

The Logical Structure of Applied Economics and the Role of Mathematics

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1. Theory and empirical studies

Applied economics has two components, theory and empirical studies. These two have different logical structure and methodology though the interaction between them is an essential process for constructive research in the field. Mathematics plays a crucial role in both theory and empirical studies.

There are macroeconomics and microeconomics, but there is a consensus that microeconomics provides a basic logical structure for economics as a whole. What I refer to applied economics covers applied fields of microeconomics which include industrial organization, international trade, a part of labor economics, and other applied microeconomics.

The theory part of applied microeconomics describes a chain of economic logic in a deductive manner. The theoretical structure consists of a number of piecemeal economic logic. We denote each logic in a mathematical form and build up a gigantic logical construction by connecting 10, 50, or even more than 100 logical blocks. The behavior of economic agents such as consumers and producers is usually presented as a solution to optimization problem of their objective functions. Constructing a large logical, deductive structure is a special feature of economics among various social science fields, which cannot be done without a language called mathematics.

A theoretical model does not have to be a precise and detailed description of an actual economy. The majority of the current researchers admit that it is almost impossible, or at least not feasible, to construct "the" model to describe all the details of an economy. A theoretical model is an abstract statement of economic logic which represents a fraction of causal relationships among economic variables. There are thus many, many models in economics, each of which focuses on one aspect of the economy. It does not, of course, mean that all theoretical models have the same value in

practice. A good model, at least in the practical sense, has to provide a useful angle to look at the reality and/or give good interpretation on empirical observation. To construct a good model, we must have a good intuition on the real economy at the beginning. In addition, once a model is completed, its empirical relevance must be tested with reference to empirical observation.

Empirical studies, on the other hand, have a completely different logical structure. If we have too strong conjecture from the beginning, we may overlook important characteristics of the real world. Empirical observation with fresh mind is essential to characterizing the economy and identifying economic policy issues. Then we try to find causality among economic variables and check whether such causality is quantitatively important or not. Such work will lead to policy studies. Quantitative analysis is often handled under the discipline of econometrics, which is the amalgam of statistics and economics. Econometrics heavily utilizes regression analysis to link empirical data with the causal structure of economic theory.

Empirical studies send messages to theoretical research at least in the following two ways. First, empirical studies show what are the critical economic issues to be analyzed and provide piecemeal causal links among economic variables. These information is utilized at the initial stage of theoretical research and is logically polished there. Second, empirical studies evaluate the empirical relevance of theoretical models by quantifying the fitness with empirical data or at least checking whether theoretical conclusions are reasonable and important with reference to empirical "common sense." Empirical studies thus help theoretical research at its initial stage and in its end.

At the same time, empirical studies obtain key inputs from theory. First, it is actually very difficult to find anything useful by looking at the real world without any speculation. Human beings can only see what they would like to see. Fresh mind is important, but the framework of empirical observation cannot be missed. Particularly in cases of quantitative analysis, the original design of statistical data collection sometimes sets the boundary of empirical analysis. Second, however far we go for econometric analysis, we cannot rigorously prove the causality among economic variables but just find statistical association among them. To connect empirical

observation with economic causal structure, we must always go back to theory.

In summary, applied economics consists of theory and empirical studies, each of which has its own approach completely different from each other. The role of mathematics is also different in two fields. However, the interaction between theory and empirical studies is an essence of economic analysis. Constructing a good feedback system between them is always an intellectually challenging task for applied economists.

2. The globalization of firms' activities and economic analysis

A distinct feature of economics is that economics must continually be revised as the structure of the real economy changes. Unlike a number of natural science fields, economics faces a qualitatively evolving object of study. The sophistication of analytical framework is a source of strength but sometimes works as an impediment to flexible updating. A delicate feedback system among theory, empirical studies, and statistical data occasionally delays the development of new analytical framework.

One of the examples which illustrate such delay of adjustment is the mishandling of the globalization of firms' activities. Since it is one of my recent research topics, I would like to use it as an illustration in the following.

International economic transactions are statistically captured by balance-of-payments (BOP) statistics. The BOP statistics is integrated into the national accounts statistics framework which has developed along with macroeconomic theory. It is thus deeply rooted in the analytical framework of macroeconomics. A recently emerging problem is that the BOP framework cannot fully capture the globalization of firms' activities.

Let me briefly review the structure of BOP statistics. Table 1 presents Japan's BOP statistics in 1995. An important but not necessarily emphasized feature of BOP statistics is that it is intended to capture transactions between a country's residents and nonresidents. According the IMF manual, the residency is defined as follows: "An institutional unit ... is a resident unit of a country when, from some location (dwelling, place of production, or other premises) within the economic territory of the country, the unit engages and intends to continue engaging (indefinitely or for a finite period) in economic activities and transactions on a significant scale. (One

year or more may be used as a guideline but not as an inflexible rule.)” (IMF (1996, p. xxii)). If all residents were in a country and all nonresidents were abroad, transactions between residents and nonresidents would be those across the national border, and the story would be simple. The problem is that economic activities of residents are not necessarily located in the home country and hence transactions do not always have a form of cross-border transactions. The residency concept allows us to quantify various types of transactions in an integrated format.

Table 1

The BOP statistics must be interpreted along the residency concept. Goods exports and imports in the BOP statistics are slightly different from those in the customs office data; the former are conceptually recorded not at the timing of crossing national border but at the timing of the transfer of property rights on the commodity between residents and nonresidents. Services trade can be reasonably quantified only when we treat it as a transaction between residents and nonresidents; services transactions can occur either in a home country or abroad. The income account captures returns to productive factors (capital and labor) employed in nonresident countries. Remittances of labor employed abroad and treated as residents of the host countries are included in the current transfers. The capital and financial account records asset transactions (i.e., international borrowing and lending) between residents and nonresidents.

Although the precision of statistical figures is always a problem, the BOP framework with the residency concept is consistent with national account statistics in which gross national product (GNP) is defined as the sum of value added earned by a country's residents. As far as we are interested in who captures income, the BOP statistics is extremely useful. However, the advancement of globalization of firms' activities has recently generated a new problem which cannot properly be captured by the traditional residency framework.

Once firms establish foreign affiliates and start making managerial decisions jointly, it becomes difficult to capture the whole activities of firms by the traditional statistical framework. Suppose that a Japanese firm establishes an affiliate in Singapore. The parent firm in Japan and the

affiliate become legally different firms. However, they are related in terms of capital holdings and may jointly make managerial decisions as if both were an integrated firm. The problem is that the parent firm is a resident of Japan while the affiliate is treated as a resident of Singapore. It means that the value added earned by them is included separately in the GNP of both countries. The information on merchandise trade transactions by affiliates and transactions between parent companies and affiliates are important to analyze firms' behavior, but those are not available in the traditional trade statistics. Services trade transactions between parent companies and affiliates are almost entirely neglected in the BOP statistics. It is thus almost impossible to treat globalized firms as an integrated economic entity in the residency-based statistics.

There are a number of current economic topics for which a firm and affiliates must be treated as an individual economic agent. The topics include the measurement of international competitiveness of firms, the analysis of the motivation of establishing foreign affiliates for production and distribution, the analysis of intra-firm transactions, and others. To deal with these issues, the residency-based framework must be supplemented by a new statistical framework, which requires a new theoretical formulation as well as reorganizing a statistical data collection system.

3. The nationality-of-firm approach

Baldwin and Kimura (1996) and Kimura and Baldwin (1996) propose a nationality-of-firm approach to supplement the currently existing statistical framework. In the approach, we attach a nationality to each firm on the control basis (actually on the majority-owned basis) and try to observe firms' behavior which cannot be captured by the residency-basis statistics such as national accounts and balance-of-payments statistics. To theoretically analyze new phenomena, we need new statistics. To collect new statistical figures, we need a design of statistics which must be based on theory. We must hence update both theory and statistical design at the same time.

Kimura (1997a, 1997b, 1997c) presents an application of the nationality-of-firm approach to the issue on choices of sales channels by Japanese firms. The estimation presented below relies on a recently

started statistics called *Basic Survey of Business Structure and Activity* by Ministry of International Trade and Industry (MITI), Government of Japan. Since the data are not collected in the form of being consistent with the approach, it is inevitable that such estimation needs to utilize other pieces of information and must be accompanied by bold "guesstimation." However, even if the following figures include large estimation errors, they still clearly convince us of the necessity of supplementing the traditional BOP framework.

Figure 1 illustrates the framework of nationality-of-firm approach. There are three countries in this setting. Three rectangles represent Japan, Asia (countries including Pakistan and other Asian countries east of Pakistan), and the rest of the world (ROW) in the geographical sense. In addition, we define three national: Japanese, Asians, and foreigners (the national of ROW). "Japanese" consist of Japanese-owned firms located in Japan, households and governments located in Japan, and majority-owned foreign affiliates of Japanese firms (FAJF) located in Asia and ROW. Note that "Japanese" in this definition is different from those on the residency basis or those in the sense of factor holders; we treat FAJF as controlled by Japanese and count the whole activities of FAJF as Japanese. Asians and foreigners are defined in the symmetric way. Three national reside in three different locations as drawn in Figure 1. Therefore, if we drew an arrow for each transaction, there would be 81 arrows ($9P_2 + 9$ or 9 times 9). The shaded parts in Figure 1 are Japanese. The numbers attached to 14 arrows in Figure 1 stand for the estimated amounts of sales by Japanese.

Figure 1

Figure 1 clearly shows that the globalization of Japanese firms' activities has substantially advanced. The traditional statistics only presents trade transactions among three countries. In Figure 1, we subtract exports by Japanese affiliates of Asian/foreign firms (JAFF owned by Asians/foreigners) from total exports by Japanese in Japan and estimate disaggregated figures by destination. Similarly, sales by foreign affiliates of Japanese firms (FAJF) in Asia and ROW are disaggregated by destination. It is perhaps surprising that the total exports by Japanese in Japan are \$300 billion while total sales by FAJF in Asia and ROW are as

large as \$498 billion.

These sales figures, however, are misleading in the sense that they do not necessarily reflect the importance of each transaction. For example, when a Japanese firm located in Japan exports a product through its wholesale affiliates abroad, the sales are counted twice; once for an arrow from Japanese parent firms to FAJF and another for the one from FAJF to foreigners abroad. One of the ways to weigh each transaction is to introduce a value added concept. Figure 2 presents the Japanese value added contents of each transaction at the origin of each arrow. Japanese value added in exports of Japanese-owned firms (\$269 billion) is calculated by subtracting the import component in the exported goods and services. Assuming that the ratio of value added to exports is the same no matter what the destination is, we obtain the figures attached to four arrows starting from Japanese in Japan. Value added earned by FAJF in Asia (\$19 billion) is calculated as sales minus purchases. Assuming again that the ratio of value added to sales is the same no matter where the sales destination is, we obtain the value added by FAJF in goods and services sold to various customers. Data are not available for sales by FAJF to Asians in Japan and ROW, or those to foreigners in Japan and ROW. Value added by FAJF in ROW in goods and services sold to various places is estimated in the same way.

Figure 2

Although these figures are only approximate estimates with a number of reservations on the data set, the value added account provides useful insights on the activities of Japanese MNEs. We know that some foreign affiliates carry out extensive production activities while others simply work as marketing branches without adding much value. To discuss the weights on various channels of activities assigned by MNEs, it is convenient to look at the value added contents embodied in goods and services sales.

From Figure 2, we can read various novel facts. Table 2 is made by using the information included in Figure 2. It shows a sharp contrast in the choices of transaction channels: Japanese firms put a heavy weight on direct exports when selling products to Asians, while they rely more on a

channel through FAJF in ROW. It is often said that Japanese firms export a large portion of their products through their wholesale foreign affiliates, but our estimates indicate that it is not the case when selling products to Asians. At the same time, the value added portion generated by FAJF in ROW is also large when selling to foreigners; both manufacturing FAJF and wholesale FAJF play important roles in ROW. It, however, is not the case in selling to Asians. If we interpret the diversification of transaction channels as an indicator of the degree of economic integration, we must conclude that economies of developed countries are considerably integrated while the integration of Asian economies is still largely immature. Moreover, we would like to stress that in selling products to foreigners in ROW, selling through FAJF in Asia has a very small portion.

Table 2

The above-shown estimates of international transactions are only rough ones. To quantify the globalization of firms' activities more seriously, the modification of statistical system is inevitable. Statistics, on the other hand, must be supported by theoretical framework. The sophisticated feedback system among theory, empirical studies, and statistics is the strength of economics but sometimes generates inflexibility in introducing a new analytical approach.

4. Conclusion

In economics, theory and empirical studies have different logical structure. Applied theory consists of a chain of piecemeal economic logic, which heavily utilizes mathematics including optimization technique. Empirical studies analyze statistical data often with using statistical technique. Although theory and empirical studies have widely different methodology, the frequent feedback between them is a special feature of economics.

Another important feature of economics is that the analytical framework must occasionally be revised as the real economy evolves. The sophisticated structure of economics may generate a certain degree of inflexibility in responding newly emerging economic issues. An example raised in this paper is a slow response to the globalization of firms'

activities. To supplement the traditional framework, both theory and empirical/statistical framework must change at the same time.

Some people claim a twilight of economics, giving up its dominant position to other social science fields such as business and management, international relations, sociology, and others. However, I believe that what people call "the limit of economics" is in most of the cases "the limit of the capability of current economists," not showing the boundary of analytical capability of economics. Mathematics is deeply rooted in economics, which provides robustness in both theory and empirical studies. A missing input is an effort strong enough to establish quick and constructive feedback between theory and empirical studies. It is of course true that economics cannot deal with all the social science questions. It is, however, still a fascinating field, which deserves more human capital inputs.

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Table 1 Balance of payments statistics of Japan, 1995
(100 million of yen)

	Exports/credit	Imports/debit	Balance		Assets/credit	Liabilities/debit	Balance
Current account	647,109	543,248	103,862	Capital and financial account	-199,209	140,756	-62,754
Goods and services trade	464,169	394,624	69,545	Financial account	-199,215	138,606	-60,609
Goods	402,596	279,153	123,445	Direct investment	-21,286	39	-21,249
Services	61,573	115,471	-53,898	Equity capital	-22,092	299	-21,793
Transportation services	21,229	33,790	-12,563	Other capital	805	-260	545
Sea transport	13,943	21,663	-7,718	Portfolio investment	-80,038	49,264	-30,772
Passenger	1	0	1	Equity securities	68	48,051	48,119
Freight	8,908	9,563	-653	Debt securities	-80,104	1,210	-78,894
Air transport	7,287	12,130	-4,844	Long-term	-84,794	-9,197	-93,991
Passenger	1,570	9,608	-8,038	Short-term	5,820	18,931	24,751
Freight	1,865	1,584	280	Financial derivatives	-1,130	-8,522	-9,652
Travel	3,048	34,644	-31,595	Other investment	-97,891	89,305	-8,585
Other services	37,299	47,032	-9,740	Loans	-156,337	97,582	-58,755
Communications	474	799	-324	Long-term	-10,432	-253	-10,685
Construction	6,200	3,019	3,182	Short-term	-145,905	97,838	-48,067
Insurance	278	2,347	-2,070	Trade credits	2,317	-284	2,033
Financial	294	440	-143	Long-term	4,445	-9	4,436
Computer and Information	n.a.	n.a.	n.a.	Short-term	-2,128	-276	-2,404
Royalties and license fees	5,668	8,881	-3,214	Currency and deposits	37,552	-255	37,297
Other business services	23,021	30,025	-7,004	Other assets	18,577	-7,744	10,833
Personal, cultural, and recreational	130	517	-389	Capital account	6	2,150	-2,144
Government, n.i.e.	1,231	1,009	221	Capital transfers	6	2,150	-2,144
Income	181,067	139,496	41,573	General government	6	2,150	-2,144
Compensation of employees	1,087	1,718	-632	Other sectors	n.a.	n.a.	n.a.
Investment income	179,980	137,778	42,204	Nonproduced nonfinancial assets	n.a.	n.a.	n.a.
Direct investment income	8,673	2,393	6,282	Reserve assets (-)			-54,235
Portfolio investment income	53,536	18,758	34,781	Net errors and omissions			13,127
Other investment income	117,935	116,792	1,144				
Current transfers	1,873	9,128	-7,253				
General government	309	3,449	-3,140				
Other sectors	1,564	5,679	-4,115				

Footnote: Balances may not be exact figures due to rounding.

Data source: Nihon Ginkou Kokusai Shuushi Toukei Kenkyuukai (1996).

Table 2 Major channels for Japanese firms to sell products abroad, 1991

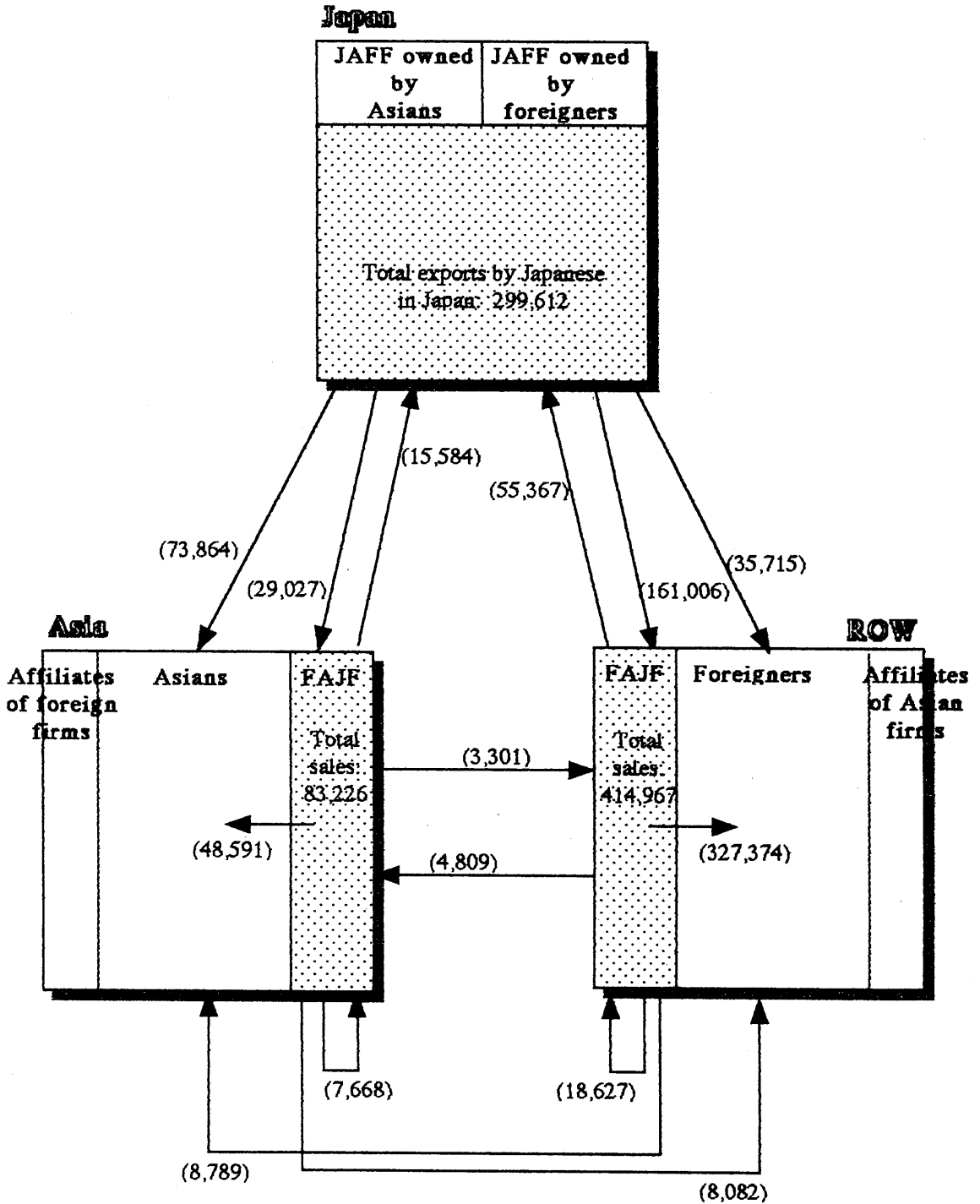
	Value added contents (Millions of U.S. dollars)	Share (%)
For Japanese firms to sell products to Asians in Asia (total of below):	97,174	100.00
To produce in Japan and export directly	66,212	68.14
To produce in Japan and distribute through FAJF in Asia	15,192	15.63
To produce in Japan and distribute through FAJF in ROW	3,058	3.15
To produce in Asia and sell locally	11,034	11.35
To produce in ROW and export to Asia	1,678	1.73
For Japanese firms to sell products to foreigners in ROW (total of below):	212,723	100.00
To produce in Japan and export directly	32,015	15.05
To produce in Japan and distribute through FAJF in ROW	113,860	53.53
To produce in Japan and distribute through FAJF in Asia	2,526	1.19
To produce in ROW and sell locally	62,487	29.37
To produce in Asia and export to ROW	1,835	0.86

Minor indirect channels such as "to produce in Japan and to distribute through FAJF in ROW and then through FAJF in Asia" are omitted.

Calculated from Figure 2. See Kimura (1997a) for data sources.

Figure 1
Sales to foreigners by Japanese:
Three-country setting (1991)

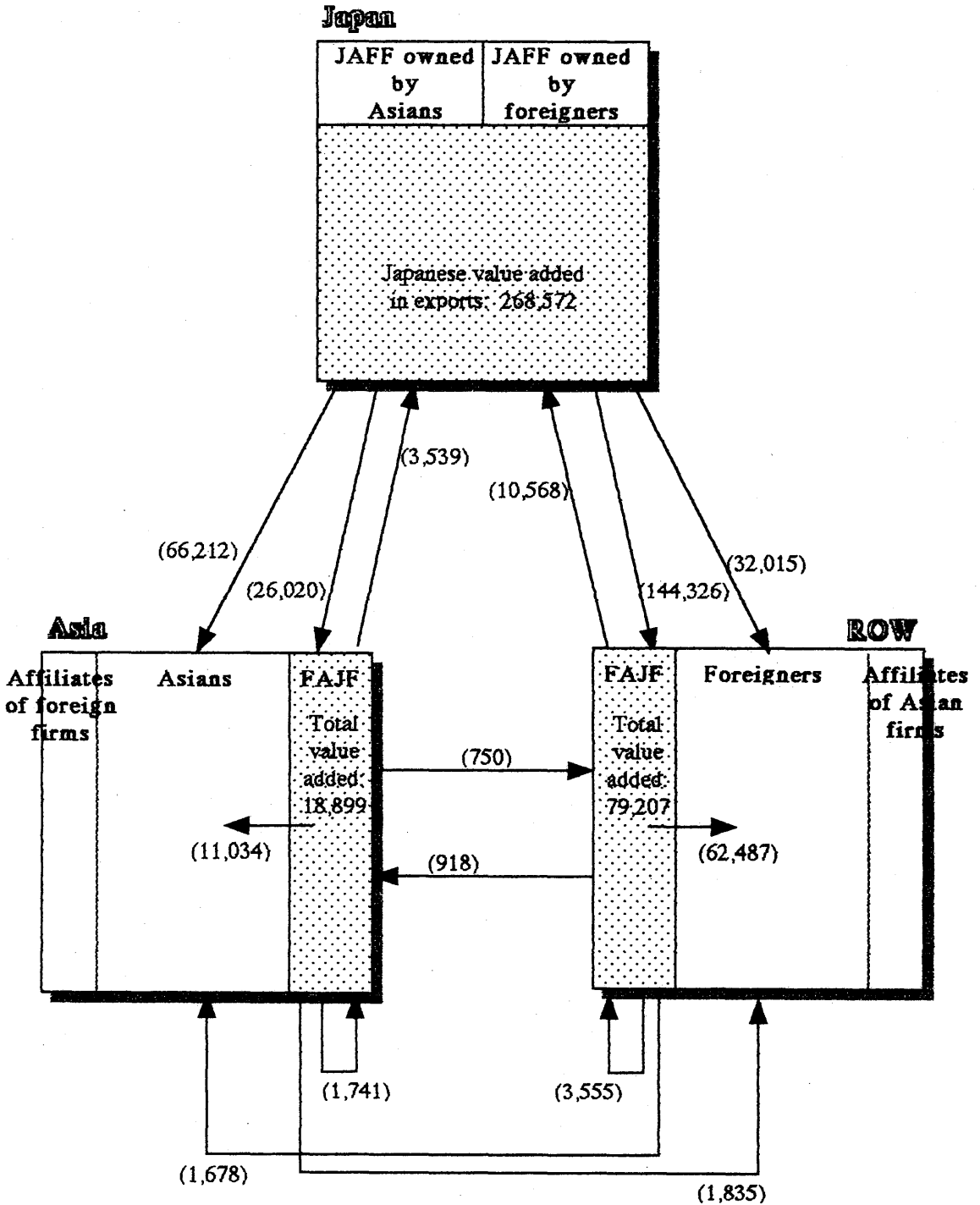
(In millions of U.S. dollars)



Source: Kimura (1997a). See the original for data sources.

Figure 2
Japanese value added embodied in
sales to foreigners by Japanese:
Three-country setting (1991)

(In millions of U.S. dollars)



Source: Kimura (1997a). See the original for data sources.