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Evaluating the influence of the internal ratings-based approach on bank lending in Japan

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Abstract

The capital adequacy requirement of banks shifted in March, 2007 from Basel I to Basel II. In Basel II, exact measurement of credit risk is adopted, and banks choose between a standardized approach (SA) and an internal ratings-based approach (IRBA). In general, the IRBA is a more risk-sensitive capital requirement measurement than the SA and Basel I. Theoretical modeling in related literatures implies that since the IRBA depends on the probability of default, a downturn implies a higher capital requirement, meaning that the IRBA is pro-cyclical to the business cycle. The purpose of this paper is to verify the effects of the IRBA on bank lending through empirical analysis. Although the empirical analysis here cannot confirm the pro-cyclicality of the IRBA, it does allow the proposal of a benchmark for the effects of this approach. The effect we estimate is the Average Treatment Effect on the Treated (ATT), and the estimation method adopted is difference-in-difference propensity score matching (DID-PSM). Using this method, we can confirm the real effects of the IRBA. The results are that in 2006-2007 when bank balance-sheets were favorable, the ATT are negative, but all these are insignificant, on the other hand, in 2006-2008 when the balance-sheets were infuluenced by the subprime-loan crisis, the ATT are negative and significant, and smaller than it in 2006-2008. Thus, we cannot say that the IRBA has the pro-cyclicality exactly.

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1. Introduction

The capital adequacy requirement of banks shifted in March, 2007 from Basel I to Basel II[1]. In Basel II, while the minimum capital requirement is 8%, exact measurement of credit risk is adopted, and banks choose between a standardized approach (SA) and an internal ratings-based approach (IRBA)[2]. The SA is a method in which part of Basel I is modified. As note in details, it plans measuring the risk precisely using the external ratings and considering the diversification effects of assets while succeeding to a conventional Basel I framework in which it calculates the risk assets based total asset on the financial accounting. Thus, the SA is more risk-sensitive than Basel I which gives the same risk weight on various assets. The IRBA is more risk-sensitive than the SA, since it reflects borrowers' risk more precisely using the bank's own internal ratings.

The purpose of this paper is to verify differences in lending behavior among banks adopting the IRBA and the SA. In general, it is considered that the IRBA depends on the probability of default. Since this correlates with cyclical factors of business, it raises or falls with every business cycle. Thus, a downturn implies a higher capital requirement, because calculations in Basel II are based on the probability of default. An increase in the capital-asset ratio reduces the volume of bank loans, which in turn reduces consumption and investment. This is a general pro-cyclical effect of the IRBA, and several related literatures have verified this through theoretical modeling. In particular, Repullo and Suarez (2004, 2007) proposed a dynamic equilibrium model introducing bank lending behavior, verified the pro-cyclicality of capital adequacy requirement, and evaluated the effects of the minimum capital requirement under Basel I and Basel II. They set the model as follow; banks anticipate that shocks changing the current business cycle can impair their capacity to lend in the future, and as a precaution they continue to hold the capital used as a buffers against debt exposure. The authors also show that,

[1]Although Japan adopted Basel II in March, 2007, the European Union (EU) did not do so until the end of 2008, and the United States plans execution for the end of 2009

[2]A denominator in the capital-asset ratio measurement of Basel II includes market and operational risk in addition to credit risk. Operational risk is newly added variable in Basel II, and deals with the risk of loss due to accidents, system glitch, and illegal acts.

regardless of banks' accumulation of precautionary buffers, credit crunch conditions in Basel II became more severe than those in Basel I[3] .

As mentioned above, several related literatures verify the pro-cyclicality of Basel II through theoretical modeling. However, there appears to be a lack of literatures that verifies the effects of Basel II or the IRBA on bank lending using empirical analysis. A wide variety of related literature deals with behavior of Japan's banks through empirical analysis (e.g. Sasaki (1998) and Ogawa (2003)). Ogawa (2003) tried to verify the effects of capital adequacy and non-performing loans using bank panel data. Ogawa (2003) performed estimation considering a Lagrange multiplier related to the capital adequacy requirement for the difference between the minimum capital requirement and the actual capital-asset ratio under a condition where banks are assumed to maximize profits. The results indicated that the capital adequacy requirement reduced the amount of loans issued. However, these studies were based on Basel I rather than Basel II[4].

Fortunately, in Japan, although two periods concerned are limited 2007 and 2008, we can compare the effects of the IRBA and the SA. These periods are insufficient to verify the pro-cyclicality of the IRBA, but we can assess how credit risk measurement affects lending according to banks' balance-sheets. Although these balance-sheets were comparatively favorable in 2007, their condition deteriorated in 2008 under the influence of the sub-prime loan crisis. Accordingly, this paper seeks to verify the effects of credit risk measurement on lending, and to proposes a benchmark between credit risk measurement and banks' lending behavior.

When verifying such effects, it is important to grasp how differences in lending would appear in two theoretical situations where the same bank adopted the IRBA and the SA, respectively. In general, the Average Treatment Effect on the Treated (ATT) is used to estimate such differences. ATT is a convenient concept for evaluating policy effects, but appropriate techniques are required to consistently estimate this metric. In this case, the problem is

[3]Related literatures verifying the pro-cyclicality of Basel II through modeling includes Estrella (2004) and Gordy and Howells (2006).

[4]We cannot confirm the papers arguing the IRBA and SA at present

that we cannot check lending (i.e. the outcome) when banks using the IRBA adopts the SA. Accordingly, we must make a counterfactual corresponding to lending in which banks choose the SA. One method of achieving this is to use the outcome of banks that adopt the SA. However, the choice of measurement method may be influences by bank characteristics. In fact, high fixed costs are incurred in adopting the IRBA option. Thus, there is a possibility that accurate estimation cannot be performed simply by substituting the outcome of the SA[5] . To solve these problems, we use matching estimation based on the propensity score proposed by Rosenbaum and Rubin (1983) and Heckman, Ichimura, and Todd (1997). Using this method allows the elimination of the selection bias.

It is also considered that banks' own heterogeneous effects influence the estimation results. However, if these heterogeneities are constant over time, we can eliminate estimation bias from differencing in outcomes. Here, we therefore use difference-in-difference matching estimation based on the propensity score (DID-PSM) to verify the difference between the real effects of the IRBA and the SA.

The rest of the paper is organized as follows; In Section 2, we give a simple introduction to the capital adequacy ratio measurement of Basel II and credit risk measurement. In particular, we preset the relations between the credit risk measurement and the business cycle. In Section 3, we analyze the average treatment effects of the IRBA using bank micro-data for Japan. Finally, Section 4 concludes the paper. Also, in Appendix, we present the ATT theory and several methods of estimating it.

2. Credit risk measurement and the business cycle

Basel II uses a three pillars concept, which is a framework that utilizes the self-discipline of financial institutions and market discipline complimentarily along with capital adequacy regulation. The first pillar consists of minimum capital requirement and monitoring methods with objectivity to secure the soundness of banks, the second pillar consists of self-discipline based on banks'

[5]These problems are known as selection bias. See Rosenbaum and Rubin (1983) and Imbens (2003)

own risk management and supervisory reviews, and third pillar is market discipline. In particular, we focus on the second pillar.

Banks choose the measurement method for "credit risk" and "operational risk" according to the characteristics of their own activities or risk-management techniques. Here, we focus on credit risk management[6] . One of the three following credit risk measurement methods is selected;

1. The Standardized Approach: This method calculates the capital requirement by multiplying assets by the risk weight according to external credit assessment or banks' internal rating systems for credit risk.

2. The Foundation Internal Ratings-Based Approach: This method measures credit risk more precisely by using banks' own internal ratings with respect to borrowers' creditworthiness. The risk components involved in determining the capital requirement for a given exposure include measurements of the probability of default (PD), loss given default (LGD), exposure at default (EAD), and effective maturity (M). In this method, banks estimate only borrowers' PD, input it into a functional formula set by a supervisory party, measure the expected loss (EL) and the unexpected loss (UL) from the anticipated maximum loss, and calculate this as the minimum capital requirement. LGD and EAD are set by a supervisory party.

3. The Advanced Internal Ratings-Based Approach: Banks are required to self-calculate all of PD, LGD, and EAD.

One feature of the IRBA is a higher capital requirement when the levels of PD, LGD, and EAD are higher.

[6]One of the following operational risk management methods is selected.

1. The Basic Indicator Approach: This method calculates operational risk by multiplying the gross income of banks by a factor (15%)

2. The Standardized Approach: Banks' activities are divided into eight business lines, and the capital charge for each line is calculated by multiplying the gross income of banks by factors (12%, 15%, 18%) assigned to these business lines.

3. The Advanced Measurement Approach: This method involves calculation based on banks' internal operational risk measurement systems.

The difference between the IRBA and the SA is that the former introduces the calculation of UL. While EL is defined simply as $PD \times LGD \times EAD$, UL is defined as the $Maximum\ loss - EL$. UL is the minimum capital requirement. Additionally, UL depends not only on PD, LGD, EAD, and M, but also on the correlation coefficient, which shows the degree of defaults simultaneously depending on common factors such as the business cycle. Finally, the formula for credit risk (capital requirement) with the IRBA is $Capital\ requirement = UL \times M\ adjustment$. Accordingly, the capital requirement in credit risk measurement fluctuates depending not only on PD and LGD, but also on the correlation coefficient. In great recessions characterized by a large decline of assets (such as those seen in recent years), the capital requirement reduces the volume of loans. Thus, in theoretical models such as Repullo and Suarez (2004, 2007), as mentioned above, it is pointed out that the risk-sensitive IRBA is pro-cyclical to the business cycle.

3. Empirical analysis

3.1. *Data*

In this section, using Japanese bank micro-data available from the Federation of Bankers' Associations of Japan, we assess the ATT of the IRBA using DID-PSM estimation. The notation show the binary variable CRE (which is denoted by 1 if bank i adopts the IRBA and by 0 if it adopts the SA), the bank loan-deposit ratio corresponding to outcome DL, the non-performing loan ratio BL, and the bank capital-asset ratio CR.

Fortunately, we can use 2007 and 2008 data for Japan, whereas 2006 data are used for the period before the adoption of the IRBA. Thus, ATT used for analysis are $\mathbb{E}\big(\Delta DL_{1,07-06} - \Delta DL_{0,07-06}\big)$ and $\mathbb{E}\big(\Delta DL_{1,08-06} - \Delta DL_{0,08-06}\big)$. The numbers of banks found using this analysis is 119.

In this analysis, we use a logit model to derive the estimated propensity score $\hat{\mathbb{P}}$. The results of logit model estimation are presented in Table 1. We also tested the balancing property of the propensity score. The null hypothesis of balancing property states that the means of each character should not differ between treated and control units.

Table 1: Logit model estimation

Variable	2006-2007	2006-2008
$\ln BL$	-0.2258 $(0.0521)^{***}$	-0.7283 $(0.2407)^{***}$
$\ln BL^2$	0.0425 (0.0312)	0.0784 (0.0692)
$\ln CR$	3.1764 $(1.0034)^{***}$	2.2686 $(0.9543)^{***}$
$\ln CR^2$	-0.5698 $(0.2210)^{***}$	-0.4489 $(0.1934)^{***}$
Pseudo R^2	0.3258	0.1928
Log likelihood	-42.9989	-55.4447
Number of observation	119	119

Note: The dependent variable is a dummy that indicates whether the bank choose the IRBA or the SA. Figures in parentheses represent standard errors, $*$, $**$, $***$ denotes statistical significance at the 10%, 5%, and 1% levels, respectively.

3.2. *Estimation results*

The results of estimation are presented in Table 2. The values presented in this table are the ATT, $\mathbb{E}\big(\Delta DL_{1,07-06} - \Delta DL_{0,07-06}\big)$ and $\mathbb{E}\big(\Delta DL_{1,08-06} - \Delta DL_{0,08-06}\big)$.That is, negative value means that the loan when bank adopt the IRBA is smaller than it when adopting the SA. Thus, when economy is recessions, if this value is negative then it implies that the IRBA is possibly pro-cyclical to the business cycle.

Table 2: Matching estimation

Propensity score metrics	2006-2007	2006-2008
One-to-one matching	-0.0304 (0.0603)	-0.1053 $(0.0462)^{***}$
Five-nearest-neighbor matching	-0.0426 (0.0369)	-0.0922 $(0.0334)^{***}$
Caliper matching	0.0163 (0.0665)	-0.968 $(0.0438)^{***}$
Kernel matching	-0.0167 (0.0719)	-0.1016 $(0.0410)^{***}$
Number of treated	18	20

In 2006-2007, all ATT vaules for the IRBA in bank lending, excepting the caliper matching, are negative, but all these are insignificant. Thus, in this period, we cannot get the clear results. Here, we consider about the ATT

values. It can be considered that bank balance-sheet during this period were favorable and that bank lending was not risky. In general, when the economy is relatively stable, the pro-cyclicality means the increase of the bank loan. However, in this estimation, even when economy is relatively stable, the IRBA functions to decrease the bank loan. That is, when economy is stable, the IRBA has not pro-cyclicality. But this estimation implies that the ATT is insignificant.

In 2006-2008, all matching estimations indicate that the effect of the IRBA on bank lending is negative and significant. During this period, the balance-sheets of banks were influenced by the subprime-loan crisis originating in the United States. In particular, the Nikkei-Heikin stock market index dipped below $10,000$ yen in September 2009, causing the balance-sheets of bank holding large quantities of marketable securities to deteriorate further. Thus, for banks adopting the IRBA, while the numerator of the capital-asset ratio formula was small, they needed to reduce risk assets (the denominator) in order to maintain a uniform capital adequacy ratio. Accordingly, in this period, we can consider that the difference between the IRBA and the SA is negative and significant. Also, in this period, the value of ATT is smaller than it in 2006-2007.

Related literatures on banks' optimization problems, including bank capital, have implies that the adoption of the IRBA must accumulate capital and reduce the volume of loans, which in turn reduces consumption and investment. Thus, in the theoretical model, it is shown that the IRBA is pro-cyclical to the business cycle. While it is not possible to verify the pro-cyclicality of the IRBA here, this paper shows that the approach reduces the volume of loans in recessions. However, it should be noted that if the IRBA fulfills the role of performing early correction of banks automatically, then it may assist economic recovery from business depression at an early stage, although it may makes the recession more serious in the short term.

4. Concluding remarks

In this paper, we verify the effects of the IRBA on bank lending. This approach is a risk-sensitive measurement, and it is expected that banks adopting

it will reduce risk assets to achieve the minimum capital requirement in terms of recession. In fact, many studies (e.g. Repullo and Suarez (2004, 2007)) point out that its effects are correlated to business cycle; that is, the effects are pro-cyclical. Accordingly, we verified the influence of the IRBA through empirical analysis using bank micro-data for Japan. The estimation method we used is DID-PSM, and we calculated the ATT, $\mathbb{E}\big(\Delta DL_{1,07-06} - \Delta DL_{0,07-06}\big)$ and $\mathbb{E}\big(\Delta DL_{1,08-06} - \Delta DL_{0,08-06}\big)$ by it.

In terms of results, we were able to confirm that the effects of the IRBA on bank lending were negative and significant for the 2006-2008 and insignificant for the 2006-2007. Also, the ATT for 2006-2008 is smaller than it for 2006-2007, that is, $\mathbb{E}\big(\Delta DL_{1,08-06} - \Delta DL_{0,08-06}\big) < \mathbb{E}\big(\Delta DL_{1,07-06} - \Delta DL_{0,07-06}\big)$. In the later, since balance-sheets were relatively sound, it can be considered that the loan situation of banks adopting the IRBA shown no great reaction to credit risk. Then, in this period, while the ATT is negative, it is insignificant. However, in general, the IRBA is pro-cyclical to the business cycle in theoretical frameworks. This estimation result implies that even when the economy is stable, the IRBA decreases the bank loan, that is, the IRBA is not pr-cyclical. On the other hand, the recession originating in the United States began to appear in 2008, and the worldwide economy sustained serious damage. It can therefore be stated that banks adopting the IRBA judge an increased level of risk and restrained their issuance of loans. Then, we can say that in the recession the IRBA is pro-cyclical.

As mentioned above, the IRBA decreases the bank loan regardless of the situation of the economy. Thus, we cannot exactly say that the IRBA is pro-cyclical to the business cycle. However, these results do not imply that the IRBA has many problems, and it is considered that accurate calculation of risk can secures the soundness of banks and mitigate the acuteness of recession conditions. It will take time to clarify the effects of the IRBA in the current financial crisis. However, if banking soundness can be shared worldwide, the global economy will be able to recover from the financial crisis at an early stage, so the prompting of temporary economic deterioration is a necessary that can be withstood.

Appendix

In this appendix, we describe about the estimation of ATT based on DID-PSM. Since estimating ATT, enables confirmation of differences in loans disbursed by identical banks between cases in which the IRBA is adopted and those in which it is not, allows us to determine the real effects of this approach. In general, average treatment effect is $\mu_1 - \mu_0$ written as follow;

$$DL_i = \mu_0 + \mathbf{X}_i\boldsymbol{\beta} + CRE_i\big(\mu_1 - \mu_0\big) + CRE_i\big(u_{1i} - u_{0i}\big) + u_{0i} \tag{1}$$

To estimate eq.(1) with a general regression model, it is necessary for either (i)$u_{1i} = u_{0i}$ or (ii)$\mathbb{E}\big\{u_{1i} - u_{0i} \;\big|\; CRE_i = 1\big\} = 0$ to be satisfied, where situation (i) implies that the effects of the IRBA are the same for bank i, which has the same $\mathbf{X}_i$, and situation (ii) implies that even if the effects are different between the banks, this difference does not affect the selection of the approach adopted.

However, the problems are cases where assumption (i) and (ii) does not hold, i.e., the effect of the IRBA is different between the banks, and the adoption of measurement methods is decided based on the idiosyncratic effect. In this case, the OLS and instrumental variable (IV) approach loses its validity. As shown in Heckman, Ichimura, and Todd (1997), however, the PSM and DID-PSM estimation methods can solve these problems.

A.1. *Propensity score matching estimation*

Matching estimation is a method that matches samples (treated units) adopting the IRBA to similar samples (control units) that adopt the SA with respect to $\mathbf{X}$, and estimates the effects of the IRBA by evaluating the difference in outcome DL. In using this estimation, it is not necessary to assume the outcome specification and the form of the error term, and we can restrain bias increase by matching the erroneous specification at the minimum value.

While several assumptions are required in order to estimate the effects of the IRBA with matching estimations, we need only the following assumption if we estimate ATT (see Smith and Todd (2005))[7].

$$\mathbb{P}\big\{CRE = 1 \;\big|\; \mathbf{X}\big\} < 1 \tag{2}$$

[7]In general, a matching estimation is set with following assumptions;

The problem is that while setting the many characters of $\mathbf{X}$, it is difficult to search for control units. Rosenbaum and Rubin (1983) propose matching estimation based on the propensity score as a method of solving this problem. This technique matches control units that have similar levels of conditional probability $\mathbb{P}\{CRE \mid \mathbf{X}\}$. If the probability is the same, then $\mathbf{X}$ have identical distributions for treated and control units, because the decision of whether or not to adopt the IRBA is random. That is, if the conditional probability $\mathbb{P}$ is the same, the outcome DL_0 is the same on average among treated and control units. Thus, we can denote the relationship as follows;

$$\mathbb{E}\{DL_0 \mid CRE = 1, \mathbb{P}(\mathbf{X})\} = \mathbb{E}\{DL_0 \mid CRE = 0, \mathbb{P}(\mathbf{X})\} \tag{3}$$

where, $\mathbb{P}\{DL_0 \mid CRE = 1, \mathbb{P}(\mathbf{X})\}$ is called the propensity score and is estimated with logit or probit models.

If eq.(2) and eq.(3) are satisfied, then we can express ATT as follows and perform consistently estimation, matching treated units to control units that have similar $\hat{\mathbb{P}}$ values, which denotes the consistent estimate of adoption probability;

$$\begin{aligned} ATT &= \mathbb{E}\{DL_{1i} - DL_{0i} \mid CRE_i = 1\} \\ &= \mathbb{E}\{\mathbb{E}\{DL_{1i} \mid CRE_i = 1, \mathbb{P}(\mathbf{X}_i)\} - \mathbb{E}\{DL_{0i} \mid CRE_i = 0, \mathbb{P}(\mathbf{X}_i)\} \mid CRE_i = 1\} \end{aligned} \tag{4}$$

The first problem is whether or not whether eq.(2) holds. To solve this, Dehejia and Whaba (1999, 2002) proposed a test based on balancing properties; using this test, they suggested that the bias of matching estimation can be mitigated. The second problem is searching for matching control units, because the probability of observing two units with exactly the same propensity score is zero. The methods to solve this problem are, for example, caliper matching and the kernel matching.

1. $DL_0, DL_1 \perp CRE|\mathbf{X}$
2. $0 < \mathbb{P}\{CRE = 1 \mid \mathbf{X}\} < 1$

Assumption 1 implies that controlling the characters of $\mathbf{X}$ and the distribution of outcome DL are independent of the binary variable CRE, which denotes program participation. Assumption 2 implies that for all characters of $\mathbf{X}$, conditions with and without participants are necessary so that a counterfactual - for participants always exists for the condition without participants.

A.2. *DID-PSM estimation*

The disadvantage of cross-sectional matching is that eq.(3) is not satisfied if and only if the factors that cannot be explained by $\mathbf{X}$ affect decision-making. Thus, since eq.(3) is not satisfied, the matching estimation is not consistent.

If this influence is based on unobservable heterogeneity, that is constant over time, such as individual potential ability, then we can obtain a consistent matching estimator from differences in DL. In this case, we must observe the treated and control units in at least two periods before and after the adoption of the IRBA. That is, if bank i adopts the IRBA in period t, then the periods we must observe are $t-1$ and $t+m$, where $m \geq 0$. This is the DID-PSM estimation method provided by Heckman, Ichimura, and Todd (1997), and can be denoted as follows;

$$\hat{\alpha}_{DID-PSM} = \frac{1}{N^T} \sum_{i \in T} \{ \Delta DL^T_{i,t+m} - \sum_{j \in C(i)} w_{ij} \Delta DL^C_{j,t+m} \} \tag{5}$$

where, $\Delta DL_{t+m} = DL_{t+m} - DL_{t-1}$. so ΔDL_{t+m} represents $m+1$ order differencing. The advantage of the DID-PSM estimator is that we can eliminate individual effects independent of time. In fact, Heckman, Ichimura, and Todd (1997) shown that the DID-PSM estimator performs better than the PSM estimator based on cross-sectional data.

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