

Impact of Environmental Factors on Credit Risk of Commercial Banks

——Research and application by ICBC based on stress test



ICBC

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Abstract

The benefits of the positive externalities of an unpolluted environment and stable climate are enjoyed by all economic actors. Conversely, the costs of the negative externalities of the pollution and emissions that damage the environment and cause climate change have historically not affected individual firms. However, both positive and negative externalities can be internalized by a firm with the introduction of relevant policy- and market-based mechanisms. For the first time for a Chinese financial institution, this paper discusses the impact of internalizing environmental costs onto a firm' s balance sheet and the consequent risks this creates for commercial banks. A relevant theoretical framework, transmission mechanisms and analytical methodologies are established to assess the impact of tightening environmental protection standards and climate change policies, joint and several liabilities that banks are exposed to via their customers' activities and changes in the bank' s reputational standing in the eyes of its shareholders and depositors. Two industries, namely thermal power and cement production, are selected for stress testing against a range of high, medium and low stress scenarios and the impact on their financial performance and credit ratings is assessed as a result. Actionable responses to this analysis are put forward. This bank-led approach to research in this focused field (i.e. assessing the impact of environmental factors on credit risk of commercial banks) is pioneering in China.

Key Words

Environmental Factors Credit Risk Stress Test Commercial Banks

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Introduction

In recent years, a common perspective on environmental risks has developed in the international community; the environmental impact of firms' operations and their use of natural resources have gone beyond the carrying capacity of the environment, resulting in increasing environmental degradation. As a result, the government, the public and non-governmental organizations have proposed tighter and tighter restrictions on the environmental impact of firms. In turn, this gives rise to a continuous increase in firms' costs associated with environmental protection policies and a growth in the environmental and social risks that they face.

Consequently, commercial banks or other financial institutions, as the fund providers for firms, are forced to consider more seriously the risks which can result, including the risk of a firm's failure to repay loans due to the rising costs of complying with environmental protection policies; the risk of assuming joint and several liability for pollution; the legal risk of compensation for damages claimed by third parties; and the reputational risk and risk of losing market share due to non-compliance with new environmental requirements. Most leading international banks have incorporated environmental risk into their risk management systems. In June 2003, 10 international banks including Citigroup, Barclays, ABN Amro and West LB announced their adoption of the Equator Principles, the industry standards developed as the reference point for environmental and social risk management in the project financing activities of commercial banks. ICBC has since formed its own green credit policies, which also use the Equator Principles as a reference point.

After more than 30 years of rapid growth, China is confronted with increasing challenges related to natural resource use and the environment. Nowadays, air, soil and water pollution are all quite severe, which makes the model of extensive economic growth at the cost of natural resources and the environment difficult to sustain. China has therefore attached great importance to the balance between economic development and environmental

protection by prioritising "green development" as a national strategy and introducing various relevant policies and regulations in succession (see Table 1).

In order to promote the fast and sound development of green finance, it is pressing for the global banking sector to effectively assess the impact of environmental policy changes, tightening of environmental standards and upgrades to industrial technology on firms' operating costs. It is also important to take appropriate preventive measures in response to the impact on credit risk of commercial banks based on the aforesaid assessment. This is fundamental to enhancing the holistic risk management practices of Chinese commercial banks, which is of great significance to the sustainable development of China's banking sector.

In response to increasing environmental risks, ICBC established a research group to study the impact of environmental factors on commercial banks' credit risks. In this paper, we begin by pointing out that both the positive and negative externalities of a firm's activities on the climate and the environment can be converted into endogenous variables in the firm's financial performance by a range of policy, market or legal factors. Secondly, stress testing approaches are used to analyze how the impact of environmental protection policies on firms' costs could translate into credit risk for commercial banks and how significant that impact on credit risk could be.

The highlights of this paper include:

1. Both transmission mechanisms and quantification methodologies for understanding the impact of environmental policies on credit risks for commercial banks are discussed for the first time by a Chinese financial institution. This provides a market-based mechanism for accelerating efforts to address global climate change. In short, commercial banks can consequently incorporate environmental risks into their credit rating systems for firms based on a quantitative assessment of the impact of environmental factors on firms' costs. In turn,

this affects the cost of capital for firms accessing commercial bank funding, hence promoting green economic development.

2. To deepen the theory of how negative externalities can be internalized on a firm's balance sheet, and what impact that has on a commercial bank's risks, a theoretical framework and basic model has been built. This methodology includes the impact of tightening of environmental protection standards and climate change policies, joint and several liability assumed by banks for pollution and reputational risk derived from a bank's mismanagement of environmental risks in its portfolio.
3. For the first time in China, a "bottom-up" approach (i.e. bank led) has been adopted to conduct a stress test of the impact of the costs of environmental protection policies on two industries (i.e. thermal power and cement) and prove the relevance of, and degree of correlation between, environmental factors and the credit risk of commercial banks.
4. Pioneering research in this focused field (i.e. the impact of environmental factors on the credit risk of banks) has been carried out, measuring and quantifying the impact of environmental risks on firms' credit ratings, using the unique perspective of stress testing.

The rest of this paper is organized as follows: Section II reviews the existing literature on environmental risk assessment and stress testing from a theoretical perspective; Section III gives a brief introduction to the main concepts underpinning ICBC's environmental stress testing framework; Section IV takes two industries, thermal power and cement, as examples to estimate firms' financial performance under stressed scenarios and assess the consequent changes to firms' credit rating and Probability of Default (PD) using ICBC's rating model; after that, the relationship between PD and the Non-Performing Loans (NPL) ratio is used to derive the change in the NPL ratio of relevant industries and deduce the variation in credit ratings.

The main findings and conclusions are presented in Section V. Firstly, the impact of environmental factors on the credit risk of banks is calculated on a quantitative basis in order to enhance the bank's capabilities in environmental risk management; secondly, environmental risk is incorporated into the enterprise credit risk rating system in order to inform the pricing of financial products including credit and investment; thirdly, the basis for reasonable adjustments to the credit arrangements and investment portfolios of banks is provided; fourthly, a reference point for banking regulators to consider the impact of environmental factors on bank risks is provided.

The Impact of Environmental Factors on Risks of Commercial Banks

i. Theoretical Research on Internalization of Environmental Costs

Climate change and ecosystem degradation have been one of the major challenges faced by humans in the 21st Century. Environmental problems such as drought, increasing depletion of water resources, rising sea levels and more frequent floods, which have significantly affected the economic and social life of humans, have caused worldwide concern. From an economic perspective, environmental protection has always been taken as a public good with distinct externalities. As a consequence, resources have not been allocated efficiently in terms of dealing with environmental problems through a pure market-based mechanism.

In terms of solutions, two ideas are routinely mentioned to improve the efficiency of a public good like environmental protection, i.e. the Pigou tax theory and the Kos theorem. In fact, with the establishment of national taxation and market trading mechanisms, firms will benefit from the positive externalities of a stable climate. The “Economics of Climate Change” published by the UK Government in 2006, popularly known as the Stern Review, proposes that climate change is the world’s greatest market failure. Consequently, different technologies and strategies must be utilized to reduce the cost of greenhouse gas emissions and economic models to internalize the costs and

benefits of transforming the economy into a low-carbon model must be adopted. Thus, it is necessary and inevitable to study the measurement of, and methods for, the internalization of environmental costs.

Various efforts have been undertaken by international researchers to quantify the costs and benefits of such responses to climate change on national economies. GIZ (an international cooperation agency in Germany) and UNEP FI (the United Nations Environment Programme Finance Initiative) cooperated to analyze the integration of water resource stress into corporate bond credit ratings using the TEV¹ framework. In this study, the direct and indirect benefits of water were calculated to assess the value of water resources and the “shadow price” of water was used to estimate the potential increase in the cost of water resulting from water stress events. As a result, the cost of water resource restriction could be internalized by various market and non-market mechanisms, resulting in impacts on capital expenditure, operational risks and stranded assets caused by the loss of water rights. Using the method mentioned above, the study conducted an analysis of 24 global companies covering three industries – mining, electricity generation and beverage production.

ii. Impact of environmental cost internalization on the credit risks of commercial banks

Lots of the literature discusses the impact of environmental factors on firms and the economy. However, in China, the role of commercial banks as intermediaries in the process of the green

transformation of industries has always been ignored. As most of the existing literature focuses on commercial banks’ social responsibilities, there are fewer studies that clarify the transmission channels

¹The concept of Total Economic Value (TEV) originates from environmental economics. The TEV framework offers a structural approach to assess and estimate the economic value of benefits for the society.

from environmental risks to a commercial bank's balance sheet. In our opinion, understanding the impact of environmental risks on the performance of commercial banks is not only a requirement of being a socially responsible financial intermediary,

but also an inevitable part of managing risks and optimizing credit structures against the background of the green economy. In general, environmental factors will amplify risks for commercial banks in at least three ways (see Figure 1):

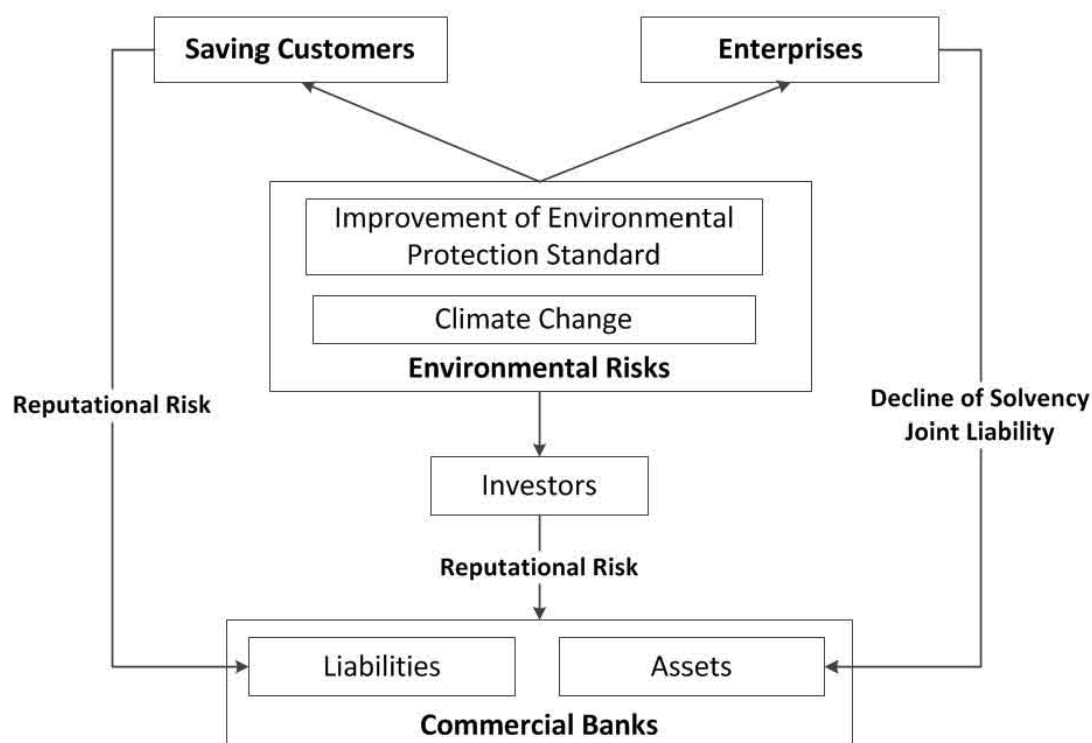


Figure 1 Theoretical Framework for the Impact of internalizing Environmental Costs on Risks faced by Commercial Banks

As indicated by Figure 1, the first is credit risk. The tightening of environmental protection standards and climate change policies will impose certain constraints on the cash flows and the balance sheets of firms, potentially weakening their solvency and consequently increasing the credit risk faced by commercial banks. The second is the risk of joint liability. In a credit-based economy, a firm cannot survive without financial support. As more and more regulators nowadays impose a transfer of liability for environmental damages to financial institutions, banks are encouraged to put pressure on firms with poor environmental performance, thus limiting the development of polluting firms. For example, the U.S. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) released in 1980 allows judges to turn against any party that could be considered as an “owner” or an “operator” of the firms when seeking compensation for an environmental pollution event. The third is reputational risk.

As environmental risk has gradually become a common risk faced by the global financial sector, poor environmental performance of a bank's borrowing customers will lead to questioning of the banks' capabilities in environmental risk management in its lending books, thus reducing the expected return of investors that are shareholders in commercial banks. Meanwhile, poor environmental performance of a bank's borrowing customers might also affect the appetite of depositors to stay loyal to that bank.

Credit risk, as the main risk confronted by commercial banks, is the focus of research in this paper. “Credit risk”, also known as default risk, refers to the risk of default for the reason that a borrower is unwilling or unable to perform its contractual conditions. In case of a default, the creditor or bank will inevitably bear a financial loss due to the failure of obtaining its expected earnings. For most commercial banks, loans constitute the

largest and the most obvious source of credit risk, so the impact of environmental risk on commercial bank primarily manifests as credit risk.

We built a simple model to illustrate the impact of environmental risk on firms and banks’ lending risk. Assuming that the demand of a firm for bank lending is jointly determined by its operating cost, C , and profit, R (both of which are a function of environmental risks, ϵ), a firm’s demand for bank lending is a function of interest rates, r , and

environmental risks, ϵ , i.e. $Q^d = Q^d(r, \epsilon)$. The derivatives of Q^d against r and ϵ are less than zero, indicating that the demand for bank lending is their decreasing function; on the other hand, the supply curve of bank lending can be considered as a function of the deposit rate, r_d , the lending rate, r , and environmental risks, i.e. $Q^s = Q^s(r, r_d, \epsilon)$. Here, environmental risks are not only a separate factor with certain impacts on other aspects, but also an important factor in determining the cost of bank deposits (see [Figure 1](#)).

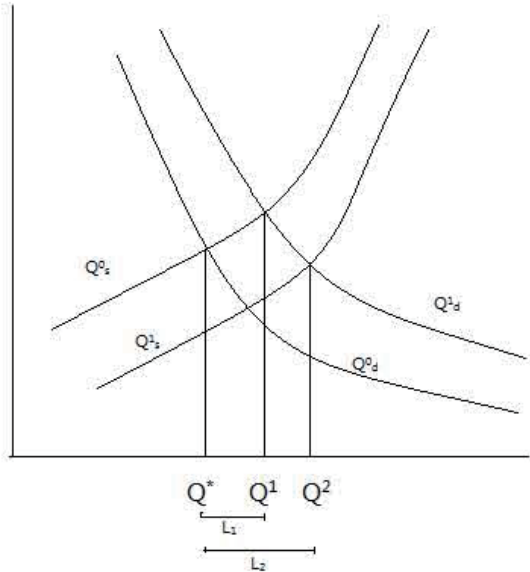


Figure 2 Relationship between Risk Exposure of Bank Loans and Environmental Risk

According to Figure 2, if both commercial banks and firms take their operating losses caused by environmental risk into account, the supply and demand curves Q^s_1 and Q^d_1 will intersect at (r_1, Q^1) , which determine the equilibrium level for the lending rate and volumes. Due to the externalities of environmental factors, however, the firm might fail to incorporate the impact of environmental factors into its costs, hence the loan demand curve will

move to Q^d_2 , which intersects Q^s_1 on (r_2, Q^2) ; moreover, if the commercial bank doesn’t measure environmental risks during its operations, the loan supply curve will ascend to Q^s_2 and intersect with Q^d_2 at (r_2, Q^2) . From the perspective of commercial banks, the difference between Q^1 and Q^2 (i.e. L_1 and L_2) is regarded as its risk exposure to environmental factors; the bigger the difference, the higher the default rate that will be faced.

iii. Stress testing is an effective way to measure the impact of internalizing environmental costs on commercial banks

Stress testing, as a forward-looking risk management tool to measure the potential losses caused by possible events, is an important approach to identify and evaluate the potential risks faced by financial institutions and the financial system. Though many commercial banks in China have developed appropriate green credit strategies and measures so

far, none of them have incorporated environmental risk into their credit rating systems. Besides, as there is no quantitative methodology for banks to measure the impact of environmental factors, it is hard for commercial banks to develop a precise policy towards a greener credit structure. In order to promote and optimize banks’ credit structure,

it is necessary to identify environmental risks both on qualitative and quantitative levels. Among all methodologies, environmental stress testing

remains at the forefront of research among financial institutions internationally.

i.Domestic and overseas work to identify environmental risk by use of stress testing

The world's major banks in recent years have initiated research regarding the impact of environmental risk on their own business, but they seldom use stress testing to assess environmental risk from a quantitative perspective. Insurance companies have a long history of using stress testing techniques to understand their exposure to natural catastrophes. In September 2015, the UK's Prudential Regulation Authority (PRA) issued a report on the impact of climate change on the insurance industry in the UK. In this report, the PRA classified the risks resulting from climate change into three types: the physical risks caused by natural disasters; the transition risks resulting from a disorderly transformation to a green economy; the indirect pressure (liability risks) arising from third parties who seek to claim for damages caused by failures related to the previous two risks. Following its strategic review, in relation to physical risk, the PRA held that the liabilities on an insurer's balance sheet would primarily be affected and that the assets, particularly investments in real estate, would also be significantly impacted. In the short term, the UK's insurance industry is capable of coping with these physical risks; in the long run, however, growing environmental risks play an increasingly important role, for instance through driving greater correlations in risks that insurers are exposed to. With regard to transition risk, the transition of the global economy to low-carbon industries will give rise to risks to the profitability of the insurance industry's investments. In addition, the report concluded that as financial regulators are attaching more and more importance to climate change, it will be necessary to more actively investigate relevant regulatory provisions.

Domestically in China, Industrial and Commercial Bank of China (ICBC) is the only bank that has explored and developed environmental stress tests. According to the focal research findings and experience, environmental stress testing should

be conducted on the basis of the precautionary principle. This is an internationally accepted approach, which means that commercial banks ought to take action even under uncertain circumstances if the consequences of inaction are thought to be sufficiently serious. Governments in Europe and the US have adopted the precautionary principle in their policy design and the environmental policy of the UN has also incorporated such a principle. Though the cost-effectiveness of the principle should be performed before it is adopted, it is certainly not a necessary pre-condition. Environmental stress testing, as well as ensuring banks prepare for the extreme scenarios, is an important measure to effectively deal with the uncertainty brought by the transition to a green economy.

Environmental stress testing can also be used to monitor and evaluate systemic risk. For systemic risk analysis, qualitative analysis is used in many countries to assess risk exposure. As a result, either the real systemic risk is ignored, or measures taken are too cautious, leading to the expansion of government intervention. Environmental stress testing can be used to assess the possible impact of environmental change factors such as natural catastrophe events, tightening of environmental standards and climate change policies, and carbon trading on the financial system, giving consideration to the spread and feedback of risk. For example, through the stress testing of thermal power and cement industries under light, medium and heavy stress scenarios, we can easily find out that firm credit ratings will decline to different degrees for different banks.

Finally, environmental stress testing is considered as a forward-looking risk analysis tool. Due to the increasingly serious problems concerning energy resources and environmental constraints in China, the government

has continuously tightened environmental regulations and standards as well as worked out appropriate requirements for the financial sector, forcing banks to emphasise the management of environmental risks. As environmental stress testing is a forward-looking risk analysis tool, quantitative approaches can be used to verify a bank’s risk

management capability in response to any sign of systemic risk, and the bank can be informed of any excessive risk-taking as a result of improper resource allocation and pricing so that it can adjust its portfolio and actively support the development of green industries in a timely manner.

ii. Basic framework for environmental stress test of ICBC

1. Basic process

Traditional stress testing consists of six steps: selecting the portfolios to be tested; selecting the stress factors and indicators to be applied; selecting stress-bearing objects and determining

stress-bearing indicators; building scenarios; constructing the transmission model; performing the stress test and analysing results (see Figure 3). In this section, we set out the detail of our approach to environmental stress testing in light of this process.

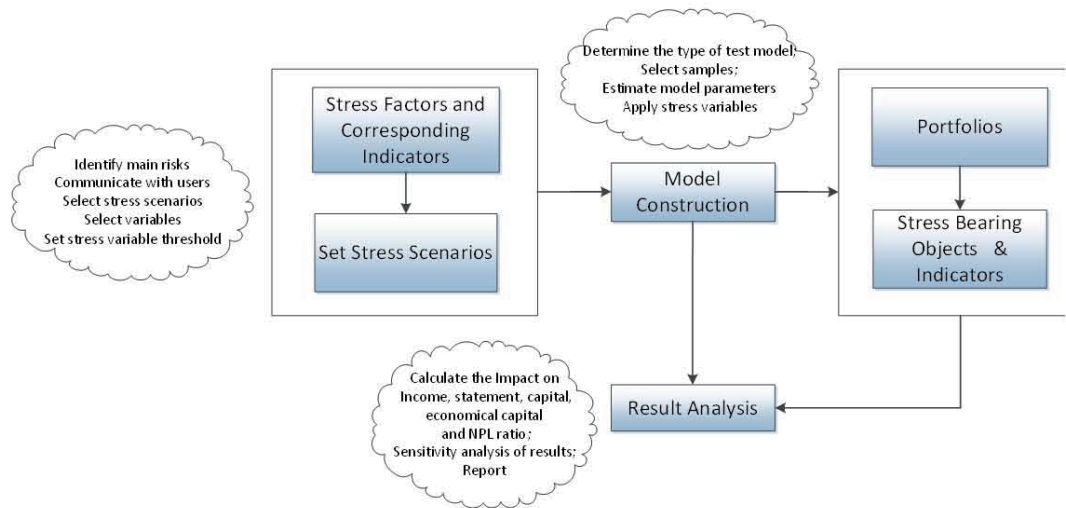


Figure 3: Flow Chart of Stress Test

2. Stress-bearing objects and indicators

Stress-bearing objects refer to the objects requiring attention for the purpose of stress testing, while stress-bearing indicators represent the performance of stress-bearing objects in some aspects. At present, Chinese commercial banks’ main business is still based on deposits and loans, therefore, stress testing should target the impact of depositors and lending customers on related credit and business indicators. We classify the stress-bearing objects of bank credit risk into three levels (or categories), i.e. “debtor or counterparty”, “portfolio” and “macro object”. The level of “debtor or counterparty” includes individuals; that of “portfolio” can be further divided by different standards, e.g. product,

industry, customer and region; and “macro object” generally focuses on all assets and overall risk at the entire bank level. According to ICBC’s experience of environmental stress testing, there are two types of stress-bearing indicators that are commonly used at the “portfolio” level: technical indicators and management indicators. The former refer to the indicators representing risk of loss, such as probability of default (PD), loss given default (LGD), expected loss, unexpected loss and risk exposure. All of these are closely related to the day-to-day operation of financial institutions including commercial banks. Management indicators include the capital adequacy ratio (CAR), the non-performing loan (NPL) ratio, economic capital, and

profit margin. These are usually the focus of regulatory authorities and governments (see Table 1).

Table 1: Commonly Used Stress-Bearing Indicators

Technical indicators	Management indicators
PD	CAR
LGD	NPL ratio
Duration	Economic capital
Gap	CAR
EL	Profit margin
Loan loss	Industry profitability
Provision	

Through our stress testing of environmental risks, ICBC has expanded the approach “from a single factor to multiple factors, from a single industry to multiple industries, and from the first-round effects to the second-round effects”. For the first step, some major polluting industries (whose combined discharged pollutants exceed 50% of total pollutants discharged by the whole society), such as thermal power, cement, iron and steel, nonferrous metals, chemical engineering and paper making, were selected as the priority for analysis and research. This is because the production technologies, resource consumption and discharge indicators of firms in various industries are quite differently, with different stress-bearing capabilities in the face of environmental protection policies. If the entire economy was tested in the initial period of stress testing, the soundness of the results would be greatly influenced. From a practical perspective, industries like thermal power and cement are not only traditionally the main source of environmental pollution in the manufacturing industry, but also the focus of national environmental protection policy. The selection of the above industries as the pilot industries for environmental stress testing also enables a completeness of analysis and results; meanwhile, the selected stress-bearing indicators should be the ones representing the long-term operating capacity of firms, because the impact of

environmental risk on firms is a long-term changing process under market conditions. The indicators selected based on traditional stress test might be insufficient to reflect the impact of environmental factors in an all-around manner; hence, it is likely to generate certain bias in the formulation of relevant policies.

3.Stress factors under the environmental stress test

(1)Policy standards and policy enforcement

In the current situation in China, tightened environmental policy will cause certain impacts on the costs and profits of firms. Particularly for credit customers in high-polluting and high-emissions industries, enhanced regulatory standards and enforcement might affect their solvency and the credit risk of commercial banks. In recent years, the government has released a variety of environmental protection policies in succession, which aim at improving environmental standards and strengthening law enforcement efforts. First, the formally enacted Environmental Protection Law, effective as of January 1, 2015, considers “promoting the construction of an ecological civilization and propelling the sustainable development of economy and society” as the purpose of legislation and puts forward the idea of

promoting harmony between man and nature and the basic principle of prior protection. Second, environmental standards are improved constantly. Since 2013, China has implemented the Action Plan on the Prevention of Air Pollution and the Action Plan on the Prevention of Water Pollution in an all-around manner. Recently, the Action Plan on the Prevention of Soil Pollution has been submitted to the State Council and is expected to be issued by the end of 2015. During this period, a range of environmental protection policies have been introduced, such as industrial pollution control technology policies covering cement, iron and steel, sulfuric acid, and volatile organic compounds (VOCs), and technical guidelines for the delineation of ecological protection red lines.

(2) Price factors

The changes in balance sheet and income statements caused by price variations have always been the focus of stress testing. For firms operating in China, the price factors impacted by environmental protection policies mainly refer to carbon, through new trading schemes and carbon tax arrangements. Relatively mature and practical experience can be found in developed countries with respect to these factors which are usually considered as important economic means to internalize environmental and social costs. In the context of China's economic transition, the government is making efforts to promote related reforms, which will impose cost pressure on the repayment capacity of firms with highly polluting activities and high energy consumption.

(3) Impact of natural disasters

With the intensification of the greenhouse effect, the frequent occurrence of natural disasters is gradually becoming another unique environmental risk of human activities. The increased frequency and widened converge of small-probability natural disasters such as drought, flood and waterlogging has also increased the possibility of risks to firms and financial institutions. Therefore, it is necessary to incorporate this factor into the range of stress tests being performed.

4.Scenario setting

Scenario setting is the next step after the selection of objects and factors. It concerns the setting of various ranges of stress factors. Common scenarios fall into

three types, i.e. historical scenario, hypothetical scenario, and mixed scenario. A historical scenario refers to stressors being set pursuant to historical data. A hypothetical scenario means the scenario is subjectively selected by risk managers, bringing the advantages of strong flexibility and the ability to simulate events that have never happened before historically. The most common scenario is the combination of a historical scenario and a hypothetical scenario, i.e., the so called "mixed scenario", which not only contains information of historical events, but also has the flexibility of a hypothetical scenario. The last type of scenario is currently strongly advocated by regulatory authorities, because it can prevent risk managers from being too much divergent in their scenario analysis though its "look-forwarding" feature.

In terms of scenario setting for environmental risks, the first step is to consider the future trends of environmental protection policies and then take the possibility of small-probability events into consideration. Traditional stress testing mainly focuses on the evaluation of small-probability events, for the reason that relatively robust risk alleviation arrangements and countermeasures have been established in the financial system for the general risks brought about by general macroeconomic fluctuations. The difference is that commercial banks generally make inadequate preparation for environmental risks. Even Basel III, the latest industry risk management standards, fails to explicitly incorporate environmental factors into the scope of consideration (CISL and UNEP FI, 2014); therefore, the first decision is to consider environmental policy factors in the scenario setting.

5.Transmission path

The construction of the transmission mechanism for how the stressors create financial impacts is at the core of the stress test. Stress tests for different risks, e.g. market risk, credit risk, liquidity risk and operational risk, always adopt different transmission mechanisms. For certain kinds of credit risk, the stress transmission mechanism is relatively clear, and can be easily described by the adoption of a financial model. For the macro stress test on credit risk, however, the transmission process might be difficult to describe, due to the complicated impact of the macro-economy on lots of individuals at the micro level; in such a case, it is more suitable to

describe the transmission mechanism through an econometric model. The modelling methods could be divided into four types: a top-down approach, a centralized test and subsection test, a structural model and a simplified model. With regards to daily stress testing, the target assets are defined as are stress-bearing objects and indicators. However, for some temporary stress tests, test objects may not

suitably defined. For environmental stress testing, it is important to build the transition mechanism not only from the perspective of cost, but also profit and risk. For this reason, one should consider the comprehensive impact of various environmental risks on firms' balance sheets as well as cash flow and income statements.

Practice of Stress Tests for the Impact of Environmental Factors on Bank Credit Risk

-- based on the thermal power and cement industries

ICBC selected two industries, i.e. thermal power and cement which cover 437 and 80 companies respectively, for the first round of our environmental stress testing. The main steps are shown as follows:

First, sort out environmental stress.

The research group firstly worked out the stress transmission diagrams for environmental factors in the thermal power and cement industries (see Figure 1 and 2). According to our research findings, at the end of 2013, 91.6% of thermal power plants in China were installed with desulfurization facilities and 50% of them were equipped with denitration facilities; as dust removal transformation had just started, the proportion of transformed units in the thermal power units in service stood at about 20% only, implying more potential for future energy-saving. In the future, the thermal power industry is likely to see the following changes due to the influence of environmental protection policies: one is the heightened atmospheric pollution emissions limits. The emissions limit of nitrogen oxides will be tightened to $100\text{mg}/\text{m}^3$ from $450\text{mg}/\text{m}^3$ (tighter than the standards of USA and EU, i.e. $135\text{mg}/\text{m}^3$ and $200\text{mg}/\text{m}^3$); that of SO_2 will be restricted to $100\text{-}200\text{mg}/\text{m}^3$ from $400\text{mg}/\text{m}^3$ (still higher than the standards of USA and EU, i.e. $184\text{mg}/\text{m}^3$ and $200\text{mg}/\text{m}^3$); and that of smoke dust will be reduced to $30\text{-}20\text{mg}/\text{m}^3$ from $50\text{mg}/\text{m}^3$, the same as the standards of USA and EU. The other factor is the raised pollutant discharge fees. For key polluting firms and major pollution areas, higher fee standards will be applied. According to the newly released pollutant discharge fee standards, total firm discharge fees are expected to increase by two to three times over the transition period².

As for the cement industry, environmental policy

changes may be expected in the followings areas.

The first one is the tightened atmospheric pollutant emissions limits. Particulate Matter (PM) emissions limits will be lowered to $30\text{mg}/\text{m}^3$ (general regions) and $20\text{mg}/\text{m}^3$ (key regions), a 40% and 33% tightening compared to the original limits; and NO_x (nitrogen oxide) emissions limits will be adjusted to $400\text{mg}/\text{m}^3$ (general) and $320\text{mg}/\text{m}^3$ (key) from $800\text{mg}/\text{m}^3$, a tightening of 50% and 60% compared to original limits. The second is that collaborative use of cement kilns will become a new way for firms to balance environmental stresses with growth pressures. Overseas cement giants such as Lafarge, Holcim and Cemex have a fuel substitution rate of above 10%; while due to deficiencies in domestic garbage processing, immature cement co-treatment technology and great pressure on investment, the average fuel substitution rate of leading cement firms in China stands at only around 4.5% (that of Huaxin Cement is higher, i.e. about 13%), indicating a large gap compared with international peers. The third is higher pollutant discharge fees. Actually, fee standards have already been raised significantly in the eastern areas (e.g. Beijing, Tianjin and Shanghai), while national standards are basically observed in the central and western areas. After the end of the transition period, the total firm discharge fees are estimated to increase by two to three times pursuant to the new pollutant discharge fee standards and the possibility of “fee-to-tax” reform.

Second, construct scenarios. Focusing on a single scenario is a weakness of traditional stress testing, while the probability of such a scenario is quite low. The scenarios constructed by the research group consist of a range of policies and standards formulated or to be issued, together representing a relatively higher probability. The research group set stress scenarios based on three levels of

²Different regions have different transition period. e.g. the transition period for Beijing is 1 year, for Heilongjiang Province is 3 year, for Shanghai is 5 year.

stress, i.e. “heavy stress” , “medium stress” and “light stress” . With regards to the thermal power industry, the research group constructed heavy, medium and light stress scenarios for the energy saving and emissions reduction of thermal power firms according to the standards released by the Ministry of Environmental Protection (end of 2014), the standards of the State Council (end of 2015), and the special limits for eastern areas released by the State Council (end of 2020). Based on that, the impact of increasing pollutant discharge fees by four, three and two times on firm costs was taken into consideration. With respect to the cement industry, the research group, after several rounds of research and expert discussion, set the stress scenarios by considering two main factors: firstly, policy changes concerning pollution control, co-treatment and pollutant discharge were selected pursuant to the new environmental protection standards for the cement industry revised and released by the Ministry of Environmental Protection in 2013, new pollutant discharge fee standards issued by the National Development and

Reform Commission in 2014 and other relevant regulations. Secondly, considering that most cement customers of ICBC were midstream and upstream firms in the industry, expert values were selected for the setting of environmental protection costs.

Third, conduct stress test in ICBC’ S financial transmission model. Due to the lack of historical data about the impact of enhanced environmental standards on bank credit quality in China, a bank-led approach was adopted in the stress test to analyse the impact of environmental policy changes on the financial position of firms. We estimated new financial statements under the stress scenarios pursuant to the financial performance of relevant firms in the scenarios. We then figured out the changes in the firm credit rating and PD under the stress scenarios by use of ICBC’ s existing rating model, and derived the growth of the NPL ratio of related industries based on the relationship between PD and the NPL ratio. See Figure 4 for specific principles:

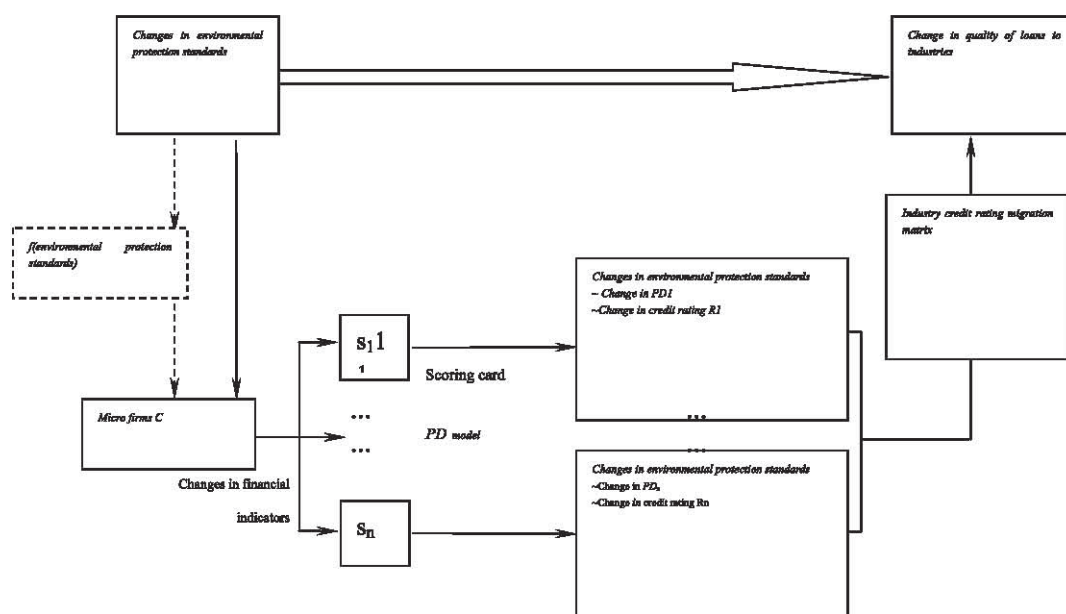


Figure 4 Schematic Diagram of Financial Transmission Model

Step 1, establish the function $C=f(\text{environmental protection standards})$ in respect of the impact of changes in environmental protection standards on financial indicators of firms, in which C indicates the change in a firm’ s cost. For thermal power firms, the annual power generation is estimated according to their prime operating revenue and on-grid power tariff, and then the increase in the

amount of prime operating cost is calculated based on the increased cost per kilowatt hour under the stress scenarios. In terms of cement firms, the prime operating costs under the stress scenario are calculated pursuant to their prime operating costs and the percentage increase of this amount.

Step 2, calculate the main indicators for balance

sheet and income statement impact according to the amount of change in prime operating costs and the inherent relationship that has to a firm's financial statements.

When imposing stress on the financial position of a sample firm, we primarily pay attention to two indicators, i.e. "revenue" and "cost of goods sold (COGS)" in the income statement. Correspondingly, other accounts in the income statement will also change, thus affecting "profit" (or "retained earnings"), which is also an item in the balance sheet.

We assume ΔB = percentage of cost change, ΔP = percentage of price change, and ΔQ = percentage of quantity change. The changes in cost, price and quantity can be calculated before the calculation of changes in revenue, COGS and profit based on the equation below:

$$\Delta R = (1 + \Delta P)(1 + \Delta Q) - 1$$

$$\Delta \text{COGS} = (1 + \Delta B)(1 + \Delta Q) - 1$$

$$\Delta \text{Profit} = \Delta R - \Delta \text{COGS}$$

In which, ΔR = percentage of revenue change, ΔCOGS = percentage of COGS change, and ΔProfit = percentage of profit change.

(1) Income statement under stress conditions

The prime operating revenue and prime operating income in the income statement are directly impacted, so the impacted items are adjusted accordingly.

(2) Balance sheet under stress conditions

The decrease of net profit in the income statement is reflected by the decrease of the owner's equity in the balance sheet. Hence, we adjust the current assets and current liabilities according to the cash flow cycle, while maintaining other assumptions basically unchanged.

On the premise of similar changes in the income statement, the balance sheets of different borrowers are impacted to different degrees. Despite there being no general rules applicable to all borrowers, we convert the impact into a decrease in retained earnings in the balance sheet. Such a simple approach ignores the possible adjustment to its financing structure by a specific company in response to the decline of revenue. The cash flow cycle may deteriorate under stress conditions, but due to the fact that the cash flow cycle has no significant weight in the customer credit rating model, we believe that the results based on the simple approach are enough to deduce a credit rating migration matrix.

Step 3, fill out the above financial indicators into corresponding scoring card in which different corporate customer credit rating and evaluation models are applied to thermal power firms and cement firms. The evaluation model consists of two parts, i.e. quantitative evaluation and qualitative evaluation. From the prudential perspective, we assume that the qualitative evaluation score

decreases in proportion to the quantitative evaluation score.

The change in credit rating of each firm can be derived from the change in its evaluation score, and then the change in the PD can be estimated by mapping the relationship between credit rating and PD. Once environmental protection standards for firms are enhanced, their profit and solvency will decline accordingly, resulting in the downward migration of credit rating and the rise of the PD.

Step 4, construct the credit rating transition matrix for their industries by summarizing the changes in credit ratings of firms; in the meantime, the change in quality of loans to related industries is further analysed based on that and the relationship between the PD and the NPL ratio.

Fourth, issue the main findings of stress test and policy recommendations.

(1) For thermal power firms, stricter environmental protection standards impose great cost pressure on the thermal power industry, but the industry will maintain stable on the whole, owing to the steady growth of the macro-economy and huge demand for electricity generated in the process of China's industrialization. That said, enhanced environmental protection standards will have major structural impact on the thermal power industry; particularly, small and medium-sized firms (SMEs) will be confronted with obvious financial pressures, with credit rating downgrades of customers currently with a AA rating and above reaching 81%, 75% and 68% in the high, medium and low stress scenarios respectively from now till 2020.

Policy recommendations: the first is to maintain existing AAA customers and continue to attract new high-quality customers from the five major power companies. The second is to pay attention to the impact of changes in environmental protection policy on the financial cost and credit risk of firms with the rating of AA+ and below, especially the corporate customers with the possibility of being degraded to BBB+ and below. The third is to attach greater priority to opportunities to grant loans to firms with energy saving and emissions reduction plans. The fourth is to lay emphasis on the upstream and downstream market segments generated due to environmental protection technology, e.g. solid waste treatment industry. And the fifth is to strictly control the access to funding for thermal power firms that violate environmental protection laws and regulations.

(2) For the cement industry, the industry will enter a low-growth stage by and large, with the remaining pressure to reduce capacity. Raised environmental protection standards will impose relatively obvious financial pressure on the cement industry. Under the

heavy, medium and light stress scenarios, credit rating downgrades of firms previously with a rating of AA and above might stand at 81%, 62% and 48%, respectively.

Policy recommendations: the first is to guard against the risks faced by small and medium-sized cement firms arising from the transformation of the sector to work within the green economy. The second is to keep track of the credit risks possibly generated from the process of reducing capacity in the cement industry. The third is to select firms that are strong on desulfurization, denitration and dust removal for expansion, as these areas of environmental protection have room to grow. The fourth is to pay attention to mergers, acquisitions and reorganization in the cement industry and improve the quality of the bank's customers by grasping appropriate environmental improvement opportunities. The fifth is to use ICBC's financial portfolio products to focus on the development of the industrial solid waste market and give more support to cement co-treatment projects. And the sixth is to grasp opportunities to grant loans to firms that are well-positioned in relation to environmental protection in the cement industry amongst firms with potential to "go global".

Fifth, further development of environmental stress testing.

(1) In our research, the first problem was the availability and accuracy of data, so relevant ministries and commissions of the state are advised to implement mandatory disclosure for environmental protection data of firms. Meanwhile, the research group is strengthening cooperation with the Ministry of Environmental Protection of China, with the expectation of improving the accuracy of estimates for the internalization of environmental cost.

(2) As ICBC has set high standards of access for high-polluting and high-energy-consuming industries to its business, the customers selected for this stress test were mainly large and medium-sized firms in the industries, producing better results in the process. The test results do reflect the impact of environmental protection policies on firms in these industries that are customers of ICBC, but cannot reveal the whole picture of the impact across the entire industry. If data for the entire industry can be obtained, the quality of the stress testing will be further improved.

(3) This stress testing work targeted the thermal power and cement industries; next, it is planned to cover major polluting industries including iron and steel, nonferrous metals, chemical and paper making. In the meantime, the approaches will be innovated to include dimensions such as price, region and climate change, with the aim to produce quantitative results. For example, stress testing concerning the impact of environmental factors on credit risk of commercial banks will be conducted from the perspective of pricing (carbon trading); the green rating (ESG) for firms will be explored; and the feasibility of incorporating environmental factors into the bank customer credit rating system will be considered to help research and develop the "ICBC Green Index", so as to prioritise bank loans and investment to green firms and fields.

Conclusions and Recommendations

Environmental risks have become one of the important factors impacting the daily operations of commercial banks, so commercial banks should incorporate environmental stress tests into their bank credit risk rating systems and processes. This will improve the ability of the banking sector to identify environmental risks and the customers who are most able to contribute to sustainable development, therefore enhancing the ability of the banking system to continuously support the green economy, while also being resilient to environmental risks itself. In our opinion, stress testing the impact of environmental factors is important for commercial banks for the following four reasons: firstly, stress testing can help to precisely estimate and quantify the impact of more extreme environmental factors on a bank's credit risk, which could effectively improve the capacity of bank's environmental risk management processes; secondly, as a result, environmental risk factors could be included in the customer credit rating system, enabling environmental risk measurement to form a basis for the pricing of credit products; thirdly, it is conducive to the rational arrangement of bank loans and investment portfolio, thus actively promoting the adjustment of credit and investment structures; fourthly, stress testing could be taken as a reference point for banks and regulators in their future consideration of environmental factors and risks.

Compared with the international banking sector, ICBC has stayed at the forefront in terms of the exploring the impact of environmental risks through stress testing analysis. The highlights of ICBC's stress testing include: First, traditional stress testing usually focuses on one single scenario which contains only one extreme, small-probability event. In contrast, the scenarios constructed by ICBC for our environmental stress testing have taken a variety of complex factors and consist of a series of policies and standards that have been formulated or may be released; Second, ICBC has developed a number of aspects of the environmental stress testing methodology that – at least in China – are completely new, i.e. the transmission mechanism from environment protection policies

to firm impacts to bank impacts, the formulation of scenarios despite the complexity faced and the forecasting methodology based on ICBC's big data. Third, ICBC started our stress testing on a single industry and gradually extended the methodology to multiple industries, which can be regarded as an innovative, but sensible, approach to developing the research methodology. Fourth, both the first-round and corresponding feedback effects are taken into account. For example, in the stress testing of the thermal power industry, the impact of changes in the on-grid power tariff on firms is considered; for the cement industry, subsequent improvement measures that firms could take in response to environmental protection policy, including co-treatment operations, are discussed. In addition, with the expanded coverage from a single stress factor to multiple factors and from one industry to multiple industries, the opportunity for the banking industry to intensify its capabilities on stress testing exists, including the construction of related systems, approaches, models and expert teams.

Based on the environmental stress test results, we believe that the construction of this market-oriented mechanism is crucial for alleviating the impact of economic development on the environment. In order to improve the efficacy of this market mechanism, authorities are recommended to actively and collaboratively promote research on fiscal policy, financial policy and industrial policy and develop a whole set of policy support systems for the internalization of environmental cost. In terms of rules and systems, emissions standards should be tightened, with strict supervision and implementation; with respect to taxes and fees, additional pollutant discharge taxes could be collected from polluting firms and, meanwhile, firms should be encouraged and supported to make green investments and upgrade technologies through tax reductions, discounts, government procurement and so on; as for carbon trading, voluntary agreements and tradable permits should be introduced to establish a well-running carbon trading market; in respect of financial policy, special re-lending policy for “environmental

protection fields” should be formulated, plus positive development of green bonds and green insurance, to reduce the operating cost of firms through a market-oriented approach to supporting green investment; with regard to infrastructure, the intermediary service system should be energetically cultivated, and policies on the open and transparent

disclosure of environmental information should be enacted. Policy and market signals together should aim to enhance the value of preserving natural resources and reduce the value of carbon intensive investments to catalyse the transformation of firms and the structure of the industries towards a green economy.

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Exhibit 1: Main Environmental Laws, Regulations Policies issued by China since 2013

Title	Issued by	Issued in	Main content
Policy on Pollution Prevention and Control Techniques in the Cement Industry, Policy on Pollution Prevention and Control Techniques in the Steel Industry, Policy on Pollution Prevention and Control Techniques in the Sulfuric Acid Industry, Policy on Pollution Prevention and Control Techniques for Volatile Organic Compounds (VOCs)	Ministry of Environmental Protection	May 2013	<p>Cement: Key pollutants in the cement industry will be effectively controlled in 2015, with Nox emissions kept below 1.5 million tons and particulate matter emissions (including unorganized emissions) below 2 million tons and full control will be in place in 2020.</p> <p>Steel: Sintering fume should be fully desulfurized. Blast furnace gas (BFG) dry-type dedusting is encouraged. Low-sulfur fuel, regenerative combustion and low-nitrogen combustion technologies are encouraged for steel-rolling industrial furnaces.</p> <p>Sulfuric acid: The pickling process shall be employed for acid production in iron-sulfur plants and acid production from smelting fume; acidic wastewater and cooling water shall be treated separately. The water reuse ratio shall not be lower than 90%.</p> <p>Volatile organic compounds (VOCs): The VOCs prevention and control system will be established in key areas in 2015; emissions reduction will be basically materialized from raw materials to final products and from production and consumption in 2020.</p>
Circular of the State Council on Issuing the Action Plan for Air Pollution Prevention and Control (G.F. [2013] No. 37)	State Council	September 2013	<p>After five years' efforts, China's overall air quality will improve, the number of days of heavy pollution will be reduced significantly and, in 2017, the concentration of inhalable particulate matters will fall by over 10% from 2012 in prefectural or higher-level cities of China.</p> <p>Air quality will improve notably in the Beijing-Tianjin-Hebei region, the Yangtze River Delta and the Pearl River Delta. The concentration of fine particulate matters will fall by 25%, 20% and 15% in the above three regions.</p>

Environmental Protection Law of the People' s Republic of China	National People' s Congress	April 2014	<p>Establish a sound system of environment and health monitoring, investigation and risk assessment, and create a mechanism for public monitoring and early warning of environmental pollution; define red lines for ecological protection in key ecological protection zones, ecologically sensitive areas and ecologically vulnerable areas to maintain strict protection; expand the scope of complainants in environment-related public interest litigations so that all social organizations that are registered with the civil affairs department of the people' s government at or above the level of city divided into districts, are specialized in environmental protection activities in public interests for more than five years and maintain good reputation are eligible for lodging a lawsuit with the people' s court. Firms that discharge pollutants illegally and refuse to take corrective actions can be fined for successive days in the amount of initial fine.</p>
Action Plan for Water Pollution Prevention and Control	State Council	April 2015	<p>Close down ten categories of small firms. Close down all product projects of small paper-making, leather-making, dyeing, dye making, coking, sulfur refining, arsenic refining, oil refining, electroplating and pesticide firm that will seriously contaminate the water environment.</p> <p>Launch crackdown on ten key industries. Develop pollution crackdown plans for paper making, coking, nitrogen fertilizers, nonferrous metals, dyeing, agricultural and sideline foodstuffs processing, active pharmaceutical ingredient (API) manufacturing, leather making, pesticide and electroplating industries and implement cleaner upgrading. Implement equivalent or reduction replacement of main pollutant emissions from new, alteration and expansion projects in the above industries.</p> <p>In 2020, over 70% of water bodies in seven key drainage basins (Yangtze River, Yellow River, Pear River, Songhua River, Huaihe River, Haihe River and Liaohe River) will reach or exceed Class III.</p> <p>Black-and-malodorous water bodies will be controlled within 10% in developed areas of cities at the prefectural and higher levels. In 2030, over 75% of water bodies in seven key drainage basins will reach or exceed Class III. Black-and-malodorous water bodies in developed urban areas will be basically removed. About 95% of centralized drinking water sources in urban areas will reach or exceed Class III.</p>

Technical Guide to Delimitation of Bio-protection Red Line (Trial) (H.F. [2014] No. 10)	Ministry of Environmental Protection	May 2015	<p>Areas that are very important to water conservation are included within the bio-protection red line according to results of water conservation function assessment and classification. Grade 1 and Grade 1 protected areas of important drinking water sources are included within the bio-protection red line. The specific method shall be as set forth in HJ/T338.</p> <p>Very sensitive areas are included within the bio-protection red line according to the results of soil erosion sensitivity assessment and classification. Zones of key soil erosion prevention and protection areas that pose a relatively significant risk of soil erosion also shall be included within the bio-protection red line.</p> <p>Assess the materiality of biological diversity preservation function.</p>
Soil Environmental Quality Standard for Agricultural Land (2nd Exposure Draft) (revision of GB15618-1995) and Risk Screening Guideline Values for Soil Contamination of Development Land (2nd Exposure Draft) (supplement to HJ 25.3-2014)	Ministry of Environmental Protection	August 2015	<p>10 soil contaminants (i.e. total manganese, total cobalt, total selenium, total vanadium, total antimony, total thallium, fluoride (water soluble fluorine), benzoapyrene, total petroleum hydrocarbon and total phthalic acid esters) are added to the test options according to relevant foreign standards and China' s National Technical Rules for Evaluation of Soil Contamination Status, which are applicable to soil contamination investigation and evaluation in specified areas.</p> <p>The soil pH level of 6.5 or below under the original standard is further divided into two levels: $\text{pH} \leq 5.5$ and $5.5 < \text{pH} \leq 6.5$, with different limits applied to the two levels, so that the three levels ($\text{pH} \leq 6.5$, 6.5 7.5) under the original standard are increased to four levels ($\text{pH} \leq 5.5$, $5.5 < \text{pH} \leq 6.5$, $6.5 < \text{pH} \leq 7.5$, $\text{pH} > 7.5$).</p> <p>The limit on lead content of soil in agricultural land is lowered to 80 mg/kg. The original standard prescribes three limit levels according to pH value according to the impact of lead on crop growth: 250mg/kg ($\text{pH} < 6.5$), 300mg/kg ($\text{pH} 6.5-7.5$) and 350mg/kg ($\text{pH} > 7.5$).</p> <p>The limit on HCH and DDT contents of soil is lowered to 0.1 mg/kg from the original standard of 0.5mg/kg.</p>

Figure 2 Stress Transmission of Change in Environmental Protection Policy for Thermal Power Industry

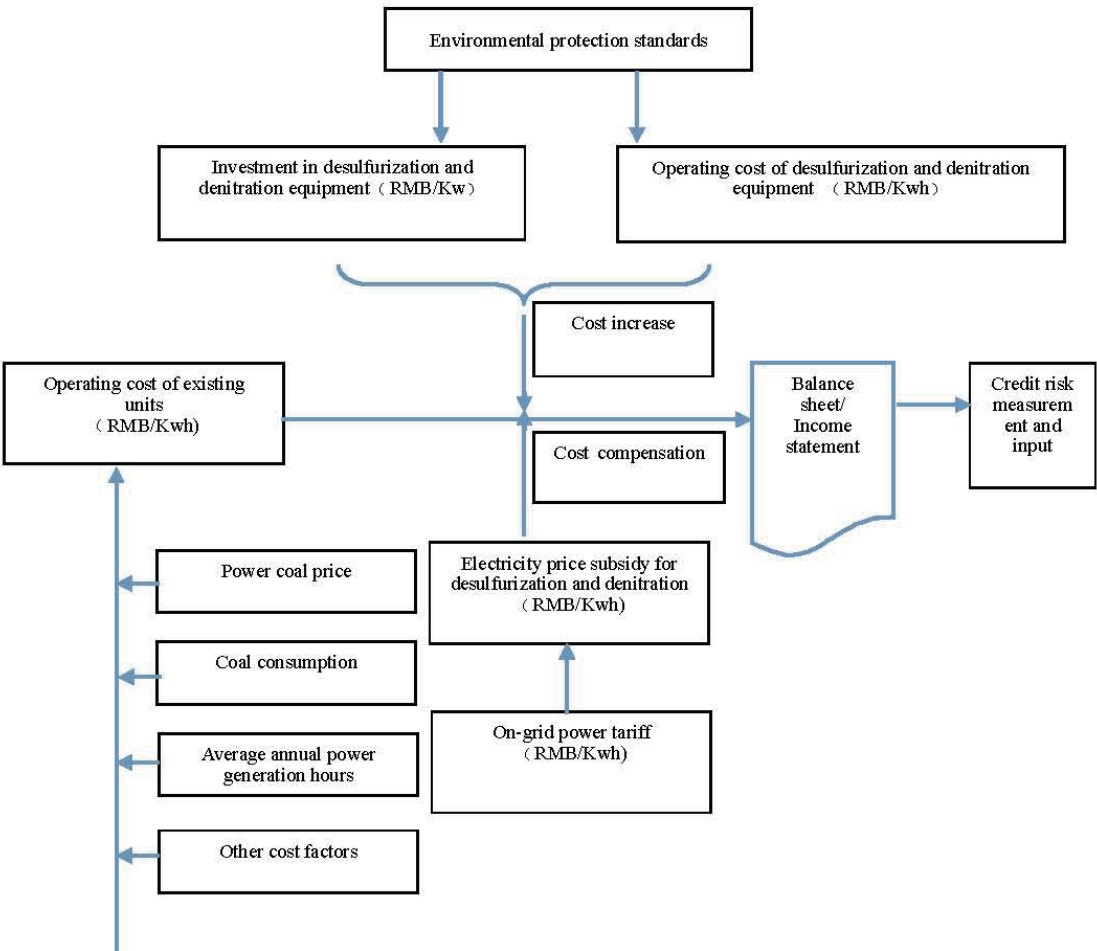
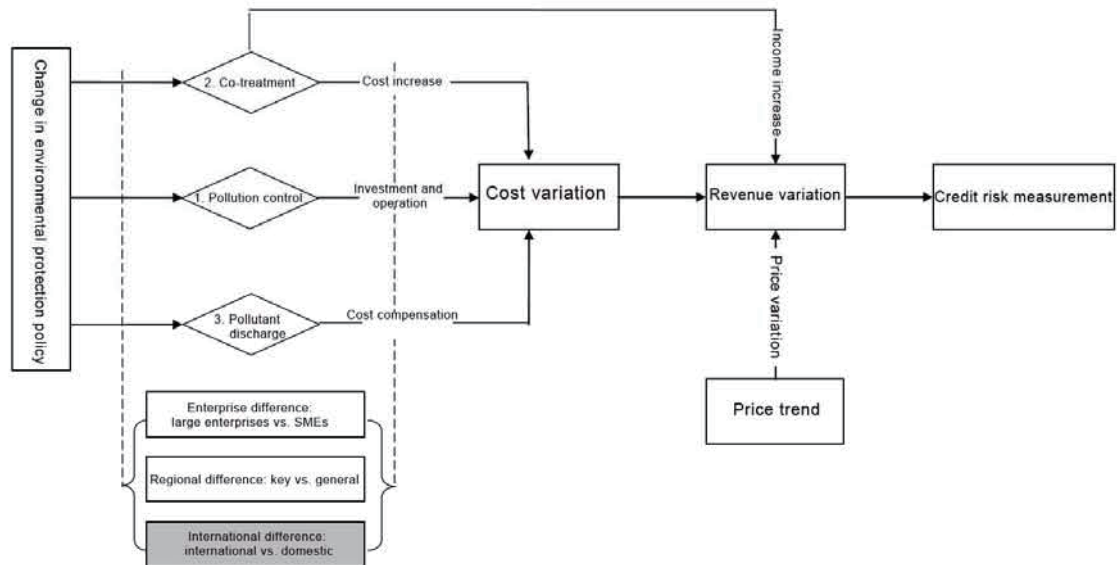


Figure 3 Stress Transmission of Change in Environmental Protection Policy for Cement Industry



Urban Finance Research Institute of ICBC, which was established in 1993, is the strategy research and planning department of ICBC Head Office. As well as providing intellectual support for top decision-making of ICBC, the Institute sets up the development vision of building “The Think-Tank for Chinese Financial Industry”, devoting itself to make contribution to healthy and sustainable development of Chinese financial system. The major responsibilities of the Institute are as follows: formulating medium-to-long term development planning and strategies; analyzing the macro-economic situations & outlooks, development of banking industry and business tactics; focusing on prospective study on green finance as well as international and domestic cooperation, exploring the methodology of environmental risk quantification, conducting environmental factors stress-testing and ESG rating; editing and publishing two journals named CHINA URBAN FINANCE and FINANCE FORUM respectively; taking charge of daily operation and organization of China Urban Finance Society; taking charge of daily operation of ICBC Post-Doctoral Research Center; compiling the history of ICBC.



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