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Spatial Perspectives of Improving Competition in Lebanon

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This paper introduces the ARZ model – a fully operational spatial computable general equilibrium model for Lebanon – and its use for the analysis of place-based policies in Lebanon, in an attempt to bring additional insights to some of the proposals presented in the National Physical Master Plan of the Lebanese Territory. The ARZ model uses a similar approach to Haddad and Hewings (2005) to incorporate recent theoretical developments in the new economic geography. We apply the model to look at the *ex ante* potential spatial implications of an increase in domestic and international integration of Lebanese regions through reductions in trade costs.

Keywords: Spatial CGE model; trade cost; spatial interaction; Lebanon; competition policies.

JEL Codes: R11, R13, R15.

Spatial Perspectives of Improving Competition in Lebanon

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Abstract. This paper introduces the ARZ model – a fully operational spatial computable general equilibrium model for Lebanon – and its use for the analysis of place-based policies in Lebanon, in an attempt to bring additional insights to some of the proposals presented in the National Physical Master Plan of the Lebanese Territory. The ARZ model uses a similar approach to Haddad and Hewings (2005) to incorporate recent theoretical developments in the new economic geography. We apply the model to look at the *ex ante* potential spatial implications of an increase in domestic and international integration of Lebanese regions through reductions in trade costs.

1. Introduction

Interest by policymakers on regional issues in Lebanon has been recently renewed with the publication of the National Physical Master Plan of the Lebanese Territory (NPMPLT, 2005). The NPMPLT has challenged the received wisdom that there is little interest in spatial development planning and spatial development issues in small size countries.[1] It defined the principles of developments for various regions as well as the basics of the usage of territory for all areas. It also proposed facilities and sites of planned activities, specifying their objectives, dimensions and locations in the tradition of regional development plans elsewhere.[2] Challenges for the future economic development of the country were identified in different sectors in a context of increasing internal and external obstacles to the Lebanese economy. In a context of growing global integration and increasing international competition, economic sectors and regions were not prepared for facing this new economic environment after a period of internal turbulence.

As indicated in the NPMPLT[3], competitive sectors were always densely concentrated in the conurbation core of the governorates of Beirut and Mount Lebanon, while peripheral regions were taken out of competition by strong protectionist policies for the agricultural sector. As more liberal policies advance in the country, new challenges

[1] With less than 11,000 km^2, Lebanon is the second smallest country in the Middle East and the Arab World (after Bahrain). Its territory represents 1/1000th that of large countries such as the USA and Canada and 1/100th that of Egypt (NPMPLT, 2005, ch. 1, p. 1).
[2] NPMPLT, 2005, Introduction, p. 1.
[3] Op. cit., Introduction, p. 4.

emerge to the Lebanese regional economies, that may be also addressed through place-based policies: (i) domestic integration of the periphery to the core, by improvements of the transportation network in the country; (ii) TFP-enhancing policies in the lagging regions, benefitting from lower local costs and geographical advantages; and (iii) sectoral policies related to regional comparative advantages in the global markets.

This paper focuses on the first set of place-based policies in response to the challenge of globalization. It looks not only at the domestic integration of the country in the form of better links to the regions' domestic markets and suppliers, but also to improved links to the world economy.

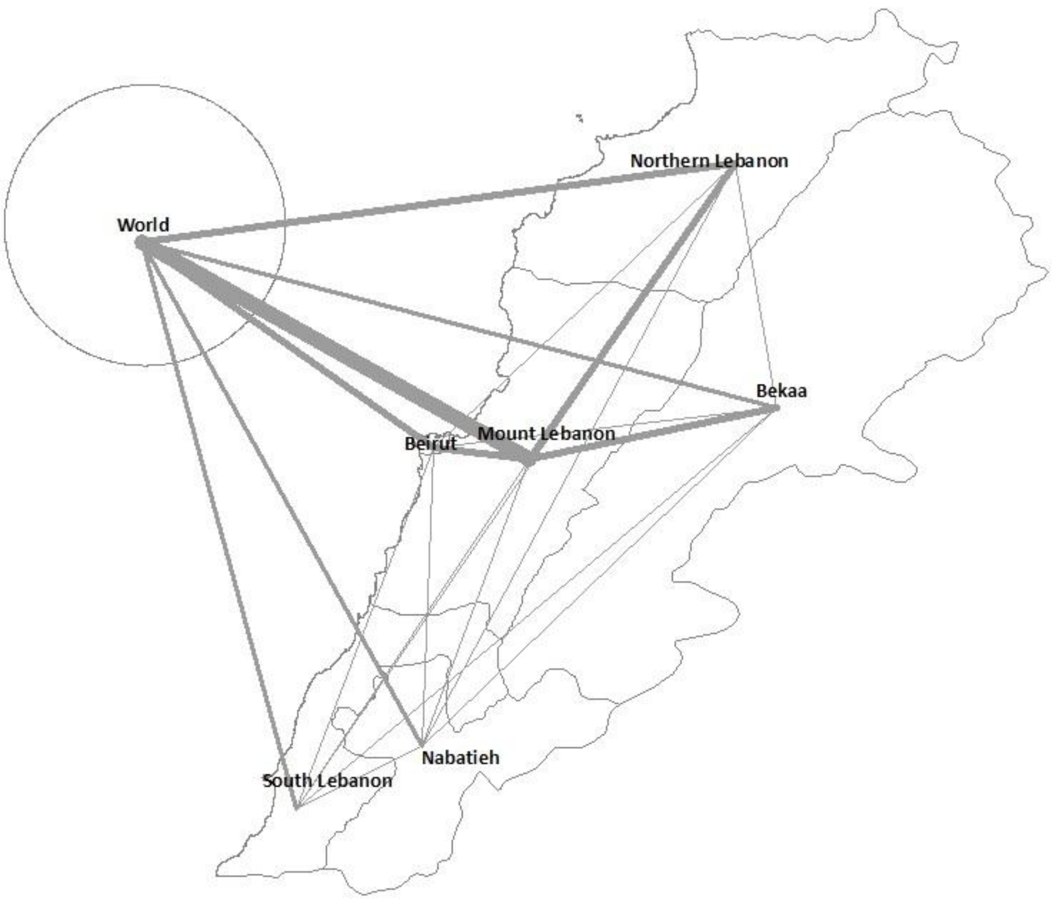
Though small, the Lebanese economy is not homogenous internally, presenting variations across sectors and regions. Thus, it is expected that the economic impact of economic policies will vary across different governorates (*mohaafazaat*). In the context of renewed attention to the spatial aspects of economic development, both from a theoretical perspective (Fujita and Krugman, 2004) and from a policy perspective (World Bank, 2009), there is a growing need for economic and socioeconomic models for bringing new insights into the process of regional planning in the country. In this paper we introduce the ARZ model, a spatial computable general equilibrium (CGE) model for Lebanon, in an attempt to bring additional insights to some of the proposals presented in the NPMPLT.

The remaining of the paper is structured as follows. After this introduction, section 2 gives the motivation for the empirical exercise in the context of competition policies for the country. Section 3 introduces the ARZ model, the spatial CGE model for Lebanon to be used in the simulations. Section 4 presents the main results of the basic simulation – in which we look at an increase in domestic and international integration of Lebanese regions through reductions in trade costs. Section 5 proceeds with a thorough decomposition of the results of the basic simulation, based on structural sensitivity analysis techniques, which considers the role played by changes in specific trade costs. Concluding remarks follow.

2. Competition in Lebanon and Freeness of Trade

Given the great importance of issues related to the globalization process and to the implicit assumption that the future of a region is strictly connected to its capacity to compete in external markets, international trade has commanded attention from most economic analysts of the Lebanese economy. However, interregional trade also plays a key role at the subnational level. Figure 1 presents the hierarchy of international and domestic trade flows in Lebanon, revealing the dominance of transactions with the rest of the world, and of internal transactions with the core region. While in absolute terms such pattern emerges, considering trade flows in relative terms uncovers the importance of domestic trade to the peripheral areas of the country; interregional trade represents about twice as much as international trade in Bekaa, South Lebanon and Nabatieh (Table 1). Interregional interactions should be taken into account in order to better understand how regional economies are affected, both in international and domestic markets, since the performance of better developed regions seems to have a pivotal role in smaller economies. The usual characterization of spatial interaction, which considers the region versus the rest of the world, does not contemplate two of its major properties for the elucidation of an interregional system: feedbacks and hierarchy. Interregional trade can potentially trigger the dissemination of feedback effects, which, quantitatively, can be larger than the effects produced by international trade. However, the impact of feedback effects will be partially determined by the hierarchical structure of the regional economic system (Haddad and Hewings, 2005). In the Lebanese case, for instance, the impacts of the interregional trade of greater Beirut on the national economy are expected to be different from the impacts produced by other governorates.

Figure 1. Hierarchy of Trade Flows in Lebanon



Source: Author's calculation based on IIOM-LIBAN (Haddad, 2012)

Table 1. Interregional and International Trade Coefficients: Lebanese Governorates, 2004-2005 (% of GRP)

	Beirut	Mount Lebanon	Northern Lebanon	Bekaa	South Lebanon	Nabatieh	TOTAL
Interregional exports	37.7	33.4	33.9	61.6	74.5	25.7	40.0
Interregional imports	-42.4	-29.6	-22.4	-57.2	-30.0	-157.4	-40.0
Total interregional trade	80.1	62.9	56.3	118.8	104.5	183.1	-
Interregional trade balance	-4.7	3.8	11.5	4.3	44.6	-131.7	-
International exports	58.3	13.1	13.4	7.5	9.9	6.1	18.1
International imports	-83.5	-49.3	-39.1	-51.8	-45.6	-77.0	-53.7
Total international trade	141.7	62.4	52.5	59.3	55.5	83.1	71.8
International trade balance	-25.2	-36.2	-25.6	-44.3	-35.7	-70.9	-35.6

Source: Author's calculation based on IIOM-LIBAN (Haddad, 2012)

Thus, the conclusion might be that the future of Lebanese regions might not only be closely related to their performance in international markets, but also to their relationship with other domestic markets. Once again, there would be room for public intervention through actions targeting the modernization of Lebanon's transportation network, as advocated in the NPMPLT, establishing a more efficient interaction between producer and consumer markets, thus maximizing the effects of the Lebanese competition policy strategies. Mechanisms for the dissemination of feedback effects could be created, and the competitive edge of Lebanese products in the international market could then be increased.

The discussion of competition policies in Lebanon has seldom considered the spatial dimension in formal economic models. Regular publication of the Lebanon's national accounts since 2002 – starting with 1997 estimates (NEA, 2010) has provided important inputs for models of the Lebanese economy.[4] Pioneering attempts to model the Lebanese economy are mostly related to accounting-based macro modeling frameworks (e.g. the RMSM-X model used by the World Bank), or national input-output and CGE models (Dessus and Ghaleb, 2006; Berthélemy *et al*., 2007; Hamade *et al*., 2011). Given the challenge of economic development the country faces, simulation exercises often attempt to assess macro and sectoral impacts of competition policies in Lebanon at the national level. Using different sorts of national general equilibrium models, it has been shown that Lebanon would largely benefit from the reduction of anti-competitive practices (Dessus and Ghaleb, 2006); that additional GDP growth could be gained through public expenditure, greater domestic competition, and tax harmonization (Berthélemy *et al*., 2007); and that reductions in domestic trade margins in agricultural commodities are important mechanisms to tackle major agricultural problems Lebanon faces associated with its inefficient marketing channels (Hamade *et al*., 2011).

There are other government initiatives in Lebanon to promote competition whose *ex ante* impacts need to be properly assessed. Both non-spatial (e.g. trade liberalization, sectoral policies) and place-based policies (e.g. investments in infrastructure) are expected to have differential regional impacts, as economic structures of regions vary,

[4] To our knowledge, other sources of data are seldom incorporated in the existing modeling efforts for Lebanon (e.g. demographic and social statistics such as population, labor force and household expenditure surveys).

and the role of infrastructure and of business and community leaders also vary from region to region. There may also exist important trade-offs between efficiency and regional equity. Understanding the nature of these trade-offs requires to take into account the key linkages between regions using appropriate policy tools. In a context where the public administrations experience a stronger and stronger demand on social policy and security, and where budgets tend to be tightened or even scaled back, the economic evaluation – and optimization – of policy actions becomes a recurrent requirement.[5]

The case study addressed in this paper is particularly interesting. We consider reductions in trade costs in the Lebanese economy to look at its implications to spatial allocation of resources. The link of freeness of trade and the equilibrium distribution of activities is addressed in the context of the six governorates in Lebanon and the rest of the world. Regional integration is simulated by reducing not only trade costs between origin-destination pairs of Lebanese domestic regions but also those associated with interactions with the international markets. Thus, we adopt the broader concept of market access and supplier areas which include both domestic and foreign trading regions. A fully specified interregional absorption matrix (Haddad, 2012), which includes flows of goods between origin-destination pairs of Lebanese regions and an external region, is used to calibrate a spatial CGE model that is in the process of being unfettered from the reins of the perfectly competitive modeling paradigm.

Lebanon's spatial structure is characterized by strong polarization from the capital city and its surroundings, encompassing the governorates of Beirut and Mount Lebanon. The very location of the greater Beirut presents a challenge to a broader (from a territorial point of view) integration of the Lebanese economy to global markets, as market/supply access from/to the economic periphery of the country is hindered by high internal trade costs. The results of our simulations show that spatial hierarchy may play an important role to explain the resulting equilibrium distribution. The interplay of forces related to domestic and foreign markets may reveal a situation in which geography favors coastal areas. As trade costs decline, the central region is positively affected; however, other regions with more privileged access to external markets may present an even better

[5] See World Road Association (2003) for a discussion in the context of transport policies.

performance. Moreover, after proceeding with a thorough decomposition of the results, from a spatial perspective of freeness of trade, we are able to identify strategic trade links in the context of the Lebanese interregional system, generating qualitative structures of influences based on different policy targets. Our results suggest a typology of regions based on the influence of forward and backward linkages. In other words, for some regions, accessibility to markets plays a major role to drive economic growth, while for others accessibility to suppliers is the main driver. There are also regions that equally benefit from forward and backward spatial linkages. Finally, there is evidence of potential changes in growth-orientation when we consider a broader integration including not only freeness of trade within the country but also better access to international markets. As will be seen, visualization techniques of such key trade links provide a useful instrument for policy analysis.

3. The ARZ Model

In this paper we use the ARZ model, the first fully operational spatial CGE model for Lebanon. We use an approach to incorporate the spatial structure that is similar to Haddad and Hewings (2005). Experimentation with the introduction of Marshallian scale economies and trade costs provide innovative ways of dealing explicitly with theoretical issues related to integrated regional systems. The model used in this research is designed for policy analysis. Agents' behavior is modeled at the regional level, accommodating variations in the structure of regional economies. Regarding the regional setting, the main innovation in the ARZ model is the detailed treatment of interregional trade flows in the Lebanese economy, in which the markets of regional flows are fully specified for each origin and destination. The model recognizes the economies of the six Lebanese governorates. Results are based on a bottom-up approach – i.e. national results are obtained from the aggregation of regional results. The model identifies 8 production/investment sectors in each region producing 8 commodities (Table 2), one representative household in each region, one government, and a single foreign area that trades with each domestic region. Two local primary factors are used in the production process, according to regional endowments (capital and labor). Special groups of equations define capital accumulation relations. The model is structurally calibrated for 2004-2005; a rather complete data set is available for 2005, which is the year of the last publication of the national input-output tables that served as the basis for the estimation of the interregional input-output database. Additional structural data from the period 2004-2005 complemented the database.[6]

The ARZ model qualifies as a Johansen-type model in that the solutions are obtained by solving the system of linearized equations of the model, following the Australian tradition. A typical result shows the percentage change in the set of endogenous variables, after a policy is carried out, compared to their values in the absence of such policy, in a given environment. The schematic presentation of Johansen solutions for such models is standard in the literature. More details can be found in Dixon and Parmenter (1996).

Table 2. Sectors in the ARZ Model

1. Agriculture and livestock
2. Energy and water
3. Manufacturing
4. Construction
5. Transport and communication
6. Other services
7. Trade
8. Administration

3.1. Overview

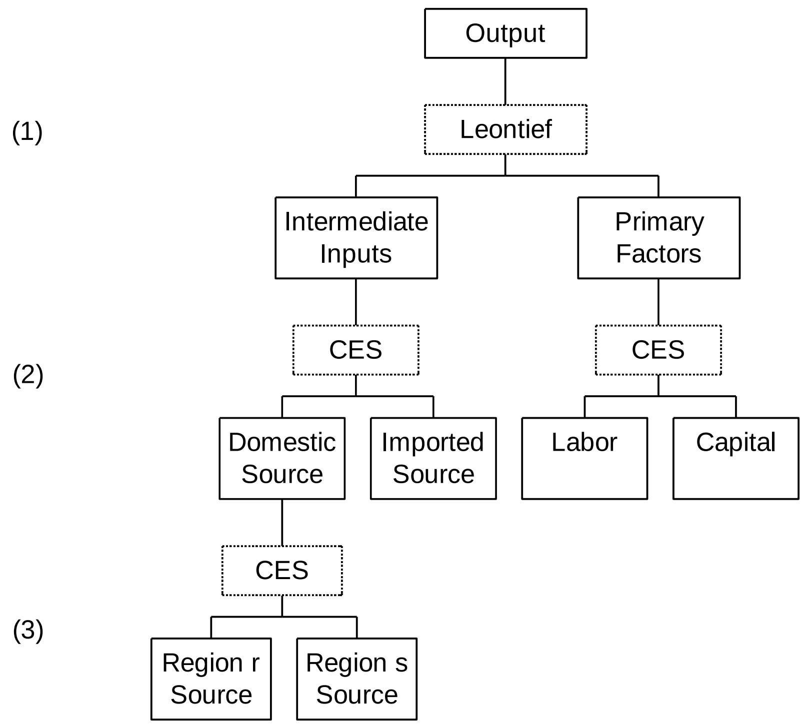
The basic structure of the ARZ model is very standard and comprises three main blocks of equations determining demand and supply relations, and market clearing conditions. In addition, various regional and national aggregates, such as aggregate employment, aggregate price level, and balance of trade, are defined here. Nested production functions and household demand functions are employed; for production, firms are assumed to use fixed proportion combinations of intermediate inputs and primary factors in the first level while, in the second level, substitution is possible between domestically produced and imported intermediate inputs, on the one hand, and between

[6] See Haddad (2012) for a detailed description of the database.

capital and labor, on the other. At the third level, bundles of domestically produced inputs are formed as combinations of inputs from different regional sources (Figure 2).

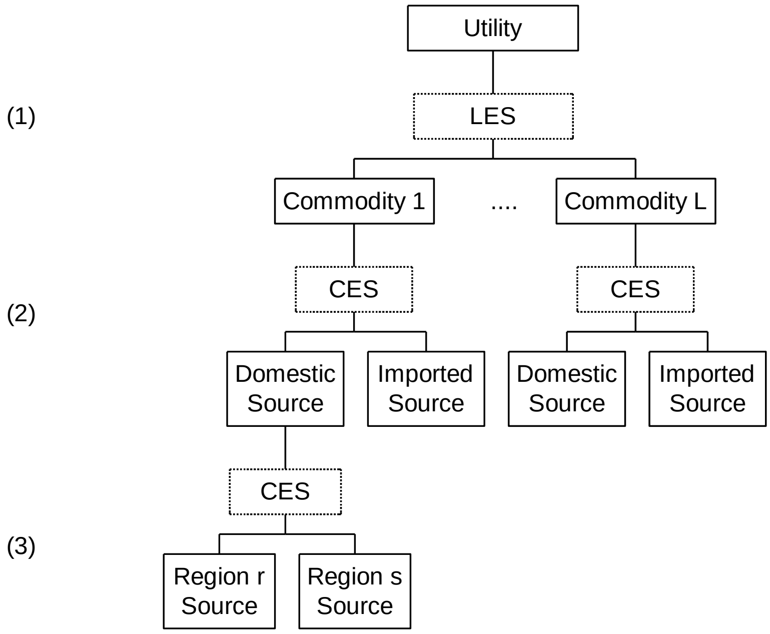
The modeling procedure adopted in the ARZ model uses a constant elasticity of substitution (CES) specification in the lower levels to combine goods from different sources. Given the property of standard CES functions, non-constant returns are ruled out. One can modify assumptions on the parameters values in order to introduce external scale economies of the Marshallian type. Changes in the sectoral production functions are easily implemented in order to incorporate non-constant returns to scale, a fundamental assumption for the analysis of integrated interregional systems. To do so, we keep the hierarchy of the nested CES structure of production, which is very convenient for the purpose of calibration (Bröcker, 1998), but we modify the hypotheses on parameters values, leading to a more general form. Non-constant returns to scale can be introduced in the group of equations associated with primary factor demands within the nested structure of production. The sectoral demand for the primary factor composite (in region r), y, relates to the total output, z, in the following way: $y = Az^{\rho}$, with the technical coefficient A, and the parameter ρ specific to sector j in region r. This modeling procedure allows for the introduction of Marshallian agglomeration (external) economies, by exploring local properties of the CES function.

Figure 2. Nesting Structure of Regional Production Technology



The treatment of the household demand structure is based on a nested CES/linear expenditure system (LES) preference function (Figure 3). Demand equations are derived from a utility maximization problem, whose solution follows hierarchical steps. The structure of household demand follows a nesting pattern that enables different elasticities of substitution to be used. At the bottom level, substitution occurs across different domestic sources of supply. Utility derived from the consumption of domestic composite goods is maximized. In the subsequent upper-level, substitution occurs between domestic composite and imported goods.

Figure 3. Nesting Structure of Regional Household Demand



Equations for other final demand for commodities include the specification of export demand and government demand. Exports face downward sloping demand curves, indicating a negative relationship with their prices in the world market.

The nature of the input-output data enables the isolation of the consumption of public goods by the government. However, productive activities carried out by the public sector cannot be isolated from those by the private sector. Thus, government entrepreneurial behavior is dictated by the same cost minimization assumptions adopted by the private sector.

A unique feature of the ARZ model is the explicit modeling of the costs of moving products based on origin-destination pairs according to the allocation of trade margins. The model is calibrated taking into account the specific trade structure cost of each commodity flow, providing spatial price differentiation, which indirectly addresses the issue related to regional transportation infrastructure efficiency. Such structure is physically constrained by the available transportation network, modeled in a stylized geo-coded transportation module.[7]

The set of equations that specify purchasers' prices in the ARZ model imposes zero pure profits in the *distribution* of commodities to different users. Prices paid for commodity *i* from source *s* in region *q* by each user equate to the sum of its basic value and the trade costs associated with the use of the relevant margin-commodity.

The role of the margin-commodity is to facilitate flows of commodities from points of production or points of entry to either domestic users or ports of exit. The margin-commodity, or, simply, margin, includes trade services, which take account of transfer costs in a broad sense.[8] The margin demand equations in the model show that the demands for margins are proportional to the commodity flows with which the margins are associated; moreover, a technical change component is also included in the specification in order to allow for changes in the implicit trade rate.[9]

Other definitions in the CGE core module include: basic and purchase prices of commodities, components of real and nominal GRP/GDP, regional and national price indices, money wage settings, factor prices, employment aggregates, and capital accumulation relations.[10]

3.2. Structural Database

The CGE database requires detailed sectoral and regional information about the Lebanese economy. Haddad (2012) reports on the recent developments in the construction of the interregional input-output system for Lebanon (IIOM-LIBAN) used in the process of calibration of the structural coefficients of the ARZ model. A fully specified interregional input-output database was developed, under conditions of limited information, as part of an initiative involving researchers from the Regional and Urban Economics Lab at the University of São Paulo (NEREUS).

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[7] Spatial friction was approximated by distance measures, calculated for each pair of origin-destination using Google Maps.
[8] Hereafter, trade services and margins will be used interchangeably.
[9] In the case of international imported goods, the implicit trade margin may be interpreted as the costs at the port of entry, while for foreign exports it would refer to costs at the port of exit.
[10] The detailed system of equations of the ARZ model is available in an appendix.

3.3. Behavioral Parameters

Empirical estimates of the key parameters of the ARZ model are not available in the literature. We have thus relied on “best guesstimates” based on usual values used in similar models. Parameter values for international trade elasticities, σ's in equation (A2) in the appendix, were set to 1.5; regional trade elasticities, σ's in equation (A1), were set at the same values as the corresponding international trade elasticities. Substitution elasticity between primary factors, σ's in equation (A3), was set to 0.5. Scale economies parameters, μ's in equation (A4), were set to one in all sectors and regions, denoting constant returns to scale. The marginal budget share in regional household consumption, β's in equation (A5), were calibrated from the input-output data, assuming the average budget share to be equal to the marginal budget share. We have set to -2.0 the export demand elasticities, η's in equation (A7).

4. Basic Simulation

The basic experiment in this paper consists of the evaluation of an overall 10% reduction in trade cost within the country and with external markets. In other words, for every domestic origin-destination pair, the usage of trade margins is reduced by 10%; in addition, trade margins related to international trade flows (both foreign imports and exports) are also reduced by 10%. The simulations were carried out under a long run environment, in which policy changes are allowed to affect regional sectoral capital stocks. The simulations with the ARZ model capture the effects associated with the static impact-effect question, i.e., given the structure of the economy, what-if questions can be addressed in a comparative-static framework. We will focus the analysis on the effects on the allocation of economic activity, looking at the model results for GRP growth. The idea behind this exercise is to assess potential efficiency gains in the Lebanese economy associated with spatial integration issues in the context of increasing competition in the country.

The simulation design looks at the impact of changes in the values of the freeness of trade parameters on the spatial allocation of resources. In our case, we are able to decompose the specific effects associated with trade cost reductions in each origin-destination pair of regions, identifying also whether it is related to outward or inward trade flows. This provides a detailed picture of the relative importance of market access and supplier access to regional performance.

For reference, Figure 4 depicts the spatial distribution of the results. There appears to be basically two spatial regimes, seemingly related to a coastal effect: geographical proximity to external markets seems to play a prominent role in driving the results. It is perceived a spatial shift of the relative benefits towards the coastal regions outside greater Beirut – where a large part of the ports locate. This movement can be noticed through the analysis of darker colors in the map, as well as the dominance of white and lighter colors in the hinterland and the core regions. In other words, in some regions the effects of regional integration may be further hindered by additional spatial impediments in the form of higher trade costs associated with the transfer of goods from the points of production to the ports of exit. As we will see, regions are positively affected by increasing market access and supply access; however, the dominant effect will vary from region to region, given their respective roles played in the Lebanese interregional system.

Noteworthy is that Beirut and Mount Lebanon performs below the average, suggesting that greater freeness of trade within Lebanese generates a less concentrated pattern of economic activity. The aforementioned coastal effect is revealed in the above-average performance of the coastal regions, namely South and Northern Lebanon.

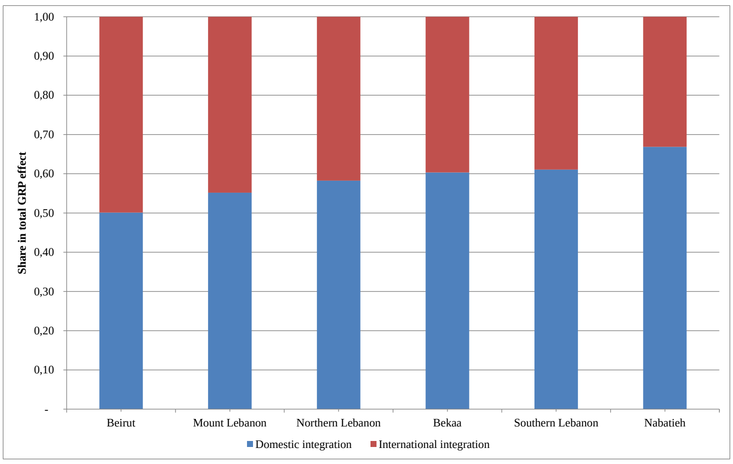
Figure 4 also highlights the specific contributions of domestic and international integration in terms of percentage changes in GRP. This information is also presented in relative terms in Figure 5. It is clear that, for the peripheral regions, domestic integration plays a more prominent role, being responsible for a larger share in total contribution to regional performance.

Given the nature of the analytical and functional structures of the ARZ model, it is important to look at the results for the changes in relative regional prices. The information in Table 3, depicted in Figure 6, provides a synthesis of the effects of the simulated increase in the freeness of trade on regional competition. Overall, Lebanese regions increase their competitiveness in relation to foreign imports, as they perceive stronger reductions in relative prices.[11] As their products become more competitive with the reduction in trade margins, they are able to increase their market share both domestically and internationally. The results also reveal that, among Lebanese regions, goods originating in Northern Lebanon and South Lebanon become even more competitive as compared to those from the other domestic regions. In the other extreme are Nabatieh and Beirut, for which competition gains are relatively smaller.

Figure 4. Spatial Effects of Domestic and International Integration on GRP Growth

Domestic *International* *Overall*

Figure 5. Contribution of Domestic and International Integration to GRP Growth

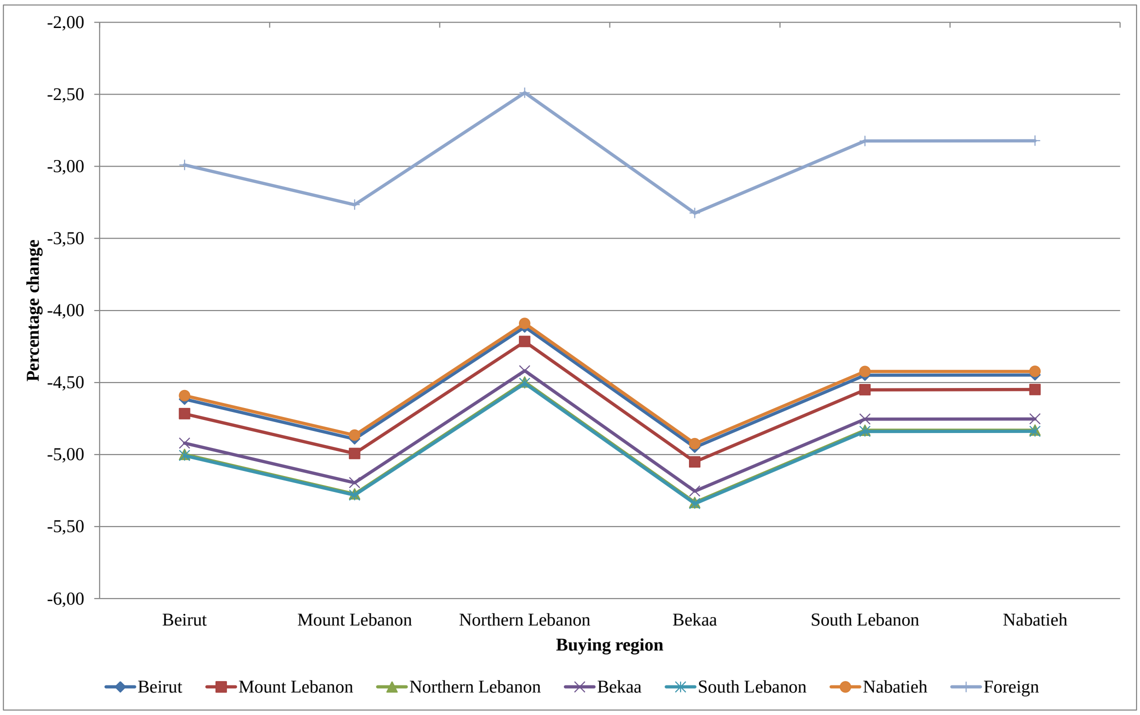


[11] This result may be suggesting that internal trade costs are relatively more important to regional competitiveness than specific trade costs associated with international transactions in Lebanon.

Table 3. Changes in Average Regional Prices, by Sources of Suppliers in the Buying Regions (in percentage change)

		Destination						Average
		Beirut	Mount Lebanon	Northern Lebanon	Bekaa	South Lebanon	Nabatieh	
Origin	Beirut	-4.62	-4.89	-4.12	-4.95	-4.45	-4.45	-4.58
	Mount Lebanon	-4.72	-4.99	-4.22	-5.05	-4.55	-4.55	-4.68
	Northern Lebanon	-5.00	-5.27	-4.50	-5.33	-4.83	-4.83	-4.96
	Bekaa	-4.92	-5.20	-4.42	-5.25	-4.75	-4.75	-4.88
	South Lebanon	-5.01	-5.28	-4.51	-5.34	-4.84	-4.84	-4.97
	Nabatieh	-4.59	-4.87	-4.09	-4.93	-4.42	-4.42	-4.55
	Foreign	-2.99	-3.27	-2.49	-3.32	-2.82	-2.82	-2.95
	Domestic composite	-4.76	-5.05	-4.40	-5.13	-4.68	-4.61	-4.77
	Domestic/foreign composite	-3.79	-4.07	-3.35	-4.14	-3.66	-3.63	-3.78

Figure 6. Changes in Average Regional Prices, by Sources of Suppliers in the Buying Regions (in percentage change)



4.1. Sensitivity Analysis

The simulation results are not only influenced by the analytical and functional structures of the model but also from its numerical structure. In the ARZ model, two sets of elasticities in the Armington demand structure determine the substitution possibilities between foreign import and the composite domestic, and among imports from different domestic sources. Given the lack of properly estimated regional and international trade elasticities for Lebanon, there is an intrinsic uncertainty in the parameter values used, making sensitivity analysis an important next step in the more formal evaluation of the robustness of model results.

One possible way to overcome the scarcity of estimates of the key parameters of the model is to estimate policy results based on different qualitative sets of values for the behavioral parameters (Haddad *et al*., 2002). A range of alternative combinations reflecting differential structural hypotheses for the regional economies can be used to achieve a range of results for a policy simulation. This method, called qualitative or structural sensitivity analysis, provides a “confidence interval” to policymakers, and incorporates an extra component to the model’s results, which contributes to increased robustness through the use of possible structural scenarios.

In what follows, qualitative sensitivity analysis is carried out in order to grasp a better understanding of the role played by the substitution structure embedded in the modeling framework. More specifically, the goal is to assess the role played by different combinations of values for the Armington elasticities of substitution between goods from different domestic regions, and for those between imported and domestic goods. Five different values were considered for each set of elasticities, providing 25 combinations for the results, which are presented in Figure 7.

Even though the six governorates seem to benefit as the possibilities of substitution with foreign goods increase (higher international trade elasticities), three different patterns emerge: (i) Beirut and Nabatieh are better-off in a situation with less possibilities of interregional substitution; (ii) Mount Lebanon and Bekaa are relatively neutral to different scenarios of interregional substitutability; and (iii) Northern Lebanon and South Lebanon are the governorates which perceive greater advantages in more flexible environments.

Figure 7. Effects of Economic Integration on GRP under Different Levels of Regional and International Trade Elasticities

Beirut

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	1.723	1.790	1.851	1.907	1.958
1.0	1.658	1.720	1.777	1.829	1.876
1.5	1.597	1.655	1.707	1.755	1.799
2.0	1.539	1.593	1.641	1.685	1.726
2.5	1.484	1.534	1.579	1.619	1.657

Mount Lebanon

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	2.100	2.216	2.322	2.418	2.507
1.0	2.088	2.204	2.311	2.408	2.497
1.5	2.076	2.193	2.300	2.398	2.487
2.0	2.063	2.181	2.289	2.387	2.477
2.5	2.051	2.170	2.278	2.377	2.467

Northern Lebanon

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	2.664	2.821	2.964	3.095	3.215
1.0	2.739	2.897	3.040	3.172	3.292
1.5	2.811	2.969	3.113	3.245	3.366
2.0	2.880	3.039	3.183	3.315	3.436
2.5	2.947	3.106	3.251	3.383	3.505

Bekaa

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	2.378	2.523	2.655	2.776	2.886
1.0	2.382	2.530	2.665	2.788	2.901
1.5	2.385	2.536	2.674	2.800	2.915
2.0	2.388	2.542	2.682	2.810	2.928
2.5	2.391	2.548	2.690	2.820	2.940

South Lebanon

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	2.275	2.437	2.584	2.718	2.841
1.0	2.362	2.528	2.679	2.817	2.943
1.5	2.446	2.616	2.771	2.912	3.041
2.0	2.527	2.701	2.859	3.004	3.136
2.5	2.606	2.783	2.945	3.092	3.228

Nabatieh

Regional \ International	0.5	1.0	1.5	2.0	2.5
0.5	1.633	1.756	1.868	1.969	2.062
1.0	1.510	1.633	1.745	1.847	1.941
1.5	1.393	1.517	1.630	1.732	1.825
2.0	1.283	1.407	1.520	1.622	1.716
2.5	1.179	1.303	1.416	1.518	1.612

OBS: Figures refer to the impacts on GRP (in percentage change) of each of the 25 simulations.

5. Structural Decomposition

5.1. Analytically Important Trade Links

In order to address the issue of identification of the analytically most important structural links in generating the CGE model outcomes, we proceed with a thorough decomposition of the results of the basic simulation considering the role played by each individual change in specific trade costs. These incremental changes are associated with (a group of) coefficient changes computed from the information contained in the initial solution. In other words, we explicitly take into account the role played by each trade link in generating the model results. Thus, one can identify the fields of influence of various structural links associated with specific policy outcomes.

For each trade link we calculate its contribution to specific outcomes considering different dimensions of regional policy. Impacts on regional efficiency are considered through the analysis of the differential impacts on GRP growth for the six Lebanese governorates. Scaffolding of the spatial results is considered in order to evaluate analytically important trade links that optimize specific regional policy goals.

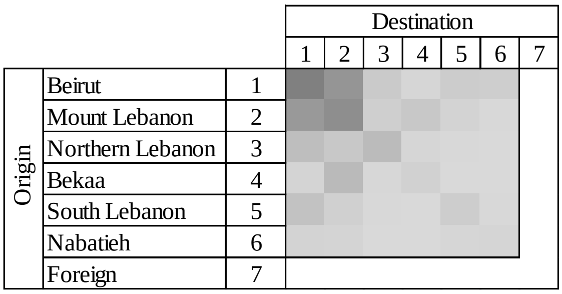
To obtain a finer perspective on the analytically most important trade links for optimizing a given policy target, we decompose the results into "domestic region to domestic region", "domestic region to foreign region" and "foreign region to domestic region" links. Key links based on their influence on each policy strategy (GRP growth in the different governorates) are highlighted in Figures 8.[12] Figures in the left column consider only trade links associated with domestic integration while those on the right expand to include also international integration. Notice that the set of most influential trade links varies according to different (spatial) policy targets. For instance, growth in Beirut associated with regional domestic integration (left) seems to be more influenced by improved access to suppliers on the coast, and to stronger links with Mount Lebanon (intra-metropolitan efficiency gains); as we also consider international integration (right), access to foreign suppliers, not only by Beirut but also by Mount Lebanon, becomes fundamental to the regional performance. A general pattern can be perceived in which better access to market/suppliers in Mount Lebanon play a prominent role in generating regional growth, and also, similarly to the Beirut case, access to foreign suppliers.

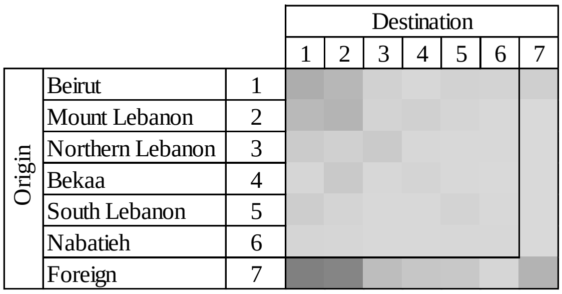
[12] Darker colors refer to higher contributions to GRP in the context of increasing integration.

Figure 8. Analytically Important Trade Links Based on Regional Efficiency

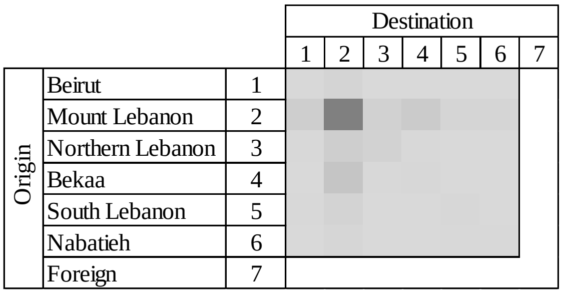
Domestic Integration | ***Domestic and International Integration***

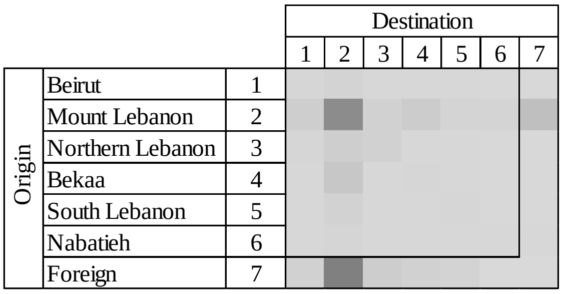
Beirut



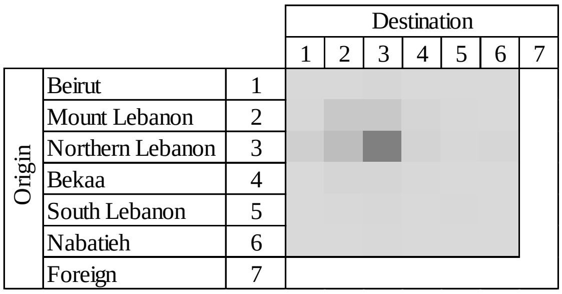


Mount Lebanon





Northern Lebanon



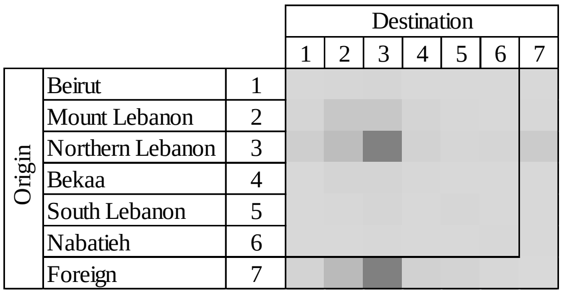
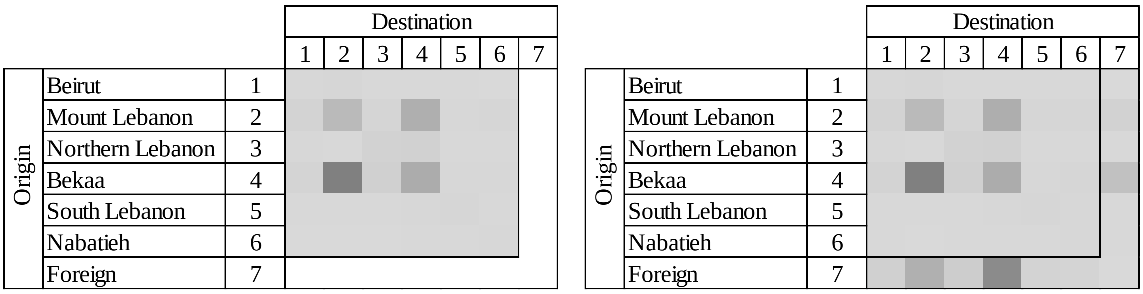


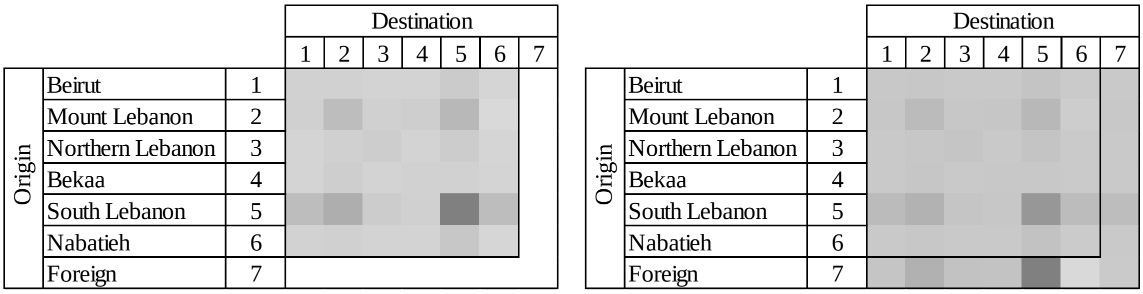
Figure 8. Analytically Important Trade Links Based on Regional Efficiency (cont.)

Domestic Integration ***Domestic and International Integration***

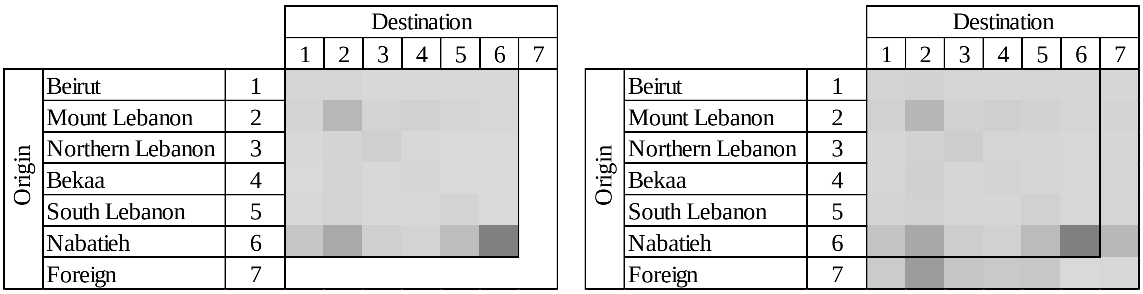
Bekaa



South Lebanon



Nabatieh



5.2. Summary

This section summarizes the simulation results focusing on the implications of domestic and international integration for regional growth. We present a visualization technique that provides an opportunity to explore regional characteristics of the Lebanese economy, reflecting the spatial economic phenomena of backward and forward linkages specifications in a fully integrated interregional system. The results are presented in a way that helps identifying the different patterns of spatial integration from a region's own perspective.

The basic information used to build the HBC[13] figure below is drawn from matrices of results that contain, for each governorate, the GRP effect of reductions in trade costs for every origin-destination pair in the Lebanese system. A typical element of this matrix is y_{sq}^{r}, the percentage change in GRP in region *r*, associated with a 10% reduction in trade costs from *s* to *q*.

It is possible to aggregate this information (Figure 9) in such a way that we obtain three summary measures reflecting the isolated effects of increasing the region's direct access to markets (MA_r); increasing direct access to suppliers (SA_r); as well as the indirect effects associated with trade costs reductions outside the region (SE_r). Notice that we do not consider changes in intraregional trade costs; hence the zero effect in the first cell.[14]

[13] HBC stands for hinge-based-circle.

[14] For each matrix of results, the main diagonal is zero.

Figure 9. Summary Matrix of Results for GRP Effects

		Destination	
		r	*R*
Origin	*r*	0	$MA_r = \sum_q y^r_{sq} = y^r_{s\bullet}$, for $s = r$
	R	$SA_r = \sum_s y^r_{sq} = y^r_{\bullet q}$, for $q = r$	$SE_r = \sum_s \sum_q y^r_{sq} = y^r_{\bullet\bullet}$, for $s, q \neq r$

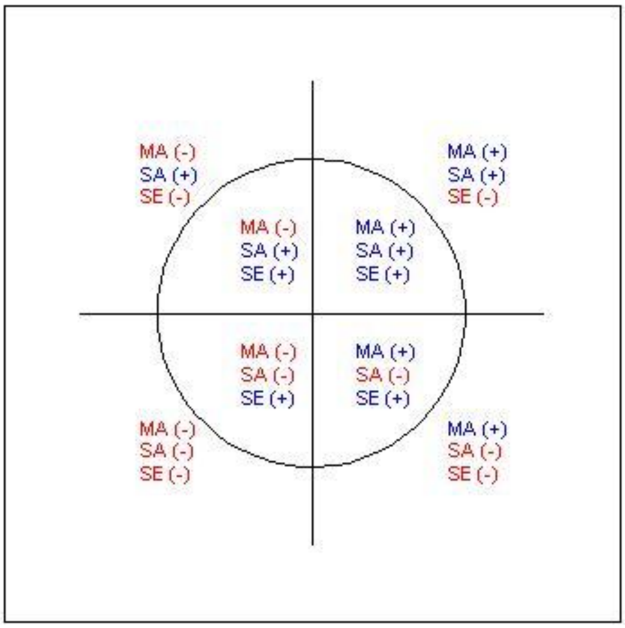
r = study region; *R* = rest of the system (domestic and international)

In order to get comparable results *for each region*, it is necessary to normalize the information presented in Figure 9. Then, we consider the values of MA_r, SA_r, and SE_r as vectors, and proceed with a normalization based on the sum of the vector norms (which will represent, as a consequence, the overall effect on GRP of the reduction in trade costs). It is important to notice that the sign of the normalized effects remains the same, as we are basing it on the norm of each vector.

The normalized vectors for *MA* and *SA* are represented in a Cartesian plan, over their respective axes (*MA* is represented in the x-axis and *SA* is in the y-axis), and their vector sum results in a vector that defines the direction and the sense in which the point will be plotted. The following step is to take the intersection of this resultant vector and a circumference with radius one and center in the origin of the Cartesian plan defined before. Departing from this so defined point, we plot the normalized vector of the *SE* (with the same direction of the resultant vector mentioned above). Positive values for *SE* are represented as pointing to the center of the circumference, and, thus, fall inside the circle. Negative values, on the other hand, fall outside the circle. This is so that the winning regions, regarding the *SE* effect, are located inside the circle.

The steps mentioned before produce the areas represented in Figure 10 with all kinds of signs combinations between the three effects. Taking the data from the Lebanese system, we obtain a comparison of the importance of each effect to the regions, what allows us to better understand the Lebanese interregional system. One last piece of information represented in Figure 10 refers to the total effect on GRP: for positive regional effects of regional integration, the symbol representing the region is a triangle turned up, and in the opposite case, is an upside-down triangle. We end up with the HBC figure (Figure 11) for the Lebanese case.

Figure 10. Schematic Representation of the HBC Figure

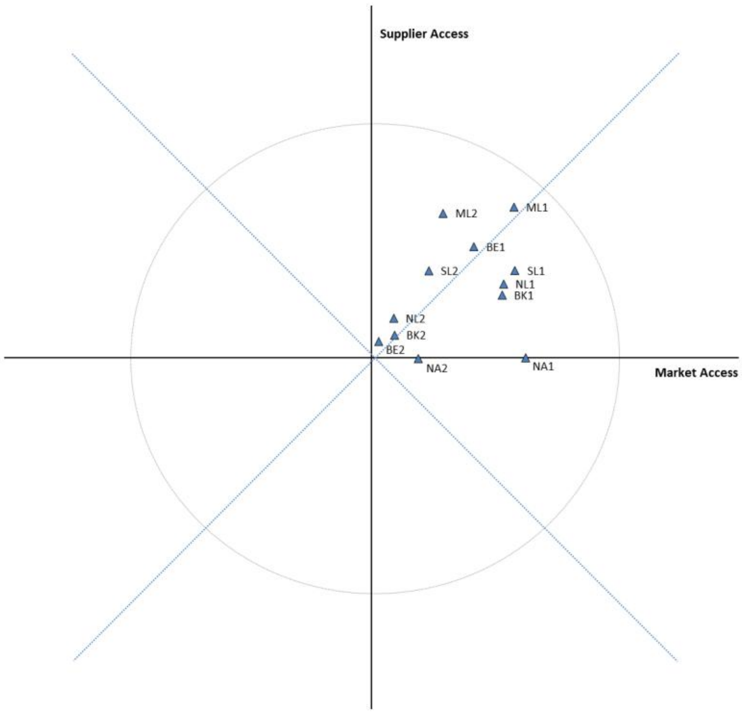


As can be seen from inspection of Figure 11, for most regions we find positive growth effects related to better access to markets and suppliers, as well as positive effects associated with the substitution effect.[15] In other words, as overall trade costs go down, a region tends to be directly benefited by better accessibility to its trade partners, and, indirectly, by trade efficiency improvements related to trade links outside its direct domain. Moreover, regional integration would generate positive overall growth to all Lebanese regions. The only exception is the negative effect of improvements in the access of suppliers to Nabatieh on regional growth, as most of the cheaper imports (both domestic and foreign) in the region are directed to final users. In such case, substitution effects away from regional products prevail, without any further positive effect in the competitiveness of products from Nabatieh.

[15] Regions in the area of MA(+), SA(+), SE(+).

One final piece of information related to Figure 11 refers to “movements” of a region in the HBC figure. Labels for a given region have two suffixes, “1” and “2”; the former is associated with domestic integration only, while the latter also considers international integration. General movements to the left indicate the important role of better access to foreign suppliers, as discussed in section 5.1.

Figure 11. Typology of Lebanese Regions According to their Growth-orientation with Increasing Domestic and International Integration



6. Final Remarks

This paper introduced the ARZ model and its use for the analysis of place-based policies in Lebanon, in an attempt to bring additional insights to some of the proposals presented in the National Physical Master Plan of the Lebanese Territory. We applied the model to look at the *ex ante* potential spatial implications of an increase in domestic and international integration of Lebanese regions through reductions in trade costs. The results provided are encouraging in the sense that the analysis suggested that there are some important differences in the internal structure of the regional economies in

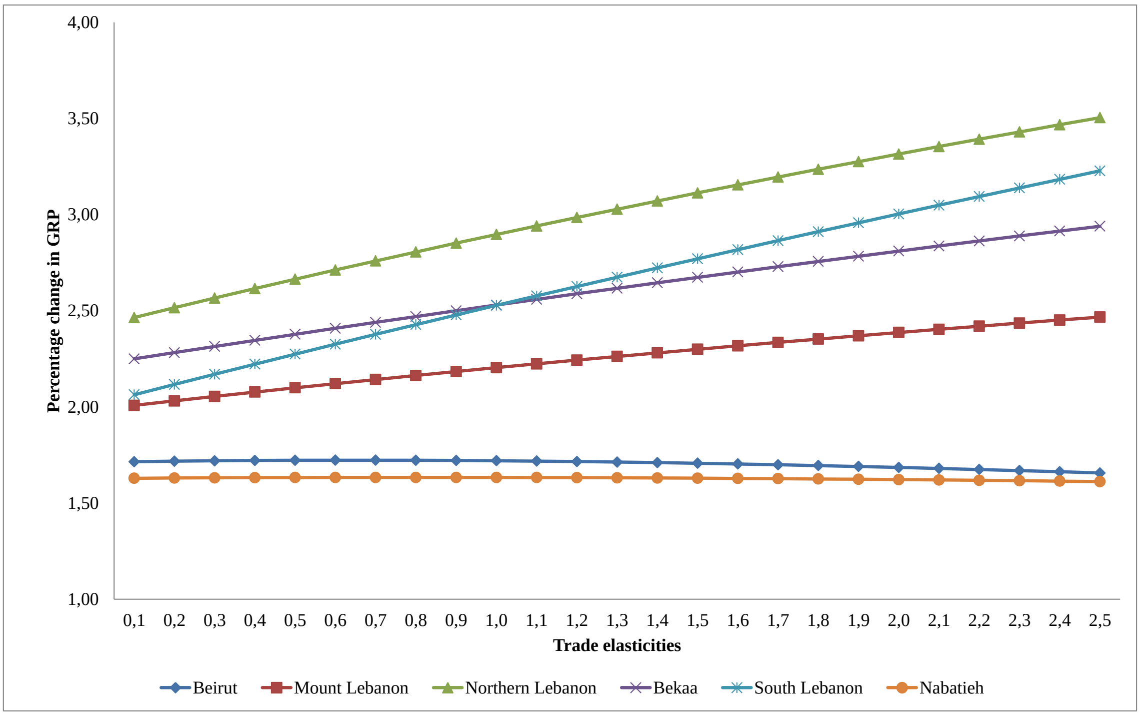
Lebanon, and the external interactions among their different agents whose consideration is fundamental for the better appreciation of spatial development processes in the country.

However, given the conditions of limited information that prevail in Lebanon, the lack of behavioral parameters to properly calibration of the model brings further uncertainty for the simulation results. Qualitative sensitivity analysis was carried out in order to direct more attention to the most important synergetic interactions in the ARZ model in the context of the proposed exercise. Armington elasticities are identified as the analytically most important parameters in generating the model outcomes. Even though the results were considered qualitatively robust to the choice of the parameters values in a pre-specified range, doubt remains on their "right" magnitudes. The default value used was in accordance with the prevailing literature estimates (1.5). Nonetheless, it denotes stronger substitution possibilities than a small, specialized economy such as Lebanon would potentially face. Substitution possibilities are intrinsically related to the complexity and diversity of an economy's productive structure. It seems to us that the "right" magnitude of such set of parameters for Lebanon would be much lower than that used in the benchmark. In order to further deal with such uncertainty, we have run additional simulations so that the two sets of regional and international trade elasticities would all have the same values ranging from 0.1 (very low substitutability) to 2.5 (high substitutability). Results for GRP are presented in Figure 12.

There seems to be no qualitatively changes in the hierarchy of winning and losing regions; the only perceivable change is the better performance of Bekaa in relation to South Lebanon in the lower values of the parameters. However, for a less flexible economy in which lower degrees of substitution prevail, two main differences from the opposite situation are noticeable: (i) growth effects tend to be lower overall, as the economy faces stronger restrictions to adjustment; and (ii) dispersion of regional GRP effects is relatively lower, suggesting a "spatial trap" in which a more stable regional allocation of the resources among regions is maintained.

Finally, this paper has offered the perspective that there is a need to pursue further some of the lines of inquiry initiated by this work. As a logical next step, the structural features of the Lebanese economy revealed in this exercise remain to be empirically tested.

Figure 12. Effects of Economic Integration on GRP Using Different Sets of Common-value Regional and International (Trade) Elasticities



Epilogue

The advent of peace in 1990 has placed Lebanon facing challenges for development in a period with a relative absence of major long-lasting turbulent events. This has provided the country the opportunity to rebuild its economic infrastructure and institutions, and take its place in global markets. However, the war of the summer of 2006 has drastically compromised the country's infrastructure, further delaying the process of sustained economic development of the country. Priorities were readdressed so that financial resources to rebuild the country had to be targeted to the most damaged areas. Long term strategic development plans, such as the NPMPLT, had to be postponed given the emergencial character of the country's population needs after the war. In this context, two notes deserve to be addressed related to the results of this paper. First, the use of 2004-2005 data represents the best photography of the Lebanese economy after a relative long period of peace. This is particularly important from the perspective of calibrating structural models such as the ARZ model. Second, and most important, even though short run priorities have been readdressed after 2006, this study revealed important structural features of the Lebanese interregional system that shed light to the discussion on the spatial perspectives of increasing competition in the country in less turbulent times.

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Appendix. The Equation System of the ARZ Model

The functional forms of the main groups of equations of the spatial CGE core are presented in this Appendix together with the definition of the main groups of variables, parameters and coefficients.

The notational convention uses uppercase letters to represent the levels of the variables and lowercase for their percentage-change representation. Superscripts *(u), u = 0, 1j, 2j, 3, 4, 5*, refer, respectively, to output *(0)* and to the five different regional-specific users of the products identified in the model: producers in sector *j (1j)*, investors in sector *j (2j)*, households *(3)*, purchasers of exports *(4)*, and government *(5)*; the second superscript identifies the domestic region where the user is located. Inputs are identified by two subscripts: the first takes the values *1, ..., g*, for commodities, *g + 1*, for primary factors, and *g + 2*, for "other costs" (basically, taxes and subsidies on production); the second subscript identifies the source of the input, being it from domestic region *b (1b)* or imported *(2)*, or coming from labor *(1)* or capital *(2)*. The symbol (•) is employed to indicate a sum over an index.

Equations

(A1) Substitution between products from different regional domestic sources

$$x_{(i(1b))}^{(u)r} = x_{(i(1\bullet))}^{(u)r} - \sigma_{(i)}^{(u)r}\,(p_{(i(1b))}^{(u)r} - \sum_{l \in S^*} (V(i,1l,(u),r) / V(i,1\bullet,(u),r)(p_{(i(1l))}^{(u)r}))$$

$$i = 1,...,g;\; b = 1,...,q;\; (u) = 3 \text{ and } (kj) \text{ for } k = 1 \text{and } 2 \text{ and } j = 1,...,h; r = 1,...,R$$

(A2) Substitution between domestic and imported products

$$x_{(is)}^{(u)r} = x_{(i\bullet)}^{(u)r} - \sigma_{(i)}^{(u)r}\,(p_{(is)}^{(u)r} - \sum_{l=1\bullet,2} (V(i,l,(u),r) / V(i,\bullet,(u),r)(p_{(il)}^{(u)r}))$$

$$i = 1,...,g;\; s = 1\bullet \text{ and } 2;\; (u) = 3 \text{ and } (kj) \text{ for } k = 1 \text{ e } 2 \text{ and } j = 1,...,h; r = 1,...,R$$

(A3) Substitution between labor and capital

$$x^{(1j)r}_{(g+1,s)} - a^{(1j)r}_{(g+1,s)} = \alpha^{(1j)r}_{(g+1,s)} x^{(1j)r}_{(g+1\bullet)} - \sigma^{(1j)r}_{(g+1)} \{ p^{(1j)r}_{(g+1,s)} + a^{(1j)r}_{(g+1,s)}$$
$$- \sum_{l=1,2} (V(g+1,l,(1j),r) / V(g+1,\bullet,(1j),r))(p^{(1j)r}_{(g+1,l)} + a^{(1j)r}_{(g+1,l)})\}$$

$j = 1,...,h;\ \ s = 1$ and $2; r = 1,..., R$

(A4) Intermediate and investment demands for composites commodities and primary factors

$$x^{(u)r}_{(i\bullet)} = \mu^{(u)r}_{(i\bullet)} z^{(u)r} + a^{(u)r}_{(i)}$$

$u = (kj)$ for $k = 1, 2$ and $j = 1,..., h$
if $u = (1j)$ then $i = 1,...,g + 2$
if $u = (2j)$ then $i = 1,...,g;$
$r = 1,..., R$

(A5) Household demands for composite commodities

$$V(i,\bullet,(3),r)(p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}) =$$
$$\gamma^r_{(i)} P^{(3)r}_{(i\bullet)} Q^r (p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}) + \beta^r_{(i)} (C^r - \sum_{j\in G} \gamma^r_{(j)} P^{(3)r}_{(i\bullet)} Q^r (p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}))$$

$i = 1, \ldots, g; r = 1,..., R$

(A6) Purchasers' prices related to basic prices and margins (trade costs)

$$V(i,s,(u),r) p^{(u)r}_{(is)} = (B(i,s,(u),r) + \sum_{m\in G} M(m,i,s,(u),r) p^{(0)r}_{(m1)},$$

$i = 1,..., g;\ (u) = (3), (4), (5)$
and (kj) for $k = 1, 2$ and $j = 1,..., h; s = 1b, 2$ for $b = 1,..., q$
$r = 1,..., R$

(A7) Foreign demands (exports) for domestic goods

$$(x^{(4)r}_{(is)} - fq^{(4)r}_{(is)}) = \eta^r_{(is)} (p^{(4)r}_{(is)} - e - fp^{(4)r}_{(is)}) ,$$

$i = 1,...,g;\ s = 1b, 2$ for $b = 1,..., q; r = 1,..., R$

(A8) Government demands

$$x^{(5)r}_{(is)} = x^{(3)r}_{(\bullet\bullet)} + f^{(5)r}_{(is)} + f^{(5)r} + f^{(5)} \qquad i = 1,\ldots,g;\; s = 1b,2 \text{ for } b = 1,\ldots,q; \text{ r} = 1,\ldots,\text{R}$$

(A9) Margins demands for domestic goods

$$x^{(is)(u)r}_{(m1)} = x^{(u)r}_{(is)} + a^{(is)(u)r}_{(m1)} \qquad \begin{array}{l} m, i = 1,\ldots,g; \\ (u) = (3),(4b) \text{ for } b = 1,\ldots,r, (5) \text{ and } (kj) \text{ for } k = 1,2; \\ j = 1,\ldots,h;\; s = 1b,\, 2 \text{ for } b = 1,\ldots,r; \\ r = 1,\ldots,R \end{array}$$

(A10) Demand equals supply for regional domestic commodities

$$\sum_{j\in H} Y(l,j,r)x^{(0j)r}_{(l1)} = \sum_{u\in U} B(l,1,(u),r)x^{(u)r}_{(l1)} + \sum_{i\in G}\sum_{s\in S}\sum_{u\in U} M(l,i,s,(u),r)x^{(is)(u)r}_{(l1)} \qquad l = 1,\ldots,g;\, r = 1,\ldots,R$$

(A11) Regional industry revenue equals industry costs

$$\sum_{l\in G} Y(l,j,r)(p^{(0)r}_{(l1)} + a^{(0)r}_{(l1)}) = \sum_{l\in G^*}\sum_{s\in S} V(l,s,(1j),r)(p^{(1j)r}_{(ls)}), \quad j = 1,\ldots,h;\, r = 1,\ldots,R$$

(A12) Basic price of imported commodities

$$p^{(0)}_{(i(2))} = p^{(w)}_{(i(2))} - e + t^{(0)}_{(i(2))}, \qquad i = 1,\ldots,g$$

(A13) Cost of constructing units of capital for regional industries

$$V(\bullet,\bullet,(2j),r)(p^{(1j)r}_{(k)} - a^{(1j)r}_{(k)}) = \sum_{i\in G}\sum_{s\in S} V(i,s,(2j),r)(p^{(2j)r}_{(is)} + a^{(2j)r}_{(is)}), \quad j = 1,\ldots,h;\, r = 1,\ldots,R$$

(A14) Investment behavior

$$z^{(2j)r} = x^{(1j)r}_{(g+1,2)} + 100 f^{(2j)r}_{(k)}, \qquad j = 1,\ldots,h;\, r = 1,\ldots,R$$

(A15) Capital stock in period T+1 – comparative statics

$$x_{(g+1,2)}^{(1j)r}(1) = x_{(g+1,2)}^{(1j)r} \qquad j = 1,\ldots,h; r = 1,\ldots,R$$

(A16) Definition of rates of return to capital

$$r_{(j)}^{r} = Q_{(j)}^{r}(p_{(g+1,2)}^{(1j)r} - p_{(k)}^{(1j)r}), \qquad j = 1,\ldots,h; r = 1,\ldots,R$$

(A17) Relation between capital growth and rates of return

$$r_{(j)}^{r} - \omega = \varepsilon_{(j)}^{r}(x_{(g+1,2)}^{(1j)r} - x_{(g+1,2)}^{(\bullet)r}) + f_{(k)}^{r}, \qquad j = 1,\ldots,h; r = 1,\ldots,R$$

Other definitions in the CGE core include: revenue from indirect taxes, import volume of commodities, components of regional/national GDP, regional/national price indices, wage settings, definitions of factor prices, and employment aggregates.

Variables

Variable	*Index ranges*	*Description*

$x_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and
	(kj) for k = 1, 2 and j = 1,…,h;
	if (u) = (1j) then i = 1,…,g + 2;
	if (u) ≠ (1j) then i = 1,…,g;
	s = 1b, 2 for b = 1,…,q; and i = 1,…,g and
	s = 1, 2, 3 for i = g+1
	r = 1,…,R
		Demand by user (u) in region r for good or primary factor (is)

$p_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and
	(kj) for k = 1, 2 and j = 1,…,h;
	if (u) = (1j) then i = 1,…,g + 2;
	if (u) ≠ (1j) then i = 1,…,g;
	s = 1b, 2 for b = 1,…,q; and i = 1,…,g and
	s = 1, 2, 3 for i = g+1
	r = 1,…,R
		Price paid by user (u) in region r for good or primary factor (is)

$x_{(i\bullet)}^{(u)r}$	(u) = (3) and (kj) for k = 1, 2 and
	j = 1, …,h.
	if (u) = (1j) then i = 1, …,g + 1;
	if (u) ≠ (1j) then i = 1, …,g
	r = 1,…,R
		Demand for composite good or primary factor i by user (u) in region r

$a_{(g+1,s)}^{(1j)r}$	j = 1, …,h and s = 1, 2, 3 r = 1,…,R	Primary factor saving technological change in region r
$a_{(i)}^{(u)r}$	i = 1,...,g, (u) = (3) and (kj) for k = 1, 2 and j = 1,..., h r = 1,…,R	Technical change related to the use of good i by user (u) in region r
C^r		Total expenditure by regional household in region r
Q^r		Number of households
$z^{(u)r}$	(u) = (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Activity levels: current production and investment by industry in region r

Variable	*Index ranges*	*Description*
$fq_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (quantity) in foreign demand curves for regional exports
$fp_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (price) in foreign demand curves for regional exports
e		Exchange rate
$x_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$a_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Technical change related to the demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$x_{(i1)}^{(0j)r}$	i = 1,…,g; j = 1,…,h r = 1,...,R	Output of domestic good i by industry j
$p_{(is)}^{(0)r}$	i = 1,…,g; s = 1b, 2 for b = 1,…,q r = 1,...,R	Basic price of good i in region r from source s
$p_{(i(2))}^{(w)}$	i = 1,…,g	USD c.i.f. price of imported commodity i
$f_{(k)}^{(2j)r}$	j = 1,…,h r = 1,...,R	Regional-industry-specific capital shift terms
$f_{(k)}^{r}$	r = 1,...,R	Capital shift term in region r
$x_{(g+1,2)}^{(1j)r}(1)$	j = 1,…, h r = 1,...,R	Capital stock in industry j in region r at the end of the year, i.e., capital stock available for use in the next year
$p_{(k)}^{(1j)r}$	j = 1,…, h r = 1,...,R	Cost of constructing a unit of capital for industry j in region r

Variable	*Index ranges*	*Description*
$f_{(is)}^{(5)r}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for government expenditures in region r
$f^{(5)r}$	r = 1,…,R	Shift term for government expenditures in region r
$f^{(5)}$		Shift term for government expenditures
ω		Overall rate of return on capital (short-run)
$r_{(j)}^{r}$	j = 1,...,h r = 1,…,R	Regional-industry-specific rate of return

Parameters, Coefficients and Sets

Symbol	*Description*
$\sigma_{(i)}^{(u)r}$	Parameter: elasticity of substitution between alternative sources of commodity or factor i for user (u) in region r
$\sigma^{(0j)r}$	Parameter: elasticity of transformation between outputs of different commodities in industry j in region r
$\alpha_{(g+1,s)}^{(1j)r}$	Parameter: returns to scale to individual primary factors in industry j in region r
$\beta_{(i)}^{r}$	Parameter: marginal budget shares in linear expenditure system for commodity i in region r
$\gamma_{(i)}^{r}$	Parameter: subsistence parameter in linear expenditure system for commodity i in region r
$\varepsilon_{(j)}^{r}$	Parameter: sensitivity of capital growth to rates of return of industry j in region r
$\eta_{(is)}^{r}$	Parameter: foreign elasticity of demand for commodity i from region r
$\mu_{(i\bullet)}^{(u)r}$	Parameter: returns to scale to primary factors (i = g+1 and u = 1j); otherwise, $\mu_{(i\bullet)}^{(u)r} = 1$
$B(i,s,(u),r)$	Input-output flow: basic value of (is) used by (u) in region r
$M(m,i,s,(u),r$	Input-output flow: basic value of domestic good m used as a margin to facilitate the flow of (is) to (u) in region r
$V(i,s,(u),r)$	Input-output flow: purchasers' value of good or factor i from source s used by user (u) in region r
$Y(i,j,r)$	Input-output flow: basic value of output of domestic good i by industry j from region r
$Q_{(j)}^{r}$	Coefficient: ratio, gross to net rate of return

Symbol	*Description*
G	Set: {1,2, …, g}, g is the number of composite goods
G*	Set: {1,2, …, g+1}, g+1 is the number of composite goods and primary factors
H	Set: {1,2, …, h}, h is the number of industries
U	Set: {(3), (4), (5), (6), (k j) for k = 1, 2 and j = 1, …, h}
U*	Set: {(3), (k j) for k = 1, 2 and j = 1, …, h}
S	Set: {1, 2, …, r+1}, r+1 is the number of regions (including foreign)
S*	Set: {1, 2, …,r}, r is the number of domestic regions