Macroprudential regulation and bank behavior: Theory and evidence from a quasi-natural experiment

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Introduction

In the wake of the financial crisis, countries have put a lot of emphasis to nurture their financial systems back to a position of soundness. Accordingly, policymakers have been experimenting with different policies towards improving the soundness and stability of their financial sector. One set of policies which has attracted the attention of policymakers are macroprudential policies (MPPs) (See, BIS, 2009; Caruana, 2010). Simply put, such policies seek to ensure systemic stability of the financial system by explicitly addressing the interlinkages between, and the procyclicality of the financial system (IMF, 2012).

In this context, the paper investigates the impact of MPPs on bank behavior. In particular, we develop a theoretical model which explores how two major macroprudential measures - an increase in risk weight on loans and an increase in provisions on standard loans - affect bank credit growth. Subsequently, we examine the testable propositions of the theoretical setup, employing quarterly data for India for the period 2002:1 to 2012:1.

For this purpose, we exploit the quasi-natural experiment of the MPPs initiated by the Indian authorities prior to the crisis to examine their efficacy. More specifically, beginning December 2004, the Indian central bank undertook a series of countercyclical MPPs targeted at sectors of the economy which seemed in danger of over-extension. These measures were calibrated during the period of the crisis and thereafter in order to moderate the impact of the global headwinds on these sectors.

The rest of the paper continues as follows. The following section reviews the relevant literature in this area. The basic framework is detailed in Section 3. Section 4 elaborates on the results under a Basel II-type setting. The concluding remarks are gathered in the final section.

II. Related Literature

The existing literature has classified MPPs into two broad categories: those designed to address the procyclicality of the financial system and second, those focused on tackling financial system interconnectedness. In essence, the former reflects an amplifying mechanism that operates within the financial system as well as between the financial system and the real economy. This mechanism, termed procyclicality, is based on the tendency of economic agents to become overtly optimistic in an upswing and thereby increase their risk exposure, and subsequently become highly risk-averse during

the bust phase. The latter, on the other hand, magnifies the impact of financial distress. This mechanism depends on risk concentration (the number and size of financial institutions, their substitutability, and their vulnerabilities) and systemic interconnectedness (the level of intra-financial system activity) and is more evident at a point in time (cross-sectional dimension).

Of late, several studies have emerged that examine the efficacy of macroprudential policies (MPP). For example, Lim et al (2011) examine the role of MPPs on bank credit and finds that, under certain circumstances such policies are effective in moderating the procyclical behaviour of credit. Subsequently, employing quarterly data for several Central, Eastern and South Eastern European (CESEE) economies for the period 1999-2011, Vandenbussche et al. (2012) found that measures such as capital adequacy ratio and marginal reserve requirements did exert a dampening effect on house prices. Dell' Ariccia et al (2012) empirically investigated the impact of MPPs on bank credit. Their findings indicate that MPPs substantially lower the incidence of a credit boom and in particular, it is especially effective in containing credit booms that might engender a financial crisis. More recently, utilising cross-national data on 36 countries for the period 2000-11, the IMF (2012) examined the impact of several MPPs on both financial and real variables. The results appear to suggest statistically significant effects for both capital requirements and reserve requirements on credit growth. In terms of real variables, the results point to the fact that limits on loan-to-value (LTV) ratio exerts a non-negligible impact on output growth. Within a dynamic panel vector autoregression approach, Tovar et al (2011) finds that Latin American countries have successfully relied on reserve requirements to contain credit over-extension during the 2004-11 period. Wong et al. (2011) find that LTVs played a key role in arresting mortgage delinquency in several Asian economies. More recently, using an extensive sample of over 2500 banks in 48 countries, Claessens *et al* (2013a) reports that MPPs are effective in preventing the build-up of risks, although the set of instruments having greater efficacy varies across emerging and advanced economies.

Besides these cross-national analyses, there are also case studies focusing on specific countries and/or market segments. Jimenez *et al.* (2012) find that dynamic provisioning requirements enabled Spain to successfully tide over the credit cycle and avoid the contractionary impact on the real economy. Igan and Kang (2011) focus on the impact of debt-to-income (DTI) and LTV ratios on house price dynamics in Korea and offer evidence to suggest that these instruments are successful in curbing house price increases. Craig and Hua (2011) report that property price build-ups were significantly dampened by the curbs on LTV in Hong Kong. Kraft and Galac (2011) document how the macroprudential response by the Croatian authorities in response to strong capital flows mitigated the ferocity of the financial crisis on domestic banks. In a similar vein, both the

experiences of Estonia (Sutt *et al,* 2011) and Turkey (Kenc *et al,* 2011) do provide some evidence in support of the relevance of MPPs.

The analysis connects several strands of literature. The first strand is the effect of MPPs on bank performance. Second, the paper contributes to the literature as to how ownership interacts with MPPs to affect bank credit expansion. Third, the paper is related to the literature on the evolution of the Indian banking sector in the post-deregulation era. The present paper complements these findings by focusing on the impact of several MPPs and comparing the response across bank ownership.

The paper comprises of two parts. First, in the spirit of related research (Wong, 1997; Broll *et al.,* 2003; Kopesky and Van Hoose, 2004; Pausch and Welzel, 2012), we develop a theoretical model of a banking firm. Two distinguishing features of our model include introduction of macroprudential features. The MPPs considered include a general provision on standard assets – a rudiment of the dynamic provisioning framework – and differential risk weight on loan categories. Contextually, it might be mentioned it is exactly these two MPPs that were employed by the Indian policymakers. The testable propositions emanating from the theoretical framework therefore lend themselves to empirical examination.

III. Basic Setup

Consider a bank with loans (denoted by L) and bonds (B) on the asset side, which is funded through deposits (D) and equity (E). The following assumptions set out the framework of the model.

Loans: The bank has some market power in the loan market. As is well-known, one key feature of the Basel III framework is the differential risk weight on loans to the (non-bank) private sector. We assume that the representative bank extends two categories of loans (L_1 and L_2), with r_1 and r_2 respectively, being the interest rate applied by the bank to the loans of type 1 and 2. Each loan gives the bank an end-of-period return of $(1+r_j)*L_j$, with probability p_j (j=1,2) or zero otherwise, with $p_1>p_2$. Type 2 loans have higher probability of default. For purposes of simplicity, the (inverse) demand schedule for loan *j* is $r_j=R_j-\delta_j L_j$, such that $\partial r_j/\partial L_j = -\delta_j<0$, with R_j and δ_j being positive parameters.

Deposits: The bank also has some market power in the deposit market. The source of this market power might stem from the bank's ability to segment the market through spatial differentiation. The supply function of deposits can be expressed as $r_D=Z+\delta_D D$ (Z and δ_D are positive parameters) such that $\partial r_D/\partial D=\delta_D>0$. As earlier, given the amount (D) of deposits contracted at the beginning of the period, the end of period cost to the bank equals $(1+r_D)*D$.

Bonds: In addition to loans, banks also hold a marketable financial asset (Government bonds); the interest rate on these bonds (i) is determined in a competitive financial market, where the bank is a price-taker.

Capital requirement: The banking sector is subject to a capital requirement, modeled on the lines of the Basel III Accord. Under this setup, it is assumed that Type 2 loans receive a higher risk weight (w_2) *vis-à-vis* Type 1 category (w_1). Thus, we may write the capital requirement as: $E \geq w_1 * L_1 + w_2 * L_2$, with $w_2 > w_1$, implying that the bank cannot have an equity level lower than w_j (j=1,2) times the volume of loans, L_j.

Macroprudential regulation: We model two types of macroprudential regulation: one related to provisions on standard loans and the other related to risk weights. First, we assume that a fraction θ_j of loan type j is not repaid, which is exogenously determined by business cycles.[1] As a result, the amount of standard loans equals $(1-\theta_j)L_j$ (j=1,2), on which the bank makes a provision of q_j. Second, as discussed earlier, we assume different risk weights on different loan categories.

Objective Function: The objective of the bank is to maximize the expected end of period income (V). This is given by expression (1), i.e.,

$$\begin{aligned} V = {} & p_1 p_2 [\{(1+r_1)(1-\theta_1)L_1 - q_1(1-\theta_1)L_1\} + \{(1+r_2)(1-\theta_2)L_2 - q_2(1-\theta_2)L_2\}] + \\ & p_1(1-p_2)[(1+r_1)(1-\theta_1)L_1 - q_1(1-\theta_1)L_1] + \\ & (1-p_1)p_2[(1+r_2)(1-\theta_2)L_2 - q_2(1-\theta_2)L_2] + \\ & (1-\pi)[(1+i)B - (1+r_D)D] - (1+i)E \end{aligned} \quad \textbf{(1)}$$

The budget constraint is:

$$E + D = L + B \quad \textbf{(2)}$$

from which the amount of bonds held can be derived as a residual: B=E+D-L, which, upon plugging back into (1) and re-arranging yields:

$$\begin{aligned} V = {} & p_1 p_2 [\{(1+r_1)(1-\theta_1)L_1 - q_1(1-\theta_1)L_1\} + \{(1+r_2)(1-\theta_2)L_2 - q_2(1-\theta_2)L_2\}] + \\ & p_1(1-p_2)[(1+r_1)(1-\theta_1)L_1 - q_1(1-\theta_1)L_1] + \\ & (1-p_1)p_2[(1+r_2)(1-\theta_2)L_2 - q_2(1-\theta_2)L_2] - \\ & (1-\pi)(1+i)(L_1+L_2) + [(1-\pi)(i-r_D)]D - \pi(1+i)E \end{aligned} \quad \textbf{(3)}$$

III.1 Short-run equilibrium

A short-run equilibrium is defined as a situation where the bank is not able to adjust the equity to its desired level. As a result, the short-run optimization problem of the bank is:

[1] Accordingly, θ can be thought of as a proxy for aggregate credit risk.

$$\underset{L_1, L_2, D}{Max}\ V \ \ subject\ \ to\ E \geq w_1 L_1 + w_2 L_2 \qquad \textbf{(4)}$$

The resultant first-order conditions (FOCs) of the problem are:

$$p_1 (1-\theta_1)[1+R_1 - 2\delta_1 L_1 - q_1] = \lambda w_1 + (1+i)(1-\pi) \qquad \textbf{(5)}$$

$$p_2 (1-\theta_2)[1+R_2 - 2\delta_2 L_2 - q_2] = \lambda w_2 + (1+i)(1-\pi)$$

(6)

$$r_D^* (1+\delta_D) = i \qquad \textbf{(7)}$$

where λ is the lagrange multiplier associated with the equity constraint.

The interest rate on deposits (r_D*) is set such that the marginal cost of deposits (LHS of 7) equals the marginal return on bank assets (i). The bank is able to earn a profit margin on its deposit taking, being higher the lower is the elasticity of the deposit supply schedule.[2]

III.2 Macroprudential policy effectiveness

We come to the main goal of the paper: to analyze the impact of a macroprudential policy intervention on the loan market. The result is summarized in Proposition 1.

Proposition 1*: (a) In case a bank is not constrained by its equity level, the short-run impact of a change in the standard provisions on loans is given by* $\partial L_j^* / \partial q_j < 0$.

(b) In case a bank is constrained by its equity level, the short-run impact of a change in the standard provisions on the loan rate is given by $\partial r_j^* / \partial q_j < 0$.

III.3 Long-run equilibrium

In the long run, it seems reasonable to assume that the bank would be able to adjust its equity level. This process leads the banking system to attain a long-run equilibrium, where E is endogenous. Formally, the long-run equilibrium level of E is determined as $E=\omega_1 * L_1 + \omega_2 * L_2$, where ω_1 and ω_2 are the internal targets for w_1 and w_2 (See, for example, Estrella, 2001).

The long run optimization problem of the bank is given as:

Max (L_1, L_2, D) V s.t. $E = \omega_1 * L_1 + \omega_2 * L_2$,

[2] To see this, we re-arrange (7) to obtain: $r_D^* = i/(1+\delta_D)$, where $1/(1+\delta_D)$ is the "mark-down" on deposits.

The first order conditions for a maximum are defined by (11.1) and (11.2) on the loan supply, while on the deposit side, it is the same as earlier (eq. 7). Explicitly writing (11.1) and (11.2) yields the following expressions:

$$p_1 (1-\theta_1)(1+R_1-2\delta_1 L_1-q_1) = (1+i)(1-\pi)+\pi(1+i)\ \omega_1 \qquad \textbf{(11.1)}$$

$$p_2 (1-\theta_2)(1+R_2-2\delta_2 L_2-q_2) = (1+i)(1-\pi)+\pi(1+i)\ \omega_2 \qquad \textbf{(11.2)}$$

In other words, the expected return on "standard" loans (LHS) equals the expected cost (RHS). The latter, in turn, comprises of two terms. The first term is the return forgone for the bank in the event of a default while the second term is the weighted marginal cost of equity.

Proposition 2: *(a) The long run impact on loans of a change in the risk weight ω_j and an increase in provisions are both negative, with the magnitude of the former lower than that on the latter.*

IV. Empirical testing

The theoretical model provides two major testable propositions. First, the impact of a rise in MPPs is to moderate credit demand. Second, the impact of an increase in risk weight on credit growth outweighs that of an increase in provisions. We test the empirical validity of these propositions by employing data on Indian commercial banks.

IV.1 The database and variables

We extract quarterly data for the period 2002:1-2012:1 from the *Prowess* database, a leading private think-tank in India. We start off with 205 banks. This includes not only commercial banks, but also regional rural banks, cooperative banks and local area banks. Since the MPPs introduced by the authorities were targeted for commercial banks, we exclude the rural, cooperative and local area banks from our sample. Additionally, we also delete several foreign banks which have become operative only recently and therefore, do not have information for an extended time span to enable a meaningful analysis. As a result, the final sample comprises of an unbalanced set on 77 banks, including all state-owned banks (SOBs), 32 foreign banks and the remaining private, including *de novo* private banks.

From this database, we cull out information on the important liabilities and asset items such as deposits, equity, loans and total assets as well as major income and expenditure numbers. Table 1 provides a description of the variables, including summary statistics.

Table 1. Variables and summary statistics

Variable	Empirical definition	Source	N.Obs	Mean	SD.
Bank-specific: Dependent					
Gr_Advance	Log ($Credit_t$) –Log ($Credit_{t-1}$)	Prowess	280	0.012	0.191
Bank-specific: Independent					
LTA	Log (Total asset)	Prowess	1677	4.234	1.036
FEE	Fee income/ Total asset	Prowess	1677	0.437	2.745
CAR	Capital adequacy ratio	Prowess	1435	0.130	0.033
NPLs	Non-performing loans/ Total loans	Prowess	1288	0.031	0.022
MPPs					
RW_CM	Coded +1 if a MPP was employed in a given quarter, else zero	Based on Sinha (2011)	3977	0.024	0.154
Provisions_CM	As above	As above	3977	0.170	0.376
RW_Housing	As above	As above	3977	0.073	0.260
Provisions_Housing	As above	As above	3977	0.098	0.297
RW_CRE	As above	As above	3977	0.073	0.260
Provisions_CRE	As above	As above	3977	0.098	0.297
Macroeconomic					
GDPGR	Quarterly growth in GDP	RBI	3977	0.019	0.071
Ownership					
SOB	Dummy=1 if a bank is state-owned, else zero	Prowess	3977	0.299	0.458
PVT	Dummy=1 if a bank is private, else zero	Prowess	3977	0.206	0.405
FOR	Dummy=1 if a bank is foreign, else zero	Prowess	3977	0.495	0.500

As it widely acknowledged, prior to the crisis, India undertook a series of MPPs to address potential over-extension in the financial sector. These comprised of two sets of measures - first, an increase in risk weights and second, an increase in provisions - and were targeted at three segments of the economy which were deemed to be vulnerable to headwinds: capital market (CM), housing (HSNG) and commercial real estate (CRE) (See, Sinha, 2011).[3]

For purposes of MPPs, we utilize the information provided in Sinha (2011) and code the variable as follows. We insert a dummy variable that takes the value of 1 during quarters in which a MPP was used and zero, otherwise. In this fashion, we allow for the MPP to be removed if circumstances call for it (Claessens et al., 2013). A drawback of this coding process is that it does not take on board the intensity in the use of the instrument: a 10 basis points (bps) increase or decrease in a MPP is treated in a similar fashion as a 100 bps increases or decrease.

To overcome this drawback, we also employ an alternate coding methodology. In case there is an increase (resp., decrease) of a measure in a given quarter of upto 25 bps, it is coded as +1 (resp., -1). Any increase (resp., decrease) in excess of (resp., lower than) 25 bps is coded as +2 (resp., -2). Provided there is no change in the measure during the quarter, it is coded as zero. In this fashion, we examine not only the MPPs *per se*, but also focus on the intensity of the impact.

[3] MPPs were also undertaken for 'Other Retail' wherein the provisions were altered, although the risk weights were kept unchanged.

IV.2 Empirical strategy

Within a multivariate framework, we employ the dynamic panel data (DPD) methodology to assess the effectiveness of MPPs on the risk variable, credit growth. A major advantage of this technique is its ability to effectively address the endogeneity problem of some of the independent variables. Accordingly, the reduced form specification for bank *b* at time *t* assumes the following form:

$$gr\_credit_{b,t} = \alpha_0 + \alpha_1\, gr\_credit_{b,t-1} + \alpha_2\, MPP_t + \alpha_3\, OWN_t + MPP_t * gr\_credit_{b,t-1} + \alpha_4\, MPP_t * gr\_credit_{b,t-1} * OWN_t + \alpha_5\, \mathbf{Z}_{b,t-1} + \alpha_6\, gdp_{t-1} + + \upsilon_{b,t}$$

The dependent credit is regressed on its lag (to check for mean reversion), a vector (**Z**) of bank-specific variables and controls for the business cycle (*gdp*). In addition, we control for bank ownership (OWN), with foreign ownership being the control category. The bank-level control variables include bank asset (to account for scale economies), ratio of fee income to total income (to account for bank's income diversification), capital adequacy ratio (as a control for bank funding structure) and finally, NPLs as a control for bank soundness.

The policy variables of interest include MPPs and their interaction terms. More specifically, we include the regression with each of the MPPs individually. To ascertain whether the impact of a specific MPP varies by the intensity of the financial cycle, we also include the interaction term – MPP**gr_credit*. A negative and significant coefficient on this variable would signify that MPPs are more effective in the upswing of the credit cycle. In addition, the inclusion of the three-way interaction term - MPP**gr_credit*.*OWN - seeks to understand as to whether the impact of a MPP over the financial cycle differs across bank ownership. We estimate our results using two different sets of MPPs as elucidated earlier: one based on *use* of the instrument and the other based on *intensity* of use of the instrument. The results are set out in table 2.

IV.3 Results and discussion

The results in Table 4 indicate that the coefficient on the lagged dependent variable (LDV) is negative. Among the bank-level controls, the coefficient on CRAR is positive and significant, whereas that on NPL is negative and significant.

In terms of policy variables, the results suggest that, taken in isolation, none of the MPPs appear to exert any perceptible influence on credit growth. This negates proposition 1 that the impact of an increase in MPPs is to moderate credit demand. On the other hand, Proposition 2 also does not appear to stand ground: the impact of an increase in risk weight is not significantly different from that of an increase in provisions.

The fact that MPPs might not necessarily be effective is consistent with previous cross-country evidence proffered by IMF (2012).

The effectiveness of MPPs in curbing the severity of the credit cycle is also not convincing, since the coefficients on the MPPs, when interacted with the LDV, are positive, when significant. By way of example, the coefficient on RW_CRE*LDV (Col. 10) is positive and significant with a point estimate equal to 0.40. What this indicates is that in the upswing of the credit cycle, the effect of an increase in MPPs is to actually, raise credit demand. However, when considered in conjunction with bank ownership, the net effect is to dampen credit demand. To see this, note that although RW_CRE*LDV is positive, the three-way interaction term RW_CRE*LDV*d_SOB is negative and highly significant with a point estimate equal to -8.39. Therefore, the net effect of an increase in risk weights (RW) on commercial real estate (CRE) for SOBs works out to be -7.99% points.

Summing up, the results provide support to the fact that although MPPs in isolation were not very effective in curbing credit expansion, when considered together with bank ownership, they played an important role in limiting overall credit growth by curbing credit growth for sectors that seemed in danger of over-extension.

V. Concluding Observations

Existing research on the Basel Accord has raised the question of how revisions to the Accord to likely to influence the efficacy of macroprudential policy. To explore this issue, the paper considers a basic framework to examine the efficacy of such policy to influence bank lending. The findings indicate the following: the impact of an increase in MPPs is to moderate credit demand and second, the impact of an increase in risk weight on credit growth outweighs that of an increase in provisions.

The basic spirit of the model is empirically explored using quarterly data on Indian banks for 2002:1-2012:1 which subsumes the imposition of MPPs. While the analysis does not unequivocally support the theoretical predictions, what is of interest is to note is that MPPs played an important role in moderating the severity of the credit cycle across bank ownership. These results are observed to be robust to alternate definitions of MPPs and after controlling for the economic environment and bank-level factors.

The findings however, would need to be treated as preliminary. In particular, as indicated earlier, the lack of a comprehensive database on the relevant variables might hinder the robustness of the results. Second, it is possible that MPPs are effective in curbing loan extension to targeted sectors, which cannot be adequately examined with the aggregate loan data. A thorough analysis of these aspects remains an important element of future research.

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Table 2. Dependent variable: Growth in advances

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lagged dependent variable (LDV)	-0.373 (0.063)***	-0.372 (0.063)***	-0.386 (0.074)***	-0.381 (0.064)***	-0.373 (0.063)***	-0.373 (0.063)***	YES	YES	YES	YES	YES	YES
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Ownership	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
RW_Capital market	0.025 (0.135)						0.025 (0.135)					
Provisions_Capital market		-0.004 (0.068)						0.121 (0.168)				
RW_Housing			0.048 (0.033)						0.022 (0.033)			
Provisions_Housing				0.037 (0.036)						0.005 (0.036)		
RW_CRE					-0.014 (0.068)						0.467 (0.180)***	
Provisions_CRE						-0.015 (0.039)						-0.021 (0.049)
RW_Capital market*LDV							-0.013 (0.024)					
Provisions_Capital market*LDV								-5.633 (5.120)				
RW_Housing*LDV									0.424 (0.221)**			
Provisions_Housing*LDV										0.455 (0.221)**		
RW_CRE*LDV											0.401 (0.0202)**	
Provisions_CRE*LDV												0.648 (1.965)
RW_Capital market*LDV*SOB							0.244 (0.523)					
Provisions_Capital market*LDV*SOB								3.836 (3.538)				
RW_Housing*LDV*SOB									-0.521 (0.068)***			
Provisions_Housing*LDV*SOB										-0.041 (0.022)*		
RW_CRE*LDV*SOB											-8.386 (3.768)**	
Provisions_CRE*LDV*SOB												-12.213

												(4.219)***
RW_Capital market*LDV*PVT							-0.024 (0.244)					
Provisions_Capital market*LDV*PVT								2.131 (2.004)				
RW_Housing*LDV*PVT									-0.027 (0.237)			
Provisions_Housing*LDV*PVT										-0.044 (0.237)		
RW_CRE*LDV*PVT											-32.870 (9.735)***	
Provisions_CRE*LDV*PVT												-0.788 (2.447)
Banks, N.Obs	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231	25; 231
Period	2002:1-2012:1	2002:1-2012:1	2002:1 - 2012:1	2002:1 - 20.12:1	2002:1 - 2012:1	2002:1-2012:1	2002:1-2012:1	2002:1-2012:1	2002:1 - 2012:1	2002:1 - 2012:1	2002:1 - 2012:1	2002:1-2012:1
Diagnostics												
Sargan (p-Value)	0.24	0.23	0.21	0.26	0.23	0.23	0.27	0.22	0.32	0.33	0.35	0.20
Difference Sargan (p-Value)	0.88	0.84	0.63	0.79	0.74	0.79	0.82	0.78	0.83	0.80	0.78	0.76
m1, m2	0.00, 0.28	0.00, 0.24	0.00, 0.61	0.00, 0.57	0.00, 0.26	0.00, 0.17	0.00, 0.28	0.00, 0.31	0.00; 0.23	0.00, 0.25	0.00, 0.36	0.00, 0.24

MPPs are based on use
Standard errors within brackets
***, ** and * denote statistical significance at 1, 5 and 10%, respectively