THE SEASONAL PATTERNS AND THE LONG-RUN FORECASTING OF THE DEMAND FOR AND SUPPLY OF MILK IN KOREA*

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Introduction

The production of milk has been exceeding the domestic consumption in Korea since 1985. This is the third time that we have ever faced an excess supply of milk over our needs since the beginning of dairy industry in Korea. The first excess supply of milk took place in 1970 because of a sensational report by a news paper about a sanitary problem of colon bacillus contained in milk. The consumption of milk was sharply dropped, resulting in an excess supply of it. But it did not last long and soon after a year or so the demand for milk was recovered. The second shock on the demand side occurred around 1980 when we had a sudden recession in the Korean economy due to a severe drought, the second energy crisis, and a political instability(the late President Park was assassinated in October, 1979). In 1982, the demand for milk was also recovered, primarily due to a rapid growth of the economy. However, our recent experience with surplus of milk production is expected for long. Then, our concern would naturally be on the question of how much and how long the surplus of milk could exist.

The Korean dairy industry is rather a newly growing one. For the first time, twenty heads of Holstein were brought by a French man in 1902. Since then, the number of dairy cattle had hardly been increasing. In 1962, there existed just 2,406 heads of dairy cattle including 1,085 heads imported in that particular year. These cattles were being raised by 676 dairy farms, which indicated that the average number of dairy cattles per farm was just 3.6 heads in 1962. This was definitely a very small size in number. Right after the late Presi-

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dent Park visited New Zealand and Australia in 1968, he announced that the government should develop the dairy industry, so that idle resources could be utilized for producing dairy products. Based on the announcement, various programs for developing the dairy industry were launched by the government. As a result, the total herds of dairy cattle have been rapidly increasing up to 437,333 heads in 1986. The total number of dairy farms was 42,728, which indicated that the average herd size per farm was 10.2 heads in 1986. Per capita consumption of milk was 0.1kg in 1962, 2.2kg in 1970, 10.8kg in 1980, and 27.8kg in 1986. Although the milk consumption has dramatically increased during the last two decades, it still remains at a low level as compared with the consumption levels in advanced countries. This implies that there will be an enormous potentiality for expanding the demand for milk and dairy products in Korea.

Now, an important question appears to be why we are experiencing an excess supply or surplus of milk even though the consumption level is still very low. In fact whether we have an excess supply or demand becomes a matter of pricing in the market. What we have an excess supply of milk in Korea means that the price level of it has been high enough to create surplus in the production of fresh milk. Milk prices have been set by the Dairy Committee since 1973. These prices had been set once or twice a year at a high level especially during 1970's. If the milk prices were relatively high, then the production of milk would increase more than what we could consume. If this is true, then we need to adjust the level of milk price towards maintaining balance between the demand for and supply of milk. In order to adjust the milk price towards an optimum level, we need to forecast both the demand for and supply of milk at a given price level.

Another problem that we face in the dairy industry is a seasonal unbalance between the production and consumption of fresh milk in Korea. Both production and consumption of milk fluctuate differently each other. For instance, the consumption of milk increases in autumn while the production decreases. Therefore, we can have a seasonal excess demand over the production, although we have surplus annually in the production of milk. Interestingly, there occurrs an excess supply in summer because of sudden reduction in the consumption of milk. These unbalances between the consumption and production of milk cause a burden of storage costs to milk processing firms and dairy farmers' organizations. Thus, many people are concerned with how to maintain seasonal balance between the consumption and production of milk.

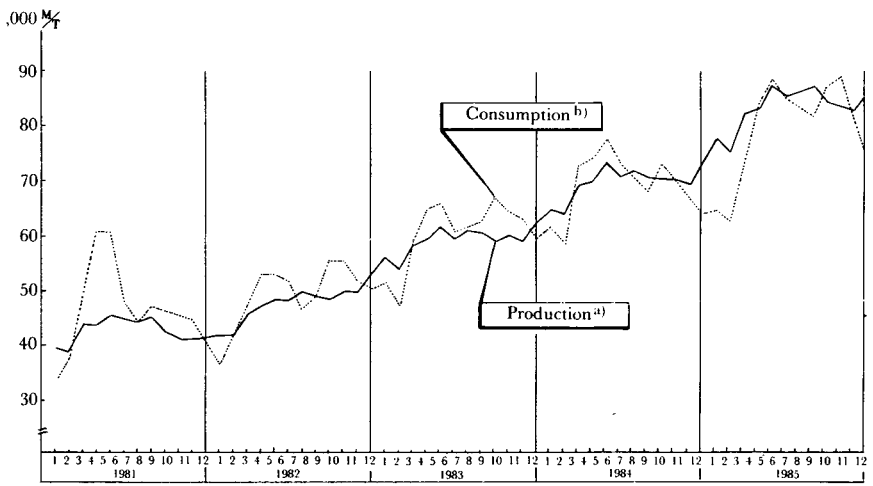
The pruposes of this study are to analyze seasonal variations of both the consumption and production of milk, and to forecast the demand for and supply of milk and dairy products.

Seasonal Patterns

First of all, let us take a look at time-series data on seasonal variations of the

consumption and production of milk, as shown in Figure 1. We can see that the consumption of milk fluctuates more widely than the production. Generally speaking, in spring and autumn the consumption of milk is greater than the production, which results in an excess demand for milk. On the other hand, in summer the consumption of milk is smaller than the production, which results in an excess supply of milk. The quantity and length of excess demand or supply vary from year to year. However, we do not know what is the real pattern of seasonal variations of those consumption and production of milk because the time-series data contain approximately four components: seasonality, trend, cycle, and randomness. In general, economic or business oriented time-series are made up of these four components. Therefore, we can assume here that the time-series data on both comsumption and production of milk are composed of the four factors. The trend represents the long-run behavior of the consumption or production of milk, and can be increasing, decreasing, or remaining constant. The cyclical factor represents the ups and downs of the consumption or production of milk. The seasonal factor relates to periodic fluctuations of constant length that are caused by such things as temperature, rainfall, timing of holidays, and the likes. Seasonality repeats itself at fixed intervals such as months or weeks, while a cyclical factor has a longer durations such as years(Makridakis & Wheelwright 1978).

FIGURE 1 **The Consumption and Production of Milk by Month, 1981 – 85**



a) Production: The total quatntity collected for processing.

b) Consumption: The total quantity consumed as food.

Source: National Livestock Cooperatives Federation.

We can identify trend, cyclical, and seasonal components separately by decomposition methods. The basic concept in such separation is empirical and consists of first removing seasonality, then trend, and finally cycle. Any residual is assumed to be randomness which can be identified, but it cannot be predicted. One can assume that the relationship among these four components is multiplicative as follows.

$$X_t = T_t \cdot C_t \cdot S_t \cdot R_t \tag{1}$$

where

X_t = the time series(actual data) at period t,
T_t = the trend component at period t,
C_t = the cyclical component at period t,
S_t = the seasonal component at period t,
R_t = the error or random component at period t,

One could compute a moving average, M_t, whose length, N, is equal to the length of seasonality, in order to eliminate seasonality and randomness. Thus, it can be denoted as follows.

$$M_t = T_t \cdot C_t \tag{2}$$

We can decompose (2) further by assuming some form of trend, for example, linear as follows.

$$T_t = a + bt \tag{3}$$

The estimated results are:

i) Milk consumption trend

$$T_t = 39.118 + 0.724t$$
$$(22.280)(14.469)$$
$$R^2 = 0.783, \qquad F = 209.35$$

ii) Milk production trend

$$T_t = 34.758 + 0.854t$$
$$(39.631)(33.906)$$
$$R^2 = 0.952, \qquad F = 1{,}149.61$$

*t-values are in parentheses.

If we divide (2) by (3), then we can obtain the cycle which will be isolated from the trend.

$$\frac{M_t}{T_t} = \frac{T_t \cdot C_t}{a + bt} = C_t \tag{4}$$

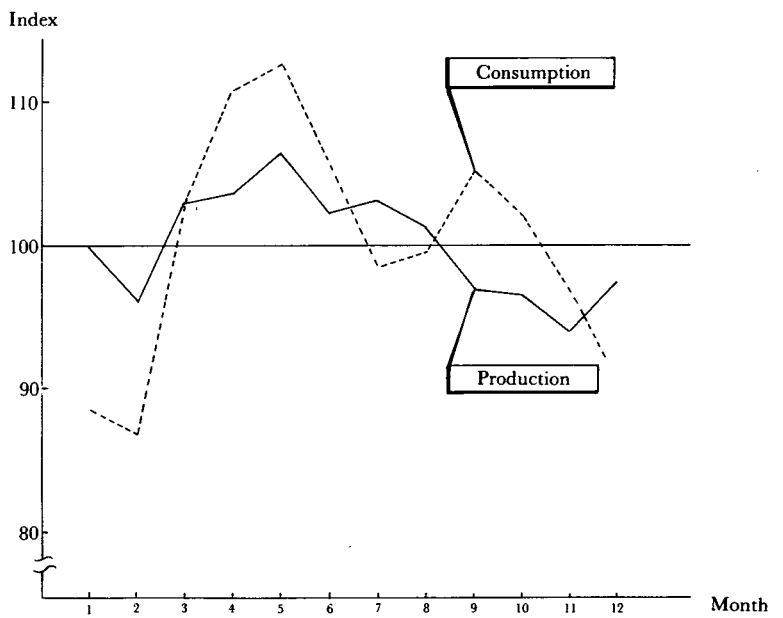
To isolate seasonality we can just divide (1) by (2).

$$\frac{X_t}{M_t} = \frac{T_t \cdot C_t \cdot S_t \cdot R_t}{T_t \cdot C_t} = S_t \cdot R_t \tag{5}$$

Thus dividing the original series by the moving averages gives the seasonal pattern and randomness. Randomness can be eliminated by averaging the different values of (5). This averaging can be done on the same months of different years. The result is a set of seasonal values, which is free of randomness, called seasonal indices.

Through a decomposition procedure, we obtained estimated results on trend, cyclical, and seasonality of the consumption and production of milk during the period Jan. 1981 – Dec. 1985, as shown in Tables 1 and 2. It is clear that the trend of both consumption and production is increasing, reflecting a rapid growth in the dairy industry. The cyclical component of the milk consumption has around two years cycle, while that of production has three years cycle. However, we connot imagine the type of seasonal behaviors. To see the seasonal behaviors of both the consumption and production of milk, let's put those estimated results on Figure 2. Based on the analytical results for the period Jan. 1981 – Dec. 1985 under investigation, there occurrs an excess demand over seasonal production between early March and the middle of June, and also between early August and early November. On the other hand, there exists a seasonal surplus in production over the consumption of milk between the middle of June and early August, and also between early November and the end of

FIGURE 2 **Seasonal Patterns of the Consumption and Production of Milk, 1981 - 85**



Note: Monthly average = 100.0

TABLE 1 **Trend, Cycle, and Seasonality of Milk Consumption Computed by Decomposition Methods, Jan. 1981 - Dec. 1985**

Year, Month	t	X_t	M_t	M_t'	$X_t \div M_t' S_t R_t$	S_t	T_t	C_t	$X_t \div S_t$
1981. 1	1	33.1				0.8873	39.842		37.3
2	2	37.2				0.8694	40.566		42.8
3	3	49.2				1.0278	41.290		47.9
4	4	61.1				1.1080	42.014		55.1
5	5	60.7				1.1247	42.738		54.0
6	6	47.8	46.5			1.0568	43.462		45.2
7	7	44.3	46.8	46.7	0.949	0.9846	44.186	1.0569	45.0
8	8	47.2	47.2	47.0	1.004	0.9955	44.910	1.0465	47.4
9	9	46.4	47.0	47.1	0.985	1.0510	45.634	1.0321	44.1
10	10	45.7	46.3	46.7	0.979	1.0184	46.358	1.0074	44.9
11	11	44.4	45.7	46.0	0.965	0.9693	47.082	0.9770	45.8
12	12	40.6	46.0	45.9	0.885	0.9072	47.806	0.9601	44.8
1982. 1	13	36.6	46.2	46.1	0.794	0.8873	48.530	0.9499	41.2
2	14	41.8	46.4	46.3	0.903	0.8694	49.254	0.9400	48.1
3	15	47.1	47.2	46.8	1.006	1.0278	49.978	0.9364	45.8
4	16	53.1	48.0	47.6	1.116	1.1080	50.702	0.9388	47.9
5	17	53.0	48.6	48.3	1.097	1.1247	51.426	0.9392	47.1
6	18	51.8	49.4	49.0	1.057	1.0568	52.150	0.9396	49.0
7	19	46.9	50.6	50.0	0.938	0.9846	52.874	0.9456	47.6
8	20	49.0	51.1	50.9	0.963	0.9955	53.598	0.9497	49.2
9	21	55.5	52.1	51.6	1.076	1.0510	54.322	0.9499	52.8
10	22	55.4	53.1	52.6	1.053	1.0184	55.046	0.9556	54.4
11	23	52.1	54.2	53.7	0.970	0.9693	55.770	0.9629	53.8
12	24	50.6	55.0	54.6	0.927	0.9072	56.494	0.9665	55.8
1983. 1	25	51.4	56.2	55.6	0.924	0.8873	57.218	0.9717	57.9
2	26	47.3	57.3	56.8	0.833	0.8694	57.942	0.9803	54.4
3	27	59.4	58.3	57.8	1.028	1.0278	58.666	0.9852	57.8
4	28	65.1	59.1	58.7	1.109	1.1080	59.390	0.9884	58.8
5	29	66.2	60.0	59.6	1.111	1.1247	60.114	0.9914	58.9

	6	30	60.8	60.8	60.4	1.007	1.0568	60.838	0.9928	57.5
	7	31	61.5	61.7	61.3	1.003	0.9846	61.562	0.9957	62.5
	8	32	62.6	62.7	62.2	1.006	0.9955	62.286	0.9986	62.9
	9	33	67.2	63.8	63.3	1.062	1.0510	63.010	1.0046	63.9
	10	34	64.5	64.6	64.2	1.005	1.0184	63.734	1.0073	63.3
	11	35	63.1	65.6	65.1	0.969	0.9693	64.458	1.0100	65.1
	12	36	59.6	66.6	66.1	0.902	0.9072	65.182	1.0141	65.7
1984.	1	37	61.7	67.4	67.0	0.921	0.8873	65.906	1.0166	69.5
	2	38	58.9	67.9	67.7	0.870	0.8694	66.630	1.0161	67.7
	3	39	73.0	68.4	68.2	1.070	1.0278	67.354	1.0126	71.0
	4	40	74.2	68.9	68.7	1.080	1.1080	68.078	1.0091	67.0
	5	41	77.9	69.2	69.1	1.127	1.1247	68.802	1.0043	69.3
	6	42	73.3	69.6	69.4	1.056	1.0568	69.526	0.9982	69.4
	7	43	70.8	69.9	69.8	1.014	0.9846	70.250	0.9936	71.9
	8	44	68.3	70.2	70.1	0.974	0.9955	70.974	0.9877	68.6
	9	45	73.4	70.3	70.3	1.044	1.0510	71.698	0.9805	69.8
	10	46	70.8	71.1	70.7	1.001	1.0184	72.422	0.9762	69.5
	11	47	67.2	72.0	71.6	0.939	0.9693	73.146	0.9789	69.3
	12	48	64.0	73.0	72.5	0.883	0.9072	73.870	0.9815	70.5
1985.	1	49	64.7	74.1	73.6	0.879	0.8873	74.594	0.9867	72.9
	2	50	62.9	75.5	74.8	0.841	0.8694	75.318	0.9931	72.3
	3	51	73.9	76.7	76.1	0.971	1.0278	76.042	1.0008	71.9
	4	52	84.3	78.3	77.5	1.088	1.1080	76.766	1.0096	76.1
	5	53	88.7	79.4	78.9	1.124	1.1247	77.490	1.0182	78.9
	6	54	85.4	80.2	79.8	1.070	1.0568	78.214	1.0203	80.8
	7	55	83.9				0.9846	78.938		85.2
	8	56	84.5				0.9955	79.662		84.9
	9	57	87.8				1.0510	80.386		83.5
	10	58	89.5				1.0184	81.110		87.9
	11	59	80.6				0.9693	81.834		83.2
	12	60	73.6				0.9072	82.558		81.1

TABLE 2 **Trend, Cycle, and Seasonality of Milk Production Computed by Decomposition Methods, Jan. 1981 - Dec. 1985**

Year, Month	t	X_t	M_t	M_t'	$X_t \div M_t' S_t R_t$	S_t	T_t	C_t	$X_t \div S_t$
1981. 1	1	39.5				1.0006	35.612		39.5
2	2	38.6				0.9617	36.466		40.1
3	3	44.1				1.0304	37.320		42.8
4	4	43.8				1.0352	38.174		42.3
5	5	45.5				1.0634	39.028		42.8
6	6	44.8	42.7			1.0216	39.882		43.9
7	7	44.2	43.0	42.9	1.030	1.0302	40.736	1.0531	42.9
8	8	45.5	43.3	43.2	1.053	1.0111	41.590	1.0387	45.0
9	9	42.4	43.4	43.4	0.977	0.9695	42.444	1.0225	43.7
10	10	41.4	43.7	43.6	0.950	0.9642	43.298	1.0070	42.9
11	11	41.3	44.0	43.9	0.941	0.9386	44.152	0.9943	44.0
12	12	41.6	44.3	44.2	0.941	0.9737	45.006	0.9821	42.7
1982. 1	13	42.2	44.8	44.6	0.946	1.0006	45.860	0.9725	42.2
2	14	42.3	45.1	45.0	0.940	0.9617	46.714	0.9633	44.0
3	15	46.1	45.6	45.4	1.015	1.0304	47.568	0.9544	44.7
4	16	47.5	46.3	46.0	1.033	1.0352	48.422	0.9500	45.9
5	17	48.7	47.1	46.7	1.043	1.0634	49.276	0.9477	45.8
6	18	48.4	48.0	47.6	1.017	1.0216	50.130	0.9495	47.4
7	19	50.2	49.2	48.6	1.033	1.0302	50.984	0.9532	48.7
8	20	49.0	50.2	49.7	0.986	1.0111	51.838	0.9588	48.5
9	21	48.7	51.2	50.7	0.961	0.9695	52.692	0.9622	50.2
10	22	50.1	52.2	51.7	0.969	0.9642	53.546	0.9655	52.0
11	23	49.8	53.3	52.8	0.943	0.9386	54.400	0.9706	53.1
12	24	53.3	54.2	53.8	0.991	0.9737	55.254	0.9737	54.7
1983. 1	25	56.6	55.1	54.7	1.035	1.0006	56.108	0.9749	56.6
2	26	53.8	56.1	55.6	0.968	0.9617	56.962	0.9761	55.9
3	27	58.1	56.9	56.5	1.028	1.0304	57.816	0.9772	56.4
4	28	59.4	57.8	57.4	1.035	1.0352	58.670	0.9784	57.4
5	29	61.9	58.6	58.2	1.064	1.0634	59.524	0.9778	58.2

	6	30	59.6	59.4	59.0	1.010	1.0216	60.378	0.9772	58.3
	7	31	61.3	60.1	59.8	1.025	1.0302	61.232	0.9766	59.5
	8	32	60.5	60.9	60.5	1.000	1.0111	62.086	0.9745	59.8
	9	33	58.9	61.9	61.4	0.959	0.9695	62.940	0.9755	60.8
	10	34	60.4	62.7	62.3	0.970	0.9642	63.794	0.9766	62.6
	11	35	59.1	63.7	63.2	0.935	0.9386	64.648	0.9776	63.0
	12	36	62.7	64.6	64.2	0.977	0.9737	65.502	0.9801	64.4
1984.	1	37	65.2	65.5	65.1	1.002	1.0006	66.356	0.9811	65.2
	2	38	64.0	66.4	66.0	0.970	0.9617	67.210	0.9820	66.5
	3	39	69.3	67.4	66.9	1.036	1.0304	68.064	0.9829	67.3
	4	40	70.0	68.3	67.9	1.031	1.0352	68.918	0.9852	67.6
	5	41	73.4	69.1	68.7	1.068	1.0634	69.772	0.9846	69.0
	6	42	70.9	70.1	69.6	1.019	1.0216	70.626	0.9855	69.4
	7	43	72.1	71.1	70.6	1.021	1.0302	71.480	0.9877	70.0
	8	44	71.2	72.1	71.6	0.994	1.0111	72.334	0.9899	70.4
	9	45	70.5	73.2	72.7	0.970	0.9695	73.188	0.9933	72.7
	10	46	70.6	74.3	73.8	0.957	0.9642	74.042	0.9967	73.2
	11	47	69.3	75.5	74.9	0.925	0.9386	74.896	1.0001	73.8
	12	48	74.2	76.7	76.1	0.975	0.9737	75.750	1.0046	76.2
1985.	1	49	77.9	77.9	77.3	1.008	1.0006	76.604	1.0091	77.9
	2	50	75.3	79.3	78.6	0.958	0.9617	77.458	1.0147	78.3
	3	51	82.4	80.5	79.9	1.031	1.0304	78.312	1.0203	80.0
	4	52	83.5	81.6	81.1	1.030	1.0352	79.166	1.0244	80.7
	5	53	87.7	82.8	82.2	1.067	1.0634	80.020	1.0272	82.5
	6	54	85.7	83.8	83.3	1.029	1.0216	80.874	1.0300	83.9
	7	55	86.6				1.0302	81.728		84.1
	8	56	87.6				1.0111	82.582		86.6
	9	57	84.9				0.9695	83.436		87.6
	10	58	84.3				0.9642	84.290		87.4
	11	59	83.3				0.9386	85.144		88.7
	12	60	86.5				0.9737	85.998		88.8

February. Thus, it becomes clear that we have a seasonal excess demand for fresh milk in spring and autumn, while we have a seasonal excess supply in summer and winter. In addition, we know that both the consumption and production of milk fall in winter, and the consumption alone decreases in summer.

Why does the seasonal variation in the consumption and production of milk repeatedly occur? One of the major reasons for having the seasonal variation of milk consumption is weather condition. Korean people consume less milk in both seasons of summer and winter because they consider it as a drink like soda. We know that most of western people drink milk as a food, not a soda. But that is not true in Korea. That's why most of the Korean people tend to drink other soda instead of milk in summer because of hot temperature, while they drink less of all drinks including milk in winter because of cold weather. Another reason might be a very typical one that is the school lunch program in Korea. The government in cooperation with milk processing companies provides milk and other food for lunch to around one third of the

TABLE 3 **Forecasting Results of the Demand and Production**

Year, Month		Production (A)	Consumption (B)	A−B	Year, Month		Production (A)	Consumption (B)	A−B
1986.	1	86.9	73.9	13.0	1990.	1	127.9	104.7	23.2
	2	84.3	73.0	11.3		2	123.8	103.2	20.6
	3	91.3	87.1	4.2		3	133.5	122.8	10.7
	4	92.6	94.7	△2.1		4	135.0	133.2	1.8
	5	96.0	96.9	△0.9		5	139.6	136.0	3.6
	6	93.1	91.8	1.3		6	135.0	128.6	6.4
	7	94.8	86.3	8.5		7	137.0	120.5	16.5
	8	93.9	88.0	5.9		8	135.3	122.5	12.8
	9	90.8	93.6	△2.8		9	130.6	130.1	0.5
	10	91.2	91.5	△0.3		10	130.7	126.8	3.9
	11	89.5	87.7	1.8		11	128.0	121.4	6.6
	12	93.7	82.8	10.9		12	133.6	114.3	19.3
	Total	1,098.1	1,047.3	50.8		Total	1,590.0	1,464.1	125.9
1987.	1	97.2	81.6	15.6	1991.	1	138.2	112.4	25.8
	2	94.2	80.6	13.6		2	133.6	110.8	22.8
	3	101.8	96.0	5.8		3	144.0	131.7	12.3
	4	103.2	104.3	△1.1		4	145.6	142.8	2.8
	5	106.9	106.7	0.2		5	150.5	145.8	4.7
	6	103.6	101.0	2.6		6	145.4	137.7	7.7
	7	105.3	94.8	10.5		7	147.5	129.0	18.5
	8	104.2	96.6	7.6		8	145.7	131.2	14.5
	9	100.8	102.7	△1.9		9	140.5	139.3	1.2
	10	101.0	100.3	0.7		10	140.6	135.7	4.9
	11	99.2	96.2	3.0		11	137.6	129.8	7.8
	12	103.7	90.7	13.0		12	143.6	122.2	21.4
	Total	1,221.1	1,151.5	69.6		Total	1,712.8	1,568.4	144.4

elementary school children. However, this lunch is not served during the vacations in both summer and winter. This affects the consumption of milk, which is cut down. Let us turn to the reasons for having seasonal variations in the production of milk. The milk production increases in spring because of good pasture for dairy cattles, and in winter because of having calves newly born in most of dairy farms. On the other hand, the milk production decreases in autumn because of poor pasture for dairy cattles. Having considered all of these factors affecting the seasonal variations, the patterns that we found may continue at least in the foreseeable future because these factors are not expected to be changed soon.

Forecasting by Month

To forecast the monthly demand for and supply of milk, we have to decide what components would be included in the seasonal pattern. What we cannot forecast is the random variable, therefore it should be excluded. In addition, we

of Raw Milk by Month, Jan. 1986 - Dec. 2001

Unit : 1,000㎏

Year, Month		Production (A)	Consumption (B)	A−B	Year, Month		Production (A)	Consumption (B)	A−B
1988.	1	107.4	89.3	18.1	1996.	1	189.4	151.0	38.4
	2	104.1	88.1	16.0		2	182.9	148.6	34.3
	3	112.4	104.9	7.5		3	196.8	176.4	20.4
	4	113.8	113.9	△0.1		4	198.6	190.9	7.7
	5	117.8	116.5	1.3		5	205.0	194.6	10.4
	6	114.0	110.2	3.8		6	197.8	183.7	14.1
	7	115.9	103.4	12.5		7	200.3	171.8	28.5
	8	114.6	105.3	9.3		8	197.5	174.4	23.1
	9	110.7	111.9	△1.2		9	190.2	184.9	5.3
	10	110.9	109.1	1.8		10	190.0	179.9	10.1
	11	108.8	104.6	4.2		11	185.7	172.0	13.7
	12	113.7	98.5	15.2		12	193.5	161.6	31.9
	Total	1,344.1	1,255.7	88.4		Total	2,327.7	2,089.8	237.9
1989.	1	117.7	97.0	20.7	2001.	1	240.7	189.5	51.2
	2	113.9	95.7	18.2		2	232.2	186.3	45.9
	3	122.9	113.9	9.0		3	249.6	221.0	28.6
	4	124.4	123.6	0.8		4	251.7	239.1	12.6
	5	128.7	126.2	2.5		5	259.5	243.5	16.0
	6	124.5	119.4	5.1		6	250.1	229.6	20.5
	7	126.4	111.9	14.5		7	253.1	214.6	38.5
	8	124.9	113.9	11.0		8	249.3	217.7	31.6
	9	120.6	121.0	△0.4		9	239.9	230.6	9.3
	10	120.8	118.0	2.8		10	239.4	224.2	15.2
	11	118.4	113.0	5.4		11	233.8	214.1	19.7
	12	123.7	106.4	17.3		12	243.4	201.0	42.4
	Total	1,466.9	1,360.0	106.9		Total	2,942.7	2,611.2	331.5

can exclude cyclical component because here what we try to forecast is seasonal variation instead of cyclical component. However, we can be better off by including the trend component in the forecasting because it allows more realistic estimate to users. Therefore, we can have a seasonal forecasting on the consumption and production of milk based on the model of $X_t = S_t T_t$. Out of all the forecasts done by month between Jan. 1986 – Dec. 2001 some of them for important years are shown in Table 3.

As we see the forecasting results in Table 3, there may occur surplus in the production over the consumption of milk for eight months in 1986 and at the end of the year. It is expected to have 50.8 thousand metric tons of raw milk as surplus. This production surplus will be expanding up to the year 2001 unless some actions are taken. If the surplus situation turns out to be persistent in the long-run, there will be many problems to be appeared in the dairy industry. Dairy farmers may loose their income, and also milk processing companies may have difficulties in both operation and financial situation.

Demand Forecasting by Year

In forecasting economic elements we can not stick on a single method like the decomposition method which is actually a tool for the analysis of seasonal pattern. Although it could be definitely one way of forecasting both the consumption and production of milk, it could be a safe way to do a forecasting work by employing other alternative methods because there are no perfect tools and there exist differences in estimates among various approaches. Hence, this time we could approach to forecasting by adopting cause and effect equations.

First of all, to forecast the annual demand for milk, let us approach in two ways: a simple relationship and a more complicated multiple regression equations. The simple relationship here is a cause and effect equation, which contains just two variables of population and income only as follows:

$$\dot{D}_j = \dot{N} + \eta_j \dot{Y}$$

where

$\dot{D}_j$ = rates of change in the demand for jth milk and other dairy products,
$\dot{N}$ = increasing rates of population,
η_j = income elasticities for jth milk and other dairy products,
$\dot{Y}$ = rates of change in per capita disposable income.

The adjusted coefficients for these variables in some selected years are shown in Table 4. Both the income elasticities and population increasing rates are adjusted to be decreasing towards the year 2001 based on changing patterns of the variables in advanced countries like Japan. Let us set up Scenario I to be the demand estimates obtained from this simple relationship.

TABLE 4 **Adjusted Coefficients for Selected Variables Affecting the Demand for Milk, 1985 - 2001**

	1985	1991	2001
Income elasticities			
Milk	1.540	1.502	1.442
Infant milk powder	0.431	0.431	0.431
Butter	3.022	2.296	1.088
Cheese	2.767	3.456	2.985
Population increasing rates(%)	1.44	1.25	0.87
Per capita income growth(%)	5.5	5.6	5.6

Next, we can approach to forecasting the demand for raw milk and dairy products by utilizing complicated multiple regression equations. The estimated demand functions are as follows:

1) The demand function for raw milk, 1969–84

$$\ln Q_{Rt} = \underset{(3.265)}{13.8973} - \underset{(1.994)}{1.3031} \ln P_{Rt} - \underset{(0.015)}{0.0002} \ln D_1 P_{Rt} - \underset{(2.971)}{1.0187} \ln P_{St} + \underset{(7.901)}{1.6435} \ln Y_{t75} + \underset{(4.143)}{0.3295} D_2$$

$$R^2 = 0.994 \qquad F = 324.693$$

2) The demand function for infant milk powder, 1975–84

$$\ln Q_{It} = \underset{(2.866)}{15.5486} - \underset{(2.940)}{1.6329} \ln P_{It} + \underset{(0.378)}{0.0069} \ln D_1 P_{It} + \underset{(1.063)}{0.4307} \ln Y_{t80}$$

$$R^2 = 0.942 \qquad F = 32.159$$

3) The demand function for butter, 1973–84

$$\ln Q_{Bt} = \underset{(2.000)}{19.7654} - \underset{(2.641)}{2.5466} \ln P_{Bt} - \underset{(1.909)}{0.0474} D_1 P_{Bt} - \underset{(3.025)}{2.0051} \ln P_{Mt} + \underset{(6.178)}{3.1426} \ln Y_{t80}$$

$$R^2 = 0.974 \qquad F = 65.128$$

4) The demand function for cheese, 1978–84

$$\ln Q_{Ct} = \underset{(1.070)}{12.6505} - \underset{(2.472)}{3.2094} \ln P_{Ct} + \underset{(0.174)}{0.0092} \ln D_1 P_{Ct} + \underset{(1.355)}{2.6527} \ln Y_{t80}$$

$$R^2 = 0.712 \qquad F = 2.475$$

* t-values are in parentheses.

where

Q_{Rt} = per capita consumption of raw milk in period t, *gr.*,
Q_{It} = per capita consumption of infant milk powder in period t, *gr.*,
Q_{Bt} = per capita consumption of butter in period t, *gr.*,
Q_{Ct} = per capita consumption of cheese in period t, *gr.*,
P_{Rt} = the wholesale price of milk(in real term:1975=100) in period t, Won/*kg*,
P_{It} = the retail price of infant milk powder (in real term:1980=100) in period t, Won/450*gr.*,
P_{Bt} = the retail price of butter (in real term:1980=100)in period t, Won/450*gr.*,
P_{Ct} = the retail price of cheese(in real term:1980=100)in period t, Won/200*gr.*,
P_{St} = the retail price of soft drinks(in real term:1975=100)in period t, Won/340*ml*,
P_{Mt} = the retail price of margarine(in real term:1980=100)in period t, Won/450*gr.*,
Y_{t75} = per capita disposable income(in real term:1975=100)in period t, 10,000Won,
Y_{t80} = per capita disposable income(in real term:1980=100)in period t, 10,000Won,
D_1 = dummy variable reflecting a sign of price change, as follows:
$D_1 = 0$, if $P_t/P_{t-1} > 1$
$D_1 = 1$, if $P_t/P_{t-1} < 1$
D_2 = dummny variable representing whether the school lunch program with the supply of milk does exist or not.

In order to forecast the demand for milk and other dairy products by utilizing these equations, we need to predict the independent variables that are included in the demand equations. The trend equations of some important independent variables are as follows:

$$P_{Rt} = 134.727 - 17.369 \ln T \qquad R^2 = 0.905$$
$$(43.284) \quad (11.515)$$
$$P_{It} = 1481.848 - 204.409 \ln T \qquad R^2 = 0.964$$
$$(63.558) \quad (14.579)$$
$$P_{Bt} = 1602.696 - 126.799 \ln T \qquad R^2 = 0.476$$
$$(20.993) \quad (3.016)$$
$$P_{Ct} = 1516.217 - 196.186 \ln T \qquad R^2 = 0.864$$
$$(31.704) \quad (5.632)$$
$$Y_{t75} = 10.5625 + 18.007 T \qquad R^2 = 0.925$$
$$(7.952) \quad (13.109)$$
$$Y_{t80} = 23.518 + 3.938 T \qquad R^2 = 0.918$$
$$(7.725) \quad (12.510)$$

We can obtain future values of these variables by simply putting a corresponding year into the time factor. In addition, the annual average price for the period 1969–84 is utilized as a future price of soft drinks P_{St}, and again the average price for the period 1973–84 is employed as a future price of margarine P_{Mt}. Let us set up Scenario II to be the demand estimates obtained from the complicated regression equations.

TABLE 5 **Forecasting Results of the Demand for Raw Milk and Dairy Products, 1985-2001**

Year	Raw Milk		Infant milk powder		Butter		Cheese	
	SI	SII	SI	SII	SI	SII	SI	SII
	----- 1,000 ₩ -----		---------- ₩ ----------					
1985	990	990	18,750	18,750	2,844	2,844	478	478
1986	1,006	951	19,326	22,471	2,757	1,624	403	430
1987	1,105	1,048	20,051	23,774	3,217	1,858	475	519
1988	1,212	1,150	20,798	25,067	3,731	2,116	563	618
1989	1,329	1,259	21,566	26,436	4,301	2,400	670	732
1990	1,457	1,375	22,358	27,796	4,929	2,713	804	862
1991	1,598	1,491	23,177	29,090	5,625	3,046	970	1,005
1992	1,751	1,614	24,016	30,411	6,378	3,409	1,175	1,161
1993	1,917	1,744	24,875	31,757	7,186	3,804	1,432	1,339
1994	2,098	1,879	25,754	33,130	8,045	4,232	1,753	1,534
1995	2,294	2,022	26,654	34,530	8,949	4,697	2,134	1,749
1996	2,507	2,171	27,575	35,956	9,890	5,199	2,583	1,983
1997	2,738	2,327	28,517	37,364	10,860	5,742	3,118	2,251
1998	2,989	2,490	29,481	38,847	10,789	6,328	3,730	2,534
1999	3,260	2,660	30,467	40,309	11,693	6,958	4,437	2,847
2000	3,554	2,838	31,476	41,849	12,590	7,635	5,248	3,193
2001	3,871	3,024	32,509	43,368	13,466	8,363	6,171	3,562

The forecasting results of the demand for raw milk and dairy products by employing two different approaches are summarized in Table 5. In this result we can find out some differences in estimates between approaches.

The estimates of Scenario I are higher than those of Scenario II except for the infant milk powder. Whether estimates are accurate or not depends upon situations of those included independent variables in coming years.

Supply Forecasting by Year

To examine whether we could have production surplus or not, we need to forecast the supply of raw milk and dairy products like what we did in the demand side. In supply side, we can simply employ a multiple regression analysis. The estimated supply equations are as follows:

1) The supply function of raw milk, 1969–84.

$$\ln Q_{Rt} = \underset{(1.245)}{-27.6657} + \underset{(0.191)}{0.1798} \ln P_{Rt-2} + \underset{(1.362)}{1.5690} \ln P_{Ft-2} + \underset{(1.706)}{1.9580} \ln P_{Kt-2} + \underset{(2.034)}{1.9562} \ln W_{t-2} + \underset{(3.681)}{0.9783} \ln T$$

$$R^2 = 0.969 \qquad F = 61.715$$

2) The supply function of infant milk powder, 1975–84

$$\ln Q_{Jt} = 7.1695 + 0.2294 \ln P_{Jt} + 0.4876 \ln T$$
$$(1.110) \quad (0.260) \quad (3.270)$$
$$R^2 = 0.974 \qquad F = 130.39$$

3) The supply function of butter, 1973–84

$$\ln Q_{Bt} = -6.5701 + 1.4245 \ln P_{Bt} + 1.5318 \ln T$$
$$(0.780) \quad (1.249) \quad (9.991)$$
$$R^2 = 0.994 \qquad F = 75.573$$

4) The supply function of cheese, 1978–84

$$\ln Q_{Ct} = 0.0599 + 1.5270 \ln P_{Ct} - 1.2900 \ln P_{Rt} + 0.7939 \ln T$$
$$(0.003) \quad (0.474) \quad (0.621) \quad (1.591)$$
$$R^2 = 0.777 \qquad F = 3.483$$

* t-values are in parentheses.

where

Q_{Rt} = the production of raw milk in period t, 톤,
Q_{Jt} = the production of infant milk powder in period t, 톤,
Q_{Bt} = the production of butter in period t, 톤,
Q_{Ct} = the production of cheese in period t, 톤,
P_{Rt-i} = the price of raw milk (in real term: 1980=100)in period t–i, Won/kg,
P_{Jt-i} = the retail price of infant milk powder(in real term: 1980=100) in period t–i, Won/450gr.,
P_{Bt-i} = the retail price of butter (in real term:1980=100) in period t–i, Won/450gr.,
P_{Ct-i} = the retail price of cheese(in real term:1980=100) in period t–i, Won/200gr.,
P_{Ft-i} = the price index of feed(1980=100) in period t–i,
P_{Kt-i} = the price of beef cattle(in real term: 1980=100) in period t–i, 1,000Won/head(400kg),
W_{t-i} = farm wage (in real term: 1980=100) in period t–i, Won/day for an adult male,
T = technology(years).

In order to forecast the supply of raw milk and dairy products, we again need to predict future values of the independent variables included in the supply equations. They can be obtained from the following trend equations:

$$P_{Rt} = 405.098 - 64.736 \ln T \qquad R^2 = 0.848$$
$$(26.746) \quad (8.820)$$
$$P_{Jt} = 1481.848 - 204.409 \ln T \qquad R^2 = 0.964$$
$$(63.558) \quad (14.579)$$
$$P_{Bt} = 1602.696 - 126.799 \ln T \qquad R^2 = 0.476$$
$$(20.993) \quad (3.016)$$

TABLE 6 **Forecasting Results of the Supply of Raw Milk and Dairy Products, 1985-2001**

Year	Raw milk	Infant milk powder	Butter	Cheese
	1,000 M/T	M/T		
1985	1,006	19,095	3,266	504
1986	951	21,157	2,102	314
1987	1,062	21,913	2,314	359
1988	1,179	22,637	2,531	407
1989	1,301	23,330	2,752	462
1990	1,411	23,997	2,980	529
1991	1,543	24,640	3,211	603
1992	1,657	25,261	3,447	691
1993	1,799	25,862	3,689	796
1994	1,947	26,444	3,934	936
1995	2,102	27,009	4,183	1,101
1996	2,223	27,558	4,436	1,314
1997	2,387	28,092	4,693	1,593
1998	2,550	28,613	4,955	2,027
1999	2,719	29,121	5,219	2,621
2000	2,894	29,617	5,488	3,567
2001	3,073	30,101	5,759	5,275

$$P_{Ct} = 1516.217 - 196.186 \ln T \qquad R^2 = 0.864$$
$$(31.704) \quad (5.632)$$
$$P_{Ft} = 184.710 - 29.267 \ln T \qquad R^2 = 0.499$$
$$(11.411) \quad (3.731)$$
$$P_{Kt} = 552.270 + 119.937 \ln T \qquad R^2 = 0.401$$
$$(6.835) \quad (3.063)$$
$$W_t = 3085.325 + 195.241 T \qquad R^2 = 0.763$$
$$(10.973) \quad (6.714)$$

The future values of the independent variables can be obtained by simply putting corresponding years into the time factor in the equations. The forecasting results of the supply of raw milk and other dairy products are summarized in Table 6.

Summary and Implications

Now, we are ready to compare the forecasting demand for with the supply of raw milk and dairy products, and draw some implications from it. In Table 7, the forecasting results of both the demand for and supply of the products are summarized in three years representing the present, the mid and long-term predictions. It is interesting to observe that the forecasting results vary depending upon approaches in terms of methodology and factors included. In 1985 there was actually an excess supply of milk and dairy products. However, the years 1991 and 2001 we may have an excess supply or an excess demand de-

pending on the situation of the dairy industry. Here, the situation means that some of the economic variables affecting both the demand for and supply of the products are assumed to be changed or unchanged. If we assume that the population and disposable income continue to increase and other factors remain constant as they used to be in recent years, then we are expected to have an excess demand for milk and dairy products in coming years. But this is unlikely. On the other hand, if the situation in which the relative price of raw milk is maintained high continues, then we may have an excess supply of raw milk in coming years. However, under the same situation there may be an excess demand for both infant milk powder and butter, while there will be an excess supply of cheese in the long-run. Even if the dairy farmers continue to follow producing raw milk as they used to do seasonally, there will be an excess supply of milk in the long-run as well as the mid-term.

We could draw some implications from the forecasting results on milk and dairy products. Firstly, the government needs to develop new policy measure to maintain balance between the demand for and supply of raw milk so that the farmers will not suffer from the problem of surplus in milk production. Alternatives for consideration would be cutting down the set price or establishing a system of production quota.

Secondly, it is needed to establish a policy measure to reallocate raw milk produced to different users at different prices, so that both the excess supply of raw milk and the excess demand for infant milk powder and butter will be disappeared in such a way that more of raw milk can be transferred for making the dairy products at a cheap price. This reallocation measure can be carried out by having a price discrimination that is a program in which a relatively high price set for the raw milk utilized for fresh drinking milk and a relatively low price set for the raw milk utilized for dairy products.

TABLE 7 **Summary of the Forecasting Demand for and the Supply of Raw Milk and Dairy Products, 1985, 1991, 2001**

Year	Commodity	Unit	Demand			Supply		Excess		
			DI	DII	DIII	SI	SII	DI-SI	DII-SI	DIII-SII
	Raw milk	1,000톤	990	990	990	1,006	1,006	16(ES)	16(ES)	16(ES)
1985	Infant milk powder	톤	18,750	18,750		19,095		345(ES)	345(ES)	
	Butter	톤	2,844	2,844		3,266		422(ES)	422(ES)	
	Cheese	톤	478	478		504		26(ES)	26(ES)	
	Raw milk	1,000톤	1,598	1,491	1,568	1,543	1,713	55(ED)	52(ES)	145(ES)
1991	Infant milk powder	톤	23,177	29,090		24,640		1,463(ES)	4,450(ED)	
	Butter	톤	5,625	3,046		3,211		2,414(ED)	165(ES)	
	Cheese	톤	970	1,005		603		367(ED)	402(ED)	
	Raw milk	1,000톤	3,871	3,024	2,611	3,073	2,943	798(ED)	49(ES)	332(ES)
2001	Infant milk powder	톤	32,509	43,368		30,101		2,408(ED)	13,267(ED)	
	Butter	톤	13,466	8,363		5,759		7,707(ED)	2,604(ED)	
	Cheese	톤	6,171	3,562		5,275		896(ED)	1,713(ES)	

Note:DI:Scenario I, DII: Scenario II, DIII:Seasonal forecasts, SI:Yearly forecasts, SII:Seasonal forecasts, ED:Excess Demand, ES : Excess Supply. The quantities in 1985 are actual.

Thirdly, it is also needed to have a seasonal stabilization program to reduce the fluctuation of the demand for and supply of raw milk. This program can be worked out by adopting a seasonal price discrimination in such a way that a relatively high price is set for raw milk during the season of an excess demand and a relatively low price during the season of a production surplus.

As we see, the government as well as dairy farmers can be able to earn enough time to adjust their activities to a new situation through this kind of forecasting efforts. In this way we could minimize social costs and maximize producers' income.

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