CHAPTER 1

INTRODUCTION

1.1 Statement and Significance of the Problem

The domestic demands of basic metals which comprise aluminum, copper, steel, lead and zinc[1] , have grown rapidly in the past decade. Considering the import values which can partly imply the amount of consumption, these have risen more than doubled from 1977 to 1986. From Table 1.1, it will be seen that the import value of steel ranked the first, which was 8,790.4 million baht in 1977 and 21,536.5 million baht in 1986. Aluminum was second with the amount of 1,009 million baht in 1977 and 2,161.5 million in 1986. The value of copper was third which was 631.5 million baht and 1,288.2 million baht in 1977 and 1986 respectively, and zinc was fourth with the value of 471.4 million baht in 1977 and tended to increase until 1984 with the value of 1,163.4 million baht, before starting to fall. In 1986, the zinc import value was 132.5 million baht.

The fall of zinc import value did not mean people consume zinc less but, because in 1985 Thailand established the zinc refinery, the Padaeng Industry Company (PDI) and their product could partly substitute for imports. However, the consumption value of zinc was still the fourth of all the metal items.

For the mineral export item (Table 1.2), in 1985, though it was the first year zinc has been exported, but zinc could occupy

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[1]Zinc in this study means zinc metal, if it is zinc ore it will be written in full term.

TABLE 1.1

IMPORT VALUE OF SOME BASIC METALS (C.I.F.PRICE)

Unit : Million Baht

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Aluminum	1,009.0	1,116.3	1,674.4	2,146.1	2,331.9	2,172.6	2,607.1	2,598.3	2,307.1	2,161.5
Copper	635.1	662.1	984.1	983.1	979.3	970.4	1,293.2	1,315.3	1,371.5	1,288.2
Iron & Steel	8,790.4	10,682.1	14,745.4	14,390.6	18,764.2	15,198.7	19,712.4	19,188.4	23,295.8	21,536.5
Pb	104.5	158.5	289.8	365.5	265.2	225.1	292.5	186.1	129.7	140.5
Zinc	471.4	455.9	582.4	667.9	813.2	654.4	733.5	1,163.4	395.4	132.5
Ni	635.1	36.8	88.7	144.9	240.8	246.4	103.1	127.2	128.5	129.5

Source : Department of Customs, Ministry of Finance.

TABLE 1.2

TOP FIVE OF MINERAL EXPORT (IN VALUE) OF THAILAND

Quantity : Tonnes
Value : Million Baht

	1983		1984		1985		1986		1987	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1. Tin										
Tin Metal	17,658	5,224.7	18,332	5,267.5	17,359	5,462.1	18,567	3,058.2	13,397	2,306.4
Tin Concentrates	-	-	-	-	-	-	628	67.4	845	104.3
Tin Ore (low grade)	-	-	-	-	-	-	99	0.6	304	19.0
Tin-Lead Alloy	1,203	202.0	1,140	164.0	1,758	325.4	150	19.2	109	10.5
2. Gypsum	469,764	160.5	737,954	229.7	869,887	265.1	1,243,574	324.3	2,354,856	576.0
3. Zinc										
Zinc Metal	-	-	-	-	21,407	470.7	27,615	497.8	19,126	382.1
Zinc Ash	-	-	-	-	3,926	34.2	4,056	34.8	2,612	18.9
Zinc Dross	-	-	-	-	174	2.6	247	2.8	82	1.0
4. Lead										
Ore	42,738	202.7	42,004	187.5	46,375	189.9	54,127	189.8	48,047	245.8
Metal	-	-	-	-	-	-	18	0.2	-	-
5. Fluorite										
Metallurgical Grade	140,540	197.7	170,133	245.5	186,835	276.2	119,858	187.6	105,216	141.9
Acid Grade	42,777	90.0	54,530	109.6	35,375	83.3	12,590	30.1	8,878	21.0
Ceramic Grade	132	0.4	-	-	50	0.3	80	0.2	-	-

Source : department of Customs, Ministry of Finance.

the second rank with the value of 470.7 million baht, while tin and gypsum were first and third respectively. The order was still the same in 1986 and changed in 1987 when the export value of zinc declined to 382.1 million baht, resulting in the fall of zinc to third and gypsum moved to second. This reduction resulted from the increment of zinc domestic consumption. It will be seen that the export of zinc came in the right time when tin, the highest export value of all the mineral items of Thailand, was being in the bad situation of the continuing low price in the world market.

Thailand has a large high grade zinc ore deposit at Doi Padaeng, Maesod District, Tak Province, with the total reserves estimated at 4.5 million tons of zinc ore. The PDI is now holding the mining right which was established on April 10, 1981. The company is entitled to undertake the zinc ore mining operation for 25 years to implement the zinc ore mining, smelting refining and supplying domestically and abroad. The refinery has a capacity of 72,000 tons of zinc a year[2].

Zinc itself, is an intermediate product which is required as an input in many industries. From the structure of zinc-uses (Table 1.3), it will be seen that the major users are the galvanized industries, using 19,257 tons of zinc in 1982 and increasing to 37,261 tons or 70.1 percent in 1987. Those industries are galvanized sheet, galvanized pipe, wire & nail, pipe fitting and accessory and other galvanied products, with shares of 31.1, 27, 1.9, 2.3 and 7.8 percent respectively in 1987. Brass products are the second major

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[2]Ministry of Industry, Department of Mineral Resources, " The Padaeng Industry Company." Mineral Resources Gazette (May 1988):4-5.

TABLE 1.3

STRUCTURE OF ZINC USES IN THAILAND

Metric Ton (Percent)

	1982	1983	1984	1985	1986	1987
1. Galvanized Products	19,257 (62.5)	18,966 (52.5)	27,781 (61.7)	24,179 (61.0)	30,155 (66.6)	37,261 (70.1)
1.1 Galvanized Sheet	14,430 (46.8)	11,240 (31.1)	17,170 (38.1)	9,857 (24.9)	12,959 (28.6)	16,545 (31.1)
1.2 Galvanized Pipe	3,130 (10.2)	6,710 (18.6)	9,002 (20.0)	9,980 (25.2)	11,728 (25.9)	14,365 (27.0)
1.3 Wire, Nail, etc.	583 (1.4)	525 (1.3)	603 (3.5)	1,406 (3.9)	1,747 (1.9)	988 (1.9)
1.4 Pipe Accessory	307 (1.0)	282 (0.8)	399 (0.9)	864 (2.2)	714 (1.6)	1,211 (2.3)
1.5 Other Galvanized Products	807 (2.6)	209 (0.6)	607 (1.4)	2,072 (5.2)	3,007 (6.6)	4,152 (7.8)
2. Brass Products	466 (1.5)	841 (2.3)	1,801 (4.0)	5,051 (12.8)	4,463 (9.8)	5,161 (9.7)
3. Zinc Oxide	956 (3.1)	2,494 (6.9)	2,001 (4.4)	1,260 (3.2)	2,319 (5.1)	2,794 (5.3)
4. Dry Cell	2,432 (7.9)	2,669 (7.4)	3,342 (7.4)	4,494 (11.3)	3,849 (8.5)	3,255 (6.1)
5. Die-Casting	1,430 (4.6)	2,675 (7.4)	2,360 (5.2)	2,360 (5.8)	3,809 (8.4)	3,889 (7.3)
6. Miscellaneous Item	6,277 (20.4)	8,505 (23.5)	7,780 (17.3)	2,317 (5.9)	714 (1.6)	797 (1.5)
Total	30,818	36,150	45,065	39,607	45,309	53,157

Source : Department of Customs, Ministry of Finance.

users, using 5,161 tons of zinc or 9.7 percent in 1987. The other zinc users are zinc-oxide, drycell and die-casting, using 5.3, 6.1 and 7.3 percent respectively. The figures in the miscellaneous item tended to declined from 6,277 ton in 1982 to 797 ton or 1.5 percent in 1987, this may be due to the improvement in the ability to distinguish the zinc-end uses.

Although zinc involves people in many ways of living, but its importance is less obvious than metals such as iron, aluminum, copper and lead because zinc tends to lose its identity in end products. The principal substitues for zinc are aluminum and plastic. However, zinc has maintained its competitive position with substitute materials in most uses and yet there is no satiafactory substitute for zinc for corrosion protection of large tonnages of iron and steel.

Now, it is already known how useful and important zinc is, so it is appropriate to accept zinc as one of the most important metals nowadays. Because of the tremendous usefulness of zinc, the consumption of zinc by domestic users have been rising and will tend to be more in the future. Therefore it is really interesting to understand the economic behavior of the zinc market in order to know what factors determine zinc demand, what factors determine zinc supply and what is the characteristic of zinc market.

The domestic zinc market is quite unique, considering the agreement in mining made between the Department of Natural Resources and the PDI. The agreement clearly states that the PDI has to provide zinc in sufficient amount for all time, in order to respond to the need of domestic users. This sufficient amount means the expected quantity that will be bought, which the PDI will annually propose to the Department ahead. These expected figures are based on the latest record of zinc used.

For the domestic zinc price, the agreement also states that the maximum price that the PDI will charge must be less than the import price (C.I.F.) by three percent. This import price is refer to the London Metal Market.

The reasons that this sole domestic supplier can sell at that lower price, though it is just the beginning period, are (1) the world zinc price in the past ten years was quite high and tend to be continue in the future. (2) It recieves promotion from the Board Of Investment (B.O.I.). The privileges that it recieves are it is granted exemption from payment of import duties and business taxes on machinery and it is granted exemption of juristic person imcome tax on the net profit in the first five year and pays only a half in the next five year. (3) The PDI itself is a very large scale firm with a very high technology as can be seen from the cost of zinc refining factory which is 2,800 million bahts.[3]

The establishment of the PDI benefits zinc domestic users very much. The discount price that they gain is not just only 3 percent as this is calculated from c.i.f. price. In fact, it has to be calculated from the real import price which has to include import tax rate which is 17 percent and business tax rate plus local government tax rate which is about 3 percent. Thus, the new price that zinc domestic users pay is about 23 percent cheaper than the import price. Consequently, this will make government lose their

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[3]Ibid., p.7.

revenue on imported zinc but this loss becomes the gain of zinc importers. Finally, the 3 percent cheaper price is the zinc importers' gain which is nobody's loss and this contributes the social net gain.

From this point of view, the domestic supplier will behave as a perfectly elastic curve, which will respond to all quantities at a given price. This is the same as when the domestic users imported and met the foreign supply curve which was also perfectly elastic since Thailand is a small country and has no effect on import price. The only difference is the price which is 23 percent cheaper than the import price at every level of quantity. Of course, all domestic users have switched to buy from the PDI, except for some zinc-alloy items which the PDI could not produce yet and still have to be imported.

The system of domestic zinc market rather works well though the zinc price is determined from outside. According to the regulation that is already described, in each year, the PDI will sell zinc to all domestic buyers and at the end of the year the excess zinc supply will be exported. Since the PDI was established, the amount of zinc consumption is always less than the amount of production (can be seen in Table 1.4). Thus, the problem of excess zinc demand has not arisen yet.

When the supply of zinc is explicitly known (also can be seen in table 4) as there is only one producer, the Padaeng Industry Company, which there is no role at all in determining the price and the quantity of zinc consumption, so, it is the domestic demand that should be studied in order to know what factors determine zinc

TABLE 1.4

ZINC PRODUCTION, EXPORT AND CONSUMPTION OF THAILAND

Quantity : Tonnes
Value : Million Baht

	1983		1984		1985		1986		1987	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production										
Zinc Ore	-	-	147,993	377.4	276,909	706.1	373,832	893.3	341,145	1,410.7
Zinc metal	-	-	-	-	46,945	1,098.2	68,270	1,393.6	63,431	1,408.7
Export										
Zinc Metal	-	-	-	-	21,407	570.7	27,615	497.8	19,126	382.1
Zinc Ash	-	-	-	-	3,926	34.2	4,056	34.8	2,612	18.9
Zinc Dross	-	-	-	-	174	2.6	247	2.8	82	1.0
Zinc Powder	-	-	-	-	34	0.9	16	0.1	-	-
Consumption										
Zinc Metal	-	-	-	-	25,538	627.5	40,655	895.8	44,305	1,026.6

Source : Padaeng Industry Company.

consumption, to understand the characteristic of those influential factors and to make an accurate prediction for the future demand.

1.2 Objectives of the Study

The main purposes of this study are firstly to analyze the domestic demand for zinc in order to know what factors determine zinc demand and understand the characteristics of those influential variables. Secondly, to forecast the future demand for zinc in order to compare with the domestic production capacity which will lead to an accurate prediction about future domestic zinc situation.

The zinc derivative industries will also be examined so as to give the general background of those major zinc buyers. This part will lead to a more understanding about their market behaviors which will finally pave the way to know their demand for zinc.

1.3 Scope of the Study

1. Zinc in this study is defined to include all kind of zinc ingots which comprise Special High Grade (SHG), High Grade (HG), Prime Western (PW) and all kind of zinc-alloys which comprise Battery Grade (BG), Die-Casting No. 3 (DC 3) and Die-Casting No. 5 (DC 5). This definition is set in order to cover all of those zinc ingots used in zinc derivative industries in Thailand.

The present study will not differentiate between them for the reason that, although there are many types of zinc ingots but all of them are almost the same commodity and can be almost perfectly substituted for each other.

2. From the structure of zinc uses in Thailand (Table 1.3), zinc end-uses are categorized into five major items plus one

miscellaneous item. For practical and statistical in analysis, this study will re-categorize those zinc end uses again by (1) combining the pipe accessory item into the galvanized pipe item and (2) combining the items of wire & nail and other galvanized products into the miscellaneous item. The reasons are pipe accessory and wire & nail item have small shares in zinc end uses, about 2.3 and 1.7 percent respectively in 1987, and the other galvanized products item overlaps with the miscellaneous item.

After categorizing the zinc derivative industries this way the industries that will be studied are (1) galvanized sheet, (2) galvanized pipe, (3) brass, (4) zinc oxide, (5) battery, (6) die-casting and (7) miscellaneous item.

1.4 Theoretical Background[4]

This section is devoted to describe theoretically the derived demand or factor demand, which is the firm 's demand for factors used in producing the final product. To show how this demand comes, it is necessary to draw some relevant conditions for this demand to derive from. For simplicity in illustration, it will be assumed (in this section only) that output (Q) is produced from only two inputs (Z_1, Z_2). The firm maximizes its profit and this firm is a price taker in all its markets. It is too small to affect either the price of its output (P) or its inputs (W_1, W_2). So the problem is :

$$\text{Max Profit} = \text{receipts} - \text{costs} = PQ - W_1Z_1 - W_2Z_2$$

For a unique local maximum one requires

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[4]P.R.G. Layard and A.A. Walters, Microeconomic Theory (New York: Mc Graw-Hill Book Company, 1978), pp.208-211 and 259-271.

$$\frac{d\ \text{Profit}}{d\ \ Z_1} = PQ_{z1} - W_1 = 0 \tag{1.1}$$

$$\frac{d\ \text{Profit}}{d\ \ Z_2} = PQ_{z2} - W_2 = 0 \tag{1.2}$$

and
$$\frac{d^2\text{Profit}}{d\ \ Z^2} = PQ_{z1z1} < 0 \tag{2.1}$$

$$\frac{d^2\text{Profit}}{d\ \ Z^2} = PQ_{z2z2} < 0 \tag{2.2}$$

In addition, since the firm always has the option of producing nothing, so the additional condition is

$$\text{Profit} \geq 0 \tag{3}$$

This simple exercise gives the very useful implications about the thoery of production and factor demand, but the latter will be mentioned only. From (2.1) and (2.2), they imply that at the optimal output the marginal products of both imputs (Q_{z1}, Q_{z2}) must be diminishing.

From (3), it implies that $\frac{Q}{Z_1} \geq \frac{W_1}{P} + \frac{W_2Z_2}{PZ_1}$

But from (1.1) $\frac{W}{P} = Q_{z1}$

Hence $\frac{Q}{Z_1} \geq Q_{z1} + \frac{W_2Z_2}{PZ_1}$ (4)

From (4), since $\frac{W_2Z_2}{PZ_1} > 0$

So $\frac{Q}{Z_1} \geq Q_{z1}$ (5)

Equation (5) implies that at the optimal output, the marginal product is less than (or equal to) the average product.

The term in equation (1.1) can be rearranged to be

$$W_1 = PQ_{z1} = \text{value of marginal product}$$

which is the demand function for Z_1. This relation is homogeneous of degree zero in all prices. From this function one finds that

$$\frac{d\,Z_1}{d\,W_1} = \frac{1}{PQ_{z1z1}} < 0$$

Thus the demand for an input falls as its price rises and vice versa. Using this information plus condition from equation (5), one can define the factor demand curve as follows:

"The factor demand curve is the value of the marginal product curve, where marginal product is falling and is less than (or equal to) average product. For higher factor price, demand is zero."[5]

From the derivation of this factor demand function, it can be seen that not only input price (W_1) but output price (P) is also included in the model. Though this study does not pose these underlined assumptions as in deriving this model but it is logic to accept these two variables in the zinc demand model of the study.

After the concept of factor demand is described, another interesting point that should be stated is the characteristic of the input price elasticity. This time, it is assumed more that returns to scale are constant. Then the production of Q can be written as

$$\frac{Q}{Z_1} = f(\,Z_2 \,/\, Z_1\,)$$

By the same token, the factor input per unit of output (i.e., the input coefficient) depends only on the factor proportions and is independent of scale:

$$\frac{Z_i}{Q} = g(\,Z_2 \,/\, Z_1\,)$$

But the relative factor quantities are also uniquely related to relative marginal products and thus depend only on factor prices:

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[5]Ibid., p.211.

$$\frac{Z_i}{Q} = h(W_1 / W_2)$$

or $$Z_i = Q \cdot h(W_1 / W_2)$$

Hence $$\log Z_i = \log Q + \log h(W_1 / W_2)$$

and $$\frac{\log Z_i}{\log W_j} = \frac{\log Q}{\log W_j} + \frac{\log h(W_2/W_2)}{\log W_j}$$

The elasticy of demand can be decomposed into an output effect and a substitution effect:

The output effect is the change which would occur if factor proportions were held constant, but output changed in response to changes in factor price. The substitution effect is the change which would occur if output was held constant, but factor proportions changed in response to the factor price change.

Since it is found from the industry survey that zinc does not have any other close substitute in all zinc derivative industries, the substitution effect will be omitted and illustrated only the output effect.

The output effect

Suppose 1 unit of Q requires **a** unit of Z_1 and **b** unit of Z_2. Then, under perfect competition the price of Q is

$$P = aW_1 + bW_2$$

The proportional change in price is

$$\frac{dP}{P} = \frac{W_1}{P}\frac{dW_1}{W_1} + \frac{W_2}{P}\frac{dW_2}{W_2}$$

or $$d\log P = v_1\, d\log W_1 + v_2\, d\log W_2$$

where v_1 and v_2 are the shares of Z_1 and Z_2 in costs respectively.

From the elasticity demand for output with respect to price

$$d\log Q = \epsilon^D\, d\log P = \epsilon^D v_1\, d\log W_1 + \epsilon^D v_2\, d\log W_2$$

where ϵ^D is the elasticity of demand for the product the factor produces.

But $d \log Z_1 = d \log Z_2 = d \log Q$ (due to fixed proportions)

and $v_2 = 1 - v_1$

Therefore $$1 = \epsilon^D v_1 \frac{d \log W_1}{d \log Z_1} + \epsilon^D (1-v_1) \frac{d \log W_2}{d \log Z_2}$$

where $\frac{d \log W_1}{d \log Z_1} = \frac{1}{\epsilon_{11}}$ refers to the demand function for Z_1

and $\frac{d \log W_2}{d \log Z_2} = \frac{1}{\epsilon^S}$ refers to the supply function for Z_2 to represent the effect of Z_2 on Z_1.

So $$\frac{1}{\epsilon_{11}} = \frac{1}{\epsilon^D v_1} \left[\frac{1 - \epsilon^D (1-v_1)}{\epsilon^S} \right]$$

Hence $$\epsilon_{11} = \frac{v_1 \epsilon^D}{1 - (1-v_1)\epsilon^D / \epsilon^S} \qquad \text{---------(5)}$$

From (5), it implies that the (absolute) elasticity of demand for a factor i ($|\epsilon_{ii}|$) varies directly with the (absolute) elasticity of demand for the product the factor produces ($|\epsilon^D|$), the share of the factor in the cost of production (v_i) and the elasticity of supply of the other factor ($|\epsilon^S|$).

In this study, the elasticity of demand for each zinc derivative product and the share of zinc in the cost of production will be used to verify the value of each estimated zinc price elasticity. In doing this, the demand for each zinc derivative product will also be estimated. For the shares of zinc in the cost of productions, though the accurate values are not available but they can be roughly estimated from the input coefficients of zinc.

1.5 Review of Selected Empirical Demand Study

Since the research about demand for zinc in Thailand has not been studied before this part will discuss the various studies about demand for other factors of production instead. Those studies are reviewed here in order to pave the basic idea about the methodologies used in other studies and their results.

All of the selected studies had similar major objectives, that is, estimating the effect of the factors influencing the demand for each specific study. However, the methodologies among these studies can be divided into two groups. The first group studied the effect of influential variables on factor demand directly. While the second group studied the effect of influential variables on final demand first and then using the conversion factors to transform the quantity of final demand to factor demand. For the latter, it requires the factor of production to be a fixed proportion.

The first group, Sunthorn[6] studied the demand for textile products in Thailand, the textile products were composed of three industries which were fibre, yarn and fabric. Demand for fibre was derived from demand for yarn and demand for yarn was derived from deman for fabric. Fabric was the final product of this industry and its demand model was formulated based of the conventional demand theory as follows:

$$NDF = F_1(GDPP, PF, PMF, PSF)$$

The study was done at the per capita level where per capita domestic consumption of local fabric (NDF) was a dependent variable. The own price and income variable were represented by real average wholesale price of fabric (PF) and real per capita gross domestic

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[6]Sunthorn Thamruanglerd, "Demand for Textile Products in Thailand," (Master 's Thesis, Faculty of Economics, Thammasat University, 1980), pp. 18-40.

product (GDPP) respectively. Real average import price of fabric (PMF) and real average price of substitution between cotton and man-made (PSF) were treated as prices of substitution products.

The demand model for yarn was derived from fabric and the derivation was the same as already stated in the part of Theoretical Background (page 11-15). The firm producing yarn was assumed to maximize its profit and was in the perfectly competive market. Finally, the obtained model was:

$$NDY = F_2(PF, PY, PMY)$$

Per capita domestic consumption of yarn (NDY) was a function of real average wholesale price of fabric (PF), real average wholesale price of yarn (PY) and real import price of yarn (PMY). The demand medel for fibre which was derived from yarn was analogously obtained as follows:

$$NDC = F_3(PY, PC, PMC)$$

Per capita domestic consumption of fibre (NDC) was a function of real average wholesale price of yarn (PY), real average wholesale price of fibre (PC) and real import price of fibre (PMC).

The estimation techniques was ordinary least squares (OLS). The estimated equations in linear and log linear form gave a very good fit to actual data though they faced the problem of a small number of observations and all assigned explanatory variables were significant with theoretically corrected signs.

Chaipat[7] studied the demand for cement in Thailand, cement

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[7]Chaipat Sahasakul, "A Demand Model for Cement in Thailand," (Master 's Thesis, Faculty of Economics, Thammasat University, 1979), pp. 23-54.

demand was derived from the demand for construction by both, government and private sector. The model derivation was also the same, by setting the assumptions about the profit maximization firm and the perfectly competitive market to underline the derivation. The obtained model were composed of the similar explanatory variables which were also included the expected cement price as hypothesized to be one of the independent variable. The expected cement price was obtained from the Adaptive model and Almon lag model. His model is as follows:

$$Q = F(CE, P1, P2, P3, P4, P5, P6, P1A)$$

The quantity of cement consumed (Q) was a function of total construction expenditures (CE), real average wholesale price of cement (P1), real average retail price of brick (P2), real average retail price of lumber board (P3), real average retail price of round steel (P4), real average earning of employees in manufacturing (P5), average gross return to equipments used in construction sector (P6) and expected price of cement (P1A).

The estimation techniques were instrumental variable method (INST) and ordinary least squares (OLS). The estimation model were linear and log-linear form. The results were quite the same for both techniques and both functional forms gave a very good fit to actual data. However, P2,P3 P4 P5 and P6 were insignificant and were reasoned to be the result of the unreliable data and the statistical problems.

Intima[8] studied the demand for corn by feed industry in Thailand, corn demand was derived from demand for feed. Again, this study obtained the demand model in the same way as the first two studies. This time, the variables representing the own price, cross price and income were appeared in the model as follows:

$$QC = F(PC, PB, QLC, T)$$

The quantity of corn demanded by feed industry (QC) was a function of real average wholesale price of corn (PC), real average wholesale price of broken rice (PB) this variable was treated as a cross price of corn, number of chicken (QLC) and time trend (T) which was included to capture the effect of technological change.

The estimation technique was ordinary least squares (OLS) and the estimation equation was in linear form. The regression result gave a very good fit to actual data ($R^2 = 0.96$) and all estimated coefficient were significant with theoretically corrected signs.

The second group, the factor demand studies which were obtained by transforming from the final demand estimations. Nilbai[9] estimated the total demand for crude oil by adding up six estimated demand equations of petroleum products ,i.e. gasoline, diesel, fuel oil, kerosene, aviation oil and LPG. The demand equation for each petroleum product was formulated according to the conventional demand theory which was composed of its own price, income, the quantity of

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[8]Intima Throngtham, "Demand for Corn by Feed Industry in Thailand," (Master 's Thesis, Faculty of Economics, Thammasat University, 1980), pp. 38-59.

[9]Tawin Nilbai, "The Total Demand for Crude Oil in Thailand," (Master 's Thesis, Faculty of Economics, Thammasat University, 1978), 16-62.

major users and some specific variables relevant to that demand. Those demand models are as follows:

Demand model for diesel oil:

$$DD = F_1(PD, B, T, ML, AGR, GNP, POP)$$

The amount of diesel oil consumed (DD) which was a dependent variable was treated as a function of its own price and income which were represented by price of diesel oil (PD) and gross national product (GNP). Other explanatory variables which represented the amount of users were number of buses (B), number of trucks (T), number of motor launches (ML), value of agriculture products (AGR) and number of population (POP) were also hypothesized to be another influential variables.

In the estimation, the number of users were aggregated to be only one variable unless each one would face the problem of low value of t-statistics. The estimation was in log-linear and gave a very good fit to actual data ($R^2 = 0.95$). However, two out of those variables ,i.e. number of population (POP) and gross national product (GNP) were insignificant.

Demand model for gasoline:

$$DG = F_2(PG, MC, TAX, MCY, GDPT)$$

The quantity of gasoline demanded (DG) was treated as a function of price of gasoline (PG), number of passenger cars (MC), number of taxis (TAX), number of motorcycles (MCY) and value of gross domestic product from transportation and communication (GDPT).

The regression result gave a very good fit to actual data ($R^2 = 0.92$) and all estimated coefficients were significant.

Demand for fuel oil

The usages of fuel oil were classified into non-electricity and electricity sector. Hence, the demand for fuel oil was also divided according to its usages. The demand models are:

Non-electricity sector:

$$DF = F_3(PF, CE, MANU, TR)$$

The amount of fuel oil consumed by non-electricity sector (DF) was treated as a function of price of fuel oil (PF) and the amount of major users which were production of cement (CE), the value of manufacturing output (MANU) and steam train operation (TR). The regression result gave a good fit to actual data ($R^2 = 0.90$) but only the coefficient of PF was significant. The insignificance of other variables were reasoned to be due to the multicollinearity problem.

Electricity sector:

$$TDE = F_4(PH, EH, PI, GI)$$

The amount of fuel oil consumed by electricity sector was treated as a function of price of electricity to households (PH), per capita household expenditure (EH), price of electricity to industry (PI) and industrial gross domestic product (GI). In this case, the explanation power was very poor and non of the variables was significant.

Demand model for kerosene:

$$DK = F_5(PK, MANU, CEH, GNP, POP)$$

The amount of kerosene demanded (DK) was treated as a function of price of kerosene (PK), the value of manufacturing output (MANU), consumption expenditure per head (CEH), gross national product (GNP) and number of population (POP). The estimated result gave a moderate fit to actual data and only two variable ,i.e. price of kerosene (PK) and value of manufacturing output (MANU) were significant.

Demand model for LPG:

$$DPG = F_6(PPG, PCI, POP, T)$$

The consumption of LPG (DPG) was treated as a function of the price of LPG (PPG), per capita income (PCI), number of population (POP) and time trend (T). The reason for putting a time variable was that LPG was such a new petroleum product that people must take time to be acquainted with.

The statistical result yielded satisfactory values, i.e. all t-statistics were higher than 2 and the value of R^2 was high.

After adding up six estimated demand equations of petroleum products, it showed that the price elasticity of demand for crude oil was very high when compared to those of petroleum products. This study also forecast the demand for petroleum products but the power of prediction tended to be inaccurate when there were changes in relatively energy share used in the major users overtime.

Ratana[10] estimated the structural demand for gasoline in Thailand and studied only the case of private passenger cars. The demand for gasoline of private passenger car was treated as a combination of (1) the stock of gasoline cars, (2) the utilization rate and (3) the fuel-burning efficiency.

The stock of gasoline cars was a stock variable and was turned to be a flow variable which was composed of (1) number of new cars adding to the stock of gasoline cars, (2) worn-out gasoline cars, (3) gasoline cars converted to LPG, (4) gasoline cars converted

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[10]Ratana Sivanunwong, "The Structural Demand for Gasoline in Thailand : A Case Study of Private Passenger Cars , " (Master 's Thesis, Faculty of Economics, Thammasat University, 1987), pp. 24-65.

to diesel. These components were separately estimated by the models as follows:

(1) Number of new cars adding to the stock of gasoline cars:

$$NC = F1(RPC, RPG, GDP)$$

Total new cars sales (NC) was treated as a function of real price of new cars (RPC), real price of gasoline (RPG) and gross domestic product (GDP). The estimated result showed a quite low R^2 and the coefficient of gross domestic product was insignificant.

(2) Worn-out gasoline cars:

$$W = F2(RPC, GDP)$$

The number of worn-out gasoline cars (W) was set as a function of real price of new cars (PRC) and gross domestic product (GDP). The regression result showed a very good fit to actual data ($R^2 = 0.99$) but the coefficient of real price of new car was insignificant.

(3) Gasoline cars converted to LPG:

$$WL = F3(RPG, RPL, RCL, D)$$

The number of LPG cars switching from gasoline cars (WL) was treated as a function of real price of gasoline (RPG), real price of LPG (RPL) real cost of changing supply system from gasoline to LPG (RCL) and the dummy variable (D) which was assigned to capture the impact of the safety law imposed by the government to control the use of LPG for driving. The estimated result gave a very high power of explanation of explanatory variables ($R^2 = 0.97$) and all of the estimated coefficients were significant.

(4) Gasoline cars converted to diesel:

$$WD = F4(RPG, RPD, RCD)$$

The number of diesel cars switching from gasoline cars (WD) was treated as a function of real price of gasoline (RPG), real price of diesel (RPD) and real cost of changing fuel supply system from gasoline to diesel (RCD). The estimated result gave a good fit to actual data (R^2 = 0.90) and all estimated coefficient were significant.

Another two combinations of demand for gasoline from private passenger cars are as follows:

Average utilization rate of gasoline cars model:

$$U = F5(RPG, GDP, UT)$$

The average utilization rate (U) was treated as a function of real price of gasoline (RPG), gross domestic product (GDP) and the average utilization rate in the period ahead (UT). The estimated result showed the value of R^2 of 0.64 and the coefficient of a lagged value of average utilization rate was insignificant.

Average fuel-burning efficiency of gasoline cars model:

$$EF = F6(RPG, EFT)$$

The average fuel-burning efficiency of gasoline cars (EF) was treated as a function of real price of gasoline (RPG) and the lagged value of the dependent variable (EFT). The estimated result showed a very high value of R^2 of 0.99 and all estimated coefficients were significant.

Finally, the overall study indicated that the effect of gasoline price through the utilization rate and real price of new cars were the major determinants on gasoline consumption.

Taweesakdi[11] estimated and forecast the demand for ethylene by firstly estimated demand of its final products, then using conversion factors of each products to transform into ethylene and finally, adding them up. Those derivatives were polyethylene (PE), polyvinyl chloride (PVC), polystylene (PS) and ethylene glycol (EG) and their demand models are:

Demand model for polyethylene (PE):

$$QPE = F1(PPE, PCFB)$$

The amount of PE consumption (QPE) was treated as a function of real price of PE (PPE) and real value of the private consumption expenditure on food and beverages (PCFB). The estimation technique was ordinary least squares with a log-linear form. The estimated result gave a value of R^2 of 0.70 and both estimated coefficients were significant.

Demand model for polyvinyl chloride (PVC):

$$QPVC = F2(PPVC, PIPE, IMH)$$

The amount of PVC consumption (QPVC) was treated as a function of real price of PVC (PPVC), the production of pipe & fitting (PIPE) and the production of imitation hide (IMH). The estimated result gave the value of R^2 of 0.93 and all estimated coefficients were significant.

Demand model for polystyrene (PS):

$$QPS = F3(PPS, PW)$$

The amount of PS consumption (QPS) was treated as a function of real price of PS (PPS) and real value of plastic ware production

[11]Taweesakdi Pornsooksawang, "Demand for Ethylene," (Master's Thesis, Faculty of Economics, Thammasat University, 1983), pp. 26-55.

(PW). The regression result showed a good fit to actual data (R^2 = 0.76) and both estimated coefficients were significant.

Demand model for ethylene glycol (EG):

QEG = F4(PEG, PPES)

The amount of EG consumption (QEG) was treated as a function of real price of EG (PEG) and the production of polyester fibers (PPES). The estimated result showed that a value of R^2 was 0.95 and only PPES was significant.

It will be seen that the independent variables assigned in most factor demand models are (1) factor's own price, (2) price of final product, (3) some variables used to represent the concept of income in each specific case. Most of these models yield quite good results (R^2 is quite high and most of the estimated coefficients are significant and give signs as they are expected.

The problem of how to assign the most appropriate variables in the model is rather serious. Since most of the previous works obtained satisfactory results by assigning the independent variables that way, this study will adopt those variables in the model. Besides, the commodity's own price and income are already most important explanatory variables in the conventional demand theory.

1.6 Organization of the Study

This study contains six chapters. Chapter 1 is the introduction including statement and significance of the study, objectives and scope of the study, review of some related literatures and the theoretical background.

Chapter 2 contains a brief background of the galvanized sheet industry, galvanized pipe industry, brass industry, zinc oxide industry, dry cell industry, die-casting and the miscellaneous. It deals with the market structures of those industries based mainly on the period of investigation 1978-1988.

Chapter 3 describes the methodology of the study comprising the model formulation, expected signs of explanatory variables and description of data accompanied by data sources.

Chapter 4 presents the empirical results of the estimated demand equations of those industries, the interpretation of the results are also given as well.

Chapter 5 discusses the forecast of future zinc demand in Thailand. Finally, Chapter 6 contains the overall summary and conclusion of this study.