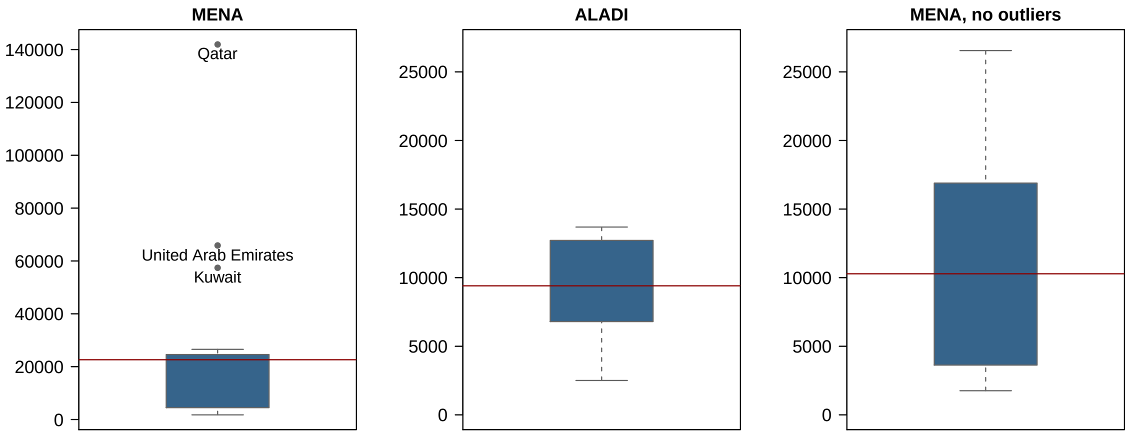
Average income per capita: MENA and ALADI

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 22618.5 international dollars.[29] 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 2.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.[30] 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 2.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

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

[30]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 2.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.

Chapter 3

Advanced Economy Inflation: the Role of Global Factors*

3.1 Introduction

Recent studies document the increased role of global factors in driving domestic inflation developments, suggesting that it could be important to augment standard inflation models with global variables.

One strand of the literature has emphasized the importance of global output gap as a determinant of domestic inflation processes. Borio and Filardo (2007), for example, found that proxies for global economic slack added considerable explanatory power to traditional benchmark inflation equations in advanced economies and that the role of global factors had grown over time. The relevance of the global output gap was also supported by Milani (2009) for the US after 1985.[1] Other studies (Ihrig *et al.*, 2010; Calza, 2008; Gerlach *et al.*, 2008), however, find conflicting evidence and suggest that Borio and Filardo (2007) results are likely to be specific to the estimation sample or particular measurement of the global output gap. No significant global output gap effects were also detected by Eickmeier and Pijnenburg (2013). The authors, however, identify that common changes in unit labour costs are im-

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[1]Importance of global output gap is also established in all New Keynesian open economy models (see, e.g. Clarida *et al.*, 2002, Galí and Monacelli, 2005).

portant in determining domestic inflation and conclude that, together with import prices, foreign competition and global interest rates, their developments should be carefully observed by policy makers.

A second strand of the literature has focused on the common component in national inflation rates. Ciccarelli and Mojon (2010) note significant co-movement in advanced economy inflation rates and find that models which include a measure of global inflation consistently improve benchmark national inflation forecasts.[2] Neely and Rapach (2011) support their view. By analyzing a larger group of countries in a dynamic factor model setting they find that on average over half of variation in domestic inflation is explained by an "international" (world or regional) component.[3] Mumtaz and Surico (2012) follow a similar approach but focus only on industrialized economies. They confirm that both the level and persistence of domestic inflation are reasonably well tracked by a single global factor. Taken together these strands of the literature suggest that inflation should be modelled as a global rather than a national phenomenon.

There are a number of reasons why global factors may be playing a more prominent role in shaping domestic inflation dynamics. One argument is that globalization has rendered national inflation less responsive to domestic capacity constraints, either because a sudden expansion in demand for goods would translate into higher imports rather than into higher prices or because foreign competition constrains wage or price increases in industries open to global competition, and lowers the sensitivity of wages to productivity increases (e.g. Guerrieri *et al.*, 2010). Another argument emphasizes the role of credible monetary policies that stabilized inflation expectations and trend inflation (e.g. Mishkin, 2009). With domestic price expectations well anchored proportionally more of the variation in national inflation rates would be explained by exogenous global price shocks such as commodity price changes.

Understanding the role of global factors may also contribute towards explain-

[2]Ferroni and Mojon (2014) perform a similar analysis but use a wider range of forecasting models and include the 2008/2009 recession in the forecasting sample. The authors draw similar conclusions - global inflation augmented model performs better than other inflation forecasting models.

[3]Instead of aggregate inflation rates Monacelli and Sala (2009) use sectoral CPI data in four advanced economies and find that one international common factor explains 15-30% of variation in inflation. They consider it to be a lower bound of common variation in domestic inflation.

ing some recent inflation puzzles. Output fell sharply after the 2008/2009 recession. However, inflation in advanced economies remained more resilient, which raised questions about the apparent decline in the sensitivity of inflation to economic slack (e.g. IMF, 2013). From mid-2011, however, simultaneous declines in inflation across many advanced economies raised further questions about the "commonality" of inflation trends and whether this reflected well-defined shocks from global economic slack on domestic inflation or other common factors. Yet, more recent heterogeneous inflation developments – with euro area inflation declining further than in other advanced economies – may have shifted the focus again towards domestic factors influencing inflation trends.

In this chapter, we assess the role of global factors in a traditional Phillips curve framework. We first augment advanced economy Phillips curves with measures of global economic slack, test their significance and assess whether their role has changed over time. We then assess the role of global inflation in helping to forecast domestic inflation rates. Section 3.2 outlines the method and approach. Section 3.3 discusses the results and robustness. Section 3.4 concludes. Appendix 3.A contains a detailed data description and additional results from model estimations.

3.2 Phillips Curve Estimates: Methods and Approach

We investigate the role of global factors in domestic inflation processes by augmenting standard Phillips curve specifications with a series of global variables. We estimate separate equations for each advanced economy in the sample, using quarterly data over the period 1970q1-2014q3.[4] The model is of the following general form:

$$\pi_{it} = \alpha_i + \beta_i \pi^e_{it} + \gamma_i y_{it} + \sum_{k=1}^{K} \theta_{k,i} z_{k,it} + \delta_i f_t + \epsilon_{it}, \tag{3.1}$$

[4]The sample includes 19 advanced OECD economies: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Spain, Sweden, Switzerland, UK and US. Starting date varies per country.

where the dependent variable π_{it} is headline inflation rate in country i at time t, computed using year-on-year changes in CPI[5] and f_t is a global factor.

The π^e_{it} term denotes expected inflation. According to the expectations formation process we distinguish three Phillips curve specifications. Namely, *(i)* a traditional backward-looking specification as in Friedman (1968) and Phelps (1968) with adaptive expectations given by (3.2) *(ii)* a micro-founded New-Keynesian specification with forward-looking expectations (3.3) which open up a channel for a credible monetary authority to affect inflation (e.g., Woodford, 2003) and *(iii)* a hybrid Phillips curve as in Galí and Gertler (1999) with the expectations term (3.4) that combines the first two.[6]

$$\beta_i \pi^e_{it} = \beta_i E_{t-1} \pi_{it} = \sum_{l=1}^{L} \beta_{l,i} \pi_{i,t-l} \tag{3.2}$$

$$\beta_i \pi^e_{it} = \beta_i E_t \pi_{i,t+h} \tag{3.3}$$

$$\beta_i \pi^e_{it} = \sum_{l=1}^{L} \beta_{l,i} \pi_{i,t-l} + \beta_i E_t \pi_{i,t+h} \tag{3.4}$$

In (3.2)-(3.4) L denotes the number of included inflation lags and h is the forward-looking horizon for inflation expectations. The most general, hybrid, Phillips curve includes both lagged inflation terms and a term that captures forward-looking inflation expectations. Because rational expectations are not entirely observable in agents' behaviour we use a survey based measure of long-term inflation expectations taken from Consensus Economics.[7] Other Phillips curve specifications include one of the two components. Data availability means that the estimation samples differ:

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[5] This definition of inflation has no seasonal pattern by construction.

[6] Despite having no clear microfoundations and being subject to the Lucas critique, backward-looking Phillips curve is common in empirical literature due to its ability to fit actual inflation data reasonably well (O'Reilly and Whelan, 2005; Estrella and Fuhrer, 2003; Paloviita, 2008; Stock and Watson, 2007). The micro-founded New-Keynesian Phillips curve, instead, avoids the Lucas critique, appears in a substantial number of theoretical papers, but shows rather inconclusive empirical support (Rudd and Whelan, 2007, Mavroeidis *et al.*, 2014).

[7] We use 6 to 10 years ahead inflation forecasts from Consensus Economics. The data are available on a biannual basis since 1990. We interpolate the data using cubic splines to obtain quarterly series.

backward-looking Phillips curves are estimated from 1970s onwards; forward-looking and hybrid curves from early 1990s. In the specifications that include lags of inflation the lag order is selected separately for each country on the basis of the four standard information criteria,[8] limiting the maximum number of lags to four. Our preferred lag order is the order selected by most of the criteria.

The next term in the Phillips curve (3.1) is domestic slack y_{it} measured with an unemployment and output gap available in OECD Economic Outlook and IMF World Economic Outlook databases. For the countries with unavailable quarterly data on the output gap and the non-accelerating rate of unemployment (NAIRU), used to compute the unemployment gap, we use cubic splines to interpolate annual data to quarterly.

The variables $z_{k,it}$ are K additional exogenous factors commonly found to affect inflation rate. We tested a range of various explanatory variables such as the year-on-year percentage changes in the price of oil, natural gas, all commodities excluding energy, money supply (M3),[9] real and nominal effective exchange rates. Our final models included only the variables that were typically significant in country estimations, i.e. change in oil price, change in non-energy prices, and change in nominal effective exchange rate.[10]

The global factor f_t includes estimates of global economic slack and global inflation. For a measure of global economic slack we considered both aggregate OECD estimates of the unemployment gap and output gap. The estimates are based on the 34 member countries of the OECD and as such are not limited only to advanced economies.[11] To investigate the role of global inflation, we considered: *(i)* a simple

[8] Akaike's information criterion, Schwarz's Bayesian information criterion, the final prediction error and the Hannan and Quinn information criterion.

[9] The link between inflation and low-frequency movements in money growth is studied, for example, in Gerlach (2004) and Assenmacher-Wesche and Gerlach (2008). Unlike the authors we do not extract the low-frequency component from the year-on-year M3 growth as long-term inflation expectations and global inflation in our models already capture this trend. Instead, we include the unfiltered year-on-year growth in M3. We detect no significant contribution of money growth that would go beyond what is already embedded in our measures of inflation expectations.

[10] Exchange rate in our data set is expressed in units of foreign currency per unit of domestic so that an increase in exchange rate corresponds to domestic currency appreciation.

[11] In addition to the 19 countries we consider, global OECD measures include Chile, Czech Republic, Estonia, Greece, Hungary, Iceland, Ireland, Israel, South Korea, Mexico, Poland, Portugal, Slovak Republic, Slovenia and Turkey.

average of inflation rates in the 19 economies under analysis and *(ii)* the aggregate OECD inflation rate based on all the 34 member countries. We have also considered the first principal component estimated on the full sample of 19 inflation rates. Because it appeared to essentially proxy average inflation, we excluded it from further analysis.

We estimate (3.1) by the two-step generalized method of moments (GMM; Hansen, 1982) to address the risk of endogeneity of some explanatory variables. Survey-based measure of (unobservable) inflation expectations may contain measurement errors that could lead to endogeneity bias. Likewise, the bias may arise due to simultaneity between actual inflation and some of the right-hand-side variables such as the global factor. While endogeneity of the global factor may not be a serious concern for smaller economies, it may well be so for larger countries that mainly determine its value. As instruments in the GMM estimation we consider two lags of inflation expectations and two lags of global factor.[12] To address slight serial correlation in the residuals we use Heteroskedasticity and Autocorrelation Consistent (HAC) estimates of the covariance matrix (Newey and West, 1987) with a Bartlett kernel and an automatic Newey-West bandwidth selection (Newey and West, 1994).

3.3 Results: the Role of Global Factors in Standard Phillips Curve Estimates

In this section we focus principally on the role of global factors in our Phillips curve estimates, assessing first the role of global slack and second the importance of measures of global inflation. Appendix 3.A provides more detail on other aspects of the Phillips curve estimates (see Table 3.A.1).

Overall, those estimates are consistent with the existing literature. Inflation is highly persistent across most countries with lagged inflation terms highly significant regardless of whether we control for forward-looking inflation expectations. Moreover, the Phillips curves that contain lagged inflation terms fit actual inflation data

[12]Adding other instruments does not bring significant changes to the estimates nor improves the outcome of model diagnostic tests. With a very few exceptions the J-test does not reject the overidentifying restrictions (see Table 3.A.1 in Appendix 3.A).

considerably better than the pure forward-looking Phillips curve. The fit of the forward-looking Phillips curve is nevertheless moderate rather than weak favouring in general the use of survey-based inflation expectations in empirical New Keynesian Phillips Curve research (see Table 3.A.2 in Appendix 3.A). Our results also confirm a prominent role for commodity price developments, which account for an important part of headline inflation dynamics, and a modest role for domestic slack variables, with coefficients on the unemployment and output gaps typically significant but small for the majority of countries (see Figure 3.1 and Figures 3.A.1 and 3.A.2 in Appendix 3.A).

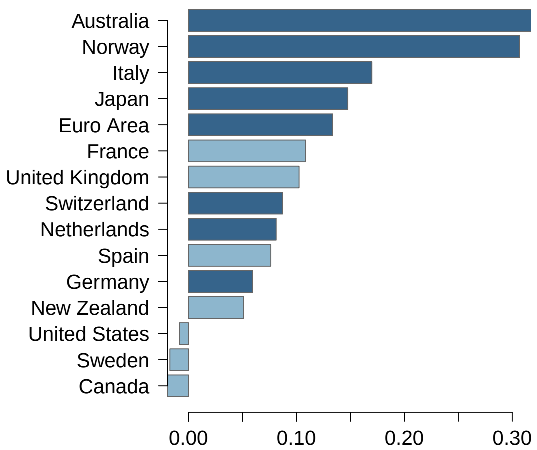
3.3.1 The Role of Global Economic Slack

We find little evidence for the role of global economic slack in driving national inflation developments. In hybrid Phillips curves, estimated from the 1990s onwards, the coefficients on global output gaps are small and insignificant for most of the countries in our sample. Moreover, significant coefficients are typically negatively signed (Figure 3.2). Although a negative sign may arise in some cases because of, for example, the amount of relative price adjustment in tradables, most of the literature looks for a positive relationship (see, e.g. Borio and Filardo, 2007, Milani, 2009). Identical conclusions can be drawn by replacing global output gaps with global unemployment gaps (Figure 3.A.2 in Appendix 3.A). Global output gaps remain insignificant also in backward-looking Phillips curves estimated since 1970.

Furthermore, we find little evidence that the role of global economic slack in driving national inflation dynamics is increasing. Rolling regressions suggest that the flattening of the Phillips curve was a common phenomenon across advanced economies, particularly during the 1980s and 1990s (Figure 3.3).[13] Although, after the 2008/2009 recession there is some evidence of the steepening, particularly notable for the major euro area economies. These results are in line with a number of recent empirical studies. Oinonen and Paloviita (2014), for example, document the recent steepening of the euro area Phillips curve while IMF (2013) provides evidence of the

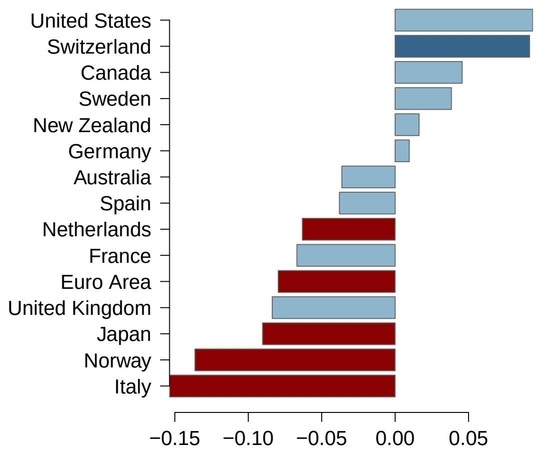
[13]Notably we find no support for the flattening of the Phillips curve for the major euro area economies. Although coefficients on the domestic unemployment gap have varied over time they do not display a trend decline.

Figure 3.1: Estimated coefficient of domestic output gap γ_i in a hybrid Phillips curve.



Source: Own calculations.
Notes: (*i*) Dark blue bars denote statistically significant (10% significance level) positively signed estimates; (*ii*) Estimated by GMM.

Figure 3.2: Estimated coefficient of global output gap δ_i in a hybrid Phillips curve.



Source: Own calculations.
Notes: (*i*) Dark blue bars denote statistically significant positively signed estimates (10% significance level). Red bars denote statistically significant negatively signed estimates; (*ii*) Global output gap is measured by OECD output gap.

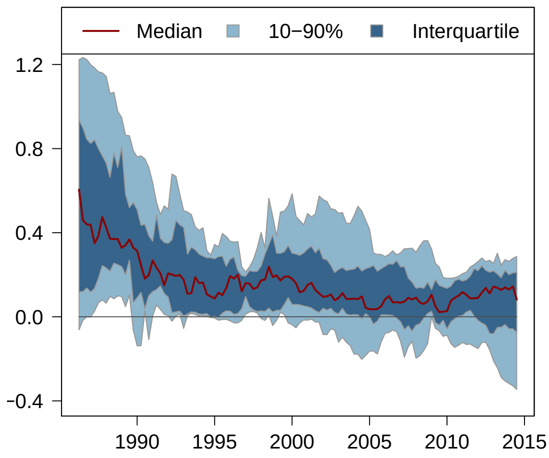
flattening of the Phillips curves for a sample of 21 advanced economies. However, despite the decreased role of domestic slack we do not find evidence of a simultaneously increasing role of global slack (Figure 3.4). Rolling estimates of coefficients on the global unemployment gap are typically insignificant and have been fairly stable over time. We find similar evidence when we use output gaps rather than unemployment gaps (Figures 3.A.3 and 3.A.4).

3.3.2 The Role of Global Inflation Measures

We find that global inflation is a significant explanatory factor in inflation models estimated since 1970s. In backward-looking Phillips curves augmented with measures of global inflation and estimated from 1970s onwards the coefficient on global inflation is statistically significant for more than half of the countries in our sample.[14]

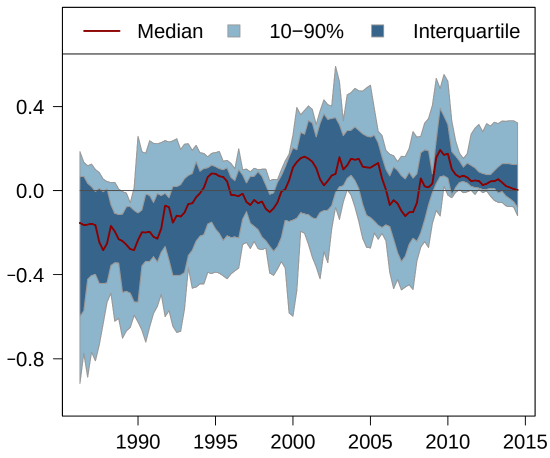
[14] The OECD inflation variable is statistically significant for 11 out of 19 advanced economies we consider. This result does not change with the measure of domestic economic slack (unemployment

Figure 3.3: Rolling coefficient of domestic unemployment gap γ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (i) The initial estimation sample covers 1971q1-1985q4 (60 quarters). Rolled forward by one quarter at a time; (ii) The coefficient is displayed with a negative sign; (iii) Eq.(3.1)-(3.2) are estimated by OLS with $L = 2$ and f_t measured by GDP weighted unemployment gap of 12 advanced economies; (iv) The chart is based on estimation results for 19 economies.

Figure 3.4: Rolling coefficient of global unemployment gap δ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)

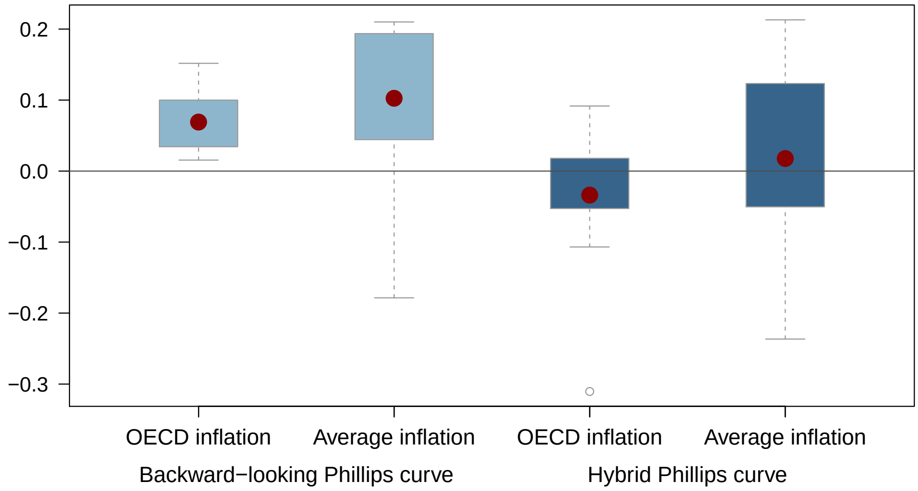


Source: Own calculations.
Notes: (i) The initial estimation sample covers 1971q1-1985q4 (60 quarters). Rolled forward by one quarter at a time; (ii) The coefficient is displayed with a negative sign; (iii) Eq.(3.1)-(3.2) are estimated by OLS with $L = 2$ and f_t measured by GDP weighted unemployment gap of 12 advanced economies; (iv) The chart is based on estimation results for 19 economies.

However, for a shorter sample, from 1990s onwards, and in a hybrid Phillips curve, which includes long-term inflation expectations, the coefficients on global inflation are smaller and typically insignificant (Figure 3.5). Backward-looking Phillips curves estimated using a decreasing sample size also suggest that the importance of OECD inflation has declined. Figures 3.A.5 and 3.A.6 in Appendix 3.A show estimates of the backward-looking Phillips curves with a decreasing window. It is evident that when the 1970s and early 1980s are included in the estimation sample, OECD inflation is significant in most countries. Once the 1970s-80s are excluded from the sample, OECD inflation plays a less important role.

or output gap).

Figure 3.5: Sensitivity to global inflation δ_i across different Phillips curve specifications.



Source: Own calculations.
Notes: (i) The chart displays the minimum, quartiles and the maximum of GMM estimates of sensitivity to global inflation δ_i. Points mark the average; (ii) The sample includes 14 countries and euro area aggregate for which inflation expectations data is available; (iii) Domestic slack in the Phillips curves is measured by unemployment gap.

How might we interpret these results? Why is global inflation a significant explanatory variable in the backward-looking Phillips curve estimated from 1970s but not in a hybrid curve estimated from 1990s onwards? Ciccarelli and Mojon (2010) offered two explanations for the prominent role for global inflation in forecasting national inflation - a structural and a statistical interpretation. The first explanation is that the global inflation component captures structural factors - i.e. the influence of global developments on national inflation processes (e.g. through the impact of commodity prices developments) or commonalities in the business cycles. The second explanation is more statistical and suggests that incorporating a global inflation measure is helpful because it identifies slow-moving trends in national inflation processes. Faust and Wright (2013), for example, argue that inflation forecasts at horizons beyond a couple of quarters should have mechanisms to capture low-frequency local mean dynamics. The second view therefore emphasizes the role of global inflation in helping to identify these slow-moving trends in national inflation rates. Our findings would tend to point towards this second, statistical explanation. We find that global inflation is highly significant for equations estimated during periods of significant changes in inflation trends (i.e. the 1970-80s). But from the mid-1990s onwards, when inflation trends converged to more stable rates, global inflation becomes considerably less helpful in explaining domestic inflation dynamics. We also find that once survey inflation expectations are included in the model, global inflation ceases to play an important role. Moreover, global inflation and (long-term) inflation expectations measures have shown a high correlation over time (see Table 3.A.3 and Figure 3.A.7 in Appendix 3.A). These findings suggest, to us, that global inflation helps in explaining domestic inflation dynamics within the reduced-form Phillips curve, possibly, because it acts as a proxy for (domestic) inflation expectations by capturing slow-moving trends in inflation rates.

To further understand the role of global inflation in explaining inflation dynamics we compare standard inflation forecasting equations with those augmented with global inflation. Following Ciccarelli and Mojon (2010) we estimate pairs of alternative inflation forecasting models for each country. We run out-of-sample forecasts and compare root mean squared errors (RMSE) for the competing models over one- and two-year-ahead forecast horizons. To replicate the exercise as closely as possible the benchmark forecasting model we consider is the global inflation augmented autoregression:

$$\pi_{it} = \alpha_{i0} + \alpha_{i1}(L)\pi_{it} + \alpha_{i2}(L)f_t + u_{it},$$

where f_t is global inflation. We contrast this model, first, with the standard autoregression, that links current inflation to its lagged values, and, second, with the inflation expectations augmented autoregression, that links current inflation to its lagged values and domestic inflation expectations:

$$\pi_{it} = \beta_{i0} + \beta_{i1}(L)\pi_{it} + \beta_{i2}(L)\pi_{it}^{e,LT} + u_{it},$$

where $\pi_{it}^{e,LT}$ are long-term inflation expectations. As in Ciccarelli and Mojon (2010) in all the forecasting models we fix the order of lag polynomials $\alpha_{i2}(L)$ and $\beta_{i2}(L)$ to four and we let the order of $\alpha_{i1}(L)$ and $\beta_{i1}(L)$ to be determined by the standard

Bayesian information criterion at every forecast generating stage. We start with the estimation sample of ten years and we subsequently increase it with one observation at a time. At every stage we re-select the optimal number of lags, re-run the estimation and compute the h-step ahead inflation forecast $\pi_{i,t+h|t}$ given inflation data up to point t.

Individual country forecast results are provided in Table 3.A.4 of Appendix 3.A. Table 3.1 summarizes the results across countries, showing the percentage of countries for which each model statistically outperformed the rival model.[15]

Table 3.1: Forecasting performance of global inflation augmented model relative to standard autoregression.
(percent of country models in which particular model is significantly better than competitor)

Model that produces significantly lower forecast RMSEs	One-year-ahead	Two-years-ahead
Forecasting sample: 1981q4-2014q3		
Global inflation augmented autoregression	77.8%	83.3%
Standard autoregression	5.6%	5.6%
Forecasting sample: 2002q1-2014q3		
Global inflation augmented autoregression	5.6%	0.0%
Standard autoregression	16.7%	27.8%

Source: Own calculations.
Notes: (*i*) The table summarises forecasting performance results of 18 economies (individual country results are provided in Table 3.A.4 of Appendix 3.A); (*ii*) Initial estimation sample covers 10 years of data (1971q1 - 1980q4 and 1991q2 - 2001q1 respectively). The sample is subsequently augmented with one observation at a time to produce the next h-step-ahead forecast; (*iii*) Estimated by OLS.

Forecast comparisons show that global inflation only improves inflation forecasts in models estimated since 1970s, but not in those estimated since 1990s. We confirm the result of Ciccarelli and Mojon (2010) that, indeed, the model augmented with global inflation significantly outperforms the standard autoregression for the majority of countries (upper panel of Table 3.1). However, this is only the case when the

[15]Since there are some countries for which the forecast performance of the two models is statistically indistinguishable the figures in Table 3.1 and 3.2 do not sum to 100%. We test statistical distinguishability using the Diebold-Mariano test statistic (Diebold and Mariano, 1995) with bootstrapped critical values.

models are estimated on a sample that includes the 1970-80s, a period of high and volatile inflation rates. When the models are estimated from 1991 and used to forecast inflation from 2002 onwards, the measure of global inflation does not provide significant improvement to the forecasting ability of a simple autoregression (lower panel of Table 3.1). Indeed, at one- and two-year-ahead horizons it is a statistically better performer only in 5.6% and 0.0% of cases, respectively.

As a further test to enhance our understanding of the role of global inflation, we also compared two further models: one which augments an autoregressive model with global inflation and another which augments it with long-term inflation expectations. The period for comparison is somewhat shorter as availability of long-term inflation expectations limits the forecasting sample to 2002 onwards. Nevertheless, the results point to a broadly similar forecasting performance of models augmented with global inflation and inflation expectations. Indeed, if anything, the models with inflation expectations augmented model performed slightly better (Table 3.2).

Table 3.2: Forecasting performance of inflation expectations augmented model relative to global inflation augmented model.
(percent of country models in which particular model is significantly better than competitor)

Model that produces significantly lower forecast RMSEs	One-year-ahead	Two-years-ahead
Forecasting sample: 2002q1-2014q3		
Global inflation augmented autoregression	0.0%	0.0%
Inflation expectations augmented autoregression	23.1%	15.4%

Source: Own calculations.
Notes: (*i*) The table summarises forecasting performance results of 13 economies (individual country results are provided in Table 3.A.5 of Appendix 3.A); (*ii*) Initial estimation sample covers 1991q2 - 2001q1 (10 years). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

We are able to perform this exercise over a longer horizon for the US. Using combined Livingston and Blue Chip long-term inflation forecasts since 1979 we find that our conclusions remain valid. The RMSE of the model augmented with inflation expectations relative to the global inflation augmented model is insignificantly different from one.[16]

3.3.3 Robustness Analysis

We perform several robustness checks to confirm the validity of our findings. We start by showing that our results are robust to using core rather than headline inflation data as a dependent variable. Estimation results with core inflation in (3.1) are broadly similar to those with headline the only difference being considerably reduced, often insignificant, effects of commodity prices. We conclude that commodity prices, included as exogenous factors, reasonably well capture temporary fluctuations of food and energy components in headline inflation and do not drive our main results. Considering that overall price stability is the policy goal of a central bank we keep the focus on headline inflation in the main text.

Furthermore, we find that our results do not change when we replace year-on-year headline inflation with annualized seasonally adjusted quarter-on-quarter headline inflation rates. Annual inflation measured by year-on-year rates is approximately the sum of quarterly (*log*) CPI differences. Thus, using year-on-year rates may introduce a moving average component to inflation data, which can complicate econometric inference. Annualized quarter-on-quarter inflation based on seasonally adjusted CPI data circumvents this drawback. By replacing year-on-year inflation with quarter-on-quarter we find that our results on the significance of global slack and global inflation measures remain unchanged. Estimates based on quarter-on-quarter inflation rates, however, deliver larger in magnitude sensitivities.

Finally, our results are robust to using lagged rather than contemporaneous measures of global economic slack. It might be that foreign or domestic measures of real activity affect inflation with some delay either directly or via other factors, which a single-equation model with contemporaneous explanatory variables is unable to capture. Bianchi and Civelli (2013), for example, while not finding significant direct effects of global slack on domestic inflation, provide evidence that might suggest the presence of indirect channels. A study by Milani (2010), based on Bayesian estimation of a structural model for a sample of G-7 economies, also presents evidence

[16]RMSE is 0.99 for one-year- and 0.95 for two-year-ahead forecasts.

suggesting that global slack affects inflation via its influence on domestic output. It may therefore be that there is a lag until global slack has its impact on domestic inflation. We tried including up to four periods lagged GDP weighted unemployment gaps and OECD output gaps in the hybrid Phillips curve equation. This did not alter our conclusions. Regardless of its measure and with a very few exceptions (Table 3.3) global slack continues to be statistically insignificant. The results are similar when lagged domestic slack is used instead.

Table 3.3: Percent of countries for which a significant positively (resp. negatively) signed global output (resp. unemployment) gap is found.

Domestic slack	Global slack	Percent of countries
Output gap	OECD output gap	6.67
Output gap	1-quarter lagged OECD output gap	6.67
Output gap	2-quarters lagged OECD output gap	6.67
Output gap	3-quarters lagged OECD output gap	6.67
Output gap	4-quarters lagged OECD output gap	6.67
Unemployment gap	GDP weighted unemployment gap	13.33
Unemployment gap	1-quarter lagged GDP weighted unemployment gap	13.33
Unemployment gap	2-quarters lagged GDP weighted unemployment gap	6.67
Unemployment gap	3-quarters lagged GDP weighted unemployment gap	6.67
Unemployment gap	4-quarters lagged GDP weighted unemployment gap	6.67

Notes: (*i*) Hybrid Philllips curve results; (*ii*) Total number of countries is 15 (14 countries and euro area aggregate); (*iii*) The calculation of the GDP weighted unemployment gap is based on unemployment gap data for 12 major advanced economies; (*iv*) 5% significance level.

3.4 Concluding Remarks

In this chapter we have examined the extent to which advanced economy inflation can be considered to be a global phenomenon. While we confirm that commodity prices have a strong effect on headline inflation, our results provide little support for other global factors as prominent drivers of domestic inflation dynamics.

First, we detect no direct effects of global economic slack on domestic inflation for the majority of advanced economies. Second, we find that measures of global inflation are helpful for forecasting domestic inflation rates during periods of significant variation in global inflation trends, particularly in the 1970s and 1980s, but have been much less useful since the mid-1990s when inflation has been more stable. From the mid-1990s onwards, as inflation trends have converged and become more stable, measures of global inflation have considerably less power for forecasting inflation dynamics. Moreover, survey measures of (national) long-term inflation expectations appear to perform much the same task as global inflation in explaining domestic inflation developments. These findings suggest, to us, that global inflation matters because it acts as a proxy for (national) inflation expectations by capturing slow-moving trends in inflation rates.

Our analysis though is limited to reduced-form Phillips curves and univariate inflation forecasting models. It might be possible that global slack influences inflation through indirect channels that are not modelled in this framework. Nonetheless, our results strongly exclude the existence of large direct effects of global factors on domestic inflation and overall suggest that, with the exception of commodity prices, there is little reason to include global factors into traditional reduced-form Phillips curves.

3.A Appendix: Data and Additional Results

Table 3.A.1: GMM estimates of the backward-looking and hybrid Phillips curves for G-7 economies.

	Canada		France		Germany		Italy		Japan		UK		US	
	Backward-looking Phillips curve													
Intercept	0.19	0.08	0.12	-0.02	0.05	0.04	0.01	-0.10	0.29***	0.15	-0.01	0.01	0.20	0.11
1-quarter lagged inflation	0.89***	1.11***	0.89***	1.15***	0.94***	0.91***	1.23***	0.99***	0.78***	1.10***	0.97***	1.07***	0.74***	0.89***
2-quarters lagged inflation		-0.22***		-0.29**			-0.29***	-0.08	0.05	-0.13		-0.16**	-0.07	
3-quarters lagged inflation				0.04					0.25**	0.12			0.11	
4-quarters lagged inflation				0.06					-0.27***	-0.15*			0.14*	
Output gap	0.05	0.08***	0.03	0.02	-0.03	0.07**	0.11**	0.01	0.14***	0.08	0.07	0.03	0.09	0.05**
Change in oil price	0.01***	0.00**	0.01***	0.00***	0.00***	0.00*	0.00***	0.01***	0.01***	0.00**	0.00*	0.00	0.02***	0.01***
Change in non-energy prices	0.01	0.00	0.00	0.00	0.00	0.00	0.00*	0.00	0.00	0.01*	0.01*	0.01	0.01	0.01**
OECD output gap	-0.01		-0.03		0.03		-0.10*		-0.09***		-0.04		-0.13	
OECD inflation		0.06**		0.01		0.05***		0.07**		0.00		0.04		0.05
Change in NEER	-0.02	-0.02*	0.00	-0.03**	-0.02**	-0.04***	-0.02***	-0.02***	-0.01	-0.01	-0.01	-0.02***	-0.01	-0.01
P-value of the J-test	0.52	0.26	0.93	0.01	0.68	0.01	0.65	0.68	0.75	0.35	0.78	0.22	0.74	0.22
Number of obs	116	175	115	135	115	135	115	135	115	174	116	136	116	175
	Hybrid Phillips curve													
Intercept	-0.19	-0.72	-0.40**	-0.26	-0.58*	-0.73	-0.11	-0.08	0.35	0.34	-0.39	-0.36	-0.45*	-0.63**
1-quarter lagged inflation	0.86***	0.92***	0.74***	0.76***	0.81***	0.78***	1.19***	1.30***	0.87***	0.82***	0.90***	0.92***	0.55***	0.63***
2-quarters lagged inflation	-0.22*	-0.22*					-0.44***	-0.47***						
Inflation expectations	0.35	0.61**	0.35***	0.28**	0.45**	0.70*	0.29***	0.21***	-0.06	-0.08	0.20	0.18	0.54***	0.62***
Output gap	-0.02	0.01	0.11	0.05	0.06*	0.11***	0.17***	0.03**	0.15**	0.15**	0.10	0.03	-0.01	0.03
Change in oil price	0.01***	0.01***	0.01***	0.01***	0.00***	0.01**	0.00***	0.00**	0.00	0.00	0.00	0.00	0.01***	0.01***
Change in non-energy prices	0.00	0.00	0.01*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01**	0.01**	0.00	0.00
OECD output gap	0.05		-0.07		0.01		-0.15***		-0.09***		-0.08		0.09	
OECD inflation		-0.03		0.00		-0.08		0.00		0.02		-0.01		-0.04
Change in NEER	-0.01	0.00	0.01	0.00	-0.02*	-0.03*	-0.02***	-0.02***	-0.01	0.00	-0.01	-0.01	-0.02	-0.04**
P-value of the J-test	0.14	0.03	0.49	0.58	0.59	0.06	0.82	0.47	0.58	0.24	0.84	0.79	0.09	0.76
R-squared	0.79	0.78	0.86	0.86	0.86	0.86	0.98	0.98	0.84	0.83	0.92	0.92	0.86	0.86
Number of obs	98	98	97	97	97	97	97	97	97	97	98	98	98	98

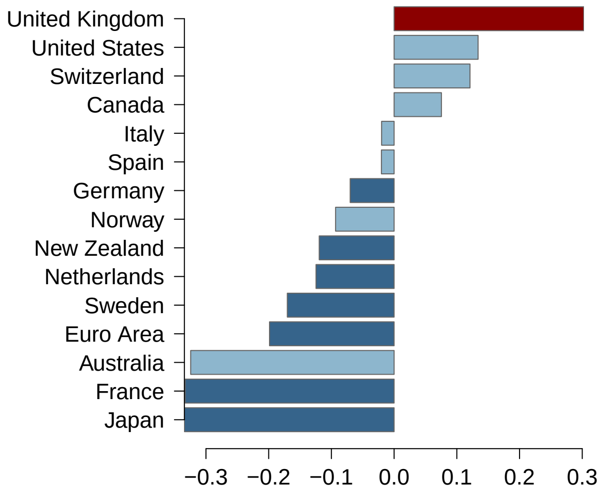
Notes: (*i*) Dependent variable is headline CPI inflation; (*ii*) Estimated by GMM; (*iii*) Instruments include two lags of OECD output gap/OECD inflation and, in the hybrid Phillips curve, include additionally two lags of inflation expectations; (*iv*) Significance stars *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Table 3.A.2: GMM estimates of the forward-looking Phillips curves for G-7 economies.

	Canada		France		Germany		Italy		Japan		UK		US	
	Forward-looking Phillips curve													
Intercept	0.37	-0.23	-0.75	-0.48	-2.10***	-3.60***	-0.46**	-0.66**	0.50	0.25	0.22	0.49	-0.46	1.53**
Inflation expectations	0.66	0.83**	1.14***	0.96***	2.10***	3.12***	1.30***	0.88***	0.39	0.08	0.82	0.47	0.95***	-0.49
Output gap	-0.01	0.15	0.24**	0.20***	0.17*	0.41***	0.57***	0.08	0.43***	0.39***	-0.17	-0.01	-0.18***	0.02
Change in oil price	0.02***	0.01***	0.00	0.01	0.00	0.01	0.01***	0.00	0.00	-0.01**	0.01	0.00	0.02***	0.01**
Change in non-energy prices	-0.01	-0.01	0.01	0.01	0.01	0.02*	-0.01***	0.00	-0.01**	0.00	0.01	0.00	0.00	0.00
OECD output gap	0.15**		-0.05		0.11*		-0.50***		-0.08		0.13		0.40***	
OECD inflation		0.11		0.04		-0.14		0.42***		0.16		0.19		0.68***
Change in NEER	0.01	0.02	0.00	0.01	0.00	-0.04	-0.03***	-0.02*	0.03**	0.03***	-0.05*	-0.04	0.00	-0.07***
P-value of the J-test	0.13	0.19	0.79	0.07	0.13	0.91	0.23	0.23	0.81	0.32	0.36	0.29	0.19	0.22
R-squared	0.40	0.38	0.56	0.56	0.59	0.64	0.87	0.85	0.65	0.62	0.35	0.36	0.67	0.74
Number of obs	98	98	97	97	97	97	97	97	97	97	98	98	98	98

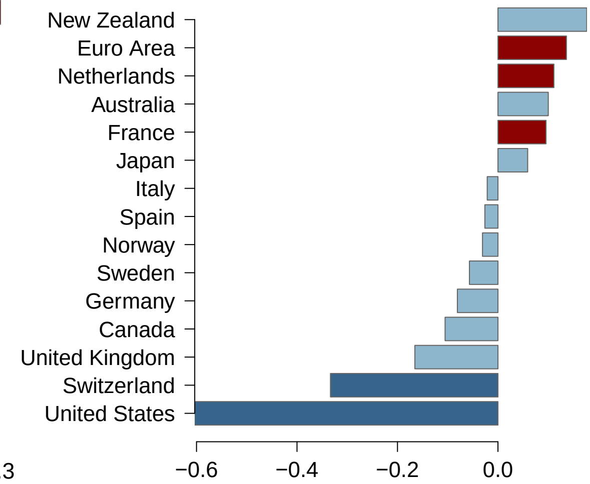
Notes: (*i*) Dependent variable is headline CPI inflation; (*ii*) Estimated by GMM; (*iii*) Instruments include two lags of OECD output gap/OECD inflation and two lags of inflation expectations; (*iv*) Significance stars *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

Figure 3.A.1: Estimated coefficient of domestic unemployment gap γ_i in a hybrid Phillips curve.



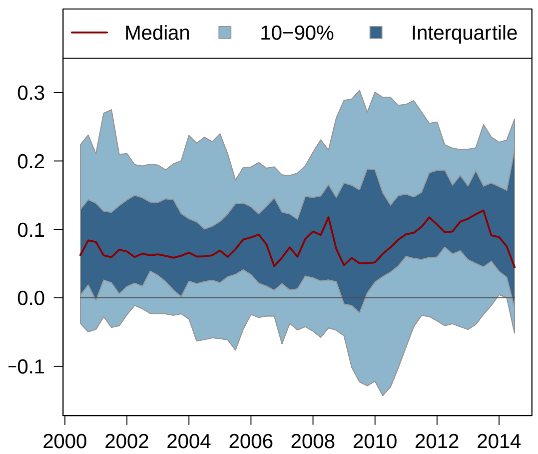
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant negatively signed estimates (10% significance level). Red bars denote statistically significant positively signed estimates; (ii) Estimated by GMM.

Figure 3.A.2: Estimated coefficient of global (OECD) unemployment gap δ_i in a hybrid Phillips curve.



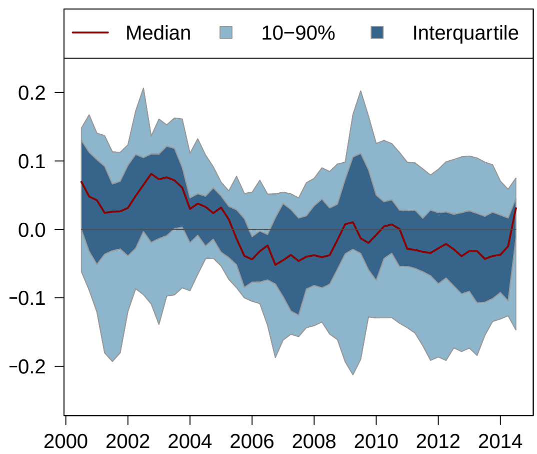
Source: Own calculations.
Notes: (i) Dark blue bars denote statistically significant negatively signed estimates (10% significance level). Red bars denote statistically significant positively signed estimates; (ii) Global unemployment gap is measured by OECD unemployment gap.

Figure 3.A.3: Rolling coefficient of domestic output gap γ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (i) The initial estimation sample covers 1985q4-2000q3 (60 quarters). Rolled forward by one quarter at a time; (ii) Eq.(3.1)-(3.2) are estimated by OLS with $L = 2$ and f_t measured by OECD output gap; (iii) The chart is based on estimation results for 19 economies.

Figure 3.A.4: Rolling coefficient of global output gap δ_i in a backward-looking Phillips curve.
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (i) The initial estimation sample covers 1985q4-2000q3 (60 quarters). Rolled forward by one quarter at a time; (ii) Eq.(3.1)-(3.2) are estimated by OLS with $L = 2$ and f_t measured by OECD output gap; (iii) The chart is based on estimation results for 19 economies.

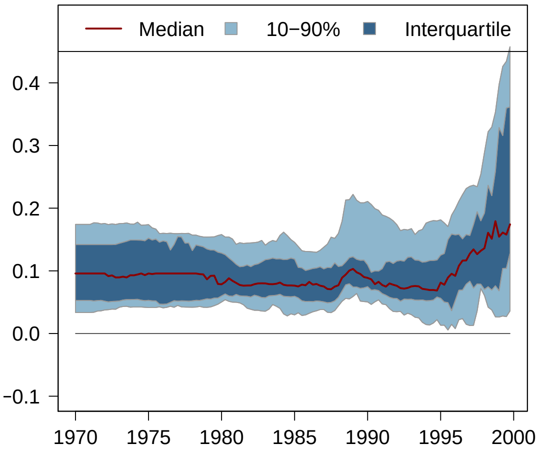
Table 3.A.4: RMSE of global inflation augmented model relative to RMSE of standard autoregression.

Country	One-year-ahead	Two-years-ahead
Forecasting sample: 1981q4-2014q3		
Australia	**0.82**	**0.66**
Austria	**0.85**	**0.82**
Belgium	**0.67**	**0.51**
Canada	**0.76**	**0.65**
Denmark	**0.73**	**0.58**
Finland	**0.70**	**0.55**
France	**0.81**	**0.66**
Germany	**1.11**	**1.15**
Italy	**0.43**	**0.27**
Japan	0.98	1.02
Luxembourg	**0.85**	**0.73**
Netherlands	**0.80**	**0.76**
New Zealand	0.93	**0.81**
Norway	**0.83**	**0.73**
Spain	**0.66**	**0.44**
Sweden	**0.75**	**0.59**
United Kingdom	**0.82**	**0.45**
United States	0.94	0.98
Forecasting sample: 2002q1-2014q3		
Australia	0.90	1.11
Austria	**0.94**	0.96
Belgium	0.90	**1.22**
Canada	0.97	0.87
Denmark	**1.14**	**1.19**
Finland	**1.16**	**1.21**
France	1.09	**1.16**
Germany	**1.22**	1.06
Italy	1.03	1.04
Japan	0.94	1.05
Luxembourg	1.07	**1.23**
Netherlands	0.94	0.88
New Zealand	1.07	1.07
Norway	1.01	1.13
Spain	0.98	1.02
Sweden	0.92	1.10
United Kingdom	1.03	1.08
United States	1.04	1.07

Source: Own calculations.

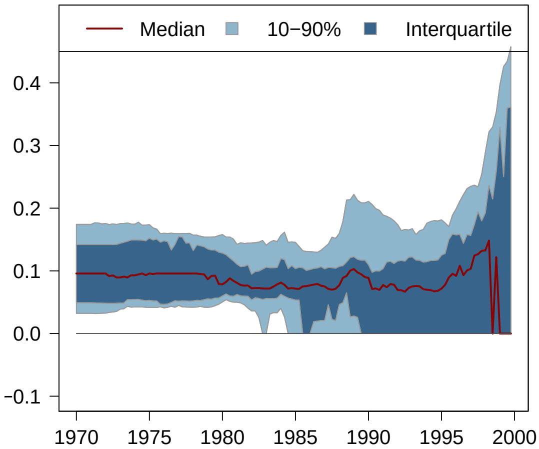
Notes: (*i*) Bold entries denote ratios statistically significant at a 5% level; (*ii*) Initial estimation sample covers 10 years of data (1971q1 - 1980q4 and 1991q2 - 2001q1 respectively). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

Figure 3.A.5: Coefficient of OECD inflation in a backward-looking Phillips curve (decreasing window).
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (*i*) The initial estimation sample covers 1970q1-2014q3. Then the estimation window is decreased by one quarter each time, i.e. the second estimation sample is 1970q2-2014q3, then 1970q3-2014q3, etc.; (*ii*) The chart ignores significance of the coefficient of OECD inflation in country-by-country regressions; (*iii*) Eq. (1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD inflation; (*iv*) The charts are based on estimation results for 19 economies.

Figure 3.A.6: Coefficient of OECD inflation in a backward-looking Phillips curve (decreasing window).
(range of estimates of coefficients across countries)



Source: Own calculations.
Notes: (*i*) The initial estimation sample covers 1970q1-2014q3. Then the estimation window is decreased by one quarter each time, i.e. the second estimation sample is 1970q2-2014q3, then 1970q3-2014q3, etc.; (*ii*) Before plotting the chart insignificant coefficient values are set to zero in country-by-country Phillips curves; (*iii*) Eq. (1)-(2) are estimated by OLS with $L = 2$ and f_t measured by OECD inflation; (*iv*) The charts are based on estimation results for 19 economies.

Figure 3.A.7: Comovement of global (OECD) inflation and Consensus long-term inflation expectations.

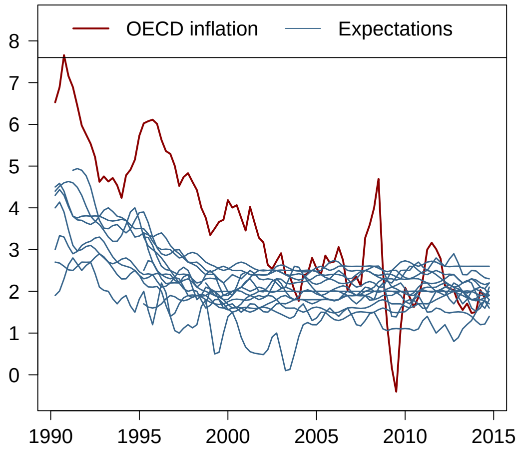


Table 3.A.3: Correlations between global (OECD) inflation and Consensus long-term inflation expectations.

Country	Correlation coefficient
Australia	0.70
Canada	0.58
France	0.69
Germany	0.75
Italy	0.76
Japan	0.61
Netherlands	0.72
New Zealand	-0.69
Norway	0.03
Spain	0.51
Sweden	0.67
Switzerland	0.24
United Kingdom	0.75
United States	0.83

Table 3.A.5: RMSE of inflation expectations augmented model relative to RMSE of global inflation augmented model.

Country	One-year-ahead	Two-years-ahead
Forecasting sample: 2002q1-2014q3		
Australia	1.03	0.81
Canada	1.09	1.12
France	1.06	1.06
Germany	**0.87**	1.03
Italy	**0.80**	**0.72**
Japan	1.06	0.99
Netherlands	**0.84**	0.83
New Zealand	0.85	**0.62**
Norway	0.79	0.88
Spain	1.01	0.90
Sweden	0.97	0.94
United Kingdom	1.11	1.15
United States	1.03	1.05

Source: Own calculations.
Notes: (*i*) Bold entries denote ratios statistically significant at a 5% level; (*ii*) Initial estimation sample covers 1991q2 - 2001q1 (10 years). The sample is subsequently augmented with one observation at a time; (*iii*) Estimated by OLS.

Table 3.A.6: Data definitions and sources.

Variable	Transformation	Source	Frequency	Notes
Dependent variables				
Headline inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using Consumer Price Index (2010=100) .
Core inflation	Year-on-year growth rate	Haver Analytics	Quarterly	Computed using CPI of all items excl. food and energy (2010=100) .
Domestic variables				
Unemployment rate		Haver Analytics	Quarterly	1970q1 - 1992q1 data for Germany is taken from FAME (West Germany).
Real effective exchange rate		Haver Analytics	Quarterly	
Nominal effective exchange rate		Haver Analytics	Quarterly	
Real GDP		Haver Analytics	Quarterly	
Output gap		Haver Analytics	Annual	Percentage deviation of actual real GDP from its potential counterpart as estimated by IMF. Data was interpolated to quarterly frequency using cubic splines. For Canada, Japan and US national quarterly output gap estimates were used. As an alternative to IMF estimates we also consider output gap measured as a cyclical component of the Hodrick-Prescott filter applied to quarterly real GDP data in logarithms. For the Hodrick-Prescott filter we use the typical for quarterly data smoothing parameter $\lambda = 1600$.
Non-accelerating inflation rate of unemployment (NAIRU)		Haver Analytics	Annual	For US national quarterly estimates of long-term natural rate of unemployment equivalent to NAIRU were used. For other countries annual OECD estimates were taken. Data was interpolated to quarterly frequency using cubic splines.

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Table 3.A.6 – *Continued from previous page*

Variable	Transformation	Source	Frequency	Notes
Broad money	Year-on-year growth rate	Haver Analytics	Quarterly	M3 data in local currency units or in index terms. For Austria, Germany, Italy, Japan, Netherlands, Spain and UK growth rates of FAME data were used to extend Haver data.
Long-term inflation expectations		Consensus Economics	Biannual	Average expected consumer price inflation 6 to 10 years ahead. Data was interpolated to quarterly frequency using cubic splines.
Industrial production index	Year-on-year growth rate	Haver Analytics	Quarterly	
Standard VAT rate	Year-on-year difference	OECD Consumption Tax Trends 2014; European Commission "VAT rates applied in the member states of the European Community"; *www.vatlive.com*; *www.tradingeconomics.com*	Quarterly	Standard non-reduced value-added/goods and services tax rate applicable in the entire or the largest part of the country. May be particularly important to control for in countries like Japan, where all the three VAT increases since 1989 were nearly fully passed through to consumer prices.
		Global variables		
OECD unemployment rate		Haver Analytics	Annual	OECD estimate of global unemployment rate.
OECD NAIRU		OECD Economic Outlook 2014	Annual	OECD estimate based on the 34 member countries of the OECD. Data was interpolated to quarterly frequency using cubic splines.
OECD unemployment gap		Own calculations	Quarterly	Computed as a difference between OECD unemployment rate and OECD NAIRU.
OECD output gap		Haver Analytics	Annual	OECD estimate of the global output gap based on the 34 member countries of the OECD. Data was interpolated to quarterly frequency using cubic splines.
OECD inflation		Haver Analytics	Annual	OECD estimate based on the 34 member countries of the OECD.

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Table 3.A.6 – *Continued from previous page*

Variable	Transformation	Source	Frequency	Notes
Average oil price	Year-on-year growth rate	Haver Analytics	Quarterly	Price index representing average spot price of UK Brent (light)/Dubai (medium)/Alaska (heavy) crude oils
Natural gas price index	Year-on-year growth rate	Haver Analytics	Quarterly	Natural gas price index
HWWI price index (all commodities)	Year-on-year growth rate	Haver Analytics	Quarterly	HWWI commodity price index (all commodities) in USD constructed by Hamburg Institute of International Economics.
HWWI price index (all commodities excl. energy)	Year-on-year growth rate	Haver Analytics	Quarterly	Commodity price index (all commodities excl. energy) in USD constructed by Hamburg Institute of International Economics.

Chapter 4

Trade Policy Options of Ukraine: East or West*

4.1 Introduction

December 1, 2016 will mark the 25th anniversary of the dissolution of the Soviet Union and the proclamation of fifteen new independent states. In this time span, former Soviet countries faced the troublesome transition from planned to market economies and went through reforms in institutional, political and social spheres. Some countries celebrated the independence they re-gained and quickly set their priorities on the integration with the European Union. Other newly proclaimed states were keen to preserve former economic ties. The latter, including Ukraine, founded the Commonwealth of Independent States (CIS), an agreement whose goal was to form a common economic space with free movement of goods, services, labour and capital.[1]

Over the years, the ruling system of Ukraine meandered through the contested grounds of ideologies, namely those of a post-soviet state and those of modern European nations. On the one hand, with the enlargement rounds of 2004 and 2007

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[1] Though country membership in CIS varied over time, our definition includes the 12 countries that were members in 1993, i.e. Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. Georgia joined in 1993 but quit in 2009. Turkmenistan was a member throughout 1991-2004.

the borders of the European Union (EU) came closer to Ukraine, making the EU a potentially more important trading partner. On the other hand, pro-soviet governments ratified numerous bilateral agreements between subsets of CIS countries in search of deeper integration. However, by bringing down their president in winter 2013, the Maidan revolution prevented the planned membership of Ukraine in the customs union initially founded by Belarus, Kazakhstan and Russia in 2007. The revolution, however, did not renege other regional trading agreements already in place. In contrast, it prompted the signing of the so-called Deep and Comprehensive Free Trade Agreement with the EU in 2014 as a new source of prosperity. Therefore, the question of what deeper economic ties with the Western nations may bring to Ukraine takes considerable importance. Particularly, what are the factors suggesting that deeper economic integration of Ukraine with the EU may well outweigh the benefits from further advancement of economic ties with the rest of CIS? The objective of this chapter is to address these trade-offs empirically by focusing on the trade implications of alternative policy choices.[2]

Several other aspects that characterize Ukraine's evolution are considered here as well. First, the quality of infrastructure is important in the determination of trade flows (Francois and Manchin, 2013; Grigoriou, 2007; Shepherd and Wilson, 2009) in that it can effectively lower the distance between two even geographically distant countries. Second, Acemoğlu and Robinson (2012) show that inclusive political institutions that support inclusive economic institutions are more likely to lead to prosperity. It is the connection between political and economic institutions which can explain why otherwise similar-looking countries might differ in terms of economic performance. In addition, good institutions as a means of protecting property rights promote entrepreneurship as they facilitate the adoption and creation of new technologies (Hausmann and Rodrik, 2003). Also, there is substantial evidence that the quality of political and economic institutions matters for trade. For example, Cuñat and Melitz (2010, 2012) focus on labor market regulations and show the role

[2] Though the analysis of this chapter considers trade flows, the latter are closely linked to the growth experience of countries. For example, Harrison and Rodríguez-Clare (2009) describe 176 studies that use a reduced form relationship between openness and economic growth. Most of the studies they review find a positive relationship between trade volumes and growth. Equally important is the abundance of studies that test for the positive role of FDI on country's growth.

of labor market flexibility as a source of comparative advantage. Levchenko (2004) studies the quality of institutions (like the imperfect recognition of property rights, the quality of contract enforcement, etc.) and shows how it affects trade flows and the distribution of gains between rich and poor countries. In Nunn (2007), Costinot (2009) and others, institutional differences across countries have consequences not only for aggregate productivity but also for productivity differences across industries within a single country. Altogether it is not surprising that democratic values and, in particular, a war on corruption[3] matter for the establishment of closer ties with the World Trade Organization (WTO) and the EU. In this analysis, we use indicators to quantify the effects of governance and infrastructure on trade and address the following questions: *(i)* Would the improvement of governance and infrastructure yield a significant positive impact on Ukraine's trade? *(ii)* How large are these effects in comparison to traditional benefits, if any, of standard trade policies like regional trade agreements?

We estimate gravity models of trade using an unbalanced panel data set that consists of bilateral export flows among world economies. The data covers 159 countries over the period 1997 – 2012 and thus includes the major developments over the past decades. While the existing literature aims at measuring general effects of trade policies, this chapter focuses rather on the assessment of counterfactuals using a novel technique for non-linear scenario analysis that accounts for the intensive and the extensive margins of trade. Although the analysis can be potentially extended to any world country, our focus is on Ukraine.

Different econometric techniques have been advanced recently to correct for estimation biases that arise from the large number of zero flows typical to bilateral trade data.[4] There are several reasons for the occurrence of zeros. A first cause is the so-called data coding problem in survey data (Wooldridge, 2002) where some of the zeros are attributed to the non-reporting of small trade flows. Further, political conflicts can give rise to the absence of trade between different subsets of countries.

[3]On the dynamics of corruption in Ukraine see *The Economist* (Sep 26, 2015; pp. 23-24).

[4]Together with the decomposition of aggregate exports into the extensive/intensive margins, Head and Mayer (2014) consider the econometric treatment of zero trade flows to be another topic at the frontier of current research. As section 4.4 will show both topics are related.

For example, there is no trade between Azerbaijan and Armenia due to their conflict over the Nagorno-Karabakh region.[5] Finally, with sunk entry and sunk exit costs in export markets it might be optimal for exporting firms not to export as it has been shown in the hysteresis literature (see, e.g. Dixit, 1992) and the firm heterogeneity literature (see, e.g. Helpman *et al.*, 2008). In this chapter we use recent estimation techniques that take into account zeros in trade. Our approach is then to select between rival models using statistical tools for model selection like the Vuong test.

Our empirical results convincingly support: *(i)* higher values for exports between CIS countries; *(ii)* a positive effect of WTO membership on trade of the order of 24-40%; *(iii)* significant positive effects of improved institutions and infrastructure. For Ukraine scenario-based estimates of the effects of improved institutions on trade are about 98%, those of improved infrastructure are about 22%.

The remainder of this chapter is organized as follows. Section 4.2 reviews relevant economic indicators for Ukraine. Section 4.3 discusses the modelling approach, the data and the results. Section 4.4 uses estimation results to compute counterfactuals and assess potential effects of improved governance and improved infrastructure on Ukraine's export flows. Section 4.5 addresses the policy relevance of our results. Section 4.6 concludes. Appendix 4.A describes the data methods and sources, includes the list of countries in our panel, provides details on the estimation of relevant models and describes the algorithms used for the analysis of counterfactuals.

4.2 Trade and Economic Development Patterns in Ukraine

Ukraine has undergone a difficult and lengthy transition from a planned to a market economy.[6] Since its independence from the Soviet Union in 1991 the country had experienced steeply declining real economic activity for eight years. Although the

[5] In contrast, trade transactions did not stop after the armed conflict between Georgia and Russia.

[6] This is regardless of its high economic potential. For example, the large and educated population of the country, availability of natural resources, favourable geographic position between the East and the West. In 1990 62% of Ukraine's adult population had at least secondary degree (see Barro and Lee, 2014) and this percentage has increased over time.

trend reversed since then Ukraine's real output in 2014 was yet lower than its level 24 years ago. This is in contrast to growth experience of any other CIS economy.[7] Ukraine is currently a lower-middle-income economy according to the World Bank classification.

Income inequality, however, has decreased since mid-1990s. The most recent GINI coefficient for Ukraine is 28.2% which is lower than the average value of the remaining CIS countries (see Table 4.1). The summary of selected indicators in Table 4.1 also shows that Ukraine is an outward oriented economy. Trade openness

Table 4.1: Trade and economic development indicators in Ukraine, EU-15 and CIS.

Indicator	Ukraine	EU-15	EU-27	CIS (excl. Ukraine)
GNI per capita *(PPP, 2011 international $)*	10055	39684	32551	10872
GINI coefficient *(%)*	28.2	29.4	30.0	33.9
Governance *(average score)*	-0.72	1.32	1.06	-0.80
Logistics performance index	2.7	3.9	3.5	2.4
Trade openness *(%)*	77.0	63.3	66.7	46.4
Tariff *(%)*	2.6	2.4	2.4	6.8
Percentage of WTO members	100	100	100	50
Number of regional trade agreements *(average)*	16	35	35	7

Source: World Bank, CIA Factbook, WTO.
Notes: (*i*) EU-15 includes 15 economies that joined the EU before 1996. EU-27 includes 27 economies that joined the EU before 2008. CIS (excl. Ukraine) refers to 10 CIS economies: Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyz Republic, Moldova, Russia, Tajikistan, Turkmenistan and Uzbekistan; (*ii*) The data refers to year 2013 for all indicators except the logistics performance index (2012 data) and the GINI coefficient (2005-2013 data); (*iii*) Governance is the average score of 6 World Bank WGI indicators that range from -2.5=low to 2.5=high (see Appendix 4.A.2 for more details); (*iv*) Logistics performance is the World Bank index that measures the quality of trade and transport-related infrastructure (ranges from 1=low to 5=high); (*v*) Trade openness is the sum of regional merchandise exports and imports divided by regional GDP, all in current US$; (*vi*) Tariff is the average of effectively applied tariff rates weighted by the product import shares.

measured by trade-to-GDP is 77%. The indicator is considerably higher than the CIS average of 46%. The country is also a WTO member since 2008 and on average participates in 16 RTAs. Furthermore, it applies an average tariff rate of 2.6%, which is similar in value to that of the EU while it is considerably lower than the

[7] Similar performance can only be observed for Moldova where real GDP in 2014 has also been lower than in 1991.

tariff rate applied by the rest of CIS. Trade, however, is hampered by a relatively poor quality of trade and transport-related infrastructure. The World Bank logistics performance index rates Ukraine 2.7 on the scale from 1 to 5 (see Table 4.1).

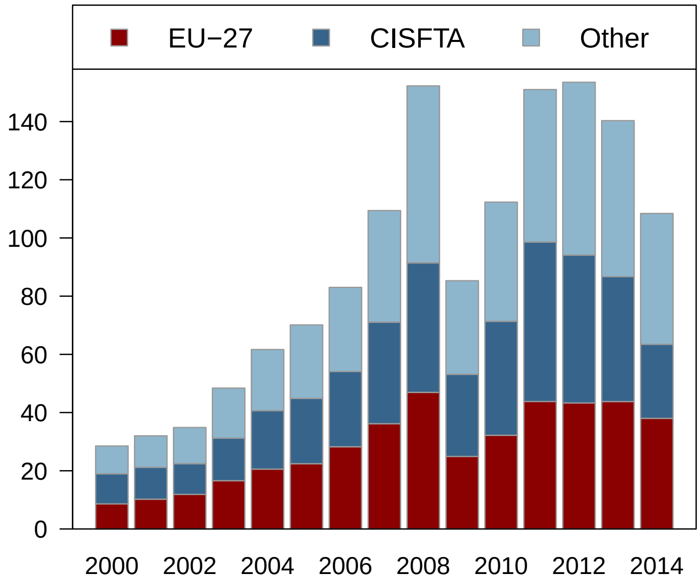
Concerning trading partners, Ukraine trades a similar amount with the CIS free trade area (CISFTA) as it does with the EU (Figure 4.1). In 2013 trade with CISFTA constituted 30.6% of total Ukrainian trade. Most of it (89.3%) is Ukraine's trade with Russian Federation, which is Ukraine's largest single country trading partner. Trade with CISFTA is certainly facilitated by a common historical past with CIS, common borders with Belarus, Moldova and Russia and a common language shared by significant parts of Ukrainian population. Nevertheless, the share of Ukrainian trade with the EU is close in value. Main goods exported to the EU are raw materials, chemical products and machinery while main imported goods include machinery, transport equipment, chemicals, and manufactured goods.[8] Thus, both EU-27 and CISFTA are important country's trading partners although it is evident from Figure 4.1 that the share of CISFTA has been on a steady decline since 2011.

An aspect of great importance for Ukraine to establish closer ties with the EU is the quality of institutions. Currently Ukraine performs considerably poorer than the EU. The average score on the quality of governance is low and similar in value to that of CIS (see Table 4.1). A particularly low score is on control of corruption. Corruption is perceived to be extensive in the Ukraine's public sector. The country scores -1.09 in 2013 on the scale of -2.5 (high corruption) to 2.5 (low). According to Transparency International the country ranks 142 out of 174 world countries in the 2013 Corruption Perceptions Index. The rule of law indicator is also low[9] and reveals limited confidence in the quality of contract enforcement, property rights, courts and police. Clearly, corruption and weak regulations are deterrents to trade and foreign investment. Importantly, however, a pro-European choice of the foreign policies of Ukraine would certainly help to bring its current governance scores to a higher level.

[8]See http://ec.europa.eu/.

[9]The score is -0.83 in 2013.

Figure 4.1: Ukraine's trade with EU-27 and CISFTA.
(percentage of total trade)



Source: Own calculations based on IMF DOTS.
Notes: (*i*) Other countries include mainly China, Turkey and Egypt; (*ii*) CISFTA consists of Armenia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Ukraine and Uzbekistan.

4.3 Model Selection, Estimation and Results

We analyze Ukraine's trade flows in a gravity model framework. Gravity equation is the result of the most modern microfounded trade models. It has been obtained in the literature that assumes product differentiation and imperfect competition (Anderson, 1979; Helpman and Krugman, 1985; Bergstrand, 1989; Anderson and van Wincoop, 2003), in the literature that builds on perfect competition and technological differences (Eaton and Kortum, 2002) and in the literature that builds on perfect competition and complete specialization (Deardorff, 1998). The equation takes the following functional form:

$$X_{ijt} = Y_{it}Y_{jt}\frac{\tau_{ijt}^{1-\sigma}}{\Sigma_{it}\Delta_{jt}}, \tag{4.1}$$

where X_{ijt} is a measure of nominal trade between two countries i and j at time t. In this chapter we measure trade by export flows from exporting country i to importing country j. To estimate the parameters of the gravity model, we use an unbalanced panel of annual bilateral export flows between 159 countries and 155 trading partners over 1997–2012. Altogether the included countries cover over 94% of reported world exports in 2012. Variables Y_{it} and Y_{jt} capture the sizes of the trading partners. We use exporting and importing country's gross domestic products as proxies for Y_{it} and Y_{jt}. The term τ_{ijt} denotes trade costs between the two countries. The costs include transportation costs (e.g., distance and infrastructure), information and search costs (e.g., common language, common historical ties) and a variety of trade policy measures (e.g. tariff rates, membership in WTO, free trade areas or customs unions) that either lower or raise the costs associated with trade. The two terms in the denominator Σ_{it} and Δ_{jt} are additional terms that vary over time and at country i and country j level, respectively. In Anderson and van Wincoop (2003), for example, these are the terms that capture multilateral price resistance and in Head and Mayer (2014) the different ways to proxy these multilateral resistance terms are listed and reviewed. Table 4.2 itemizes the variables included into final model specifications. More details on the included countries and the data sources can be found in Appendices 4.A.1 and 4.A.2, respectively.

4.3.1 Zeros in Trade

On average around one forth of country pairs in the world exhibit zero trade (see Table 4.3). Although the number of trading country pairs is declining over time and each year more and more countries engage into trade, accounting for zeros is important to avoid possibly biased inference (see, e.g., Helpman *et al.*, 2008). Zeros occur for a variety of reasons. It may be that trade between two specific countries is small and therefore appears as null in reported data due to rounding. Alternatively, it may be that countries do not trade indeed either because of political conflicts or because firms find it optimal not to trade. Melitz (2003), in fact, explains emergence of zero trade flows as a result of firms' self-selection into exporters and non-exporters. As also in later trade models with self-selection (Bernard *et al.*, 2007;

Table 4.2: Explanatory variables included in the final model specifications.

Notation	Variable
$lnGDP_{it}$	log of GDP of exporting country i in current million US dollars at time t
$lnGDP_{jt}$	log of GDP of importing country j in current million US dollars at time t
$effdist_{ijt}$	effective (corrected for infrastructure) distance between countries i and j at time t
$tariff_{jt}$	average tariff rate in percent applied by importing country j at time t
gov_{it}	average score on six World Bank governance indicators for exporting country i at time t
gov_{jt}	average score on six World Bank governance indicators for importing country j at time t
WTO_{ijt}	1 when both countries i and j are WTO members at time t 0 otherwise
EU_{ijt}	1 when both countries i and j are EU members at time t 0 otherwise
$CUBKR_{ijt}$	1 when both countries i and j are members of the customs union between Belarus, Kazakhstan and Russia at time t 0 otherwise
$EUFTA_{ijt}$	1 when country i is an EU country and country j has an FTA with EU at time t and vice versa 0 otherwise
CIS_{ijt}	1 when both countries i and j belong to CIS at time t 0 otherwise
$language_{ij}$	1 when a common language is spoken by at least 9% of the population in countries i and j 0 otherwise
$adjacent_{ij}$	1 when countries i and j share a common border 0 otherwise
$religion_{ij}$	religion similarity between country i and j

Note: See Appendix 4.A.2 for more details on data sources and methods.

Chaney, 2008; Arkolakis, 2011) firms decide whether to export based on fixed costs of trade that need to be carried on. As a result zero trade in the exporting country is observed when no firms find it profitable to carry on the fixed costs. Depending on the source of zeros, different econometric methods are applicable to estimate the parameters in (4.1). In this chapter we use the three most commonly encountered techniques: Heckman two-stage procedure (Heckman, 1979), Eaton-Tamura tobit (Eaton and Tamura, 1994) and Poisson pseudo-maximum likelihood (PPML) (Santos

Table 4.3: Occurence of zero trade flows.

Year	Number of country pairs with positive export flows	Number of country pairs with zero export flows	Zero export flows (%)
1997	10633	4204	28.3
1998	11183	4307	27.8
1999	12010	4100	25.5
2000	12571	4777	27.5
2001	13898	5481	28.3
2002	14731	5776	28.2
2003	14993	5557	27.0
2004	15270	5390	26.1
2005	15830	5075	24.3
2006	16152	4679	22.5
2007	16328	4536	21.7
2008	15997	4371	21.5
2009	15602	3998	20.4
2010	13203	3198	19.5
2011	10359	2280	18.0
2012	9668	2054	17.5

Source: Own caclulations based on IMF DOTS.
Notes: (*i*) Calculations are based on nominal bilateral export flows in US dollars; (*ii*) Country pairs with reported missing export values were omitted.

Silva and Tenreyro, 2006).[10] The first two - Heckman two-stage procedure and Eaton-Tamura tobit - are directly built under the assumption that firms self-select into export markets. Both models allow to carry out an extensive comparative statics in that both intensive and extensive margins of trade can be computed. The latter - PPML - is an alternative to self-selection models. It accounts for zero trade flows assuming that zeros occur at random. An advantage of using PPML is that it eliminates the bias that arises due to the log-linearization of trade flows in the presence of heteroskedasticity. However, unlike, for example, the Heckman model, PPML postulates identical data generating processes for trading and non-trading country-pairs.

As selecting from the three types of specification is difficult due to the different

[10]Other methods are available as well, e.g., negative binomial, but they are generally special cases or extensions of the models discussed in this section and are significantly less encountered in empirical literature.

distributional assumptions, we apply in this chapter all three specifications and compare the implied results from the models. We however perform a model selection procedure within each model family to select the proper specification of intercepts and explanatory variables.

4.3.2 Model Specification and Selection

Heckman model (Heckman, 1979) assumes that whether two specific countries engage into trade is determined by a latent variable Z_{ijt} (propensity to trade). This unobserved factor linearly depends on a vector of explanatory variables $\mathbf{W}^{\intercal}_{ijt}$:

$$Z_{ijt} = \mathbf{W'}_{ijt}\beta + \epsilon_{ijt,1}, \tag{4.2}$$

where $\epsilon_{ijt,1} \sim NID(0,1)$ and the parameter vector β describes the effect of the explanatory variables on the propensity to trade. As long as the propensity to trade is positive, positive trade flows are observed. Otherwise, trade flows are zero:

$$X^*_{ijt} = \begin{cases} 1 & \text{if} \quad Z_{ijt} > 0 \\ 0 & \text{if} \quad Z_{ijt} \leq 0 \end{cases}. \tag{4.3}$$

Here X^*_{ijt} is a binary variable that is 0 for country pairs with zero bilateral trade and 1 otherwise. When $X^*_{ijt} = 1$ positive trade flows X_{ijt} are observed. It is then possible to take the *log* of the gravity equation (4.1) which gives a *log-log* relationship between existing trade and its determinants:

$$\ln X_{ijt} = \mathbf{V'}_{ijt}\alpha + \eta_{it} + \eta_{jt} + \epsilon_{ijt,2}, \tag{4.4}$$

where $\mathbf{V'}_{ijt} = (\ln Y_{it}, \ln Y_{jt}, \ln \tau_{ijt})^{\intercal}$, $\eta_{it} = -\ln \Sigma_{it}$ and $\eta_{jt} = -\ln \Delta_{jt}$ and where $\epsilon_{ijt,2}$ is an error term potentially correlated with $\epsilon_{ijt,1}$. The parameters of (4.4) can be estimated using ordinary least squares after accounting for the correlation between $\epsilon_{ijt,1}$ and $\epsilon_{ijt,2}$ (see Appendix 4.A.3). In some studies, the term $\eta_{it} + \eta_{jt}$ is replaced by $\eta_i + \eta_j + \eta_t$.

Just as in the Heckman model, bilateral exports X_{ijt} in Eaton-Tamura framework (Eaton and Tamura, 1994) are determined by the latent propensity to trade Z_{ijt}.

As long as it is positive, positive trade flows between two countries are observed:

$$X_{ijt} = \begin{cases} Z_{ijt} & \text{if} \quad Z_{ijt} > 0 \\ 0 & \text{if} \quad Z_{ijt} \leq 0 \end{cases} .$$

In Eaton-Tamura model the latent variable Z_{ijt} is defined as

$$\ln(Z_{ijt} + a_t) = \mathbf{V}'_{ijt}\alpha + \eta_i + \eta_j + \eta_t + u_{ijt} \tag{4.5}$$

with $u_{ijt} \sim NID(0, \sigma^2)$. It is clear from (4.5) that the right hand side has to reach a certain time-varying threshold level $\ln a_t$ before actual trade takes place. This is a typical outcome of oligopoly models of trade where entry sunk costs must be covered before profitable trade transactions can be established. The possibility to estimate this threshold is clearly an advantage of this method. To capture possible deviations from homoskedasticity in the error term of (4.5) we follow Martin and Pham (2015) and we replace σ by σ_{ijt} and let it depend on regressors in the following manner:

$$\sigma_{ijt} = \xi + \delta \left(\mathbf{V}'_{ijt}\alpha + \eta_i + \eta_j + \eta_t \right) .$$

To estimate the parameters we can use maximum likelihood approach, see again Appendix 4.A.3 for details.

Estimation of trade elasticities by using a *log-log* functional form as in Heckman has its limitations. Santos Silva and Tenreyro (2006) show that when errors are heteroskedastic the *log-log* specification of the gravity equation leads to biased parameter estimates due to Jensen's inequality. We therefore follow the authors and as a yet another estimation method use PPML to overcome potential bias. The method is essentially Non-Linear Least Squares when the conditional variance of trade flows $Var(X_{ijt}|\mathbf{V}'_{ijt})$ is proportional to the conditional mean $E(X_{ijt}|\mathbf{V}'_{ijt})$:

$$X_{ijt} = e^{\mathbf{V}'_{ijt}\alpha + \eta_i + \eta_j + \eta_t} + \nu_{ijt}. \tag{4.6}$$

Details on parameter estimation can be found in Appendix 4.A.3. Besides accounting for the bias associated with Jensen's inequality, the method does not pose restrictions to the inclusion of zero trade country-pairs and, in addition, it does not specify the distribution of ν_{ijt}.

All three methods allow for a large range of specifications of the deterministics and the inclusion of explanatory variables. Some authors opt for country-pair fixed effects to control for unobserved heterogeneity in country pairs (e.g., Cheng and Wall, 2005). Others employ country fixed effects (e.g. Mátyás, 1997; Egger, 2000). Yet others estimate time-varying country fixed effects or a combination of those (e.g., Baltagi *et al.*, 2003). Furthermore, the use of both nominal and real trade data is common. Although the gravity equation is a demand function in value terms Glick and Rose (2002), Baltagi *et al.* (2003) among others choose to use real trade flows in their empirical studies. In this case, however, the way nominal bilateral trade flows are deflated to obtain real data is important as this may well affect the accuracy of estimates when panel data is used (see, e.g., the bronze medal mistake in Baldwin and Taglioni, 2007).

In this chapter we do not choose a particular specification but instead let the data choose between alternative models using statistical tests. This allows us to directly address the following important choices that have to be made in the empirical analysis of trade flows: *(i)* What is the best specification of fixed effects to capture unobserved heterogeneity in bilateral trade? Should the correct empirical specification of gravity equation include time-varying country effects directly prescribed by economic theory? *(ii)* How do gravity models of trade with nominal variables compare to gravity models of trade with real variables? Should nominal gravity model specifications be preferred? *(iii)* Is bilateral trade data characterized by homoskedasticity? Do models that allow for heteroskedastic errors perform equally well to models that assume error homoskedasticity? We address all these questions in our empirical analysis.

To select the proper model specification we use statistical tests. When two rival models are nested we apply a regular log-likelihood test. When the two are non-nested we proceed with the Vuong test (Vuong, 1989; Clarke, 2007). The Vuong test cannot be applied for PPML and Heckman models as parameter estimation in these models does not involve a full maximum likelihood approach. However, for the choice of nominal and, separately, real variables, we still apply the Vuong test in the Heckman model using the likelihood of the second stage. This approach seems reasonable as the first step estimation results are identical irrespective of the fixed effects specification in the second step. In the case of PPML we compare and report the results of all model specifications. To investigate the difference in coefficients we also report the results of truncated PPML models that are estimated using a subset of positive trade flows.

4.3.3 Empirical Results

We estimate the parameters of the three families of gravity specifications, that is, the Heckman specification, the Eaton-Tamura framework and the PPML approach. Within each family we select the best model specification as discussed in the previous section. Columns (1)-(4) of Table 4.4 provide the parameters estimates for three possible specifications of the Heckman model using nominal data. The Vuong test indicates that the model with country-pair and time fixed effects is significantly better than the other two specifications, see the first panel of Table 4.5. This also holds for the case where we use real data instead of nominal data. The parameters estimates for the real specification are given in Table 4.A.2.

For the Eaton-Tamura framework we consider specifications with time-invariant and time-variant entry costs, homoskedastic and heteroskedastic errors and nominal and real variables. Statistical tests indicate that the Martin-Pham specification with time-varying entry costs a_t is preferred, see third panel of Table 4.5. The nominal Martin-Pham model with time-variant entry costs significantly outperforms 6 out of 7 or 86% of its competitors in pairwise model comparisons. The same holds for its real counterpart. Parameter estimates of this specification can be found in the final column of Table 4.4 for the nominal specification and Table 4.A.2 for the real specification, respectively.

The estimation results for the PPML specification can be found in Table 4.6 for the nominal specification. We consider both a country-pair, time fixed effects specification as well as an individual-country effect in combination with a time effect specification. Furthermore, we also consider the truncated version of the PPML. As

Table 4.4: Estimates of the gravity model using alternative estimation techniques.

	Heckman first step	Heckman second step			Martin-Pham, time-varying entry costs
	$\mathbf{1}_{Export_{ijt}>0}$	$lnExport_{ijt}$	$lnExport_{ijt}$	$lnExport_{ijt}$	$Export_{ijt}$
	(1)	(2)	(3)	(4)	(5)
$lnGDP_{it}$	0.30***	0.49***	0.19***		0.30***
$lnGDP_{jt}$	0.30***	0.84***	0.58***		0.61***
$effdist_{ijt}$	-0.51***	-0.80***	-1.59***	-1.58***	-1.59***
$tariff_{jt}$	0.00	-0.02***	-0.01***		-0.01***
gov_{it}	0.33***	0.43***	0.28***		0.29***
gov_{jt}	0.09***	0.31***	0.28***		0.43***
WTO_{ijt}	0.22***	0.34***	0.33***	0.36***	0.22***
EU_{ijt}	-0.58***	0.08***	-0.29***	-0.34***	-1.12***
$CUBKR_{ijt}$	-3.45***	-1.19***	-1.00***	-0.86***	-4.30***
$EUFTA_{ijt}$	0.05*	0.00	-0.11***	-0.19***	-0.27***
CIS_{ijt}	1.73***	0.61***	3.11***	3.01***	4.08***
$language_{ij}$	0.42***		0.81***	0.77***	0.83***
$adjacent_{ij}$	0.11***		0.64***	0.64***	-0.09**
$religion_{ij}$	0.06***				
$inverseMills_{ijt}$		1.42***	-0.37***	-0.58***	
$constant$	-1.85***	-8.15***	2.78***		1.96***
Fixed effects		ij, t	i, j, t	it, jt	i, j, t
Number of obs	288211	218428	218428	218428	288211
R-squared	0.34	0.90	0.74	0.75	

Notes: (*i*) Dependent variables in the third row; (*ii*) *, **, *** denote statistical significance on the 10%, 5% and 1% levels respectively; (*iii*) Robust standard errors; (*iv*) R-squared is computed as a squared correlation between a dependent variable and fitted values.

the estimation approaches are not likelihood based it is impossible to use the Vuong test for non-nested model comparison.

We focus the discussion of parameter interpretation on models with nominal variables. The results for the real variables are rather similar. We obtain robust (with respect to model specification) and theory-consistent outcomes for a number of variables. In line with existing literature we obtain significant positive effects of GDPs on trade and significant negative effects of the effective distance. Tariff rate also affects trade adversely although it does not seem to impact the probability of trade. Robust positive effects on trade are found via improved governance. In all the model specifications in Table 4.4 governance indicators enter equations positively

Table 4.5: Model performance relative to the performance of competing models.

Model A	Fixed effects specification	Variables	Number of competing models	Percentage of times model A is (strictly) preferred
Heckman	i, j, t	nominal	2	50%
Heckman	ij, t	nominal	2	**100%**
Heckman	it, jt	nominal	2	0%
Heckman	i, j, t	real	2	50%
Heckman	ij, t	real	2	**100%**
Heckman	it, jt	real	2	0%
Eaton-Tamura with time-invariant entry costs	i, j, t	nominal	7	14%
Eaton-Tamura with time-variant entry costs	i, j, t	nominal	7	29%
Martin-Pham with time-invariant entry costs	i, j, t	nominal	7	71%
Martin-Pham with time-variant entry costs	i, j, t	nominal	7	**86%**
Eaton-Tamura with time-invariant entry costs	i, j, t	real	7	0%
Eaton-Tamura with time-variant entry costs	i, j, t	real	7	29%
Martin-Pham with time-invariant entry costs	i, j, t	real	7	57%
Martin-Pham with time-variant entry costs	i, j, t	real	7	**86**%

Notes: Competing models can be found in each panel. For example, Heckman model with i, j, t fixed effects and nominal variables competes with two models: nominal Heckman models with ij, t and nominal Heckman model with it, jt fixed effects.

and significantly. We also obtain robust results on a number of trade agreements relevant for Ukraine. The membership of two countries in CIS free trade area shows a relatively strong positive coefficient in all the model specifications suggesting that CIS countries trade with each other more than a gravity model would predict. Conversely, membership in the customs union of Belarus, Kazakhstan and Russia does not seem to lead to higher trade flows even though we included anticipation effects since 2007. Negative coefficients are found in all the model specifications suggesting that the customs union members overtrade with each other under the CIS agreement. Finally, common language and WTO membership are found to promote trade. The latter effect is approximately of order of 24-40% all else equal and assuming constant inverse Mills coefficient.

While most of the variables take expected signs and, in addition, similar magnitudes across different specifications, the effect of EU agreements on trade is not as stable as expected. Estimates of *EU* and *EUFTA* dummies do not only change significance, but also change their sign under different specifications and under some specifications suggest that EU members trade less with each other than non-EU member states. Several observations might explain why these results occur. First, our sample is limited to 1997 - 2012, which means that only the countries that entered EU in 2004 and 2007 contribute to the estimation of the effect. The contribution of older members is absorbed by fixed effects. Thus, the effect might well be underestimated. Second, many countries that joined the EU in 2004 and 2007 have previously had special trade agreements with the union and therefore the *EU* dummy may be in principle unable to capture the true effect. Third, integration efforts among non-EU economies may have had an even larger effect on their trade so that the gains from the EU agreement may have been relatively more moderate. Nevertheless, abstracting from possible limitations of using the *EU* dummy, we do not find robust evidence with respect to EU or EUFTA membership. The effects are null or negative in Heckman specifications while positive in PPML. Based on this, therefore, we cannot conclude that direct gains from the creation of a trade agreement with EU will be positive and significant. Large and significant gains, however, are expected indirectly, via improved governance and improved infrastructure, the coefficients of which are robust and signed as expected throughout all the model specifications.

We note that the effect of the governance of the exporting country appears to be insignificant in the PPML specification of the gravity equation (see Table 4.6). However, we question the validity of PPML estimates since the results obtained using a full data sample are almost identical to those obtained using a truncated sample that only includes positive trade observations (see columns (3) and (4) of Table 4.6). This is in conflict with the outcome of Heckman models where non-zero trade observations have been found to significantly impact the results.

An interesting outcome of our analysis are the estimates of the entry costs in Eaton-Tamura and Martin-Pham model specifications. Figure 4.2 shows the dynamics of estimated initial costs. The results capture well the decreasing trend in global entry costs since 1997 and point to an increase in costs during the 2008/2009

Table 4.6: Estimates of the gravity model using alternative estimation techniques.

	PPML		Truncated PPML	
	$Export_{ijt}$		$Export_{ijt}$	
	(1)	(2)	(3)	(4)
$lnGDP_{it}$	0.69***	0.73***	0.69***	0.72***
$lnGDP_{jt}$	0.57***	0.57***	0.56***	0.56***
$effdist_{ijt}$	-0.48**	-0.80***	-0.55**	-0.79***
$tariff_{jt}$	-0.03***	-0.03***	-0.03***	-0.03***
gov_{it}	0.01	0.03	0.01	0.03
gov_{jt}	0.29***	0.28***	0.26***	0.25***
WTO_{ijt}	0.23***	0.18***	0.24***	0.19***
EU_{ijt}	0.24***	0.37***	0.25***	0.38***
$CUBKR_{ijt}$	-0.65***	-0.56***	-0.54***	-0.31**
$EUFTA_{ijt}$	0.04	0.25***	0.04	0.25***
CIS_{ijt}	0.35**	1.68***	0.35**	1.66**
$language_{ij}$		0.24***		0.24***
$adjacent_{ij}$		0.36***		0.36***
Fixed effects	ij, t	i, j, t	ij, t	i, j, t
Number of obs	266592	288211	217650	218438

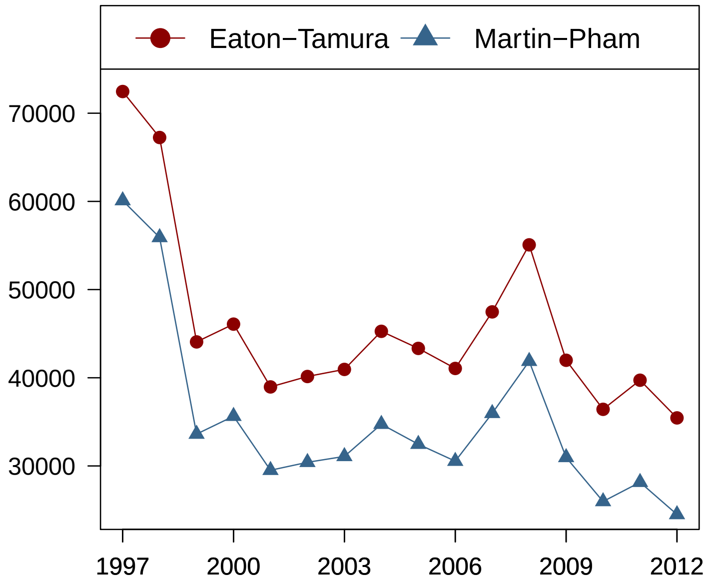
Notes: (*i*) All the variables are in nominal terms; (*ii*) Dependent variables in the second row; (*iii*) *, **, *** denote statistical significance on the 10%, 5% and 1% levels respectively; (*iv*) Robust standard errors.

recession.

Finally, in estimating gravity equations there is a concern of possible endogeneity of trade agreement variables. The decision on whether to form a free trade agreement is unlikely to be independent of the initial trade level between countries. However, the fixed effects included in our models should if not eliminate then at least lower the possible endogeneity bias by capturing differences in initial trade levels. Moreover, the variety of fixed effects deals well with possible endogeneity that may stem from unobserved heterogeneity (e.g. non-tariff measures specific to each country pair or domestic regulations that control international trade).

In the next section we perform several scenario analyses based on the estimation results. As the models with real dependent variable show similar results, we only focus on nominal models. Based on the test results, we consider for these analyses the Heckman model with η_{ij}, η_t fixed effects, the Martin-Pham model with time-variant entry costs a_t and the PPML.

Figure 4.2: Entry costs estimated by Eaton-Tamura and Martin-Pham specifications.



Note: Estimated coefficient a_t in (4.5) expressed in US dollars.

4.4 Scenario Analyses

Model estimates in Table 4.4 lead to a set of robust results for a number of key variables. However, estimated elasticities do not necessarily represent the entire effect of those variables on export flows. Inference based on elasticities assumes that, for example, in a Heckman model, the Mills ratio does not play a role as a policy variable of interest changes. In this section we perform scenario analyses where we account for changes in the inverse Mills ratio.

For the scenario analyses, we use the fitted values of the models to quantify a number of counterfactuals. Particularly, we consider the following three questions: *(i)* what are the trade gains that are expected to accrue to Ukraine as it gains the EU access via a free trade area agreement compared to those of being a member of the customs union with Belarus, Kazakhstan and Russia? *(ii)* how would the trade pattern of Ukraine change if its level of infrastructure were to improve to reach the average value of EU-15? *(iii)* what would be the level of trade of Ukraine if it were to adopt the governance quality of Western economies?

As discussed at the end of the previous section, we consider the three best performing models selected in the previous section and we focus on the evolution at two margins: the intensive margin and the extensive margin. The intensive margin refers to a variation in the amount of trade of exporting firms that have already entered the foreign market. The extensive margin instead refers to trade that is created because new firms that did not export before enter the foreign market. We refer to Appendix 4.A.5 for computational details.

The estimated coefficient of the $EUFTA_{ijt}$ dummy takes a significant negative value of $\hat{\alpha}_{EUFTA} = -0.27$ in the Martin-Pham specification of Table 4.4, a null value in the Heckman specification with country-pair and time fixed effects and a significant positive value of $\hat{\alpha}_{EUFTA} = 0.25$ in the PPML specification with country specific fixed effects of Table 4.6. There is therefore not enough evidence to verify the null hypothesis that trade between countries that have a free trade agreement with the EU is in line with gravity model predictions. There is not only lack of consensus on the significance, but neither it is on the sign of the effect. We approximate the bilateral $EUFTA_{ijt}$ effect by $e^{\hat{\alpha}_{EUFTA}} - 1$ and report it as an entry of the second column of Table 4.7. Similarly in the third column we obtain marginal trade effects of the customs union between Belarus, Kazakhstan and Russia. These are negative according to all model estimates. The results of Table 4.7 therefore point to an ambiguous effect of the free trade area with the EU and to a negative effect of the customs union between Belarus, Kazakhstan and Russia.

Table 4.7: Marginal trade effects of policy changes.

Model	Free trade agreement with EU ($EUFTA_{ijt}$)	Customs union with Belarus, Kazakhstan and Russia ($CUBKR_{ijt}$)
Heckman with ij, t fixed effects	0.00%	-69.58%
Martin-Pham, time-varying entry costs	-23.66%	-98.64%
PPML with i, j, t fixed effects	28.40%	-42.88%

Note: The effects in Heckman model are computed conditional on trade being positive.

Trade benefits, however, are not limited to traditional policy instruments like the establishment of free trade areas. The effects may be indirect and play a role via improved infrastructure or improved governance. Tables 4.8 and 4.9 illustrate the results. Scenario analyses are performed in few steps. First, governance (resp. infrastructure) is lifted to the EU-15 average in 2012. In this specific case Ukrainian governance is lifted from -0.57 to 1.31 and Ukrainian infrastructure is lifted from 2.69 to 3.85. This changes the model predicted probability of positive trade between a pair of countries. The difference in this probability averaged across all export destinations of Ukraine is then reported in column (1) of Tables 4.8 and 4.9. This outcome represents the extensive margin in probability terms. Namely, the percentage of all bilateral export flows that are no longer zero as a result of the policy change. Further, the intensive margin is obtained by computing the effect of the policy change on X_{ijt} while conditioning on $X_{ijt} > 0$ and while accounting for the change in the Mills ratio. The average of percentage changes across all export destinations gives then column (2) of Tables 4.8 and 4.9. Further as a next step the total effect of the policy change on X_{ijt} is computed, i.e. when we do not condition on $X_{ijt} > 0$. Again, the average of percentage changes across all export destinations gives then the total effect of the policy change on bilateral export flows after a correction has been made for the sample selection bias. This corresponds to column (4) of Tables 4.8 and 4.9. Finally, the difference between the total effect and the intensive margin gives column (2), i.e. the extent of the extensive margin in value terms. The exact formulas are available in Appendix 4.A.5.

Tables 4.8 and 4.9 show robust outcomes, particularly with respect to the improvement in infrastructure. The results suggest that on average across all the three models the total effect of improving Ukraine's infrastructure to the EU-15 level would lead to a 22.31% increase in country's exports. Most of this increase originates from the intensive margin of trade. The last column of Table 4.9 also indicates that the impact of improved governance on Ukraine's exports can be as large as 126.54% following the results of the Heckman model. Martin-Pham model estimates deliver a lower gain while PPML suggests that the gain is insignificant. The latter result, however, is questionable as it conflicts with the results of all the remaining models and it does not seem to account well for zeros in trade.

Table 4.8: Trade effects of improved infrastructure.

Model	Extensive Margin: Change in Probability (%)	Extensive Margin: Change in Export Flows (%)	Intensive Margin: Change in Export Flows (%)	Total Country Exports: Change (%)
	(1)	(2)	(3)	(4)
Heckman with ij, t fixed effects	1.34	1.66	14.80	16.47
Martin-Pham, time-varying entry costs	0.54	0.58	33.44	34.02
PPML with i, j, t fixed effects	–	–	–	16.43

Table 4.9: Trade effects of improved governance.

Model	Extensive Margin: Change in Probability (%)	Extensive Margin: Change in Export Flows (%)	Intensive Margin: Change in Export Flows (%)	Total Country Exports: Change (%)
	(1)	(2)	(3)	(4)
Heckman with ij, t fixed effects	6.23	12.80	113.73	126.54
Martin-Pham, time-varying entry costs	0.81	1.02	67.93	68.96
PPML with i, j, t fixed effects	–	–	–	6.21

4.5 Policy Relevance

Our empirical results enable to establish a hierarchy of policies. Estimated models suggest that most of the gains can be realized through improved governance. In our computations of counterfactuals we find that lifting governance of Ukraine to the EU-15 level would, all else equal, provide trade gains of around 98% on average. To a lesser extent but nevertheless significant is the quality of infrastructure that, according to our counterfactuals, could lead to on average 22% increase in Ukrainian exports if lifted to the EU-15 level. Significant trade benefits are associated with a WTO membership (approximately 24-40%). Thus, directions for changes at the country level require commitment from Ukraine to increase the quality of its governance and infrastructure. Furthermore, the analysis provides evidence that, net of significant positive effects from reduced tariff rates, relatively small gains are expected from regional trading agreements. Our analysis suggests that access to the EU does not bring additional significant effects. Also, no positive trade boost was found resulting from the customs union between Belarus, Kazakhstan and Russia. It is questionable whether such a customs union will ever lead to positive trade effects since we find that CIS countries still substantially over-trade with each other. Not much has been said regarding the costs of implementing these policies. For example, an improvement in infrastructure requires large investments. However, the policy with the largest trade effects at both margins, namely, improved governance seems the cheapest to implement in economic terms.

4.6 Conclusion

This chapter has analyzed alternative trade policy options for Ukraine. We focused on two scenarios. The first scenario evaluated possible consequences for Ukraine of closer economic integration with the EU (West). The second assessed possible outcomes of further integration with the CIS (East). Our results suggest that CIS countries significantly overtrade with each other. We find that yet closer ties of Ukraine with CIS via, for example, granted access to the customs union of Belarus, Kazakhstan and Russian Federation, would not bring additional trade benefits. We also find no robust results emerging from the establishment of a free trade area agreement with the EU. The models deliver conflicting evidence. However, our results point to robust and significant indirect trade effects that would accrue to Ukraine from closer economic ties with the EU. In particular, we find that Ukraine's governance improved to the EU-15 level could lead to trade gains of order of 98% while improved infrastructure could lead to lower, yet significant, 22%. Closer ties with the EU would certainly help to bring Ukraine's governance and infrastructure scores to a higher level.

Our analysis was based on the results of the gravity model of trade estimated using three alternative estimation approaches that account for zeros in trade: Heckman two-stage procedure, Martin-Pham tobit and PPML. We used a panel dataset of bilateral export flows among 159 world economies to obtain our results. Moreover, our approach included the application of statistical tests to select between competing models. We drew our conclusions from the non-linear scenario analysis of counterfactuals based on the results from the best performing models.

Our analysis has also yielded a number of robust results relevant for the general application of the gravity model of trade. We find that the inclusion of time-varying fixed effects does not improve the performance of an empirical model due to a large loss of degrees of freedom. Gravity model of trade that includes importer, exporter and time fixed effects is sufficient to fit the data. Furthermore, we find that models with nominal variables perform similarly to models with real variables if fixed effects are accounted for. Finally, our results show that PPML and truncated PPML yield almost identical results. This suggests that PPML may not always account well for the large number of zeros in trade.

4.A Appendix

4.A.1 Included Countries

Afghanistan
Albania
Algeria
Angola
Argentina
Armenia
Australia
Austria
Azerbaijan
Bahamas
Bahrain
Bangladesh
Belarus
Belgium
Benin
Bhutan
Bolivia
Bosnia and Herzegovina
Botswana
Brazil
Bulgaria
Burkina Faso
Burundi
Cambodia
Cameroon
Canada
Chad
Chile
China
Djibouti
Dominican Republic
Ecuador
Egypt
El Salvador
Eritrea
Estonia
Ethiopia
Fiji
Finland
France
Gabon
Gambia
Georgia
Germany
Ghana
Greece
Guatemala
Guinea
Guinea-Bissau
Guyana
Haiti
Honduras
Hong Kong
Hungary
Iceland
India
Indonesia
Iran
Kyrgyzstan
Laos
Latvia
Lebanon
Lesotho
Liberia
Libya
Lithuania
Luxembourg
Macedonia
Madagascar
Malawi
Malaysia
Maldives
Mali
Malta
Mauritania
Mauritius
Mexico
Moldova
Mongolia
Morocco
Mozambique
Namibia
Nepal
Netherlands
New Zealand
Nicaragua
Niger
Qatar
Romania
Russian Federation
Rwanda
Sao Tome and Principe
Saudi Arabia
Senegal
Serbia
Sierra Leone
Singapore
Slovakia
Slovenia
Solomon Islands
South Africa
Spain
Sri Lanka
Sudan
Sweden
Switzerland
Syria
Tajikistan
Tanzania
Thailand
Togo
Tunisia
Turkey
Turkmenistan
Uganda

Colombia	Iraq	Nigeria	Ukraine
Comoros	Ireland	Norway	United Arab Emirates
Dem. Rep. of Congo	Israel	Oman	United Kingdom
Rep. of Congo	Italy	Pakistan	United States
Costa Rica	Jamaica	Panama	Uruguay
Cote d'Ivoire	Japan	Papua New Guinea	Uzbekistan
Croatia	Jordan	Paraguay	Venezuela
Cuba	Kazakhstan	Peru	Vietnam
Cyprus	Kenya	Philippines	Rep. of Yemen
Czech Republic	Rep. of Korea	Poland	Zambia
Denmark	Kuwait	Portugal	Zimbabwe

4.A.2 Data Sources and Methods

Table 4.A.1: Data definitions and sources.

Variable	Description	Formula and notes	Source
X_{ijt}	Exports of country i to country j, f.o.b. value in million current US dollars		IMF DOTS
x_{ijt}	Real exports of country i to country j	$x_{ijt} = \frac{X_{ijt} \times RGDP_{it}}{GDP_{it}}$	IMF DOTS, World Bank WDI
$GDP_{\cdot t}$	GDP in million current US dollars		World Bank WDI
$RGDP_{\cdot t}$	GDP in million constant 2005 US dollars		World Bank WDI
$adjacent_{ij}$	Dummy for the common border	1 if countries i and j are contiguous; 0 otherwise	CEPII, GeoDist database, Mayer and Zignano (2011), variable: *contig*
$language_{ij}$	Dummy for the common language	1 if common language is spoken at least by 9% of the population in countries i and j; 0 otherwise	CEPII, GeoDist database, Mayer and Zignano (2011), variable: *comlang_etno*
$distance_{ij}$	Distance between countries i and j in km based on bilateral distances between the biggest cities of the two countries with inter-city distances being weighted by the share of the city in the overall country's population	$d_{ij} = \left(\sum_{k \in i} \sum_{l \in j} \frac{pop_k}{pop_i} \frac{pop_l}{pop_j} d_{kl}^{\theta}\right)^{1/\theta}$, $\theta = -1$	CEPII, GeoDist database, Mayer and Zignano (2011), variable: *distwces*

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Table 4.A.1 – *Continued from previous page*

Variable	Description	Formula and notes	Source
$religion_{ij}$	Religion similarity index calculated as the product of the ratios for the exporting and importing country of people practising the same religion to the sum of people practising nine religions: Anglicanism, Buddhism, Catholicism, Confucianism, Hinduism, Islam, Judaism, Orthodoxy and Protestantism	$religion_{ij} = \sum_{k=1}^{9} \frac{r_{ki}}{\sum_{l=1}^{9} r_{li}} \frac{r_{kj}}{\sum_{l=1}^{9} r_{lj}}$, r_{ki} - number of people practising religion k in country i, ranges from 0 to 1	Own calculations based on 2010 data from World Christian Database, *worldchristiandatabase.org*, dataset *Religious makeup by country*
$infra_{\cdot t}$	Logistics performance index: quality of trade- and transport-related infrastructure	ranges from 1 (low) to 5 (high)	World Bank WDI
$effdist_{ijt}$	Effective distance (corrected for infrastructure)	$effdist_{ijt} = \ln\left(\frac{d_{ij}}{infra_{it}+infra_{jt}}\right)$	Own calculations
$tariff_{jt}$	Tariff rate of country j, most favoured nation, weighted mean of all products, %		World Bank WDI
WTO_{ijt}	Dummy for the WTO membership (country i and j are both members at time t)	1 if both countries i and j belong to the WTO; 0 otherwise	*www.wto.org*
EU_{ijt}	Dummy for the EU membership (country i and j are both members at time t)	1 if both countries i and j belong to EU; 0 otherwise	*www.europa.eu*
$CUBKR_{ijt}$	Dummy for the membership in the customs union of Belarus, Kazakhstan and Russia (country i and j are both members at time t)	1 if both countries i and j belong to the customs union of Belarus, Kazakhstan and Russia; 0 otherwise	*www.tsouz.ru*

Continued on next page

Table 4.A.1 – *Continued from previous page*

Variable	Description	Formula and notes	Source
$EUFTA_{ijt}$	Dummy for an FTA with the EU of country i and j	1 if country i is an EU country and country j has an FTA with the EU and vice versa; 0 otherwise	WTO RTA database
CIS	Dummy for CIS membership (country i and j are both members at time t)	1 if both countries i and j belong to CIS; 0 otherwise	*www.cisstat.com*
$gov_{\cdot t}$	Average governance score based on: control of corruption, rule of law, regulatory quality, voice and accountability, government effectiveness, political stability and absence of violence	$gov_{\cdot t} = (cor_{\cdot t} + law_{\cdot t} + reg_{\cdot t} + acc_{\cdot t} + gov_{\cdot t} + polstab_{\cdot t})/6$, ranges from -2.5 (low) to 2.5 (high)	Own calculations based on World Bank WGI database

Notes: (*i*) Data on infrastructure is available for 2007, 2010 and 2012. Missing data is interpolated using cubic splines and the earliest available data point (2007 for the majority of contries) was used to extrapolate the data till 1997; (*ii*) CIS dummy refers to CIS and not necessarily to CISFTA countries; (*iii*) For a number of countries missing tariff rate data was interpolated using cubic splines; (*iv*) The membership in the customs union of Belarus, Kazakhstan and Russia is assumed to be in force for the three countries since 2007 to take into account the anticipation effect. The actual enforcement took place in 2011. This does not bring sinificant changes to the estimated coefficient; (*v*) Missing data on governance (years 1997, 1999, 2001) is interpolated using cubic splines. The definitions of the indicators are: (1) *Voice and Accountability* - capturing perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media; (2) *Political Stability and Absence of Violence/Terrorism* - capturing perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism; (3) *Government Effectiveness* - capturing perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies; (4) *Regulatory Quality* - capturing perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development; (5) *Rule of Law* - capturing perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence; (6) *Control of Corruption* - capturing perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

4.A.3 Parameter Estimation

In this appendix we provide more details on the parameter estimation methods used in the chapter.

Heckman Model

To estimate the parameters of the Heckman model (4.2)–(4.4) we use a two-step approach. In the first step the parameters of a probit model are estimated by maximum likelihood. The probit model relates the probability of trade between two countries to a set of explanatory variables:

$$\Pr(X^*_{ijt} = 1|\mathbf{W}_{ijt}) = \Pr(\mathbf{W}'_{ijt}\beta + \epsilon_{ijt,1} > 0) = \Phi(\mathbf{W}'_{ijt}\beta), \tag{4.7}$$

where $\Phi(\cdot)$ is the cumulative distribution function of a standard normal distribution. In the second step we consider a linear panel data model explaining existing trade relationships $X_{ijt} > 0$ as given in (4.4) where $\epsilon_{ijt,2} \sim N(0, \sigma_2^2)$ and the correlation between the error terms of the probit and linear regression is represented by:

$$E\left(\epsilon_{ijt,1}\epsilon_{ijt,2}\right) = \sigma_{12}.$$

The expected value of $\ln X_{ijt}$ given that $X_{ijt} > 0$ is given by:

$$E(\ln X_{ijt}|X_{ijt} > 0, \mathbf{V}_{ijt}, \mathbf{W}_{ijt}) = \mathbf{V}'_{ijt}\alpha + \eta_{it} + \eta_{jt} + \sigma_{12}\frac{\phi(\mathbf{W}'_{ijt}\beta)}{\Phi(\mathbf{W}'_{ijt}\beta)},$$

where $\phi(\cdot)$ is the density function of a standard normal distribution. To estimate the parameters of the linear regression (2nd step), we apply ordinary least squares to the original regression where we add the inverse Mills ratio $\frac{\phi(\mathbf{W}'_{ijt}\beta)}{\Phi(\mathbf{W}'_{ijt}\beta)}$ as an extra explanatory variable to correct for the correlation between the probit and linear regression:

$$\ln X_{ijt} = \mathbf{V}^{\intercal}_{ijt}\alpha + \eta_{it} + \eta_{jt} + \omega\frac{\phi(\mathbf{W}'_{ijt}\hat{\beta})}{\Phi(\mathbf{W}'_{ijt}\hat{\beta})} + u_{ijt}.$$

Here $\hat{\beta}$ is obtained from the probit regression in the first step. The parameter $\hat{\omega}$ is the estimate for σ_{12} and if it is significantly different from zero, the probit equation cannot be ignored. As the included Mills ratio is based on estimates, the resulting errors of the panel regression are heteroskedastic. For correct inference we opt therefore for White standard errors. Note that the test for $\omega = 0$ relies on regular standard errors as under the null hypothesis the inverse Mills ratio disappears. For nonparametric identification of the model parameters, the vector $\mathbf{W}_{ijt}$ should include at least one explanatory variable which is not included in $\mathbf{Z}_{ijt}$. This excluded variable is one that is influential in determining the probability of trade but not the amount of trade. See Wooldridge (2002, Section 17.4) for more details. We use the religion similarity index for this purpose.

Eaton-Tamura Model

To estimate the parameters of the Eaton-Tamura model (4.5) we use maximum likelihood. The likelihood function is given by:

$$L = \prod_{i,j,t} \left[\Pr\left(X_{ijt} = 0\right) f_X\left(X_{ijt}|X_{ijt} = 0\right)\right]^{1-d_{ijt}} \left[\Pr\left(X_{ijt} > 0\right) f_X\left(X_{ijt}|X_{ijt} > 0\right)\right]^{d_{ijt}},$$

where d_{ijt} is an indicator variable equal to 1 when exports X_{ijt} are positive and 0 otherwise. Considering that $f_X\left(X_{ijt}|X_{ijt} = 0\right) = 1$ and $\Pr\left(X_{ijt} = 0\right) = 1 - \Phi(\mathbf{V}_{ijt}^{\intercal}\alpha + \eta_i + \eta_j + \eta_t - \ln a_t)$ the log-likelihood simplifies to:

$$\ln L = \sum_{i,j,t} \left[(1 - d_{ijt}) \left(1 - \Phi(\mathbf{V}_{ijt}^{\intercal}\alpha + \eta_i + \eta_j + \eta_t - \ln a_t)\right) + d_{ijt} \ln\left(f(X_{ijt} + a_t)\right)\right], \tag{4.8}$$

where f is a log-normal density function:

$$f(X_{ijt} + a_t) = \frac{1}{(X_{ijt} + a_t)\sqrt{2\pi\sigma^2}} e^{-\frac{1}{2\sigma^2}\left(\ln(X_{ijt}+a_t) - \mathbf{V}_{ijt}^{\intercal}\alpha - \eta_i - \eta_j - \eta_t\right)^2}.$$

To obtain the estimates of a_t, α and fixed effects η_i, η_j, η_t we maximize (4.8) using the Newton–Raphson algorithm.

Pseudo-Poisson Maximum Likelihood

The parameter estimates of the PPML estimator follow from a moment estimator based on (4.6)

$$(\hat{\alpha}, \hat{\eta}_i, \hat{\eta}_j, \hat{\eta}_t)^{\intercal} = \arg \min_{\alpha, \eta_i, \eta_j, \eta_t} \sum_{i,j,t} \left(X_{ijt} - e^{\mathbf{V}_{ijt}^{\intercal}\alpha + \eta_i + \eta_j + \eta_t}\right)^2,$$

The first-order conditions correspond with the first-order conditions of a Poisson model. The estimator attributes the same weight to all observations. A log-linear specification gives more weight to observations with high $e^{\mathbf{V}'_{ijt}\alpha+\eta_i+\eta_j+\eta_t}$. As long as the pattern of heteroskedasticity increases with $e^{\mathbf{V}'_{ijt}\alpha+\eta_i+\eta_j+\eta_t}$ this approach results in a more efficient estimator as it does not give more weight to "noisier" observations.

The method also overcomes a potential bias arising due to the estimation of elasticities by using a log-linear form of a gravity equation. The fact stems from Jensen's inequality which states that the expectation of the log of the error term is not equal to the log of the expectation.

4.A.4 Estimation Results for Real Variables

Table 4.A.2: Estimates of the gravity model using alternative estimation techniques.

	Heckman				Martin-Pham, time-varying entry costs
	first step	second step			
	$\mathbf{1}_{Export_{ijt}>0}$	$lnExport_{ijt}$	$lnExport_{ijt}$	$lnExport_{ijt}$	$Export_{ijt}$
	(1)	(2)	(3)	(4)	(5)
$lnGDP_{it}$	0.31***	0.96***	0.32***		0.40***
$lnGDP_{jt}$	0.31***	1.63***	1.05***		0.90***
$effdist_{ijt}$	-0.49***	-0.69***	-1.57***	-1.57***	-1.57***
$tariff_{jt}$	-0.01***	-0.01***	-0.01***		0.00
gov_{it}	0.31***	0.31**	0.09**		0.19***
gov_{jt}	0.05***	0.28***	0.26***		0.45***
WTO_{ijt}	0.26***	0.38***	0.29***	0.37***	0.21***
EU_{ijt}	-0.44***	0.19***	-0.22***	-0.33***	-1.08***
$CUBKR_{ijt}$	-3.17***	-1.54***	-1.00***	-0.88***	-4.22***
$EUFTA_{ijt}$	0.18***	0.16***	-0.06***	-0.17***	-0.24***
CIS_{ijt}	1.67***	1.06***	3.05***	3.00***	4.06***
$language_{ij}$	0.45***		0.79***	0.77***	0.82***
$adjacent_{ij}$	0.15***		0.66***	0.64***	-0.08*
$religion_{ij}$	0.05***				
$inverseMills_{ijt}$		2.32***	-0.56***	-0.62***	
$constant$	-2.18***	-23.17***	-4.04***		-1.88**
Fixed effects		ij, t	i, j, t	it, jt	i, j, t
Number of obs	281255	214461	214461	214461	281255

Notes: (*i*) All the variables are in real terms; (*ii*) Dependent variables in the third row; (*iii*) *, **, *** denote statistical significance on the 10%, 5% and 1% levels respectively; (*iv*) Robust standard errors.

4.A.5 Computations of the Intensive and Extensive Margins

Besides dealing with zero trade, the Heckman and Eaton-Tamura models provide estimates of the intensive and extensive margins of trade. The former refers to the change in sales of incumbent exporters after a policy change, the latter to the change in sales of new entrants.

Heckman Model

Suppose that because of a policy change the kth explanatory variable $w_{k,ijt} = v_{k,ijt} \in \{\mathbf{W}'_{ijt}, \mathbf{V}'_{ijt}\}$ in (4.2) and/or (4.4) increases from a to b. In the Heckman framework, all else equal, the policy change transforms the estimated probability of positive trade between two countries as follows:

$$\Pr(X^*_{ijt} = 1|\mathbf{W}_{ijt})|_{w_{k,ijt}=b} - \Pr(X^*_{ijt} = 1|\mathbf{W}_{ijt})|_{w_{k,ijt}=a} = \Phi(\mathbf{W}^{\intercal}_{ijt}\hat{\beta})|_{w_{k,ijt}=b} - \Phi(\mathbf{W}^{\intercal}_{ijt}\hat{\beta})|_{w_{k,ijt}=a},$$

where the notation $|_{w_{ijt}=a}$ means "evaluate the function at a". This outcome follows directly from (4.7). The average across all export destinations of a selected country i (e.g. Ukraine) represents the extensive margin in probability terms, i.e. the percentage of all potential bilateral export flows that are no longer zero as a result of the policy change. This result is shown in column (1) of Tables 4.8 and 4.9.

The entrance of new exporters[11] to the market affects incumbents' trade flows. This effect arises in incumbents' equation (4.4) via the inverse Mills ratio. To estimate this effect we use *conditional* expectation, i.e. expected export flow from country i to country j (in levels) given that there is trade between these two countries:

$$E(X_{ijt}|X_{ijt} > 0, \mathbf{V}'_{ijt}, \mathbf{W}'_{ijt}) = \exp(\mathbf{V}^{\intercal}_{ijt}\alpha + \eta_{it} + \eta_{jt} + 1/2\sigma^2_2)\frac{\Phi(\mathbf{W}^{\intercal}_{ijt}\beta + \sigma_{12})}{\Phi(\mathbf{W}'_{ijt}\beta)}.$$

An intensive margin of trade is then a percentage change in this conditional expectation:

$$\frac{E(X_{ijt}|X_{ijt} > 0, \mathbf{V}'_{ijt}, \mathbf{W}'_{ijt})|_{w_{k,ijt}=b}}{E(X_{ijt}|X_{ijt} > 0, \mathbf{V}'_{ijt}, , \mathbf{W}'_{ijt})_{w_{k,ijt}=a}} - 1$$
$$= \exp((b-a)\alpha_k)\frac{\Phi(\mathbf{W}'_{ijt}\beta + \sigma_{12})|_{w_{k,ijt}=b}}{\Phi(\mathbf{W}'_{ijt}\beta)|_{w_{k,ijt}=b}}\frac{\Phi(\mathbf{W}'_{ijt}\beta)|_{w_{k,ijt}=a}}{\Phi(\mathbf{W}'_{ijt}\beta + \sigma_{12})|_{w_{k,ijt}=a}} - 1.$$

[11] If the policy change is negative some firms may exit the market giving a negative extensive margin in probability terms.

To obtain an estimate we replace model parameters α_k, σ_{12}, β with their estimated values $\hat{\alpha}_k$, $\hat{\omega}$, $\hat{\beta}$. The average across all export destinations gives then an estimate of the intensive margin of trade after a correction has been made for the entry of new exporters. We report the result in column (3) of Tables 4.8 and 4.9. To compute the total (*unconditional*) change of the policy change we use the unconditional expectation for export flows in levels given by:

$$E(X_{ijt}|\mathbf{V}'_{ijt}, \mathbf{W}'_{ijt}) = \exp(\mathbf{V}^{\intercal}_{ijt}\alpha + \eta_{it} + \eta_{jt} + 1/2\sigma_2^2)\Phi(\mathbf{W}^{\intercal}_{ijt}\beta + \sigma_{12}).$$

The unconditional percentage change in the bilateral export flow as a result of the policy change is then:

$$\frac{E(X_{ijt}|\mathbf{V}'_{ijt}, \mathbf{W}'_{ijt})|_{w_{k,ijt}=b}}{E(X_{ijt}|\mathbf{V}'_{ijt},, \mathbf{W}'_{ijt})_{w_{k,ijt}=a}} - 1 = \exp((b-a)\alpha_k)\frac{\Phi(\mathbf{W}'_{ijt}\beta + \sigma_{12})|_{w_{k,ijt}=b}}{\Phi(\mathbf{W}'_{ijt}\beta + \sigma_{12})|_{w_{k,ijt}=a}} - 1.$$

Again, we average across all export destinations of Ukraine. This gives the total effect of the policy change on bilateral trade flows after correction for the sample selection bias. We report the outcome in column (4) of Tables 4.8 and 4.9.

The difference between the total change and the intensive margin gives then the extent of the extensive margin, i.e. the value of exports of newly entered firms. This is column (2) of Tables 4.8 and 4.9.

Eaton-Tamura Model

In Eaton-Tamura model (4.5) the effect of policy change on the probability of non zero trade between two countries is computed as follows:

$$\begin{aligned}
&\Pr(X_{ijt} > 0|\mathbf{V}'_{ijt})|_{v_{k,ijt}=b} - \Pr(X_{ijt} > 0|\mathbf{V}'_{ijt})|_{v_{k,ijt}=a} \\
&= \Phi\left(-\frac{\ln a_t - \mathbf{V}'_{ijt}\alpha - \eta_i - \eta_j - \eta_t}{\sigma_{ijt}}\right)\Bigg|_{v_{k,ijt}=b} - \Phi\left(-\frac{\ln a_t - \mathbf{V}'_{ijt}\alpha - \eta_i - \eta_j - \eta_t}{\sigma_{ijt}}\right)\Bigg|_{v_{k,ijt}=a}.
\end{aligned}$$

Like in Heckman model the average across all export destinations of a selected country i gives the extensive margin in probability terms (column (1) of Tables 4.8 and 4.9), where we replace the parameters with their ML estimates.

From the structure of the Eaton-Tamura model it follows that $Q_{ijt} = Z_{ijt} + a_t$ is a lognormal random variable with the mean $\mu_{ijt} = \mathbf{V}'_{ijt}\alpha + \eta_i + \eta_j + \eta_t$ and the variance σ^2_{ijt}.

This gives the *conditional* expectation necessary to compute the intensive margin:

$$E\left(X_{ijt}|X_{ijt}>0,\mathbf{V}'_{ijt}\right)=E(Q_{ijt}-a_t|Q_{it}>a_t,\mathbf{V}'_{ijt})=\exp(\mu_{ijt}+\sigma^2_{ijt}/2)\frac{\Phi\left(\frac{\mu_{ijt}+\sigma^2_{ijt}-\ln a_t}{\sigma_{ijt}}\right)}{\Phi\left(-\frac{\ln a_t-\mu_{ijt}}{\sigma_{ijt}}\right)}-a_t,$$

and the *unconditional* expectation relevant for the computation of the total effect of the policy change:

$$E(X_{ijt}|\mathbf{V}'_{ijt})=E\left(X_{ijt}|X_{ijt}>0,\mathbf{V}'_{ijt}\right)\Pr(X_{ijt}>0|\mathbf{V}'_{ijt})=E\left(X_{ijt}|X_{ijt}>0,\mathbf{V}'_{ijt}\right)\times$$
$$\times\,\Phi\left(-\frac{\ln a_t-\mu_{ijt}}{\sigma_{ijt}}\right).$$

The intensive margin, the extensive margin in value terms and the total effect of the policy change are computed in the same way as for the Heckman model using the relevant conditional and unconditional expectations and the ML parameters estimates.

Chapter 5

Summary and Directions for Further Research

This thesis has examined three topics relevant for a number of world regions and economies. Chapter 2 developed a measure of economic integration. By using the Middle East as an example it argued that measures of economic integration should take into account not only trade but also the extent of human and physical capital mobility within the region. Chapter 3 analyzed the effects of global factors on inflation in advanced economies. It focused particularly on the role of global economic slack, global inflation and commodity prices in driving domestic inflation developments. Chapter 4 evaluated trade policy options of Ukraine. It analyzed the gains that Ukraine could benefit from by signing a free trade area agreement with the European Union. Thus, the thesis addressed the following three research questions: (1) Is the Middle East poorly integrated? (2) Do global factors determine inflation in advanced economies? (3) What are the implications of Ukraine's trade policy?

5.1 Summary

The Middle East and North Africa is a region often portrayed as economically poorly integrated owing to a low intra-regional trade with relatively little economic policy coordination efforts and a limited involvement to the world trading system (e.g. Rouis and Tabor, 2013). However, with the steady mobility of human capital across regional borders is this conjecture correct? To address this question, Chapter 2 develops production equilibrium that arises in a fully integrated economic area characterized by free trade, similar technologies and free mobility of human and physical capital. It then applies metrics to measure the distance between a fully integrated benchmark and the actual data. The metrics allow to compare the extent of economic integration both over time and across different world regions. Chapter 2 applies these to three different regions - the Middle East, Latin America and the European Union. Despite apparent differences present between the regions, we find that their measures of economic integration are remarkably close in 2009. We argue therefore that human capital mobility is an important instrument to achieve closer economic integration and that its omission can strongly understate the extent of actual economic integration within an economic area.

Chapter 3 focuses on the role of global factors in advanced economy inflation. There has been an increasing interest both in academic and policy circles on the extent to which advanced economy inflation can be considered to be a global phenomenon (Ciccarelli and Mojon, 2010, Borio and Filardo, 2007). To contribute to the discussion, Chapter 3 estimates country-specific Phillips curves for 19 advanced economies. The Phillips curves are augmented with global factors that include different measures of global economic slack, global inflation and commodity prices. We find that except of commodity prices other global factors have limited role in shaping domestic inflation developments. In particular, we find no direct effects of global economic slack and global inflation on domestic inflation rates for the majority of countries. Measures of global economic slack are rarely significant and their importance does not grow over time. With regard to the role of global inflation and in line with existent literature we find that global inflation has been indeed a useful factor in forecasting advanced economy inflation rates. However, we find that this role is limited solely to 1970-80s when inflation rates have been high and volatile. Since 1990s global inflation does not add any improvement to domestic inflation forecasts anymore. More specifically, inflation forecasting models that include measures of global inflation do not perform better in terms of their root mean squared errors than a simple autoregression. Our results also provide evidence suggesting that global inflation helps to forecast domestic inflation in 1970-80s because it happens to capture well the slow-moving trends in inflation rates. Much the same role can be performed by domestic long-term inflation expectations. This questions the usefulness of a global component to forecast domestic inflation rates. Thus, irrespective of the variety of global measures considered, once we control for commodity prices we find no direct effects of other global factors on domestic inflation. Commodity prices and, to a more moderate extent, domestic economic slack remain the main drivers of inflation in advanced economies.

Chapter 4 evaluates trade policy options of Ukraine. In 2014 the country opted for closer economic cooperation with the European Union and signed a so called Deep and Comprehensive Free Trade Agreement with the latter. To evaluate possible implications of this policy choice Chapter 4 considers two scenarios. One looks at the consequences for Ukraine from stronger economic ties with the European Union, whereas another focuses on the consequences from stronger economic ties with the Commonwealth of Independent States. We use a gravity model framework and a world bilateral export data set to evaluate the two scenarios. Our data set includes bilateral export flows between 159 economies over 1997 - 2012. We control for a number of relevant free trade area and customs union agreements and we take into account the effects of infrastructure and governance on trade. We use three different estimation approaches that account for a large number of zeros in bilateral trade data - Heckman two-stage procedure, Poisson pseudo-maximum likelihood and Martin-Pham tobit - and we apply statistical tests to discriminate between alternative models. Our scenario analyses rely on the results of the best performing models. We find persistently robust outcomes for a number of variables. First, we find that CIS countries significantly overtrade with each other under the CIS agreement and that the access of Ukraine to the customs union of Belarus, Kazakhstan and Russian Federation would not bring additional trade benefits. On the other hand, we find no conclusive evidence on direct effects stemming from a free trade area agreement with the EU. However, the results reveal several indirect effects of relevance to Ukraine. Namely, closer ties with the EU would certainly facilitate the improvement of Ukraine's governance and infrastructure. The following could, *ceteris paribus*, lead to respective gains of order of 98% and 22% for Ukrainian exporters.

5.2 Directions for Further Research

Chapter 2 has shown that output and production factor shares in a fully integrated area are characterized by the Zipf's law. The formal derivation of the result, however, assumed no correlation between shares neither across the types of shares nor across countries. An extension could be to investigate the conditions under which Zipf's law still holds for correlated reflected geometric Brownian motions. It is known that for a set of correlated reflected geometric Brownian motions there exists a stationary distribution as long as the so called skew-symmetry condition is satisfied. The question of whether the existing limiting distribution leads to the Zipf's law may be an interesting and important generalization of our findings in Chapter 2. Clearly, the application of our integration measures can be extended to other world regions (e.g., the countries of the Commonwealth of Independent States or the members of East Asean trade arrangements).

Chapter 3 has focused on the role of global factors in domestic headline inflation developments. While the results point to no direct effects of global factors, indirect channels may yet play a role. Given significant heterogeneity of the coefficients across countries, a direction for future research could be to estimate country specific vector autoregressions to capture possible indirect effects. A promising channel could be commodity prices that significantly affect headline inflation rates. Less so, but nevertheless significant, could be a domestic slack channel. Another direction for future research could be focusing on an even more extended variety of measures of global economic slack. As in Borio and Filardo (2007) a yet another measure could be country-varying and based on, for example, trade weights of the most important trading partners. Alternatively, measures of global economic slack could be extended to include non-OECD members and, in particular, China that takes an important share of world output. In this case, however, the availability of accurate output gap data, could be an issue. Further research could also be directed to look for regularities in parameter time-variation. Though not for all, for some advanced economies like the United States, Australia and Canada the flattening of the Phillips curve has been confirmed. Does this change in the coefficient occur due to global factors? Models with time-varying coefficients may be a possible research methodology for this group of advanced economies. It is also interesting to look at whether the effect of global factors on domestic inflation depends on the list of countries included into global measures. A hypothesis could be whether, e.g. neighbouring countries have a larger weight in driving domestic inflation developments.

Chapter 4 has estimated the gravity model of trade using world bilateral export flow data. The focus has been on Ukraine. However, the model is potentially suitable for any world country. An extension to non-EU trade agreements could be performed and the focus could be shifted to, for example, the Middle East or Latin America. Further, although the models, that the analysis was built on, included a wide range of fixed effects to control for unobserved heterogeneity, it could be interesting to investigate the role of, for example, exchange rate, exchange rate volatility or other possibly omitted trade determinants. This raises the question of how various exchange rate arrangements affect trade, which, in turn, relates to a large literature on the role of monetary unions in stimulating trade (see, e.g. Glick and Rose, 2002). Additionally, we may seek for alternative ways governance affects trade flows. In our models of Chapter 4 governance indicators entered directly either linearly or *log*-linearly. Although it has lead to robust outcomes, a formal theoretical derivation of how governance influences trade may deserve future research to further strengthen our findings.

Samenvatting (Summary in Dutch)

De afgelopen jaren waren rijk aan gebeurtenissen in de internationale arena. De wereld heeft toen de diepste recessie sinds de Tweede Wereldoorlog ervaren. Het langzame economisch herstel dat volgde en de langdurige fase van lage inflatie stelde overheden en centrale banken van veel economieën in de wereld voor uitdagingen. Eind 2010 kwam de Arabische lente naar het Midden-Oosten en Noord-Afrika. De onrust had belangrijke geopolitieke en economische gevolgen voor de regio. Het raakte de regionale toerisme-industrie, verlaagde overdrachten naar werkenden en creëerde onzekerheid bij zowel binnenlandse als buitenlandse investeerders. Vier jaar later vond de Maidanrevolutie plaats in Oekraïne, wat resulteerde in de ondertekening van de zogenaamde Deep and Comprehensive Free Trade Area Agreement tussen het land en de Europese Unie. Het handelsverdrag is op 1 januari 2016 in werking getreden. Dit proefschrift onderzoekt de belangrijkste aspecten rondom deze gebeurtenissen op empirische wijze.

Het Midden-Oosten en Noord-Afrika is een regio die is vaak als economisch slecht geïntegreerd wordt beschouwd. Dit komt door een laag niveau van intraregionale handel met relatief weinig economische beleidscoördinatie, en een beperkte betrokkenheid bij het wereldhandelssysteem (bijv.Rouis and Tabor, 2013). De vraag is echter of deze veronderstelling juist is, gezien de gestage mobiliteit van menselijk kapitaal over de regionale grenzen. Om deze vraag te beantwoorden, ontwikkelt Hoofdstuk 2 een productie-evenwicht dat ontstaat in een volledig geïntegreerd economisch gebied met vrije handel, vergelijkbare technologieën en volledige mobiliteit van menselijk en fysiek kapitaal. Het model gebruikt vervolgens de maten om de afstand tussen een volledig geïntegreerd evenwicht en de daadwerkelijke data te meten. Het is mogelijk om met deze maten de mate van economische integratie te vergelijken, zowel over de tijd als tussen verschillende regio's in de wereld. In Hoofdstuk 2 worden de maten toegepast op drie verschillende regio's - het Midden-Oosten, Latijns-Amerika en de Europese Unie. Ondanks evidente verschillen die bestaan zijn tussen deze regio's, vinden we dat de maten van economische integratie opmerkelijk overeenkomstig zijn in 2009. We stellen daarom dat de mobiliteit van menselijk kapitaal een belangrijk instrument is om nauwere economische integratie te bewerkstelligen, en dat het weglaten van deze factor de werkelijke mate van economische integratie binnen een economische ruimte sterk onderschat.

Hoofdstuk 3 onderzoekt de rol van mondiale factoren ten aanzien van inflatie in ontwikkelde economieën. Er is een toenemende belangstelling, zowel in academische als in beleidskringen, voor de mate waarin inflatie in ontwikkelde economieën een globaal fenomeen is (Ciccarelli and Mojon, 2010; Borio and Filardo, 2007). Om aan deze discussie bij te dragen, schat Hoofdstuk 3 land-specifieke Phillips curves voor 19 ontwikkelde economieën. De Phillips curves worden vermeerderd met mondiale factoren met inbegrip van verschillende maten van de globale economische vertraging, globale inflatie en grondstofprijzen. We vinden dat, met uitzondering van de grondstofprijzen, mondiale factoren een beperkte invloed hebben ten aanzien van de ontwikkeling van binnenlandse inflatie. In het bijzonder vinden we in de meeste landen geen directe effecten van globale economische vertraging en globale inflatie op binnenlandse inflatie. De maten van globale economische vertraging zijn zelden significant en het belang hiervan groeit niet over de tijd. Wat betreft de rol van globale inflatie en in overeenstemming met bestaande literatuur is globale inflatie inderdaad een nuttige factor voor het voorspellen van inflatie in ontwikkelde economieën. We vinden echter dat deze rol zich uitsluitend beperkt tot de jaren '70 en '80, toen de inflatie hoog en volatiel was. Sinds de jaren '90 draagt de globale inflatie niet meer bij aan het verbeteren van de prognoses van de binnenlandse inflatie. Meer specifiek doen de voorspellingsmodellen van inflatie die maten van globale inflatie bevatten het niet beter in termen van hun gemiddelde kwadratische afwijkingen dan een simpele autoregressie. Onze resultaten leveren ook bewijs dat suggereert dat de globale inflatie helpt om de binnenlandse inflatie in de jaren ‘70 en ‘80 te voorspellen, omdat het de trage ontwikkeling van de inflatie goed vastlegt. Deze rol kan ook worden vervuld door de binnenlandse inflatieverwachtingen op de lange termijn. Dit resultaat zet vraagtekens bij het nut van een globale component om de binnenlandse inflatie te voorspellen. Dus ongeacht de verscheidenheid aan mondiale factoren die we onderzochten, zodra we controleren voor grondstofprijzen vinden we geen directe effecten van andere mondiale factoren op binnenlandse inflatie. Grondstofprijzen en, in iets mindere mate, binnenlandse economische vertraging blijven de belangrijkste verantwoordelijken voor inflatie in ontwikkelde economieën.

Hoofdstuk 4 evalueert de opties voor het handelsbeleid van Oekraïne. In 2014 koos het land voor nauwere economische samenwerking met de Europese Unie en ondertekende daartoe een zogenaamde Deep and Comprehensive Free Trade Agreement. Om de mogelijke gevolgen van deze beleidskeuze te evalueren, beschouwt Hoofdstuk 4 twee scenario’s. Het eerste scenario kijkt naar de gevolgen voor Oekraïne van sterkere economische banden met de Europese Unie, terwijl het tweede scenario zich richt op de gevolgen van sterkere economische banden met het Gemenebest van Onafhankelijke Staten. We gebruiken een gravity model raamwerk en een dataset met wereldwijde bilaterale exportdata om de scenario’s te evalueren. De dataset betreft bilaterale exportstromen tussen 159 economieën in de periode 1997-2012. We controleren voor een aantal relevante factoren zoals overeenkomsten over vrijhandelszones en douane-unies, en we houden rekening met de effecten van infrastructuur en het bestuur op de handel. We gebruiken drie verschillende schattingsmethoden die rekening houden met het grote aantal nullen in bilaterale handelsdata - de Heckman tweetrapsprocedure, de Pseudo-Poisson Maximum Likelihood, en de Martin-Pham Tobit - en we passen statistische tests toe om de alternatieve modellen met elkaar te vergelijken. We baseren onze scenario-analyses op de resultaten van de best presterende modellen. We vinden aanhoudend sterke resultaten voor een aantal variabelen. Ten eerste vinden we dat de GOS-landen overmatig met elkaar handelen op basis van de GOS-overeenkomst, en dat de toegang van Oekraïne tot de douane-unie met Wit-Rusland, Kazachstan en de Russische Federatie geen extra handelsvoordelen oplevert. Aan de andere kant vinden we geen sluitend bewijs dat er directe effecten voortvloeien uit de vrijheidszone met de EU. De resultaten onthullen echter verschillende indirecte effecten die relevant zijn voor Oekraïne, namelijk dat hechtere banden met de EU bijdragen aan het verbeteren van het bestuur en de infrastructuur van Oekraïne. Dat kan, *ceteris paribus*, leiden tot een toename van orders van respectievelijk 98% en 22% voor Oekraïense exporteurs.

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