Online Appendix (2)

PSM METHODOLOGY APPLIED TO THE M&A INVOLVEMENT OF CCBs

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ORIGINAL ARTICLE

All that Glitters is Not Gold! Could M&As Post-Bank Reforms be Just a Tool for Balance Sheet Embellishment?

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PSM METHODOLOGY APPLIED TO THE M&A INVOLVEMENT OF CCBs

The PSM method allows economists to measure the effect of a treatment (e.g., a regulatory change) on a series of outcomes, assuming unconfoundedness and common support conditions (Rosenbaum and Rubin 1983). Over the last decades, PSM approaches have become a popular nonparametric technique in the field of finance to estimate causal treatment effects in observational (non-randomized) studies, especially adopted to evaluate policy and regulatory impacts (see, e.g., Ayadi et al., 2021; Casu et al., 2013; Cumming and Zambelli, 2017; Caliendo and Kopeinig, 2008; Beccalli and Franz, 2009; Jalan and Ravallion, 2003). PSM can be applied in any study where we can identify: (a) a treatment; (b) a group of treated subjects and; (c) a control sample of non-treated subjects (Casu et al., 2013; Caliendo and Kopeinig, 2008). In our case, the treatment is represented by the M&A involvement, and the treated group is composed of the CCBs involved in M&As. Given that the M&A is a decision taken by the Board of Directors, it may suffer from endogeneity and selection biases. To address this issue, we employ PSM by following four steps, in line with the above literature: (1) propensity score estimation; (2) matching of units; (3) control for balance; and (4) estimation of the final impact of M&A involvement in terms of Average Treatment Effect on the Treated (ATET).

(1) First, we estimate the propensity scores *p(x),* defined as the conditional probability of receiving a treatment or being assigned to a particular treatment (i.e., M&A involvement), given a set of observed pre-treatment characteristics or confounders (Rosenbaum and Rubin, 1983; Caliendo and Kopeinig, 2008).

$$p(x) = P\,(T=1|X=x) \qquad (1)$$

where: p(x) is the propensity score, conditional on a set of observed characteristics; P is the probability of receiving the treatment; T is the treatment (M&A); Xs are the observed covariates. Given that M&As are captured by a binary time-variant variable, to estimate the probability of being involved in an M&A, conditional on a set of observed characteristics (X_{it-1}) taken at time t-1, we adopt a probit model according to the following binary response, in line with Casu et al. (2013) and Ayadi et al. (2021):

$$P\,(T_{it} = 1) = P\,(\alpha_0 + \sum_{k=1}^{k} \beta_k X_{ki,t-1} + Y_{kt} + \varepsilon_{it} > 0) \qquad (2)$$

where: (T_{it}) is a dummy variable indicating the treatment, taking the value of 1 if bank *(i)* is involved in an M&A at time *t,* and 0 otherwise; α_0 is a constant; K represents the number of explanatory variables ($X_{ki,t-1}$) in the selection equation, taken at the time *t-1,* as the variables included in the PSM should not be affected by the treatment (Casu et al., 2013; Caliendo and Kopeinig, 2008); Y_t are the year dummies and ε_{it} represents the identically and independently distributed error term.

(2) Once the propensity scores are estimated, as a second step, for each year we proceed by matching the CCBs involved in the M&A deals (treat group) with the banks not involved in M&As (control group). To this end, we employ a matching algorithm based on the nearest-neighbor procedure (Abadie and Imbens, 2002) with multiple neighbor matching (considering 3 matches, in line with Ayadi et al., 2021). In this way, for each treated unit, the method will identify and match the three untreated units with the closest propensity scores to the treated unit. By matching on the propensity score, it is possible to create comparable treatment and control groups that are similar with respect to the distribution of observed characteristics. If this similarity is ensured, we can estimate the effect of M&As on CCB performance more accurately. In the matching procedure, we control for bank-specific characteristics, taken at year t-1. Such a procedure allows us to compare banks that share the same cluster and are very similar in terms of performance, differing only in the decision to implement the M&A.[1]

(3) Once the matching procedure is completed, as a third step, we proceed by checking the balance of the created groups to make sure that the characteristics of the treated and control groups are statistically comparable. The main purpose of the propensity score estimation is not only to predict the conditional probability of a certain treatment but also to balance the covariates between the two groups (Caliendo and Kopeinig 2008).[2] In our case, the matched units in the treated and control groups do not show significant differences for all the covariates included in the propensity score (results of our matching procedure are reported in this Online Appendix, Figure A1; Tables A1-A2).

[1] More specifically, the covariates included in the matching procedure are reported in the Appendix of this Author's Response, in Table A1 (EQUITY/TA; RWA_DENSITY; GROSS LOANS/TA; NPL; GROWTH GL; SIZE; LISTED; BANK ASSET CONCENTRATION; DOMESTIC CREDIT_GDP; GDP_GROWTH). Table A2 reports the differences in means, before and after the matching. For brevity reasons, we do not report these Tables and Figures in the paper, but are available upon request.

[2] Given the difficulties of implementing a direct matching on covariates, PSM can be very helpful in cases of highly dimensional vector of covariates (see, Casu et al., 2013; Rosenbaum and Rubin, 1983).

(4) As a last step, we proceed by evaluating the effects of M&As on the bank performance, by considering the average treatment effect on the treated (ATET), which in theory represents the difference between the outcome of the treated group in the case of treatment (Y^1) and the outcome of the same treated group in the absence of treatment (Y^0):

$$ATET = E[Y^1 - Y^0 \mid T=1] \quad (3)$$

$$ATET = E[\Delta Y^1_{i,t+1} \mid T_{i,t}=1] - E[\Delta Y^0_{i,t+1} \mid T_{i,t}=1] \quad (4)$$

where, in our case: T is the treatment (i.e., the M&A involvement); Y represents the outcome (e.g., capitalization, risk, stability, cost efficiency); E[.] is taken from the distribution of observed characteristics (X) among the treated (T=1); $\Delta Y^1_{i,t+1}$ is the performance change of the cooperative $bank_i$ (treat group) after the M&A in the period t+1 in case of treatment; $\Delta Y^0_{i,t+1}$ is the potential performance change that the same treat units (CCBs) would have obtained at time t+1, if they were not treated (i.e., not involved in M&As). The second part of equation (4) represents the counterfactual components (Egger and Hahn, 2010), which is the outcome of the treated units in case they were not treated. In summary:

$$Y = \begin{cases} Y^1 & \text{if } T=1 \quad \text{(outcome of treat group, with treatment)} \\ Y^0 & \text{if } T=1 \quad \text{(outcome of treat group, with no treatment)} \end{cases}$$

As well known, $\Delta Y^0_{i,t+1}$ is only hypothetical because the counterfactual component is not observable in practice (Splawa-Neyman et al., 1990; Rubin, 1973), as it is not possible to observe both outcomes (Y^1) and (Y^0) for the same treated group (T=1). As such, we need to identify a proxy for it. In experimental studies, this underlying potential sample selection bias is addressed by using a random assignment of individuals to the treated group, in order to ensure that every individual has the same probability of receiving a treatment (Jyotsna and Ravallion, 2003). This is not possible in the non-experimental studies, as is our case, and we need to approximate the counterfactual term $\{E[Y^0 \mid T=1]\}$ with a close match $\{E[Y^0 \mid T=0, p(x)]\}$, by considering comparable control units not exposed to the treatment (T=0), matched upon their propensity scores p(x). With this assumption, banks not involved in M&As (T=0) can serve as an adequate control group.

$$Y = \begin{cases} Y^1 & \text{if } T=1 \quad \text{(treat group)} \\ Y^0 & \text{if } T=0 \quad \text{(control group)} \end{cases}$$

In this way, by matching on the propensity scores, we can reduce the potential selection biases in the estimation of treatment effects in observational studies. We can then estimate the final impact of the treatment (M&A involvement) on the treated group (CCBs), as the average difference in outcomes between the results (Y^1) observed in the treat units (T=1) and the results (Y^0) observed in the matched group not treated (T=0), both matched on the propensity scores (p), conditional on a set of covariates (x). As such:

$$\text{ATET} = E[\Delta Y^1_{i,t+1} \mid T_{i,t}=1, p(x)] - E[\Delta Y^0_{i,t+1} \mid T_{i,t}=0, p(x)] \qquad (5)$$

where:

$$\Delta \begin{cases} E[Y_1 \mid T=1, p(x)] \text{ is the outcome of created treat group (CCBs)} \\ E[Y_0 \mid T=0, p(x)] \text{ is the outcome of the matched control group} \end{cases}$$

As anticipated, the PSM requires two key assumptions: (a) the assignment to treat group must be independent of the outcomes (*conditional independence assumption*, or unconfoundness),[3] and (b) the probability of assignment is bounded away from 0 to 1 (*overlap condition* or common support).[4] In other terms, the PSM technique requires that the function generating balancing scores is independent of the assignment of firm *i* into the treatment group in year *t*. Given the above key assumptions, for the purpose of our study, we can identify the average treatment effects on the treated (CCBs), as follows:

$$\text{ATET} = E[\Delta Y^1_{i,t+1} \mid T_{i,t}=1, p(X_{i,t-1})] - E[\Delta Y^0_{i,t+1} \mid T_{i,t}=0, p(X_{i,t-1})] \qquad (6)$$

where: $E(\Delta y^1_{i,t+1} \mid w_{i,t} = 1, p(X_{i,t-1})$ represents the average performance change at time *t+1* of banks involved in an M&A at time t; $E(\Delta y^0_{i,t+1} \mid w_{i,t} = 0, p(X_{i,t-1}))$ represents the average performance change at time t+1 of banks not involved in an M&A deal at time t (control group); and $X_{i,t-1}$ is a vector of conditioning covariates observed at time *t-1*.

[3] This implies that, after controlling for observed characteristics, there is no systematic difference between the treated and control groups that could affect the outcome variable (see Table A2).

[4] This implies that, for every level of the observed characteristics, there is a positive probability of being either in the treated or in the control group and, as such, for each treated unit, it is possible to find a similar unit in the control group (and vice versa). See Figures A1 and Tables A1-A2 for more details.

Online Appendix - **References**

Abadie, A., Imbens, G. W. (2002). Simple and bias-corrected matching estimators for average treatment effects (No. t0283). National Bureau of Economic Research.

Ayadi, R., Bongini, P., Casu, B., Cucinelli, D. (2021). Bank business model migrations in Europe: Determinants and effects. *British Journal of Management*, 32(4), 1007-1026.

Beccalli, E., Frantz, P. (2009). M&A operations and performance in banking. *Journal of Financial Services Research,* 36, 203–226.

Caliendo, M., & Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. *Journal of economic surveys*, *22*(1), 31-72.

Cumming, D.J., Zambelli, S. (2017). Due Diligence and Investee Performance. *European Financial Management*, 23, 211-253.

Casu, B., Clare, A., Sarkisyan, A., Thomas, S. (2013). Securitization and Bank Performance. *Journal of Money, Credit and Banking*. 45(8), 1617-1658.

Egger, P., & Hahn, F. R. (2010). Endogenous bank mergers and their impact on banking performance: Some evidence from Austria. *International Journal of Industrial Organization*, 28(2), 155-166.

Jalan, J., Ravallion, M. (2003). Estimating the Benefit Incidence of an Antipoverty Program by Propensity-Score Matching. *Journal of Business & Economic Statistics*, 21, 19-30.

Jyotsna J., and Ravallion, M. (2003). Estimating the Benefit Incidence of an Antipoverty Program by Propensity-Score Matching. *Journal of Business & Economic Statistics*, 21(1), 19-30.

Rosenbaum, P.R., Rubin, D.B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika,* 70(1), 41-55.

Rubin, D. B. (1973). The use of matched sampling and regression adjustment to remove bias in observational studies. *Biometrics*, 185-203.

Splawa-Neyman, J., Dabrowska, D. M., & Speed, T. P. (1990). On the application of probability theory to agricultural experiments. Essay on principles. Section 9. *Statistical Science*, 465-472.

Figure A1 - Propensity score matching before and after matching

Figure shows the distribution of the propensity score before and after the matching procedure. Treated refers to the cooperative banks involved in M&As and Untreated to banks not involved in any M&As.

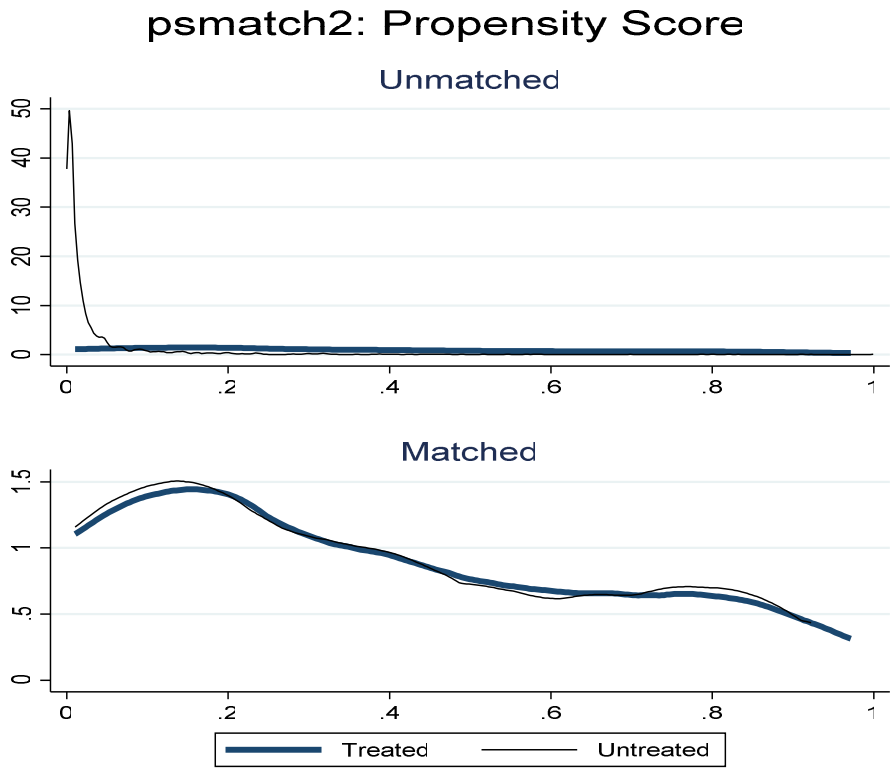

Table A1 - Propensity score matching on cooperative banks – CCB focus

This Table describes the probability of M&A involvement (depending on a series of observable matching characteristics: E/TA; RWA density ratio; GL/TA; NPL ratio; Growth GL; SIZE; LISTED; Bank Assets concentration; Domestic credit to GDP; GDP growth). The dependent variable is the probability of being involved in an M&A (dummy variable equals 1 if cooperative bank is involved in a M&A in a specific year and 0 otherwise).

M&A	Coefficient	Std. err.	P>z
EQUITY/TA	2.513	4.556	0.581
RWA DENSITY	-1.937	1.440	0.179
GROSS LOANS_TA	4.558	1.302	0.000
NPL RATIO	6.400	1.950	0.001
GROWTH GL	11.421	0.966	0.000
SIZE	0.836	0.117	0.000
LISTED	-7.507	2.984	0.012
BANK ASSET CONCENTRATION	10.441	3.618	0.004
DOMESTIC CREDIT_GDP	19.254	17.423	0.269
GDP GROWTH	-1.211	0.669	0.070
Constant	-23.176	4.291	0.000
Obs	2,043		
R-squared	0.403		

Table A2 - Differences in means before and after matching

The table reports the difference in means for each variable used in the PSM method before and after the matching. "U" refers to the *unmatched* group (i.e., before the matching procedure), "M" refers to the *matched* group (i.e., after the matching procedure). The "Treated" group refers to the banks involved in the M&A in a specific year; "Control" group refers to the banks not involved in a M&A in a specific year. P-value shows the significance of the difference in means. V(T)/V(C) is the variance ratio given by the variance of treated on variance of control.

		Mean			
	Groups	Treated group	Control group	P-value	V(T)/V(C)
EQUITY_TA $_{t-1}$	U	0.0919	0.10328	0.004	0.45*
	M	0.09262	0.09781	0.613	0.22*
RWA_DENSITY $_{t-1}$	U	0.50887	0.5465	0.006	0.55*
	M	0.51012	0.48612	0.356	0.61*
GROSS LOANS_TA $_{t-1}$	U	0.65165	0.64778	0.091	0.59*
	M	0.6494	0.65075	0.972	0.31*
NPL $_{t-1}$	U	0.16686	0.13767	0.000	0.81
	M	0.16645	0.17742	0.993	0.37*
GROWTH_GL $_{t-1}$	U	0.28694	0.06757	0.000	2.54*
	M	0.28537	0.27252	0.366	0.64*
SIZE $_{t-1}$	U	14.45	13.163	0.000	1.2
	M	14.424	14.525	0.671	0.54*
LISTED $_{t-1}$	U	0.0588	0.0029	0.000	.
	M	0.0594	0.0097	1.000	.
BANK ASSET_CONCENTRATION $_{t-1}$	U	0.65811	0.67566	0.001	0.71
	M	0.65843	0.65964	0.982	0.7
DOMESTIC CREDIT GDP $_{t-1}$	U	0.81237	0.83092	0.000	0.57*
	M	0.81188	0.81359	0.851	0.92
GDP_GROWTH $_{t-1}$	U	0.0099	0.0029	0.000	0.27*
	M	0.00988	0.00988	0.995	1.05