Modelling of selected S&P 500 share prices

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Abstract
Historical share prices of selected S&P 500 companies have been accurately approximated by linear functions of the difference between core CPI and subsets of the CPI in the United States. The pricing model describes the evolution of share price along a predetermined trajectory. The selected share prices can be quantitatively estimated at a several year horizon because the driving force behind the prices is characterized by the presence of sustainable long-term trends.

Key words: CPI, prediction, IBM, DOV, PG, DD, APD, CVX, DVN, HAL
JEL classification: G1, D4, E3

Introduction

In the previous paper (Kitov, 2009), we have modelled and predicted the evolution of share prices of ConocoPhillips (COP) and Exxon Mobil (XOM), which are classified in the S&P 500 list as related to energy. It was demonstrated that the time history of these prices could be accurately approximated by a linear function of the difference between core CPI and headline CPI in the United States. This difference is found to be the best to predict share prices in the energy subcategory of the S&P 500. Apparently, there exist other stock pricing models, which we do not consider or even mention in this paper. In general, these models are based on random walk techniques, which come from the assumption that investors are rationale. In other words, an investor adjusts existing share prices only when new information becomes available. Our model is an intrinsically deterministic one and describes the evolution of share prices along *predetermined* trajectories. Hence, our model is opposite to the mainstream concept, i.e. only one of the models can be right. Here we predict the time histories of share prices for several companies from S&P 500 list in order to prove that they can be quantitatively estimated at a several year horizon because the driving force behind the prices is characterized by the presence of sustainable long-term trends. In other words, the prices should follow the trends.

Considering the extremely parsimonious set of defining parameters (one) and the uncertainty associated with definitions and methods of evaluation of the CPI components, the prediction accuracy of COP and XOM share price was reasonable. It is important that both share prices depend on the difference between two consumer price indices, only one of which includes prices of goods related to energy. At the same time, the difference between the core CPI and the price index for energy fails to explain the observed share prices of energy-related companies. It implies that the influence of the change in energy-related consumer prices on share prices of energy-related companies is a rather indirect one. Therefore, one can assume that all price changes in any subcategory of the headline CPI are likely distributed over a number of subcategories in the S&P 500 list.

In this paper, we have modelled share prices for companies in five subcategories: information technology – International Business Machines (IBM); industrials – Dover Corporation (DOV); consumer staples – Procter and Gamble (PG); materials – Du Pont (DD) and Air Products and Chemicals (APD); and energy – Chevron (CVX), Devon Energy Corporation (DVN), and Halliburton (HAL). The latter three companies join COP and XOM. Unlike in the previous paper, we do not extend our prediction into the future. We intentionally avoid any quantitative share price prediction because the readers might be

interested in making own forecasts based on various assumptions on the future evolution of the CPI components.

The prediction of share prices in various S&P 500 groups is of a great importance not only for our pricing model, but also for understanding the driving forces behind share prices for different industries. In a sense, our pricing model might affect the S&P 500 company classification when its price is driven by forces different from other companies in given subcategory. The presence of sustainable (linear and nonlinear) trends in the differences between subsets of the CPI potentially allows predicting share prices at various time horizons.

The remainder of the paper consists of two sections. Section 1 introduces the pricing model. Section 2 presents main results of the modelling and compares price evolution is five subcategories.

1. The pricing model

Our pricing model is simple. We assume the presence of a linear link between a share price and the difference between the core (or headline) CPI and some other subset of goods and services comprising the headline CPI. The intuition behind the model is simple; a higher pricing power for a given subcategory of goods and services, and thus related companies, is expressed in a faster increase in corresponding stock prices. In the first approximation, the deviation between relevant price indices is proportional to the ratio of the pricing powers. The presence of sustainable (linear or nonlinear) trends in the differences, as found in (Kitov, Kitov, 2008; Kitov, Kitov, 2009ab) allows predicting the evolution of the differences, and thus the deviation between prices for corresponding goods and services. The share prices have to follow up.

So, there exist sustainable trends in the differences between various subcategories of consumer (and producer) price indices. We consider the sustainability as an equivalent to the possibility to describe such trends by simple functions of time. Figure 1 shows that the difference between the core CPI, *cCPI*, and the headline CPI, *CPI*, can be approximated by a simple time function:

$$dCPI(t) = a + bt \quad (1)$$

where *dCPI(t)* is the difference, *a* and *b* are empirical constants, and *t* is the elapsed time. Between 1981 and 1999, the linear trend has a slope +0.67, and from 2002 to 2008 the slope

is (-1.65). Hence, the "distance" between the core CPI and the headline CPI is a linear function of time, with a positive or negative slope *b*. It might be of fundamental importance that absolute value of the ratio of the slopes is inversely proportional to the ratio of durations: $|0.67/(-1.65)| \approx 7/19$. If such a trade-off actually exists, one can predict the duration of the next trend from its slope.

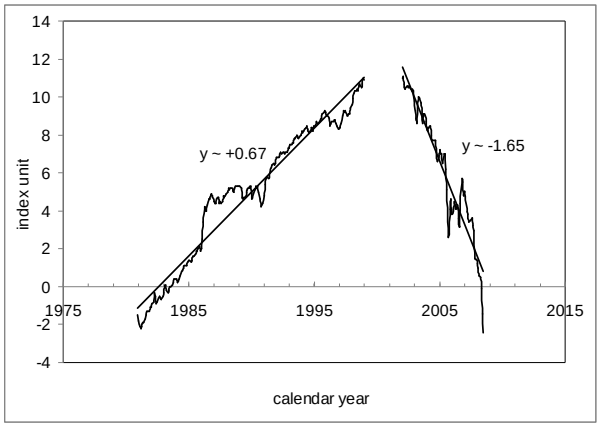

Figure 1. The difference between the core CPI and the headline CPI between 1980 and 2008. There are two distinct periods from 1981 to 1999 and from 2002 to 2008, where the growth in the difference can be accurately approximated by linear functions of time with slopes +0.67 and -1.65, respectively. Notice that absolute value of the ratio of slopes is inversely proportional to the ratio of durations: $|0.67/(-1.65)| \approx 7/19$.

Then, the pricing model states that a share price, for example that of ConocoPhillips, *COP(t)*, can be approximated by a linear function of the difference between the core and headline CPI (Kitov, 2009):

$$COP(t) = A + BdCPI(t + t_1) \qquad (2)$$

where *A* and *B* are empirical constants (for COP, *A=80* and *B=-6.0* for the period between 1998 and 2009); *t* is the elapsed time; and t_1=1/6 year is the time delay between the share and the CPI changes, i.e. the CPI has a lag behind the share price.

Empirical constants in (2) have to be determined for all distinct periods with different trends. This implies the possibility of structural breaks in the link between share price and CPI as caused by the turns to new trends. For example, the set of long-term economic bounds between goods and services, comprising the CPI and defining the linear trend in the *dCPI* between 1981 and 1999, underwent a three-year-long transition to a new set. In turn, the new set defined the trend observed from 2002 to 2008. So, it is reasonable to assume that the sign of slope in (2) should change to an opposite one after the end of the current transition period, which started in 2008.

We have found the force defining the evolution of share prices for energy companies. The problem is how to determine the CPI subset relevant to any given company? The trial-and-error method is the only tool we used at this initial stage of analysis. Figure 2 presents several possibilities: the difference between the core CPI (*cCPI*) and the following subsets: *mcCPI* (the CPI less medical care); *sCPI* (the CPI less shelter); *fsCPI* (the CPI less food and shelter); *h* (the CPI for housing); *f* (the CPI for food); *t* (the CPI for transportation). We have tested only these differences as preliminary candidates explaining share prices for each of the studied subcategories. In the left panel of Figure 2, all differences are very similar in shape, but not in amplitude. So, it might be difficult to distinguish between them when modelling the prices. The difference between the core CPI and the index for housing, shown in the right panel, provides an example of early start of the turn to a new trend in 1996 with a longer transition period. The difference between the core CPI and the index for food is characterized by constant level between 1996 and 2003. Finally, the difference between the core CPI and the index for transportation is similar to those in the left panel.

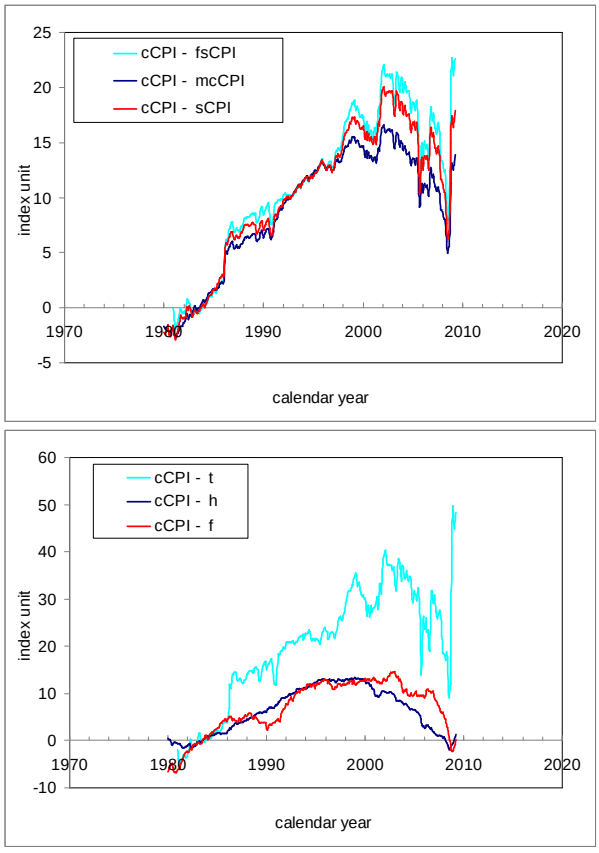

Figure 2. The difference between the core CPI (*cCPI*) and other subsets of the headline CPI: *mcCPI* is the CPI less medical care; *sCPI* is the CPI less shelter; *fsCPI* is the CPI less food and shelter; *h* is the CPI for housing; *f* is the CPI for food; *t* is the CPI for transportation.

2. Comparison

We begin with a model for IBM – a representative of information technologies in the S&P 500 list. By trial-and-error method we have found that the best-fit difference is the following: *cCPI-fsCPI.* It is displayed in the left panel of Figure 3 for the period between 1980 and 2009. There are distinct period of sustainable trends: from 1980 to 1999, and after 2001. The model of IBM share pricing implies a slightly more complicated pattern with turning points in 1986, 1993, and 1999. Right panel of Figure 3 displays the observed (dividend and split adjusted) share price and that predicted from the CPI difference using the following relationships for various time segments (here and below we neglect the time delay t_1 as insignificant):

$$IBM = -5*(cCPI - fsCPI) + 170;\ 1999\text{-}2009$$

$$IBM = 10*(cCPI - fsCPI) - 100;\ 1993\text{-}1999$$

$$IBM = -3*(cCPI - fsCPI) + 43;\ 1986\text{-}1993$$

$$IBM = 3*(cCPI - fsCPI) + 17;\ before\ 1986$$

The 1993 turning point in the difference is not convincing, but the 1986 point has all credits – sharp and big change in the slope. Despite the obvious artificiality of the model it gives some positive signals in the direction of the future investigations.

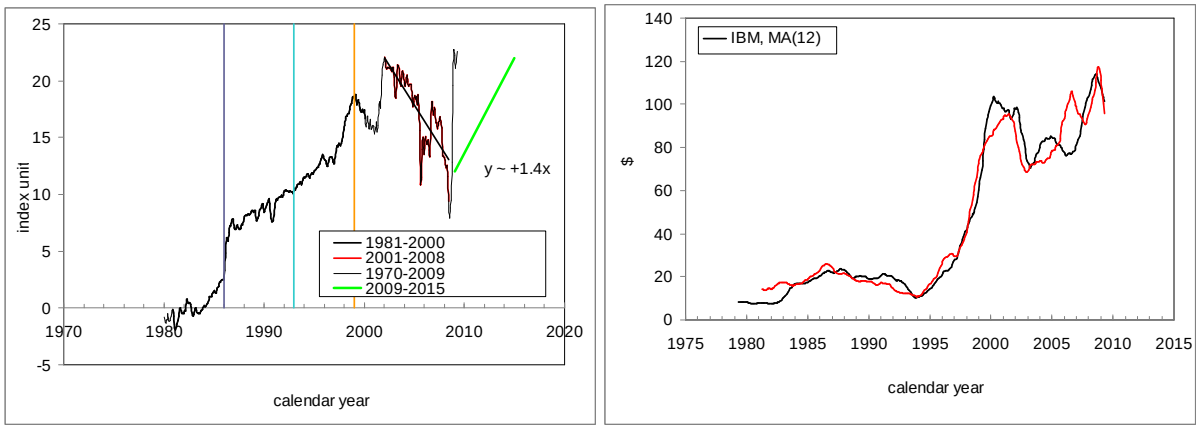

Figure 3. *Left panel*: The difference *cCPI-fsCPI*. *Right panel*: The observed and predicted IBM share price (see text for relationships). The former is a 12-month average, MA(12), of the price adjusted for dividends and splits.

In the long run, the difference will likely grow. The next move in IBM share price is not clear, but if the increasing difference in 2008 and 2009 will have the same effect on the price in the future, then one could expect a slightly declining stock price in the next several years.

As for IBM, the difference driving the price of DOV share (a representative of industrials) is likely that between the core CPI and the headline CPI less food and shelter. There are several lines of consideration that potentially explain why this difference affects the

price. It is important that it is *not* the CPI of relevant subcategory, which drives the share. We distinguish two main periods, as shown in Figure 4:

$$DOV = -2.2*(cCPI - fsCPI) +75;\ 1999\text{-}2009$$

$$DOV = 2.0*(cCPI - fsCPI) - 10;\ before\ 1999$$

The model for Procter and Gamble (consumer staples) share is presented in Figure 5, which displays the observed (dividend and split adjusted) price and that predicted from the difference between the core CPI and the CPI less medical care. Simple visual fit has revealed the following relationships for two time segments:

$$PG = -4.0*(cCPI - mcCPI) +100;\ 1999\text{-}2009$$

$$PG = 2*(cCPI - mcCPI) - 10;\ before\ 1999$$

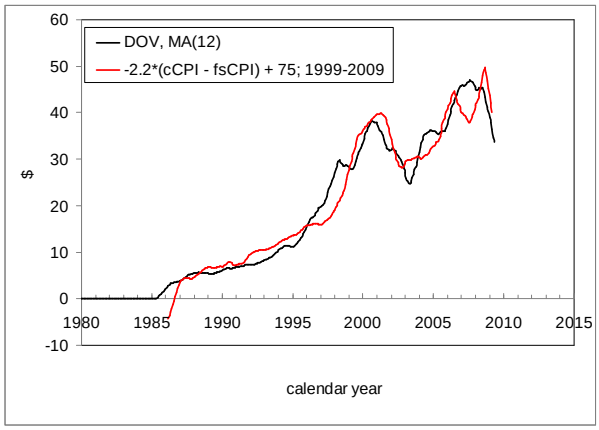

Figure 4. The observed and predicted DOV share price. The former is a 12-month average, MA(12), of the price adjusted for dividends and splits.

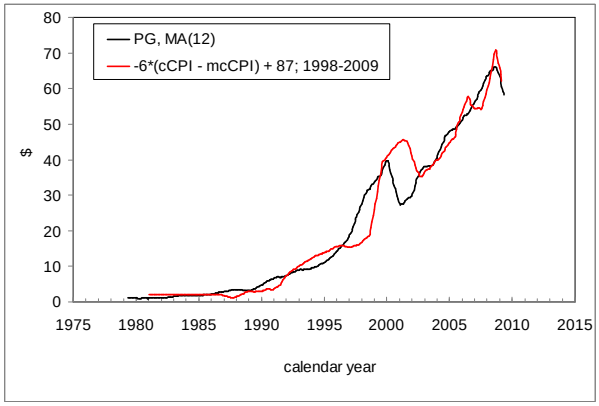

Figure 5. The observed and predicted Procter and Gamble share price. The former is a 12-month average, MA(12), of the price adjusted for dividends and splits.

The model for DuPont (materials) share is presented in Figure 6, which displays the observed (dividend and split adjusted) price and that predicted from the CPI difference using the following relationships for two distinct time segments:

$$DD = -1.1*(cCPI - fsCPI) +58;\ 2000\text{-}2009$$

$$DD = 4*(cCPI - fsCPI) - 25; \text{ before } 2000$$

For DD, we skip the period before 1986, which is represented by a constant. The predicted price is very close to the observed one over the whole period. Of special importance is the prediction of the peak between 1998 and 2000, and the following drop in early 2000, which is not related to the 2001 recession. A remarkable feature is the prediction of the amplitude and timing of the sharp and deep fall in the second part of 2008. This is an indispensable validation of the pricing model for DD.

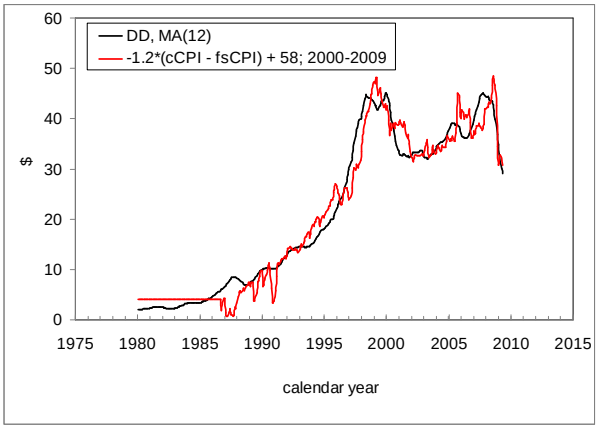

Figure 6. The observed and predicted Du Pont share price. The former is a 12-month average, MA(12), of the price adjusted for dividends and splits.

Trial-and-error method is applied to obtain the best visual fit between the APD (materials) monthly (close) price adjusted for dividends and splits and the *dCPI(t)*. Figure 7 illustrates the fit between actual share price and that predicted using the following relationships:

$$APD = -5.5*dCPI(t) + 87; \text{ from } 1998 \text{ to } 2009$$

$$APD = +5*dCPI(t) - 20; \text{ before } 1998$$

DuPont and Air Products and Chemicals both represent materials-related companies in the S&P 500 list. However, they have been modelled using different subsets of the CPI: the headline CPI and the CPI less food and shelter, respectively. Figure 2 shows that both differences are similar in shape, but not in amplitude. So, the models are practically equivalent, with slopes and free terms dependent of the difference chosen. The possibility to use various differences for companies in one subcategory demonstrates the necessity of a thorough study with all potential pairs of the CPI components tested. But even the initial models in Figure 6 and 7 indicate a high predictive power of our share pricing concept.

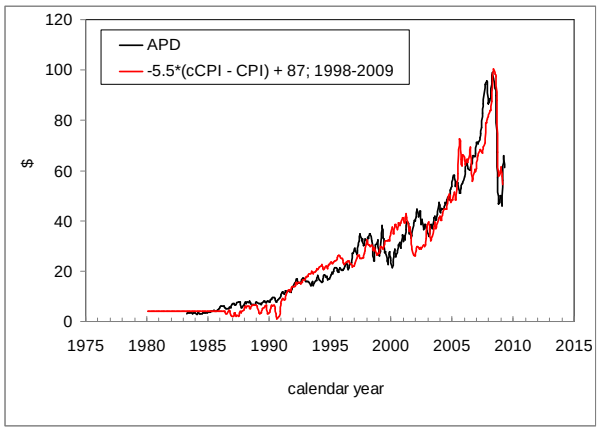

Figure 7. The observed and predicted Air Products and Chemicals share price.

Figure 8 presents Chevron, Devon Energy, and Halliburton. As for other energy-related companies, the difference driving relevant share prices is likely that between the core and headline CPI. The models for CVX, DVN, and HAL share price contain one turning point in 1999:

$$CVX = -5.5*(cCPI - CPI) +85;\ 1999\text{-}2009$$

$$CVX = 3*(cCPI - CPI) - 10;\ before\ 1999$$

$$DVN = -7.7*(cCPI - CPI) +97;\ 1999\text{-}2009$$

$$DVN = 3.5*(cCPI - CPI) - 18;\ before\ 1999$$

$$HAL = -3.5*(cCPI - CPI) + 43;\ 1999\text{-}2009$$

$$HAL = 2*(cCPI - CPI) - 7;\ before\ 1999$$

The next move in all three shares will be up in line with the increasing oil price (Kitov, 2009). In the long run, the *dCPI* will likely be growing. The increasing difference will have the same effect on the prices in the future as always before – share price grows at a rate proportional to the slope in the *dCPI*.

Three energy related companies in Figure 8 are characterized by different coefficients *B* between 1998 and 2009: from -3.5 (HAL) to -7.7 (DVN). Previously, we determined the slopes for COP (-6.0) and XOM (-6.0). Now one can conclude that these five energy-related companies demonstrate different levels of effectiveness in converting of the *dCPI* into share price. Devon Energy Corporation was the most efficient among the five: from $11 in 1998 to $101 in 2008. Halliburton was only a half as efficient with the share price increase from $10 in 1998 to $52 in 2008. If this tendency will continue in the future, one should have a good reason when investing into HAL. Major energy companies demonstrate very close slopes over the entire period after 1980, with the slope of -6.0 between 1998 and 2008.

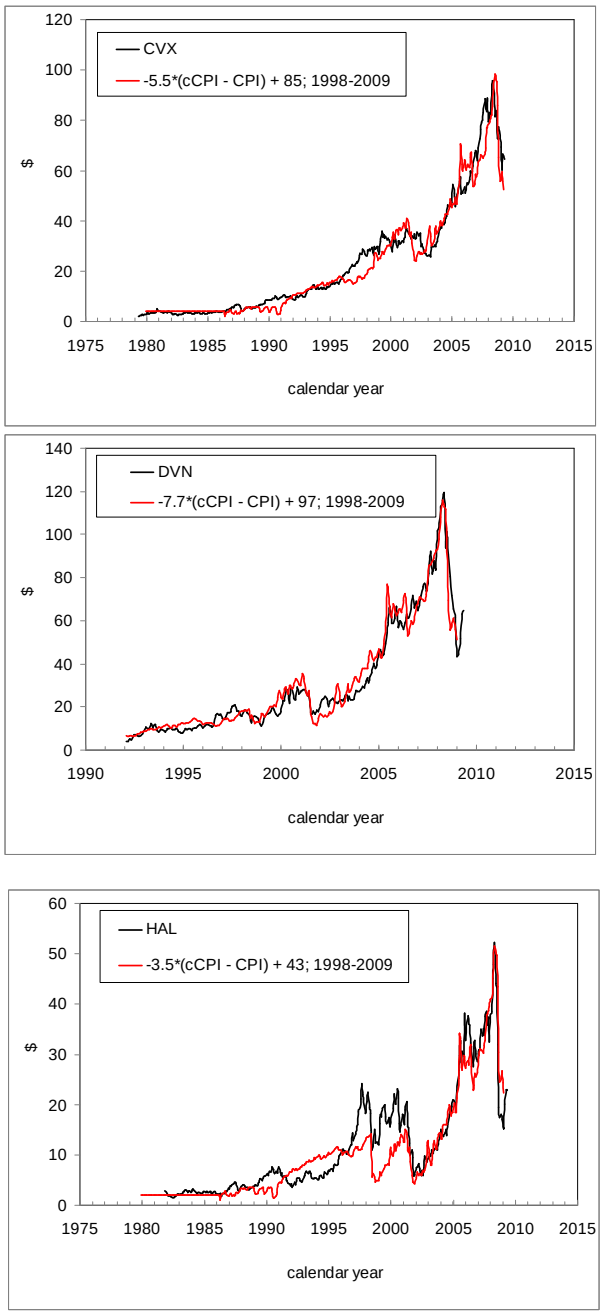

Figure 8. The observed and predicted shaer price of Chevron (CVX), Devon Energy Corporation (DVN), and Halliburton (HAL).

Conclusion

Despite its striking dissimilarity to the mainstream concepts, our pricing model is deeply rooted in economics as expressed in terms of common sense: a higher pricing power achieved by a given company should be converted into a faster growth in corresponding consumer price index. So, the link between these two measured variables is, effectively, a causal one. If the evolution of the difference between various components of the CPI would have been a random walk, the mainstream stock pricing models would be correct. However, the existence

of sustainable trends in the differences makes these models obsolete, at least for some companies from the S&P 500 list.

An important possibility arises from our analysis. Using different subsets of the CPI, one can improve our tentative models for the studied companies, and easily obtain quantitative relationships for other companies. By extrapolating previously observed trends into the future, one may forecast share prices at various horizons. What likely is more important for a broader investor community, the proposed model also allows predicting the turning points between adjacent trends, when share prices suffer substantial decline. For example, the 2008 turning point in oil price was predicted in advance (Kitov, Kitov, 2008). Since this first prediction, the model has been improved and corrected.

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