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Specification of the World City Network

World cities are generally deemed to form an urban system or city network but these are never explicitly specified in the literature. In this paper the world city network is identified as an unusual form of network with three levels of structure: cities as the nodes, the world economy as the supranodal network level, and advanced producer service firms forming a critical subnodal level. The latter create an interlocking network through their global location strategies for placing offices. Hence, it is the advanced producer service firms operating through cities who are the prime actors in world city network formation. This process is formally specified in terms of four inter-city relational matrices—elemental, proportional, distance, and asymmetric. Through this specification it becomes possible to apply standard techniques of network analysis to world cities for the first time. In a short conclusion the relevance of this world city network specification for both theory and policy-practice is briefly discussed.

The contemporary study of world cities can be said to begin with Friedmann and Wolff's (1982) identification of "command centers" to control and articulate the "new international division of labor" being created by multinational corporations. They introduced the concept of a "global network of cities" (King 1990, p. 12) performing these functions and this idea has persisted to the present: for instance, Sassen's (1994, p. 47) "transnational urban system," Lo and Yeung's (1998, p. 10) "functional world city system," and Short and Kim's (1999, p. 38) "global urban network." Many other similar phrases could be listed from the literature but the key point is that they all have one shared characteristic, the failure adequately to specify the system or network. Castells (1996) does theoretically incorporate Sassen's ideas as part of the middle layer in his "space of flows," global cities as "the most direct illustration" of his "nodes and hubs" (p. 415), but he does not provide any additional specificity to this global network (p. 413). *The general purpose of this paper is to supply just such a specification.*

The need for a precise specification of the world city network is obvious. Without it there can be no detailed study of its operation—its nodes, their connections, and how they constitute an integrated whole. Smith and Timberlake (1995, p. 85) have recognized this point but offer only a taxonomy of flows before calling for the use of net-

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work analysis as "a rigorous way to operationalize theoretical conceptions" (p. 86). However, without precise specification this call remains an ambition rather than a reality. But it is important for the world city network to be analyzed in the same way as other networks in the social sciences. *The particular purpose of this paper is to specify the world city network so that formal network analysis can be applied.*

The argument is developed through two main sections. First, the initial need is to identify what type of network world cities constitute. The world city network is interpreted as an example of a relatively unusual form of network with three distinct levels of structure. Second, formal specification of this triple-level structure is presented to create the "cities in global matrices"—this is Smith and Timberlake's (1995) term—which can be input to standard network analyses. In the conclusion, both theoretical and practical-policy implications of this exercise are explored: the importance of city competition within a city network is reassessed to provide new insights for theory-practice relations in this field of study.

SPECIFYING THE TYPE OF NETWORK

Topologically, a network consists of nodes and links that display a pattern of connections. In human geography this simple graph theory approach has been used to describe transportation and communication networks (Taaffe, Gauthier, and O'Kelly 1996). For world cities, international airline flights have been used to define a global transport network (for example, Keeling 1995; Kunzmann 1998; Rimmer 1998), and new electronic communication linkages have been researched (for example, Graham and Marvin 1996; Rimmer 1998). These are not the networks this paper deals with. Infrastructure networks are important and are necessary to support the world city network but they do not define it. Here the concern is for the world city network as a social network, a form of organization where nodes are actors and links are social relations. The social relations of this world city network are economic, particular intercity relations that operate to geographically structure the world economy.

The world city network is an unusual social network. This is not just because of its large scale—most social network analyses involve individuals within small organizational settings—because the international system of nation-states has been subjected to network analyses as a relatively unproblematic social network (for example, Snyder and Kick 1979; Smith and White 1992). The problem arises with the idea of city as actor. In other social networks, individuals in roles or nation-states through governments can be reasonably interpreted as the key agents in their network production and reproduction. Cities are different: they do have decision-making administrations and competition between cities is part of world city network formation (Kresl 1995), but it constitutes just a small component of the overall process. In the original conception of world cities as control and command centers it is the multinational corporations who are the key actors, the loci of the decisions behind the control and command. Thus, as well as the world economy as the supranodal level, there exists a critical subnodal level within the network: it is the behavior of firms within and across cities that creates world cities as the nodes of the network. World city network formation is more an outcome of global corporate decisions than the collective works of urban policymakers. This is critical for theory and practice—of which more later—but the initial point is that this subnodal process makes the world city network an unusual and difficult-to-specify social network.

World Cities and Advanced Producer Services

Following on from the idea of control and command centers, *world city formation* was initially defined in terms of location of transnational corporate headquarters (both worldwide and regional) [see King (1990, ch. 2) and Beaverstock, Smith, and

Taylor (2000) for reviews]. More recently, a more refined definition focuses upon just one category of multinational firm, those providing business services.[1] Like all cities past and present, world cities provide services but contemporary *advanced producer services* (for example, accounting, advertising, finance, insurance, and law applied in transnational contexts) are different; they constitute a leading edge of the world economy in their own right. This is Sassen's (1991, p. 126) basic argument: these cities have "a particular component in their economic base" that gives them a "specific role in the current phase of the world economy." World cities have become centers for the production and consumption of the advanced services in the organization of global capital. As locales for service innovations in such areas as multijurisdictional law and new financial instruments, world cities constitute concentrations of information and knowledge necessary for new service productions by advanced producer service firms (Beaverstock, Smith, and Taylor 2000). There have been, of course, numerous studies of the "geography of advanced producer services" (for example, Daniels and Moulaert 1991) but they have not addressed the topic of this paper, city network formation. Within world city studies, maps of service provision have been used to illustrate the nodes in the network, but concern for connections typically focuses upon infrastructure (for example, Moss 1987). In the specification developed below, nodes and connections are *both* derived from service provision.

Accepting Sassen's (1994) basic conception of world city formation, how can it be extended to account for world city *network* formation? The starting point is that it is large global service firms, not cities per se, that are the key actors in world city network formation. In order to carry out their business they seek out knowledge-rich environments—world cities—in which they can prosper. The success of each firm is dependent upon their location strategies of having offices in selected world cities. These are the office networks of firms through which they provide their global service. The ideal is to be able to produce a seamless service for every client whatever the locational scale and complexity of a given project. Each world city, therefore, is constituted as a particular mix of advanced producer service offices. In short, the world city network is a complex amalgam of multifarious office networks of corporate service firms.

Boundary Penetration Relations: Interlocking Networks

Social networks are normally specified at two levels: a system level where the network operates and a unit level consisting of the nodes as actors whose behaviors define the relations (Knoke and Kuklinski 1982). A typical example would be to interpret a gang as a network at the system level with, at the unit level, each gang member being a node. In the world city network, as already noted, the definition of node is not so straightforward. The existence of a subnodal input means that there are three levels: the world economy in which the network operates to dispense services, the cities that constitute the knowledge constellations for production of services, and the advanced producer service firms who produce the services. Such a triple structure is unusual in network analysis but is by no means unique: in Knoke and Kuklinski's typology of network relations (1982, p. 16) there is one category with a triple configuration that they call networks connected by *boundary penetration relations*. In such interlocking networks the nodes are connected through constituent subcomponents. A well-known example is the network of corporate boards linked together through overlapping directorships. The directorships example will be used as an initial analogue for the world city network.[2]

1. This change was partly induced by empirical studies showing a trend for multinational corporate headquarters to be found in lower-level cities; see, for instance, Lyons and Salmon (1995).

2. It is important to note that my use of analogy is very different from that of Camagni (1993) whose "deductive conjecture" (p. 74) is that the theory of networks of firms can be applied to networks of cities.

In the classic study of overlapping directorships in the United States, Burt (1983) treats directorate ties between firms as a means of lessening market constraints on corporate profits. As nonmarket connections, these ties reduce the uncertainty of free markets, either through enhanced information or through mutual influences on, even coordination of, policy making. The ties of relevance here are the "direct interlocking ties" where autonomous firms share certain directors (Burt 1983, pp. 74–77). Hence a board will consist of inside and outside directors and it is the latter which provide the links with other firms to create an interlocking network. The triple configuration consists of the U.S. economy in which the network operates, firms with their boards attempting to reduce market influences, and outside directors linking firms through their board memberships. Burt (1983, pp. 85–89) specifies such a network.

However, despite the configurational similarity, it is important to recognize the limitations of Burt's network as an analogue of the world city network. Basically, in the analogue network the nodes remain the prime actors in the sense that firms through their boards are the key decision-making units, they choose (and can dismiss) outside directors and thus control their relations in the network. In contrast, in the world city network it is the subnodal component, the service firm, which is the prime actor. To be sure, city governments will operate in ways to attract and keep leading firms through their boosterism policies and hence influence relations between nodes but they are certainly not able to control relations in the way boards of directors do. Hence, in the interlocking relations between cities within the world economy, the nodes themselves constitute vital enabling environs to be sure but they are not the critical level of decision making within the triple structure. I am aware of no other network specification in which the subnodal level is so important.

It follows that, if the world city network is indeed a particularly unusual case of an uncommon form of social network, precise specification becomes even more of a prerequisite for advancing our researches. The purpose of specification is to make transparent the basic forms in which world city network formation can be described. The idea is to articulate the process in such a way that the unusual and uncommon features of the network do not inhibit analysis in the first instance. Of course, the particular nature of world city network formation will come to the fore in any interpretation of network analysis results. This theme is returned to after formal specification of the world city network as a triple configuration.

FORMAL SPECIFICATION

Figure 1 has been constructed to aid in describing the formal specification. It depicts a minuscule part of the world city network as an interlocking structure: ten cities [these are the leading world cities, identified as "alpha" in Beaverstock, Smith, and Taylor (1999a)], and three advanced producer service firms, one from advertising, one from finance, and one from law. This example will be used in what follows to to provide concrete results at different stages of the specification; they should be treated as strictly illustrative and not as meaningful findings about the world city network.

Site and Situation: The Status of Cities

A universe of m advanced producer service firms located in n world cities is defined. The *elemental attribute* is x_{ij} where firm j has a presence or not in city i. These simple binary observations can be arrayed as a $n \times m$ presence matrix, $\mathbf{X}$. Normally in

He equates city cooperation with network cooperation rather than integrating firms and cities into a single network in the manner attempted here. His brief statement numbered e" (p. 76) defining "the case of world cities" as a "synergy network" is similar to my proposal but he does not specify a triple configuration that is the heart of my argument.

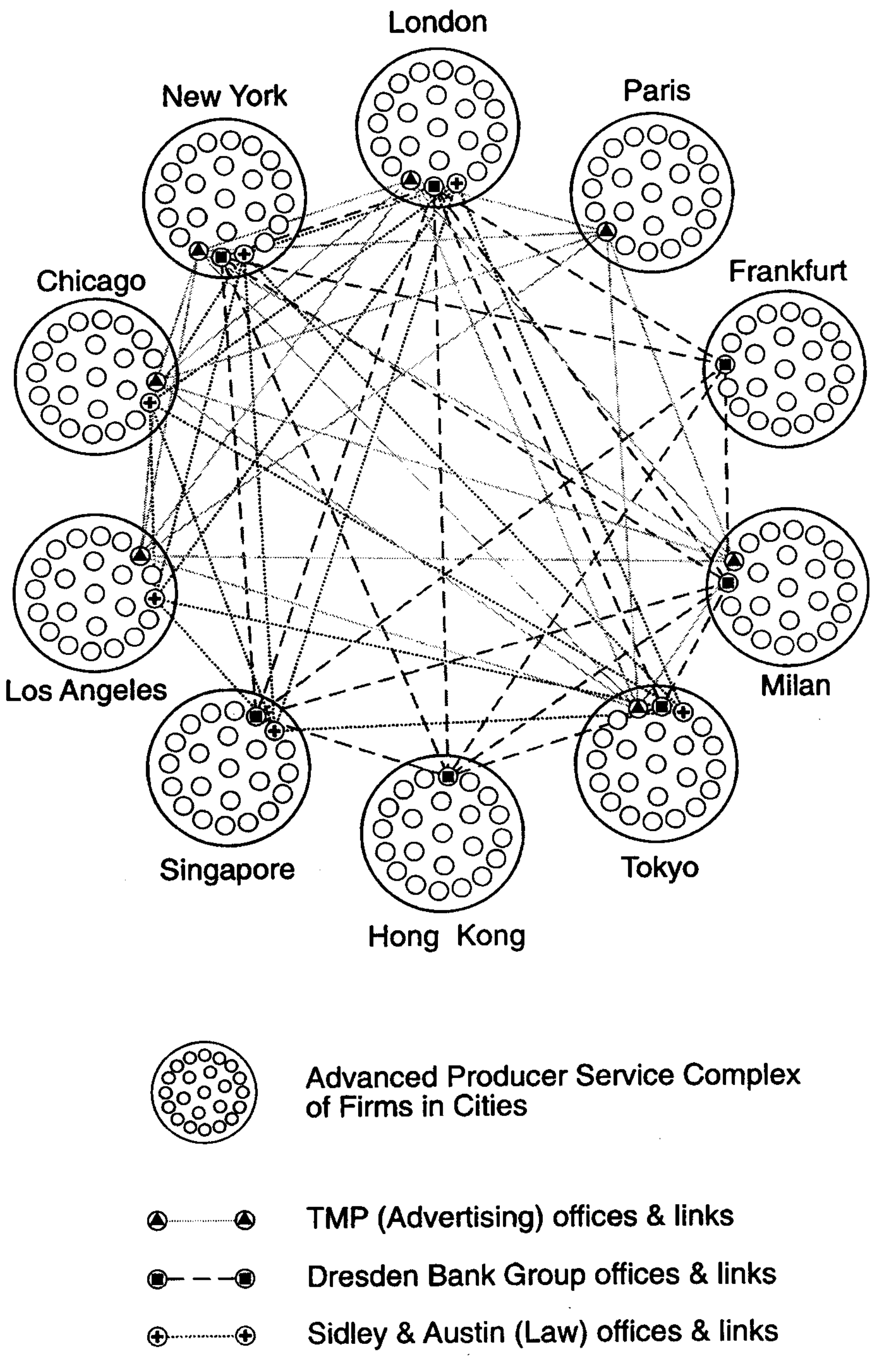

FIG. 1. Minuscule Section of the World City Network as an Interlocking Network: Ten "Alpha" Cities and Three Advanced Producer Service Firms. Note: Alpha world cities are defined by Beaverstock, Smith, and Taylor (1999).

this area of research, there is more information than mere presence: the size of the office of firm j in city i, which is called the *service value* of a firm in a city, can be measured as v_{ij} and a service value matrix, **V**, created.[3] The conjecture behind using these values is that the larger the office the more connections there are with other offices in a firm's network. This needs to be empirically investigated; here it is treated as a plausible assumption as long as large data sets are used to iron out idiosyncracies. For illustrative purposes, a small data set is used with sizes presented as simple integers ranging from 0 to 3: Table 1 (using the same firms and cities as Figure 1) shows **V** as an actual 10-city x 3-firm service value matrix.

The first attribute is the *total advanced producer services in the universe:*

$$S = \sum_i \sum_j v_{ij} \ . \tag{1}$$

In Table 1, $S = 38$. This attribute measure can be used comparatively in tracing the quantity of the service over time and in comparing total services across different sectors. These particular possibilities are not followed up in this specification exercise.

This universe attribute can be decomposed into two measures of the statuses of firms and cities:

$$F_j = \sum_i v_{ij} \ ; \tag{2}$$

$$C_i = \sum_j v_{ij} \ . \tag{3}$$

Both sets of sums are given in Table 1. Equation (2) measures the total service value provided by firm F_j across all cities. This defines the *firm service status* of F_j and can be used in comparative analyses to stratify or rank firms: in Table 1 the Dresden Banking Group has the lowest rank. Equation (3) measures the total service value provided within city C_i by all firms: in Table 1 New York has the highest sum. This is a measure of the world city status of C_i which will be called *site service status* for rea-

TABLE 1
Service Value Matrix

City:	Advanced producer service firm: I	II	III	Σ [C_i in equ. (3)]
1. Chicago	2	0	3	5
2. Frankfurt	0	3	0	3
3. Hong Kong	0	1	0	1
4. London	3	1	3	7
5. Los Angeles	3	0	3	6
6. Milan	1	1	0	2
7. New York	3	2	3	8
8. Paris	1	0	0	1
9. Singapore	0	1	1	2
10. Tokyo	1	1	1	3
Σ (F_j in equ. (2))	14	10	14	(38)

NOTES: I is TMP (advertising); II is Dresden Banking Group; and III is Sidley and Austin (law).
This is a subset of a 55 (world cities) x 72 (global service firms) matrix. For details of its production, see Beaverstock, Smith, and Taylor (1999b).

3. See the treatment of this, using a variety of measures, in Beaverstock, Smith, and Taylor (1999b).

sons that will become apparent below. Since this paper's concern is for a network among cities, concentration is upon developing the specification by building on equation (3), and not equation (2), although there is a parallel argument for firms to that which can be presented for cities.[4]

The basic relational element for each pair of cities derived from matrix **V** is

$$r_{ab,j} = v_{aj} \cdot v_{bj} \tag{4}$$

which defines the relation between cities a and b in terms of firm j. This is an *elemental interlock link* between the two cities for one firm. The aggregate *city interlock link* is then produced from

$$r_{ab} = \sum_{j} r_{ab,j} \, . \tag{5}$$

For each city there are $n-1$ such links, that is, one to every other city. Table 2 shows the products from equation (4) and the sums from equation (5) for the first two cities in Table 1, Chicago and Frankfurt. In an egocentric analysis (taking one city at a time), these links can be used to measure the overall status of a city within the network:

$$N_a = \sum_{i} r_{ai} \, . \qquad a \neq i \tag{6}$$

This will be called the *interlock* or *nodal connection* which defines the situational status of city a. From Table 2 it can be seen that Chicago's situational status is 57 and Frankfurt's is 20. The sum of the situational status for all cities defines the *total network interlock linkage* (T):

$$T = \sum_{i} N_i \tag{7}$$

TABLE 2
Elemental Interlock Links

Cities	For Chicago: I	II	III	Σ*	For Frankfurt: I	II	III	Σ*
1.	-	-	-	-	0	0	0	0
2.	0	0	0	0	-	-	-	-
3.	0	0	0	0	0	3	0	3
4.	6	0	9	15	0	3	0	3
5.	6	0	9	15	0	0	0	0
6.	2	0	0	2	0	3	0	3
7.	6	0	9	15	0	6	0	6
8.	2	0	0	2	0	0	0	0
9.	0	0	3	3	0	3	0	3
10.	2	0	3	5	0	3	0	3
Σ [N_a in equation (6)]				57				20

Notes: * r_{ab} from equation (5) and for matrix (i) in Table 3. For city and firm codes see Table 1.

4. However, in this case, because the firms are actors, a multiple-network approach might be more suitable; see Burt (1982, pp. 22–29).

For the cities in Table 1, $T = 401$. This sum can be used to express the situational status of a city as its proportion of total interlock (T):

$$L_a = (N_a/T)\ . \tag{8}$$

For Chicago and Frankfurt the proportions are 0.12 and 0.05 respectively which compare with the highest proportion, New York's $L = 0.2$.

Complete Network Specification

The egocentric approach is the simplest level of network analysis (Knoke and Kuklinski 1982, p. 16) and does not take full advantage of all the dyadic information available from equation (5). A complete network level of analysis considers all relations to ascertain the systemic patterning of nodes and linkages. This requires the creation of a square ($n \times n$) relational matrix, **E**, using the city interlock link, r_{ab} [equation 5)], for all city pairs. This elemental relational matrix is more interpretable if transformed into a proportionate relational matrix **P** where linkages are given as proportions of the maximum possible linkage. This maximum is

$$H = \sum_j h_j^{\ 2} \tag{9}$$

where h_j is the highest service value provided by firm j from across all cities.[5] From Table 1 it can be seen that the highest values for each firm is 3 so that $H = 27$. Matrix **P** is the array of $n \times n$ proportional city interlinks:

$$p_{ab} = r_{ab}/H \tag{10}$$

where $0 \leq p_{ab} \leq 1$.

Finally, to complete specification of these relational matrices it is necessary to define the matrix diagonal as the *self-relation* of each city. This is not given in equation (4); for dimensional equivalence these self-relations are defined as

$$r_a = \sum_j v_{ja}^{\ 2} \tag{11}$$

for matrix **E** and

$$p_a = r_a/ H \tag{12}$$

for matrix **P**. The elemental and proportional matrices derived from the data in Table 1 are presented as Tables 3(i) and 3(ii) respectively.

Relations in matrix **P** can be converted to *social distances* by taking the proportional intercity interlinks from unity:

$$d_{ab} = 1 - p_{ab}\ . \qquad a \neq b \tag{13}$$

5. See Beaverstock, Smith, and Taylor (1999b).

TABLE 3
Relational Matrices

(i) Elemental Relational Matrix: E, from Equations (5) and (11)

	1	2	3	4	5	6	7	8	9	10
1	13	0	0	15	15	2	15	2	3	5
2	0	9	3	3	0	3	6	0	3	3
3	0	3	1	1	0	1	2	0	1	1
4	15	3	1	19	18	4	20	3	4	7
5	15	0	0	18	18	3	18	3	3	6
6	2	3	1	4	3	2	5	1	1	2
7	15	6	2	20	18	5	22	3	5	8
8	2	0	0	3	3	1	3	1	0	1
9	3	3	1	4	3	1	5	0	2	2
10	5	3	1	7	6	2	8	1	2	3

(ii) Proportional Relations Matrix: P, from Equations (10) and (12)

	1	2	3	4	5	6	7	8	9	10
1	.48	.00	.00	.56	.56	.07	.56	.07	.11	.19
2	.00	.33	.11	.11	.00	.11	.22	.00	.11	.11
3	.00	.11	.03	.03	.00	.03	.07	.00	.03	.03
4	.56	.11	.03	.70	.67	.15	.74	.11	.15	.26
5	.56	.00	.00	.67	.67	.11	.67	.11	.11	.22
6	.07	.11	.03	.15	.11	.07	.19	.03	.03	.07
7	.56	.22	.07	.74	.67	.19	.81	.11	.19	.30
8	.07	.00	.00	.11	.11	.03	.11	.03	.00	.03
9	.11	.11	.03	.15	.11	.13	.19	.00	.07	.07
10	.19	.11	.03	.26	.22	.07	.30	.03	.07	.11

(iii) Social Distance Matrix: D, from Equation (13)

	1	2	3	4	5	6	7	8	9	10
1	.00	1.0	1.0	.44	.44	.93	.44	.93	.89	.81
2	1.0	.00	.89	.89	1.0	.89	.78	1.0	.89	.89
3	1.0	.89	.00	.97	1.0	.97	.93	1.0	.97	.97
4	.44	.89	.97	.00	.33	.85	.26	.89	.85	.74
5	.44	1.0	1.0	.33	.00	.89	.33	.89	.89	.78
6	.93	.89	.97	.85	.89	.00	.81	.97	.97	.93
7	.44	.78	.93	.26	.33	.81	.00	.89	.81	.70
8	.93	1.0	1.0	.89	.89	.97	.89	.00	1.0	.97
9	.89	.89	.97	.85	.89	.97	.81	1.0	.00	.97
10	.81	.89	.97	.74	.78	.93	.70	.97	.97	.00

(iv) Asymmetrical Relations Matrix: A, from Equations (16) and (12)

	1	2	3	4	5	6	7	8	9	10
1	.48	.00	.00	1.0	1.0	.13	1.0	.13	.20	.33
2	.00	.33	.50	.50	.00	.50	1.0	0	.50	.50
3	.00	1.0	.03	.33	.00	.33	.67	.00	.33	.33
4	.71	.14	.05	.70	.86	.19	.95	.14	.19	.33
5	.83	.00	.00	1.0	.67	.17	1.0	.17	.17	.33
6	.33	.50	.17	.67	.50	.07	.83	.17	.17	.33
7	.63	.25	.08	.83	.75	.21	.81	.13	.21	.33
8	.67	.00	.00	1.0	1.0	.33	1.0	.03	.00	.33
9	.50	.50	.17	.67	.50	.17	.83	.00	.07	.33
10	.56	.33	.11	.78	.67	.22	.89	.11	.22	.11

NOTE: For city codes see Table 1

The resulting distance matrix, **D**, defines intercity relations in terms of low dyad values indicating similarity. Since these are interpreted as distances, the diagonal values are defined as zero. For the data in Table 1, this matrix is presented in Table 3(iii).

All the $n \times n$ matrices above are symmetrical because

$$r_{ab} = r_{ba} \,. \tag{14}$$

This may make them suitable for defining the basic structures of the world city network, but they are unsuitable for searching out hierarchical tendencies in the relations. This requires an asymmetric matrix where relations between cities can be unequal.

An asymmetrical relational matrix, **A**, can be produced by changing the denominator from a common total, H in equation (9), to totals specific to each link. In particular, direction has to be distinguished:

$$H_{ab} = \sum_{j} h_j \cdot v_{ia} \tag{15a}$$

and

$$H_{ba} = \sum_{j} h_j \cdot v_{ib} \tag{15b}$$

where h_j is the highest service value for firm j [as in equation (9)] and v_{ja} and v_{jb} are the service values for firm j in cities a and b, respectively [as in equation (4)]. Matrix **A** is an array of

$$q_{ab} = r_{ab}/H_{ab} \tag{16a}$$

and

$$q_{ba} = r_{ab}/H_{ba} \tag{16b}$$

so that $q_{ab} \neq q_{ba}$ except in special circumstances such as where $H_{ab} = H_{ba}$. Of course, this change makes no difference to the matrix diagonal which continues to be given by equation (12). Table 3(iv) shows this matrix for the data from Table 1.

Interpretation

The specification in the first section above is a straightforward ranking exercise in terms of quantity in situ or quantity in relation to position in the network. The latter is particularly important because the situation of cities has been neglected in recent urban geography even when dealing with world cities (Taylor 2001a). However, the complete network specification in the second section requires some further explication. This will be carried out through interpretation of Tables 3(ii) and 3(iv).

To simplify discussion, I start with the original presence matrix, **X**, because binary measures of presence/absence are easier to interpret. For instance, for any two cities, p_{ab} [from equation 10)] is a simple measure of shared firms as a proportion of total firms. (Note that with presence/absence measures, H [from equation (9)] will simply equal m, the number of firms.) This has a very simple interpretation: if a client wishes to use a given service firm to do business involving both city a and city b, p_{ab} gives the probability of this being possible within this universe of firms, that is, whether the firm has offices in both cities. Switching now to matrix **V** and variable service values upon which Table 3(ii) is based, p_{ab} defines the relative degree or quality of mutual services between the two cities. In this case, p_{ab} can be interpreted as the predicted relative quality of service a client can expect when doing business in a given pair of cities. Not surprisingly, in Table 3(ii) the highest value, 0.74, is for the London-New York dyad which compares with, for instance, a value of 0.30 for New York-Tokyo. In contrast, there are seven examples where city dyads do not share any offices so that p_{ab} is zero, for instance, Chicago and Frankfurt (see also Table 2).[6]

Before looking at the asymmetrical matrix, it is necessary to mention briefly the distance matrix, **D**. This does not have a direct behavioral interpretation; rather it is an array for use in representing cities in terms of their particular mixes of service firms. Cities with similar mixes will have shorter distances recorded between them so that they will be closer together in any social mapping exercise, for instance, when using multidimensional scaling techniques.

Returning to the binary data to begin explicating the asymmetrical matrix, **A**, the interpretation is surprisingly simple. If a client randomly contacted a firm in city a to do business in city b, q_{ab} is the probability that the selected firm would have an office in city b. Conversely, if a client randomly contacted a firm in city b to do business in city a, q_{ba} is the probability that the selected firm would have an office in city a. High-status cities will tend to have firms with offices in many or most low-status cities but low-status cities will not be able to match the range of offices available in high-status cities. Thus, pairs of relations are normally asymmetrical. Reverting to service values, q_{ab} defines the relative levels of services that can be expected for doing business in city a from city b. This is clearly shown in Table 3(iv) by looking down the columns where London and New York consistently have the highest values: selecting a firm in other world cities will invariably provide a good seamless service for doing business in London and New York. Because of their global importance, all other cities are well connected to London and New York. In contrast, selecting a firm in London or New York does not guarantee a seamless service to other cities because many global city firms will not feel it necessary to locate in some more minor world cities. In Table 3(iv), for instance, although from Chicago to London and New York records maximum levels of service, in the other direction values of 0.71 and 0.63 are recorded respectively.[7]

In conclusion, the three intercity matrices, **P**, **D**, and **A**, deriving from the elemental matrix **E**, each constitute different working specifications of the world city network. With information ordered in this way, world cities can be subjected to various forms of analysis available to simpler types of network. This means the wide repertoire of network techniques from elementary derivation of indices to scaling, ordinating, factoring, clustering, and blocking (Knoke and Kuklinski 1982). For instance, by using standard principal components analysis typologies of world cities in terms of interfirm connections can be produced [for some preliminary experiments see Taylor and Walker (2001), Taylor and Hoyler (2000), and Taylor et al. (2000)]. In addition, simple network diagrams are shown in Beaverstock, Smith, and Taylor (2000), and new corporate spaces derived from multidimensional scaling are depicted in Taylor (2001b). Importantly, the fact that the links being analyzed are relatively unusual interlocking or boundary penetration relations becomes a relevant consideration before (planning research design) and after (interpreting results) but need not affect the analysis itself if the matrices are specified as above.

6. The zero results are a function of the small size of the data; in practice, of course, all world cities share some firms with all other world cities (Taylor and Walker 2001).

7. For a full analysis of the ten cities using forty-six global service firms, see Taylor (2000a).

IMPLICATIONS FOR THEORY AND PRACTICE

The world city network is an interlocking network but, as indicated, it is not an exact analogue of other such networks. In particular, this relates to the cities' being nodes but not being primary actors. This specific feature of the world city network has important implications for both theory and practice which are dealt with briefly in turn.

There is a conundrum at the heart of the world city literature: if these cities do indeed constitute a network how does this square with the process of city competitiveness? The reason why this is a theoretical problem is because economic networks develop and prosper through processes of cooperation between actors. Competition is a feature of open market exchange which is anathema to networks that depend upon "closed reciprocity" between members (Powell 1990). This problem has been identified by Sassen (1994, p. 50) who argues that if cities "compete with one another for global business, then they do not constitute a transnational system." For Sassen, cities have to do more than compete if there is to be a "systemic dynamic binding these cities." She describes a form of cooperation between London, New York, and Tokyo in terms of their different roles in finance and investment to show that "cities do not simply compete with each other for the same business." Camagni (1993) provides the fullest argument along these lines but provides little further evidence of what he terms "close cooperation between cities" (p. 81). Specifying the world city network as an interlocking network provides an alternative to searching out such cooperation between cities.

In an influential article on competition, Krugman (1994) argues that the concept of economic competition should be restricted to entities which participate directly in markets. Thus, he argues, countries are not in economic competition with one another, it is only firms that compete in the world market. From this perspective, a competitive situation exists only where failure means actual disappearance from the market (absolute failure via bankruptcy, relative failure via take-over). Of course, markets do not make countries disappear, nor do they force cities out of business. There is a sense in which countries and cities compete by providing conducive conditions for their firms to succeed in the world market but this is not itself a separate market competition, it operates merely as an adjunct to existing markets. City competition exists, therefore, to attract firms but the real competition is between the firms themselves. However, within firms there is cooperation across offices to provide a seamless global service. The results are the office networks that provide the basic dependent mutuality necessary for a network to operate. Thus in the world city network the nodes may operate a weak "adjunctive competition" but the network has been able to develop because of the cooperative behavior within the prime agents, the firms, through their world city offices.

The practical implications of the triple configuration are equally important for city policymakers but here there does not seem to have been recognition of the competition/network conundrum. The reason is simple: the literature on city competition has been atomistic in nature with little or no concern for the world city network [Kresl 1995; for a critique, see Beaverstock et al. (1999)]. Camagni (1993, pp. 78–81) is an important exception but his policy strategies at the level of the city system are premised on cooperation between cities which, for reasons previously rehearsed, severely limits their efficacy. In general, however, because the policy levers of city governments are local, practical focus has been single-city based, such as intrastructural-type policies to attract firms (new offices, airports, and electronic communication investments, etc.) so that the world city network itself has been ignored. It is argued here that appreciating the triple configuration in which service firms are prime agents has critical political implications for building private sector alliances in support of policy.

The situation is as follows: city administrations can be successful in marshalling support for general policy to improve conditions for business by lobbying national government but not for specific competitive instruments aimed at other cities. For instance, international banks will have no collective interest in promoting London at the expense of Frankfurt or vice versa. In terms of finance, London has been "Wimbledonized," that is to say, like the tennis tournament, the City provides the world's outstanding stage upon which "foreigners" win all the prizes. In other words, the leading players in London are not British firms, they are banks for which London is very important, but so, too, is New York, Tokyo, and Frankfurt. A similar argument can be made about Hong Kong-Singapore competition; most large advanced producer service firms in both cities are "foreign." Hence the policy making behind city competitiveness should begin with the understanding that every world city is part of an interlocking network which is the world city network.

This paper has concluded with examples from theory and practice to show the general utility of more rigorous thinking on the world city network than that commonly found in the relevant literature. This is where the paper began, with a brief set of descriptions of systems and networks without clear specification; it is hoped that by showing conversion of these imprecise and, frankly, vague conceptions first, to a precise type of network with an unusual configuration, and second, to formal definitions to provide matrices for standard network analyses, knowledge of the world city network can be advanced both quantitatively and qualitatively.

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