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CAUSALITIES IN THE WORLD SUGAR MARKET: SOME EMPIRICAL FINDINGS, 1951–1982

Yoshihiro IWASAKI*

Abstract: The Sims test reveals a fairly strong feedback relationship between the world free market price and the world stocks of sugar. However, between the price and the world production the causality is found uni-directional running only from the latter. The beet-sugar exerts a disproportionately large influence on the price. The lagged price, the lagged stocks and the current production together explain 73% of the year-to-year changes in the world free market price.

STRUCTURE OF WORLD SUGAR MARKET

In spite of the successive International Sugar Agreements since as early as 1937 sugar remains as one of the most volatile major primary commodities. Instability of the world free market price of sugar appears to be aggravated by a number of factors which weaken the causal chains between the world free market price and the world demand and supply of sugar. The causal relationship running from the world free market price to the world demand and supply seems to be weakened at least at the following stages.

First, the world free market price of sugar as determined at the New York Coffee, Sugar and Cocoa Exchange[1] or at the London Exchange[2] is not the equilibrating world price in that it is different from what it would be if there were only one integrated international market for sugar. Over the period from 1951 to 1982 roughly one third of the world production was traded internationally on the average. There were four important preferential agreements for sugar during the period: the U.S. Sugar Program under the Sugar Act,[3] the U.S. Commonwealth Sugar Agreement,[4] the Lomé Convention and the Cuba-COMECON sugar agreements. Their significance for the exporting countries lies in the fact that they provide more secure outlets at more stable prices which have normally been considerably higher than the world free market prices.[5] Furthermore, some sugar

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[1] Up to the end of 1960 it was an f.a.s. (free alongside ship) Cuban port price. From the beginning of 1961 it has been f.a.s. stowed at Caribbean ports.

[2] It is a c.i.f. (cost, insurance and freight) London price.

[3] The U.S. Sugar Act ended in 1974.

[4] The U.K. Commonwealth Sugar Agreement expired in 1974 and was replaced in part by the Lomé Convention.

[5] Or imported with lower tariffs, as for example under the Lomé Convention.

exporters turned to medium- and long-term bilateral contracts with importers to achieve some additional future security, especially at the times when the economic provisions of International Sugar Agreements were not in force. The world "free market" outside those preferential agreements and bilateral contracts ranged from only one fourth to one half of total exports. Exporters who receive prices higher than the current free market price under preferential agreements or bilateral contracts for a substantial portion of their exports may dump on this relatively thin free market just to get rid of the remainder and make the free market supply curve steeper and more inelastic.

Second, various protective measures and subsidies especially in industrialized countries enfeeble the link between the world prices, including both the free market price and the prices under special arrangements, and the domestic prices of sugar in those countries. This further blunts the responses of the world consumption and stocks and production to the free market price. It is to be noted that the consumption is already highly price-inelastic even vis-à-vis domestic prices, sugar being an essential foodstuff without perfect substitutes.[6] The existence of domestic producer price support in developed countries renders more inelastic their domestic production and hence their import demand with respect to the world price than would be the case without the support.

Third, sugar is produced from both sugar cane which is a tropical perennial plant and sugar beet which is a temperate biennial plant. The cane supplied about 60 per cent of the total sugar production during the period and the beet supplied 40 per cent. Their relative share remained fairly stable over time although a slight increase in the share of cane has been witnessed. Cane-sugar and beet-sugar are virtually perfect substitutes in consumption. Beet is mainly grown in industrialized countries, e.g. Europe, North America and the U.S.S.R. Beet produces seeds in the second year of cultivation but for the purpose of sugar production, it is harvested in the first year within eight months after sowing. Cane is widely produced in tropical as well as temperate countries. Its maturity ranges from 12 to 24 months, but averages 15 months. Therefore, the production of cane-sugar responds to price changes with a lag of 15 months on an average whereas beet-sugar responds with a lag of 8 months. From the same cane a number of successive harvests can be obtained. However, usually yield of cane and its sugar extraction rates decline as the number of ratoonings increases.[7] The number of ratoonings in most cases is several times but it varies widely.[8] The fact that cane can be ratooned economically for several times causes a downward rigidity in cane production.

[6] High fructose corn syrup (HFCS) and other starch-based sweeteners cannot be crystallized at present and are largely limited in usage to industrial purposes. Some estimates indicate short-run price elasticities of −0.02, −0.05 and −0.12 and long-run price elasticities of −0.04, −0.05 and −0.47 respectively for developed countries, developing countries and the centrally planned economies. World Bank (1980), p. 80.

[7] Yield of the fifth harvest is about 75 per cent of the first harvest. Cost per acre of ratoons is 58 per cent of the first harvest. Grissa (1976), pp. 13–14.

[8] Zero in Java and often twenty times in Cuba.

Fourth, sugar processing requires a relatively large fixed investment. Both cane and beet are subject to a rapid detarioration in quality after harvesting and need to be processed within a few days. This makes the installation of mills close to the cane or beet fields imperative and limits the exploitation of economies of scale in sugar processing. Processing cost looms large in the total production cost of sugar,[9] which also contributes to the downward inflexibility of the price response of production.[10]

Fifth, yields and the sugar extraction ratios of cane and beet are quite sensitive to climatic conditions, especially to rainfall. Disruptions in weather, therefore, are another important factor which makes the response of sugar production to the free market price more erratic. The causal chain running from the world free market price of sugar to its world demand and supply may have been weakened considerably, if not severed completely, at least by these five disturbing factors. It seems prudent, therefore, not to take for granted that there exists a causality running from the world free market price of sugar to its world demand and supply.

The other side of the coin, i.e. the existence of the reverse causal relationship running from the world demand and supply to the world free market price of sugar is not unambiguous either. The free market accounts for only a small portion of international trade of sugar and is subject to heavy and volatile trade barriers, too. Another important factor which affected the price behavior is the International Sugar Agreements which covered part of the period. They were generally seen to be more efficient in mitigating downward rather than upward movements of price due to the inadequacy of their buffer stocks and their heavy reliance on export quota system. When price fell below certain pre-negotiated levels the export quotas were imposed on the member countries with a view to preventing it from falling further. Thus, the responsiveness of price to change in production may have been reduced considerably. It is not a priori clear, therefore, to what extent and how world production, consumption and stocks affect the world free market price. However, there is a popular belief among sugar traders in the international markets that the free market price is strongly influenced by the movements in current world production and/or current world stocks, both relative to the world consumption of the preceding year.[11] Such kind of price behavior may appear to be difficult to hold since it requires that all the members of the sugar exchanges have fairly precise knowledge of current levels of production and stocks as well as their past levels. But in practice, this information is obtainable on a quite updated basis from such organizations as F. O. Licht of West Germany and the

[9] A USDA estimate of costs for the 1981/82 US sugar production shows that the processing accounts for approximately 50 per cent (cane) and 70 per cent (beet) of the total raw sugar costs. *Journal of Commerce*, April 30, 1981.

[10] Gordon Gemmill indicates that price elasticities of world cane production are higher (+1.00) when the price is high or rising and lower (+0.30) when the price is low or falling. Gemmill (1976), passim.

[11] This belief was repeatedly heard during private interviews and hearings with leading Japanese trading companies. A theoretical formulation of such a belief is given by Tewes (1976).

International Sugar Organization.

In what follows these causal relationships between the world free market price of sugar and its world production and stocks are tested with the annual data for the three decades from 1951 to 1982.

METHODOLOGY AND FINDINGS

The causality test is carried out by a procedure suggested by Sims (1972). The main hypothesis to be tested is the existence of a feedback relation between the world free market price (P_t) on the one hand and the ratio of world production to the previous year's world consumption (RY_t) and the ratio of world stocks to the previous year's world consumption (RS_t) on the other hand. Note that the world consumption increases fairly steadily over time[12] and therefore these ratios, RY and RS are good indicators of excess production and excess stocks corrected for the time trends. The basic equations used for the test are two-sided regressions. In order to test the null hypothesis that price does not cause production or stocks ($P \nRightarrow RY$ or $P \nRightarrow RS$), we test,

$$P_t = \sum_{i=-n_1}^{n_2} f_i RY_{t-i} + \xi_t \tag{1}$$

In order to be able to reject the null hypothesis $P \nRightarrow RY$ (or $P \nRightarrow RS$) we must have coefficients f_i's significantly different from zero for $i<0$, i.e. for the future (lead) values of RY, as a group. Similarly we estimate the following equation for testing the reverse causal relationships,

$$RY_t = \sum_{j=-n_2}^{n_1} g_j P_{t-j} + \eta_t \tag{2}$$

It should be noted that when RY is the Left Hand Side (LHS) variable, because of the lags between planting and harvest of beet and cane, lag zero ($j=0$) can be considered as a "lead", rather than "current," value in Eq. (2). In order to be able to reject the null hypothesis that production (or stocks) does not cause price, i.e. $RY \nRightarrow P$ (or $RS \nRightarrow P$), we must find g_j's significantly different from zero for $j \le 0$ (or $j<0$ for RS), as a group.

In this kind of test, where we should make a fairly precise use of F-tests on groups of coefficients, it is important that the assumption of serially uncorrelated residuals be approximately accurate.[13] Furthermore as suggested by Feige and Pearce (1980), the choice about how to whiten the variables may affect the result in a substantial way. To be free from any serious biases from a particular choice of whitening method, the above regressions were run in three different ways: (1)

[12] World sugar consumption grew by about 3.6 per cent per year from 32 million metric tons in 1951 to 92 million metric tons in 1982 in raw sugar values. The growth has been smooth though with some gradual deceleration over the period.

[13] Sims (1972), p. 545.

prefiltering the variables in log by $(1-L)$ where L is the lag operator, i.e. taking the first difference in log. This prefiltering is designed to take care of simple auto-correlations between the current period (t) and the immediately preceding period ($t-1$); (2) prefiltering the variables in log by the filter used by Sims, i.e. $(1-0.75L)^2$. This filter is aimed at auto-correlations between the current (t) and the two preceding periods ($t-1$ and $t-2$)[14]; and (3) "innovations" of the variables in log, i.e. residuals from the regressions against each variable's own past.[15] This method can take care of the peculiarities of structure of auto-correlation of each variable as to the number of lags involved and their coefficients.

The causality tests are based on the annual data for 1951–1982. Various lengths of leads and lags were examined up to eight years and the length of three years ($n_1=n_2=3$) appears to be the most appropriate in terms of overall F-value and the adjusted coefficient of determination. For the relationship between production and price an asymmetric lag structure of $n_1=3$ and $n_2=1$ was also tested. Since, on the one hand, considerable delay in response of production to price is expected due to such factors as the planting-harvesting lags of beet and cane and the ratooning of cane as discussed earlier. On the other hand, no time lag is conceivable in price response because of the ready availability of quick information about production and stocks to the members of exchange.

First, as to the relationship between the production variable (RY) and the price variable (P), the first null hypothesis: $P \nRightarrow RY$, i.e. that P does not cause RY cannot be rejected, whereas the second one: $RY \nRightarrow P$ can be rejected (see Table 1). There is no "P" equations (the type of Eq. (1) above) with positively-signed and statistically significant lead coefficients regardless of method of whitening. On the other hand, all the "RY" equations (the type of Eq. (2)) have correctly- (negatively-) signed and significant lead coefficients and the joint F-values for lead coefficients are significant mostly at the one per cent level. Thus, as far as the RY–P relation is concerned, the direction of causality is detected only from RY to P and no feedback relation is found between the production and the price of sugar.

Second, the stocks variable (RS) appears to have a much stronger relationship with P than RY does. All the "RS" equations have a correctly- (negatively-) signed and significant coefficient at P_0 (not shown in the table). However, unlike in "RY" equations, we cannot regard $j=0$ in "RS" equations as a lead and interpret this immediately as an evidence for the response of the price to the stock level. Since

[14] For variable X it is equivalent to:

$$\ln X_t - 1.5 \ln X_{t-1} + 0.5625 \ln X_{t-2}$$

[15] Various lengths were examined for each variable (in log) and the number of lags was selected at the first peak of the adjusted R-squared: two lags for P, RY, RCA, $RCPE$, and three lags for the rest of the variables (see tables for notations). For some variables $\bar{R}^2$ is higher at its second peak. However, the inclusion of a much larger number of lags does not seem to have much economic justification to offset the cost of lost degrees of freedom.

TABLE 1. SIMS TEST (1951–1982)
WORLD PRODUCTION AND WORLD STOCKS

#	Variables		(a) Filter $(1-L)$ on ln			(b) Filter $(1-0.75L)^2$ on ln			(c) Innovations of ln		
	LHS	*RHS*	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients
1	P_0	$RY_{-3} \sim RY_{+3}$	1.007	(3, 15)	0.566 at RY_{+3}	1.065	(3, 14)	0.116 at RY_{+1}	0.470	(3, 14)	0.652 at RY_{+3}
2	P_0	$RY_{-1} \sim RY_{+3}$	1.152	(3, 19)	1.844 at RY_{+1}	1.609	(3, 18)	1.564 at RY_{+1}	0.754	(3, 18)	0.877 at RY_{+1}
3	P_0	$RS_{-3} \sim RS_{+3}$	5.311*	(3, 15)	2.812* at RS_{+1}	9.828**	(3, 14)	2.770* at RS_{+1}	3.574*	(3, 13)	2.873* at RS_{+1}
4	RY_0	$P_{-3} \sim P_{+3}$	6.396**	(4, 16)	−3.267** at P_{+1}	3.415*	(4, 15)	−2.394* at P_{+1}	4.659*	(4, 15)	−3.120** at P_0
5	RY_0	$P_{-3} \sim P_{+1}$	11.473**	(2, 18)	−3.847** at P_{+1}	5.617**	(2, 17)	−3.320** at P_{+1}	10.370**	(2, 17)	−3.289** at P_0
6	RS_0	$P_{-3} \sim P_{+3}$	7.653**	(3, 16)	−4.330** at P_{+1}	6.936**	(3, 15)	−3.636** at P_{+1}	2.354	(3, 15)	−2.593* at P_{+1}

Notations: P = Averages of ISA Daily
RY = Ratio of world production (t) to world consumption $(t-1)$
RS = Ratio of ending stock (t) to consumption $(t-1)$
(Note that all the variables are in logarithmic)

None: *: significant at the 5% level
**: significant at the 1% level

Source: International Sugar Council, *The World Sugar Economy Structure and Policies*; *Vol. II, The World Picture*, 1963 and *Sugar Yearbooks*, various issues.

the stocks are a function of current price[16] and, therefore, contemporaneous response of the stocks to the price is also expected. The sign of contemporaneous coefficient does not help either, because it is expected to be negative in both directions of the causality between the current stocks (RS_0) and the current price (P_0). However, even at P_{-1} the coefficients remain statistically significant regardless of whitening method. And the joint F-value for lead coefficients fails to be significant at the one per cent level only in one case. It seems, therefore, fairly safe to reject the null hypothesis that the level of stocks does not cause the level of price. The other null hypothesis that price does not cause stocks can be rejected with even more confidence. In all the "P" equations coefficient is correctly-(positively-) signed[17] and significant at RS_{+1} and the lead coefficients as a group are significant at the five per cent level. Thus, a feedback relation is revealed between world free market price and world stocks of sugar.

The second part of the causality analysis by the Sims test is aimed at identifying the causes of the uni-directional nature of the causal relationship between RY and P.

Table 2.1 presents the result for the disaggregation of the variable (RY) into the ratio of cane-sugar production to world consumption in the previous year (CA) and the similar ratio for beet-sugar (BE). First, as to "P" equations, beet-sugar shows generally higher joint F-values of lead coefficients than cane-sugar does. They are statistically significant at the five per cent level in three of the six cases. Although this is a noticeable improvement over the performance of total production (RY), we are still unalbe to reject the null hypothesis that price does not cause beet-sugar production. The even weaker price response of cane-sugar production may be explained, at least in part, by its longer planting-harvest lag as well as widely practiced ratooning.

Second, as to the reverse relationship, "BE" equations again have higher F-values and t-values than their "CA" counterparts, and this time by substantially larger margins. In "BE" equations the lead coefficients are jointly significant at the five per cent level in all but one case, whereas in "CA" equations they fail to be significant in all but one case. In short, while neither of the two null hypothesis can be rejected for cane-sugar, a uni-directional causality from production to price is found for beet-sugar. Beet-sugar which is produced mainly in temperate industrialized countries such as the EEC, the USA, the USSR and the other Centrally-Planned Economies (the CPEs) in Europe seems to be dominant in causing year-to-year variations of world free market price.

Because of the existence of the Cuban-Comecon Agreement and wide variations

[16] Both the level of price (P_t) and the change in price ($\Delta P_t = P_t - P_{t-1}$) affect the level of stocks negatively. Producers, consumers and speculators alike, know that a tight market is temporary in the sugar economy and tend to deplete their stocks quickly at high and rapidly increasing prices.

[17] Positively-signed since the higher is the previous year's price (P_{t-1}) the smaller will be the ΔP_t, given P_t. And the smaller is the ΔP_t both producers and consumers will tend to increase (decrease) the stock the more (the less).

TABLE 2.1. SIMS TEST (1951–1982)
CANE-SUGAR PRODUCTION AND BEET-SUGAR PRODUCTION

#	Variables		(a) Filter $(1-L)$ on ln			(b) Filter $(1-0.75L)^2$ on ln			(c) Innovations of ln		
	LHS	RHS	F-value for Lead Coefficients	(d.f.)	Max t-value for Lead Coefficients	F-value for Lead Coefficients	(d.f.)	Max t-value for Lead Coefficients	F-value for Lead Coefficients	(d.f.)	Max t-value for Lead Coefficients
1	P_0	$CA_{-3} \sim CA_{+3}$	0.409	(3, 15)	1.016 at CA_{+2}	0.395	(3, 14)	—all negative—	2.544	(3, 14)	2.436 at CA_{+2}
2	P_0	$CA_{-1} \sim CA_{+3}$	1.501	(3, 19)	1.707 at CA_{+1}	0.943	(3, 18)	0.477 at CA_{+2}	2.625	(3, 18)	2.303* at CA_{+2}
3	P_0	$BE_{-3} \sim BE_{+3}$	2.479	(3, 15)	1.554 at BE_{+3}	3.946*	(3, 14)	1.223 at BE_{+3}	2.844	(3, 13)	1.766 at BE_{+3}
4	P_0	$BE_{-1} \sim BE_{+3}$	2.045	(3, 19)	1.554 at BE_{+1}	3.678*	(3, 18)	1.528 at BE_{+1}	3.373*	(3, 17)	1.746 at BE_{+3}
5	CA_0	$P_{-3} \sim P_{+3}$	2.188	(4, 16)	−2.194* at P_{+1}	1.105	(4, 15)	−1.768 at P_{+1}	1.174	(4, 15)	−1.334 at P_0
6	CA_0	$P_{-3} \sim P_{+1}$	4.840**	(2, 18)	−2.521* at P_{+1}	2.409	(2, 17)	−2.202* at P_{+1}	1.785	(2, 17)	−1.395 at P_0
7	BE_0	$P_{-3} \sim P_{+3}$	5.266**	(4, 16)	−2.437* at P_{+1}	3.993*	(4, 15)	−1.462 at P_{+1}	7.543**	(4, 15)	−3.564** at P_{+1}
8	BE_0	$P_{-3} \sim P_{+1}$	7.243**	(2, 18)	−2.972** at P_{+1}	2.807	(2, 17)	−2.268* at P_{+1}	10.789**	(2, 17)	−3.367** at P_{+1}

Notations: P = Averages of ISA's Daily
CA = Ratio of cane-sugar production (t) to world consumption $(t-1)$
BE = Ratio of beet-sugar production (t) to world consumption $(t-1)$
(Note that all the variables are in logarithmic)

None: *: significant at the 5% level
**: significant at the 1% level

Source: International Sugar Council, *The World Sugar Economy Structure and Policies*; *Vol. II, The World Picture*, 1963 and *Sugar Yearbooks*, various issues.

TABLE 2.2. SIMS TEST (1951–1982)
CENTRALLY-PLANNED ECONOMIES AND THE REST OF THE WORLD

#	Variables		(a) Filter $(1-L)$ on ln			(b) Filter $(1-0.75L)^2$ on ln			(c) Innovations of ln		
	LHS	*RHS*	*F*-value for Lead Coefficients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coefficients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coefficients	(d.f.)	Max *t*-value for Lead Coefficients
1	P_0	$CPE_{-3} \sim CPE_{+3}$	0.249	(3, 15)	0.831 at CPE_{+1}	0.349	(3, 14)	0.185 at CPE_{+1}	0.579	(3, 14)	0.930 at CPE_{+1}
2	P_0	$CPE_{-1} \sim CPE_{+3}$	0.184	(3, 19)	0.627 at CPE_{+1}	0.440	(3, 18)	0.307 at CPE_{+1}	0.461	(3, 18)	0.817 at CPE_{+2}
3	P_0	$ROW_{-3} \sim ROW_{+3}$	0.712	(3, 15)	0.995 at ROW_{+3}	1.436	(3, 14)	1.680 at ROW_{+3}	2.333	(3, 16)	2.347* at ROW_{+1}
4	P_0	$ROW_{-1} \sim ROW_{+3}$	1.380	(3, 19)	1.674 at ROW_{+3}	3.202**	(3, 18)	2.436 at ROW_{+3}	1.702	(3, 20)	2.042* at ROW_{+3}
5	CPE_0	$P_{-3} \sim P_{+3}$	1.217	(4, 16)	−2.064* at P_0	1.265	(4, 15)	−1.518 at P_0	1.464	(4, 15)	−1.955 at P_0
6	CPE_0	$P_{-3} \sim P_{+1}$	2.718	(2, 18)	−2.341* at P_0	2.693	(2, 17)	−2.290* at P_0	2.880	(2, 17)	−2.139* at P_0
7	ROW_0	$P_{-3} \sim P_{+3}$	2.610	(4, 16)	−2.144* at P_{+1}	2.993	(4, 15)	−1.529 at P_{+1}	2.120	(4, 15)	−1.498 at P_0
8	ROW_0	$P_{-3} \sim P_{+1}$	3.387	(2, 18)	−2.673** at P_{+1}	3.244	(2, 17)	−2.120* at P_{+1}	1.165	(2, 17)	−1.180 at P_0

Notations: P = ISA's daily average
CPE = Ratio of beet sugar production (t) in the USSR and the *CPE*s in Europe to world consumption $(t-1)$
ROW = Similar ratio for the beet-sugar production in the rest of the world. For *ROW*, "innovations" is simply log of this ratio since this variable does not show any significant autocorrelation.
(Note that all variables are in logarithmic)

None: *: significant at the 5% level
**: significant at the 1% level

Source: International Sugar Council, *The World Sugar Economy Structure and Policies*; *Vol. II*, *The World Picture*, 1963 and *Sugar Yearbooks*, various issues.

of their beet-sugar production due to adverse climatic conditions, the USSR and the other *CPE*s (referred to as "the *CPE*s" collectively in the following) are often cited as a major source of instability in the world sugar economy.[18] To examine the validity of such an argument, world beet-sugar production (*RE*) is divided into the ratio of the beet-sugar production in the *CPE*s to the previous year's world consumption (*CPE*) and the similar ratio for the beet-sugar production in the rest of the world (*ROW*). Table 2.2 summarizes the outcome. First, with respect to "*P*" equations, joint *F*-values and individual *t*-values for lead coefficients are higher for the rest of the world than for the *CPE*s[19] and imply a somewhat greater price response of the beet-sugar production in the rest of the world than in the *CPE*s. However, the lead coefficients, as a group, are significant at the five per cent level only in one case even for the rest of the world and in none for the *CPE*s.

Second, for "*CPE*" and "*ROW*" equations the result is mixed. Though the joint *F*-value is higher for the rest of the world than the *CPE*s in five out of the six cases the difference between the two regions is small. There are several significant *t*-values for individual lead coefficients. They are not, however, jointly significant at the five per cent level in any case. In short, while the beet-sugar production in the *CPE*s does appear to be slightly more irresponsive to world free market price than that in the rest of the world, neither of them is found to cause the price variations, probably because each of these beet regions taken alone accounts for only a relatively small portion of the world sugar production.

As seen earlier, possible causes for the revealed absence of causality directed from price to production are of both artificial and natural in origin. The data limitation does not permit us to single out the effect of each of these obstacles. We can, nevertheless, examine the relative effects of artificial and natural obstacles as a group. For this purpose, another set of causality tests are run between harvested area and price. The change in harvested area is largely, if not completely, free from the major natural disturbances such as the variations by yield and extraction ratio (i.e. sugar content) of beet and cane caused by climatic vagaries. Therefore, by comparing the results with those for production and price, we may obtain some idea about the combined effects of natural obstacles. As usual for the harvested area of sugar its ratio to the world consumption of the previous year (*HA*) was used in the regressions. Table 2.3 summarizes the results.

First, all the "*HA*" equations have markedly lower values for both *F*-values and *t*-values of lead coefficients than counterparts for the world sugar production (*RY*). This is expected, since price responds to actual production rather than harvested area and the result confirms that the effects of natural disturbances on sugar output have been substantial. Second, in some of the "*P*" equations, the *F*-values and *t*-values are considerably higher for harvested area (*HA*) than for world

[18] The *CPE*s' average share in the world beet-sugar production was 43% in the 1950s, 49% in the 1960s and 39% in the 1970s, respectively.

[19] The beet-sugar in the *CPE*s and that in the rest of the world accounted for on an average about 15 to 20% and 20 to 25% of the world sugar production respectively during the past decades.

TABLE 2.3. SIMS TEST (1951–1982)
HARVESTED AREA

#	Variables		(a) Filter $(1-L)$ on ln			(b) Filter $(1-0.75L)^2$ on ln			(c) Innovations of ln		
	LHS	*RHS*	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients	*F*-value for Lead Coeffi-cients	(d.f.)	Max *t*-value for Lead Coefficients
1	P_0	$HA_{-3} \sim HA_{+3}$	1.941	(3, 15)	1.838 at HA_{+2}	0.786	(3, 14)	1.559 at HA_{+2}	0.193	(3, 13)	0.544 at HA_{+1}
2	P_0	$HA_{-1} \sim HA_{+3}$	3.153	(3, 19)	2.477* at HA_{+2}	1.907	(3, 18)	2.374* at HA_{+2}	0.688	(3, 17)	1.251 at HA_{+2}
3	HA_0	$P_{-3} \sim P_{+3}$	1.216	(4, 16)	−1.356 at P_0	1.229	(4, 15)	−1.500 at P_{+3}	1.416	(4, 15)	−1.984 at P_{+2}
4	HA_0	$P_{-3} \sim P_{+1}$	0.346	(2, 18)	−0.768 at P_0	1.286	(2, 17)	−0.555 at P_0	0.350	(2, 17)	−0.786 at P_0

Notations: P = ISA's Daily average
HA = Ratio of harvested area (t) to world consumption ($t-1$)
(Note that all variables are in logarithmic)

None: *: significant at the 5% level.
**: significant at the 1% level

Source: International Sugar Council, *The World Sugar Economy Structure and Policies*; *Vol. II, The World Picture*, 1963 and *Sugar Yearbooks*, various issues.

production (RY) and become statistically significant at the five per cent level. But in the other cases they are slightly lower for harvested area. In other words, although as a balance natural disturbances do seem to contribute to weakening the response of production to price they alone account for only a small part of the revealed absence of causality running from price to production.

To summarize the Sims tests, we have found a fairly strong feedback relation between the world free market price and world stocks of sugar. However, between the world free market price and world production the causality is shown to be unidirectional running only from the latter to the former. Although beet-sugar appears to be somewhat more price responsive it falls far short of gaining statistical significance. The analysis between harvested area and price indicates that natural obstacles alone can explain only a part of the absence of causality from price to production. Thus, the effectiveness of both natural and artificial obstacles that weaken the causal chain between world free market price and world production has been confirmed.

On the other hand, the finding that the world free market price is responsive to both world production and world stocks is consistent with the popular belief among the sugar traders mentioned earlier. Tewes (1976) formulated a theoretical model of sugar market that is compatible with such a belief and, therefore, offers a

TABLE 3. DETERMINANTS OF WORLD FREE MARKET PRICE OF SUGAR (1951–1982)

#	LHS	RHS	Coefficient	T-value	Overall F-value (d.f.)	Adjusted R^2
1	P_0	P_{-1}	0.64	5.71**	26.80** (3, 26)	0.73
		RS_{-1}	−0.70	−1.58		
		RY_0	−6.13	−6.06**		
2	P_0	P_{-1}	0.87	5.82**	17.83** (3, 26)	0.64
		RS_{-1}	−0.20	−0.38		
		CA_0	−5.57	−4.57**		
3	P_0	P_{-1}	0.35	2.61**	16.72** (3, 26)	0.62
		RS_{-1}	−1.30	−2.49**		
		BE_0	−3.59	−4.34**		
4	P_0	RS_{-1}	−1.82	−3.14**	11.02** (2, 27)	0.41
		RY_0	−5.02	−3.43**		
5	P_0	RS_{-1}	−1.81	−2.68**	4.43* (2, 27)	0.19
		CA_0	−1.78	−1.16		
6	P_0	RS_{-1}	−1.92	−3.75**	17.84** (2, 27)	0.54
		BE_0	−4.17	−4.75**		

Notations: All the variables are in logarithmic. Unlike in the other tables they are not filtered.
Notes: * = significant at the 5% level
** = significant at the 1% level
Source: International Sugar Council, *The World Sugar Economy, Structure and Policies; Vol. II, The World Picture*, 1963 and *Sugar Yearbook*, various. issues.

good explanation for our findings. Tewes argues that the members of the sugar exchange behave on the basis of their expectations about the "world equilibrium" price of sugar that would clear the "world market" which encompasses both the free market and the organized market under special arrangements. The expected world equilibrium price reflects directly the current world production and the current world stock levels—both in relation to the previous year's world consumption. Furthermore, the world free market price adjusts partially to the expected equilibrium price and is, therefore, indirectly related to world production and world stocks. The existence of the feedback relation between the world free market price and world stocks can be explained partly by the fact that unlike production, the stocks of sugar respond to price without a lag and are virtually free from natural disturbances as well as by the importance of the role played by the well-informed exchange dealers in the manipulation of world stocks.

Based on these results of the Sim's test we will examine here the way the world free market price is actually determined by world production and world stocks. Table 3 presents the results. The first set of equations have as arguments the lagged price and the lagged stock variables (P_{-1} and RS_{-1}) and the current production variable (RY_0, CA_0 or BE_0). Here, RS has the previous year's consumption as denominator rather than the current year's consumption, but otherwise these equations replicate the reduced form equation of the Tewes' model.[20] The second set of equations on the other hand do not include the lagged price as explanatory variable.

All the equations are highly significant and explain up to 73 per cent of the year-to-year variations in the world free market price. The coefficients are all correctly signed and mostly significant at the five per cent level. However, the coefficient for the lagged stock variable becomes non-significant when the lagged price variable is included due to the contemporaneous feedback relation between the two explanatory variables. Tewes' formulation of the price with a Koyck-type distributed lag (equations #1 ~ #3) appears to have a substantially higher explanatory power than the equations without the lagged price, suggesting the existence of partial adjustment of the world free market price to the expected world equilibrium price. With or without the lagged price variable, the beet sugar production variable consistently shows its strong influence on the variations in the price.

SUMMARY AND CONCLUSIONS

The world free market price of sugar is one of the most unstable among the

[20] Tewes' reduced form equation is:

$$P_0 = -\varepsilon_1 \frac{Y_0}{C_{-1}} - \varepsilon_2 \frac{S_{-1}}{C_{-1}} + \varepsilon_3 P_{-1} + \varepsilon_4$$

where P, Y, C, S are respectively the world free market price, world production, world consumption and world stocks. See Tewes, *ibid.*, pp. 187–190.

primary commodity prices. Various natural and artificial factors can be cited as causes of such instability. Adding to the inelasticities of the demand and supply they contribute in one way or another to weaken the causal chains between the world free market price and the world consumption, production and stocks. Because of such disturbances the world free market price of sugar may not be the "equilibrating" world price and we cannot a priori assume the existence of usual feedback relationship between the world free market price and the world demand and supply. World consumption of sugar has been highly price-inelastic over the past three decades. In fact we can fairly safely assume world consumption to be a function of population and income per capita and, therefore, exogenous to the world sugar market. Thus the main purpose of the paper has been to examine whether world production and world stocks of sugar respond to the world free market price and how the world free market price reflects world consumption, world production and world stocks.

The Sims test failed to support the feedback relation between the world free market price and world production. Instead, a uni-directional causality running from production to price was found. Some evidence for a causal relation in the reverse direction was obtained in the case of beet-sugar production. However, the evidence is incomplete and not strong enough to reject the null-hypothesis that price does not cause production. Furthermore, neither the exclusion of the Centrally-Planned Economies from the beet-production nor the substitution of production by harvested area succeeded to establish the feedback relation between price and production. On the other hand, a fairly strong feedback relation was revealed between the world free market price and world stocks. All these findings appear to be compatible with a popular belief among the dealers of the international sugar exchanges about the determinants of the world free market price and explained well by the Tewes' model which theorizes around such a belief.

The Tewes' formulation of price behavior with partial adjustment is successful to explain up to 73 per cent of the changes in the world free market price. In spite of its minor share in total sugar production beet sugar appears to play a dominant role in causing year-to-year variations of the world free market price.[21]

A way to mitigate the short-term fluctuations of the world free market price of sugar implied by the above findings is to establish the feedback relation between the world free market price and world production by restoring the causal link running from the former to the latter. For this purpose natural disturbances cannot be avoided. We are left, therefore, with the conclusion that elimination or reduction of artificial obstacles (i.e. government policies) that weaken the response of production to the world free market price shall be the main avenue for mitigating the instability in the world sugar market.

Asian Development Bank

[21] However this does not preclude cane sugar's contribution to the price instability of sugar, especially as to the medium-term price cycles which is not analyzed here.

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