HIERARCHICAL SPATIAL INTERACTION: AN EXPLORATORY ANALYSIS

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REAL 01-T-12 November, 2001

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Abstract

Regional interaction is generally understood as implying movement between regions at the same level of an hierarchy. This paper extends the notion to include an hierarchical system, thus facilitating the consideration of vertical interaction in the analysis of regional interaction. Obviously vertical interaction is not altogether a new concept. One could find this concept in many analyses related to national-local or federal-state relationships. This paper is different, however, in the sense that the lower level units are parts of a more aggregated unit that, in turn, is part of a set of units that combine to form a national economy. A particular example drawn in this paper is the province-region relationships for the case of Indonesia. In this framework, provinces form a region, and regions form the nation. The Dendrinos-Sonis model is then used as the basis of measuring the hierarchical spatial interaction in Indonesia. The analysis will explore the degree to which complementarity and competitive interaction revealed at one level in the hierarchy persist at lower or higher levels.

Keywords: hierarchical interaction, Dendrinos-Sonis Model, Indonesia

JEL Classification:

1. Introduction

Regional interaction happens in two important dimensions: horizontal and vertical. Horizontal interaction takes place among regions at the same level of an hierarchical structure, for example, interaction among states, among provinces, etc. Vertical interaction, on the other hand, is among regions at different level of the hierarchy. A typical example of this interaction is that between central and local economies, or federal and state governments. Clearly, these vertical and horizontal relationships can take place at the same time. It is this combination that will be attempted by this paper, providing an analytical framework to examine regional interaction that takes into account both vertical and horizontal relationships.

Interaction can be of two distinct forms. First, two interacting regions may engage in a competitive relationship. In the economic growth sphere, this would mean that economic growth in one region is positively related to the growth in the other region. Alternatively, two interacting regions may be involved in a competitive relationship. Again in the sphere of economic growth, the economic growth of one region results in a decline in the other region.[1] In the model to be developed here, interaction may be considered as the resultant of a complex set of flows that might include capital and other financial flows such as remittances, goods and services and government expenditures. Since many of these flows are not documented individually or in terms of a strict origin-destination flow, the analyst is forced to consider surrogates and to view competitive forces at a more macro (aggregated) level than might otherwise be desirable.

The Dendrinos-Sonis (1988, 1990) model will be employed as the basic methodology. The model, originally developed to explain the dynamics of population changes, has been applied to income variables in several different contexts, for example Hewings *et al.* (1996), Nazara *et al.* (2001) and Magalhães *et al.*, (2001). The present paper would differ from previous applications since several layers of hierarchical regional structure are considered. In that sense, the paper provides a framework for a multi-layered economic analysis of interaction. More specifically, the model will be applied to Indonesian data, for the 1975-1999 period. The analysis will use the gross domestic regional product (GDRP) at the regional level at 1993 constant prices.[2]

This paper is organized as follows. Part two will elaborate the Dendrinos-Sonis model since it is this model that will be the working framework for the interaction analysis. Part

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[1] This way of understanding regional interaction is different from those defining regional interaction that is agent-based. An example of agent-based definition of regional interaction is provided by Poot (2000:205) where he defines regional competition, which is one type of interactions, as actions of economic agents that are taken to enhance the standard of living of their own territories, such as regions, cities, or countries

[2] The term product and income should have different meaning at the regional level. However we ignore such distinction in this paper. Hence, the two terms will be used interchangeably.

three of this paper will extend the standard model elaborated in part two to fit the hierarchical regional structure. Part four presents and analyses the estimation results for the 1975-1999 period in Indonesia. Some reflections and further considerations complete the paper.

2. The Basic Dendrinos-Sonis model

The model was first introduced by Dendrinos and Sonis (1988, 1990). Initially proposed to handle the dynamics of population changes, this model has also been applied to economic analysis in various countries. For example, Hewings *et al*. (1996) explored applications to economic interactions in the US Midwest economy, while Magalhães *et al.* (2001) compared these results with an application in the Northeast Brazilian economies. In this section, we will elaborate the model as it is used for the analysis of interaction among regions at the same level of hierarchy. We will extend the methodology further for the hierarchical regional interaction in the following section.

Let $y_i(t)$ denote the relative income of province *i*, i.e., its share in the total national income at time *t*. Further, assume that there are *n* provinces in the economy. Thus, the distribution of the relative income can be written as

$$Y(t) = [y_1(t),..., y_i(t),..., y_n(t)] \qquad i = 1,...,n \qquad t = 1,...,T \ .$$

It can be seen here that we are dealing with a discrete system of distributional dynamics. The relative discrete socio-spatial dynamics is thus given by

$$y_i(t+1) = \left(\frac{F_i[y(t)]}{\sum_{j=1}^{n} F_j[y(t)]} \right) \qquad i, j = 1,...,n \ ; \quad t = 1,...,T \qquad \ldots(1)$$

where $0 < y_i(0) < 1$, $F_i[y(t)] > 0$, and $\sum_i y_i(0) = 1$. Note that the function $F_i(\cdot)$ can take any arbitrary form as long as it satisfies the positive value property.

The expression, $F_i[y(t)]$ presents the locational and temporal comparative advantages enjoyed by the population at (*i*,*t*) (Sonis and Hewings, 2000:141). We also need to determine a numeraire or reference region, a reason for which will become clear as we move on with the model. Assume that the first province is considered as the numeraire. Then we can always state another region's observations in terms of this numeraire, that is

$$G_j[y(0)] = \frac{F_j[y(0)]}{F_1[y(0)]} \qquad \text{for all } j = 2,3,...,n.$$

With this specification, equation (1) can be expressed in the following system of equations

$$\begin{cases} y_1(t+1) = \dfrac{1}{1+\sum_{j=2}^{n} G_j[y(t)]} \\ y_j(t+1) = y_1(t+1) G_j[y(t)] \end{cases} \qquad \text{where} \qquad j = 2,3,...,n. \qquad \ldots(2)$$

The numeraire serves two functions in the model. First, it ensures that the shares of all regions sum up to one. This notion is important since regions can only divide a fixed total; the national income has to be mutually divided among existing regions. One may think of this model as the working framework of Richardson's (1973) competitive model of growth in terms of the regional income share. Secondly, the numeraire also makes sure that regions interact because the growth of a specific region is specifically expressed in terms of others. A single region is not standing alone in the system of regions; it interacts with others, the nature of which is represented by the existence of the numeraire.

As mentioned earlier, the function $F_i(\cdot)$ can take any arbitrary form as long as it satisfies the positive value property. In this paper, we will assume a multiplicative specification of $G_j[y(0)]$ as suggested by Dendrinos and Sonis (1988). That is:

$$G_j[y(0)] = A_j \prod_k y_{kt}^{a_{jk}} \qquad \text{where, } j = 2,...,n; \quad k = 1,...,n. \qquad \ldots(3)$$

Coefficient $A_j > 0$ represents the locational advantages of provinces $j = 2,...,n$. The log-linear modification yields:

$$\ln y_j(t+1) - \ln y_1(t+1) = \ln A_j + \sum_{k=1}^{n} a_{jk} \ln y_k(t) \qquad \ldots(4)$$

where $j = 2,...,n$; $k = 1,...,n$. The coefficient a_{jk} thus implies:

$$a_{jk} = \frac{\partial \ln G_j[y(0)]}{\partial \ln y_{kt}}$$

which is an elasticity term. It is the percentage change of income, i.e., the percentage growth in share in region *j* relative to that in region 1, the numeraire, with respect to one percentage change of income in region *k*.

The coefficient a_{jk} is central to the competition and complementarity analysis, both in terms of its sign as well as its magnitude. A positive value would indicate complementarity growth in shares between the two regions *j* and *k*. That is, every one per cent income growth in share in region *k* would correspond to an a_{jk} percent income growth in share in region *j*. On the other hand, a negative value of a_{jk} would indicate a competitive relationship between the two regions; if the share in one region grows, the other's share will decline.

Given the assumed functional form, note that equation (4) is completely linear in parameters. Therefore, equation (4) could be estimated using a least squares estimator. Further, the system of equations may require a proper estimation technique. We will use the Seemingly Unrelated Regression (SUR) estimator. However, it should be noted that as it stands, the application of the SUR technique on equation (4) will yield the same estimates as those obtained with the Ordinary Least Square (OLS) estimator. The reason is simply the fact that each of *n*-1 equation in (4) has exactly the same set of explanatory variables (Judge *et al.*, 1988).

As a final note to this section, this model deals with spatial interaction without the need of a so-called spatial weight matrix, an *a priori* structure of regional interrelationship imposed on the regional system. This suits certain cases, such as the Indonesian case in this paper; as it is an archipelago country, the determination of spatial weights that are typically based on a contiguity criterion presents a daunting logistical and definitional problem.[3]

[3] For further exposition on the spatial econometrics technique involving the use of spatial weight matrix, look at Anselin (1988).

3. Interaction in an hierarchical structure: a methodological framework

In the spatial context, it is always possible to characterize an economy as a collection of smaller spatial economies. In practice, one defines a nation as a collection of regions, a region as a collection of states or province, a province as a collection of municipalities, and so on. Economic interaction, therefore, will take place in two spheres. One is in a horizontal sense where regions at the same level of hierarchy, for instance region *A* and region *B*, interact. This is referred to as horizontal interaction. The other is in a vertical sense, leading to vertical interaction. The latter is an interaction between upper and lower level economies. In this sense, we have the vertical interaction such as central-local interaction, or federal-state relationship.

As is asserted in the introduction of this paper, these two interregional interaction schemes take place at the same time. Therefore, it is necessary to build a methodological framework where the two are taken into account at the same time. This is exactly what this section will try to accomplish.

Before the modeling framework is presented, a review will be provided of the kind of hierarchical structure that will be considered. Figure 1 provides the typical hierarchical regional structure of an economy, the one that will be adopted in this paper. The economy has two layers in the hierarchy, namely regions and provinces. Assume that there are two regions, *R* and *S*, in the economy. The dotted line between *R* and *S* means that the two are interacting; this is the horizontal interaction. The solid line from the 'nation' to the two regions means that each of *R* and *S* engages in a vertical relationship with the upper level. Further assume that there are three provinces within region *R*, and two provinces within region *S*. Just as each region interacts with the nation, each province is in a vertical interaction with its region and it is in a horizontal interaction with other fellow provinces within the region. Further, interaction between Province 1 in *R* and Province 4 in *S* is not direct. Such an across-region interaction is conducted through the appropriate regions. Such a structure is also known as a strict hierarchy. Obviously the hierarchical structure can be extended to lower administrative units such as districts within each province, sub-districts within each sub-district, and so on.[4]

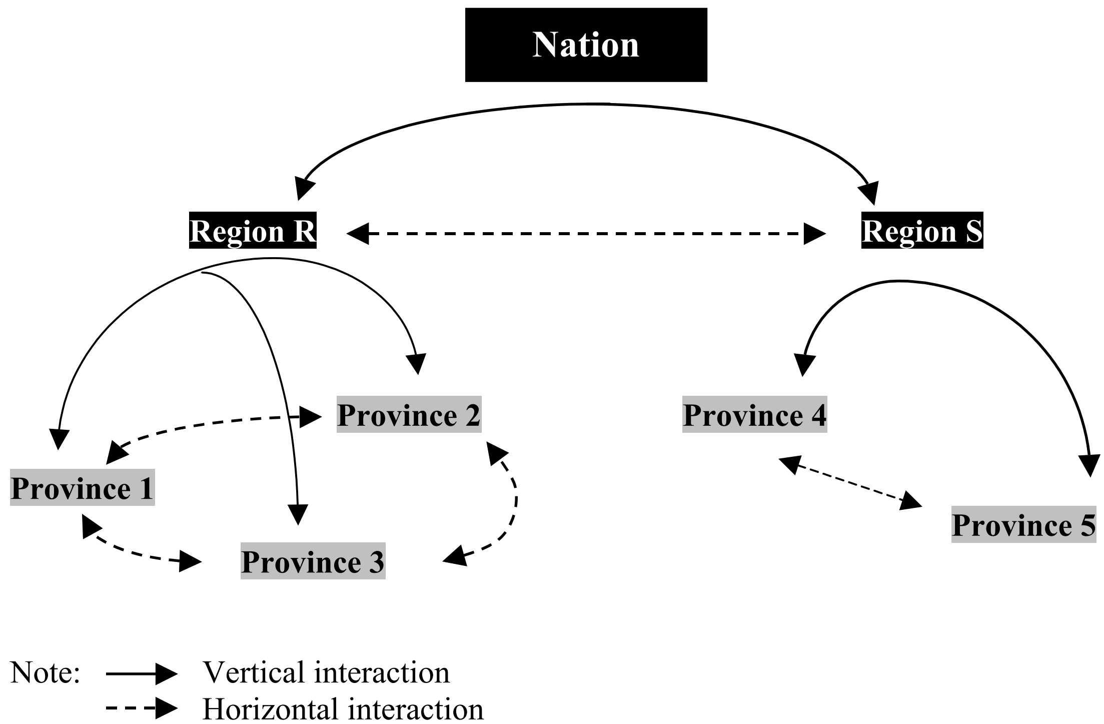

Figure 1
Hierarchical regional structure

Recall the Dendrinos-Sonis model as discussed in the previous section. One may note that the regions defined there, i.e., $i = 1,2,...,n$ are of the same level. When provinces are grouped within different regions, then the economic growth or a particular province is also dependent on the economic growth of other regions in the country. Employing the

[4] That fact raises another issue to address, which is beyond the scope of this paper, i.e., the appropriateness of the spatial categorization. This question carries many different concerns, among them are the appropriate level of structure for the analysis, should vertically hierarchical structure be defined in accordance with the term nodal or functional regions or administrative regions, etc.

Dendrinos-Sonis model as is shown in equation (4), the regional interaction within a hierarchical structure can be written as follows:

$$\ln y_j(t+1) - \ln y_1(t+1) = \ln A_j + \sum_{k=1}^{n} a_{jk} \ln y_k(t) + \sum_{l=1}^{m} a_{jm} \ln y_l(t) \qquad (5)$$

where now $l = 1,2,...,m$ denotes regional index, and other variables are defined as earlier. Note that the economic growth of region *j* is still represented in terms of the numeraire region 1. Coefficient a_{jk} as before denotes the percentage change of income growth in region *j* (in terms of the numeraire) as a result of a percentage change of income growth in province *k*. In a same spirit, coefficient a_{jl} would denote the percentage change of income growth in region *j* (in terms of the numeraire) as a result of a percentage change of income growth in region *l*. The interpretation of the sign of the *a*'s will be similar to the previous definitions.

Note that equation (5) is specified in a very general way so as not to restrict any symmetrical relationship between two provinces within the same region. Asymmetry in provincial relationships is not an implausible feature of regional interaction. Of course, that that does mean that symmetry is impossible. When a region *j* finds region *k* as its complement (or competitor), it is always possible for *k* to have a mutual feeling toward *j*. This is the case of symmetric interaction. What can be asserted here, however, is the possibility of an asymmetrical relationship. This is the case where region *j* finds *k* as its complement while *k* finds *j* as its competitor. More specifically, economic growth in *k* will bring a positive effect to the economic growth in *j*, but economic growth in the latter region negatively affects that of the former. How is such a relationship possible? One could argue that this kind of situation may be triggered by the existence of an imbalance in the transactions between the two regions (Nazara *et al.*, 2001). For instance, imagine that there exists a massive flow of production input, i.e., capital, labor, etc., from one region to the other. The sending region may be negatively affected by the outflow while the receiving region may be benefiting from this phenomenon. The asymmetric relationship may also take place when one region is used as nothing but a pure market, such as a hinterland serving as a market for the core region's products.

4. Indonesian application: context and model structure

Indonesia is an archipelago country, comprising more than 13,000 islands. The country is now divided into 32 provinces. The number of provinces has been in flux recently, in particular since the launch of the new reform movement in 1998 and the decentralization scheme adopted in 1999. More and more localities are asking to form their own, new provinces. For the purpose of this paper, we will use the 26-province system. The convenience of this aggregation stems from the fact that it is in accordance with the available published data by the Indonesian Central Bureau of Statistics. The Gross Domestic Regional Product (GDRP) data are at the provincial level from 1975-1999 in 1993 constant prices.

For the Indonesian case, despite provincial boundaries, there is no single way of regionalizing the country. In fact, there are several common regionalizations. The first is in terms of western and eastern part of Indonesia. Some would include Sumatra and Java as part of the western part, and the rest in the eastern counterpart (see Figure 2). Another scheme would include Kalimantan in the western part of Indonesia. A third regionalization follows the natural break of largest islands. Those regions would be Sumatra, Java, Kalimantan, Sulawesi, and the rest of Indonesia (the latter is commonly called the Eastern Island). This is the classification adopted in Sonis *et al* (1997). One would also find another classification where the latter Eastern Island is divided into two separate regions, namely Maluku and Papua, and Bali and Nusa Tenggara. In this paper, we are going to use a five-region classification. They are Sumatra, Java, Kalimantan, Sulawesi, and the Eastern Island. The data set employed for this study is based on 26 provinces, with Sumatra comprising eight provinces, Java five, and Kalimantan and Sulawesi are each with four. The Eastern Island, basically the rest of the nation, comprises five provinces.

Figure 2. Indonesian map of regions

The distribution of income among these five regions can be seen in figure 3. The figure suggests the uneven distribution of income among regions with almost 60 per cent of national income is in Java. Adding Sumatra, to form the western part of Indonesia, the proportion increases to about 80 per cent. The hegemony of Java in the Indonesian regional structure is no surprise. Several other studies have also pointed this out (see, among others, Sonis *et al*, 1997). Partly, it is a result of the centralistic pattern of development during the last three decades. High dependency on the central government, located in Java, results in the one-way flow of all resources to the region. Therefore, it should not come as a surprise that there is almost no significant change in the proportional distribution during the last twenty-five years. One may appropriately predict that the pattern shown in figure 3 will continue into the future should there be no significant policy intervention.

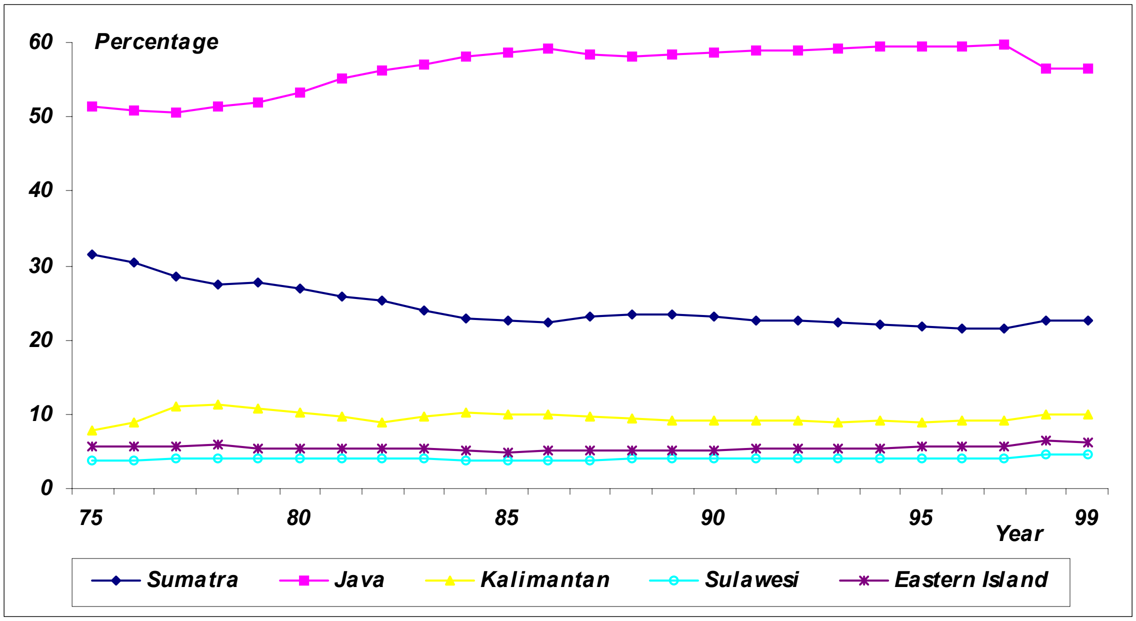

Figure 3. Regional share of income in Indonesia, 1975-1999.

A very close development topic to this subject is the question of regional convergence. In retrospect, it is quite logical to raise the question about regional convergence especially after thirty years of active government intervention. Rooted in the neoclassical exposition on growth theory, the empirical studies do confirm evidence of convergence. Garcia and Soelistianingsih (1997) find evidence of σ and β convergence for the period of 1975-1993. The former, σ convergence, refers to a decrease in the dispersion of provincial per capita Gross Domestic Regional Product (GDRP) over time. The latter, β convergence, refers to the test of absolute and conditional convergence in the annual growth rate of regional GDP. Several time periods were chosen and the annual regional growth rate is regressed on the income of the initial year. In all three periods, i.e., 1975-93, 1980-93, and 1983-93, there was convincing evidence of convergence. In the same spirit, Nazara (1999) took suggestions made by Mankiw *et al.* (1992) on the correct specification of the Solow growth model, and using the fixed effect model for pooled provincial and time series data, again confirms the evidence of convergence among provincial per capita income in Indonesia.[5]

[5] Some other studies have also confirmed the existence of regional convergence within a country, e.g., Barro and Sala-i-Martin (1995) for the case of US states and Japanese prefectures. For the case of

For the current data set, figure 4 depicts the σ convergence in Indonesia. Having two layers of hierarchy, the convergence in regional income can be seen using these two units of analysis, namely with province and regional data. These are depicted by the dotted lines. Using the province as the unit of analysis, the deviation of regional product is in a constant decline from 1.273 in 1975 to 1.165 in 1998 (before it increased slightly to 1.850 in 1999). This is a significant decrease in the standard deviation. The convergence hypothesis, however, is less convincing when one looks at the standard deviation obtained using the region-based data. A negative trend is apparent but is not as strong as the one with province-based data.

Different stories are perceived within each region. The eight provinces in Sumatra are convincingly in a convergent path during the last 25 years, as are those in Kalimantan. Sulawesi is also on a downturn swing, at least since the mid 1980s. However, the standard deviation of provinces in Java shows a significant upswing trend. The Eastern Island seems also on the divergence development path, especially after the mid 1980s. Another important feature shown is the degree of income dispersion, interpreted by the level of standard deviation. Notably, one could see that the Eastern Island has the lowest dispersion in any years during the study period. This is to be contrasted to Java whose dispersion, in addition to an increasing pattern, takes place at relatively high values of standard deviation. In the early to mid 1990s, Java's level of income dispersion is approximately twice that in the Eastern Island. As suggested by figure 3, however, the feature of dispersion between the two are quite distinct. The great level of dispersion is caused by the high degree of income spread. However, this is not the case for the provinces in the Eastern Island. The low dispersion in the Eastern Island is attributed to low levels of income. In a sense, this is the analogue to greater equality derived from widespread poverty. For an illustration, in 1999, the highest provincial incomes in the two regions (i.e., Jakarta in Java, and Papua in Eastern Island) differ by a factor of seven, while those of the lowest (i.e., Jogya in Java, and East Nusa Tenggara in Eastern Island) by a factor of two.

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developing countries look at Cashin and Sahay (1996) for the convergence among 20 states in India. From the theoretical point of view, the convergence among sub-nations is sparked by the relatively homogenous conditions of exogenous variables. In terms of the Solow growth model, the exogenous variables may be the saving rates, population or labor supply growth, depreciation, or rate of technical progress.

A very important lesson to take from this analysis is that units of analysis do matter. This finding should be considered by any convergence analysis, especially using regional data. Thus, convergence is also 'conditional,' but in this sense, upon the unit of analysis.

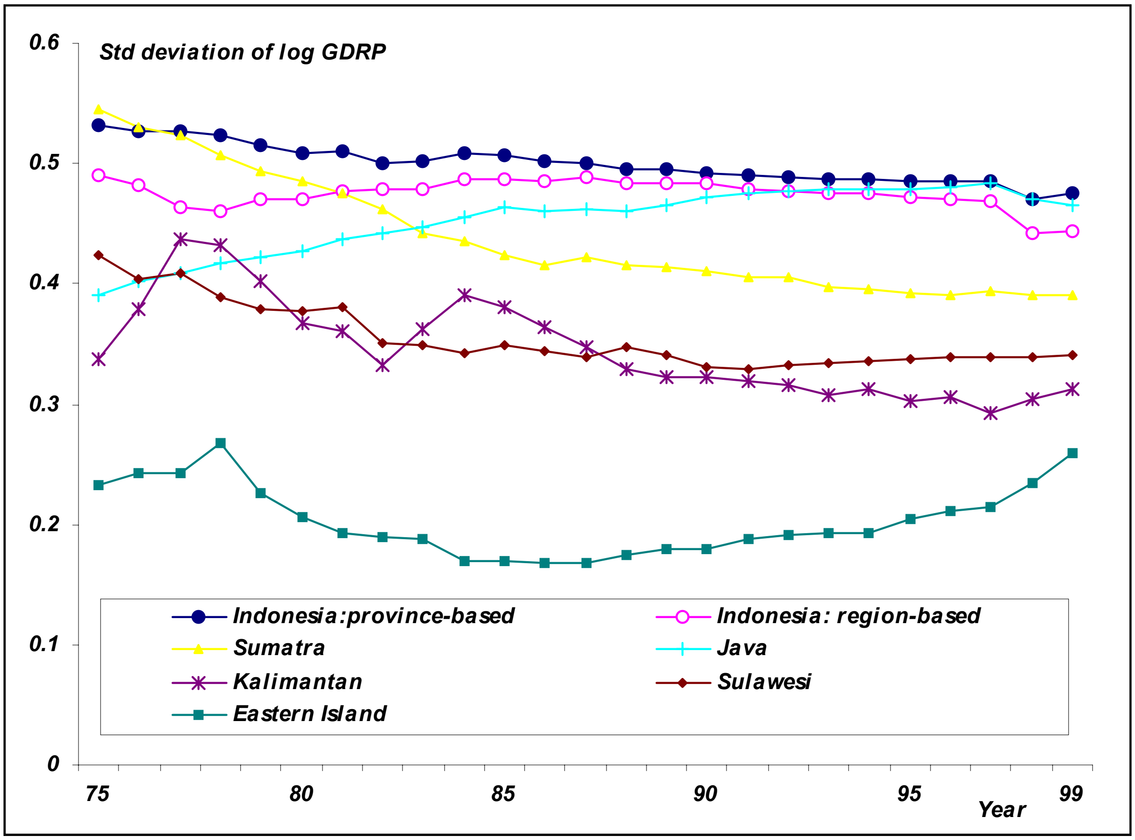

Figure 4. Standard deviation of log of GDRP, 1975-1999

5. The Hierarchical System: Regional-provincial Interaction

Two alternative models, as shown in equations (4) and (5), will be estimated. The analysis here will focus on the signs of the interaction. As elaborated earlier, a positive sign for the regression coefficients means that growth in the share of the explanatory region will have a positive effect on the share of the region in the dependent variable. A negative coefficient will correspondingly bring negative effects on the share of the region in the dependent variable.

Table 1 presents the signs of interaction following specification in equation (4). The unit of analysis is the province. Recall that this model only captures the interprovincial interactions within a particular region. Naturally, only interregional signs of interaction are obtained. Note that the signs from statistically significant coefficients are presented with circles.

Each cell in table 1 represents the sign impact of the growth of the shares of the column province to that of the row province. Each row would represent equation (4) for each region *j*. For the numeraires, we use the following: Lampung (18) for Sumatra, Jogya (24) for Java, South Kalimantan (33) for Kalimantan, Southeast Sulawesi (44) for Sulawesi, and East Nusa Tenggara (53) for Eastern Island. The numbers in parentheses are the provincial number.[6]

Attention should be directed to two observations in table 1. First, the majority of provinces within the western part of Indonesia have a complementarity relationship with one another within the same region. Secondly, moving eastbound, one would note more and more negative signs indicating more competitive provincial interaction.

[6] We use the provincial numbering system to make table reading easier. Note that this numbering system is different from one officially used by the Central Bureau of Statistics.

Table 1 Qualitative (sign) analysis without regional effect

		Sumatra								Java					Kalimantan				Sulawesi				Eastern Island				
		11	12	13	14	15	16	17	18	21	22	23	24	25	31	32	33	34	41	42	43	44	51	52	53	54	55
Aceh	**11**	⊕	+	+	+	-	+	⊖	+																		
N.Sum	**12**	+	⊕	+	+	⊖	+	-	-																		
W.Sum	**13**	-	⊕	+	+	⊖	⊕	+	⊖																		
Riau	**14**	⊕	-	+	⊕	-	+	⊖	⊕																		
Jambi	**15**	⊕	⊕	+	⊕	⊖	⊕	-	⊕																		
S.Sum	**16**	⊕	⊕	⊕	⊕	⊖	+	⊖	-																		
Bengkulu	**17**	⊕	⊕	+	+	⊖	+	+	+																		
Jakarta	**21**									⊕	+	+	⊖	⊕													
W.Java	**22**									+	⊕	+	⊖	+													
C.Java	**23**									+	-	⊕	⊖	+													
E.Java	**25**									-	+	+	⊖	⊕													
W.Kal	**31**														⊕	⊕	-	⊖									
C.Kal	**32**														+	⊕	-	⊖									
E.Kal	**34**														+	⊕	+	⊖									
N.Sul	**41**																		⊕	⊖	⊕	-					
C.Sul	**42**																		⊕	-	⊕	⊖					
S.Sul	**43**																		+	-	⊕	⊖					
Bali	**51**																						⊕	+	⊖	-	⊖
NTB	**52**																						⊖	⊕	⊖	⊕	⊖
Maluku	**54**																						-	-	⊖	+	⊖
Papua	**55**																						-	-	⊖	+	⊕

Note: circled positive and negative denote statistically significant signs with α at least 10%

Table 2 Qualitative (sign) analysis with regional effect

		Sumatra								Java					Kalimantan				Sulawesi				Eastern Island				
		11	12	13	14	15	16	17	18	21	22	23	24	25	31	32	33	34	41	42	43	44	51	52	53	54	55
Aceh	**11**	⊕	⊕	⊕	⊕	+	+	⊖	⊕			⊕					⊕				⊕				⊖		
N.Sum	**12**	+	⊕	+	⊕	+	⊕	-	+			⊕					⊕				⊕				-		
W.Sum	**13**	+	+	+	⊕	+	⊕	-	⊖			⊕					⊕				⊕				+		
Riau	**14**	⊕	-	⊕	⊕	+	+	⊖	⊕			+					-				-				-		
Jambi	**15**	⊕	⊖	+	⊕	+	⊕	⊖	+			+					+				⊖				+		
S.Sum	**16**	-	⊕	⊕	+	⊖	+	+	⊖			+					+				+				⊖		
Bengkulu	**17**	⊕	+	⊕	⊕	+	⊕	⊖	⊕			⊕					⊕				⊕				+		
Jakarta	**21**				⊕					⊕	⊕	⊕	+	⊕			⊕				⊕				⊕		
W.Java	**22**				-					-	-	-	⊖	-			-				-				-		
C.Java	**23**				+					+	+	⊕	⊖	+			+				+				+		
E.Java	**25**				⊕					+	+	+	⊖	⊕			+				+				-		
W.Kal	**31**				⊖							⊖			⊕	+	-	⊖			+				⊖		
C.Kal	**32**				⊖							⊖			-	⊕	-	⊖			+				⊖		
E.Kal	**34**				⊖							⊖			+	+	-	⊖			⊕				⊖		
N.Sul	**41**				+							+					+		⊕	⊖	+	-			⊕		
C.Sul	**42**				+							+					+		+	-	+	-			+		
S.Sul	**43**				-							-					-		+	-	-	-			-		
Bali	**51**				+							+					+				+		⊕	+	⊖	-	-
NTB	**52**				-							-					⊖				-		-	⊕	⊖	⊕	-
Maluku	**54**				+							+					-				⊖		+	⊖	⊖	+	-
Papua	**55**				⊖							⊖					⊖				-		⊖	⊕	+	⊕	+

Note: circled positive and negative denote statistically significant signs with α at least 10%

Extending the Dendrinos-Sonis model to the hierarchical Indonesian structure, the specification as outlined by equation (5) is presented in table 2. Note that we now have the regional effects. They are the signs outside the within-region interaction rectangle. For example, the North Sumatra province in the Sumatra region interacts with other provinces within the region, and also with other regions in the country.[7] The same set of numeraires is used as in the previous estimation. To illustrate, the interpretation of results for Aceh province in Sumatra is shown by row signs. Aceh's GDP share growth is positively related to the share growth of other provinces in Sumatra island; positively related to share growth of Java, Kalimantan, and Sulawesi regions; but is negatively impacted by growth in the shares in the Eastern Island region.

Provinces in Sumatra are largely complementary one to another. A negative impact on other provinces, however, is apparent from Bengkulu (17). In relation to other regions, provinces in this region are also positively impacted by growth in shares in Java and Kalimantan. Share growth in the latter region only has a negative impact on Riau provinces, possibly because the Kalimantan economy is to a great extent dominated by oil and gas, two products that are also the backbone of the Riau economy. In the eastern part of Indonesia, more and more provinces in Sumatra engage in a competitive fashion. Share growth in the Eastern Island creates a negative impact on growth in Aceh, North Sumatra, Riau, and Jambi.

In Java, the capital city Jakarta seems to benefit from share growth from any province and regions. Interestingly enough, West Java province seems to engage in a competitive relationship with all province and regions. In general Java provinces, except West Java, are in complementarity mode with other regions. Within Kalimantan, South and East Kalimantan provinces seem to be in a competitive mode with their West and Central counterparts. The whole region is also in a competitive relationship with Sumatra, Java and Eastern Island. Complementarity is only apparent with Sulawesi. In Sulawesi, two relatively poor provinces, i.e., Central and Southeast Sulawesi, seem to be in competition

[7] Note again that it is assumed that provinces of different regions do not interact directly. Recall the strictly hierarchical structure as presented in figure 1. This assumption is driven largely by the limitation in data availability. When greater number of observations is available in the future, a model with direct interprovince interaction can be estimated.

with the other two relatively richer provinces, i.e., North and South Sulawesi. In relation to other regions, South Sulawesi seems to receive a negative impact from economic growth in all other regions. Provinces within the Eastern Island region seem to be largely in competition one with another. The poorest province, i.e., East Nusa Tenggara, is definitely in competition with all other provinces but Papua. Bali seems to be positively affected by share growth in other regions and negatively impacted by changes in shares in the far eastern provinces. West Nusa Tenggara and Papua seem to be in competition with all other regions in the country.

As expected, the above results highlight important characteristics of regional interaction in Indonesia. The western part of Indonesia, whose economic status is generally higher than the eastern part, dominates the whole regional system of development. Indonesian intraregional trade are mainly among regions in the western part. As observed by Sonis *et al* (1997), Java island holds a hegemonic role of Indonesian regional economic system. Note that table 2 suggests that Java's economic growth brings significant positive effect to Sumatra but significant negative effect to Kalimantan and Papua province. On the other hand, notice also that Kalimantan and Sulawesi do bring significant positive effects to three first provinces in Sumatra, Bengkulu and Jakarta.

It is important to note here about the interpretation of non-significant signs. While these signs econometrically denote coefficients of zero values, but from the interregional-trade point of view obviously the no-interaction argument is defenseless. Such an argument is even weaker among adjacent or close regions as is suggested by the first law of geography: all points on the map are interrelated but close points are more so than distant ones. Therefore, we would argue that non-significant coefficients merely denote unclear significant patterns of relationship rather than absence of interaction. Non-significant coefficients do not dismiss the possibility of interregional interaction; they simple denote that no convincing positive or negative relationships are apparent using this methodology.

Next, the differences between table 1 and table 2 are examined; they are denoted by in gray shading on the signs. That is, gray cells in table 2 have the opposite signs of interaction to those in table 1. One could see that the changes are largely in the Sumatra and Java regions, while in the eastern regions, Sulawesi only has one sign change, Kalimantan has two, and the Eastern Island has three. This result may be due to the larger number of provinces in Sumatra (eight provinces) and Java (five provinces). However, in percentage to the total interaction signs, i.e., the number of cells within each particular region, the sign changes in the western part of Indonesia far outweigh those in the eastern part. The 13 sign-changes mean 23% of the total 56 interaction signs are found in the Sumatra region. The percentages for Java, Kalimantan, Sulawesi and Eastern Indonesia are 35%, 17%, 8%, and 15%, respectively. What does this mean? This can be interpreted as the degree of provincial linkage with other regions in the country. Clearly Java has the most intensive linkage. Analysis of provinces in the region should not be considered without taking into account other regions in the country. Ignoring other regions for Java analysis will significantly affect the plausibility of provincial interactions. It is also the case for Sumatra, although the intensity may be less than that of Java. Other regions, on the other hand, have less intensive linkages with regions other than their own.

We also would like to argue here that sign changes denote unclear interaction patterns. It is easy to see that the majority of changing-sign cells are statistically non-significant in table 2. Again, this fact does not necessarily mean no interaction between the two regions. Rather, this suggests that any existing interaction does not lead to any convincing positive nor negative relationships between the two.

6. Concluding Remarks

This paper has demonstrated a methodological framework of regional interaction analysis in a hierarchical regional structure, interpreted as the existence of several layers of vertically-related spatial structure. The methodology extends the standard Dendrinos-Sonis model that has been applied to several cases. We use the strict hierarchical structure as the working framework where the available observations for the estimation process are limited, and so derived the working specification from the structure.

Applied to the provincial-regional interaction in Indonesia, the model has reveals the importance of taking into account both vertical and horizontal effects in regional interaction analysis. Ignoring regional effects in the Indonesian case leads to substantially different configurations of interaction phenomena. This is especially true for the most-connected provinces and regions such as those in Sumatra and Java. Other regions play important roles in these regions' interaction scheme. However, it seems that other region's effect is not so much an important issue when one deals with the eastern part of Indonesia.

Also discussed in this paper is the interpretation of statistical significance in the interaction coefficient. We argue that statistical insignificance does not signify no interaction between two localities, but rather denotes unclear and indeterministic interaction patterns. As may already be noted, the methodology developed in this paper deals with the regional interaction in an indicative fashion, i.e., it shows the pattern but says nothing about the determinants. Clearly the latter are important elements for a complete understanding of regional interaction system as well as policy making process. Further studies should cover this area.

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