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Global Supply Networks and Multilateral Trade Linkages: A Structural Analysis of East Asia

David Roland-Holst

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About the Author

David Roland-Holst *is the James Irvine Professor of Economics at Mills College and Director of the Rural Development Research Consortium at the University of California, Berkeley. He holds a PhD in Economics from U.C. Berkeley and is a one of the world's leading experts on policy modeling. In addition to being a Visiting Scholar at the Asian Development Bank Institute, Professor Roland-Holst has held academic positions in the United States, the Netherlands, and Switzerland, and worked with a variety of public institutions, including the Asian Development Bank, Inter-American Development Bank, OECD, World Bank, several UN agencies, and many government agencies in the United States and elsewhere. Professor Roland-Holst has done applied research on more than 25 countries and published over 75 scholarly articles and chapters in books, including the Review of Economics and Statistics, Canadian Journal of Economics, Journal of Development Economics, World Development, and the Review of Income and Wealth.*

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PREFACE

Under its general research project on development paradigms, the ADB Institute Research Paper Series disseminates works-in-progress to advance general understanding of important research issues, inform interested parties, and invite comments and questions.

I trust that this series will facilitate constructive dialogue among policymakers as well as among researchers about the most beneficial course of development and growth for the Asian economies.

Peter McCawley
Dean
ADB Institute

ABSTRACT

As the global economic regime shifted from post-colonial bilateralism to multilateralism, one of the most dramatic events has been the emergence of private agency. Beneath the official veneer of open multilateralism and WTO sponsored globalization, there is a remarkably diverse and dynamic mosaic of private commercial linkages that link the world's economies. These linkages are generally incorporated in global networks or supply chains, where ten, hundreds, even thousands of intermediate product linkages are realized through bilateral deliveries within and across boundaries. The result is a remarkably diffuse mosaic of economic activity, coexisting with and often transcending official networks of bilateral and multilateral diplomacy and trade negotiation. As the system has grown in scope and complexity, well beyond the administrative capacity of individual enterprises and nation states, it relies for its existence on price mediated market interactions and a liberal trade an investment climate. With better understanding of this complex web of linkages, policy makers can see both the rewards of multilateralism and the importance of policies that facilitate it.

In this paper, we analyze these global supply networks, particularly in the context of East Asia and in recognition of the catalytic role played by international capital allocation or FDI. What we see in today's global economy is a process of supply chain decomposition, where FDI is distributing production tasks across an international matrix of intermediate producers. Individual components of this production matrix are chosen for a variety of reasons, only one of which is the traditional Ricardian or Heckscher-Ohlin criteria of relative resource cost. At least as important for many firms is market access, domestically or in a neighboring country. Transport costs, infrastructure, network externalities, and administrative climate are also important. Finally, it makes sense for firms to diversify their supply chains simply as a hedging strategy, where the components of risk can be local, national, or global.

In East Asia, this process has advanced very rapidly and pervasively, facilitated by both western FDI and a regional cascade effect, where more advanced Asian economies re-allocate production to less advanced ones. In the process of

distributing supply chains, foreign investors in the region create new nodes of production in different localities, and another indirect phenomenon emerges. Bamboo Capitalism describes a process where fully autonomous enterprises and markets sprout from these nodes in the "root system" of global intermediate supply. This process is long established in the Tiger economies and can be seen to emerge now in China (and across China) and other emerging Asian economies. The result is replication of industries and markets are an exponential rate.

To better understand the empirical significance of these phenomena, we present a novel approach to international multiplier analysis, based on a multi-country Social Accounting Matrix estimated from detailed data on domestic economic structure and international trade. This was used for multiplier decomposition analysis, and the results reported below support a general inference that multilateralism is a much more pervasive phenomenon than simple bilateral trade statistics would suggest. Indeed, we find that anywhere between 20 and 70 percent of total income realized in bilateral linkages arises from very long and complex multilateral chains of income-expenditure linkages. These network effects reach across geographic boundaries and sectors in ways that would be quite impossible for policy makers or trade negotiators to anticipate by intuition alones. Such "general equilibrium" trade linkages are apparently responsible for the majority of international value creation and trade. For this reason, the conventional view of gains from trade seriously understates the value of more a more liberal global trading environment.

Global supply networks have leveraged the world's resource base and a more liberal trading environment to increase incomes in ways more pervasive than most of us can imagine, and broadening the basis for these activities can only amplify these benefits, distribute them ever more widely, and reduce the risks of economic concentration and instability.

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1. Introduction

Since the middle of the last century, the global economy has changed in ways that are transparent and historically intuitive, but also in ways that are subtle and unprecedented. As the global economic regime shifted from post-colonial bilateralism to multilateralism, one of the most dramatic events has been the emergence of private agency. A more open multilateral trading environment appears to be especially congenial to propagation of global supply networks, where private parties diversify their economic ties across complex webs of ownership, contracts, and general factor and product market seeking activities. The result is a remarkably diffuse mosaic of economic activity, coexisting with and often transcending official networks of bilateral and multilateral diplomacy and trade negotiation.

In the East Asian region, supply chains have proliferated to an extent and at a rate unimagined decades ago. The role of private capital flows in this process has been essential, and we shall see that investment behavior has exerted a decisive influence on patterns of regional production and trade. An important implication of the resulting supply chain decomposition is that the global network of value creation and income linkages is much more extensive and complex, than would be suggested by bilateral trade statistics alone. For this reason, the significance of existing multilateral ties, as well as the gains from a more liberal trading environment, may be seriously underestimated.

In this paper, we discuss the phenomena of such global networks and supply chain decomposition generally, and then use detailed international data to assess their empirical significance with a novel application of multiplier techniques to an international Social Accounting Matrix. Our general results indicate that the complex indirect linkages in these trading systems, largely mediated by intermediate supply and intra-industry trade, can often represent the majority of value creation. For this reason, the multilateral agenda deserves even more attention from policy makers.

The next section provides a general discussion and overview of the issues. This is followed in Section 3 by a description of the data resources used for our analysis. In Sections 4 and 5, we introduce the multiplier decomposition techniques that we use to estimate the detailed economic impacts of global supply networks. Finally, conclusions are offered in Section 6, followed by references.

2. An Overview of Global Supply Networks

Trade patterns in the modern international economy bear only a vague resemblance to their colonial pre-colonial antecedents. The world trading system, as it evolved from a series of imperial ages down the post-colonialism of the last century, as steadily expanded both the public and private basis for an international division of labor that is unprecedented in both scope and depth.[1] While trade has always been remarkable in its ability to move resources and resource services over great distances, today's supply chains and systems of overlapping ownership and contracts are beyond the most vivid imaginings of Levantine traders of centuries past.

The changes that have taken place are the result of a combination of public and private forces, working in parallel and often (but not always) in concert to expand and deepen global trade linkages. In this section, we summarize some of the principal mechanisms at work, with particular reference to East Asia.

2.1. Public Multilateralism/Globalization: WTO and the Bilateral Contagion

The most visible public agent in today's multilateral trade environment is of course the World Trade Organization, the official embodiment of collective aspirations toward open multilateralism. Certainly, the many rounds multilateral negotiations sponsored by the WTO and its predecessors have advanced the cause of globalization. Some have argued that membership or even conformity to the WTO is not statistically correlated with trade expansion, but this simple causality test ignores the obvious precedence effect the entire GATT-WTO process has had on all forms of

[1] There are many historical overviews of this issue. More recently see Coates (1997) and, in the East Asian regional context, Lee and Roland-Holst (1998).

public and private trade dealings.[2] Most observers think it obvious that the spirit of open multilateralism enshrined in WTO rulemaking reflects and facilitates the historic expansion of trade relations.[3] Having said this, however, there are many features of this mechanism that limit the extent and timeliness of what it can accomplish.

While accepting the importance of the WTO, its practical limitations have had both negative and positive effects on trade growth.[4] On the negative side, three areas are of special significance here:

1. The bargaining environment of WTO accession has many imperfections that have been used strategically to limit the scope and pace liberalization. This occurs primarily in the area of phase-in and exception negotiation, and for this reason might be viewed as temporary. The length of some phase-ins can be quite long, however, leading to persistent distortions.

2. The "water in the tariff" problem: Some incoming members have negotiated phase-in nominal tariff bindings above their existing effective tariff rates, allowing the potential for increased protection upon WTO accession.

3. Some countries have also adapted their protection regimes away from WTO actionable mechanisms. The main culprits here are contingent protection (e.g. anti-dumping clauses) and administrative mechanisms such as Sanitary and Phytosanitary (SPS) Measures.

Despite many strategic attacks on its liberal principals, whoever, the majority of WTO member trade appears to have been liberalized over the last two decades, and this process may take a dramatic step toward completion if the Doha Round can fulfill its putative goal of phasing out global agricultural protection. This is clearly the biggest residual category of international protectionism and represents a very large distortionary burden on both OECD and non-OECD economies.[5]

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[2] See e.g. Rose (2002).
[3] See e.g. Anderson et al (2000), Brown et al (2001), Hoekman and Kosteki (1995), Kahler (1995), and UNCTAD (1999).
[4] See for example Hoekman and Leidy (1993), Schiff and Winters (1998), and World Bank (2000).
[5] Recent global estimates (Beghin et al:2002) indicate that abolishing OECD farm protection would raise rural incomes in developing countries by more than USD 60 billion per year, a figure larger than even the most ambitious goals for expanded development assistance.

Returning to imperfections in the WTO process, this time from the positive side, we note that the bargaining inefficiencies of global trade talks have spawned what might be termed "Bilateral Contagion," a proliferation of Bilateral Trade Agreements (BTAs) and other smaller scale negotiated trade arrangements that are quite self-conscious responses to the WTO process. In particular, bilateral deals have proliferated for several reasons:

1. To lock in early gains from liberalization with proximate trading partners, accepting the principles of the WTO on a smaller scale rather than waiting for a Round to deliver such gains at a later date.

2. To gain "first mover advantage" by establishing presence in a partner's market before WTO entrants flock in.

3. As a blueprint for WTO accession. China, Vietnam, and perhaps other new and aspiring WTO members have use a BTA with the US as a blueprint or template for their WTO accession. This was done for many reasons, among them the desire to establish negotiating capacity, learn standards, phase in liberalization, signal intent multilaterally and finally, to obtain strategic support from an influential WTO member.

All these factors are attributable to imperfections in the global negotiating mechanism, yet they have facilitated trade liberalization. Some authors have argued that agendas of bilateralism, regionalism, and globalism are not necessarily compatible and may indeed inhibit one another.[6] It is obvious, however, that the general trend in international trade has been toward lowering of average distortionary burdens on the price system and facilitation of the flow of goods and services. Each of these agreements, on whatever scale, has played a role in this process. Eventually, a global WTO-type agreement may have to tie up many loose ends and reconcile partially conflicting regional or bilateral standards, but the trend toward proliferation of trade linkages has been greatly advanced by the WTO and hundreds of smaller scale trade deals.[7]

In the East Asian theatre, the dominant issue is of course China's emergent economy. By using the WTO as a platform for projecting itself into the global

[6] See in particular Bhagwati et al (1998) and Panagariya (1999).
[7] There are many able surveys of regionalism, especially recent initiatives that appear impelled by globalization. See e.g. World Bank (2000), Martin and Winters (1996), and Frankel (1998).

economy, China lent decisive impetus to multilateralism generally. As this author has argued elsewhere in a detailed study of China's WTO accession, East Asia now finds itself in a unique position vis-à-vis globalization. China can apparently go it alone with WTO accession, in the sense that other regional or bilateral agreements offer it only small benefits in addition to those it gets in the long run from WTO accession. The rest of East Asia, however, could gain very substantially, and in two ways, by drawing China into a regional arrangement.

Firstly, China's internal market will grow to become a great prize for regional exporters, and those with early and established market access are likely to gain the most. Secondly, joining with China in early and rapid bilateral or multilateral trade liberalization would permit East Asian exporters to get on the China-WTO "bandwagon" leveraging Chinese burgeoning exports to the OECD as intermediate suppliers. This phenomenon, which I have termed the Asian Trade Triangle, calls for rapidly growing Chinese exports to the western OECD. This in turn induces rapid growth of Chinese absorption from its own region to meet the needs for supply expansion. This in turn leads to rapidly exports from the rest of East Asian to satisfy Chinese absorption.[8]

Thus China sets the pace for rapid progress toward East Asian multilateralism, at once directly and indirectly tied to the WTO process. Regardless of the WTO policies of individual East Asian economies, the need to respond strategically to China's WTO initiative will impel them toward more liberal trade regimes and expand the scope and depth of official regional trade ties.

2.2. Private Multilateralism/Globalization: The Invisible Handshake

While policy makers can certainly exert influence on global trade, through a combination of rule making, negotiating initiatives, and their many ways of influencing expectations, trade linkages are ultimately animated by private agency. This is especially so in today's world, where state trading is probably smaller in relative terms than in ever. Indeed, one of the most arresting features of modern globalization is the unprecedented initiative and pervasive influence of private sector forces. Nowhere is this more apparent than in the East Asian region.

[8] Roland-Holst (2002).

Over the last generation, the Pacific Basin has yielded a new paradigm of market-directed economic coordination and the kind of synergistic multilateral growth envisioned by classical trade theorists, significantly improved upon by modern private enterprise. While elements of traditional comparative advantage exert a strong influence on resource allocation in individual countries, specialization is much less extreme than that would be extrapolated from historic trade patterns. Multinational business exerts a pervasive influence on growth and resource allocation patterns in these economies, replicating abroad to exploit not only natural resources but also internal markets in each country. By infusing each FDI destination with new capital, technology, and expertise, thousands of foreign private interests contribute simultaneously to greater economic diversity within each economy, greater uniformity across economies. For the poorer countries, the result is a broader basis for employment and opportunity in their own economy, leading to greater diversification, stability, and generally higher rates of productivity and wage growth.

Two of the most compelling aspects of this new, private multilateralism are its spontaneity and (de facto) collaborative nature. Historically, economic policy in general and trade policy in particular was closely circumscribed by official institutions representing abstract notions of national interest. Like many forms of regulation, the relatively simplistic agendas of national trade policy do not mesh well with complex and often conflicting incentives/signals that permeate today's international commerce. But the risks of commerce always carry the prospect of reward and, for every reticent trade negotiator, there may be hundreds of firms eager to establish a lucrative foreign partnership or open a new market. The resulting "Invisible Handshakes" ultimately serve national interest by transcending it, reaching beyond the short-term perspective of (e.g.) domestic protection to broaden the basis for economic activity globally and take a (national) material interest in the resulting economic growth.

Capital mobility is the primary mechanism for this kind of private globalization, but it has many attendant features that warrant closer inspection. Firstly, it should be emphasized that much FDI is really doubly targeted, at both an internal and external market.[9] Every investor in export capacity knows that there is or may

[9] Local market FDI targeting has long been practiced and recognized, but it takes on added significance in Asia because of rapid domestic growth experiences. For example, Toshiba arrived in China about a

someday be a local market for the same product. Foreign investors in Chinese export industries are well aware of the dynamism of this country's domestic market, and are likely seeking another first mover advantage in terms of local market presence, even when their first beachhead is in an export zone. Indeed, the implicit opportunity presented by its emergent internal economy has given China an edge in the global FDI "beauty contest" over many smaller or more slowly growing developing countries.

By converse logic, investors in the local market are often mindful of the existence or emergence of neighboring markets which can provide later opportunities or simply a marketing hedge for excess local supply. Just as Mexico used the NAFTA to enhance its attractiveness as an FDI destination for US export capacity, so might low income ASEAN attract for FDI to produce exports for Japan, China, and the Asian Tiger economies.

These kind of inter-country comparisons lead to relatively complex and strategic portfolio decisions for foreign investors, and we have seen a kind of resource cost arbitrage across regions with varying economic structures and stages of progress. What this look like to the causal observer is a continuing process of supply chain decomposition, distributing intermediate linkages across many economies. Obviously, the incentive to do this is economic, reflecting a complex mix of cost advantages and market access motives. The ability to do it, however, is largely dependent upon the local, national, and multilateral regulatory environment, which exerts many influences on this behavior via both administrative constraints and costs.

In East Asia, direct costs of supply chain decomposition are relatively low, except where there are very tight administrative constraints. The latter can be formal, like regional trade restrictions (e.g. North Korea, some bilateral relations with China), or informal, like corruption or civil insecurity. Otherwise, supply chains are spreading rapidly in the region and, as we shall see in the empirical results below, there are already significant multilateral income-expenditure linkages across East Asia. Clearly, additional commitments by regional governments to facilitate this, by a combination of rule making and infrastructural investments, will on accelerate the process.

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decade ago as an investor in export capacity. By the end of 2002, Toshiba had 32 production facilities in China, and was selling two thirds of its output in the domestic market for total of over USD 2 billion. For more on such FDI spillovers and strategies, see e.g. Singh and Jun (1995), Smarsynska (2002), and Aizenmann and Marion (2001).

Accompanying the direct allocation of capital along these supply chains are two elements that can have an essential influence on local economic development, value added and accumulation of intermediates, including in particular capital goods and technology. Consider an example of one multinational firm, although in most cases the process being described applied to a mosaic of independent or partially cross-controlled firms. Allocating capital across a distributed supply chain confers different components of the cumulative production process upon different locations. With this allocation come two hierarchies, one of pecuniary value added (i.e. the margin between cost of components and value of deliverables) and one of capital/technology. Each of these represents an important local benefit of FDI, one direct and the other indirect. The former is easier to measure, but the latter can make a more decisive impact on long term development.

In the past, developing countries have often been content to attract any form of FDI that stimulates employment, seeking in the first instance to capture value added. What some have learned from frustrating experience, however, is that the quality of FDI can be as important as its quantity. Many Latin American countries have seen inbound FDI pour into resource-intensive sectors, often simply displacing expatriated domestic interests (capital flight). In these cases, the predominate form of employment remains unskilled labor and low wage traps that have been in place since colonial times are simply perpetuated. Even worse, such FDI is often simply displacing real or implicit (devaluation driven) domestic capital flight, leading to a zero sum outcome for the domestic economy.

More sustained FDI benefits, on the other hand, can arise from inbound capital flows associated with production activities that upgrade domestic technology and, especially, promote local skill development and intermediate linkages. Many of the most successful Asian FDI stories include all these components. Technology transfer has been an essential primer for growth in the dynamic Asian economies. Rapid and relatively egalitarian increases in living standards have resulted for steady, technology induced appreciation of the skill base in the same economies.

As has been argued persuasively in a companion ADBI study, the success of individual FDI experiences can in significant part be measured by the recipient's progress from simply accumulation of foreign capital and technology to its

assimilation.[10] The distinction is an essential one, because it measures the extent to which the benefits of modernization can be internalized and put to the task of promoting autonomous domestic growth and innovation.

2.3. Bamboo Capitalism

The process of regional supply chain decomposition represents much more than capital allocation. For a recipient country, inbound FDI represents employment, value added capture, and a place in the regional and global hierarchy of technology and growth. Moreover, localization of a node in an international supply chain stimulates intermediate linkages that would not arise from the internal market. These spillovers not only promise longer term endogenous growth benefits, but they help to articulate local markets and commercial networks that can serve a variety of purposes and, eventually, contribute to the development of autonomous local markets. Each big green field FDI development in the NIEs spawned a community of small intermediate and appurtenant suppliers who have since achieved maturity as independent suppliers for the domestic and/or export market.[11]

In East Asia, this phenomenon is already well established and might be referred to as Bamboo Capitalism. In these situations, because of network externalities in local production and finance, complete markets are sprouting from nodes in the international root system of intermediate supply. This culminating feature of FDI-driven supply chain decomposition has created a diverse and vibrant population of independent local industries around the East Asian region. Many of these emergent enterprises are still bound to their original roots via ownership or contracts, but increasingly they arise as independent enterprises who contribute to the dynamics of regional and global competitiveness and innovation.

The further supply chains (the root system) are decomposed and extended geographically, the faster and more profuse will be the proliferation of new

[10] Yoshitomi et al (2003).

[11] A intermediate supplier, as the name implies, provides intermediate goods directly to the primary (in this case foreign financed) firm. An appurtenant supplier supplies to the local market created by the principal's presence. The latter includes everything from makers of intermediate goods to beauty salons, but the multiplier effects represented by these enterprises can easily outweigh direct income generated from the principal firm. These insights were suggested as long ago as Kindleberger (1969) and are implicit in much of the FDI case study material (see Razin (2002) for a survey).

enterprises. This phenomenon is already part of history for Japan, Korea, and the Asian Tigers, and now we see these countries joining Western investors to propagate bamboo across China and lower income ASEAN. Even within China, this phenomenon has entered a secondary phase, where local enterprises are decomposing supply chains across the country's 28 provincial economies.

Increasingly, the issue for localities is not whether or not they are in a network, but where they lie in the network's implicit hierarchy. The sophistication, extent, and especially the capital intensity of their component task will ultimately determine what kind of long term benefits network membership confers upon them. In this implied (and very real) competition for value added allocation, localities and nations must compete with a combination of local human and nonhuman resources, facilitating infrastructure, a congenial regulatory environment, and lastly, inviting domestic market conditions. The latter takes recalls earlier discussion, where we identified the scale of the internal market as an important strategic asset for countries trying to attract FDI. Finally, there is no absolute standard for all these competitive elements, since foreign investors make their choices by comparing alternative venues.[12]

3. Global Trade Database

While the phenomena discussed above are remarkable and fascinating, it is reasonable to ask how we might assess their importance empirically. Given the microeconomic nature of the process of supply chain decomposition and the dynamic role of private agency in building these networks, data on constituent linkages would be nearly impossible to obtain and of doubtful reliability in any case. Indeed, one could make a liberal argument that the benefits of this activity are manifest in the simple fact of its existence, and the private sector needs no quantitative guidance from economists. For policy makers, however, it would still be useful to elucidate the geographic composition of gains from these economic linkages, as it might justify more concerted and focused efforts to facilitate trade and other economically beneficial activities.

[12] Recognition of this fact reveals much about the profound influence China's emergence has had on the East Asian region.

In this paper, we use trade data as a proxy for the more complex web of global financial linkages that underlie the processes we have been taking about. In particular, we use a global trade database to construct an international Social Accounting Matrix (SAM) that captures expenditure and income linkages between countries and domestic institutions.[13] Basically, we set up an international table with ten countries/regions and detailed bilateral trade flow data. Trade data may not capture the initial allocation of foreign capital across countries, nor the repatriated profit flows. Despite this, it accurately detailed the supply chain linkages that are responsible for the majority of direct and indirect international income creation.

The basic information set used for our estimation is the Global Trade Analysis Project (GTAP) Version 5.0 database.[14] The original data set, calibrated to 1997, is defined across 66 country/region groupings and 57 economic sectors. For this paper, we aggregate the regions to those of primary interest and consolidate agricultural, energy, and food processing sectors. The regions and sectors used in the present application are listed below:

Table 3.1: Regional Aggregation

Reg	Label	Name
1	chn	China
2	jpn	Japan
3	kor	Korea
4	twn	Taipei,China
5	asn	ASEAN
6	usa	United States
7	eur	Western Europe
8	row	Rest of the World

[13] The SAM approach is more thoroughly explicated in a variety of sources, including Reinert and Roland-Holst (1997), Pyatt and Round (1985), and Stone (1981).
[14] This dataset is extensively documented on the www.gtap.org website.

Table 3.2: Sectoral Aggregation

No.	Label	Name
1	agr	Agriculture
2	enr	Energy and Minerals
3	pfd	Processed Food
4	txa	Textiles and apparel
5	lum	Wood products
6	ppp	Paper products publishing
7	pyc	Petroleum coal products
8	crp	Chemical rubber plastic products
9	nmm	Mineral products n.e.s.
10	met	Metals
11	mvh	Motor vehicles and parts
12	otn	Transport equipment n.e.s.
13	ele	Electronic equipment
14	ome	Machinery and equipment n.e.s.
15	omf	Manufactures n.e.s.
16	ely	Electricity
17	gdt	Gas manufacture distribution
18	wtr	Water
19	cns	Construction
20	trd	Trade
21	tps	Transport Services
22	cmn	Communication
23	fin	Financial services
24	obs	Business services n.e.s.
25	ros	Recreation and other services
26	osg	Public administration
27	dwe	Dwellings
28	cgd	Investment goods

4. Block Multiplier Decomposition

As indicated above, we want to use international trade data to elucidate the expenditure-income linkages arising from global supply networks. While direct trade flow data are revealing, however, they only capture direct bilateral effects. In the real economy, a myriad of interactions delineate the path from initial expenditure to ultimate incomes. This is particularly the case with trade in an era of globalization, where international supply chains are ever more elaborate and indirect linkages often represent the majority of value creation.

To more fully capture these complex, trade mediated interactions, we developed an international multiplier model based on the multilateral SAM estimated from the GTAP database. Detailed decomposition analysis with this model will reveal regional trade interactions at unprecedented levels of detail. To further analyze this issue, we apply two separate methods, block decomposition and path decomposition. The former was popularized by Sir Richard Stone (1981) and applied by Pyatt and Round (1985), Roland-Holst and Tarp (2003) and others, and we shall discuss it first.[15]

For simplicity, consider the case of three countries/regions. Schematically, the individual country (k) SAM looks like

$$T_k = \begin{bmatrix} T_{kk} & F_k \\ V_k & X_k \end{bmatrix}$$

where the component matrices denote commodity flows (T), final demand (FD), value added (V), and other domestic and accounts (X). Note that the commodity flow table T_{kk} is intended to include domestic supply for domestic use, exports by destination, and imports by origin.

[15] The reader should be reminded that multiplier estimation is based on an assumption of local excess capacity that permits us to ignore local variations in prices. While this assumption may be open to empirical question in some Western domestic economies, East Asian regional has exhibited remarkable supply elasticity in recent years. Indeed, price deflation with rising supply is a greater preoccupation in the region than capacity constraints. To the extent that supply might be constrained, our multipliers will overestimate induced income effects. In any case, however, the point of the present exercise is not to precisely calibrate income effects precisely, but to reveal their extent.

Now consider a consolidated SAM for all three countries, partitioned as follows

$$S = \begin{bmatrix} T_{11} & T_{12} & T_{13} & X_{1x} \\ T_{21} & T_{22} & T_{23} & X_{2x} \\ T_{31} & T_{32} & T_{33} & X_{3x} \\ X_{x1} & X_{x2} & X_{x3} & X_{xx} \end{bmatrix} \tag{4.1}$$

where the subscripts denote the three countries and the X matrices now include domestic demand (X_{kx}= [F_k] nd X_{xk} = [V_k].

To evaluate economywide multiplier effects and linkages to external trade, first consider the expenditure shares[16]

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} & A_{1x} \\ A_{21} & A_{22} & A_{23} & A_{2x} \\ A_{31} & A_{32} & A_{33} & A_{3x} \\ A_{x1} & A_{x2} & A_{x3} & A_{xx} \end{bmatrix} \tag{4.2}$$

and define the additive decomposition

$$A_{-X} = B + C \tag{4.3}$$

where A_{-X} denotes the submatrix of A with only inter-country transactions and

$$B = \begin{bmatrix} A_{11} & 0 & 0 \\ 0 & A_{22} & 0 \\ 0 & 0 & A_{33} \end{bmatrix} \tag{4.4}$$

$$C = \begin{bmatrix} 0 & A_{12} & A_{13} \\ A_{21} & 0 & A_{23} \\ A_{31} & A_{32} & 0 \end{bmatrix} \tag{4.5}$$

[16] These are given as appendix tables below.

From standard accounting identities one then obtains

$$
\begin{aligned}
y &= Ay + x \\
&= By + Cy + x \\
&= (I - B)^{-1}Cy + (I - B)^{-1}x \\
&= [I - (I - B)^{-1}C]^{-1}(I - B)^{-1}x \\
&= (I - D)^{-1}(I - B)^{-1}x \\
&= (I - D^2)^{-1}(I + D)(I - B)^{-1}x \\
&= M_3M_2M_1x \\
&= Mx \qquad (4.6)
\end{aligned}
$$

where $D = (I - B)^{-1}C$, and

$$
M_1 = (I - B)^{-1} = \begin{bmatrix} (I-A_{11})^{-1} & 0 & 0 \\ 0 & (I-A_{22})^{-1} & 0 \\ 0 & 0 & (I-A_{33})^{-1} \end{bmatrix} \qquad (4.7)
$$

is a matrix of domestic economywide multiplier effects. These are the standard multipliers from domestic production-factor-consumption linkages and could be further decomposed with methods proposed by Stone (1981) or Pyatt and Round (1979). The activity block in the upper left corner corresponds to the standard Leontief inverse. The second factor matrix details the so called direct or open loop linkages between domestic institutions, i.e.,

$$
M_2 = (I + D) = \begin{bmatrix} I & D_{12} & D_{13} \\ D_{21} & I & D_{23} \\ D_{31} & D_{32} & I \end{bmatrix} \qquad (4.8)
$$

where, e.g. $D_{12} = (I\text{-}A_{11})^{-1}A_{12}$ defines cumulative unrequited outflows from country 1 to 2, taking account of the combined effects of cumulative domestic output effects (the Leontief inverse) and direct export linkages (A_{12}). Finally, closed loop effects are detailed in the third factor matrix

$$M_3 = (I - D^2)^{-1} = \begin{bmatrix} E_{11} & E_{21} & E_{31} \\ E_{21} & E_{22} & E_{32} \\ E_{31} & E_{23} & E_{33} \end{bmatrix}$$

$$= \begin{bmatrix} I - D_{12}D_{21} - D_{13}D_{31} & D_{13}D_{32} & D_{12}D_{23} \\ D_{23}D_{31} & I - D_{21}D_{12} - D_{13}D_{31} & D_{21}D_{13} \\ D_{32}D_{21} & D_{31}D_{12} & I - D_{31}D_{13} - D_{32}D_{23} \end{bmatrix}^{-1} \qquad (4.9)$$

This last factor matrix represents the income effects originating in one (column) country, passing through trade linkages, and returning to the recipient row country. The E_{ij} multipliers aggregate all the indirect income gains accruing between i and j from the existing pattern of international trade linkages.

The M_i matrices enter the decomposition multiplicatively and the contribution of each to economywide income generation is difficult to interpret directly. It is more transparent to use the additive component matrices

$$N_1 = M_1 \qquad (4.10)$$

$$N_2 = (M_2 - I)M_1 \qquad (4.11)$$

$$N_3 = (M_3 - I)M_2M_1 \qquad (4.12)$$

which together satisfy $M = N_1 + N_2 + N_3$.

For the international SAM, we defined as endogenous the five East Asian countries/regions of China, Japan, Korea, Taipei,China, and ASEAN. With the Rest of the World defined as exogenous, we then calculated the multiplier decomposition as in the above derivations, producing a series of 165x165 tableaux detailing trade induced global network linkages for East Asia.[17]

To give a general indication about patterns of long term income generation, we focus in this section on households. Table 4.1 shows total multiplier effects on household income, for each of the five East Asian economic areas, as these would result from a one (currency) unit increase in demand for exports from each of the five. More specifically, results are grouped by national household (five rows each), then by exporting country (each row), for each export (column). For example, in the first column, and row, Chinese households gain 4.26 Yuan in the long run from each additional Yuan of Chinese agricultural (agr) exports. The first entry in the second row indicates that, because of linkage effects, Chinese households would in the long run see their incomes rise by .41 Yuan for each Yuan increase in demand for Japanese agricultural exports, and so on.

Before discussing these results, we refer to Table 4.2, which will aid interpretation. This table has the same layout in terms of bilateral correspondences, but it measures something different. Table 4.2 lists percentages of total multiplier effects attributable to the feedback component (N3) of global supply networks. The remainder of the multiplier (N1+N2) is due to direct domestic and direct bilateral transfer effects. Generally speaking, these shares are small for domestic sectoral stimulus, but vary considerably when capturing linkages to trading partners. Cross country multipliers seem to embody between 20 and 60 percent network feedback effects, depending mainly on the trade dependence of the sector under consideration. For example, agriculture is generally relatively low in terms of N3 or network linkage, while electronic goods are quite high.

Returning to the total effects in Table 4.1, we see that the global network linkages in part explain differences in these effects. Own sector, or domestic effects, are generally much larger than cross country ones, because the multiplier chains are much more internalized for own-sector export demand stimulus. Note also that the

[17] More detailed results, including the complete multiplier matrix and factor matrices used to produce these results, may be obtained from the author.

multiplier vary across countries, with Japan's being generally larger because of its absolute size in regional expenditure accounts. Countries that are more trade dependent, like Taipei,China, will have larger N3 components, but in cases where trade may be constrained (like that with China), these values fall off.

Generally speaking then, we find that indirect (closed loop) global network effects can account for anywhere from about 20 percent to two thirds of total income effects in trade, often outweighing the direct effect of bilateral demand and supply linkages. In these cases at least, it is clear that the regional basis of trade is more important to livelihoods than direct import and export flows would suggest. For this reason, while bilateralism can accelerate trade and domestic market expansion, it should not be pursued at the expense of more highly articulated, multilateral trade and investment linkages. For example, trade diversion arising from a BTA could be detrimental if, as our results indicate, the more complex web of distributed supply chains account for more than half the domestic income arising from trade.

Table 4.1: Long Term Household Income Mulltipliers

China	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	4.26	3.82	3.91	3.69	3.77	3.43	3.35	3.22	3.86	3.29	3.13	3.00	2.18	3.05	3.73	4.03	3.93	4.32	3.94	4.07	3.89	4.06	4.12	4.00	3.68	4.09	4.57	4.80
Japan	.41	.24	.42	.84	.44	.41	.29	.40	.43	.41	.39	.37	.42	.44	.49	.40	.31	.42	.42	.42	.39	.41	.41	.42	.41	.42	.42	.42
Korea	.35	.24	.35	.54	.42	.29	.23	.31	.35	.34	.32	.26	.31	.31	.41	.30	.03	.31	.33	.32	.27	.31	.32	.29	.32	.32	.32	.33
Taipei,China	.31	.23	.30	.47	.47	.31	.25	.31	.35	.34	.30	.22	.33	.34	.44	.30	.21	.32	.33	.32	.29	.31	.31	.31	.31	.32	.32	.32
ASEAN	.36	.27	.36	.54	.36	.33	.29	.33	.40	.38	.33	.21	.34	.35	.45	.33	.33	.34	.35	.40	.32	.33	.31	.25	.32	.34	.35	.35

Japan	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	2.34	2.25	2.27	2.43	2.33	2.31	2.12	2.45	2.42	2.47	2.93	2.22	3.06	2.70	2.39	2.36	2.33	2.43	2.44	2.36	2.31	2.46	2.37	2.32	2.44	2.42	2.44	2.44
Japan	9.03	2.36	9.32	8.19	7.28	10.21	5.65	9.31	9.27	9.56	9.72	8.74	9.52	9.31	9.01	10.01	7.49	10.75	10.22	10.73	9.49	10.68	10.60	10.64	10.37	10.64	11.11	11.22
Korea	1.57	.57	1.59	1.77	1.59	1.64	.78	1.94	1.82	1.76	1.85	1.48	2.35	2.30	1.82	1.48	.09	1.68	1.77	1.69	1.50	1.69	1.71	1.55	1.64	1.73	1.76	1.78
Taipei,China	2.11	1.04	2.21	2.53	2.20	2.46	1.29	2.84	2.86	2.80	3.17	1.81	3.09	3.26	2.72	2.28	1.35	2.62	2.65	2.61	2.33	2.59	2.59	2.56	2.60	2.61	2.64	2.65
ASEAN	2.13	1.64	2.04	2.19	2.14	2.04	1.51	2.31	2.44	2.67	3.64	1.66	2.82	3.02	2.17	2.04	2.09	2.21	2.31	2.11	1.98	2.26	2.06	1.60	2.10	2.17	2.29	2.28

Korea	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	.29	.27	.28	.39	.30	.35	.30	.34	.30	.32	.27	.26	.33	.29	.30	.29	.29	.30	.30	.29	.28	.29	.29	.28	.29	.30	.30	.30
Japan	.15	.06	.16	.23	.14	.15	.12	.16	.15	.17	.15	.14	.18	.16	.16	.15	.12	.15	.15	.15	.14	.15	.15	.15	.15	.15	.16	.16
Korea	3.44	.74	3.29	3.00	2.44	3.33	1.29	2.65	2.79	2.36	3.18	2.52	2.36	2.59	2.87	3.25	.12	3.72	3.46	3.89	2.96	3.82	4.04	3.48	3.47	3.85	4.11	4.33
Taipei,China	.14	.08	.15	.23	.16	.18	.09	.20	.17	.20	.19	.17	.22	.18	.18	.15	.09	.17	.17	.17	.15	.17	.17	.17	.17	.17	.17	.17
ASEAN	.19	.15	.19	.32	.20	.20	.15	.23	.20	.27	.24	.15	.26	.20	.21	.19	.19	.20	.21	.20	.18	.21	.19	.18	.19	.20	.20	.21

Taipei,China	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	.27	.25	.25	.35	.28	.28	.23	.32	.28	.29	.25	.25	.30	.27	.29	.26	.26	.27	.28	.26	.25	.27	.26	.26	.26	.27	.27	.27
Japan	.11	.04	.12	.16	.14	.12	.07	.12	.11	.12	.11	.11	.14	.12	.14	.11	.09	.12	.12	.12	.11	.12	.12	.12	.11	.12	.12	.12
Korea	.07	.03	.07	.11	.09	.07	.04	.08	.08	.07	.07	.06	.11	.07	.10	.07	.01	.07	.07	.07	.06	.07	.08	.07	.07	.07	.08	.08
Taipei,China	2.93	.97	2.88	2.81	2.32	3.03	1.29	2.39	2.65	2.62	2.21	1.90	2.10	1.98	2.83	3.29	1.76	3.79	3.21	3.89	3.08	3.84	3.91	3.74	3.67	3.85	4.07	4.19
ASEAN	.14	.10	.13	.26	.14	.15	.10	.17	.16	.18	.13	.08	.17	.14	.17	.13	.13	.14	.14	.13	.12	.14	.13	.10	.13	.14	.14	.14

ASEAN	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	.33	.33	.35	.33	.43	.33	.44	.34	.32	.30	.29	.26	.39	.30	.33	.34	.34	.32	.32	.33	.32	.32	.31	.31	.32	.32	.33	.33
Japan	.28	.34	.30	.32	.51	.29	.30	.29	.29	.28	.28	.25	.33	.28	.30	.30	.25	.29	.30	.29	.28	.29	.28	.29	.28	.29	.29	.29
Korea	.23	.30	.25	.25	.64	.24	.27	.24	.25	.20	.22	.17	.27	.21	.28	.25	.05	.24	.24	.24	.23	.23	.24	.24	.24	.23	.24	.24
Taipei,China	.28	.53	.28	.33	.77	.29	.46	.31	.32	.26	.26	.18	.41	.24	.32	.34	.32	.29	.30	.28	.27	.28	.28	.27	.27	.28	.28	.28
ASEAN	3.01	2.30	2.76	2.30	2.86	2.33	2.01	1.95	2.28	1.44	1.85	.69	1.47	1.21	2.03	2.76	2.93	2.98	2.55	2.86	2.54	2.77	2.76	2.05	2.55	2.89	2.99	3.43

Table 4.2: Percent of Household Income Arising Indirect (N3) from Global Network Linkages

China	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	4.2	4.5	4.5	5.9	5.1	5.2	5.4	5.9	4.8	5.6	6.0	5.4	10.0	6.3	5.1	4.5	4.6	4.3	4.7	4.4	4.5	4.5	4.3	4.4	4.9	4.5	4.0	3.9
Japan	18.5	22.3	19.1	13.7	23.8	19.3	22.6	19.7	18.3	19.8	19.5	18.8	22.3	19.0	17.9	19.4	19.9	19.2	19.3	19.1	19.4	19.1	19.1	19.2	19.1	19.1	19.1	19.1
Korea	27.3	23.1	28.4	23.2	32.8	33.8	26.4	36.4	31.6	29.6	33.2	33.7	44.0	40.7	28.9	31.2	24.1	32.5	32.7	32.2	33.6	33.0	32.7	33.6	31.3	32.9	32.7	32.7
Taipei,China	40.8	41.8	44.0	37.9	37.9	46.8	41.8	52.8	47.2	46.7	55.8	48.6	58.9	52.0	37.6	46.8	44.6	48.1	47.3	48.0	46.1	47.9	47.8	47.5	48.5	47.9	48.1	48.2
ASEAN	33.6	34.0	32.3	31.3	34.1	35.1	30.6	39.4	34.3	39.9	53.9	41.1	46.9	46.9	29.7	35.5	36.2	36.8	36.9	30.2	35.5	38.3	37.1	37.6	36.5	36.6	37.4	36.5

Japan	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	34.5	34.4	34.7	37.4	37.3	35.2	38.5	36.3	34.0	33.1	25.9	32.1	35.8	31.0	34.4	34.3	34.6	33.8	33.5	33.9	33.6	33.4	33.5	33.7	33.5	33.9	33.8	33.9
Japan	6.7	16.5	6.7	11.1	10.3	6.2	8.5	6.8	6.9	6.8	6.4	6.5	8.2	7.4	7.7	6.2	6.5	5.9	6.3	6.0	6.3	5.9	5.9	6.0	6.0	6.0	5.8	5.8
Korea	28.5	59.3	29.0	33.6	46.4	26.1	43.9	23.6	25.6	25.2	24.3	24.3	26.0	19.6	29.6	28.9	57.6	26.4	26.0	26.7	26.3	25.9	26.3	27.6	27.0	26.0	26.0	26.0
Taipei,China	25.1	51.0	23.8	28.0	41.6	23.1	40.5	21.8	21.3	21.4	18.6	23.9	30.1	19.0	25.3	25.5	31.9	22.6	22.7	22.5	22.6	22.5	22.5	22.4	22.1	22.7	22.6	22.6
ASEAN	23.8	23.7	24.3	33.7	24.0	24.3	25.6	23.8	22.7	23.1	14.9	19.0	24.2	19.1	26.5	23.5	23.1	22.9	22.9	24.8	23.1	23.0	22.7	23.6	22.7	23.0	22.7	23.0

Korea	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	26.6	27.2	26.9	22.8	27.6	22.0	25.6	24.5	26.4	24.8	29.7	27.0	32.4	28.5	26.1	26.7	26.6	26.6	26.5	26.6	27.0	27.0	26.6	26.6	27.0	26.4	26.6	26.7
Japan	41.1	68.4	40.3	49.6	52.9	42.2	38.2	40.4	42.3	38.5	41.2	42.1	42.3	41.2	43.6	42.6	42.3	42.0	42.1	41.9	42.0	41.6	41.6	42.1	41.7	41.8	42.0	42.0
Korea	1.7	5.0	1.9	2.9	3.4	1.7	3.1	2.4	2.3	2.6	1.9	2.0	3.4	2.5	2.5	1.7	4.7	1.6	1.8	1.6	1.8	1.5	1.5	1.6	1.7	1.6	1.5	1.5
Taipei,China	46.5	70.1	45.6	42.2	63.5	41.0	62.8	40.1	47.5	40.9	41.2	31.3	48.4	47.0	48.4	47.9	54.1	45.3	45.5	44.8	45.2	44.9	44.7	44.7	44.7	44.7	45.0	45.0
ASEAN	32.1	32.1	32.2	28.0	32.2	29.8	31.3	29.4	35.0	28.3	32.9	28.5	30.5	37.9	34.1	31.6	31.5	31.6	31.5	32.2	31.2	31.0	30.1	25.9	30.9	31.2	31.7	31.6

Taipei,China	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	19.7	20.1	20.3	16.8	20.3	18.6	23.0	17.3	18.8	18.4	22.2	18.9	23.9	20.7	18.7	20.3	20.4	19.7	19.5	20.1	20.2	20.1	19.9	19.4	20.4	19.6	19.7	19.7
Japan	43.6	69.7	43.6	58.4	43.3	44.1	52.2	43.5	45.9	42.5	43.6	42.6	43.0	44.8	41.9	45.2	46.4	44.3	44.1	44.1	43.3	43.9	43.8	43.4	44.2	44.0	44.3	44.4
Korea	65.5	85.5	65.7	61.0	73.1	63.9	77.7	64.7	64.3	67.7	66.0	62.7	54.1	68.4	58.9	66.7	84.6	64.7	64.8	63.9	62.9	63.2	63.0	62.9	64.1	63.5	63.9	63.8
Taipei,China	1.8	4.3	1.8	2.8	3.5	1.9	3.4	2.7	2.4	2.4	2.7	2.2	3.9	3.3	2.5	1.7	2.2	1.6	1.9	1.5	1.7	1.5	1.5	1.6	1.6	1.6	1.5	1.5
ASEAN	36.6	37.1	36.1	27.3	35.7	30.3	38.2	30.5	34.5	32.7	46.2	41.3	35.9	40.2	34.6	36.7	36.4	36.2	35.6	38.7	36.5	36.1	36.2	36.1	36.3	35.9	36.3	36.3

ASEAN	agr	enr	pfd	txa	lum	ppp	pyc	crp	nmm	met	mvh	otn	ele	ome	omf	ely	gdt	wtr	cns	trd	tps	cmn	fin	obs	ros	osg	dwe	cgd
China	34.1	32.9	31.5	39.3	27.8	34.6	25.7	37.0	36.0	39.5	42.7	39.3	39.1	40.5	36.2	33.7	33.0	35.9	36.5	34.5	34.3	36.7	35.9	35.6	36.4	35.9	36.0	35.9
Japan	21.3	9.7	20.8	31.5	15.4	21.6	16.5	22.0	21.6	22.6	22.2	23.0	23.0	23.8	23.5	20.7	19.5	21.9	21.6	22.0	21.0	22.1	22.1	22.2	22.0	22.1	22.1	22.2
Korea	31.5	11.8	29.0	37.4	13.7	29.7	15.6	33.0	31.7	38.0	35.4	35.5	38.2	42.6	30.4	26.6	11.5	30.7	31.5	30.8	28.6	32.1	31.6	27.7	30.5	31.9	32.2	32.5
Taipei,China	31.1	9.4	32.4	34.7	14.5	34.1	13.5	35.7	35.2	41.5	43.8	39.5	31.2	49.0	36.7	27.2	17.6	35.8	34.4	36.4	34.6	36.4	36.5	36.6	36.9	36.2	36.3	36.5
ASEAN	3.3	3.4	3.6	5.7	3.7	4.2	4.0	5.6	5.0	8.3	7.3	9.8	9.2	9.9	5.4	3.5	3.3	3.4	4.2	3.6	3.6	3.8	3.4	3.7	3.8	3.5	3.5	3.1

5. Path Decomposition

The previous section shows that block decomposition of the SAM can elucidate the linkages between distinct national economies. Income-expenditure linkages can be computed and decomposed according to three different categories of interdependence, providing us with a detailed view of the extent and magnitude of the forces responsible for income generation as they work their way through the main linkages. To obtain a more comprehensive description of these linkage effects, however, we need to go one step further and identify the specific paths or channels by which expenditure propagates income effects across the global economy.

The structural path analysis put forth by Lantner (1974) and Gazon (1979) to study abstract linear systems of equations has been used by several authors to examine input-output systems. Recognizing the applicability of this technique to extended linear models, Defourny and Thorbecke (1984) showed the rich information structure that could be derived by applying this approach in a SAM framework. Following the ideas in the contributions by these authors, we now examine international trade with this technique for the first time, shedding new light on the complex interactions that carry income effects across supply networks.

To summarize the methodology, each pair $<i,j>$ of indices in the underlying SAM accounts is called an arc. A path is a sequence s of indices $s=<i,k,l,...,m,j>$ which can be decomposed into consecutive arcs $<i,k>$, $<k,l>$,...,$<m,j>$. A path with non-repeating indices is termed an elementary path. A circuit of influence is a path s such that the first and last index coincide. The influence of account i on account j through a path s will be represented by $(i \circledR j)_s$. To estimate the income effect of account i on account j along $<i,j>$, note from the basic expenditure relationship, before economywide linkages are taken into account, we have:

$$\frac{\partial y_j}{\partial y_i} = a_{ji} \tag{5.1}$$

Thus any exogenous income increase affecting i gives rise to a direct income increase in j measured by entry (j,i) of the transpose of the column normalized (expenditure share) matrix A. Due to the linear structure of the model, the *direct* income

influence along an elementary path $s=<i,k,...,m,j>$ is a composite effect of the direct influences along the constituent arcs, i.e.:

$$D^P_{(i\to j)s} = a_{ki}...a_{jm} \tag{5.2}$$

In any given path s there may exist feedback effects among its indices. Account i influences k but k in turn may influence i, either directly or through other intermediary indices. Accounts influence themselves through loops as well. All of these feedback effects taking place along circuits in the path work to amplify the magnitude of the direct influence being transmitted over the path. The expanded influence will be called *total* influence, the ratio of total to direct influence being the income path-multiplier:

$$T^P_{(i\to j)s} = D^P_{(i\to j)s}\mu^P_s \tag{5.3}$$

Notice, on the other hand, that more than one elementary path, each one with its respective feedback circuits, may span two indices i,j. Therefore the total income influence along a path does not capture the full or global influence in the network of channels linking i and j. Let $S=\{s/i,j\}$ be the set of all elementary paths joining i and j. By additivity, the *global* price influence is defined as:

$$G^P_{(i\to j)s} = \sum_{s\in S} T^P_{(i\to j)s} = \sum_{s\in S} D^P_{(i\to j)s}\mu^P_s \tag{5.4}$$

The last equality, where m_{ji} is the (j,i) entry in the multiplier matrix M, follows from the fact that S includes all connecting paths between accounts i and j. Direct, total and global influence are three distinct components that make up the transmission mechanism underlying income determination.

Applying these techniques to the international SAM for 1997, we can examine in detail the process by which diverse economic activities, are tied together by downstream supply chain linkages, and how these chains transmit income effects within economies and across the global marketplace. For policy makers, this can elucidate many otherwise unanticipated consequences of policies targeted elsewhere in the economy.

Given that the underlying multiplier matrix is 165x165, the number of possible paths for even a single bilateral linkage numbers in the tens of the thousands. To keep

things manageable, we shall focus present discussion on an instructive set of examples, revealing only those network chains that contribute more than a reasonable minimum to income-expenditure linkages. Returning to the block decomposition of the previous section, consider linkages between, for example, Japanese households and the Japanese electronics sector. In Table 4.1 above, we see that the total multiplier effect on Japanese households, induced by a unitary increase in export demand for Japanese electronics, is 9.515. We also note from the block decomposition information in Table 4.2 that only 8.21 percent of this effect is due to feedback from global supply networks.

Using the path technique, we can completely decompose this bilateral expenditure-income chain and examine the contribution of each constituent multilateral linkage. Table 5.1 provides the details, explicating components of this multiplier effect up to direct effects of .001 or more. The result is a list of 38 paths, with up to four bilateral components, accounting for 76.5 percent of the total multiplier effect. Note first of all that international linkages play no role in these components, which is consistent with the block decomposition estimate indicating weak feedback. Secondly, we see that 45.8 percent of the total effect (last column) is captured in direct factor payments (to Unskilled and Skilled labor and Capital) within the sector, remitted to domestic households. These effects are supplemented by fiscal linkages (row 4) and downstream links to a variety of other domestic sectors (ppp, crp, nmm).

The first example reveals the complexity of income determination, but sheds little or no light on international linkages. To better understand the role of global supply chains, however, it is more revealing to examine international bilateral linkages. Table 5.2 shows the results of path analysis for the bilateral link between the Chinese electronics sector and Japanese households. Here we see a very diffuse pattern of linkages, with the stronger ones (direct effect > .001) accounting for only 32.5 percent of the total income effect under consideration. Not surprisingly the strongest paths between China's electronics sector and Japanese households is through the Japanese electronics sector, which accounts for about two-thirds of the effects under consideration or 21.8 percent of the total. This channel suggests the essential role of intra-industry trade and the global supply chain in contributing to domestic income growth.

Table 5.1: Income Linkages from Japanese Electronics to Japanese Households

Path	Global Effect	Direct Effect	Path Mult	Total Effect	% of Global	Total %
1. jpn-ele -> jpn-Usk -> jpn-hhs	9.515	0.141	11.396	1.603	16.8	16.8
2. jpn-ele -> jpn-Skl -> jpn-hhs		0.087	11.396	0.991	10.4	27.3
3. jpn-ele -> jpn-Cap -> jpn-hhs		0.155	11.396	1.768	18.6	45.8
4. jpn-ele -> jpn-gov -> jpn-hhs		0.013	16.134	0.208	2.2	48.0
5. jpn-ele -> jpn-ppp -> jpn-Usk -> jpn-hhs		0.003	11.547	0.030	0.3	48.3
6. jpn-ele -> jpn-ppp -> jpn-Skl -> jpn-hhs		0.002	11.547	0.021	0.2	48.6
7. jpn-ele -> jpn-ppp -> jpn-Cap -> jpn-hhs		0.003	11.547	0.031	0.3	48.9
8. jpn-ele -> jpn-crp -> jpn-Usk -> jpn-hhs		0.006	11.652	0.074	0.8	49.7
9. jpn-ele -> jpn-crp -> jpn-Skl -> jpn-hhs		0.004	11.652	0.043	0.5	50.1
10. jpn-ele -> jpn-crp -> jpn-Cap -> jpn-hhs		0.009	11.652	0.103	1.1	51.2
11. jpn-ele -> jpn-crp -> jpn-gov -> jpn-hhs		0.001	16.388	0.023	0.2	51.4
12. jpn-ele -> jpn-nmm -> jpn-Usk -> jpn-hhs		0.002	11.437	0.021	0.2	51.7
13. jpn-ele -> jpn-nmm -> jpn-Skl -> jpn-hhs		0.001	11.437	0.013	0.1	51.8
14. jpn-ele -> jpn-nmm -> jpn-Cap -> jpn-hhs		0.002	11.437	0.023	0.2	52.0
15. jpn-ele -> jpn-met -> jpn-Usk -> jpn-hhs		0.011	13.078	0.144	1.5	53.5
16. jpn-ele -> jpn-met -> jpn-Skl -> jpn-hhs		0.006	13.078	0.083	0.9	54.4
17. jpn-ele -> jpn-met -> jpn-Cap -> jpn-hhs		0.011	13.078	0.139	1.5	55.9
18. jpn-ele -> jpn-met -> jpn-gov -> jpn-hhs		0.001	18.503	0.021	0.2	56.1
19. jpn-ele -> jpn-ome -> jpn-Usk -> jpn-hhs		0.002	11.529	0.020	0.2	56.3
20. jpn-ele -> jpn-ome -> jpn-Skl -> jpn-hhs		0.001	11.529	0.012	0.1	56.4
21. jpn-ele -> jpn-ome -> jpn-Cap -> jpn-hhs		0.002	11.529	0.018	0.2	56.6
22. jpn-ele -> jpn-ely -> jpn-Cap -> jpn-hhs		0.004	11.516	0.050	0.5	57.1
23. jpn-ele -> jpn-trd -> jpn-Usk -> jpn-hhs		0.020	11.607	0.228	2.4	59.5
24. jpn-ele -> jpn-trd -> jpn-Skl -> jpn-hhs		0.012	11.607	0.144	1.5	61.0
25. jpn-ele -> jpn-trd -> jpn-Cap -> jpn-hhs		0.010	11.607	0.120	1.3	62.3
26. jpn-ele -> jpn-tps -> jpn-Usk -> jpn-hhs		0.005	12.083	0.056	0.6	62.9
27. jpn-ele -> jpn-tps -> jpn-Skl -> jpn-hhs		0.003	12.083	0.035	0.4	63.3
28. jpn-ele -> jpn-tps -> jpn-Cap -> jpn-hhs		0.003	12.083	0.032	0.3	63.6
29. jpn-ele -> jpn-fin -> jpn-Usk -> jpn-hhs		0.003	11.572	0.031	0.3	63.9
30. jpn-ele -> jpn-fin -> jpn-Skl -> jpn-hhs		0.002	11.572	0.021	0.2	64.2
31. jpn-ele -> jpn-fin -> jpn-Cap -> jpn-hhs		0.003	11.572	0.034	0.4	64.5
32. jpn-ele -> jpn-obs -> jpn-Usk -> jpn-hhs		0.012	11.875	0.143	1.5	66.0
33. jpn-ele -> jpn-obs -> jpn-Skl -> jpn-hhs		0.008	11.875	0.098	1.0	67.0
34. jpn-ele -> jpn-obs -> jpn-Cap -> jpn-hhs		0.019	11.875	0.223	2.3	69.4
35. jpn-ele -> jpn-obs -> jpn-gov -> jpn-hhs		0.001	16.707	0.018	0.2	69.6
36. jpn-ele -> jpn-osg -> jpn-Usk -> jpn-hhs		0.031	11.950	0.365	3.8	73.4
37. jpn-ele -> jpn-osg -> jpn-Skl -> jpn-hhs		0.018	11.950	0.210	2.2	75.6
38. jpn-ele -> jpn-osg -> jpn-Cap -> jpn-hhs		0.007	11.950	0.082	0.9	76.5

Table 5.2: Income Linkages from Chinese Electronics to Japanese Electronics

Path	Global Effect	Direct Effect	Path Mult	Total Effect	% of Global	Total %
1. chn-ele -> jpn-ele -> jpn-Usk -> jpn-hhs	3.059	0.018	13.242	0.234	7.6	7.6
2. chn-ele -> jpn-ele -> jpn-Skl -> jpn-hhs		0.011	13.242	0.144	4.7	12.4
3. chn-ele -> jpn-ele -> jpn-Cap -> jpn-hhs		0.019	13.242	0.258	8.4	20.8
4. chn-ele -> jpn-ele -> jpn-gov -> jpn-hhs		0.002	18.748	0.030	1.0	21.8
5. chn-ele -> jpn-ele -> jpn-crp -> jpn-Cap -> jpn-hhs		0.001	13.538	0.015	0.5	22.3
6. chn-ele -> jpn-ele -> jpn-met -> jpn-Usk -> jpn-hhs		0.001	15.195	0.021	0.7	23.0
7. chn-ele -> jpn-ele -> jpn-met -> jpn-Cap -> jpn-hhs		0.001	15.195	0.020	0.7	23.6
8. chn-ele -> jpn-ele -> jpn-trd -> jpn-Usk -> jpn-hhs		0.002	13.488	0.033	1.1	24.7
9. chn-ele -> jpn-ele -> jpn-trd -> jpn-Skl -> jpn-hhs		0.002	13.488	0.021	0.7	25.4
10. chn-ele -> jpn-ele -> jpn-trd -> jpn-Cap -> jpn-hhs		0.001	13.488	0.017	0.6	26.0
11. chn-ele -> jpn-ele -> jpn-obs -> jpn-Usk -> jpn-hhs		0.002	13.799	0.021	0.7	26.6
12. chn-ele -> jpn-ele -> jpn-obs -> jpn-Skl -> jpn-hhs		0.001	13.799	0.014	0.5	27.1
13. chn-ele -> jpn-ele -> jpn-obs -> jpn-Cap -> jpn-hhs		0.002	13.799	0.032	1.1	28.2
14. chn-ele -> jpn-ele -> jpn-osg -> jpn-Usk -> jpn-hhs		0.004	13.886	0.053	1.7	29.9
15. chn-ele -> jpn-ele -> jpn-osg -> jpn-Skl -> jpn-hhs		0.002	13.886	0.031	1.0	30.9
16. chn-ele -> asn-ele -> jpn-ele -> jpn-Usk -> jpn-hhs		0.001	17.867	0.023	0.8	31.7
17. chn-ele -> asn-ele -> jpn-ele -> jpn-Cap -> jpn-hhs		0.001	17.867	0.025	0.8	32.5

To better see the role of these supply chain effects, consider now the results in Table 5.3, showing the paths of income linkage form Chinese Electronics to Japanese electronics. Note first of all that this is in fact a component path of the previous example, since chn-ele->jpn-ele was the primary channel from Chinese electronics to Japanese household income. In this more detailed example, however, we see that intra-industry trade propagates income effects from China to Japan through all three of the other East Asian countries/regions considered. This is the essential characteristic of modern global supply networks, that indirect and feedback effects along intermediate delivery channels tie income-expenditure effects across geographically dispersed economies.

Table 5.3: Income Linkages from Chinese Electronics to Japanese Electronics

Path	Global Effect	Direct Effect	Path Mult	Total Effect	% of Global	Total %
1. chn-ele -> jpn-ele	0.379	0.125	1.883	0.236	62.3	62.3
2. chn-ele -> kor-ele -> jpn-ele		0.003	2.142	0.007	2.0	64.3
3. chn-ele -> twn-ele -> jpn-ele		0.006	2.128	0.013	3.4	67.7
4. chn-ele -> asn-ele -> jpn-ele		0.009	2.545	0.023	6.2	73.9
5. chn-ele -> chn-ome -> jpn-ome -> jpn-ele		0.000	3.640	0.001	0.2	74.1
6. chn-ele -> kor-ele -> asn-ele -> jpn-ele		0.000	2.884	0.001	0.2	74.3
7. chn-ele -> twn-ele -> kor-ele -> jpn-ele		0.000	2.418	0.000	0.1	74.3
8. chn-ele -> twn-ele -> asn-ele -> jpn-ele		0.001	2.859	0.002	0.5	74.9
9. chn-ele -> asn-ele -> kor-ele -> jpn-ele		0.000	2.884	0.001	0.2	75.1
10. chn-ele -> asn-ele -> twn-ele -> jpn-ele		0.000	2.859	0.001	0.2	75.3
11. chn-ele -> asn-ele -> asn-ome -> jpn-ome -> jpn-ele		0.000	3.876	0.000	0.1	75.4

A final example generalizes these results by examining another path emanating from Chinese electronics, this time to the ASEAN electronics sector. As would be expected, the total effect is smaller because ties are weaker than to Japanese electronics, but the complexity of the underlying pattern of network linkages is comparable, a total of seven paths, traversing every economy in the region, accounts for 87.7 percent of the total linkage. It is noteworthy in this case, however, that ASEAN's direct links to China and Japan account for 78.7 percent of the total. This implies that ASEAN's third party supply links are relatively undiversified, and that its links to Korea and other regional economies are indirect. While the individual ASEAN economies may have complex internal supply chains, these results suggest that more regional diversification could increase both the level and reliability of ASEAN electronics revenues arising from trade.

Table 5.4: Income Linkages from Chinese Electronics to ASEAN Electronics

Path	Global Effect	Direct Effect	Path Mult	Total Effect	% of Global	Total %
1. chn-ele -> asn-ele	0.216	0.097	1.617	0.157	72.8	72.8
2. chn-ele -> jpn-ele -> asn-ele		0.005	2.546	0.013	5.9	78.7
3. chn-ele -> kor-ele -> asn-ele		0.002	1.839	0.004	1.8	80.6
4. chn-ele -> twn-ele -> asn-ele		0.008	1.824	0.014	6.4	87.0
5. chn-ele -> jpn-ele -> twn-ele -> asn-ele		0.000	2.860	0.000	0.2	87.2
6. chn-ele -> kor-ele -> jpn-ele -> asn-ele		0.000	2.885	0.000	0.2	87.4
7. chn-ele -> twn-ele -> jpn-ele -> asn-ele		0.000	2.860	0.001	0.3	87.7

6. Conclusions and Extensions

Beneath the official veneer of open multilateralism and WTO sponsored globalization, there is a remarkably diverse and dynamic mosaic of private commercial linkages that link the world's economies. These linkages are generally incorporated in global networks or supply chains, where ten, hundreds, even thousands of intermediate product linkages are realized through bilateral deliveries within and across boundaries. This system has growth in scope and complexity well beyond the administrative capacity of individual enterprises and nation states, and relies for its existence on price mediated market interactions. With better understanding of this complex web of linkages, policy makers can see both the rewards of multilateralism and the importance of policies that facilitate it.

In this paper, we discussed the evolution of these global supply networks, particularly in the context of East Asian and in recognition of the catalytic role played by international capital allocation or FDI. What we see in today's global economy is a process of supply chain decomposition, where FDI is distributing production tasks across an international matrix of intermediate producers. Individual components of this production matrix are chosen for a variety of reasons, only one of which is the traditional Ricardian or Heckscher-Ohlin criteria of relative resource cost. At least as important for many firms is market access, domestically or in a neighboring country. Transport costs, infrastructure, network externalities, and administrative climate are also important. Finally, it makes sense for firms to diversify their supply chains simply as a hedging strategy, where the components of risk can be local, national, or global.

In East Asia, this process has advanced very quickly and pervasively, facilitated by both western FDI and a "stepladder effect" where more advanced Asian economies re-allocate production to less advanced ones. In the process of distributing supply chains, foreign investors in the region create new nodes of production in different localities, and another indirect phenomenon emerges. Bamboo Capitalism describes a process where fully autonomous enterprises and markets sprout from these nodes in the "root system" of global intermediate supply. This process is long established in the Tiger economies and can be seen to emerge now in China (even across China) and other

emerging Asian economies. The result is replication of industries and markets are an exponential rate.

To better understand the empirical significance of these phenomena, we developed and international Social Accounting Matrix with detailed bilateral trade statistics. This international SAM was then used for multiplier decomposition analysis, and the results of this were reported in with a few generic examples and more exhaustive tables for motivated readers. The general inference that emerges from these results is that multilateralism is indeed a much more pervasive phenomenon than simple bilateral trade statistics would suggest. Indeed, we find that anywhere between 20 and 70 percent of total income realized in bilateral linkages arises from very long and complex multilateral chains of income-expenditure linkages. These network effects reach across geographic boundaries and sectors in ways that would be quite impossible for policy makers or trade negotiators to anticipate by intuition alones. These "general equilibrium" trade linkages are at once responsible for the majority of international value creation and trade itself. For this reason, the conventional view of gains from trade seriously understates the value of more open multilateralism.

Global supply networks have leveraged the world's resource base and a more liberal trading environment to increase incomes in ways more pervasive than most of us can imagine, and broadening the basis for these activities can only amplify these benefits, distribute them ever more widely, and reduce the risks of economic concentration and instability.

7. References

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