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The Analysis of Durable Goods Possession of Urban Dwellers in Beijing Based on Gompertz Model

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Abstract: Durable consumer goods are people's indispensable component in the life. Since the reform and opening, with people's income growth, people's consumption structure transformation and the people's consumption dramatically, people for the changes in the concept of the consumer durables increase gradually. Based on the data of Beijing urban residents, according to the possession of durable goods through building of Gompertz model for urban residents' possession of durable goods the developing trend of the description, and make the short-term forecast.
Key words: Gompertz Model; Durable Goods; Economical forecasting

Reforming and opening to the outside world drag out the curtain for the speeding growth of economy, there is no doubt that trades in China shoot up to a new height. Further more, the 2008 Olympic game is the symbol of rapidly developed economy and upper-standard of living. There are great changes through the past 30 years, especially at the view of economy development. Take Beijing as example, the mileage of road and the area of commercial housing are rapidly growing. Also the GDP and consume per day are increasingly higher. Durable goods are the most important part of national consumption, also the indispensable section of residential activities.

1. THE DEVELOPMENT OF DURABLE GOODS IN CHINA

At the early days of RPC, national income represents a low level because of the limitation of development. Everybody focus on earning the life but not enjoying the life. Few have purchased the commercial products. Durable goods are limited to cabinet or normal furnishing. Radio, bicycle, sewing machine and other essential equipment spring up at 1960s. At the end of 1970s, these goods emerge in large numbers and mostly accepted by people. TV, refrigerator, washing machine, electric fan and recorder became progressively popular since the 1990s. Durable goods consumption of urban dwellers steps up to a new stage. People need not to buy original durable goods such as TV and washing machine but new type of durable goods with characteristic, for example, air conditioner.

The statistical data of major durable goods owned by urban dwells in Beijing in the past 30 years shows that, most families are much more familiar with some durable goods, and let them became there essential goods at last. (Showed in the Figure 1 below)

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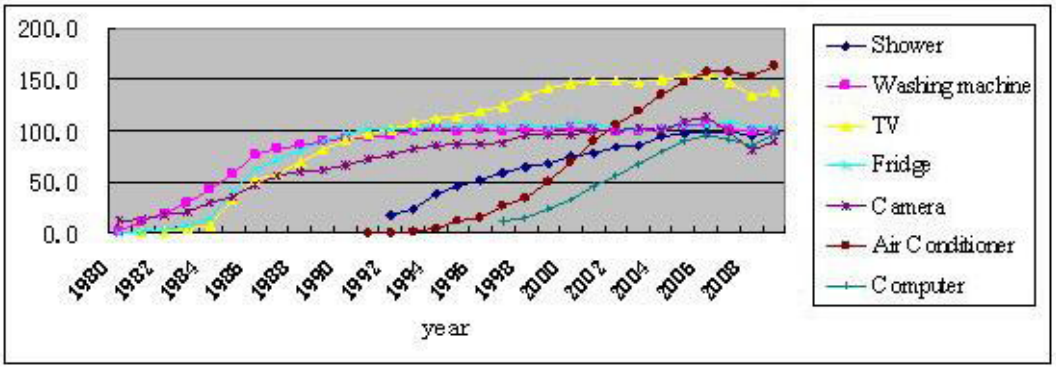

Figure 1: Per 100 Households Annual Possession of Durable Consumer Goods (1980-2009)

Durable goods owned by dwellers have increased during these years, which mean that the decline of purchases of durable goods while durable goods on the market are still growing. Facing too many choices, consumers tend to purchase those high quality, low cost, costs-effective durable goods, which can exacerbate the pressure of competition on the market. Therefore, finding saturation point of durable goods consumption in time could be effective in pointing out direction for the manufacturers to reduce unnecessary losses. And it also provide the Government, management institutions and other research institutions which study market changes with a reliable basis.

2. MODELING ANALYSIS

2.1 Data Collection

We picked a representative analysis of durable goods as objects in a large number of durable goods. It's obvious that the consumption of the washing machine appears very early, and has the major characteristic of durable goods; it may be represented as a traditional type of durable consumer goods. At the same time air conditioning consumption began in the 90 's, appear relatively late, with the demand for air conditioning, air conditioner's consumption have shoot up, and became the representative of new durable consumer goods.

Both data are available from Beijing Statistical Yearbook 2010 edition:

Table 1: Possession of Washing Machines Per 100 Households in Beijing

Year	Possession	Year	Possession	Year	Possession
1980	1.9	1990	93.2	2000	102.8
1981	12.3	1991	93.0	2001	102.2
1982	18.8	1992	96.1	2002	98.6
1983	28.7	1993	99.8	2003	99.3
1984	42.2	1994	102.8	2004	102.0
1985	57.5	1995	100.4	2005	105.0
1986	75.9	1996	101.4	2006	106.9
1987	82.6	1997	100.6	2007	102.2
1988	86.0	1998	102.2	2008	98.6
1989	89.7	1999	99.6	2009	100.4

Table 2: Possession of Air Conditioners Per 100 Households in Beijing

Year	Possession	Year	Possession	Year	Possession
1992	0.6	1998	34.0	2004	135.7
1993	1.8	1999	49.9	2005	146.5
1994	5.0	2000	69.6	2006	157.1
1995	11.8	2001	89.7	2007	157.3
1996	14.2	2002	106.5	2008	152.5
1997	27.2	2003	119.3	2009	162.7

2.2 Model Choosing

The durable goods have their different law of demand: They need not to be purchased too often due to their long using cycle. Generally speaking, their prices are more expensive, consumers will choose them in a more careful way. After purchase they are not easily replaced. Because of the features above, durable goods tend to have a saturation point. In the model selection, the emergence of the saturation point should be noted. Considering the S curve trend of the durable goods, we can fit it in S curve model.

Usually, S curve model is applied to describe the life cycle of production. Gompertz model, a kind of S curve model which is also known as double exponential model, was proposed for population prediction by British statistician and mathematician B Gompertz in 1820. American scholar R Prescott applied it in merchandise prediction for the first time. As we can see from the data of washing machine and air conditioner, both of them are in the maturity and Gompertz model is especially suitable for mature products forecasting (XU Guoxiang, 2002). Therefore, we can apply Gompertz model to modeling analysis.

The form of Gompertz model is: $\hat{y} = ka^{b^t}$

Among the formula, k, a and b are undetermined parameters.

The researches about durable goods on the use of Gompertz model were made by domestic and international scholars very early. Dargay and Gately (1997) have used time series data of 26 countries from 1960 to 1992 to set up Gompertz model and forecasted the trend in car possession rate till 2015 (FANG Lan, 2007). Fang Lan and Li Xibin (2007) have set up Gompertz model using relevant data to analyze and forecast the rolled steel production in China. So it is an effective approach to analyze the durable goods of urban dwellers in Beijing based on Gompertz model.

2.3 The Measure of Gompertz Model

The method of division into groups for the measurement of Gompertz model is often applied in Actual estimates. This method requires the collection of data can be aliquot by 3. Take the measurement of the washing machine's possession as an example:

Make all 30 data(y) arranged in chronological order, and divide them into 3 equal groups. Each group has 10 data, sequentially numbered, starting from 0. And then calculate the logarithm value ($\lg y$):

Table 3: Calculations of lg y

Year	y	t	$\lg y$	Year	y	t	$\lg y$	Year	y	t	$\lg y$
1980	1.9	0	0.2788	1990	93.2	10	1.9694	2000	102.8	20	2.0120
1981	12.3	1	1.0899	1991	93.0	11	1.9685	2001	102.2	21	2.0095
1982	18.8	2	1.2742	1992	96.1	12	1.9827	2002	98.6	22	1.9939
1983	28.7	3	1.4579	1993	99.8	13	1.9991	2003	99.3	23	1.9969
1984	42.2	4	1.6253	1994	102.8	14	2.0120	2004	102.0	24	2.0086
1985	57.5	5	1.7597	1995	100.4	15	2.0017	2005	105.0	25	2.0212
1986	75.9	6	1.8802	1996	101.4	16	2.0060	2006	106.9	26	2.0290
1987	82.6	7	1.9170	1997	100.6	17	2.0026	2007	102.2	27	2.0095
1988	86.0	8	1.9345	1998	102.2	18	2.0095	2008	98.6	28	1.9939
1989	89.7	9	1.9528	1999	99.6	19	1.9983	2009	100.4	29	2.0017

Calculate the summation of 10 $\lg y$ from each group:

$$\begin{cases} \sum \text{I} \lg = 15.1702 \\ \sum \text{II} \lg = 19.9498 \\ \sum \text{III} \lg = 20.0761 \end{cases}$$

According to the formula of Gompertz model, we can figure out the value of k, a and b (as it shown below).

$$\begin{cases} b^n = \dfrac{\sum \text{III} \lg y - \sum \lg y}{\sum \text{II} \lg y - \sum \lg y} \\ \lg a = (\sum \text{II} \lg y - \sum \lg y) \bullet \dfrac{b-1}{(b^n-1)^2} \\ \lg k = \dfrac{1}{n}\left[\sum \text{I} \lg y - \dfrac{b^n-1}{b-1} \bullet \lg a\right] \end{cases} \qquad \begin{cases} \text{k} = 101.848 \\ \text{a} = 0.029 \\ \text{b} = 0.695 \end{cases}$$

Take k, a and b into the model, and we can acquire Gompertz model of the washing machines' possession per 100 households of urban dwellers in Beijing.

$$y = 101.848 \times 0.029^{0.695^t}$$

In the same approach, we can acquire Gompertz model of the air conditioners' possession per 100 households of urban dwellers in Beijing.

$$y = 206.306 \times 0.003^{0.814^t}$$

Then in order to test the fitting of equations, we can use goodness of fit to test.

$$R^2 = 1 - \frac{\sum_{i=1}^{n} (y_i - \hat{y})^2}{\sum_{i=1}^{n} (y_i - \overline{y})^2}$$

By calculating, the goodness of fit about washing machines' possession is 0.99244, and the e goodness of fit about air conditioners' possession is 0.98995. Both of them are very close to 1, that is to say, the regular pattern of the 2 durable goods of Beijing urban dwellers can be described precisely by Gompertz model.

2.4. Explanation of the Model

By urban residents in Beijing, saturation point of washing machine and air conditioner can be concluded from the two models. As for washing machine, the saturation point is 101.848, and for air conditioner the saturation point is 206.306. At present, the urban dwells' desire for washing machine has been saturated, and the situation of air conditioner is the opposite. In other words, for manufacturers of washing machine, the market competition is more intense, and the local demand for washing machines is relatively small. On the other hand, competition in manufacturers of air conditioner is not fierce, because the air conditioner market has not yet reached the saturation point, residents still have a strong desire to buy them.

3. FORECAST

Using Gompertz model, we can acquire a series of forecast statistics (as shown in the table). But Gompertz model can not be accurate all the time. Like other forecasting models, it is not only prone to systematic errors, but also affected by unexpected events such as natural disasters, political events and laws. Each of them has a significant impact on the forecast. With the increase in the forecast period, forecast statistics will gradually lose their accuracy. As a result we can forecast in short-term but not in medium or long term.

Table 4: Forecast Statistics

Year	Washing machine	Air conditioner
2010	101.8414	179.2447
2011	101.8434	183.9998
2012	101.8448	187.9624
2013	101.8458	191.2500
2014	101.8465	193.9678
2015	101.8469	196.2081

According to the data above, washing machine capacity is already at saturation point and will remain at 101.8 in short term with little changes. Air conditioner capacity is still growing and will increase year by year, the growth rate tend to be slower from faster, and it will not reach saturation point in few years.

4. CONCLUSION

Both durable goods possession and sales of products follow the same fixed period, namely infant period, the period of growth, maturity and decline. By analysis and forecasting above, possession of washing machine is in the period of mature, washing machine market achieved saturated level. But it doesn't mean washing machine market will pop up to recession period. Because durable goods characteristics shows that only when there is promotion of new technology like new laundry way appears or great changes in life habits, washing machine market reform can be inevitable and finally end with recession. Otherwise washing machine capacity will keep saturated, and maintained in each hundred households residents has about 102 washing machines. Compared with washing machine, the possession of air conditioner is in the period of growth, every hundred households have a far way to reach the 206 saturation point. This shows that in the future, the demand for air conditioner remained a high level in the market. Also showed by Gompertz models, air conditioner capacity will go through a more substantial growth, as to say slowly grow after 2012, maintained at the saturation point 206 in the end. (shown in Figure 2)

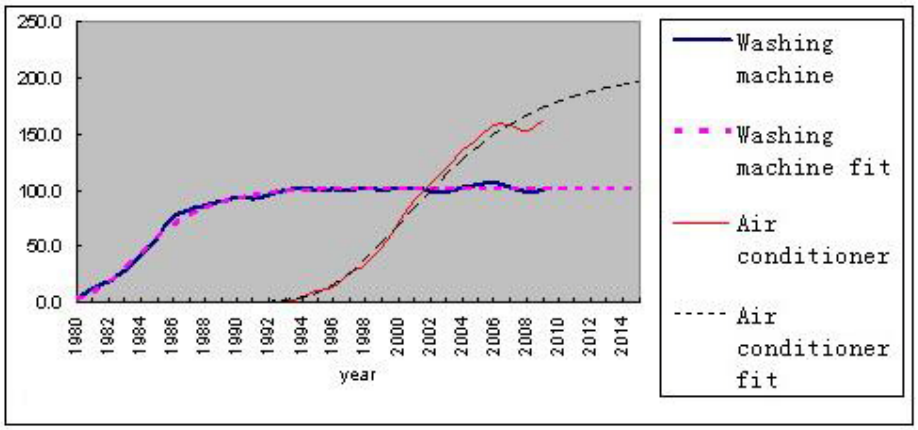

Figure 2: Forecast

Therefore, consumption of the traditional type of durable goods such as washing machine has already reached saturation point, properly remaining close to the saturation point with little chance to float. Possession of air conditioner as the representative of the new possession of durable goods is still in fast-growing stage, its movement will gradually and eventually reach saturation point.

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