

International forecasts of pulp and paper production capacity: accuracy of alternative methods

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For one-year forecasts for Canada, 41% of the error for the pulp forecast was systematic, and 64% was systematic for the paper forecast.

Production capacity is a closely watched index in the pulp and paper industry. The predicted change in capacity indicates the extent of investment taking place in the industry. Capacity utilization, or the ratio of production to capacity, is a suitable indicator of demand and of the rentability of capital. Each firm wishes to invest only when the future capacity of the industry appears to be too low. For that reason, timely and accurate forecasts of capacity around the world are of key importance.

Here, we review the forecasting accuracy of the annual surveys published by the Food and Agriculture Organization (FAO) of the United Nations from 1969 to 1988. A method is proposed to correct the survey forecasts for systematic errors. Next, we look at the accuracy of extrapolation formulas used to forecast capacity. Finally, we examine the accuracy of econometric models to forecast capacity.

Accuracy of forecasts in capacity surveys

Every year, the FAO of the United Nations publishes, by country, data on the current and predicted capacity of the production of pulp and paper (1). In most instances, these data are provided by national pulp and paper trade associations, which in turn obtain their data from individual companies. However, when the data from a country does not arrive in time to be included in the survey, the FAO replaces the missing data by last year's estimate.

For this study, we excluded countries that had more than two years of capacity estimated in that way. This approach left fourteen countries, two in North America, nine in Europe, two in Oceania, and one in Asia (Table I). In 1988, these countries had a production capacity of about 128 million tons of wood pulp a year, representing 80% of total world capacity. For paper and paperboard, their capacity was about 170 million tons, or 70% of world capacity. For simplicity, we will refer to the capacity of these fourteen countries as the "world capacity."

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I. Capacity of production of selected countries in 1988, thousands of metric tons per year

Countries	Pulp	Paper
Austria	1,545	3,001
Finland	9,335	9,095
France	2,475	6,550
West Germany	2,265	11,404
Norway	2,150	1,913
Portugal	1,403	833
Spain	1,558	3,534
Sweden	10,585	8,630
U.K.	445	4,676
Subtotal	31,761	49,636
Total Europe surveyed by FAO	38,959	69,760
Australia	1,240	1,935
New Zealand	1,462	823
Subtotal	2,702	2,758
Total Oceania surveyed by FAO	2,702	2,758
Canada	24,744	17,028
U.S.	55,837	73,719
Subtotal	80,581	90,747
Total North America surveyed by FAO	80,581	90,747
Japan	12,847	27,143
Total Asia surveyed by FAO	17,330	51,933
World total in this study	127,891	170,284
World total surveyed by FAO	160,174	242,570

Although the FAO capacity surveys contain five years of forecasts, we concentrate here on forecasts of one and three years only. To determine how these forecasts compared with the actual capacity, the following measure of error was used:

II. Root mean square error and its components for 1-year survey forecast (1970-1988)

Country	Product	RMSE	Bias	Regression	Systematic	Disturbance
Australia	Pulp	4.7	0.01	0.08	0.09	0.91
	Paper	6.0	0.01	0.02	0.03	0.97
Austria	Pulp	3.4	0.01	0.01	0.02	0.98
	Paper	4.1	0.25	0.01	0.26	0.74
Canada	Pulp	1.5	0.38	0.03	0.41	0.59
	Paper	1.6	0.62	0.02	0.64	0.36
Finland	Pulp	1.3	0.31	0.01	0.32	0.68
	Paper	4.5	0.06	0.60	0.66	0.34
France	Pulp	3.4	0.24	0.10	0.34	0.66
	Paper	4.4	0.26	0.00	0.26	0.74
W. Germany	Pulp	5.0	0.10	0.00	0.10	0.90
	Paper	3.6	0.18	0.05	0.23	0.77
Japan	Pulp	2.1	0.04	0.00	0.04	0.96
	Paper	2.2	0.15	0.10	0.25	0.75
New Zealand	Pulp	16.5	0.02	0.13	0.15	0.85
	Paper	19.1	0.00	0.14	0.14	0.86
Norway	Pulp	6.1	0.22	0.02	0.24	0.76
	Paper	2.2	0.33	0.01	0.34	0.66
Portugal	Pulp	9.6	0.02	0.20	0.22	0.78
	Paper	18.8	0.00	0.10	0.10	0.90
Spain	Pulp	5.1	0.08	0.03	0.11	0.89
	Paper	12.3	0.15	0.00	0.15	0.85
Sweden	Pulp	1.4	0.16	0.06	0.22	0.78
	Paper	2.7	0.03	0.38	0.41	0.59
U.K.	Pulp	8.8	0.05	0.11	0.16	0.84
	Paper	3.0	0.48	0.00	0.48	0.52
U.S.	Pulp	0.9	0.01	0.10	0.11	0.89
	Paper	1.2	0.07	0.24	0.31	0.69
World	Pulp	0.8	0.41	0.00	0.41	0.59
	Paper	1.0	0.14	0.00	0.14	0.86

Systematic error = bias + regression error.

$$e(t+h, t) = a(t+h, t) - p(t+h, t) \quad (1) \quad RMSE = \{[1/(T-h)] \sum_{t=1}^{T-h} [e^2(t+h, t)]\}^{1/2} \quad (2)$$

for

$$h = 1 \text{ or } 3$$

and

$$t = 1 \text{ to } T - h$$

where

$e(t+h, t)$ = relative error, in percent, of the forecast made in year t over h years

$a(t+h, t)$ = actual percentage change in capacity between year t and year $t+h$

$p(t+h, t)$ = predicted percentage change in capacity over the same interval

T = the number of years in the sample.

In doing so, we assumed that underestimation had the same cost as overestimation and that the cost of the error was proportional to the square of its magnitude (2). The advantage of the root mean square error, computed from the relative error, $e(t+h, t)$, is that the $RMSE$ can be interpreted as an average relative error, in percent.

Using a procedure first suggested by Theil (3), the mean square error ($MSE = RMSE^2$) was also broken down into a bias component (U_m), a regression component (U_r), and a disturbance component (U_d), as follows:

$$MSE = (\bar{p} - \bar{a}) + \sigma_p^2 (1 - \beta)^2 + (\sigma_a^2 - \beta^2 \sigma_p^2) \quad (3)$$

$$1 = (\bar{p} - \bar{a})/MSE + \sigma_p^2 (1 - \beta)^2/MSE + (\sigma_a^2 - \beta^2 \sigma_p^2)/MSE \quad (4)$$

$$1 = U_m + U_r + U_d \quad (5)$$

where

$\bar{p}$ = mean of the predicted percentage changes of capacity

$\bar{a}$ = mean of the actual percentage changes of capacity

σ = standard deviation

β = coefficient of p in a linear regression of actual on predicted change:

A measure of the relative error, rather than absolute error, was used to facilitate comparisons between countries, product groups, and lengths of forecast.

We used the root mean square error ($RMSE$) to measure the "average" forecast error over the sample period:

III. Root mean square error and its components for 3-year survey forecast (1972-1988)

Country	Product	RMSE	Bias	Regression	Systematic	Disturbance
Australia	Pulp	4.7	0.07	0.04	0.11	0.89
	Paper	10.5	0.14	0.14	0.28	0.72
Austria	Pulp	8.7	0.30	0.00	0.30	0.70
	Paper	12.4	0.59	0.14	0.73	0.27
Canada	Pulp	4.7	0.53	0.20	0.73	0.27
	Paper	4.8	0.55	0.24	0.79	0.21
Finland	Pulp	4.2	0.42	0.04	0.46	0.54
	Paper	3.3	0.02	0.11	0.13	0.87
France	Pulp	11.7	0.60	0.22	0.82	0.18
	Paper	15.6	0.04	0.65	0.69	0.31
W. Germany	Pulp	8.2	0.27	0.00	0.27	0.73
	Paper	6.6	0.45	0.17	0.62	0.38
Japan	Pulp	5.7	0.27	0.00	0.27	0.73
	Paper	6.5	0.00	0.00	0.00	1.00
New Zealand	Pulp	17.5	0.06	0.02	0.08	0.92
	Paper	29.5	0.05	0.18	0.23	0.77
Norway	Pulp	13.1	0.44	0.01	0.45	0.55
	Paper	8.0	0.53	0.20	0.73	0.27
Portugal	Pulp	12.9	0.13	0.26	0.39	0.61
	Paper	26.6	0.03	0.69	0.72	0.28
Spain	Pulp	17.5	0.11	0.16	0.27	0.73
	Paper	33.4	0.22	0.07	0.29	0.71
Sweden	Pulp	6.2	0.48	0.05	0.53	0.47
	Paper	4.9	0.52	0.00	0.52	0.48
U.K.	Pulp	32.7	0.07	0.28	0.35	0.65
	Paper	13.5	0.61	0.00	0.61	0.39
U.S.	Pulp	1.7	0.01	0.38	0.39	0.61
	Paper	2.5	0.10	0.50	0.60	0.40
World	Pulp	3.0	0.55	0.04	0.59	0.41
	Paper	3.4	0.22	0.17	0.39	0.61

Systematic error = bias + regression error.

$$\alpha = \alpha + \beta p + \epsilon \quad (6)$$

The disturbance component, U_d , is the variance of the residuals, ϵ . The other two components measure systematic errors. Systematic error is absent when $\alpha = 0$ and $\beta = 1$, in which case $U_m = U_r = 0$.

Measures of errors obtained from Eqs. 1-5 appear in **Table II** for one-year forecasts and in **Table III** for three-year forecasts. The errors are reported for the capacity of each country and for the world, for wood pulp, or simply "pulp," and for paper and paperboard, or simply "paper." The data came from the yearly capacity surveys of the FAO for the period 1969-1988. A regression of the *RMSE* for each country on capacity, length of forecast, and product type gave the following results:

$$RMSE = 3.5 + 2.2P - 0.19C + 3.1F \\ (+ 3.5 + 1.8 \quad - 0.05 \quad + 0.9) \quad (7)$$

where

P

P

C

F

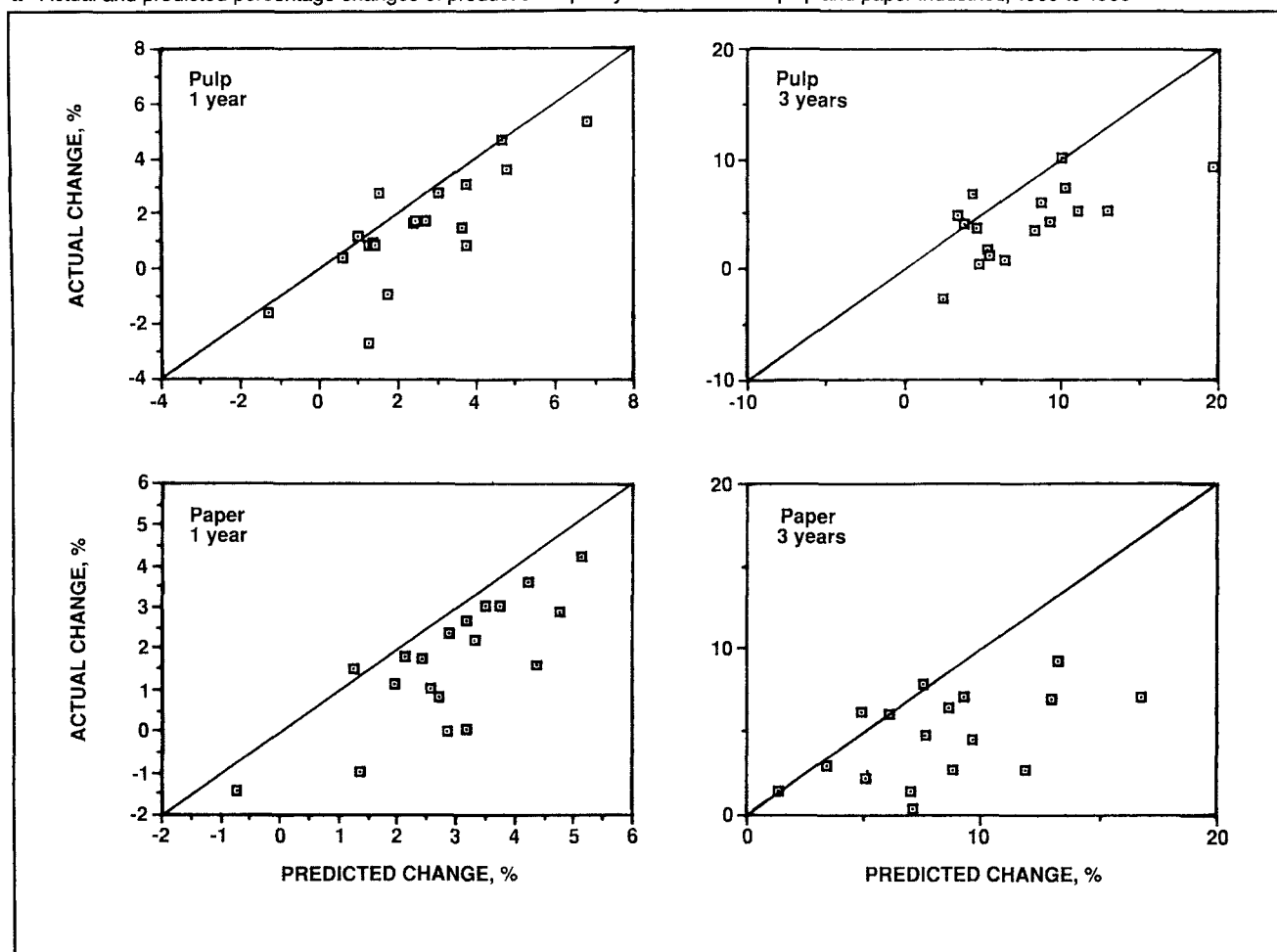
and the numbers in parentheses are standard errors.

Thus, the *RMSE* was significantly smaller in countries of larger capacity, by $0.19 \pm 0.05\%$ per thousand tons. It was significantly larger for longer forecasts, by $3.1 \pm 0.9\%$ per year. There was no significant difference in accuracy between the pulp and the paper industries.

Table II shows that, for forecasts of one year, the *RMSE* for the world was 0.8% for pulp and 1.0% for paper, but the error varied widely by country. The systematic error was considerable in several countries, some of which were large producers. For Canada, 41% of the error of the pulp forecast was systematic, with 38% of that being due to bias, while 64% of the error of the paper forecast was systematic, with 62% being due to bias. Systematic errors of approximately the same magnitude were in the forecasts of Finland and, to a lesser extent, in those of France and Germany. Even for the United States, which had some of the lowest root mean square errors, 31% of the error for paper capacity was systematic. Aggregation of capacity across countries did not eliminate the systematic error. For pulp, 41% of the forecast error of world capacity was due to bias. For paper, 14% of the forecast of world capacity was due to bias.

Table III shows the errors for three-year forecasts. The *RMSE* ranged from 1.7% for pulp capacity in the United States to 33.4% for paper capacity in Spain. For the world capacity, the *RMSE* was 3% for pulp and 3.4% for paper, almost three times the magnitude of corresponding errors

1. Actual and predicted percentage changes of production capacity in the Canadian pulp and paper industries, 1969 to 1988



for one-year forecasts. However, the error did not always increase with the length of the forecast. For example, the *RMSE* of the Finnish forecast for paper capacity was smaller for three-year forecasts (3.3%) than for one-year forecasts (4.5%). The systematic part of the error tended to be larger for three-year than for one-year forecasts. For the world capacity, the systematic error was 59% for pulp and 39% for paper. Thus, the bias observed for one-year forecasts tended to get worse for three-year forecasts, and aggregating the countries did not eliminate it.

Additional information about the magnitude and direction of the bias was obtained by plotting the predicted change in capacity against the actual change. The results, for Canada, Sweden, and for the world appear in Figs. 1-3. For Canada, Fig. 1 shows that the predicted changes tended to systematically overestimate actual changes. This was true for forecasts of either one or three years, although it was much more pronounced for three-year forecasts. The upward bias of the forecast was apparent for both pulp and paper capacity.

For Sweden (Fig. 2), the forecasts were usually good both for pulp and for paper capacity over one year. They were not as good for three-year forecasts. Not only were the errors large, but as for Canada, the overestimation of future capacity was evident.

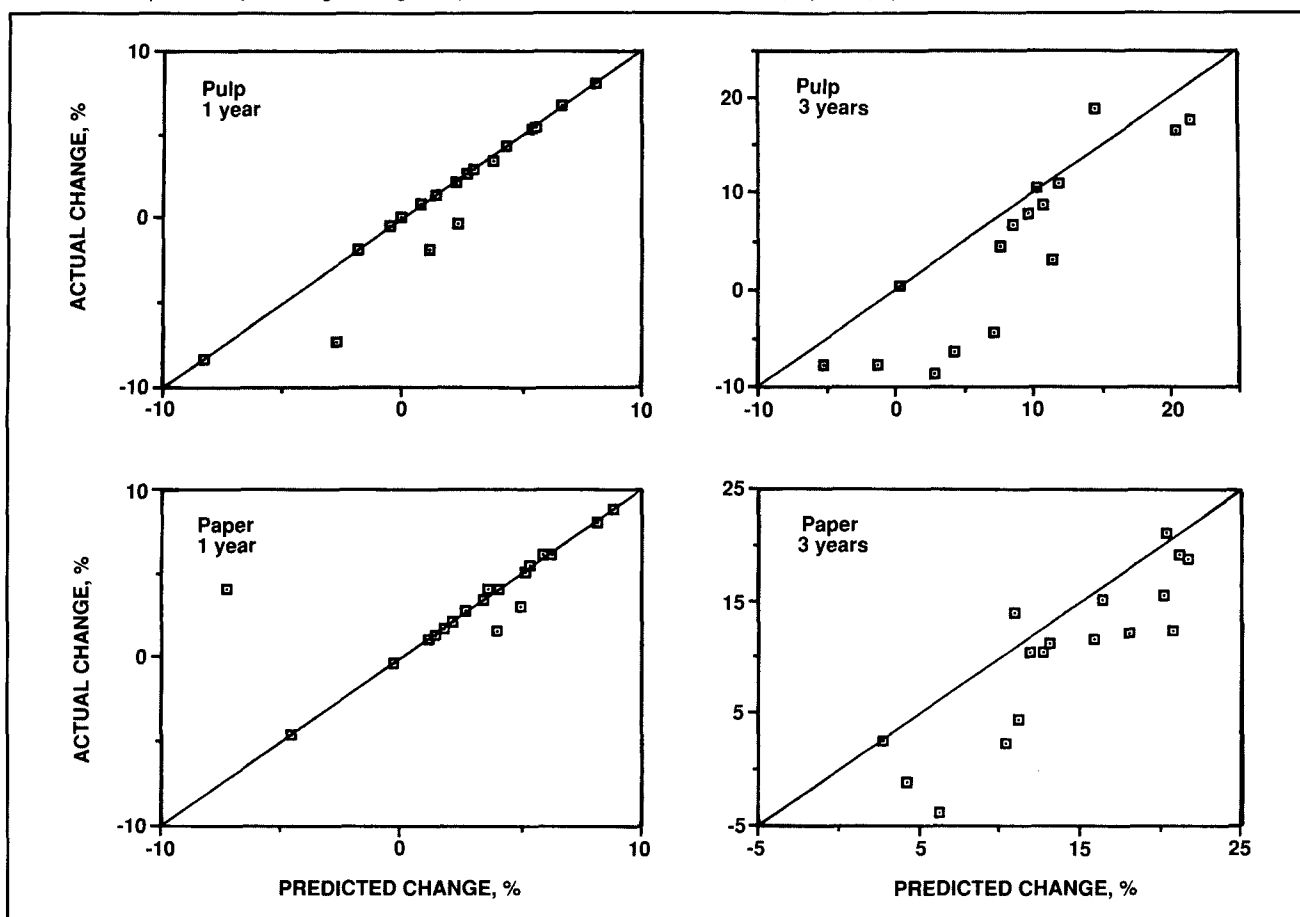
Figure 3 shows the effect that aggregating the countries

has on the error. Although the bias was not as strong for the world as for some countries, it was still apparent. Predicted capacity changes tended to be larger than actual capacity changes. The most obvious bias occurred in three-year forecasts of world pulp capacity. This confirms the results obtained for a shorter period and with different methods (4). The reason for this overestimation of capacity is not clear. Dixit (5) and Masson and Shaanan (6) have argued that firms may be able to deter the entry of competitors by installing excess capacity. Announcing future capacity in excess of what is actually planned may have the same purpose. Still, this does not explain why the phenomenon is more pronounced in some countries than in others.

Correcting survey forecasts for past errors

Because systematic errors were substantial in surveys of future capacity, we attempted to improve the forecasts of the surveys by taking into account past errors. The efficacy of this proposed method was tested using data on forecasts and actual outcomes for 1970 to 1988, for one-year forecasts, and 1972 to 1988 for three-year forecasts. For example, for one-year forecasts, the change predicted by the survey from, say, 1975 to 1976 was adjusted by the average of the error made by the survey from 1970 to 1975.

2. Actual and predicted percentage changes of production capacity in the Swedish pulp and paper industries, 1969 to 1988



The corrected forecasts obtained in this way for 1970 to 1988 were then compared with the actual survey forecasts, to assess what would have been gained by applying this correction procedure.

The formula used to correct the survey forecasts was:

$$p_c(t+h, t) = p(t+h, t) + \bar{e}(t, t-h) \quad (8)$$

for

$$t = 1 \text{ to } T-h$$

where

$p_c(t+h, t)$ = the rate of capacity change predicted at t over the period h , corrected for past errors

$p(t+h, t)$ = the rate of change predicted by the survey over the same period

$\bar{e}(t, t-h)$ = mean of the past errors made by the survey, or:

$$\bar{e}(t, t-h) = [1/(t-h+1)] \sum_{i=h}^t e(i, i-h) \quad (9)$$

with

$$e(h, 0) = 0$$

The root mean square errors of the corrected forecasts obtained by Eqs. 8 and 9 appear in Table IV, for each country and product and for forecasts of one and three

years. For individual countries, the correction improved ten of the one-year forecasts and eleven of the three-year forecasts. The largest improvement (almost 3.5 percentage points) occurred for three-year forecasts of paper capacity in Austria. Other improvements were modest, and in some cases the correction worsened the *RMSE*, especially for Spain and Portugal.

For the world capacity, the correction procedure improved the three-year forecasts of pulp capacity (*RMSE* of 2.4%, against 3.0% without correction), but it had little effect on the other forecasts.

Extrapolating past capacity changes

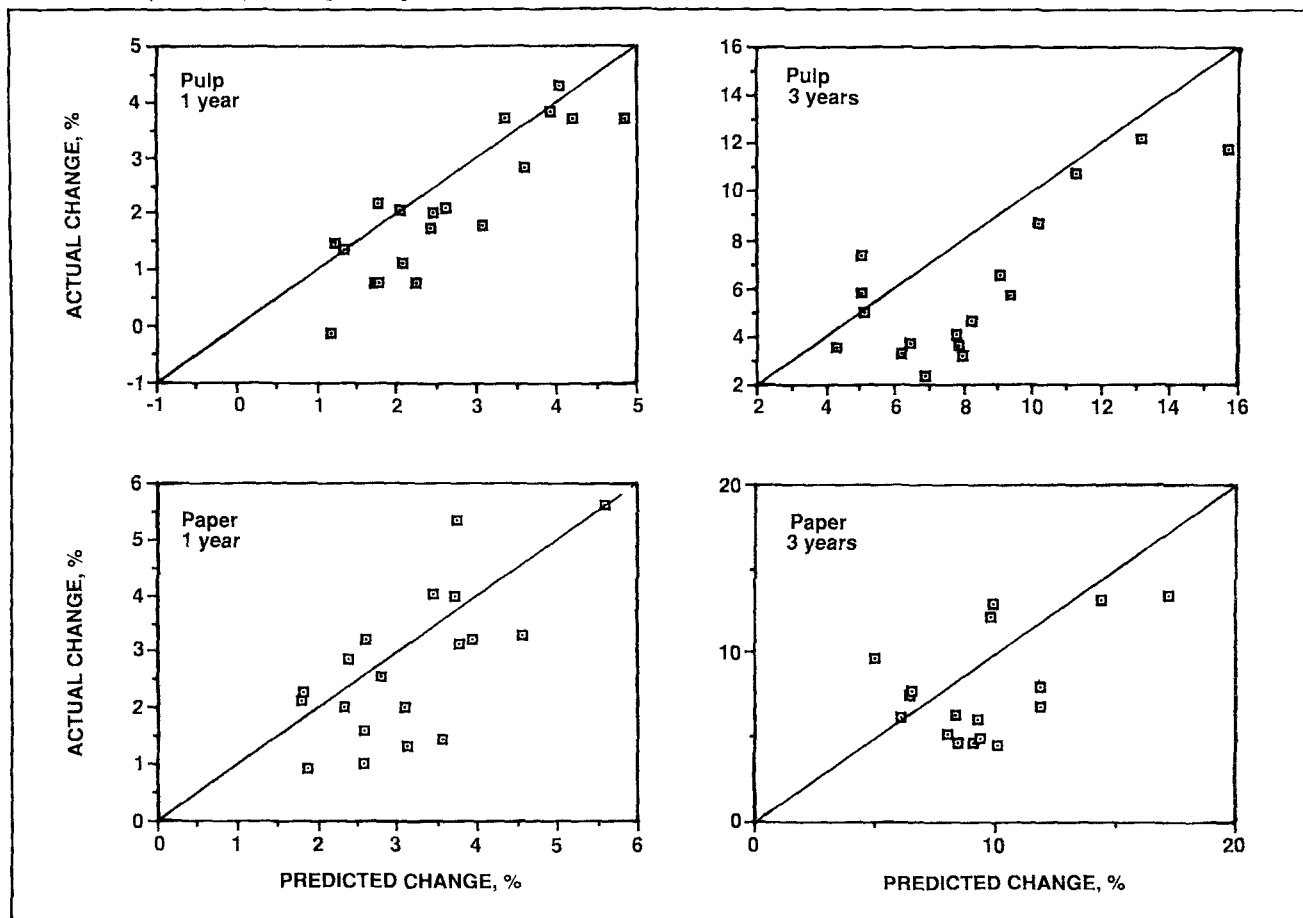
The surveys of future capacity require considerable time before they are completed and published. It is therefore desirable to produce early forecasts of capacity. Here, two simple forecasting approaches were tried: extrapolation and exponential smoothing. In both, past capacity data were used exclusively to predict future capacity. (Another approach, using an econometric model and past production is presented in the next section.) The simple extrapolation formula was:

$$p_e(t+h, t) = a(t, t-h) \quad (10)$$

for

$$t = h \text{ to } T-h$$

3. Actual and predicted percentage changes of world production capacity, 1969 to 1988



That is, the extrapolated rate of capacity change from t to $t+h$, $p_e(t+h, t)$, was simply equal to the last observed change of same duration.

The exponential smoothing formula was taken from Granger (2). It is an extension of Eq. 10 in that the predicted change is the weighted average of the last observed change and of the smoothed past changes:

$$\text{for } p_s(t+h, t) = \alpha a(t, t-h) + (1-\alpha)p_s(t+h-1, t-1) \quad (11)$$

$$t = h \text{ to } T-h$$

and

$$p_s(2h-1, h-1) = a(h, 0)$$

for

$$t = h$$

where

$p_s(t+h, t)$ = exponentially smoothed forecast made in year t for year $t+h$.

Following Granger's suggestion, the smoothing constant α was set at 0.3. Experiments showed that the accuracy of the forecasts would not have been much different with other values of the constant.

The results of forecasting capacity by Eqs. 10 and 11 are shown in Table V. For one-year forecasts, simple extrapolation was at least as accurate as the survey for pulp capacity in Spain and for paper capacity in Finland and Spain only. Exponential smoothing was as accurate or more accurate than the survey for pulp capacity in France and for paper capacity in Finland, Spain, and the United States. Exponentially smoothed forecasts were usually more accurate than simple extrapolations. For Australia, Portugal, and the United Kingdom, simple extrapolation gave forecasts that were substantially worse than the survey. But for the world, simple extrapolation gave forecasts that were nearly as accurate as the survey, especially for paper capacity.

For three-year forecasts, simple extrapolation gave forecasts that were at least as good as the survey for pulp capacity in France and for paper capacity in New Zealand, Norway, the United Kingdom, and the United States. Exponential smoothing performed better than the survey for pulp capacity in France and for paper capacity in Canada, Norway, Portugal, and the United States. Exponential smoothing was not generally better than simple extrapolation. The survey was considerably more accurate than either formula in several countries. At the world level, simple extrapolation gave substantially better three-year forecasts for paper (*RMSE* of 2.8%, against 3.6%) and slightly better forecasts for pulp. On the other hand, the exponential smoothing formula performed

IV. Root mean square errors of survey forecast corrected for past errors

Country	Product	1-year forecast (1970-88)		3-year forecast (1972-88)	
		Survey	Corrected	Survey	Corrected
Australia	Pulp	4.7	4.9	4.7	4.9
	Paper	6.0	6.7	10.5	11.6
Austria	Pulp	3.4	3.7	8.7	8.1
	Paper	4.1	3.9	12.4	8.9
Canada	Pulp	1.5	1.3	4.7	4.9
	Paper	1.6	1.2	4.8	4.5
Finland	Pulp	1.3	1.2	4.2	4.7
	Paper	4.5	5.6	3.3	4.2
France	Pulp	3.4	3.2	11.7	9.6
	Paper	4.4	5.0	15.6	16.5
West Germany	Pulp	5.0	5.1	8.2	8.1
	Paper	3.6	3.5	6.6	5.7
Japan	Pulp	2.1	2.4	5.7	6.5
	Paper	2.2	2.4	6.5	8.6
New Zealand	Pulp	16.5	18.4	17.5	20.9
	Paper	19.1	20.4	29.5	34.1
Norway	Pulp	6.1	5.7	13.1	12.0
	Paper	2.2	2.0	8.0	7.5
Portugal	Pulp	9.6	10.5	12.9	14.7
	Paper	18.8	24.4	26.6	38.4
Spain	Pulp	5.1	5.6	17.5	26.4
	Paper	12.3	13.7	33.4	54.3
Sweden	Pulp	1.4	1.3	6.2	5.3
	Paper	2.7	2.8	4.9	4.1
U.K.	Pulp	8.8	8.9	32.7	35.4
	Paper	3.0	2.4	13.5	11.3
U.S.	Pulp	0.9	1.0	1.7	1.9
	Paper	1.2	1.3	2.5	2.9
World	Pulp	0.8	0.7	3.0	2.4
	Paper	1.0	1.0	3.5	3.7

substantially worse for the world than the survey did, for both products.

Econometric models

While the extrapolation formulas were essentially empirical and used exclusively past data, the econometric models have a stronger theoretical basis. They rely on the accelerator theory of investment pioneered by Clark (7) and Chenery (8). In this model, future capacity change is a function of past production changes. Lee (9) has shown that this approach, applied to the U.S. pulp and paper industry, explained capacity changes at least as well as other, more complex theories that used considerably more information. Here the accelerator model had the following form:

$$p(t+h, t) = \alpha_0 + \alpha_1 q(t, t-h) + \alpha_2 q(t-1, t-h-1) + \alpha_3 q(t-2, t-h-2) \quad (12)$$

for

$$t = h+3 \text{ to } T-h$$

where

$$p(t+h, t) = \text{absolute capacity change from } t \text{ to } t+h$$

$q(t-1, t-h-1)$ = absolute observed change of production from year $t-i$ to t

$\alpha_0, \alpha_2, \alpha_3$ = parameters to be estimated by the forecaster, from data available in year t

Equations of this form were used by Gilles and Buongiorno (10) as part of a larger model to predict changes in the pulp and paper industries of North America.

Equation 12, like Eqs. 10 and 11, can be applied before the survey data are available. However, once the survey has been published, it may be useful to improve the forecasts. This idea suggests a model that combines the accelerator theory and the survey data:

$$p(t+h, t) = \alpha_0 + \alpha_1 q(t, t-h) + \alpha_2 q(t-1, t-h-1) + \alpha_3 q(t-2, t-h-2) + \beta p_s(t+h, t) \quad (13)$$

for

$$t = h+3 \text{ to } T-h$$

where

$p_s(t+h, t)$ = absolute capacity change predicted in the survey over the interval t to $t+h$

β = a parameter to be determined by the forecaster.

V. Root mean square errors of forecasts made by extrapolative methods

Country	Product	1-year forecast (1971-88)			3-year forecast (1975-88)		
		Survey	Simple extrapol.	Exponential smoothing	Survey	Simple extrapol.	Exponential smoothing
Australia	Pulp	4.8	10.6	7.8	5.1	14.8	12.7
	Paper	6.0	11.3	8.0	10.6	11.5	11.7
Austria	Pulp	3.5	6.9	5.8	9.5	17.1	12.9
	Paper	4.2	6.7	5.2	13.0	8.6	10.1
Canada	Pulp	1.6	3.2	2.2	3.8	4.6	4.3
	Paper	1.5	2.3	1.7	4.5	6.0	3.5
Finland	Pulp	1.4	3.2	2.8	3.6	8.3	7.7
	Paper	4.6	3.2	3.5	3.1	11.6	13.6
France	Pulp	3.5	3.8	3.5	12.8	7.1	8.0
	Paper	4.5	5.2	4.9	16.7	14.6	12.1
W. Germany	Pulp	5.2	7.5	6.0	9.0	17.1	15.3
	Paper	3.7	6.7	5.7	7.0	5.5	5.8
Japan	Pulp	2.1	3.6	3.8	5.8	7.7	11.0
	Paper	2.3	3.3	3.3	5.8	7.3	13.1
New Zealand	Pulp	17.0	26.4	20.3	10.9	54.8	45.5
	Paper	19.5	25.9	20.9	30.3	24.6	35.8
Norway	Pulp	6.2	8.4	6.9	14.2	18.8	18.0
	Paper	2.3	3.0	2.7	7.8	6.0	6.0
Portugal	Pulp	9.6	13.9	13.0	13.6	21.6	18.5
	Paper	18.2	31.4	22.2	25.3	40.4	19.1
Spain	Pulp	5.2	4.8	6.0	5.6	23.5	28.6
	Paper	12.7	12.7	12.2	5.4	7.2	45.2
Sweden	Pulp	1.4	5.0	4.2	6.6	10.2	12.7
	Paper	2.7	3.9	3.2	5.2	7.2	9.5
U.K.	Pulp	9.1	24.6	22.1	35.3	70.2	70.0
	Paper	3.1	6.3	5.9	13.4	10.4	15.1
U.S.	Pulp	0.9	1.4	1.2	1.7	2.6	2.0
	Paper	1.2	1.4	1.2	2.4	2.4	2.1
World	Pulp	0.8	1.1	1.1	3.1	3.0	4.0
	Paper	1.1	1.2	1.3	3.6	2.8	4.2

Models 12 and 13 were implemented using the capacity data used above, together with data on national annual production, contained in the FAO Yearbook of Forest Products (11). The coefficients were fitted by ordinary least squares, using data on capacity changes and production changes available up to the year when the prediction was made. So the predictions from Eqs. 12 and 13 were genuine, unconditional, forecasts. Since Eq. 13 had five parameters and the first observation was for the year 1969, the first estimate of the parameters for a one-year forecast could be made with data from 1969 to 1978, leading to the first forecast for the year 1979. Similarly, the first genuine three-year forecast could be made for the year 1983.

The root mean square errors obtained in forecasting capacity with Models 12 and 13 appear in Table VI. For one-year forecasts, the RMSEs of Model 12, which used past production only, were equal or smaller than those of the survey in France, Spain, Sweden, and the United States for paper capacity and in Norway for pulp capacity. Forecasts based on Model 13, which used the survey forecast in conjunction with past production, were better than those of the survey in Australia, Canada, France, the Federal Republic of Germany, Norway, and Portugal for paper capacity and in Australia and the Federal Republic of Germany for pulp capacity. For the world, both

econometric models gave worse one-year forecasts than the survey.

For three-year forecasts, the econometric models performed better than the survey in more cases. Model 12 led to equal or smaller *RMSEs* than the survey for paper capacity forecasts in six countries: Australia, Austria, Canada, France, Japan, and the United States and for pulp capacity forecasts in the Federal Republic of Germany, Japan, and the United States. Model 13 did better than the survey for paper capacity in ten of the fourteen countries and better than the survey for pulp capacity in seven countries, including some of the largest producers. For the United Kingdom, both models gave poor forecasts. Nevertheless, for the world, the two econometric models gave three-year forecasts of capacity that were substantially better than those of the survey.

Conclusions

Over the period considered, the survey forecasts tended to be systematically too high. Reasonably good forecasts could be obtained before the survey was published, using extrapolative or econometric methods. However, using the information in the survey once it was available did improve substantially the forecasts of capacity for individual countries and for the world.□

VI. Root mean square errors of forecasts made by the econometric model

Country	Product	1-year forecast (1979-88)			3-year forecast (1983-88)		
		Survey	Method 12	Method 13	Survey	Method 12	Method 13
Australia	Pulp	5.9	9.6	4.3	6.1	13.8	12.1
	Paper	5.0	8.2	4.2	12.7	10.7	7.4
Austria	Pulp	2.1	4.6	11.9	9.3	9.8	8.0
	Paper	3.0	4.2	4.6	15.3	11.9	6.1
Canada	Pulp	1.7	1.9	2.5	3.3	3.4	2.3
	Paper	1.3	1.4	1.2	5.1	2.3	2.2
Finland	Pulp	1.3	3.2	2.4	2.4	2.5	3.4
	Paper	0.9	3.0	1.9	3.3	7.4	3.0
France	Pulp	3.3	4.3	3.6	5.1	9.0	4.4
	Paper	4.2	3.6	2.2	21.8	6.7	18.1
W. Germany	Pulp	5.1	11.0	2.3	9.1	7.6	5.3
	Paper	4.4	5.1	2.4	6.7	7.1	6.1
Japan	Pulp	1.4	2.2	1.9	5.4	4.8	3.6
	Paper	1.2	2.6	2.0	4.7	3.0	2.7
New Zealand	Pulp	5.6	9.4	8.7	9.5	12.6	6.7
	Paper	23.9	27.6	31.4	41.1	45.2	49.5
Norway	Pulp	5.0	4.5	5.5	4.8	10.4	9.9
	Paper	2.6	2.9	2.3	4.8	4.6	4.2
Portugal	Pulp	4.6	9.7	6.5	4.6	12.9	12.1
	Paper	5.7	6.5	4.8	8.0	8.9	5.1
Spain	Pulp	1.9	5.8	5.0	3.5	5.7	11.4
	Paper	3.8	3.5	5.0	3.4	6.5	7.8
Sweden	Pulp	1.9	5.5	4.7	5.3	10.2	9.1
	Paper	3.7	3.6	4.3	2.8	9.8	8.8
U.K.	Pulp	11.4	39.4	43.7	35.9	68.9	93.6
	Paper	3.2	6.2	7.1	7.6	15.7	11.3
U.S.	Pulp	0.8	1.1	1.0	2.1	1.4	1.3
	Paper	0.7	0.7	0.7	1.8	1.3	0.7
World	Pulp	0.8	1.2	1.1	2.5	2.2	1.5
	Paper	0.8	0.9	0.7	2.9	2.5	1.2

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