# Web版ニューラルネットワークと線形回帰分析のハイブリッド解析法によるデータ解析法

## — 英国におけるビル価格指数決定モデル —

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# Web-based Data Analysis: The Hybrid Approach to Neural Networks and Linear Regression

## – A British Tender Price Index Modelling –

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[**Abstract**]

This paper demonstrates the process of using the Web-Based Approach to Neural Networks and Liner Regression by working through the British TPI model. The Hybrid Approach to Neural networks and Linear Regression was proposed in 2003 as a solution to achieve both high data consistency and lucidity in model interpretation. The Web-Based Approach is a further development to simplify the computation process and allow more researchers to carry out hybrid approach analyses at ease. Using the hybrid approach at the Web-Based system, we manage to find a British TPI model, which is more consistent with the data without losing the simplicity in interpretation.

Key Words: Latent structure, sigmoid decomposition, Model selection, Tender Price Index, Web-Based.

## 1. Introduction.

Building Tender Prices are contract prices agreed between clients and contractors for constructing buildings. Since buildings are heterogeneous, the general price level of constructing new buildings

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[1] Yu and Ive (forthcoming) explicate in more detail the TPI complication method in Britain.

This work was supported by Grant-in-Aid for Scientific Research (C) (19500241): KAKENHI.2007. Representative researcher: Miyoko Asano, Co-researcher: Hiroe Tsubaki, Title "Web-based Hybrid Approach to Neural Networks and Linear Regression Analysis."

needs to be measured by a price index – Tender Price Index (TPI) [1]. TPI is a useful indicator of the general price level movement in building Market and thus is a component of the Gross Domestic Product deflator.

It is different from the construction price index (CPI) calculated by the Japanese Ministry of Construction in the sense that TPI is an output index measuring the prices of different components of buildings while CPI measures input costs such as material prices and labor wages. Since TPI is a macroeconomic indicator like consumer price index, it is generally believed that TPI is driven by macroeconomic factors such as unemployment levels, labor wages, material price, oil price, profits in manufacturing sector and so on. We will return to it in the next section.

In Britain, the major applications of TPI modelling and forecasting for government and the private companies are as follows:

1. For government: by knowing the movement of the general price level of constructing buildings in the future, the government can form better fiscal policy. They can build hospitals, schools, and social housing at the time of lower price to stabilise the economy. When they expect there will be a deflation (i.e. a drop in the building TPI), they can speed up the programme of constructing new buildings to curb the deflation.
2. For private property developers: accurate forecast of TPI allow them to have better financial planning of their development projects. Particularly in some cases, they would sell or lease the properties before they are constructed.
3. For contractors: accurate forecast of the TPI allow them to have a better view of the competitive level of the market. Therefore, they will be in a better position to submit competitive and sustainable bids for new building projects.

Therefore it is not surprising that a lot of research efforts have been devoted to the modelling and forecasting of TPI (Akintoye et al 1998, Akintoye & Skitmore 1993, Bowen & Edwards 1985, Dawood 2001, Fellows 1991, Goh 2005, McCaffer et al 1983, Ng et al 2004, Runeson 1988, Ssegawa 2003 and Taylor & Bowen 1987). The statistical workhorse underpinning these studies is linear regression model because the result of linear regression is simple to interpret, but it may not fully utilise the data information for accuracy. Akintoye & Skitmore (1993) provide a sophisticated linear regression model to relate the British TPI to other macroeconomic factors such employment levels, real interest rates, labor wages and material prices.

Using the information and model in Akintoye & Skitmore (1993), this paper aims at demonstrating the appealing feature of the hybrid approach to neural network and linear regression. This approach was proposed by Asano and Tsubaki (2003): while maintaining the simple interpretational facet of linear regression, the hybrid technique improves the accuracy of the model. Asano et al (2006) applied the hybrid approach to Data Editing and also propose the Asano-Bhattacharyya graph to facilitate visual inspection of the model structure. This paper introduces the Web-based Data Analysis which was planned and developed by Asano and Tsubaki in 2007. The intention is to facilitate all researchers to carry out the hybrid approach analysis through the internet at ease.

## 2. Model and Statistics

In addition to the academic research mentioned in the introduction, there are a few organisations in Britain modelling and forecasting Building TPI such as Building Cost Information Services (BCIS), Davis Langdon LLP, and the Department of Business, Enterprise and Regulatory Reform. However, all of these organisations such as BCIS would not disclose their models because the models are their trade secret.

We find that Akintoye and Skitmore is the most thorough academic research in modelling TPI in Britain. In Akintoye and Skitmore (1994), they compare the forecasts of their models to the forecasts of two well established private organisations in Britain, and find their model perform better. The model is described and explained in Akintoye and Skitmore (1993).

For simplicity, we focus on the single structure equation of construction price estimated in Akintoye and Skitmore (1993: pp. 285). When we used the data from Akintoye and Skitmore (1993) for the period between 1974Q1 and 1988Q4, we have obtained the linear regression result as follows:

$$\ln TPI_t = -3.131 + 0.679 \ln BCI_t + 0.005 \ln STR_{t-4} - 0.341 \ln PRO_{t-2} - 0.133 \ln FRM_{t-5} + 0.003 RIR_{t-3} + 0.423 \ln MAN_{t-7} - 0.194 \ln EMP_{t-2} + 0.459 \ln GNP_t + 0.057 OIL_{t-1}$$

Adjusted R square = 0.965; AIC = -405.77

Where,

- *BCI* : labour wage & material price
- *STR* : number of strikes or stoppages
- *PRO* : labour productivity
- *FRM* : number of construction firms

- *RIR* : real interest rate
- *MAN* : profit margin in manufacturing sector
- *EMP* : level of unemployment
- *GNP* : real Gross National Product
- *Oil* : Oil crisis dummy for 1978Q2 to 1980Q2

The result is comparable to that reported in Akintoye & Skitmore (1993: pp. 285) but is different in the values of same coefficients. We have contacted Professor Akintoye and he could not find any errors in our linear regression analysis. He currently attempts to figure out why he got a different result and it appears that he made some errors in the data input process.

Despite the small difference, the result confirms that *TPI* is related to labour wage and material price (measured by *BCI*), number of strikes or stoppages (measured by *STR*), labour productivity (measured by *PRO*), number of construction firms (measured by *FRM*), real interest rate (measured by *RIR*), profit margin in manufacturing sector (measured by *MAN*), level of unemployment (measured by *EMP*), real Gross National Product (measured by *GNP*), and oil price (*OIL* is a dummy for the period of oil crisis: 1978 Q2 to 1980 Q2). All signs of the coefficients are as expected: a higher material price, more industrial actions, a higher interest rate, a higher manufacturing profit margin and a higher GNP all push the *TPI* higher; whereas a higher labour productivity, more construction firms, and higher unemployment rate should reduce the rise in *TPI*.

## 3. Web-based Data Analysis: A British TPI Modelling

We have applied the hybrid approach to neural networks and linear regression proposed by Asano & Tsubaki (2003) to model the British TPI. Limited by the length of the paper, we do not repeat the procedure here. Asano and Yu (2007) demonstrated how to apply the hybrid approach to model building cost data from Hong Kong.

In the past, the lack of access to appropriate computer software and the barrier to computer programming knowledge may prohibit some researcher to carry out hybrid approach analysis. Because of this, we have set up a webpage to allow researchers to carry out hybrid approach analysis. No prior knowledge of computer programming is required, and we will demonstrate how to use this Web-based Data Analysis tool to apply the hybrid approach to the British TPI Modelling.

The webpage address of the Hybrid Approach to Neural Networks and Linear Regression is as below, and an operating manual (both English and Japanese versions) can be found at the webpage.

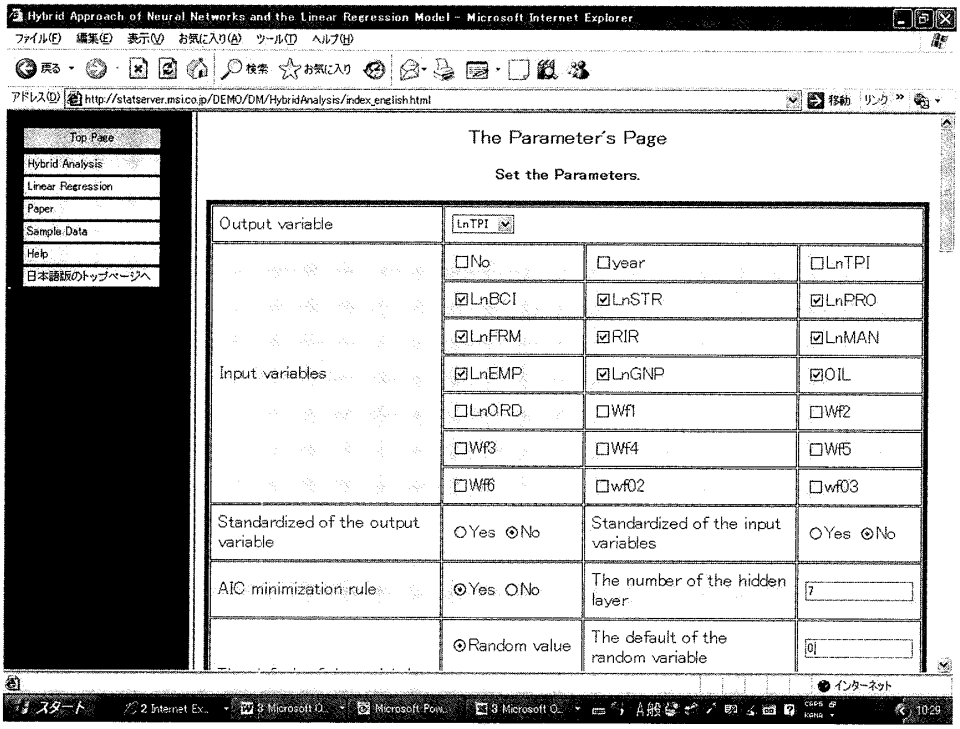


Figure 1. Parameter's Page (1).

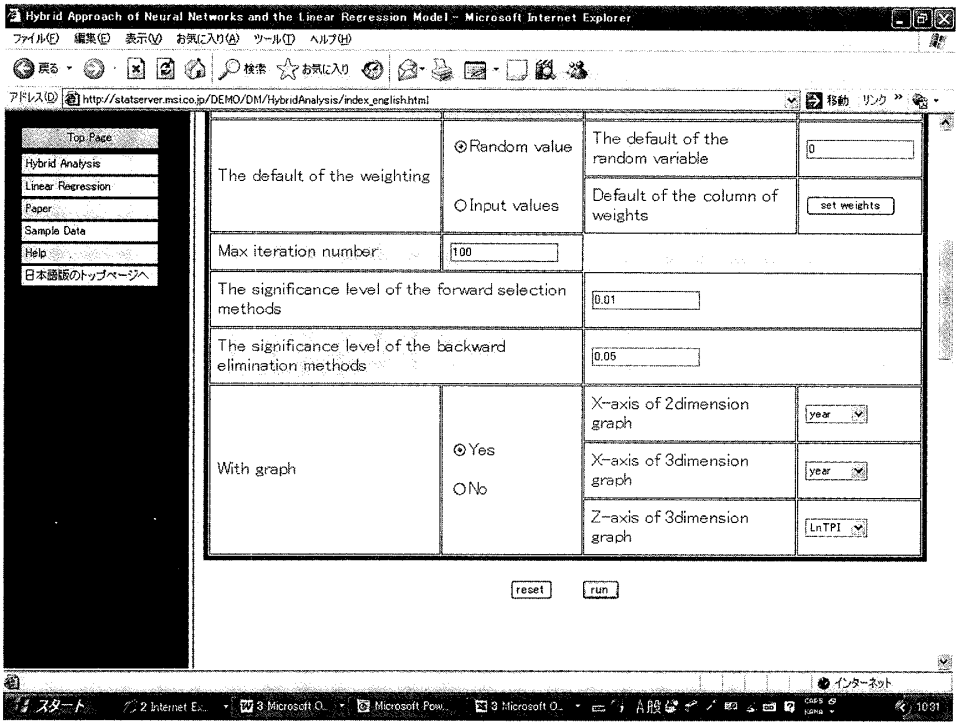


Figure 2. Parameter's Page (2).

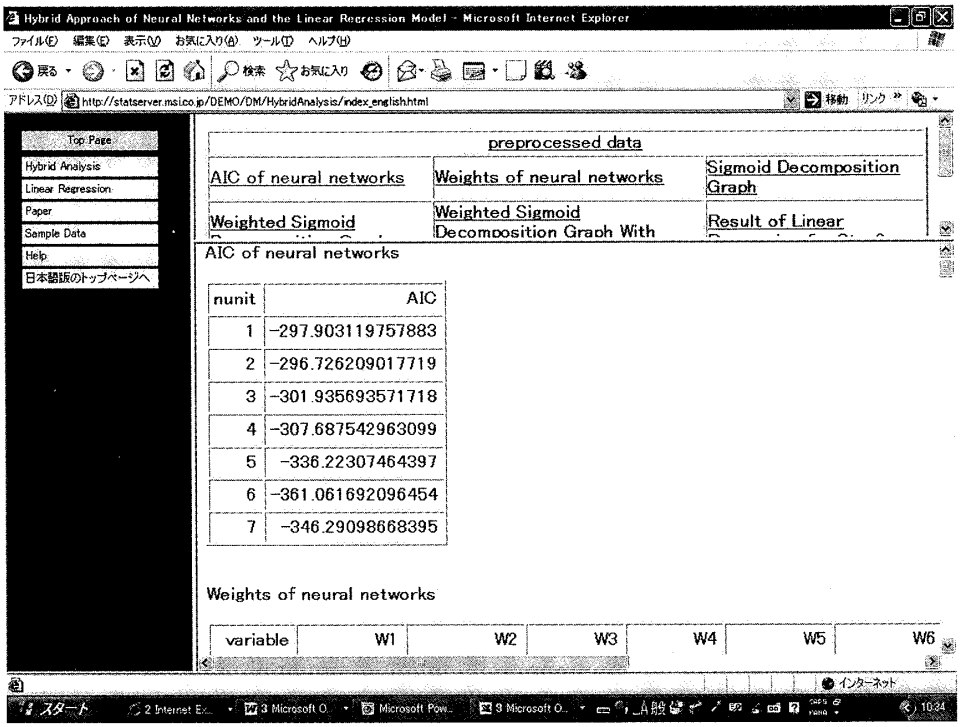


Figure 3. AIC of neural networks ($p = 9$ and $q = 6$).

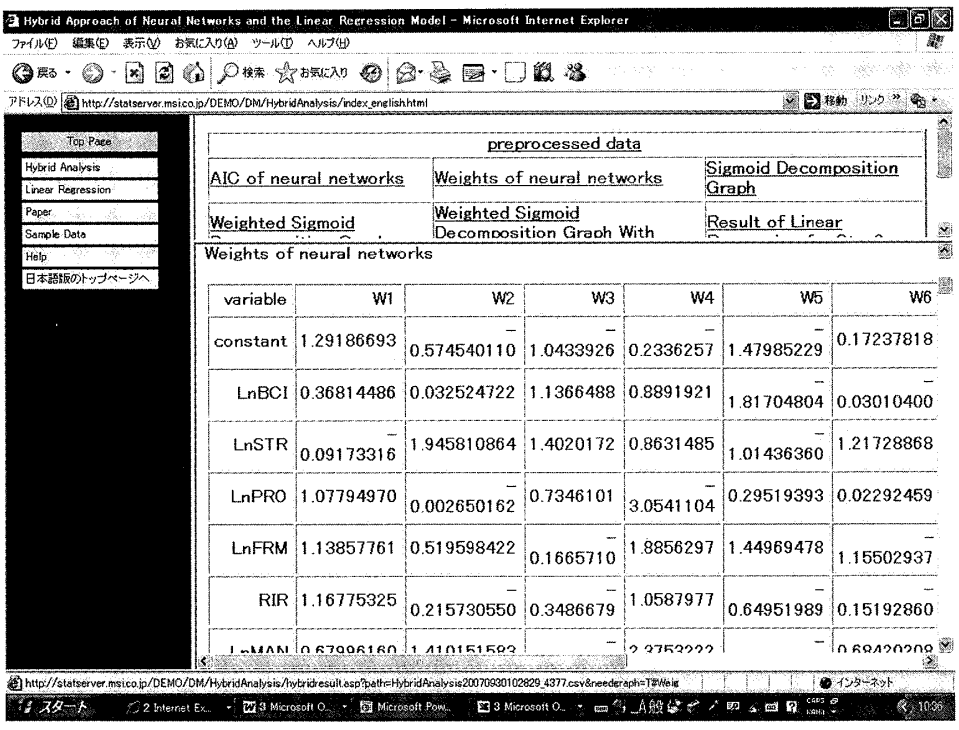


Figure 4. Weights of neural networks. (The weights of the independent variables in the 6 hidden layers.)

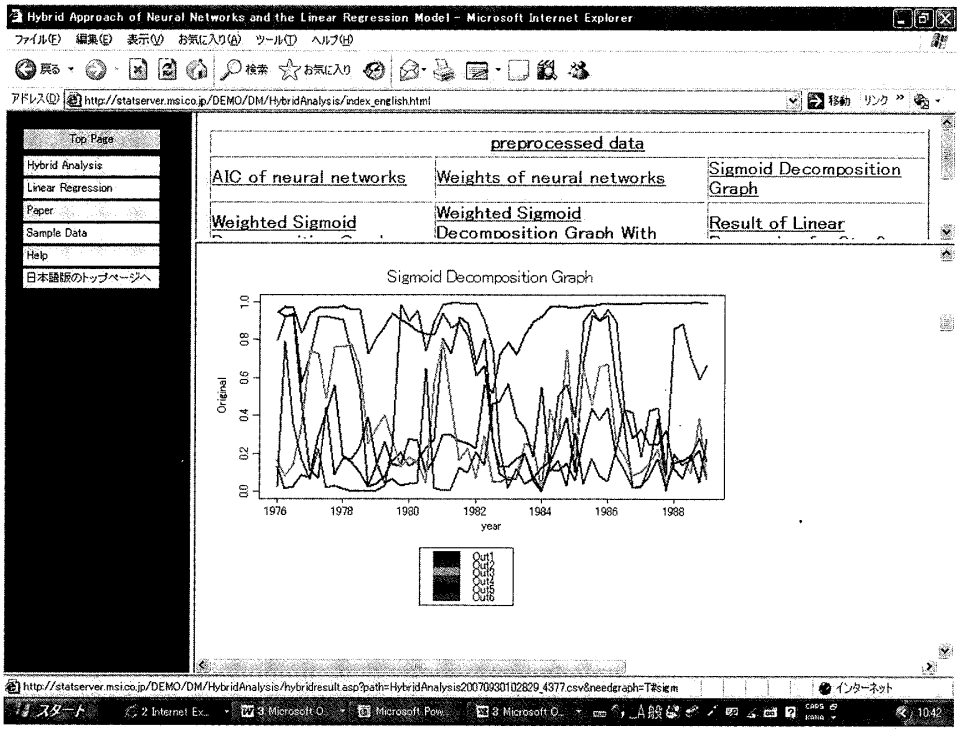


Figure 5. Sigmoid Decomposition Graph.

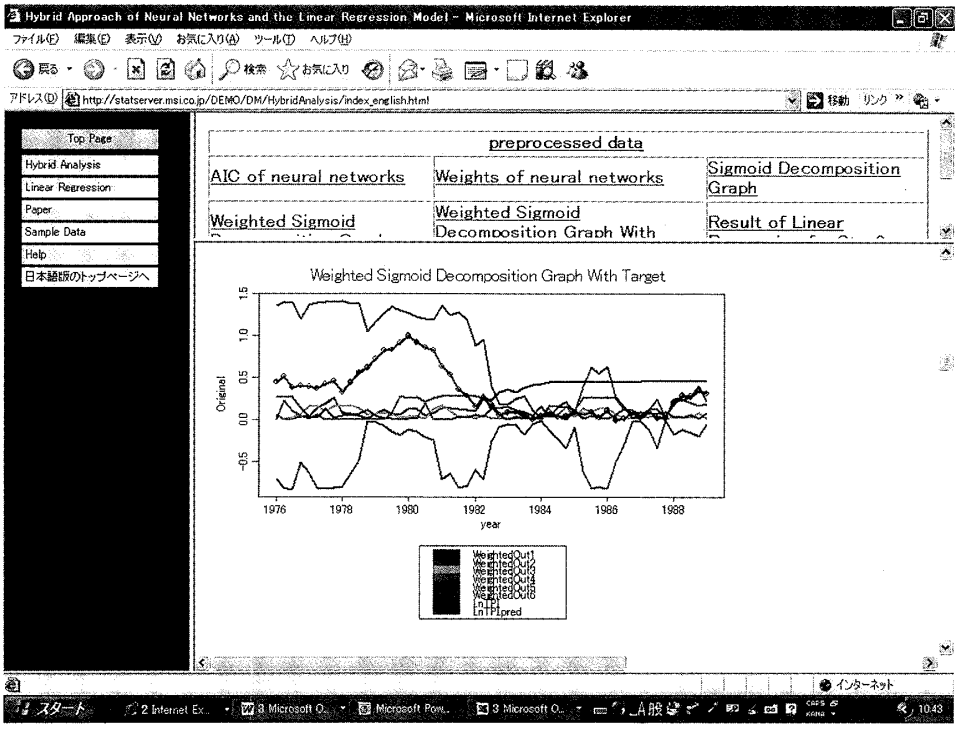


Figure 6. Weighted Sigmoid Decomposition Graph with the Target: Dependent Variable (*TPI*).

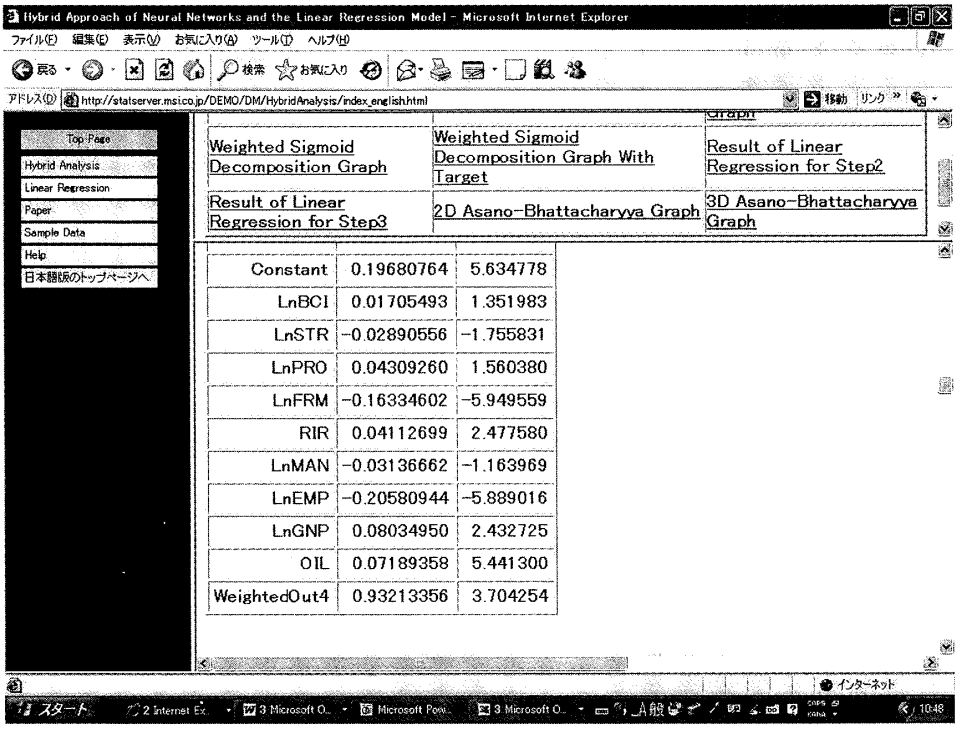


Figure 7. Result of Linear Regression for Step2. ($p$ = 9, $q$ = 6, and $q'$ = 1)

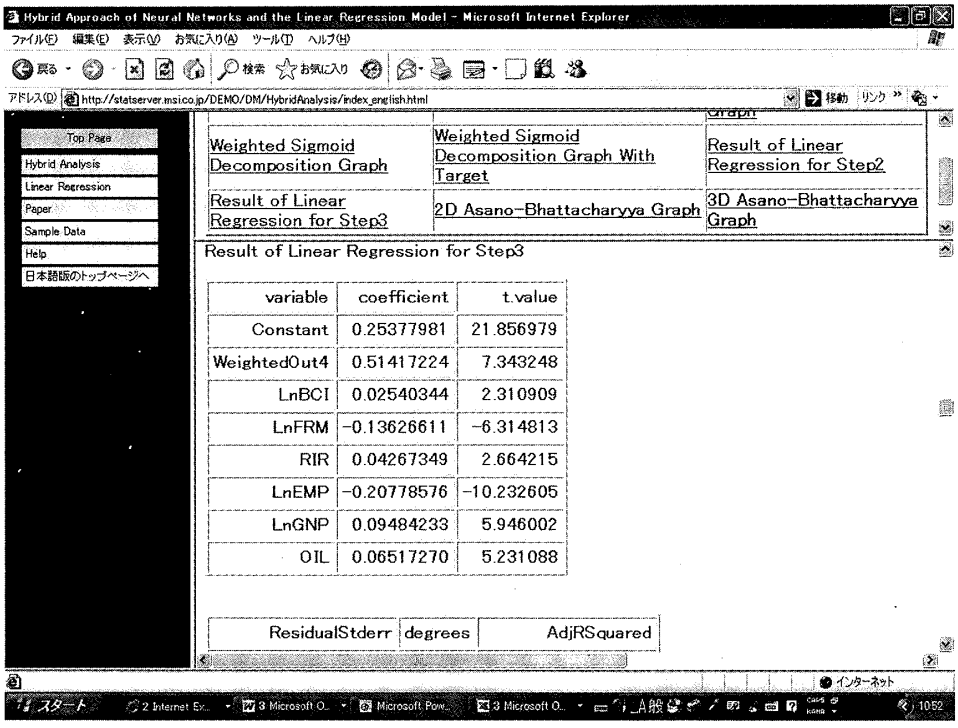


Figure 8. Result of Linear Regression for Step3. ($p$=9, $p'$=6, $q$=6, and $q'$=1.)

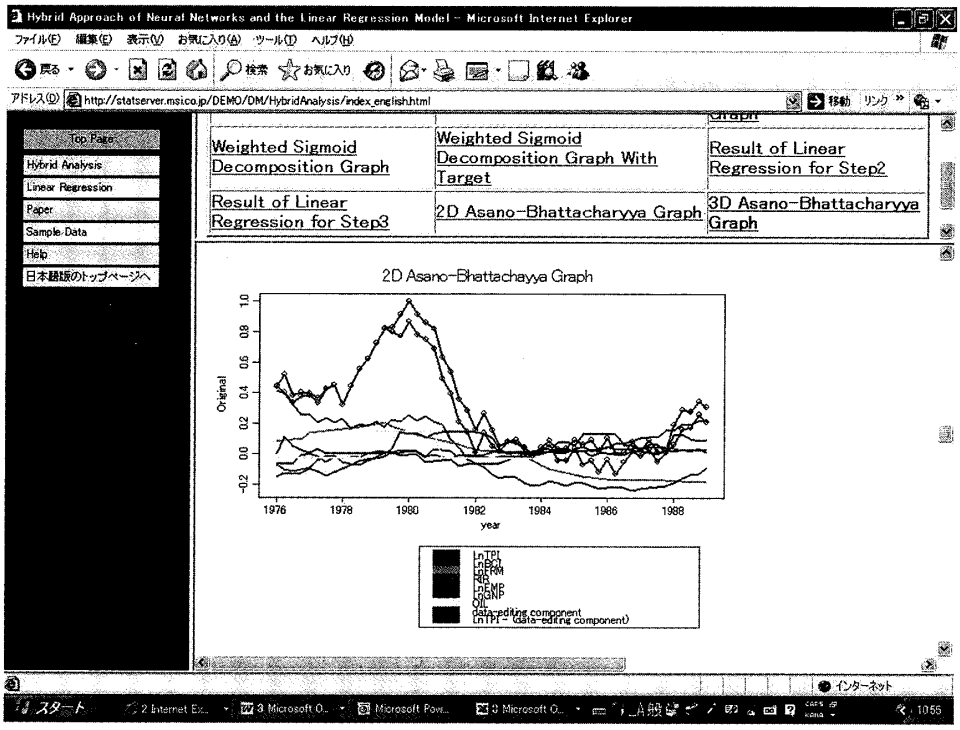


Figure 9. A graphic presentation of the British TPI Modelling by the hybrid approach. (2D Asano-Bhattacharyya Graph.)

http://statserver. msi. co. jp/DEMO/DM/HybridAnalysis/index. html

To begin with, we have 9 potential independent variables ($p = 9$). Having uploaded the data (in CSV format) to the webpage, and it computes that the number of hidden layer to minimize AIC is 6 ($q = 6$). Figure 3 provides the AIC minimization result obtained from the webpage.

The Web-based Data Analysis programme also provides the weightings of the independent variables in the 6 hidden layers as shown in Figure 4.

Figures 5 and 6 show the Sigmoid Decomposition of the 6 hidden layers with and without the dependent variables (*TPI*). Using the step-wise multiple regression method at 0.01 significance level, only 1 hidden layer: out4 is chosen ($q'$=1) from the six potential hidden layers. (Figures7).

Fixing $q' = 1$ as shown in Figure 7, the programme goes on to use backward elimination at 0.05 significance level to select independent variables in the linear part of the model. 6 independent variables ($p' = 6$) are chosen from the 9 potential variables as shown on Figure 8. The Web-Based Data Analysis programme also provides graphical presentation of the result in 2-D and 3-D Asano-Bhattacharyya Graph. Figure 9 is an example of the 2-D Asano-Bhattacharyya Graph.

## 4. Conclusion

Taking the most thorough British TPI Model and the associated dataset we can find, we apply the hybrid approach to neural networks and linear regression to re-model the TPI. The hybrid approach model is found to be more succinct with improved accuracy measured by AIC. This complex data analysis process is being automated in the Web-Based Data Analysis and the process to obtain the hybrid model for British TPI is demonstrated.

## References


Asano, M., Tsubaki, H., and Yoshizawa, T. (2002) "Effectiveness of neural networks to regression with structural changes", *Applied Stochastic Models in Business and Industry*, Vol. 18, No. 3, pp. 189-195.

Asano, M. and Tsubaki, H. (2003) "Hybrid Approach with Neural Networks and the Linear Regression Analysis and its application to prediction of the amount of the water supply in Tokyo 23 districts", *Japanese Journal of Applied Statistics*, Vol. 31, No. 3, pp. 227-138 (in Japanese).

Asano, M. and Yu, M. K.W. (2007) "An Introduction to the Hybrid Approach of Neural Networks and the Linear Regression Model: An Illustration in the Hedonic Pricing Model of Building Costs", *Bulletin of Daito Bunka University (Social Science Series)*, Vol. 45, pp. 1-14.

Akintoye, S. A., and Skitmore, R. M (1993) "Macro Models of UK Construction Prices", *Civil Engineering Systems*, Vol. 10, No. 4, pp. 279-299.

Akintoye, S. A., and Skitmore, R. M. (1994) "A Comparative Analysis of Three Macro Price Forecasting Models", *Construction Management and Economics*, Vol. 12, pp. 257-270.

Bowen, P. A., and Edwards, P. J. (1985) "Cost Modelling and Price Forecasting: Practice and Theory in Perspective", *Construction Management and Economics*, Vol. 3, pp. 199-215.

Dawood, N. N. (2001) "Development of a Forecasting Methodology for Cost Indices: an Application to the Greek Construction Industry", *Journal of Construction Procurement*, Vol. 7, No. 1, pp. 42-50.

Fellows, R. F. (1991) "Escalation Management: Forecasting the Effects of Inflation on Building Projects", *Construction Management and Economics*, Vol. 9, pp. 187-204.

Fizgerald, Eamon, and Akintoye, Akintola (1995) "The Accuracy and Optimal Liner Correction of UK Construction Tender Price Index Forecasts", *Construction Management and Economics*, Vol. 13, pp. 493-500.

Goh, Bee Hua (2005) "The Dynamic Effects of the Asian Financial Crisis on Construction Demand and Tender Price Levels in Singapore", *Building and Environment*, Vol. 40, No. 2, pp 267-276.

McCaffer, R., and McCaffrey, M. J. and Thorpe, A. (1983) "The Disparity between Construction Cost and Tender Price Movements" *Construction Papers*, Vol. 2, No. 2, Chartered Institute of Building, pp. 17-27.

Ng, S. Thomas, Cheung, Sai On, Skitmore, R. Martin, and Wong, Toby C. Y. (2004) "An Integrated Regression Analysis and Time Series Model for Construction Tender Price Index Forecasting", *Construction Management and Economics*, Vol. 22, pp. 483-493.

Runeson, K. G. (1988) "Methodology and Method for Price-Level Forecasting in the Building Industry", *Construction Management and Economics*, Vol. 6, pp. 49-55.

Runeson, G. and Bennett, J. (1983) "Tendering and the Price Level in the New Zealand Building Industry", *Construction Papers*, Vol. 2, No. 2, pp. 29-35.

Ssegawa, J. K. (2003) "A Building Price Index: a Case for Botswana", *Journal of Financial Management in Property and Construction*, Vol. 8, No. 1, pp. 17-28.

Taylor, R. G. and Bowen, P. A. (1987) "Building Price-Level Forecasting: an Examination of Techniques and Applications" *Construction Management and Economics*, Vol. 5, No. 1, pp. 21-44.

Yu, M. K.W. and Ive, G. (forthcoming) "The Compilation Methods of Building Price Indices in Britain: A Critical Review", *Construction Management and Economics*.

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(2007年９月29日受理)