9. MACROECONOMICS FRAMEWORK CONSIDERED RISK FACTORS: BASED ON DEFAULT DISTANCE[1]

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Abstract

This paper adopts the macro-financial engineering method, taking risk factors into account to build a new framework for macroeconomic research in the IS-LM-BP model. Based on the balance of commodity markets, currency markets and the international balance of payments, the framework studies the balance of the level of risk, and analyzes a series of changes of the BP curve under given risk factors. Meanwhile, this paper also conducts empirical study using Chinese data from years 2007-2010.

Keywords:macro-financial engineering, IS-LM-BP, risk, debt crisis

JEL Classification: E17, E19

Introduction

Since the U.S. subprime crisis in 2007, the global economy and finances have entered into a relatively chaotic era. With the deepening of the debt crisis in Europe and the United States, economic and financial crisis happened in these countries and rapidly spread in the euro area and the world. With the changes in trade and financial condition, the volatility of foreign exchange market and stock prices was greatly enlarged, which negatively affected the global economic recovery process, and

[1]*This paper is supported by the key project on philosophy and socialscience of national Ministry of Education in 2012-* Research on the effectsand countermeasures of the debt crisis in Europe and the United States on China*(12JZD029) and the Youth Fund Project on Humanity and Social Science of national Ministry of Education in 2010-* Research on theextremeriskoffinancialsectorandgovernment-guaranteedriskresponsibility*(10YJC790217).*

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brought to China both crises and development opportunity in economy and finances. Combined with the international status of China in the global economy, we need a profound understanding of the national debt crisis in Europe and the United States, which needs first confirmation of the impacts and later response measures according to these impacts.

According to the recent research, the *Balance Sheet Approach*waslargely used in the research of the risk between different countries, the financial sector and in the country's internal departments; Gray (2007) is representative. Ye Yonggang, Song Lingfeng and Zhang Pei (2011) put forward the *Macrofinancial Engineering Theory*, and based on the *Balance Sheet Approach* they conducted comprehensive research on the risk of multiple departments. However, the European debt crisis and the US debt crisishave different characteristics.And their research productiondid not give a full description of the risk conduction across. In the multinational public sector risk *Conduction, Contingent claims Approach* (CCA) is more suitable. For the debt crisis, using CCA in debt sustainability issues, Gray and Malone (2008) created a calculation method of external debt default probability. Based on CCA, considering the implied expected losses from the financial markets and the government to provide implicit guarantees to the financial sector, Gray and Jobst (2010) improved the CCA and named it as systemic risk CCA. If considering multiple countries as a whole, the method can be used to study the risk of conduction between the two countries. At the same time, they also mentioned the possibility of the network model with CCA, and put forward the idea of the Merton-based-Network, the network can be established through more direct indicators of risk model to study risk conduction across.

In theoretical research, risk factors introduced into the study of macroeconomics research on the strategy for the debt crisis in Europe and the United States provides a new method. Gray and Malone (2008) point that traditional macroeconomics and macroeconomic variables studied do not reflect the risk of the economy, but through the way of the combination of risk and macroeconomics methods study. According to the classification of Pagan (2003), they discuss the combination of different research methods. Pagan (2003) classified macroeconomic modelsinto two types: the empirical methods and the theoretical models. From theory to empirical, the order is IS-LM model, DSGE models, dynamic random macroeconomic policy model and VAR model. In Gray and Malone (2008b), the risk factors in the form of a risk premium is introduced into the model in the IS-LM-BP model of the formation of the IS-LM-BP-MF, BP curve shape under the influence of the risk factors into a backward bending of the curve, thereby forming the different results with the IS-LM-BP model. Based on Bardsen (2006), which using DSGE in the financial stability studies, Gray and Malone (2008a) advanced the idea of further study, but did not build a new model.

The paper is divided into four parts;Section 2 outlines the framework of the entire study, Section 3 interprets the key models, Section 4 takes advantage of China's data to prove the validity of the model of the IS-LM-BP-MF, and Section 5 summarizes.

2. The Theory

In this study, the basic idea is the introduction of the risk factors into the macroeconomic model, in aform suitable for macroeconomic policy analysis and decision-making mechanism under the new conditions. The macroeconomic model is a new open macroeconomic IS-LM-BP model and the introduction of the risk factors is based on therisk premium macro-balance sheet.

The new open economy Mundell-Fleming model stems from Fleming (1962) and Mundell (1962,1963), and was developed in Obstfeld (2001). On the one hand, the Mundell-Fleming model is a simple framework, but able to play a very important role in policy-making, as well as to be used as the foundation of other complex models. On the other hand, due to the introduction of the BP curve, capital flow is introduced into the framework of macroeconomic analysis, which is characterized by the most favorable conditions.

In the IS-LM-BP model, there are three equilibriums of commodity markets, money market and the international balance of payments:

$$IS: \quad Y^S = Y$$

$$Y^D = C(Y) + I(r) + G + NX$$

Commodity market equilibrium is reached when the total output is equal to the total supply(total supply including consumption, investment, government spending and net exports).

$$LM: \quad m^S = M/P$$

$$m^D = L(r,Y)$$

The money supply, M, and price index, P, are exogenously given variables, and the currency demand is a function of the interest rate, r, and aggregate supply, Y.

$$BP: \quad BP = NX + KA(r,e)$$

The BP function reflects the balance of international payments, including the balance of the current account and capital account, net exports and net inflow of foreign capital; the international balance of payments means BP = 0.

When considering the risk factors introduced in the Mundell-Fleming model, the risk equilibrium has to be considered. In the CAPM model, the risk and the corresponding yield are the two integral variables. When relatively low income is obtained against relatively high risk, the rational investors often choose or change their portfolios based on their own risk preference, so to achieve a given level of revenue risk, or give a higher risk premium. This process will continue in theinvestment process until the risk level of the portfolio and the yield reach the efficient frontier. If there are some differences in the yield of the two different regions of the same financial products, investors will arbitrate on these two markets, until making the price in different marketsto reach arbitrage-free state, and the same as regards the yield of the two markets. Based on the CAPM and the arbitrage-free theory, the two-risk market under the open economic conditions will get equilibrium and the risk is reflected by the risk premium. Therefore, the introduction of the risk factors in the Mundell-Fleming model is adding the equilibrium analysis of risk factors to the three equilibriums of the IS-LM-

BP model. Assuming balanced risk premium, the IS-LM-BP model will become an IS-LM-BP-RP model.

This article will introduce the balance of risk levels, which is the fourth balance besides the above-mentioned three balances. The first way of linking the risk factors is based on the risk level of balance between the different market arbitrage theories, the second is based on the balance of the theory of value and the actual value of the level of risk based on CAPM theory.

As the formula shows:

$$MF(A): \quad RF_D = RF_F$$

$$MF(B): \quad RP = F(DD)$$

Formula A is based on the risk level of balance between the different markets represented by the no-arbitrage theory, and formula B is based on the theoretical value and the actual value of the balance of the risk level of the macro-financial engineering theory, where: RF_D means risk factors of the local market, RF_F means the risk of external market factors, RP is the risk premium, DD is the distance to default.

Under the framework of macro-financial engineering, there are many conditions to research. On the one hand, the balance sheet and contingent claim approach can be applied to the study of risk indicators, as macro-financial engineering system provides a variety of different indicators of macroeconomic risks, including the distance to default, probability of default, and volatility. On the other hand, a lot of research experience provides a rich data base, and achieved certain results. The risk premium has completely different pricing methods for different investors, because of the difference of risk preference, and to get a recognized risk premium causes considerable difficulty. However, in the framework of macro-financial engineering we can take advantage of the distance to default, probability of default and volatility indicators to reflect the level of risk objectively. Therefore, the following research discusses how to establish a certain link between the risk premium and distance to default, and to explain the distance to default instead of the feasibility of the risk premium.

3. The Models

In this paper, the main technical methods include three models,namely the balance sheet method, the contingent claim method, the Mundell-Fleming Model under open condition that introduces the risk factors.

3.1. Balance Sheet Approach and CCA

According to Gray (2007), the contingent claim method uses option pricing to make a new definition of the condition when a corporation defaults. There are three main items in the balance sheet; namely assets, liabilities and equity. If we consider the equity as a put option, the assets are underlying asset. When the underlying price is below the strike price, the companies will choose to default, and from the perspective of an option, the option holder will give up the option.

The market value of one economic entity A(t) is equal to the market value of the subordinated interests J(t) and the market value of the risky debt D(t), that is

$$A(t) = J(t) + D(t) \tag{3.1}$$

where: J(t) is usually equity that can be seen as a call option.

At the same time, the risky debt is default-free debt minus debt guarantee. Among them, the default-free debt is the default point (DB), which is usually using a short-term debt plus half of the long-term debt to calculate; and debt guarantee can be seen as a put option. Thus:

$$D(t) = DB - Put \tag{3.2}$$

The J(t) can be obtained from financial market prices, DB can be taken from the balance sheet, so that they are all known variables. Here are the steps to calculate the put options.

In the first step, we take the market value of observed equity J(t) and its volatility σ_J, the default point DB and the risk-free rate into the following equations, and then get the market value of the asset (A) and the asset volatility (σ_A)。

$$J = N(d_2)A - DB \cdot e^{-rT} N(d_1) \tag{3.3}$$

$$A\sigma_A = J\sigma_J N(d_2) \tag{3.4}$$

where:

$$d_1 = \frac{\ln(A/DB) + (r + \sigma_A^2/2)T}{\sigma_A T^{\frac{1}{2}}} \tag{3.5}$$

$$d_2 = d_1 - \sigma_A T^{\frac{1}{2}} \tag{3.6}$$

where: N(d) is the calculated probability of a standard normal distribution function (d is integral upper limit) and r is the risk-free rate.

Secondly, we take the value of company's asset (A) and asset volatility (σ_A) intoput option pricing formula.

$$P = DB \cdot e^{-rT} N(-d_2) - N(d_2) A \tag{3.7}$$

However, calculating the market value of equity is not our aim, but we can get a more important risk indicator through the process. In the macro-financial engineering system, the default distance and the default probability are two more important risk indicators. The formulas are as follows:

The default distance:

$$DD = \frac{A - DB}{A\sigma_A} \tag{3.8}$$

The smaller default distance represents the greater risk level, closer to the trigger threshold of a default event.

The default probability:

$$DP = N(-d_2) = 1 - N(d_2) \tag{3.9}$$

The greater default probability represents the greater risk level, and the higher possibility of a default event occurring.

3.2. The IS-LM Model with Risk Factors

3.2.1. Assumptions

The IS-LM model under open conditions has been for long one of the main models to study macroeconomic policy of open economy, whose premise is, in the case of given price, output and money supply, that the interest rate which plays a decisive role in investment and capital flows is determined by the currency market. However, the above assumption does not take default risk and the contacted risk premium problem into account.

In the framework of balance sheet of macro-financial engineering, the potential possibility of default can have an impact through a variety of channels.

(1) *Precautionary savings*. If the situation of the balance sheet of most of economic sectors deteriorated, the consumption wouldinevitably decline, which will led to a decline in debt and equity, then there will be the risk of labor income reducing. In order to prevent the reduction of income, risk averter will choose to save more in this environment.

(2) *Decrease in investment*. Under the framework of CCA model, we assume a single enterprise,whose expected benefits and risk debt are related to the expected return of underlying assets of the borrowers. When the default probability increases, the risk-adjusted return on investment will decline, leading to the reduction of investment. In addition, due to the presence of the financial accelerator effect, the borrowing capacity is linked to the net assets directly, the smaller net assets, the higher risk premium, and the more difficult to get the loan.

(3) *Capital inflows diminution*. In the IS-LM model, domestic and foreign interest is positively correlated to the capital inflows, but in the case of the presence of a risk premium, the difference between domestic and foreign risk premium will have a negative impact on capital inflows, that is the rise in domestic risk premium will reduce the net capital inflows.

The above three channels will influence the total outputs and net capital inflows in varying degrees, because of the changes in risk premium level.

3.2.2. The Model

The IS-LM-BP model is a static model, and its main goal is to provide a set of formation mechanism of fiscal policy and monetary policy of an open economy, but under the macro-financial engineering theoretical framework the changes in assets value and default point can be adjusted over time, so the combination of the macro-financial engineering theoretical framework and macroeconomic model can provide some dynamic analysis, making the policy formation more effective.

After introducing the risk into the IS-LM-BP model, the IS-LM-BP-RP model specific form is as follows:

IS: $$Y = D(Y, r, \rho) + G + NX(Y, e) \quad (3.10)$$

LM: $$M / P = L(r, Y) \quad (3.11)$$

BP: $$BP = NX(Y, e) + KA(r - r^*, \rho - \rho^*) \quad (3.12)$$

RP: $$\rho = f(\rho_C, \rho_G) \quad (3.13)$$

where:

(1) Precautionary savings and financial accelerator effect has impact on $D(Y, r, \rho)$ at the same time;

(2) ρ represents the risk premium of investment;

(3) The capital account will be influenced by the difference between the liquidity premiums[6] and the difference between the risk premiums at the same time;

(4) Domestic risk premium is the function of enterprise's risk premium (ρ_c) and sovereign risk premium (ρ_G)[7].

When the risk factors are introduced into the model, the mechanism of the model will obviously change. Specifically, due to the presence of rate (r) and risk premium (ρ) at the same time, the shape of the BP curve will change. This implies a very important assumption that investors are attracted by the interest margin, but they also hate risk, while a high-risk premium level will have a restraining influence on capital flows. This phenomenon is very common in the capital markets, such as investment funds will not only invest in bonds when the bonds are below the lower limit of evaluation criteria, although they are often able to provide a high expected return. In addition, due to the asymmetric information, investors usually take the yield as the indicators of foreign bonds products; when the bond yield is ultra-high they will choose to sell such products. Under the above assumption, the rise in the risk-free rate will increase the risk premium significantly; the decline in aggregate demand and net capital inflows will reduce the marginal product. Therefore, the BP curves is a backward curve in the (*Y* , *r*) space.

4. Empirical Analysis

According to the above analysis, the backward bending BP curve will be researched empirically. Becausethere is no uniform standard to calculate the risk premium, DDwillsubstitute the risk premium ρ in (3.12), and using a certain function form the backward bending BP curve will be estimated.

There are several reasons of using distance to default as indicators reflecting the risk; on the one hand, because of the risk propensity of investors is different, different investors have different premium for the same risk requirements, and then the

[6] Liquidity premium is interest rate.

[7] *Due to insufficient data, the public sector's risk premium could not be temporarilyobtained, and the paper considersonly the risk premium of the corporate sector.*

valuation of the risk premium will not be able to form a unified standard; on the other hand, the distance to default, probability of default, asset volatility and credit spreads are derived from the balance sheet method and CCA. In comparison, possibility of default most directly reflects the occurrence of an event of default, but as empirical data show the probability of default values in most cases are 0. For empirical research, the numerical sequence to reflect the information is very limited, and distance to default can reflect more comprehensive information.However, distance to default also has some disadvantages, because the data itself is obtained by calculating the raw data after multiple processing, so accuracy will significantly decrease.

Balance of payments means BP=0 in (3.12), net exports NX is a function of the total output Y and the exchange rate e, net capital inflows is a function of the difference of domestic and foreignriskless interest rate and the difference of domestic and foreign default distance. Thus, expanding (3.14), and considering the characteristic of the backward bent of BP curve, we estimate the BP curve in the form of quadratic function, as follows:

$$gdp = c + \alpha_1 e + \alpha_2 r^2 + \alpha_3 \left(r - r^* \right) + \alpha_4 \left(DD - DD^* \right) + \varepsilon \qquad (4.1)$$

Using the OLS method, we obtain the following estimated parameters[8] of the above equation.

Table 1

Values of estimated parameters

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-149.5665	50.54026	-2.959353	0.0051
E	25.09487	7.692856	3.262101	0.0022
RR	-0.524582	0.169449	-3.095804	0.0035
DR	5.162192	1.655315	3.118555	0.0033
DDD	-3.014633	0.832102	-3.622911	0.0008
R-squared = 0.514633 Adjusted R-squared = 0.467280				

At the same time, we also used the form of a function to estimate the BP curve, as follows:

$$gdp = c + \alpha_1 e + \alpha_2 r + \alpha_3 r^* + \alpha_4 DD + \alpha_5 DD^* + \varepsilon \qquad (4.2)$$

Using OLS method to estimate the parameters of the above equation, we get the following results.

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[8] *Exchange rate, risk-free interest rate is derived from theEIU Country-data (https://eiu.bvdep.com/countrydata/).and the growth rate of industrial added value is derived from the Chinese National Bureau of Statistics website. The default distance data are mainly derived from the "China and Global Risk Report 2012",United States is defined asthe foreigneconomy. Due to the problem of the date frequency, part of the data is obtained by the smoothing processing.The sample interval ranges from March 2007 to December 2010.And there are 46 samples in each sequence.*

Table 2

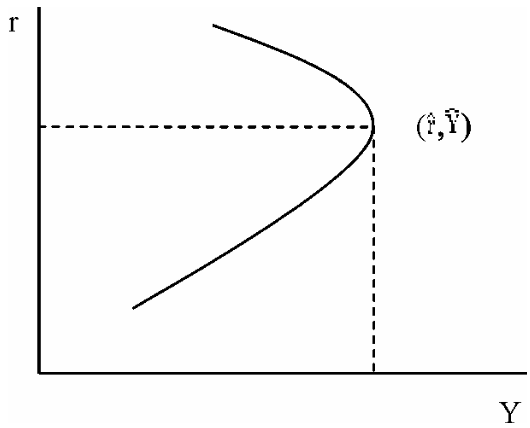
Values of estimated parameters

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-150.6045	38.77413	-3.884149	0.0004
E	24.15024	5.921978	4.078069	0.0002
R	2.639375	1.300935	2.028830	0.0492
RX	-4.915892	1.264797	-3.886704	0.0004
DD	-0.948237	0.761127	-1.245833	0.2201
DDX	3.629965	0.647903	5.602633	0.0000
R-squared = 0.717565 Adjusted R-squared = 0.682261				

Comparing the two results, (4.2) has a higher regression level, and R^2 and adjusted R^2 are 0.72 and 0.68, respectively.Estimation using quadratic function has a lower regression level, and R^2 and adjusted R^2 are 0.51 and 0.46, respectively. However, the key variables in (4.1) were significantly higher. Distance to default is the main variable which could affect the BP curve. As Tables1 and 2 show, the t-test value of the difference between domestic and foreign distance to default (variable DDD) is better than the domestic and foreign distance to default (the variable DD and variable DDX) in (4.2).

Figure 1

Backward bending BP curve



China's economy experienced a high-speed development, and the economic indicators are still mainly one-way increasing. This phenomenon makes that the situation in China is likely to be at the stage of the BP curve extending to the upper right; in other words, the risk-free rate of change has not yet reached the threshold ($\hat{r}$, $\hat{Y}$) in Figure 1. Above this threshold, if interest rates continue to rise, the negative impact of the high-risk premium will prompt foreign investors to reduce investment, resulting in a decline in output. On the other hand, as the number of samples is less than normal,the empirical effect of a certain extent has been affected. If using data of the other country, which has relatively complete statistical data, we may get better result, especially using those of a country experiencing recession in history and significant changes in the level of risk. Therefore, using the form of a quadratic function to estimate the BP curve does not necessarily get optimum results, but to a certain extent reflects the characteristics of BP curves having a backward bent.

5. Conclusions

Linking risk factors into the macroeconomic model provides a full potential way to study the macroeconomic risk; however, it is very complicated. Based on preliminary studies, by the assumptions of Gray and Malone (2008) who proposed linking a risk premium to the IS-LM-BP model, this paper improved the IS-LM-BP model. Beside the three equilibriums of commodity markets, currency markets and the international balance of payments, the equilibrium of the level of risk is discussed, and we conclude that the introduction of the risk factors makes the BP curve to bent back. Thus, when theIS-LM-BP model is used to formulate corresponding policies,the risk factors will be sufficient to affect the validity of the policy. In addition, by using the balance sheet method and CCA, instead risk premium by default distance, the risk factors are computable.

The empirical results show that using a quadratic function to estimate the form of the BP curve has certain feasibility, while China is still below the bend point of the BP curve, and the risk level has not reached a high enough peak to make the outputdegree fall.

References

Bardsen, G., Lindquist, K.-G., and Tsomocos, D.P., 2006.*Evaluation of Macroeconomic Models for Financial Stability Analysis*.Working Paper, Financial Markets Department, Norges Bank, Oslo, Norway.

Gray, D.F., Merton, R.C., and Z.,Bodie, 2007. Contingent Claims Approach to Measuringand Managing Sovereign Credit Risk.*Journal of Investment Management*, 5(4), pp. 5–28.

Gray, D.F., 2009. Modeling Financial Crises and Sovereign Risks.*Annual Review of Financial Economics*, 1, 117–144.

Gray, D.F. and Jobst, A. A., Systemic Contingent Claims Analysis (SystemicCCA): Estimating Potential Losses and Implicit Government Guarantees to Banks.*IMF Working Paper*, forthcoming.

Gray, D.F., and Malone,S., 2008.*Macrofinancial Risk Analysis*, New York, John Wiley &Sons.

Pagan, A., 2003.Report on modeling and forecasting at the Bank of England,*Bank of England Quarterly Bulletin*, Spring,1-29.

Ye Yonggang, Song Lingfeng and Zhang Pei, 2011.*Financial Risk Report on China and the World(2011)*. Beijing: People's Publishing House.

Ye Yonggang, Song Lingfeng and Zhang Pei, 2012.*Financial Risk Report on China and the World(2012)*. Beijing: People's Publishing House.