Identifying the Structural Changes of China's Spatial Production Linkages Using a Qualitative Input-Output Analysis

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Abstract: In this paper, we try to identify the structural changes in China's interregional input-output linkages over the period 1987-1997 using the Minimal Flow Analysis (MFA) introduced by Schnabl (1994, 2001). MFA clearly reveals that some major changes in the structure of China's interregional linkages took place along with the increasing self-sufficiency of many regions. Although many interregional linkages between manufacturing industries within coastal areas have decreased their relative importance, some new linkages with other industries and with other regions have gradually become more important over the same time period, leading us to conclude that China is now reorganizing the structure of economic interdependencies between its spatial units.

JEL classification: P2; O53; R12; R15.

Key Words: China; interregional linkages; input-output; market fragmentation; spatial interaction

1.Introduction

China is experiencing a transition from a highly centralized planned economy to a market economy since economic reform began in 1978. During the several decades of the reform, China has never reached a negative growth rate, something that was common to other transitional countries in Eastern Europe and the Former Soviet Union (EEFSU). What is more, it has accomplished rapid economic growth that is rare in world economic history. A great deal of research has been conducted to try to understand the process in this economic system transition. In these studies, the exceptional success of China, in comparison with the EEFSU countries, has largely been attributed to the characteristics of its reform strategies known as “gradualism,” “incrementalism,” “experimentalism,” and “decentralism” etc. (see Lin et.al., 1994 among others). A further issue, that has received far less attention, concerns the spatial aspects of the transitional economy: What influences have there been on the spatial configurations and the spatial interactions of the Chinese economy generated by its distinctive reform strategies?

With respect to the above questions, the fiefdom economy problem (*Zhuhou Jingji*) and the market fragmentation has received the attention of many researchers on the Chinese economy. They argued that the Chinese economy looked like an aggregation of “fiefdom economies,” that is, regional economies each of

which have strong decision-making powers over economic management inside the region and acts as if it were a dukedom relatively independent from the control of the central government. Against the background of the decentralization and the dual-track reform, each region, driven by its own benefits, tended to make duplicate investments in a small number of industries expected to be profitable. This tendency resulted in the convergence of industrial structure among regions and prepared the market fragmentation or "trade war" caused by local protectionism (Watson et.al., 1989; Chen, 1994; World Bank, 1994; Wang, 2001).

In contrast to the strategies adopted by the regional governments, the central government has tried to establish the internal division of labor between regions based on their comparative advantages and to deepen the economic interdependency among them, accompanied by strengthening of interregional economic linkages. For instance, with the beginning of the 9th Five Year Plan, China has launched to construct seven major economic areas. By enhancing various kinds of interregional economic cooperation within each area, this policy tried to accelerate the economic integration of regions. In addition, the policy also aimed at building rational economic relationships between the areas based on comparative advantages of each area (Fan & Lu, 2001). Subsequently, since the beginning of the Western Development Program, large investments have been made to construct the infrastructures of interior areas, which were expected to greatly enhance China's

interregional economic linkages (Huang & Wei, 2001). These examples prove that attaining a spatially more integrated market economy and establishing spatial division of labor based on economic rationale have been important policy objectives of China's regional policy.

Given this recent economic background, several questions arise. How have China's spatial economic linkages changed during the economic reform? Has China succeeded in deepening the economic interdependencies between its spatial units? How has China's internal division of labor between its spatial units evolved? Quantitative analyses are needed to approach these problems, and the interregional input-output analysis is one of the basic methods for such a purpose. The object of this study is to identify the structural changes of China's spatial input-output linkages using a qualitative input-output analysis, the Minimal Flow Analysis. At first, among all the intraregional and interregional input-output linkages of productive activities, some important linkages are extracted and the structures constituted by those linkages are identified by a simple graph theoretical method. Then we apply the analysis to two time points after the economic reform, namely 1987 and 1997. The inter-temporal comparison of the results is expected to provide new insights into the changes of China's spatial linkages.

Our analysis is different from related previous researches for several reasons. Previous studies on

China's spatial linkages are roughly divided into three types. (1) Research using econometric analyses to identify the existence of spillover effects (Chen, 1998; Ying, 2000; Brun et.al., 2002). Although they revealed the volume and the pattern of China's interregional spillover effects using different methods, the interest of their research is exclusively focused on the spillovers from "growth poles" in coastal area to hinterlands in interior area. Therefore identifying the structural changes of spatial linkages is left unanswered in their work. (2) Research using input-output techniques to identify China's spatial structure (for example, Ichimura & Wang, 2003; Okamoto & Ihara,2003) applied several basic input-output analyses and found some interesting results related to China's interregional linkages, however they failed to consider the structural changes since their work lacked the inter-temporal analysis. (3) Research analyzing the relationship between the integration of the Chinese domestic market and the local protectionism with quantitative methods (Xiong, 1993; World Bank, 1994; Young, 1999; Park et.al., 2002; Kato & Chen, 2002; Naughton, 2003; Bai et.al. 2004; Poncet, 2003 and 2004). These analyses tried to identify the evolution of China's domestic market integration (or disintegration) and its causes using various kinds of methods and data, however debate exists on whether China's domestic market has disintegrated more with the deepening of economic reform (Young and Poncet) or has gradually integrated (Kato and Chen, Naughton and Bai et.al.). Park et.al. concludes that there is no strong evidence to

support the former point of view, seemingly favoring the latter. Our analysis is expected to provide an additional view to the recent debate by directly showing the structural changes in China's interregional intermediate transactions.

The remainder of this paper is organized as follows: Section 2 briefly explains the basic data, that is, China's interregional input-output tables and the methodology we use in this research. Section 3 presents and discusses the main empirical results. Section 4 presents concluding remarks.

2.Data and Methods

2-1.Data

We use two sets of China's interregional input-output tables as the most basic statistical data for our research. One is a 1997 table (IDE/JETRO, 2003) and the other is a 1987 table (Ichimura et.al.,2003).

There is reasonable comparability between both tables even though there are several discrepancies in sectoral and regional classifications between them. The activities included in each sector are presented in Table 1, showing that there are some differences in activities contained in the same sector of both tables. The most notable discrepancy among them is that communication services are included in sector 7 in the 1987 table, but sector 9 in the 1997 table. In 1997, the ratio of transportation output to transportation plus communication

output is 72% and the ratio of service plus communication output to mere service is 108%. These figures suggest that we should take the error into account to a certain extent, especially when we consider the results about transportation sector (sector 7). Next, the provinces included in each region are shown in Table 2. There are two discrepancies[1]; one is that Inner Mongolia is included in North China in the 1987 table but in the Northwest in the 1997 table. As for North China, the ratio of gross regional output based on 1997 criteria compared to that of 1987 criteria is about 94%. As for the Northwest, the same ratio is 128%. These figures indicate that we should consider the error given by this discrepancy, especially when we try to make a time series comparison on the Northwest. The other discrepancy is that Chongqing had not been divided from Sichuan in 1987 but separated as a municipal city in 1997. This does not give any error to our analysis because both Sichuan and Chongqing are aggregated into the same regional unit, namely the Southwest. In order to avoid the errors derived from the discrepancies associated with sectoral coverage, we don't focus on the findings associated with the transportation sector. In addition, we will find later that the fact-findings of our analysis mainly relate to the interregional transactions between coastal regions (North China, the Central Coast, and the South Coast) and two interior regions (the Northeast and the Central China). Therefore the results of our analysis are thought to be quite robust to the errors caused by the discrepancies in regional coverage stated

so far. As a result, the problem concerning inter-temporal comparability of data is not so crucial.

(Insert tables 1 and 2)

Basic economic indicators and location of regions are shown in Table 3 and Figure 1. From Table 3, we can understand some general characteristics of China's regional economies, such as (1) coastal areas are more industrialized and developed than inner areas, (2) coastal areas especially the South Coast and the Central Coast are more open to the world economy than inner areas, and (3) coastal areas also grow faster than inner areas, etc. The South Coast and the Central Coast were projected to be growth centers for the whole Chinese economy by the central government and have enjoyed various preferential policies since the early phase of the reform. It is also noteworthy that with good geographical endowments, historical accumulation of productive resources that preceded liberalization, and various preferential policies, the Central Coast and the South Coast have gradually formed massive industrial agglomerations. These facts should be put into consideration during the interpretation of the results of our analysis.

(Insert figure 1 and table 3)

2-2.Methodology

We use Minimal Flow Analysis (MFA) introduced by Schnabl (1994, 2001) to identify the structure

of China's spatial input-output linkages[2]. MFA is a qualitative input-output analysis (QIOA), that is intended to reveal the underlying structure of an input-output table by classifying which intermediate transactions are regarded as important (or unimportant). There is a rich body of literature on how to identify underlying fundamental economic structures in input-output tables. They are ranging from the ones using triangulization (Simpson & Tsukui, 1965, among others), the ones associated with the concept of predictability (Jensen et.al., 1988 and 1991), and the qualitative input-output analysis (Aroche-Reyes, 1996 and 2002) etc. QIOA, in which MFA is included, is an approach that makes it possible to grasp fundamental economic structure easily using digraphs derived from application of graph theory on input-output tables. The reason why we apply MFA in this paper is that an inherent drawback of QIOA associated with transitivity is mitigated in MFA analysis. (Schnabl, 2001) MFA works with intermediary "layers" composing a transaction matrix. Since the entries of layer matrices decrease as the stage of layers increase, MFA can avoid over-counting the number of important linkages, although conventional QIOA cannot because it usually works with a direct coefficient matrix which provides only one adjacency matrix.

In MFA, we begin with the decomposition of a transaction matrix into some layers by using the following relationships:

$$T = A\langle X \rangle \qquad (1)$$

In equation (1), A and $\langle X \rangle$ are the input coefficient matrix and a diagonal matrix of output vector X respectively; T denotes the intermediate transaction matrix. Substituting X by the following equations,

$$X = RY \qquad (2)$$

and

$$R = I + A + A^2 + A^3 + \cdots. \qquad (3)$$

Then we obtain equation (4) representing the decomposition of T into several layers T^i ($i = 0,1,2,\cdots$).

$$T = T^0 + T^1 + T^2 + \cdots \qquad (4)$$

where

$$T^0 = A\langle Y \rangle, T^1 = A\langle A\ Y \rangle, T^2 = A\langle A^2 Y \rangle, \cdots. \qquad (5)$$

In equations (2) through (5), R, Y, and I denotes the Leontief inverse matrix, the final demands vector, and the identity matrix respectively. Note that the superscripts in equation (4) and (5) represent the layer number, not the exponential of power for each matrix.

The next step is to convert each matrix layer $T^i(i = 0,1,2,\cdots)$ to a corresponding adjacency matrix $W^i(i = 0,1,2,\cdots)$ using a given filter value F. The filtering is implemented based on the following equation

(6),

$$w_{ij}^{k}\begin{cases}=1, & if \quad t_{ij}^{k} \geq F \\ =0, & if \quad t_{ij}^{k} < F\end{cases} \qquad (6)$$

where $W^{k}=\left(w_{ij}^{k}\right)$ and $T_{ij}^{k}=\left(t_{ij}^{k}\right)$ respectively.

The last step is to obtain a dependence matrix D and a connectivity matrix H from the adjacency matrices. The derivation of each matrix is based on the following equations,

$$D=\left(W(1)+W(2)+W(3)+\cdots\right) \quad (7)$$

and

$$H=D+{}^{t}D \quad (8)$$

where $W(i)=W^{i-1}W(i-1)$ for each $i=1,2,3\cdots$ ($W(0)=I$). (9)

Note that the matrix multiplications in (9) and the summation of $W(\cdot)$ in (7) should be done in Boolean fashion. However, the summation in the last equation follows usual algebraic rules. Each entry of the dependency matrix d_{ij} equals to 1 if and only if there exist direct and indirect flows from sector i to sector j, which, altogether, sum up to a value greater than or equal to a given filter value F (Schnabl, 2001). Each entry of the connectivity matrix h_{ij} may take one of three possible values (0, 1, 2). If h_{ij} takes the value 0, sector i and sector j are isolated. If h_{ij} takes the value 1, there is a unidirectional link between

sector i and sector j. In this case, we can identify the direction of the flow by checking the value of d_{ij} and d_{ji} in D. If h_{ij} takes the value 2, there is a bilateral link between sector i and sector j, showing that there is a circular relationship in which two sectors are likely to generate both supply and demand impulses with each other.

MFA usually chooses the best filter value using the information maximization principle, however, we changed the methods in one point because of a technical reason. MFA procedure is performed 50 times for 50 equidistant filter levels, where F^1 is zero and F^{50} is the last filter value, which is identified by the value that makes the last bilateral links within H into a unilateral one when it is surpassed. Using 50 filter values, we can obtain 50 corresponding H matrices, from which we choose the one with the highest entropy (that is, choose the one with maximum information). The original procedure stated above can also be implemented in our research, but it makes the structure derived by the analysis too complicated. The number of linkages contained in the structure becomes so large[3] that it is hard to grasp the structure easily. As a result, we apply the following way to determine the filter value more appropriate for our analysis. First, find the filter value to maximize the entropy and obtain the entropy value at the filtering level. Secondly, calculate the 20% value of the maximum entropy and choose a new filter value which entropy value is nearest to the 20% value. In this

research, we call the linkages found with this new filter value the “most important linkages.” Thirdly choose another new filter value whose entropy value is nearest to the 30 % value and specify a set of linkages with this filter value. Additional important linkages are found by the change of filter values. These linkages are referred to as “secondary important linkages” in this research. By comparing the digraph of the most important and secondary important linkage at different time points, we can identify the structural changes that took place in China’s fundamental spatial linkages.

Finally, the sectors are divided into 3 groups with different characters (e.g. (1) source, (2) center and (3) sink) according to a centrality index of each sector. The centrality index here is defined as a ratio of the incoming to outgoing degree for each sector. When we calculate the incoming and outgoing degree of each sector, we sum up 50 *D* matrices, each of which is identified with a filter value varying from F1 to F50, to obtain a cumulated matrix and observe the degree of each sector within the cumulated matrix. Sectors with a centrality index that is more than 2.0 are identified as sinks, indicating that the sector has relatively more input linkages than output linkages. These sectors are thought to locate at the top of the hierarchy of intermediate transactions between sectors and/or supply more final goods rather than intermediate goods. Sectors with a centrality index of less than 1.0 are regarded as source, indicating that the sector has relatively more output

linkages than input linkages. These sectors are thought to be relatively important sectors supplying intermediate goods to many sectors in the economy. Sectors with a centrality index in the interval [1.0, 2.0] are thought to have intermediate character (called “center”) in this paper.[4]

3.Empirical Results

3-1.Preliminary Analysis

Before turning to MFA, it is appropriate for us to check the changes in the interregional input-output linkages briefly with some basic indicators. The indicators examined here show that the interregional input-output linkages as a whole have been more or less weakening during the period of our analysis. Table 4 presents the export and import ratio for each region.[5] Note that almost all the regions except the Northwest have increased the level of autarky between 1987 and 1997. Table 5 shows output multipliers and input multipliers[6] measuring average backward and forward linkage effects respectively. During the period of our analysis, overall backward and forward linkages in every region have increased considerably, showing that the degree of intermediation has been strengthened (this might be a common phenomenon observed in most growing economies). However industries in a region have mainly intensified their productive relationships with industries within the same region (the Northwest is an exception), leading to the relative weakening of the interregional linkages. It

follows from these results that China's regional economies have moved to a state of increased self-sufficiency during the term of our analysis, which seems to confirm the reported tendencies that each region plans to develop independently.

(Insert tables 4 and 5)

3-2.Main Analysis

The results of our analysis show that some major changes took place in the structure of spatial linkages in China although some unchanged factors are also found. Figures 2 and 3 show the structure of the most important linkages in 1987 and 1997 respectively. Note that if a sector locates more at the right side of the ellipse for each region, then it means that the sector has a higher (at least not lower) centrality index than sectors which locate more at the left side of the ellipse. Therefore, sink sectors (depicted by circles with a normal line) and source sectors (depicted by circles with a broken line) are put in the right and the left side of the ellipses respectively, whereas central sectors (depicted by circles with a fat line) are put in the central part of the ellipse. Some of the more important characteristics are highlighted in the remainder of this section.

(Insert Figures 2 and 3)

(1) The character of each sector (e.g. its position in the hierarchy of a region in terms of the centrality

index and whether it is a sink, central or source sector) is fairly stable during the decade except foe a few changes. An observed tendency is that sector 9 (i.e. other services) of almost all the regions moved more to the left side of the ellipses (in other words, it tended to lower its relative position in the production hierarchy of each region), indicating that the sector has reinforced its intermediate sales to other sectors. However, excluding this change, the hierarchy is quite stable. The classification of sectors has not changed considerably although there are a few changes, such as the decreasing source sectors in the Central Coast. The observed stability is plausible because the character of a sector is to significant degree determined by its technical nature, which is likely to be stable during such a short time period.

(2) Most of the important intra- and interregional linkages shown in the figures tend to concentrate in three regions (e.g. North China, the Central Coast and Central China) and there are only a few important linkages in the other regions. This represents the uneven distribution of economic activities in China, with the concentration of linkages reflecting significant concentration of economic activities in the same regions (see Table 3). It is noteworthy that with the present filter values, no important interregional linkage related to western areas (i.e. the Northwest plus the Southwest) is identified for both years. Besides, Table 5 shows that the backward linkage effects on western areas by coastal areas are very small although they have slightly

increased as a whole. These results imply that the volume of spillovers from coastal areas to western areas was limited through the 1990's. Bearing this point in mind, we can evaluate the ongoing Western Development Program as a timely scheme for balanced growth of regions. Since the swift enhancement of spillovers from coastal areas cannot be predicted, formation of strong industrial basis within the western area may be essential to the acceleration of its growth. Furthermore, several major infrastructure projects in the strategy will strengthen spatial linkages with other regions and improve investment conditions, all of these gradually leading to future increase of spillovers to the western area.

(3) The structure made by the bilateral linkages of 1997 is totally different from that of 1987. Bilateral linkages especially draw our attention because two sectors are expected to exercise positive influences on each other if they are linked bilaterally. In other words, bilateral linkages form "growth engines," because the growth of one sector stimulates intermediate transaction from the other, which in turn gives repercussions to the first one. The bilateral structure of 1987 resembles a triangle whose apexes are heavy industries of North China, the Central Coast and Central China. In addition to them, light industry and agriculture of the Central Coast have bilateral linkages with heavy industries of North China and Central China. In this structure, the growth of the Central Coast might spillover to North China and Central China easily and the growth of these

two regions might in turn stimulate the growth of the Central Coast. Compared to 1987, the bilateral structure of 1997 is only made of intraregional linkages and service sectors seem to take a pivotal role in the structure. The changes of the bilateral structures between 1987 and 1997 might be attributed to two important changes taking place in the Chinese economy during the decade. One is that the deepened intermediation involved the relative increase of service inputs[7] and the other is the increase in the self-sufficiency of each regional economy that we have already pointed out above.

For the purpose of identifying the changed and the unchanged factors in the important linkages more effectively, we developed additional figures from Figures 2 and 3. Figure 4 shows the stable important linkages during the decade, while Figures 5 and 6 show the changes that took place in the important linkages. Note that the characteristics of sectors in terms of the centrality index in Figures 4, 5 and 6 are based on that of 1987. Hereafter, our attention will be focused on the interregional linkages.

(Insert Figures 4,5,6)

(4) In the Northeast and the Central Coast, which have long histories of manufacturing industries since the planning era or even before, it can be seen that many outgoing interregional linkages have changed to become relatively unimportant during the period of our analysis (see Figure 5). For instance, the linkages of the

Northeast's heavy industry to various industries of North China and the Central Coast used to be very important in 1987, but have become relatively unimportant by 1997. In the case of the Central Coast, the same tendency is observed with respect to many sectors such as heavy industry, light industry, agriculture and so on. This major change is consistent with the large declines of the interregional forward linkage effects shown by the input multipliers in Table 5. In the case of the Northeast, this change might be attributed to the stagnation of the economy[8], whereas the case of the Central Coast will be considered briefly in the last part of this section.

The Northeast and the Central Coast show a common tendency stated thus far. However we should note an important difference between the Northeast and the Central Coast. In the latter case, although many outgoing linkages to North China and Central China have been weakened relatively, some important outgoing linkages to the South Coast have emerged at the same time, as shown in Figure 5 and 6.[9] This fact is of interest because, from the perspective of spatial interactions, it clearly shows that the economic centroid of China has moved from its northern to southern part gradually.

(Insert table 6)

(5) In North China and Central China, we can observe two common tendencies. First, in contrast to the case of the Northeast and the Central Coast stated above, the reduction of the outgoing interregional

linkages is not so obvious. Although the linkages from the heavy industry of North China to various industries of the Northeast and Central China have weakened relatively, North China has started to build some new important linkages with other region and/or in other sectors. The linkages from its mining industry, heavy industry to some industries in the Central Coast and the South Coast have intensified. Almost the same tendency is observed with respect to Central China. In addition, the interregional forward linkages effects shown by the input multipliers in Table 5 have increased considerably in absolute terms, indicating that these two regions have become more important as supply origins of intermediate goods.

Secondly, many of the incoming interregional linkages from the Central Coast and the Northeast to these two regions have changed to become insignificant by 1997. For example, many linkages from agriculture, light industry, energy industry and heavy industry of the Central Coast to the various industries of Central China have decreased their importance rapidly. In unit terms, the interregional backward linkage effects have also decreased considerably as the output multiplier of Table 5 shows. The missing incoming linkages and the weakening backward effects indicate that North China and Central China have decreased their original dependence on the other regions (especially originally advanced industrial regions such as the Northeast and the Central Coast) in the supply of intermediate goods, gradually increasing the self-sufficiency of their

economies.

(6)The Central Coast and the South Coast are thought to be growth centers, which generate relatively large spillover effects to other regions (only taking the backward linkage effects into account). Although the structure involving bilateral interregional linkages of manufacturing industries of North China, the Central Coast and the Central China has disappeared, we can still see from Figure 4 that almost all the stably important interregional linkages from the heavy industry of North China and Central China are absorbed by industries of the Central Coast. In addition, the linkages from the mining industry of North China and Central China have become more important as shown in Figure 6. Moreover, although the interregional backward linkage effects of the Central Coast have decreased, the portion to the Central China has increased in absolute terms. These facts indicate that the Central Coast has been an enduring source of input-output spillovers to its surrounding regions, especially to Central China. On the other hand, the South Coast has changed to be a receiver of various secondary important linkages from North China, the Central Coast and Central China. In other words, the South Coast can be regarded as an emerging growth center in the Chinese Economy.

It is beyond the scope of this paper to specify the reasons why China's regional economies have proceeded toward self-sufficiency with the deepening of economic reform. Nevertheless it is useful for further

research to consider the possible reasons briefly. The bottlenecks of transportation have been mitigated gradually, because a large amount of investments have been made in the infrastructure constructions to enhance China's transportation capacity[10]. Moreover, some institutional factors have hindered China's market integration (such as the immaturity of interregional payments and settlement mechanisms) but may have been improved gradually along with the market-oriented reform. Taking these factors into consideration, the observed tendency toward self-sufficiency seems to be a somewhat unexpected result. The possible causes might be the following: (1) the inaccuracy of China's statistical information, (2) the formation of industrial clusters in coastal areas, (3) the influence of the fiefdom economy or the market fragmentation caused by the local protectionism, and/ or (4) the problem associated with the aggregation of regional units.

As Huenemann (2001) pointed out, it is possible that China's official transportation statistics have been unreliable because of the rapid liberalization and the privatization that took place during the reform. If it were true, the results of our analyses would be influenced in one way or another. However it does not seem to explain why it caused the very decrease of the portion of interregional transaction.

The cause (2) might be partly due to the observed tendency in coastal areas, since several massive industrial agglomerations have actually been formed in some coastal regions such as Pearl River Delta Zone in

Guangdong, Wenzhou in Zhejiang, and Yangzi River Delta Zone in the Central Coast. Industries are likely to have denser linkages with related industries within the cluster than with those outside the cluster. It follows that the relative amount of intraregional transactions to interregional transactions gets larger as the degree of intermediation gets higher (Wolf, 2000).

As for the cause (3), recent researches on border effects are instructive. For instance, by estimating border effects on China's intra- and international trade, Poncet (2003; 2004) pointed out that China's market fragmentation caused by the local protectionism has been deteriorated during the 1990's. It is possible that the artificial market fragmentations have generated negative influences on the volume of the interregional trades in China. If we relied solely on this explanation, one would conclude that China's distinctive reform strategies have had a strong influence on the pattern of spatial interactions between its spatial units; however this claim should be examined by further research that use other data and methods.

Finally, it is important to note that the result and its interpretation depend crucially on how to aggregate regional units in our analysis. By aggregating provincial administrative units into the seven major regions, we found that the intraregional linkages of many regions have been intensified relative to the interregional linkages. However if we could have analyzed with more disaggregated spatial units, say,

provincial or county level, we might have been able to conclude that the interregional linkages (i.e. interprovincial or intercounty linkages) have been strengthened. Because data on interprovincial or intercounty trade is not available for us, we compute how a province has changed the degree of production specialization among provinces belonging to the same major region, in order to indirectly show the direction of changes in interprovincial linkages within a major region. Table 7 shows changes in the regional structural coefficient[11] of each major region over the period 1988 to 1997. We can find out from Table 7 that the degree of specialization has gone up during the period. Thus, if we assume that interindustry trade is a prevailing pattern of interprovincial trade present in China, then it follows that the degree of market integration within a major region has been reinforced through growing amount of trade between provinces all together constituting the major region. Given the present conditions of infrastructure that are expected to charge quite large transaction costs on domestic trades, it might be realistic that the spatial integration of the Chinese economy would take place at first within relatively small geographical areas such as the major economic regions that we use in this paper, gradually leading to spatial integration of the whole national economy. All of these possible reasons stated so far will need to be carefully evaluated in our future research.

4.Conclusion

The motivation of this paper is to explore how interdependencies between economies of China's major regions have changed along with the deepening of the reform. For this purpose, we computed some linkage measures and visualized structural changes in the interregional input-output linkages using Minimal Flow Analysis. Our analysis reveals that the interdependencies between regions have decreased, that is, the self-sufficiency of each regional economy has increased on average. This fact-finding seems to favor the view that China's decentralized and gradual reform strategy has had negative impacts on the spatial integration of its economy, however the implications of this fact-finding should be reconsidered by further research using other data and/or analytical methods. The interpretation of our results depends on the way to aggregate spatial units in our analysis. More important fact-findings of our analysis are that some major changes have emerged in the structure of interregional linkages behind the tendency toward regional autarky. The Northeast, which used to have several important interregional linkages emanating from its heavy industry, has changed to become an economy that is rather isolated from other regions. The same is true in the Central Coast, that is, both regions have decreased their importance as suppliers of intermediate goods to other regions. However, the Central Coast has strengthened intermediate supplies to the South Coast instead and has continued to be a stable source of spillover effects to surrounding regions such as Central China. The South Coast has gradually become

another growth center that receives several important linkages of some industries in other regions. North China and Central China have become self-sufficient especially in manufacturing industries and furthermore they became important in supplying heavy-industrial and mining products to the Central Coast and the South Coast. All of these findings lead us to conclude that China is now experiencing the structural changes of economic interdependencies between its spatial units.

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Notes

(1) Taiwan is not included in both tables because of data limitations.

(2) The procedure explained here follows Schnabl (2001) with some slight changes in detail.

(3) This might be the case when the size of the input-output table is large like ours (63 sector by 63 sector) because the entropy-maximizing filter value is one at which a nearly equal number of differently qualified linkages in the connectivity matrix.

(4) In selecting the critical values of the interval, we based on the following considerations: after removing outliers from the set of centrality index of 1987, we found the maximum value to be 3.0. Dividing the value by three gives the lower threshold 1.0 and multiplying 1.0 by 2 gives the upper threshold, 2.0. The outliers relate to sector 6, in which almost all the sales are, by construction of the Chinese input-output tables, counted as final demands (in other words, there are only negligible amount of intermediate sales to other sectors), inevitably leading to extremely large centrality index (in some cases, it becomes infinite). Therefore we treated them as outliers.

(5) Exports and imports here only include export and import associated with intermediary goods because of the limitation of data.

(6) As for the output and input multiplier, see Miller and Blair (1985) and Hewings (1985).

(7) The development of China's service industries during the period is quite sluggish. For example, the share of the tertiary industry in China's total GDP is almost unchanged during the period (29.3% in 1987 and 30.9% in 1997). However, increases of service industries are observed in North China and the Central Coast, where service sectors locate the central position in the structure of their bilateral linkages. For example, the ratio of tertiary industry over regional GDP went up from 36.7% of 1987 to 54.5% of 1997 in Beijing, from 28.8% to 42.3% in Tianjin, and from 29.2% to 45.5% in Shanghai.

(8) As shown in Table 6, the Northeast economy has suffered from sluggish growth in comparison with other regions because state owned enterprises (SOEs) in heavy industries, which have had a dominant position in its regional economy since the first five-year plan period (1953-1957), could not adapt easily to growing economic market environments (the stagnation of the Northeast economy owing to the dominance of old SOEs in the economy is called as "the Northeast Phenomenon" in China).

(9) There are two reasons to explain the emerging linkages from the Central Coast to the South Coast. Although the average interregional input multiplier of the region shown in Table 5 exhibits a large decrease from 0.631 to 0.432, the portion of the South Coast adversely increases from 0.096 to 0.106. This partly

explains the observed change. Another important reason is that the demand for the South Coast's manufacturing products (including export from the region to overseas) relative to other regions increased rapidly, leading to the enforced linkages from several industries in the Central Coast to the South Coast. For example, the rate of the demand for the South Coast's heavy industrial products to the national total goes up from 7.0% in 1987 to 14.5% in 1997 (almost the same change can be observed from the production side as shown in Table 6).

(10) The ratio of investment in capital construction (*jiben jianshe*) of transportation and communication industries to nominal GDP goes up from 16% in 1987 to 30% in 1997.

(11) The regional structural coefficient takes values between 0 and 1. The closer the coefficient of a major region is to 1, the more provinces in the major region specialize in terms of production. As for the definition of the regional structural coefficient, see World Bank (1994) pp.16-17. To compute the coefficients, we used values from the output of 36 (35 in 1994 and 1997) secondary industrial sectors in all provinces. These data are available in *China Statistical Yearbook of Industrial Economy* (various years).

Table 1 Sectroal corespondance between 1987 and 1997

1987	1997
1 Agriculture	1 Agriculture
2 Mining	2 Coal mining and processing
	3 Crude petroleum and natural gas products
	4 Metal ore mining
	5 Non-ferrous mineral mining
3 Light Industry	6 Manufacture of food products and tobacco processing
	7 Textile goods
	8 Wearing apparel,leather,furs,down and related products
	9 Sawmills and furniture
	10 Paper and products, printing and record medium reproduction
4 Energy Industry	11 Petroleum processing and coking
	24 Electricity, steam and hot water production and supply
	25 Gas production and supply
	26 Water production and supply
5 Heavy Industy	12 Chemicals
	13 Nonmetal mineral products
	14 Metal smelting and pressing
	15 Metal products
	16 Machinery and equipment
	17 Transport equipment
	18 Electric equipment and machinery
	19 Electric and telecommunication equipment
	20 Instruments, meters, cultural and office machinery
	21 Maintenance and repair of machine and equipment
	22 Other manufacturing products
	23 Scrap and waste*
6 Construction	27 Construction
7 Transport and communication**	28 Transport and warehousing
8 Wholesale and retail trade***	29 Wholesale and retail trade
9 Services	30 Services

*) Scrap and Waste(sector 23) is not included in 1987's table.

**)Communication is included in services for 1997.

***)Wholesale and retail trade of 1987 includes catoring industry which is encompassed in Services for 1997.

Table 2 Regional corespondance between 1987 and 1997

1987		1997	
region	provinces	region	provinces
Northeast	Liaoning, Jilin, Heilongjiang	Northeast	Liaoning, Jilin, Heilongjiang
North China	Beijing, Tianjin Hebei, Shandong Inner Mongolia	North Municiparities North Coast	Beijing, Tianjin Hebei, Shandong
East China	Shanghai, Jiangsu, Zhejiang	East Coast	Shanghai, Jiangsu, Zhejiang
South China	Guangdong, Fujian, Hainan	South Coast	Guangdong, Fujian, Hainan
Central China	Shanxi, Henan, Anhui Hubei, Hunan, Jiangxi	Central	Shanxi, Henan, Anhui Hubei, Hunan, Jiangxi
Northwest	Shaanxi, Gansu,Ningxia Qinghai, Xinjiang	Northwest	Shaanxi, Gansu,Ningxia Qinghai, Xinjiang Inner Mongolia
Southwest	Sichuan, Quizhou, Yunnan Guangxi, Tibet	Southwest	Sichuan, Chongqing, Guizhou Guangxi, Tibet

Table3 Summery statistics of each region 1)

1997	Northeast	North China	East China	South China	Central China	Northwest	Southwest
GDP (100 million yuan)	7738	14749	14679	10726	16388	3544	9002
Primary industry(%)	17	16	12	16	25	23	28
Secondary industry(%)	49	47	52	47	45	41	40
Tertiary industry(%)	34	36	36	37	31	36	32
Export 2) (million dollars)	11398	29715	39251	85603	8438	2460	5927
Incoming FDI 3) (million dollars)	3352	8185	12104	16619	7832	720	1728
Population (10 thousand people)	10428	19777	12876	10975	34981	8807	23888
Area (square km)	787200	1555805	210746	333300	1027300	3092600	2507400
Population density(person／square km)	132	127	611	329	341	28	95
Per capita fixed assets (yuan)	2002	2734	4494	3127	1365	1512	1135
Length of railway and highway (m/km2) 4)	180	144	351	494	311	48	134
Per capita GDP (yuan)	7420	7458	11400	9773	4685	4025	3768
Growth rate of per capita GDP 5) (%)	7.5	10.3	11.5	13.1	9.1	7.5	8.5

1)Regional classification is according to one of the 1987 table (see table 2).

2)Export value by location of China's foreign trade managing units.

3)FDI actually used.

4)1999 data.

5)Average annual growth rate in real terms from 1987 to 1997.

Table 4 Export and Import Ratio of Each Region

	1987		1997	
	export ratio	import ratio	export ratio	import ratio
Northeast	20.1	18.5	8.7	12.5
North China	25.3	26.2	16.7	10.8
Central Coast	27.0	25.5	12.1	16.3
South Coast	19.6	24.7	13.5	17.7
Central China	23.0	21.9	20.8	13.7
Northwest	14.5	18.0	18.9	22.1
Southwest	15.5	15.2	11.1	14.2

Table 5-1-A Average Output Multipliers of Each Region in 1987

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	2.029	1.701	0.328	---	0.157	0.077	0.012	0.068	0.006	0.009
North China	2.098	1.644	0.455	0.120	---	0.134	0.021	0.152	0.011	0.017
Central Coast	2.147	1.665	0.482	0.063	0.154	---	0.067	0.155	0.015	0.028
South Coast	2.100	1.615	0.486	0.046	0.091	0.170	---	0.097	0.014	0.068
Central China	2.110	1.700	0.409	0.043	0.092	0.202	0.026	---	0.014	0.032
Northwest	2.063	1.748	0.314	0.019	0.054	0.095	0.009	0.051	---	0.086
Southwest	1.929	1.662	0.268	0.015	0.027	0.096	0.041	0.050	0.039	---

Table 5-2-A Average Output Multipliers of Each Region in 1997

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	2.464	2.099	0.365	---	0.131	0.081	0.031	0.085	0.023	0.014
North China	2.393	2.083	0.311	0.057	---	0.085	0.023	0.102	0.031	0.013
Central Coast	2.438	1.966	0.471	0.038	0.150	---	0.058	0.176	0.023	0.026
South Coast	2.149	1.725	0.425	0.020	0.088	0.108	---	0.136	0.018	0.054
Central China	2.445	2.066	0.379	0.023	0.135	0.107	0.043	---	0.042	0.030
Northwest	2.308	1.794	0.513	0.039	0.141	0.089	0.042	0.154	---	0.049
Southwest	2.296	1.921	0.376	0.016	0.076	0.069	0.062	0.117	0.035	---

Table 5-3-A Average Input Multipliers of Each Region in 1987

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	2.248	1.818	0.429	---	0.186	0.113	0.036	0.073	0.007	0.013
North China	2.402	1.801	0.601	0.132	---	0.233	0.060	0.138	0.016	0.021
Central Coast	2.576	1.946	0.631	0.055	0.141	---	0.096	0.259	0.023	0.056
South Coast	2.278	1.821	0.457	0.026	0.057	0.214	---	0.087	0.007	0.066
Central China	2.421	1.817	0.604	0.065	0.197	0.226	0.065	---	0.014	0.037
Northwest	2.353	1.967	0.386	0.022	0.056	0.088	0.034	0.082	---	0.103
Southwest	2.256	1.894	0.362	0.017	0.043	0.084	0.080	0.088	0.051	---

Table 5-4-A Average Input Multipliers of Each Region in 1997

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	2.619	2.265	0.354	---	0.129	0.097	0.035	0.049	0.025	0.019
North China	3.116	2.380	0.735	0.096	---	0.262	0.097	0.175	0.052	0.053
Central Coast	2.808	2.376	0.432	0.045	0.106	---	0.106	0.111	0.026	0.037
South Coast	2.306	1.948	0.358	0.028	0.039	0.144	---	0.073	0.019	0.054
Central China	3.153	2.310	0.842	0.067	0.152	0.321	0.152	---	0.063	0.086
Northwest	2.583	1.954	0.629	0.057	0.142	0.128	0.061	0.165	---	0.076
Southwest	2.657	2.250	0.407	0.022	0.037	0.099	0.124	0.083	0.042	---

Table 5-1-B Average Output Multipliers of Each Region in 1987
(Percentages in total)

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	100.0	83.8	16.2	---	7.7	3.8	0.6	3.3	0.3	0.5
North China	100.0	78.3	21.7	5.7	---	6.4	1.0	7.2	0.5	0.8
Central Coast	100.0	77.6	22.4	2.9	7.2	---	3.1	7.2	0.7	1.3
South Coast	100.0	76.9	23.1	2.2	4.4	8.1	---	4.6	0.6	3.2
Central China	100.0	80.6	19.4	2.0	4.4	9.6	1.2	---	0.7	1.5
Northwest	100.0	84.8	15.2	0.9	2.6	4.6	0.4	2.5	---	4.2
Southwest	100.0	86.1	13.9	0.8	1.4	5.0	2.1	2.6	2.0	---

Each number is an average of 9sectors in a region.

Table 5-2-B Average Output Multipliers of Each Region in 1997
(Percentages in total)

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	100.0	85.2	14.8	---	5.3	3.3	1.3	3.5	0.9	0.6
North China	100.0	87.0	13.0	2.4	---	3.6	1.0	4.3	1.3	0.5
Central Coast	100.0	80.7	19.3	1.6	6.2	---	2.4	7.2	0.9	1.0
South Coast	100.0	80.2	19.8	0.9	4.1	5.0	---	6.3	0.8	2.5
Central China	100.0	84.5	15.5	0.9	5.5	4.4	1.7	---	1.7	1.2
Northwest	100.0	77.8	22.2	1.7	6.1	3.8	1.8	6.7	---	2.1
Southwest	100.0	83.6	16.4	0.7	3.3	3.0	2.7	5.1	1.5	---

Table 5-3-B Average Input Multipliers of Each Region in 1987
(Percentages in total)

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	100.0	80.9	19.1	---	8.3	5.0	1.6	3.3	0.3	0.6
North China	100.0	75.0	25.0	5.5	---	9.7	2.5	5.8	0.7	0.9
Central Coast	100.0	75.5	24.5	2.1	5.5	---	3.7	10.1	0.9	2.2
South Coast	100.0	80.0	20.0	1.1	2.5	9.4	---	3.8	0.3	2.9
Central China	100.0	75.1	24.9	2.7	8.1	9.3	2.7	---	0.6	1.5
Northwest	100.0	83.6	16.4	1.0	2.4	3.8	1.5	3.5	---	4.4
Southwest	100.0	83.9	16.1	0.7	1.9	3.7	3.5	3.9	2.3	---

Table 5-4-B. Average Input Multipliers of Each Region in 1997
(Percentages in total)

	total	Intra-regional	Inter-regional	Northeast	N.China	C.Coast	S.Coast	C.China	Northwest	Southwest
Northeast	100.0	86.5	13.5	---	4.9	3.7	1.3	1.9	1.0	0.7
North China	100.0	76.4	23.6	3.1	---	8.4	3.1	5.6	1.7	1.7
Central Coast	100.0	84.6	15.4	1.6	3.8	---	3.8	3.9	0.9	1.3
South Coast	100.0	84.5	15.5	1.2	1.7	6.3	---	3.2	0.8	2.3
Central China	100.0	73.3	26.7	2.1	4.8	10.2	4.8	---	2.0	2.7
Northwest	100.0	75.7	24.3	2.2	5.5	5.0	2.4	6.4	---	2.9
Southwest	100.0	84.7	15.3	0.8	1.4	3.7	4.7	3.1	1.6	---

Table 6 Growth of Secondary Industries in Each Region

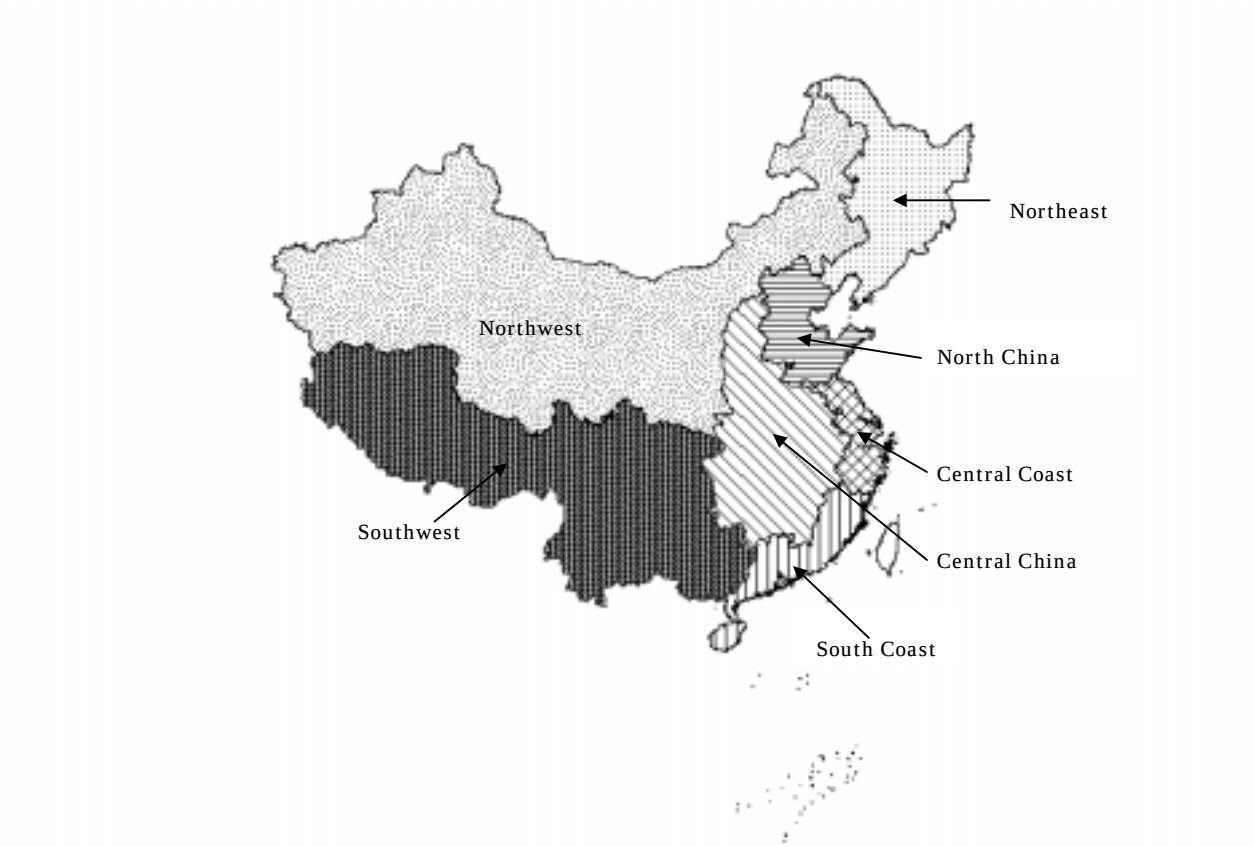
(Unit:%)

	Avg. annual growth rate				Share in National Total					
	78-88		88-98		78		88		98	
Liaoning		8.0		7.7	2)	9.0	4)	7.2	7)	4.6
Jilin		10.4		8.7		2.4		2.4		1.7
Heilongjiang		5.9		8.2	5)	5.9	10)	3.9		2.6
Northeast		7.7		8.0		17.3		13.4		8.8
Beijing		7.6		8.6	8)	4.3		3.3		2.3
Tianjin		8.6		9.0		3.2		2.7		1.9
Hebei		9.1	10)	13.3	6)	5.2	7)	4.5	6)	4.8
Shandong	8)	11.8	5)	15.0	4)	6.6	3)	7.4	3)	9.1
Neimenggu		8.4		10.3		1.5		1.2		1.0
North China		9.6		12.6		20.7		19.1		19.1
Shanghai		7.7		10.2	1)	11.7	2)	9.0	4)	7.3
Jiangsu	4)	14.0	9)	13.4	3)	7.3	1)	9.9	2)	10.6
Zhejiang	1)	18.2	4)	15.2		3.0	6)	5.8	5)	7.3
Central Coast		11.9		12.8		22.0		24.7		25.2
Fujian	3)	14.2	1)	18.2		1.6		2.2		3.5
Guangdong	2)	14.6	2)	17.9	7)	4.8	5)	6.9	1)	10.9
Hainan		9.7	3)	15.2		0.2		0.2		0.2
South China		14.4		17.9		6.6		9.3		14.7
Shanxi		8.8		10.0		2.9		2.4		1.9
Anhui	5)	13.0	7)	14.6		2.2		2.8		3.3
Jiangxi		11.1	6)	14.8		1.8		1.9		2.3
Henan	7)	11.9		12.7	9)	3.9	8)	4.3	8)	4.4
Hubei	6)	12.8		12.6		3.5	9)	4.3	9)	4.4
Hunan		10.0		11.8		3.3		3.2		3.0
Central China		11.4		12.8		17.6		19.0		19.3
Shaanxi		10.1		9.9		2.3		2.2		1.8
Gansu		5.6		9.5		2.2		1.4		1.0
Qinghai		7.1		7.3		0.4		0.3		0.2
Ningxia		8.4		8.6		0.4		0.3		0.2
Xinjiang		9.0		10.9		1.0		0.9		0.8
Northwest		8.2		9.7		6.3		5.1		3.9
Guangxi		9.8	8)	14.3		1.4		1.3		1.6
Chongqing		9.4		11.8		1.7		1.5		1.4
Sichuan		10.6		12.3	10)	3.6		3.7	10)	3.6
Guizhou	9)	11.6		9.5		1.0		1.1		0.9
Yunnan	10)	11.5		11.0		1.5		1.7		1.4
Xizang		-1.5	3)	15.6		0.1		0.0		0.0
Southwest		10.5		12.0		9.4		9.4		8.9
National Avg. (Total)		10.5		12.6		100.0		100.0		100.0

Table 7 Regional Structural Difference Coefficients

	1988	1991	1994	1997
Northeast	0.323	0.336	0.395	0.404
North China	0.230	0.236	0.252	0.296
Central Coast	0.190	0.203	0.229	0.210
South Coast	0.346	0.341	0.380	0.384
Central China	0.235	0.246	0.262	0.272
Northwest	0.328	0.350	0.396	0.413
Southwest	0.431	0.422	0.472	0.444
Simple Average	0.298	0.305	0.341	0.346

Figure 1 Location of Regions



Note of Figure 1: This figure is based on the regional aggregation of the 1997 table.

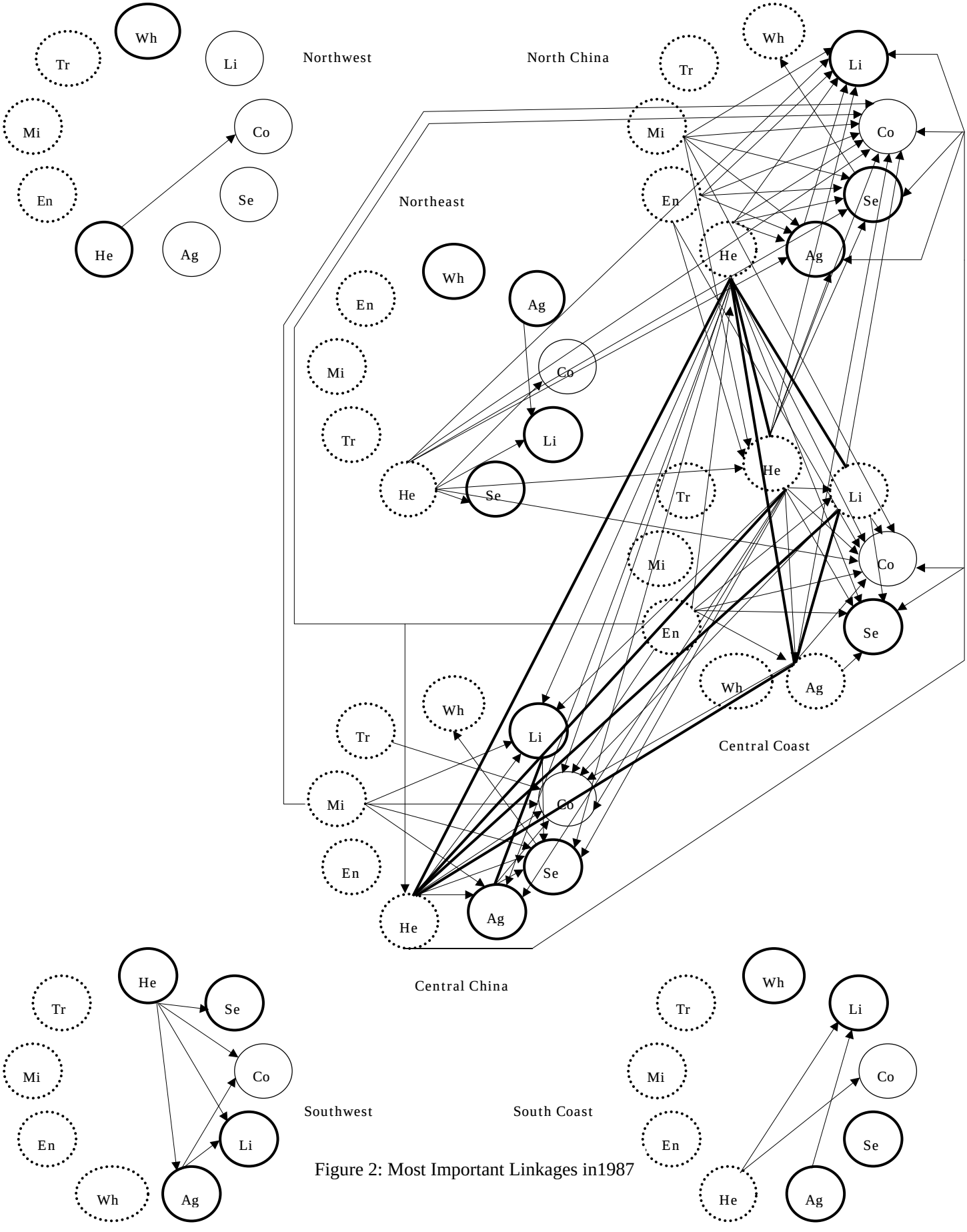
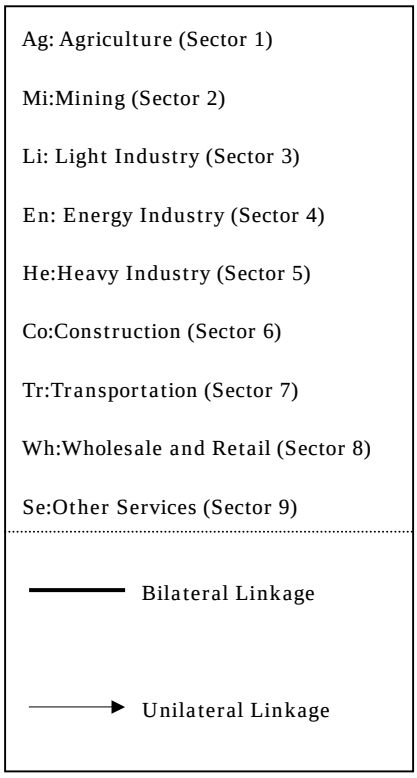


Figure 2: Most Important Linkages in1987

legend of figure 2:



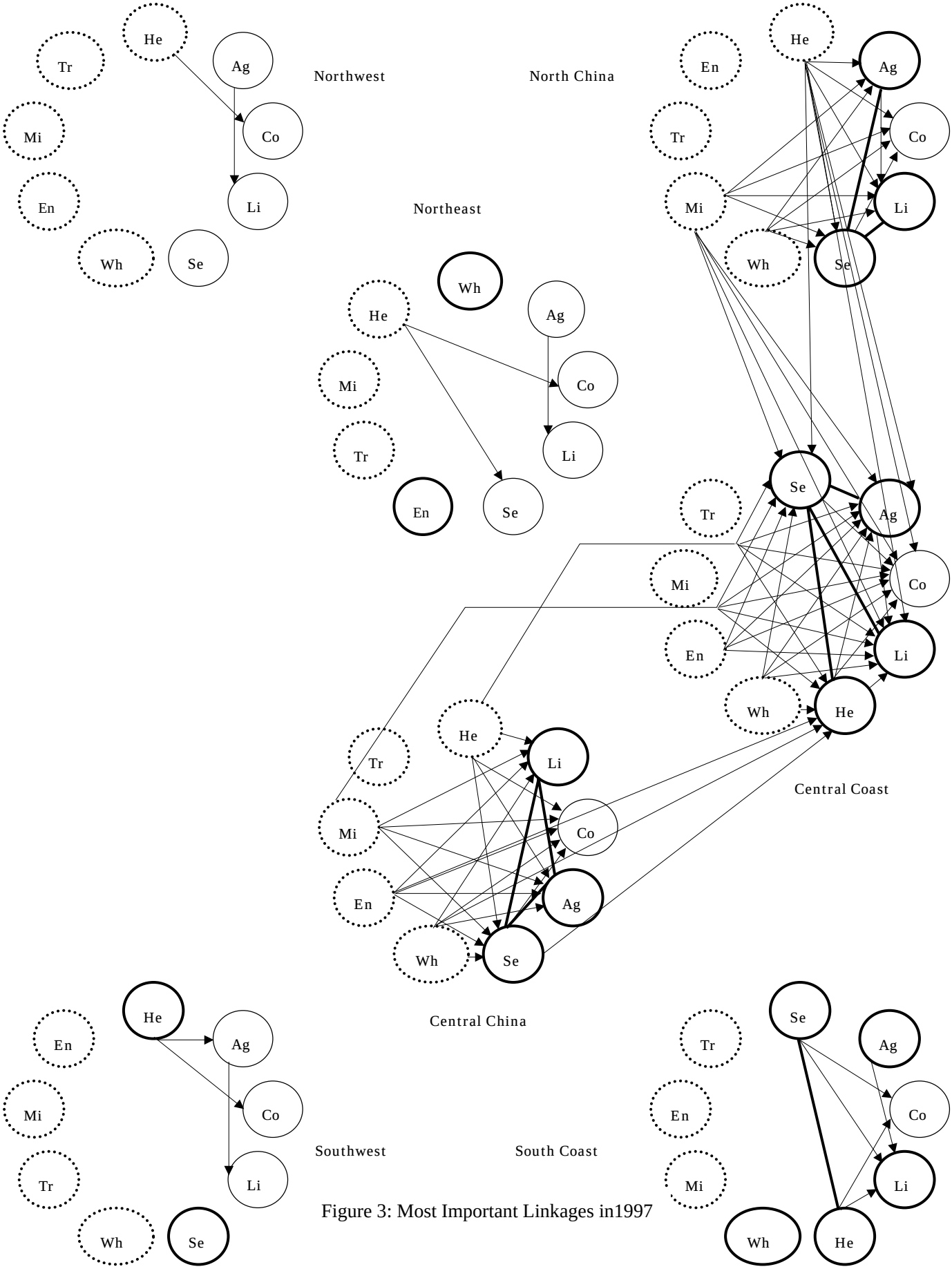


Figure 3: Most Important Linkages in1997

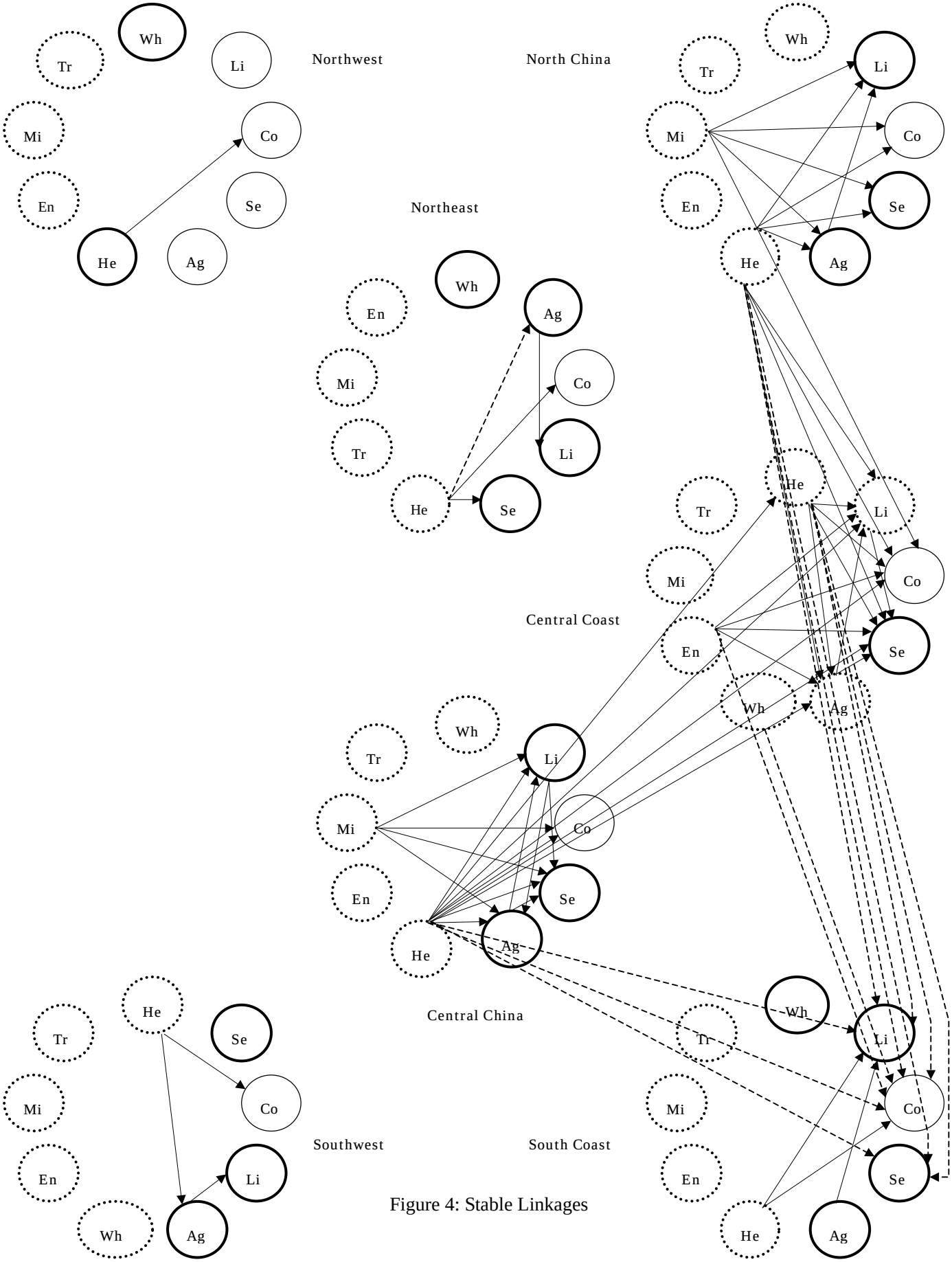


Figure 4: Stable Linkages

Legend of Figure 4:

Ag: Agriculture (Sector 1)

Mi:Mining (Sector 2)

Li: Light Industry (Sector 3)

En: Energy Industry (Sector 4)

He:Heavy Industry (Sector 5)

Co:Construction (Sector 6)

Tr:Transportation (Sector 7)

Wh:Wholesale and Retail (Sector 8)

Se:Other Services (Sector 9)

——→ : Most important linkage in both years.

------→ : Secondary important linkage in both years.

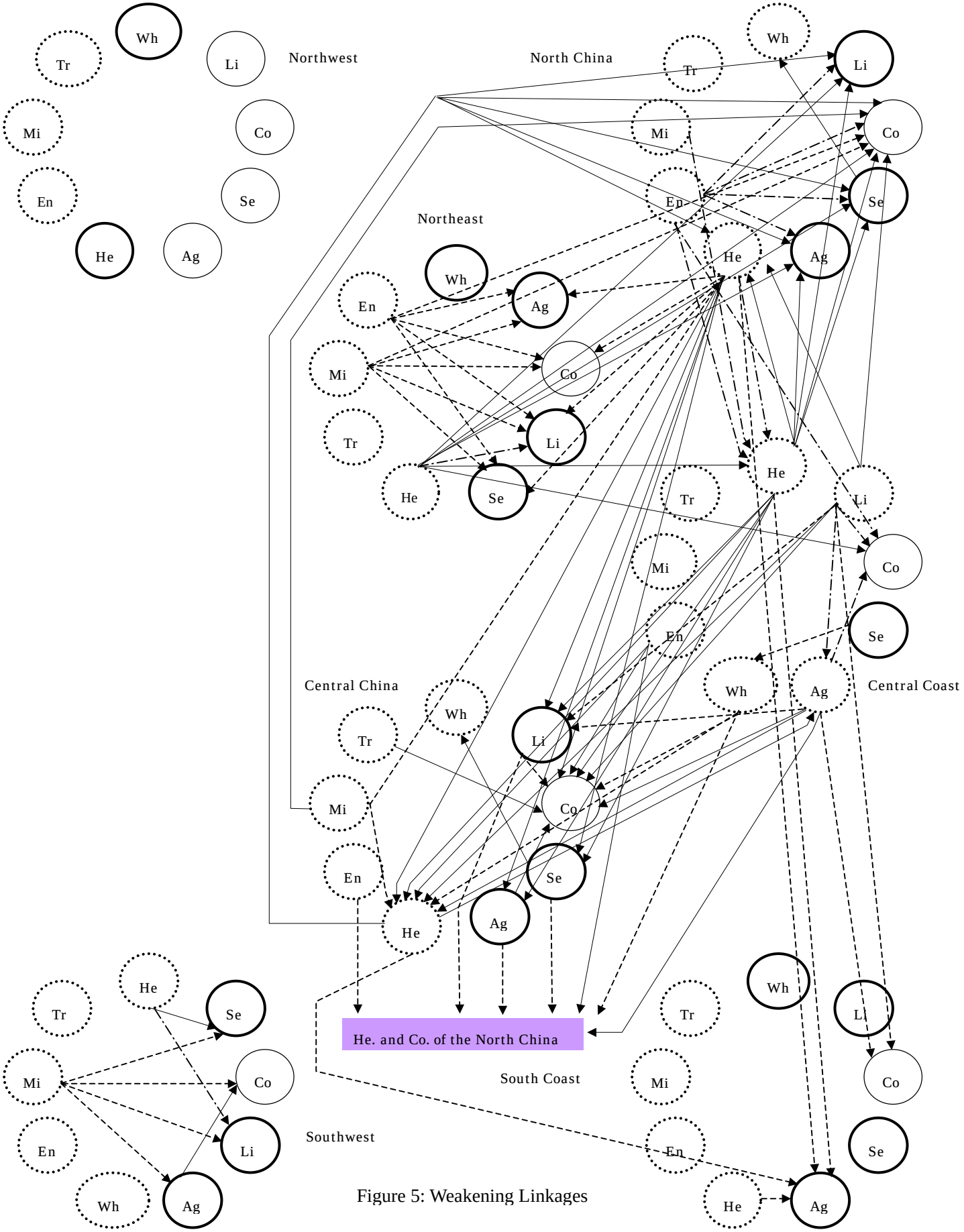
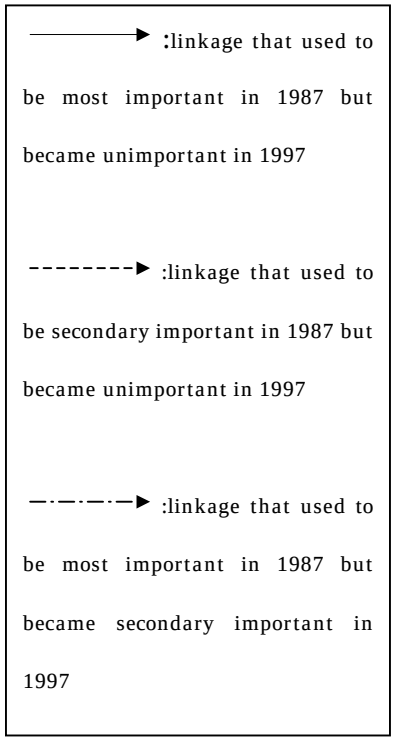


Figure 5: Weakening Linkages

Legend of Figure 5:



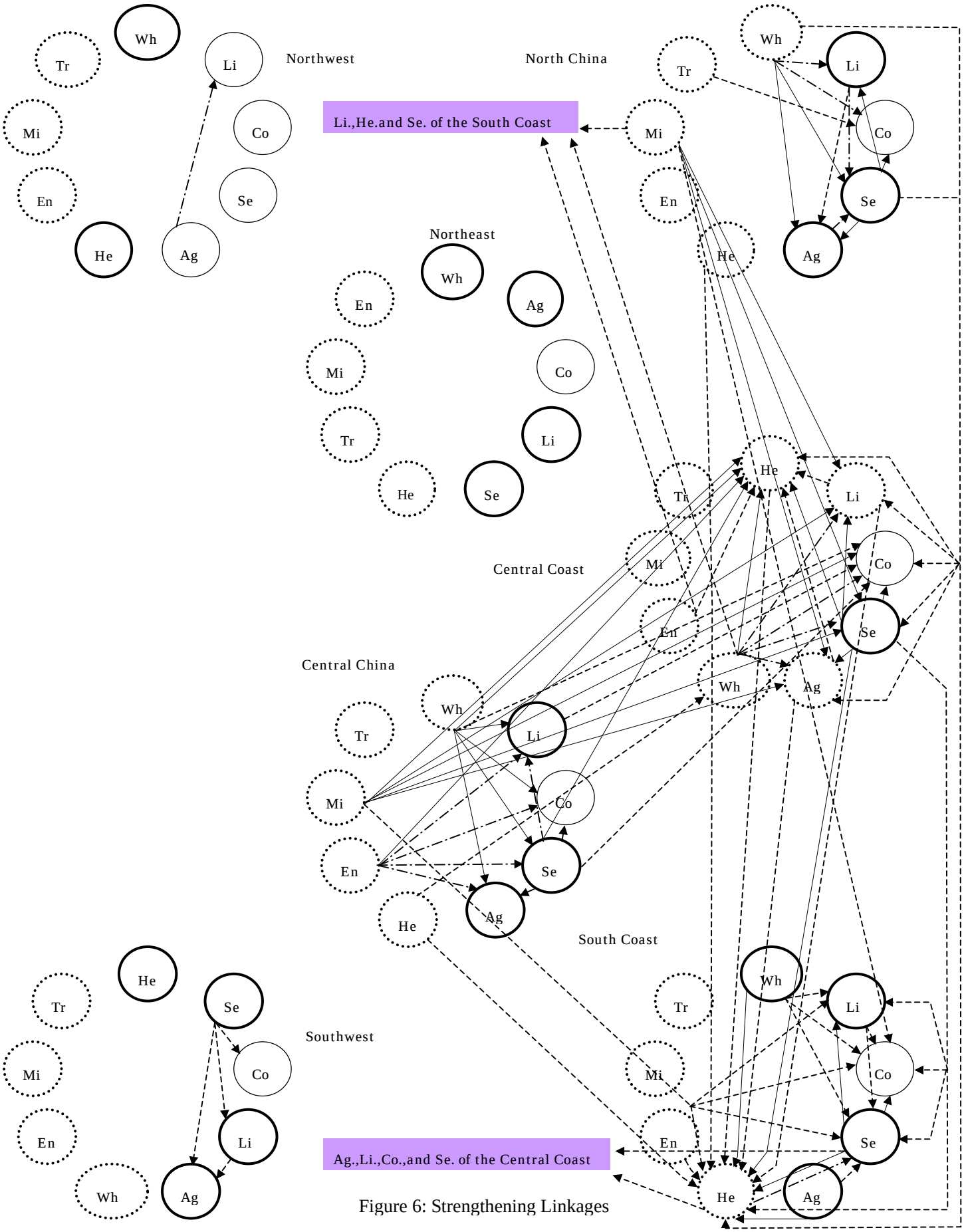


Figure 6: Strengthening Linkages

Legend of Figure 6