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THE EVALUATION OF COPPER PROJECTIONS

by

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The purpose of this paper is to evaluate the status of the long-term projection efforts that have been made for copper. This commodity was chosen for study in view of its critical importance especially for a relatively small number of less developed producing countries and because it has been subject to unusual circumstances on both the demand and supply sides. It is hoped that the method of analysis and issues raised in the paper may have a wider applicability to other primary commodities.

In Section I, we present a brief outline of the situation in copper. Section II analyzes some copper projection models and focuses in particular on the projections made in Balassa's work (1964) on the export prospects for developing countries. Section III evaluates the copper projections overall and contains some methodological comments on projections in general. Bibliographic references and data used are given at the end of the paper.

I. The Copper Industry: Technology and Economic Structure

This section presents a brief outline of the important technological and economic factors in the copper industry. Its

purpose is to facilitate discussion of the copper projections in Section II, and it is not meant as an extensive analysis of the industry. For a more thorough description, the reader is referred to U.S. Bureau of Mines (1965).

The "world" will refer to noncommunist countries since trade between communist and noncommunist countries is negligible.

Production

Mining - Most copper ores are mined from relatively large, low-grade deposits. The copper content of the ore varies from 6 per cent in Zambia to less than 1 per cent in the U.S. Throughout this century there has been a continual move to lower-grade deposits as the richer ore bodies were exhausted. However, due to technological improvements these lower-grade ores have been mined without significant cost increases.

The primary minerals that make up the ore are copper sulphide and copper oxide compounds. The ores of many deposits also contain traces of other metals that are economically recoverable at the refining stage. The most important are nickel, gold, and silver.

The countries that lead the world in mine production are the U.S., Zambia, Chile, Canada, Congo (Kinshasa), Peru, South Africa, the Philippines, and Japan. (The U.S.S.R. is second largest.) These countries account for more than 95 per cent of world copper output.

Concentrating and Smelting - After the ore is mined, it is crushed, ground, and concentrated to about 30 per cent copper content. The concentrates are then roasted to remove sulphur and smelted to produce a copper matte, 32-42 per cent of which is copper. The matte is then partially refined, producing blister copper, 90-95 per cent of which is copper.

Due to the low copper content of the ore, most concentrators and smelters are located close to the mines. Hence, the leading ore producers are also the leading producers of smelted copper. The chief exception is the Philippines, which exports all of its ore to smelters in Japan and the U.S. Most of the trade between LDC's and the industrial countries is in blister copper due to its high copper content. Trade flows are from Africa to Western Europe and Japan, and from Latin America to the U.S. Blister copper's share of copper trade, however, has been falling as the LDC copper producers have been refining a larger share of output.

Besides copper ore, a major source of supply for smelters in industrial countries is secondary copper, i.e., copper recovered from scrap.

Refining - At the refineries, blister copper is either electrolytically refined to a copper content of 99.9 per cent or mixed with other metals to produce copper alloys. The large power demands dictate that most of the refineries are located close to sources of cheap electrical power.

As was mentioned, trade in refined copper from LDC's to industrial countries is becoming more important. This implies an increase in the value of copper exports by the cost of refining, given the same copper content of exports. This move away from blister has been especially pronounced in Zambia where refined copper accounts for 85 per cent of copper exports, as compared to 45 per cent in 1955.

Trade in refined copper is also important among industrial countries. Until 1966 the U.S. re-exported copper to Western Europe and Japan. Today this flow has been partially reversed with Western Europe re-exporting copper to the U.S.

Fabricating - The refined copper is used to produce copper wire, copper base alloys, and semi-fabricated products such as strips, sheets, plates, tubes, etc. Fabricators are usually located close to areas of consumption; consequently, world trade in fabricated and worked copper is relatively small.

Consumption

Copper finds its chief uses in the electrical and construction industries. Consumption data in end-use products are not gathered on a regular basis since it is difficult to collect data on the copper content of all final goods. Consumption, therefore, refers to net consumption of refined copper. Net consumption is derived from refined copper production and by taking account of net exports and changes in stocks. Unfortunately, the data are not generated in exactly

the same manner for all countries, thus making cross-country comparisons of consumption difficult. The data are also difficult to interpret for those countries that meet copper needs by importing products at advanced stages of production since they are not charged with any consumption.

Since copper's uses are in industrial products, almost all of the world consumption is in the industrial countries of North America, Western Europe, and Japan. The correlation between consumption and industrial production for these countries is very high except for those countries where consumption data are misleading due to imports of copper at advanced stages of production.

Aluminum is copper's chief substitute in many of its end uses. This competition has been particularly intense, and since 1955 there has been a gradual shift away from copper to aluminum, due to the new-found uses of aluminum, a rise in the copper-aluminum price ratio, and the instability of copper prices. The U.S. copper industry has attempted to stabilize prices since they feel that during times of excess demand there is long-term substitution of aluminum, i.e., customers do not return to copper when prices reach more "normal" levels. The costs of retooling and redesigning machines may account for the substitution due to unstable prices.

Prices

United States. Of the various price quotations, the most important is the primary producers as it covers the largest volume of metal. All of U.S. primary production and, until 1966, imports into the U.S. from U.S.-woned Chilean properties were

marketed according to producers' quotations. As is typical in oligopolistic industries, these prices tend to remain fixed for long periods with nonprice methods being used to allocate supplies during periods of excess demand or supply.

During times of excess supply, the industry, in an attempt to maintain prices, has frequently stockpiled copper and/or asked for voluntary restraints on production. These restraints sometimes become involuntary due to actual or threatened strikes. These restraining efforts have been hindered, however, because the supply of copper scrap, which accounts for over 30 per cent of consumption, is not controlled by the large firms.

Western Europe and World Trade - The most important price quotation for international trade is the London Metal Exchange (LME) price. The LME is a hedger's market with only small amounts of copper actually changing hands. The quotation is used, however, for pricing almost all of the copper imported into Western Europe, Japan, and the U.S. The LME price fluctuates widely. It is difficult to assess whether the wide fluctuations reflect the thinness of the London Market, actual prices that are needed to clear markets, or some combination of these factors.

Industrial Organization

United States - The primary copper industry in the U.S. is composed of approximately 200 firms. However, Kennecott, Phelps Dodge, and Anaconda account for more than 80 per cent of production. These firms are vertically integrated from the mining through the fabricating stage. Secondary copper, i.e., copper recovered from scrap, is also an important source of supply. This industry is

composed of several hundred scrap dealers, who sell to secondary smelters and brass mills.

Chile - Until 1965 the significant copper companies in Chile were subsidiaries of U.S.-based firms. In 1965, the Chilean government acquired controlling interest in the mines. In the past, most of Chile's copper was exported to the U.S. as blister copper. The present situation is subject to imminent change as the Allende government is in the process of nationalizing the industry. The results of this action on the level of exports and the direction of trade are uncertain.

Peru - Almost all of the copper companies are subsidiaries of U.S. or European corporations. Most of the copper is exported to the U.S. as smelted and blister copper. Recently, the Japanese have shown interest in developing other Peruvian properties.

Zambia - Prior to 1970, the Anglo American Corporation and Roan Selection Trust Group produced all of Zambia's copper. In 1970, the mines and properties of AAC and RST were reorganized, with the government acquiring a controlling interest in the new corporation, ZIMCO. Zambia is the world's leading exporter of refined copper. Principle customers are Japan, the U.K., and West Germany.

Congo - Prior to 1967, Union Miniere, a Belgian based corporation owned the important mines in the Congo. In 1967, the firm was reorganized, with the government acquiring controlling interest in the new firm, Geocomines. Most production goes to Western Europe as blister and refined copper.

Others Factors

Stocks and the Strategic Stockpile - The refiners and fabricators in the industrial countries all stock significant amounts of copper. This is in response to the uncertainty of foreign supplies, the possibility of strikes, and the attempt to stabilize prices. In the U.S., copper is considered a strategic commodity and is stockpiled to meet emergencies. During the past decade, the stockpile has been used at times to combat "inflationary" price increases in the copper industry.

Strikes - Strikes are a way of life in the copper industry. It is difficult to find any twelve-month period over the past two decades in which there were no strikes. While the reasons for this strike proness are not clear, three facts stand out. First, while the copper industry is oligopolistic, it faces severe competition from aluminum; second, it has been necessary to implement technological improvements as mining moved to lower grade deposits; and third, voluntary restraints on production have been sought during times of excess supply. If the likelihood of strikes increases as competition increases (wage increases cannot be easily reflected in price increases due to elastic demand), or as the rate of implementing changes in production increases (workers are threatened by automation) or when supply is excessive (the cost of a strike to the industry is not as severe), then these factors may account for the numerous strikes in the copper industry.[1]

II. Projections of Copper-Export Earnings

This section analyzes the projections of copper-export earnings. The first part reviews the organizations and individuals that generate commodity projections and offers some reasons for the limited number of projections dealing with copper. The second part establishes some identities and notation that are then used in comparing the different approaches used in generating copper projections. Balassa's projections (1964) are then extensively analyzed by decomposing them into errors arising in exogenous variables. Finally, we review these errors and attempt to explain them from knowledge of what has occurred over the past ten years. The evaluation of Balassa's projections and projections in general is left for Section III.

Sources of Projections

A first source of projections is the private price forecasts for speculators and hedgers. Copper futures are traded in London and New York, and there is evidence that speculators play an active role in these markets, especially in London. So we should expect that price projections are being generated by brokerage firms, independent research organizations, and copper companies. By their very nature, these private projections are not widely circulated and could not be obtained for the present study. The absence of these projections for our purposes may not be too serious since all are short run and many rely on some form of "magic" that is unrelated to that practiced by economists.

To illustrate this point, annual "projections" are published annually in the Review of the British Metal Corp., Ltd. The

excerpt below from the 1970 Review is indicative of the projections made:

> Whether actual output in 1971 will increase by as much as [the increase in capacity] is very much in the lap of the gods.... Whilst the outcome for the copper market is anything but clear cut, a range of prices above 43¢ a pound--say from 43¢ to 55¢ a pound--seems a much better bet than a region below it.

The value of these projections depends on the size of a "god's lap," which is an interesting question, but one that is clearly beyond the scope of the present study.[2]

Projections are also generated for many commodities by international organizations and LDC's that are involved in long-term resource-allocation decisions. In the case of copper, there was no evidence of any projections or forecasts generated for these reasons. A possible explanation is that until recently the copper companies operating in Africa and Latin America were subsidiaries of corporations in Western Europe and the U.S. Decisions relating to expansion of capacity or the level of exports were not being made by the LDC's and so there was no need for projections that might help in making these decisions. This situation has changed drastically in the last few years as the governments of Zambia, the Congo, and Chile now control production and marketing. In the next decade we will probably see increasing interest in copper projections as an aid to LDC governments since they are now faced for the first time with decisions concerning copper.

Finally, there are copper projections generated as a means of analyzing other problems, such as, growth rates, savings and foreign exchange, gaps, aid requirements, etc. This is the source of projections that will be analyzed in this section. The problem is that, since copper projections are only incidental to some larger problems, they tend to be very simple. Still the analysis can be valuable to see where the projections erred and to ascertain the losses associated with using these simple projections. Also, this souce of projections is relevant since an interest in these larger problems was the primary reason for the present effort to evaluate copper projections.

Originally, we intended to evaluate extensively all of the projections presented below by comparing projected values with actual realizations. Unfortunately, the data sources used in generating the various projections were all different and not comparable. It would have been necessary to recreate each projection model and data source in order to make the comparison. Therefore, we have decided to analyze in detail only one projection, Balassa's, and describe the other projection models. The analysis of only Balassa's projection, however, does not imply that our findings are restricted to this special case since we will argue in Section III that all the projections suffer from a basic flaw that is independent of any actual realizations.

Notation

We set out below some notation and indentities that will be used in comparing the projection models. Subscripts refer to the reporting country or area, and the origin or destination,

respectively. Superscripts are used to clarify variables. Where there is no superscript, the variable refers to copper. The important variables are:

X = exports

M = imports

P = price

MS = market share

C = consumption of primary refined (copper)

IP = industrial production

OP = ore production

ΔS = change in stocks

NF = nonferrous metal

FF = ferrous and nonferrous metals

V = value of exports

Using these variables, we get the following identities

(1) $V_j = \sum V_{ji}$

(2) $V_{ji} = P_{ji} X_{ji}$

(3) $X_{ji} = MS_{ji} M_i$

(4) $M_i = C_i + X_i - OP_i + \Delta S_i$

The first identity states that country j's value of copper exports is the sum of the value to all countries of destination. The second states that country j's value of copper exports to country i is the product of price and exports. The third identity states that j's exports to i are the product of i's total imports and j's share of those imports. Four sets out i's imports as the residual of i's consumption plus exports plus stock changes minus ore production.

Using these identities we can now examine the projection models since all use these identities or some derivative thereof.

Balassa, Trade Prospects for Developing Countries (1964)

Balassa was concerned with LDC growth rates which he took to be a function of export earnings. He disaggregated exports to include copper and projected copper earnings to LDC regions (Latin America, Africa, Asia). Since Balassa's assumptions were relatively explicit, his projections can be analyzed in detail, as will be done below.

His model was:

$$C_i = f(IP_i)$$

and identities (1) - (4) except that (4) was amended to:

$$M_i = 1.03(C_i + X_i) - OP_i + \Delta S$$

since roughly 3 per cent of the copper is lost in smelting. M_i is then the copper content of i's imports. Values for the exogenous variables were generated by extrapolations and various ad hoc considerations. Prices were projected by guessing future supplies and then finding a plausible price that would equate future supply and demand.

C. Duprez and E.S. Krischen (eds.), Megistos: A World Income and Trade Model for 1975 (1970)

Megistos was primarily concerned with projecting growth rates for LDC's. The world was separated into three regions: developed, communist, and LDC. These regions were further subdivided into various zones. LDC growth was taken to be a function of, among other things, the growth of exports. Exports were disaggregated

into commodity groups, one of which was copper. The copper projections were based on the following model:

$$M_i^{FF} = f(IP_i^{FF}, \text{Time})$$

$$M_i = \alpha M_i^{FF}$$

and identities (1), (2), and (3). α was copper's share of ferrous and nonferrous (FF) metal imports. The function f varies according to importing zone and was estimated by simple regression. α and MS were estimated by extrapolations from the past and making "commonsense" adjustments of the extrapolations. The value of copper exports was in 1960 prices.

The authors claim to have made forecasts as opposed to projections which are conditional on the values of the exogenous variables. However, this is not the case since their 1975 "forecast" depends on a host of variables generated outside of their model, including industrial projection, market shares, etc. The model used 1960 as a base year even though the authors had data through 1966. Megistos' projections will not be analyzed since data were only complete through 1968 at the time of writing.

A. Maizels, Exports and Economic Growth of Developing Countries (1966)

Maizels was concerned with the growth rate of the Overseas Sterling Area (OSA). To this end he generated projections of the value of copper exports. The OSA includes only one major copper producer, Zambia.

The projections were based on the following model:

$$C = \beta^{NF}$$

and identities (1) - (4). β is copper's share of nonferrous metal consumption in the industrial countries. It is taken to be a function of the copper-aluminum price ratio, which is assumed to rise by 25 percent by 1975. The values for all other variables in (1) - (4) were based on extrapolations from the past and various ad hoc considerations. The value of copper exports is in 1960 prices. We did not evaluate these projections because of the time span involved.

Trade Prospects and Capital Needs of Developing Countries. Study Prepared by the UNCTAD Secretariat (1964)

The model UNCTAD used for demand is approximately the same as Maizels'. These demand estimates were then compared with supply estimates derived from extensive analysis of various LDC's. The only copper producer that was included was Peru. We decided, therefore, not to evaluate these projections in favor of Balassa's, which covered all the major producers.

Summary Projections for 1975

The above projections of copper imports for 1975 are summarized in Table 1, while Table 2 presents a comparison of Megistos' and Balassa's projections by exporting and importing region. However, the projections are not strictly comparable since the composition of developed countries as well as the base year differ in each projection. These problems are compounded due to data inconsistencies that were previously discussed in Section I. For the purpose of making comparisons, the annual rate of growth statistic is the best, although still suffering from some of the above problems. As mentioned above, we did not

attempt to evaluate the 1975 projections due to lack of sufficient data. Our interest below will be focused accordingly on Balassa's projections for 1970

Table 1

Projections of Developed Country Copper Imports From Less Developed Countries

	1975 (000 Metric Tons	Base Year	Annual Rate of Growth
Balassa		1960	
Low	3,060		4.4%
High	3,360		5.1
Megistos	2,886	1964	5.2
Maizels		1960	
Low	2,900		4.5
High	3,200		6.3
UNCTAD		1965	
Low	2,066		4.1
High	2,173		4.6

Note: The low and high projections are based on different assumptions in the developed countries. Also, the projections for 1975 are not comparable since the composition of developed countries varies, and the data used in generating the projections are different. Therefore, the annual rate of growth is the best statistic for comparing projections although still suffering from some of the above problems.

Table 2

Comparison of Megistos' and Balassa's 1975 Projections

	1975 Copper Imports by Reporting Region (000 metric tons)		
	Megistos	Balassa Low	Balassa High
North America	436	420	450
Western Europe	2,167	2,360	2,570
Japan	282[a]	280	340
Total	2,884	3,060	3,360

	1975 Copper Exports by Reporting Region (000 metric tons)		
	Megistos	Balassa Low	Balassa High
Latin America	1,361	1,310	1,440
Africa	1,433	1,620	1,780
Total[b]	2,884	3,060	3,360

[a]Also includes Israel and South Africa

[b]Includes negligible amounts from Asia

Conceptual Overview

All of the projection models mentioned above are basically the same. Their method can be roughly summarized as follows. First, choose a variable of interest, V, the value of copper-export earnings. Second, find some "other variables," which when added or multiplied, yield V as an identity. Third, plug in some numbers for these "other variables," and out pops a projection of

V. The models concentrate on establishing the identities and then, faced with the difficulty of projecting the "other variables," assume they will remain constant or move like they have in the past. Only infrequently is there any analyses of the underlying reason for changes in the variables. Usually the "other variables" are plugged in without any explicit reason given for the particular value chosen. Presumably it is the author's own best guess. It is here that the models fail.

The reason for the models is ostensibly to understand the forces affecting V. Therefore, the distinguishing characteristic of a projection model is the process used to plug in numbers for the "other variables." Or, the model attempts to simulate how the real world plugs in the "other variables." In the above identities, the parameters all equal one and the exogenous variables equal V by definition. What the models accomplish, therefore, is only a transformation of the problem. There is no solution to the problem of understanding the forces that determine V.

A related problem concerns the simultaneous nature of the models. Price is related to exports, market share is related to price, etc. Failure to account for this avoids the main problem just mentioned, that is, understanding the forces that determine V.

Now all of this criticism may be a little unfair. One cannot hope to grapple with all these problems when interested primarily in LDC growth rates, gaps, or whatever. But implicit in their use is the belief that they are somehow better than merely extrapolating V or doing nothing at all. This question is taken up again in Section III.

Analysis of Balassa's Projections

Balassa's projections will be analyzed by decomposing the total error of the value of copper exports into errors attributable to each parameter and exogenous variable. The total error is the difference between Balassa's projection for 1968 (as defined below) and the actual value of copper exports in 1968. Now there is the possibility that, in choosing only a single year for comparison, the errors that we find are not indicative of errors in Balassa's exogenous variables. The reason is that Balassa did not claim to make projections for a single year, but rather to make an average projection for the years around the projection date. The model, in assuming average rates of growth, was not meant to take account of exceptional years. In the case of copper, using only a single year for comparison is especially dangerous since every year tends to be exceptional for one reason or another. Originally we hoped to avoid this problem by comparing Balassa's projections with the average of the variables between 1960-68. However, this could not be done since comparable data on the value of copper exports between regions for all years between 1960-68 were not available. Therefore, in reviewing Balassa's errors, an attempt will be made to note the errors that arose as a result of forces that were exceptional in 1968.

In order to decompose the total error into errors attributable to the exogenous variables, define the total error as:

(5) $$V^* - V = P^*X^* - PX$$

where the variables are the same as those used previously. An asterisk indicates Balassa's projection for 1968. No asterisk

indicates actual 1968 figures. Adding and subtracting P*X gives:

$$V^* - V = P^*(X^*-X) + X(P^*-P)$$

where $P^*(X^*-X)$ is the error in the value of copper exports due to errors in projecting exports and $X(P^*-P)$ is the error due to price. This decomposition is not unique (PX^* could have been added and subtracted) and introduces index number problems. These problems will be ignored since we are primarily interested in making qualitative judgements. It can be shown that the findings would be qualitatively the same had a different index been used.

Now we can decompose further:

$$X^* - X = MS^* \cdot M^* - MS \cdot M$$

Adding and subtracting MS*M yields:

$$X^* - X = MS^*(M^*-M) + M(MS^*-MS).$$

Furthermore,

$$M^* - M = 1.03(C^*-C) + (OP-OP^*) + (\Delta S^* - S)$$

Finally, to decompose (C^*-C) into errors attributable to the elasticity of consumption with respect to IP (i.e., η); and IP itself, we get:

$$C^* - C = 1.03C^{1960}[\eta^*(\%\Delta IP^*-\%\Delta IP) + \%\Delta IP(\eta^*-\eta)$$

If we substitute all these equations into (5), we have the error in V attributable to all parameters and exogenous variables for all reporting countries and all destinations.

To make this decomposition operational, the following assumptions were necessary: (1) our data were only complete through 1968, so Balassa's high income estimate for 1970 was chosen and a geometric growth rate assumed, thereby yielding Balassa's projections for 1968, except as noted below; (2) the market share

and price projected for 1970 were assumed to be the same as projected for 1968; (3) the elasticity of consumption, with respect to industrial production (η) was "estimated" by taking the projected percentage change in consumption divided by the projected percentage change in industrial production, thus assuming the projected elasticity to be independent of industrial production; (4) the actual elasticity was "estimated" by taking the actual percentage change in consumption between 1960 and 1968 and dividing by the actual percentage change in industrial production, this crude procedure means that the actual elasticity may be different than what we infer since 1968 consumption may be high or low for reasons other than industrial production; in the review of the findings we will take note of this.

The results are presented in Table 3 in terms of the error in V due to each variable for each LDC and industrial region. For example, the value of copper exports to Europe from Africa was overestimated by $340,000 due (solely) to Balassa's overestimate of Europe's elasticity of copper consumption with respect to industrial production.

Before reviewing the errors in the value of copper exports we will review a few of the events in 1968 that may have caused 1968 to be unrepresentative of long term trends in copper.

March 1968 saw the end of the copper strike in the U.S. that had lasted since July 1967. The losses in U.S. production in 1968 due to the strike were estimated at 150-200 thousand metric tons or about 15 per cent of U.S. production. U.S. producers raised

Table 3

Decomposition of Errors in Islam's Projections

(Thousands of Dollars)

Exporting/ Importing Region	(1) Industrial Production	(2) Consumption Electricity	(3) Developed Country Exports	(4) Ore Production	(5) Change in Stocks	(6) Total Due to Import Demand Price[a]	(7) Market Share	(8) Exports[b]	(9) Price	(10) Total Error[c]
Latin America										
N. America	- 57	+ 19	+ 43	+ 58	-125	- 62	+107	+ 45	+ 8	+ 53
W. Europe	- 18	+202	- 25	+ 9	+ 50	+218	+ 56	+274	-375	-101
Japan	- 67	- 42	0	0	+ 13	- 96	+115	+ 19	- 48	- 29
Total	-142	+179	+ 18	+ 67	- 62	+ 60	+278	+338	-415	- 77
Africa										
N. America	- 9	+ 3	+ 7	+ 9	- 21	- 11	+ 21	+ 10	- 7	+ 3
W. Europe	- 31	+340	- 43	+ 15	+ 14	+365	+117	+482	-600	-118
Japan	- 41	- 26	0	0	+ 8	- 59	- 65	-124	- 44	-168
Total	- 81	+317	- 36	+ 24	+ 71	+295	+ 73	+368	-651	-283
Middle East										
N. America	0	0	0	0	0	0	0	0	0	0
W. Europe	- 1	+ 16	- 2	+ 1	+ 4	+ 18	+ 25	+ 43	- 47	- 4
Japan	0	0	0	0	0	0	- 6	- 6	0	- 6
Total	- 1	+ 16	- 2	+ 1	+ 4	+ 18	+ 19	+ 37	- 47	- 10
Asia										
N. America	- 4	+ 1	+ 3	+ 4	- 9	- 5	+ 11	+ 6	- 11	- 5
W. Europe	0	0	0	0	0	0	0	0	0	0
Japan	- 23	- 14	0	0	+ 4	- 33	- 15	- 48	- 18	- 66
Total	- 27	- 13	+ 3	+ 4	- 5	- 38	- 4	- 42	- 29	- 71
Total LDC's										
N. America	- 70	+ 23	+ 53	+ 71	-155	- 78	+139	+ 61	- 10	+ 51
W. Europe	- 50	+558	- 70	+ 25	+138	+601	+198	+799	-1022	-223
Japan	-131	- 82	0	0	+ 25	-188	+ 29	-159	- 110	-279
Total	-251	+499	- 17	+ 96	+ 8	+335	+366	+701	-1142	-441

Note: + signifies overestimate and - signifies underestimate.

[a]Sum of columns (1)-(5). [b]Sum of columns (6)-(7). [c]Sum of columns (8)-(9).

prices from 38¢ to 42¢ after the strike and these prices remained constant throughout the rest of the year. These prices, however, were far below the LME price. The LME price opened the year at 64¢ per pound and by midyear had climbed to 90¢ per pound. This extremely rapid price increase was due to two factors. First, by the beginning of 1968, stocks in the hands of consumers (i.e., refineries) were almost completely exhausted since consumers had to get through six months of 1967 without any U.S. production. Second, as a result of the war in Vietnam, the U.S. had released large quantities of copper from the strategic stockpile in 1965, 1966, and 1967. The result was that consumer demand had to be met almost entirely by current production and so prices rose rapidly. After the strike, prices fell just as dramatically and by May 1 were at 50¢ per pound. Prices stayed close to 50¢ for the remainder of the year. The year then was marked by wide price swings, which were due to the length of the U.S. strike. And while prices were high relative to 1967 they were averaged close to 1969 and 1970 prices which were 63¢ and 69¢, respectively. Some of our findings below would change had we used a different year for comparison, but they probably would not change by a significant amount so as to invalidate the findings.

Industrial Production (IP) - Balassa underestimated IP for every industrial region and as a result he underestimates the value of copper exports to LDC by $251,000. (Once more to clarify, this means that had Balassa known IP in 1968 he would have raised his projection of V by $251,000.) The most severe error was for Japan

hence, Africa and Latin America showed the largest underestimates since they were the chief exporters to Japan.

Elasticity (η) - Elasticity was severely overestimated for Western Europe, with smaller errors being made for the U.S. and Japan. Balassa noted that the substitution of aluminum for [illegible] would proceed at a faster rate in Europe and projected a fall in elasticity from 1.0 to .9. In fact, elasticity fell all the way to .65. There were two reasons for this. First, supplies of copper from Africa became uncertain when the governments of Zambia and the Congo indicated they were taking controlling interest in the mines. Hence consumers switched to other metals. Second, when the governments took over, they discarded the old producer pricing policies where prices remained constant for long periods and started pricing on the basis of the (higher and less stable) LME price. This fact also contributed to a substitution away from copper that Balassa could not foresee. The result then was a large overestimate of V to LDC's with almost the whole error attributable to Western Europe.

Exports of Industrial Countries to Industrial Countries - Errors here were small with a slight overestimate of North American exports and an underestimate of Western Europe's exports. This was due to a change in the direction of trade between the U.S. and Western Europe. The result of the error was an underestimate of V to Africa and an overestimate for Latin America.

Ore Production (OP) - This was slightly higher than expected and therefore LDC exports were slightly overestimated. This error would have been largerhad U.S. production continued for a full year.

Changes in Stocks (ΔS) - This variable is actually a residual with the largest part due to changes in stocks. It also takes account of discrepancies in the data. One can see from Table 1 that there were large errors in ΔS in the industrial countries, but as a whole the errors almost completely canceled. These errors, however, were not due to Balassa's method since he projected ΔS to be equal to zero. Since he was concerned with projecting trends, it is natural that he assumed ΔS equal to zero even though he knew that this would not hold for any particular year. Therefore, we cannot attribute these errors to Balassa's projections.

Market Share (MS) - Almost all market shares were overestimated. The reason was an increase in trade among industrial countries. Among LDC's, Africa gained at the expense of Latin America since Africa (Zambia) captured a large share of the Japanese market. Balassa thought that Latin America would be the chief benefactor from the increase in Japanese demand.

Prices (P) - Balassa underestimated prices by a considerable amount. The error in V attributable to prices was an underestimate of $1,152,000. This error, however, is not really comparable to the others since we have to face (even if Balassa did not) the fact that price is not exogenous and we cannot hold all other things equal. If Balassa could have foreseen actual exports, then he presumably would have guessed a higher price (given his ad hoc supply considerations). Therefore we cannot say that the greatest error in V arose because of prices since all other things affect prices.

F. Truth - Many of the errors that were made tended to cancel out either by chance or because the errors were actually inversely related (and not independent). The result is that LDC copper-export earnings were underestimated. Pinpointing an exact reason depends on the reader's own view of the independence among the errors.

This decomposition of Balassa's errors is only intended as a comparison of actual realizations with projected values. Whether we view these errors as significant depends on what we expected in the first place. No attempt is made here to "evaluate" the projections on the basis of what actually occurred or on the outcome of any decisions that were made using Balassa's projections. In the next section it will be argued that such an evaluation is logically incorrect. Furthermore, we will show that a correct evaluation does not depend on how close the projections were to actual values. Or, Balassa would have failed even if his projections came true.

III. The Methodology and Interpretation of Projections

The purpose of this section is to clarify a minor point in the methods used to evaluate projections. Clarification is needed because of a misconception of the role of projections that (apparently) arises from viewing projections in a decision-making framework. And while the point is minor, the implications for the projections and evaluations that have been made is to cast some doubt on their worth.

Economic development requires that decisions be made concerning a number of variables that will affect a country in the long

and short run. The decision-maker may be an international body, a developed country allocating aid, or an LDC planner allocating resources. Whoever the decision-maker, he is making decisions that best fit his or someone else's objectives for the economy. At this stage, it is usually impossible to specify the best decisions, since the best decision is conditional upon some future occurrence. For example, the Congo's decision to increase copper mining capacity is based on the future prices of copper, future supplies of copper from other countries, as well as every other future occurrence that affects copper. So decisionmaking by its very nature is a function of the future states of the world, and any particular (optimal) decision is conditional on a particular state of the world. At this stage, projections are introduced as a way of seeing or guessing what the world will look like in the future. It seems, therefore, that projections can be evaluated by comparing either the actual future state of the world with that which is projected or the losses in decisionmaking that arose from using the projection. A projection is better the more closely it reflects the future. Or as Aho (1971) has stated:

> After considering the problems inherent in making export projections, one is skeptical of the degree of accuracy that can be obtained and therefore how useful the projections can be as information for decision making . . . Decision theory instructs us that information should be valued according to how it aids in achieving the objective at hand. This is found by comparing the results based upon given information with what could have been achieved

optimally under perfect information.

This view is also apparently held by many of the people generating projections.

If the foregoing were the criterion for evaluating projections and we believed that economists could make good projections, then all economists would be rich via their earnings in futures, securities, and land. Casual empiricism shows that all economists are not rich. Therefore, either economists cannot make good projections (as defined above), the criterion for evaluating projections is incorrect, or both. The answer is both and fortunately we do not have to rely on casual empiricism to demonstrate.

Just as a decision is conditional on some future state of the world, so also a projection is conditional on some future state of the world, namely, the exogenous variables of the model generating the projections. So when we compare projections with what actually occurred, we are really comparing how close the exogenous variables that were plugged into the model were to actual realizations of the exogenous variables, given that the model is correct. In other words, a projection states what the world will look like, given some values of the exogenous variables. It is logically incorrect then to evaluate the projections or the decisions of which they are a function with what actually occurs since the projection makes no attempt to state unconditionally what will occur. If we want to be consistent then we have to compare the actual state of the world with the projection <u>given</u> the actual realizations of the exogenous variables. Or what is the same thing, compare the structure of the projection model (i.e.,

the parameters and the way in which the variables are related) with actual structure. A correct structure (i.e., a perfect projection model) with incorrect exogenous variable realizations will generate projections that are never realized while an incorrect structure, i.e., a "bad" projection model) may generate projections that are by chance exact. The value of projections is in no way related to deviations from actual realizations, but rather their value comes from understanding the nature of the forces that will determine the future.

Now suppose we adopt an extreme view of Balassa's projection model and the other models discussed by taking the model to be the identities presented earlier. Actually this is not too extreme since the only endogenous variable is consumption. Then if we substitute in the actual exogenous variable realizations, we find that the model is exact. But this is not surprising since the model yields V as a function of the exogenous variables by definition. Plugging numbers into the identities on the basis of extrapolation or ad hoc considerations in no way aids our understanding of the determinants of V. Therefore, there is nothing to evaluate. It would have been just as useful and easier to project V directly on the basis of these same considerations.

One may still feel that evaluations can be made by comparing complicated models with simple extrapolations and seeing how much closer the complicated model's projections are to actual realizations. This notion, given the current state of economics, is false and also is the reason why economists are not rich.

Assume that we have two projections of some variable Y. They are the same in every way except that one of the projections uses

the exact real world structure and the other is ignorant of the structure and therefore extrapolates Y from past data.

Suppose that the exact structure is given by:

$$Y(t) = f(X(t)),$$

where X stands for all exogenous variables that affect Y and t stands for time. In the first case we know f. Hence our projection of Y for time T is:

$$Y(T) = f(X(T))),$$

and this will be actually realized. The problem is that we do not know X(T). So we estimate X(T) from past data and this yields:

$$X^1(t) = g(t)$$

Thus, our projected value of Y for time T is:

$$Y^1(T) = f(g(T)).$$

In the second model, Y is estimated solely as a function of time:

$$Y^2(t) = h(t),$$

but

$$h(t) = f(X^1(t)),$$

since extrapolation in both models is done in exactly the same way. Thus the second model's projected value of Y at time period T is:

$$Y^2(T) = h(T) = f(g(T)) = Y^1(T)$$

Knowledge of the exact structure therefore does not allow us to make projections that are any better than naive extrapolation.

Now it may be argued that if we only knew the determinants of X, we could make projections that were close to actual realizations. This only removes the problem a stage since we are then faced with projecting the exogenous variables that determine the exogenous variables. There are, however, two cases where knowledge

of the structure allows projections that are better than extrapolation. If the structure specifies variables that we can collectively forecast better than Y, then our projections will be closer than extrapolations. Unfortunately this is hardly ever the case, especially for long-term projections. We are usually faced with the problem of forecasting exogenous variables that are just as difficult to ascertain as the variable we are interested in. Second, if the structure is dynamic (and correct), then projections will be correct. Once the structure has specified the laws of motion, all we have to do is observe the current state and then make projections into the distant future. There is no problem with forecasting exogenous variables since none exist. This is the advantage one has in forecasting eclipses versus projecting copper export earnings. And while we have the access to some dynamic models, they are all qualitative or sufficiently abstract so as to be of no use in decision making.

The above argument implies that even if we incorrectly evaluate projections by seeing how well they forecast the future, there is no reason to expect them to outperform naive extrapolations. Those that do outperform extrapolations do so purely by chance.

Conclusion

Three things have been shown. First, projections cannot be evaluated by comparing projected values with actual realizations. Evaluation consists of comparing the structure of the projection model with actual structure. Second, an evaluation of the projections we have discussed is impossible since they make almost no attempt to understand the factors affecting the value of copper

export earnings. And third, there is no reason to expect any (long-term) projection to outperform a naive extrapolation, except by chance.

These findings do not imply that evaluating projections is worthless or uninteresting. It implies the opposite. Only by evaluating projections can we learn where they erred and how they can be made better. We are only arguing that we may have been looking in the wrong places for those errors.

Footnotes

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[1]Some of the factors may be mutually exclusive since we are arguing that competition increases and decreases the likelihood of strikes. They are not necessarily mutually exclusive since an oligopolistic industry could be subject to competitive influences from outside the industry while maintaining oligopolistic behavior within the industry.

[2]We have recently come across a more sophisticated approach by a Working Group consisting of Central Planbureau and four other Commodity Institutes prepared in March 1971. The annual average LME price, P_t, was estimated by

$$P_t = 66.94 + .10\ C_t - .62\ S_{t-1} - 70.02D$$
$$(193.2)\quad (20.0)\quad (52.0)\quad (61.1)$$
$$R_2 = .84 \qquad DW = 1.48 \qquad SE = 17.1$$

where C was world consumption of refined copper, S was total stocks, and D was a dummy for the years 1961-63 when producers were able to control the LME price. World consumption was estimated by

$$C_t = 1052.6 + 36.07\ Q_t - .79\ P_{t-1} - .72\ L_t$$
$$(15.4)\quad (6.2)\quad (65.8)\quad (41.7)$$
$$R^2 = .97 \qquad DW = 1.31 \qquad SE = 3.4$$

where Q was world industrial production and L was output lost through strikes. Note that the only statistically significant independent variable is industrial production.

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HWWA - Institut fur Wirtschaftsforschung, Hamburg.

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